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Undergraduate

To Mines Students:

This Catalog is for your use as a source of continuing reference. Please save it.

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Main Telephone: 303-273-3000 Toll Free: 800-446-9488

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Student Life: Dan Fox, Vice President of Student Life
Financial Aid: Jill Robertson, Director of Financial Aid, finaid@mines.edu
Registrar: Paul Myskiw, Registrar, registrar@mines.edu
Academic Affairs: Rick Holz, Provost, academic-affairs@mines.edu

Welcome

The Academic Environment

We strive to fulfill this educational mission through our undergraduate curriculum and in an environment of commitment and partnership among students and faculty. The commitment is directed at learning, academic success and professional growth, it is achieved through persistent intellectual study and discourse, and it is enabled by professional courtesy, responsibility and conduct. The partnership invokes expectations for both students and faculty. Students should expect access to high quality faculty and to appropriate academic guidance and counseling; they should expect access to a high quality curriculum and instructional programs; they should expect to graduate within four years if they follow the prescribed programs successfully; and they should expect to be respected as individuals in all facets of campus activity and should expect responsive and tactful interaction in their learning endeavors. Faculty should expect participation and dedication from students, including attendance, attentiveness, punctuality and demonstrable contribution of effort in the learning process; and they should expect respectful interaction in a spirit of free inquiry and orderly discipline. We believe that these commitments and expectations establish the academic culture upon which all learning is founded.

Mines offers the Bachelor of Science degree in Applied Mathematics & Statistics, Chemical Engineering, Chemistry, Civil Engineering, Computer Science, Economics, Electrical Engineering, Engineering Physics, Environmental Engineering, Geological Engineering, Geophysical Engineering, Mechanical Engineering, Metallurgical and Materials Engineering, Mining Engineering, and Petroleum Engineering.

A pervasive institutional goal for all of these programs is articulated in the *Profile of the Colorado School of Mines Graduate:*

- All Mines graduates must have depth in an area of specialization, enhanced by hands-on experiential learning, and breadth in allied fields. They must have the knowledge and skills to be able to recognize, define and solve problems by applying sound scientific and engineering principles. These attributes uniquely distinguish our graduates to better function in increasingly competitive and diverse technical professional environments.
- Graduates must have the skills to communicate information, concepts and ideas effectively orally, in writing, and graphically. They must be skilled in the retrieval, interpretation and development of technical information by various means, including the use of computer-aided techniques.
- Graduates should have the flexibility to adjust to the ever changing professional environment and appreciate diverse approaches to understanding and solving society's problems. They should have the creativity, resourcefulness, receptivity and breadth of interests to think critically about a wide range of cross-disciplinary issues. They should be prepared to assume leadership roles and possess the skills and attitudes which promote teamwork and cooperation and to continue their own growth through life-long learning.
- Graduates should be capable of working effectively in an international environment, and be able to succeed in an increasingly interdependent world where borders between cultures and economies are becoming less distinct. They should appreciate the traditions and languages of other cultures, and value diversity in their own society.
- Graduates should exhibit ethical behavior and integrity. They should also demonstrate perseverance and have pride in accomplishment. They should assume a responsibility to enhance their professions through service and leadership and should be responsible citizens who serve society, particularly through stewardship of the environment.

History of Mines

In 1865, only six years after gold and silver were discovered in the Colorado Territory, the fledgling mining industry was in trouble. The nuggets had been picked out of streams and the rich veins had been worked, and new methods of exploration, mining, and recovery were needed.

Early pioneers like W.A.H. Loveland, E.L. Berthoud, Arthur Lakes, George West and Episcopal Bishop George M. Randall proposed a school of mines. In 1874, the Territorial Legislature appropriated $5,000 and commissioned Loveland and a Board of Trustees to found the Territorial School of Mines in or near Golden. Governor Routt signed the Bill on February 9, 1874, and when Colorado became a state in 1876, the Colorado School of Mines was constitutionally established. The first diploma was awarded in 1883.

As Mines grew, its mission expanded from the rather narrow initial focus on nonfuel minerals to programs in petroleum production and refining as well. Recently it has added programs in materials science and engineering, energy and environmental engineering, and a broad range of other engineering and applied science disciplines. Mines sees its mission as education and research in engineering and applied science with a special focus on the earth science disciplines in the context of responsible stewardship of the earth and its resources.

Mines long has had an international reputation. Students have come from nearly every nation, and alumni can be found in every corner of the globe.

Colorado School of Mines is a public research university devoted to engineering and applied science. It has the highest admission standards of any public university in Colorado and among the highest of any public university in the United States.

Unique Programs

Colorado School of Mines is an institution of engineering and applied science with a special focus in Earth, Energy, Environment and Materials. As such, it has unique programs in many fields. This is the only institution in the world, for example, that offers doctoral programs in all five of the major earth science disciplines: Geology and Geological Engineering, Geophysics, Geochemistry, Mining Engineering and Petroleum Engineering. It has one of the few Metallurgical and Materials Engineering programs in the country that still focuses on the complete materials cycle from mineral processing to finished advanced materials.

In addition to these traditional programs which define the institutional focus, the school is pioneering programs in interdisciplinary areas. One of the most successful of these is in the College of Engineering and Computational Sciences, which currently claims more than one-third of the undergraduate majors. This program combines civil, electrical, environmental and mechanical engineering in a nontraditional curriculum that is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone (410) 347-7700.

While many of the programs at Mines are firmly grounded in tradition, they are all experiencing continual evolution and innovation. Recent successes in integrating aspects of the curriculum have spurred similar activity in other areas such as the geosciences. There, through the medium of computer visualization, geophysicists and geologists are in the process of creating a new emerging discipline. A similar development is occurring in geo-engineering through the integration of aspects of civil engineering, geology and mining. Mines has played a leadership role in this kind of innovation over the last decade. Many degree programs offer Mines undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Master's Degree, or Master's Degree while completing the requirements for their Bachelor's Degree. These combined Bachelors-Masters programs have been created by Mines faculty in those situations where they have deemed it academically advantageous to treat BS and MS degree programs as a continuous and integrated process. These are accelerated programs that can be valuable in fields of engineering and applied science where advanced education in technology and/or management provides the opportunity to be on a fast track for advancement to leadership positions. These programs also can be valuable for students who want to get a head start on graduate education.

Location

Golden, Colorado has been the home for Mines since its inception. Located 20 minutes west of Denver, this community of 18,000 is located in the foothills of the Rockies. Skiing is an hour away to the west. Golden is a unique community that serves as home to Mines, the Coors Brewing Company, the National Renewable Energy Laboratory, a major U.S. Geological Survey facility that also contains the National Earthquake Center, and the seat of Jefferson County. Golden once served as the territorial capital of Colorado.

Accreditation

Mines is accredited through the doctoral degree by the Higher Learning Commission (HLC) of the North Central Association, 230 South LaSalle Street, Suite 7-500, Chicago, Illinois 60604-1413 – telephone (312) 263-0456. The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone (410) 347-7700, accredits undergraduate degree programs in Chemical Engineering, Civil Engineering, Electrical Engineering, Engineering, Engineering Physics, Environmental Engineering, Geological Engineering, Geophysical Engineering, Mechanical Engineering, Metallurgical and Materials Engineering, Mining Engineering and Petroleum Engineering. The American Chemical Society has approved the degree program in the Department of Chemistry and Geochemistry.

Administration

General management of the School is vested by State statute in a Board of Trustees, consisting of seven members appointed by the governor. A non-voting student member is elected annually by the student body and a non-voting faculty member is elected to serve a two-year term by the academic faculty. Financial support comes from student tuition and fees and from the State through annual appropriations. These funds are augmented by government and privately sponsored research, private gift support from alumni, corporations, foundations and other friends.

Colorado School of Mines Non-Discrimination Statement

In compliance with federal law, including the provisions of Titles VI and VII of the Civil Rights Act of 1964, Title IX of the Education Amendment of 1972, Sections 503 and 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act (ADA) of 1990, the ADA Amendments Act of 2008, Executive Order 11246, the Uniformed Services Employment and Reemployment Rights Act, as amended, the Genetic Information Nondiscrimination Act of 2008, and Board of Trustees Policy 10.6, the Colorado School of Mines does not discriminate against individuals on the basis of age, sex, sexual orientation, gender identity, gender expression, race, religion, ethnicity, national origin, disability, military service, or genetic information in its administration of educational policies, programs, or activities; admissions policies; scholarship and loan programs; athletic or other school-administered programs; or employment.

Inquiries, concerns, or complaints should be directed by subject content as follows:

The EO, ADA Coordinator, and Section 504 Coordinator for employment:
Human Resources Office
1500 Illinois Street
Golden, Colorado 80401

The ADA Coordinator and the Section 504 Coordinator for students and academic educational programs:
Marla Draper, Director of Disability Support Services
Ben H. Parker Student Center, Suite E110
Golden, Colorado 80401
(Telephone: 303.273.3297)

Discrimination Complaints and Title IX Complaints:
Katie Schmalzel, Title IX Coordinator + Director of Institutional Equity & Title IX
Golden, Colorado 80401
(Telephone: 303.273.3206)
(email: kschmalz@mines.edu)

The ADA Facilities Access Coordinator is:
Gary Bowersock, Director of Facilities Management
1318 Maple Street
Golden, Colorado 80401
(Telephone: 303.273.3330)

Student Life

Facilities

Student Center

The Ben H. Parker Student Center contains the offices for the Vice President of Student Life, Dean of Students, Student Activities, Involvement, and Leadership (SAIL), Student Government (USG & GSG), Financial Aid, Bursar and Cashier, Disability Support Services, Student Outreach & Support (SOS), Career Center, Registrar, Campus Events, Blaster Card Office and student organizations. The Student Center also contains The Periodic Table food court, bookstore, student lounges, meeting rooms, and banquet facilities.

Student Recreation Center

Completed in May 2007, the 108,000 square foot Student Recreation Center, located at the corner of 16th and Maple Streets in the heart of campus, provides a wide array of facilities and programs designed to meet student's recreational and leisure needs while providing for a healthy lifestyle. The Center contains a state-of-the-art climbing wall, an eight-lane, 25 meter swimming and diving pool, a cardiovascular and weight room, two multi-purpose rooms designed and equipped for aerobics, dance, martial arts programs and other similar activities, a competition gymnasium containing three full-size basketball courts as well as seating for 2500 people, a separate recreation gymnasium designed specifically for a wide variety of recreational programs, extensive locker room and shower facilities, and a large lounge intended for relaxing, playing games or watching television. In addition to housing the Outdoor Recreation Program as well as the Intramural and Club Sports Programs, the Center serves as the competition venue for the Intercollegiate Men and Women's Basketball Programs, the Intercollegiate Volleyball Program and the Men and Women's Intercollegiate Swimming and Diving Program.

W. Lloyd Wright Student Wellness Center

The W. Lloyd Wright Student Wellness Center, 1770 Elm Street, houses several health and wellness programs for Mines students: the Coulter Student Health Center, the Student Health Insurance Plan, the Counseling Center, the Dental Clinic, and Student Wellness Promotions. The Wellness Center is open from 8:00 am to 5:00 pm, Monday through Friday, during the fall and spring semesters. Check the website for summer and holiday hours. The Wellness Center follows the delay and closure schedule set for the campus.

Coulter Student Health Center: Services are provided to all students who have paid the student health services fee. The Coulter Student Health Center (phone 303-273-3381, FAX 303-273-3623) is located on the first floor of the W. Lloyd Wright Student Wellness Center at the corner of 18th and Elm Streets (1770 Elm Street). Nurse practitioners and registered nurses provide services by appointment Monday through Friday 8:00 am to 12:00 pm and 1:00 pm to 4:45 pm. A physician has office hours on campus during the fall and spring semesters. The Health Center offers primary health care. For X-rays, specialists or hospital care, students are referred to appropriate providers in the community. More information is available at https://www.mines.edu/student-health/

Immunization Requirement: All incoming students are required to submit documented proof of specific vaccinations or laboratory evidence of immunity. These requirements are submitted through Trailhead, using the Health Portal icon on the main page. Detailed information on uploading this required information is available at https://www.mines.edu/student-health/student-health-center/forms/

- **Measles, Mumps, and Rubella (MMR) Vaccine**: Colorado law requires every student to submit proof of two (2) valid vaccinations for measles, mumps, and rubella (MMR) given no earlier than 4 days before the student's first birthday. There must be at least 28 calendar days between the two vaccinations.
- **Meningococcal ACWY Vaccine**: Colorado law requires all students living on campus in student housing to either submit proof of a Meningitis ACWY vaccine given within the last five years, or to sign the Meningococcal waiver form. If the 5-year period will expire while the student is living on campus, we recommend receiving another Meningococcal ACWY vaccine. Students will have a hold placed on their account 5 years after the date of the most recent Meningitis ACWY vaccine if they are still living on campus. Currently, Meningitis ACWY is required, Meningitis B is recommended.
- **Tuberculosis:** Completion of the Tuberculosis questionnaire is required. This form is located in the Health Portal under the Forms tab. In some cases, TB testing may also be indicated.

Dental Clinic: The Dental Clinic is located on the second floor of the W. Lloyd Wright Wellness Center. Services include comprehensive exams, cleanings, fillings, x-rays and emergency services. Students who have paid the student health services fee are eligible for these services. The dental clinic is open Tuesdays, Wednesdays, and Fridays during the academic year with limited hours during the summer. Services are by appointment only and can be made by calling the Dental Clinic, phone 303-273-3377. Dental care is on a fee-for-service basis at a fraction of the cost of other dental offices. For the fee schedule, please refer to our website, https://www.mines.edu/student-health/student-health-center/dental-clinic/ The Dental Clinic accepts cash or checks, as well as credit/debit cards.

Fees: *Students are charged a mandatory health services fee each semester, which allows them access to services at the Health Center and Dental Clinic.*

Student Health Insurance Plan (SHIP): *Having adequate health insurance is a condition of enrollment at Colorado School of Mines. All students are charged for the Student Health Insurance Plan (SHIP) and those students with approved waivers will see the waiver credit.* Enrollment confirmation or waiver of the Mines Student Health Insurance Plan is done online. The deadline to submit a waiver is Census Day.The SHIP office is located on the second floor of the W. Lloyd Wright Student Wellness Center.

Student Health Insurance Plan--Adequate Health Insurance Requirement*: All degree seeking U.S. citizen and permanent resident students, and all international students regardless of degree status, are required to have health insurance. Students are automatically enrolled in the Student Health Insurance Plan and may waive coverage if they have coverage under a personal or employer plan that meets minimum requirements. International students must purchase the SHIP, unless they meet specific requirements. Information about the Mines Student Health Insurance Plan, as well as the criteria for waiving, is available online at* https://www.mines.edu/student-health/student-insurance/ *or by calling 303.273.3388.*

Counseling Center: Located on the second floor of the W. Lloyd Wright Student Wellness Center, phone 303-273-3377. The Mines Counseling Center is staffed by licensed and experienced mental health professionals skilled in handling a variety of presenting concerns.

Services are designed to assist students in resolving issues that interfere with their ability to successfully navigate the Mines journey. Services are confidential, voluntary and covered by student fees. The Counseling Center utilizes a Stepped Care model, which allows students to create a wellness plan that connects them to services that best meet their unique needs. Available service options include initial counselor consultations, skills-based workshops, online assisted therapy tools, brief therapy interventions, support groups, drop-in office hours, and care coordination to connect students with community providers for more intensive treatment. Visit our website to learn more about updated virtual and in-person service offerings and resources: https://www.mines.edu/counseling-center/.

Services

Academic Advising

Center for Academic Services and Advising (CASA)

Academic Advising: All students are advised by Academic Advising Coordinators in CASA throughout their undergraduate studies at Mines. First-year and new transfer students are assigned to a CASA First-Year Advisor based on their last name as they complete core course requirements and explore majors at Mines. Students can begin their Mines coursework undecided or with an intended major, and students are encouraged to explore all of the majors Mines has to offer before deciding which one or more to pursue. The Registrar's Office creates the first-semester schedule for incoming first-year and transfer students and the schedule is based on a student's intended major and takes into consideration any applicable AP, IB, and/or Dual/Concurrent Enrollment credit.

Once a student confirms their major, either at the end of their first year or the beginning of their second year, they will transition from their First-Year Advisor to their CASA Major Advisor and a faculty mentor within their academic department. Academic advising occurs through individual, walk-in, and group advising sessions as well as online, readily-available content via Canvas. Students are encouraged to work not only with their academic advisor but also peer advisors, student leaders who provide peer advising to students about registration, course enrollment, majors, minors, and more.

Academic Support Services: CASA offers a wide variety of support services designed to assist students throughout their undergraduate degree. Examples include pre-finals workshops, major exploration events, and the specific support services listed below.

Tutoring: Tutoring services are offered for all core curriculum courses and many major courses by peers. Tutoring is offered Sunday through Thursday in both CASA and in the Library.

Core Review Sessions: Core Review Sessions are group review sessions held by a peer facilitator before common core course exams. Peer facilitators also host regular office hours for more individualized assistance.

Academic Coaching: Students can work with CASA Advisors to develop the skills and technique of studying well in college, such as test-prep and cognitive learning development, in a one-on-one setting.

Faculty in CASA: Faculty from various departments host their regular office hours in CASA. Students are encouraged to utilize these professors for assistance with material and/or questions on course planning.

Visit casa.mines.edu for more information.

CSM101: The First-Year Symposium, CSM101, is a required, credit-bearing class. CSM101 aims to facilitate the transition from high school to college; create community among peers and upper-class students; assess and monitor academic progress; and provide referrals to appropriate campus resources. CSM101 is taught by 55 professional staff members (including faculty) and over 100 Peer Mentor students.

Transfer students who have successfully completed fewer than 30.0 transcripted semester hours at an institution of higher education after high school graduation will automatically be enrolled in the First-Year Advising and Mentoring Program in their first semester at CSM.

Support Services

Career Center

The Mines Career Center mission is to assist students in developing, evaluating, and/or implementing career, education, and employment decisions and plans. Career and professional development is integral to the success of Mines graduates and to the mission of Mines.

Students and recent graduates who develop, utilize and apply the services offered by the Mines Career Center will be educated, coached and empowered to conduct a strategic, personalized career exploration and ethical job search that highlights the passions, skills and strengths of each individual. In addition, students are offered opportunities to engage with companies and organizations in a variety of forums to enhance their professional knowledge and diversity of career prospects.

Services are provided to all students and for all recent graduates, up to 24 months after graduation. Students must adhere to the ethical and professional business and job searching practices as stated in the Career Center Student Policy, which can be found in its entirety on the Student's homepage of DiggerNet. In order to accomplish our mission, we provide a comprehensive array of career services:

Career, Planning, Advice, and Counseling

- "The Mines Strategy" a practical, user-friendly career manual with interview strategies, resume and cover letter examples, career exploration ideas, and job search tips;
- Online resources for exploring careers and employers at https://www.mines.edu/careers/;
- Individual job search advice, resume and cover letter critiques;
- Practice interviews;
- Salary and contract negotiation and networking skills
- Career and Professional Development Workshops - successful company research, interviewing, resumes, professional branding, networking skills;
- Career resource library.

Job Resources and Events

- Career Day (Fall and Spring);
- Online job search system: DiggerNet;
- Online and in-person job search assistance for internships, CO-OPs, and full-time entry-level job postings;
- Virtual Career Fairs and special recruiting events;

- On-campus interviewing - industry and government representatives visit the campus to interview students;
- General employment board.

Disability Support Services

Disability Support Services (DSS) is committed to providing equal access to university courses, programs and activities for students with a disability. In compliance with the ADA Amendments Act of 2008 (ADAAA) and Section 504 of the Rehabilitation Act of 1973, staff work with students to manage the impact of their disability on learning and living at Mines by providing reasonable academic, housing and dining accommodations for qualifying students. DSS determines eligibility and appropriate accommodations based on an interactive process. For more information or to request disability accommodations, please visit http://disabilities.mines.edu/. Located in the Ben H. Parker Student Center, Suite E110.

The Mines Testing Center (MTC) serves to support and proctor exams for students with approved testing accommodations. The Mines Testing Center also provides limited exam proctoring support for faculty and students when adjustments to the exam schedule are needed or requested (e.g. make-up exams, Ramadan). The MTC is located in the Green Center, Room 240. For more information, please visit: https://www.mines.edu/disability-support-services/mtc/.

Identification Cards (Blaster Card Office)

All new students must have a Blaster Card made as soon as possible after they enroll. The Blaster Card office also issues RTD College Passes, which allow students to ride RTD buses and light rail free of charge.

The Blaster Card can be used for student meal plans, to check material out of the Arthur Lakes Library, to access certain electronic doors, and may be required to attend various campus activities.

Motor Vehicles Parking

All motor vehicles on campus must be registered with the campus Parking Services Division of Facilities Management, 1318 Maple Street, and must display a CSM parking permit. Vehicles must be registered at the beginning of each semester or upon bringing your vehicle on campus, and updated whenever you change your address.

Public Safety

The Colorado School of Mines Department of Public Safety is a full service, community oriented law enforcement agency, providing 24/7 service to the campus. It is the mission of the Colorado School of Mines Police Department to make the Mines campus the safest campus in Colorado.

The department is responsible for providing services such as:

- Proactive patrol of the campus and its facilities
- Investigation and reporting of crimes and incidents
- Motor vehicle traffic and parking enforcement
- Crime and security awareness programs
- Alcohol / Drug abuse awareness / education
- Self defense classes
- Consultation with campus departments for safety and security matters
- Additional services to the campus community such as: vehicle unlocks and jumpstarts, community safe walks (escorts), authorized after-hours building and office access, and assistance in any medical, fire, or other emergency situation.

The police officers employed by the Department of Public Safety are fully trained police officers in accordance with the Peace Officer Standards and Training (P.O.S.T.) Board and the Colorado Revised Statute.

More information on the Mines Police Department is available at: https://www.mines.edu/campus-safety/

Student Publications

Two student publications are published at CSM by the Associated Students of CSM. Opportunities abound for students wishing to participate on the staffs. A Board of Student Media acts in an advisory capacity to the publications staffs and makes recommendations on matters of policy.

The *Oredigger* is the student newspaper, published weekly during the school year. It contains news, features, sports, letters and editorials of interest to students, faculty, and the Golden community.

The literary magazine, *High Grade*, is published each semester. Contributions of poetry, short stories, drawings, and photographs are encouraged from students, faculty and staff.

Veterans Services

The Registrar's Office provides academic certification services for veteran students attending the School and using educational benefits from the Veterans Administration. Additional non-academic services are provided through the Dean of Student's Office.

Activities

Student Activities, Involvement, and Leadership (SAIL)

Student Activities, Involvement, and Leadership (SAIL) coordinates the various activities and student organizations on the Mines campus. Student government, professional societies, living groups, honor societies, interest groups and special events add a balance to the academic side of the CSM community. Participants take part in management training, event planning, and leadership development. To obtain an up-to-date listing of the recognized campus organizations or more information about any of these organizations, contact the SAIL office.

Student Government

The Associated Students of Colorado School of Mines (ASCSM) is sanctioned by the Board of Trustees of the School. The purpose of ASCSM is, in part, to advance the interest and promote the welfare of CSM and all of the students and to foster and maintain harmony among those connected with or interested in the School, including students, alumni, faculty, trustees and friends. Undergraduate Student Government (USG) and Graduate Student Government (GSG) are the governing bodies recognized by Mines through ASCSM as the representative voice of their respective student bodies. The goal of these groups is to improve the quality of education and offer social programming and academic support.

Through funds collected as student fees, ASCSM strives to ensure a full social and academic life for all students with its organizations, publications, and special events. As the representative governing body of the students ASCSM provides leadership and a strong voice for the student body, enforces policies enacted by the student body, works to integrate the various campus organizations, and promotes the ideals and traditions of the School.

The Mines Activity Council (MAC) serves as the campus special events board. The majority of all-student campus events are planned by MAC. Events planned by MAC include comedy shows to the campus on most Fridays throughout the academic year, events such as concerts, hypnotists, and one time specialty entertainment; discount tickets to local sporting events, theater performances, and concerts, movie nights bringing blockbuster movies to the Mines campus; and E-Days and Homecoming.

Special Events

Engineering Days festivities are held each spring. The three day affair is organized entirely by students. Contests are held in drilling, hand-spiking, mucking, and oil-field olympics to name a few. Additional events include a huge fireworks display, the Ore-Cart Pull to the Colorado State Capitol, the awarding of scholarships to outstanding Colorado high school seniors and a concert.

Homecoming weekend is one of the high points of the year. Events include a football rally and game, campus decorations, election of Homecoming queen and beast, parade, burro race, and other contests.

International Day is planned and conducted by the International Student Council and the International Student and Scholar Services Office. It includes exhibits and programs designed to further the cause of understanding among the countries of the world. The international dinner and entertainment have come to be one of the campus social events of the year.

Outdoor Recreation Program

The Outdoor Recreation Program is housed at the Student Recreation Center. The Program teaches classes in outdoor activities; rents mountain bikes, climbing gear, backpacking and other equipment; and sponsors day and weekend activities such as camping, snowshoeing, rock climbing, and mountaineering.

Residence Hall Association (RHA)

Residence Hall Association (RHA) is a student-run organization developed to coordinate and plan activities for students living in the Residence Halls. Its membership is represented by students from each residence hall floor. Officers are elected each fall for that academic year. For more information, go to RHA.

Student Organizations

For a complete list of all currently registered student organizations, please visit the Student Activities office or website at http://studentactivities.mines.edu/.

Social Fraternities and Sororities - There are seven national fraternities and four national sororities active on the CSM campus. Fraternities and Sororities offer the unique opportunity of leadership, service to one's community, and fellowship. Greeks are proud of the number of campus leaders, athletes and scholars that come from their ranks. Colorado School of Mines chapters are:

- Alpha Phi
- Alpha Tau Omega
- Beta Theta Pi
- Kappa Alpha Theta
- Kappa Sigma
- Phi Gamma Delta
- Pi Beta Phi
- Sigma Alpha Epsilon
- Sigma Kappa
- Sigma Nu
- Sigma Phi Epsilon

Honor Societies - Honor societies recognize the outstanding achievements of their members in the areas of scholarship, leadership, and service. Each of the CSM honor societies recognizes different achievements in our students.

Special Interest Organizations - Special interest organizations meet the special and unique needs of the CSM student body by providing co-curricular activities in specific areas.

International Student Organizations - The International Student Organizations provide the opportunity to experience a little piece of a different culture while here at Mines, in addition to assisting the students from that culture adjust to the Mines campus.

Professional Societies - Professional Societies are generally student chapters of the national professional societies. As a student chapter, the professional societies offer a chance for additional professional development outside the classroom through guest speakers, trips, and interactive discussions about the current activities in the profession. Additionally, many of the organizations offer internship, fellowship and scholarship opportunities.

Recreational Organizations - The recreation organizations provide the opportunity for students with similar interests to participate as a group in these recreational activities. Most of the recreational organizations compete on both the local and regional levels at tournaments throughout the year.

International Student Services

The International Student and Scholar Services Office (ISSS) serves approximately 850 international students and 150 scholars from 80 countries.

The ISSS provides the following services:

- Provide student orientation for incoming international undergraduate, graduate, and exchange students.
- Issue initial immigration documents used to attain a U.S. visa.
- Advise on immigration regulations by individual appointment and group seminars.
- Prepare legal documents that allow international students to attain work authorization and gain work experience.
- Provide forms required by international students and their dependents to travel outside of the United States.
- Advise various international student groups, such as the International Student Council and fourteen student associations.

- Provide key pre-departure and arrival information for incoming students and their dependents.
- Oversee the international scholarship program.
- Management of the international scholar program. Provide initial immigration documents and scholar orientation.

The ISSS office also sponsors events and programs to help students adjust to life in the United States and at Mines. International Student and Scholar Services also provides advising related to emergencies and unexpected immigration problems.

If you have questions about international admissions, degree programs, billing, financial aid, or housing, please visit those specific Colorado School of Mines web pages. Please send other questions and comments about international student life at Colorado School of Mines to mcramer@mines.edu

For more information see www.isss.mines.edu

Multicultural Engineering Program

Multicultural Engineering Program

The Multicultural Engineering Program (MEP) is located at 1700 Maple Street. MEP provides support that contributes to the recruitment, retention and graduation of students historically underrepresented in STEM. MEP provides professional development as related to equity and inclusion to students, staff, and faculty. MEP offers academic support, leadership opportunities, professional development, tutoring, community outreach, cultural, and social activities.

The Multicultural Engineering Program helps to build community with students through our many partnerships and advocacies. MEP supports the following professional societies: American Indian Science and Engineering Society (AISES), National Society of Black Engineers (NSBE), Out in Science, Technology, Engineering and Mathematics (oSTEM), Society of Asian Scientists and Engineers (SASE), and the Society of Hispanic Professional Engineers (SHPE).

American Indian Science and Engineering Society (AISES) is a non-profit national organization that represents American Indians and Alaskan Natives in engineering, science, and other related technology disciplines. The mission of AISES is to substantially increase the representation of American Indians and Alaskan Natives in engineering, science, and other related technology disciplines. Through the quality and reach of its programs and the longevity and devoted commitment of its “family,” AISES is the undisputed leader in STEM opportunity in Indian Country. Members from over 200 tribal nations are represented within AISES, and AISES enjoys the support and partnership of corporate, government, academic, and tribal decision-makers.

National Society of Black Engineers (NSBE) is a non-profit organization managed by students. It was founded to promote the recruitment, retention and successful graduation of Black and other under-represented groups in the field of engineering. NSBE operates through a university-based structure coordinated through regional zones, and administered by the National Executive Board. The local chapters, which are the center of NSBE activity, create and conduct projects in the areas of pre-college student interaction, university academic support mechanisms and career guidance programs. “We instill pride and add value to our members which causes them to want to give back to NSBE in order to produce a continuum of success.”

Out in Science, Engineering, Technology & Mathematics (oSTEM) is a national society dedicated to educating and fostering leadership for LGBTQA communities in the STEM fields. Originally established at Mines in 1997, and formally Sigma Lambda.

Society of Asian Scientists and Engineers (SASE) The Colorado School of Mines student chapter of the Society of Asian Scientists and Engineers is dedicated to the enhancement of Asian Pacific Americans in the engineering and scientific community. We strive to develop leaders who are educated in issues facing both Asian and non-Asian communities and promote the academic and professional success of our members. Our goal is to erase ignorance and maintain equality through empowerment and positive community impact.

Society of Hispanic Professional Engineers (SHPE) is a non-profit organization that exists for the advancement of Hispanic engineering students to become professional engineers and scientists, to increase the number of Hispanics entering into the field of engineering, and to develop and implement programs benefiting Hispanics seeking to become engineers and scientists. Anyone interested in joining may do so. SHPE is a national organization with student and professional chapters in nearly 100 cities across the country. The organization is divided into five regions. The SHPE organization is governed by a National Board of Directors which includes representatives from all regions including two student representatives.

For further information, contact:

Andrea Salazar Morgan, Director, Multicultural Engineering Program
Colorado School of Mines
1700 Maple Street
Golden, CO 80401
Phone: (303)273-3021
asalazar@mines.edu

Office of Global Education (OGE)

The Office of Global Education (OGE) fosters and facilitates international linkages, cultural exchange, and the development of international expertise across all sectors of the University. OGE is responsible for study overseas through exchange and education abroad programs and offers immigration and orientation services for international students and scholars who study and work at Mines.

OGE is located in the Green Center, Room 219. For specific information about study abroad and other international programs, contact OGE at 303 384-3210 or visit the OGE web page (https://www.mines.edu/global).

The office works with the departments and divisions of the School to:

1. Promote internationalization of Mines' curricular programs and activities
2. Help develop and facilitate study abroad opportunities for Mines students while serving as an informational and advising resource for them;
3. Assist in attracting new international students to Mines;

4. Serve as a resource for faculty and scholars of the Mines community, promoting faculty exchanges, faculty-led study abroad, and the pursuit of collaborative and bilateral exchange agreements;
5. Facilitate arrangements for official international visitors to Mines.

Office of Women in Science, Engineering and Mathematics (WISEM)

The Women in Science, Engineering, and Mathematics (WISEM) Program office is located at 1710 Illinois Street.

Mission: The WISEM Program advocates and strives for an inclusive and equitable environment for women students, faculty and staff by enhancing opportunities and providing programming for the Mines community.

Vision: To lead campus in enhancing women's experiences at Mines by

- preparing students for successful, sustainable, rewarding careers.
- equipping Mines employees with professional success and advancement opportunities.
- providing all members of the Mines community with educational opportunities and resources that contribute to an inclusive and welcoming campus environment.

The office sponsors programs and services for the Mines community regarding gender and equity issues, and produces the Chevron Lecture Series, Women's History Month events, and the Continuum. The Society of Women Engineers (SWE) falls under the WISEM umbrella, and is a student run organization. The WISEM Director serves as an advisor to SWE.

For additional information, contact:

Annette Pilkington
Director
Women in Science, Engineering and Mathematics Program
COLORADO SCHOOL OF MINES | mines.edu
1710 Illinois St., Golden, CO 80401
303-273-3498 | apilking@mines.edu | WISEM.MINES.EDU

Tuition, Fees, Financial Assistance, Housing & Dining Rates

Tuition, Fees, Financial Assistance, Housing & Dining Rates

Tuition and fees are established by the Board of Trustees of Colorado School of Mines following the annual budget process and action by the Colorado General Assembly and Governor.

Tuition

The official tuition and approved charges for the academic year will be available prior to the start of the academic year and can be found online on the Bursar's website.

Fees

The official fees, approved charges, and fee descriptions for the academic year will be available prior to the start of the academic year and can be found online on the Bursar's website.

Housing & Dining Rates

Room and board charges are established by the Board of Trustees and are subject to change. Payment of room and board charges falls under the same guidelines as payment of tuition and fees. For more information, go to Resident Life's website or Mines Dining.

Payments and Refunds

Financial Responsibility

It is the student's responsibility to abide by Mines payment and refund policies when registering for classes.

- Full payment of tuition and fees are due by 4pm MST on the first business day following Census Day for each term. Please see the Bursar's website for specific semester information.
- Students are responsible for viewing their account balance online through Trailhead. Mines generates electronic invoices only, no paper invoices will be mailed.
- Students are responsible for dropping their courses by the published drop deadline if they don't plan to attend. Failure to do so will result in charges incurred on the student account.

If you don't fulfill your financial obligations:

- Any unpaid balance at 4pm MST on the due date will be assessed a 1.5% late fee.
- An additional 1.5% late fee will be assessed to any unpaid balance each month thereafter.
- Accounts not paid in full by the last day to drop classes are considered past due. Holds will be placed on past due accounts preventing registration, transcripts, diplomas, and access to other student records.
- Accounts not paid in full at the end of each semester are considered delinquent. Delinquent accounts will be turned over to a collections agency in accordance with Colorado law and all collection fees and costs will be added to the account balance. The collection agency may report delinquent accounts to the national credit bureau.
- Students whose accounts have been sent to a collection agency must pay their balance in full and prepay for any subsequent semester before registration will be allowed.
- Any students whose debt to Mines was written off due to a bankruptcy discharge will be required to prepay for future semesters before registration will be allowed.

Refunds

The amount of tuition and fee assessments is based primarily on each student's enrolled courses. In the event a student withdraws from a course or courses, assessments will be adjusted as follows:

- If withdrawal from a course or courses is made prior to the end of the add/drop period for the term of enrollment, as determined by the Registrar, tuition and fees will be adjusted to the new course level without penalty.

- If withdrawal from a course or courses is made after the add/drop period, regardless of whether or not the student officially withdraws from Mines, no adjustments in charges will be made.

Please note: students receiving federal financial aid under the Title IV programs may have a different refund as required by federal law or regulations.

Room and board refunds are pro-rated to the date of checkout from the Residence Hall. Arrangements must be made with the Housing Office.

Student health insurance charges are not refundable. The insurance remains in effect for the entire semester.

Late Fee for Application to Graduate after Stated Deadlines - $250

Undergraduates:

The deadline to apply to graduate and participate in commencement is the first day of class of the term in which the student intends to graduate/participate.

Any request to be added to the graduation list and/or commencement ceremony after the first day of class (and before November 10th for fall or April 10th for spring and summer) may be made in writing and will be considered by the Registrar's Office. If the request is denied, the student will be required to apply for the next available graduation/ceremony. If the request is approved and all other conditions are met (i.e. degree requirements can be met, required forms are turned in, and outstanding hours limitations are not exceeded), a mandatory $250 fee will be applied to the student's account. This fee cannot be waived and cannot be refunded if the student does not meet the graduation check-out deadlines.

For late requests that are approved, tickets to the commencement ceremony for family and friends of the graduate are not guaranteed, as they may have already been distributed or assigned. Additionally, the student's name may not appear in the commencement program due to publishing deadlines.

No undergraduate student will be added to a graduation or commencement when the request is made after November 10th for the fall commencement (which includes December graduation), or April 10th for the spring and summer commencement ceremony (which includes May and August graduations).

College Opportunity Fund

The College Opportunity Fund provides State financial support to eligible students for higher education. It was created by an Act of the Colorado State Legislature and signed into law by Governor Owens in May 2004.

What does it mean? In the past, the State gave money directly to the colleges. Now, if you authorize use of the stipend for any given term, the college you are attending will receive the funding, and you will see it appear as a credit on your tuition bill.

Who is eligible? Undergraduate students who are eligible for in-state tuition, and who apply for COF, are admitted to and enrolled in an eligible institution of higher education, and who authorize the institution to collect the funds on their behalf. Once enrolled at the Colorado School of Mines, the student must authorize the School to collect these funds from the state on the student's behalf. Once authorized, the School will continue to collect these funds on the student's behalf unless and until the student chooses to revoke the authorization.

How much is the stipend? It will vary. The amount will be determined each year by the Colorado Legislature.

For additional information please refer to:

Colorado School of Mines website: https://www.mines.edu/registrar/college-opportunity-fund/

Colorado Department of Higher Education's website: http://highered.colorado.gov/Finance/COF/default.html

The College Opportunity Fund website: https://cof.college-assist.org/

Financial Aid and Scholarships

Undergraduate Student Financial Assistance

The role of the Mines Financial Assistance Program is to assist students to enroll and complete their education. Please visit the financial aid website for more information on how financial aid works, current costs and other processing questions. finaid.mines.edu

Applying for Assistance

The Mines Application for Admission serves as the application for merit-based scholarships for new students. Students will receive information regarding additional scholarship applications once admitted. Continuing students may be recommended by their major department for scholarships designated for students from that department. To apply for need-based Mines, Federal and Colorado assistance, students should complete the Free Application for Federal Student Aid.

Once evaluated, a financial aid award notification will be sent to the student. New students are sent a paper award letter beginning in early January. Continuing students are notified in early June via their Mines email.

Types of Financial Assistance

Need-based assistance will typically include grants, part-time employment, and student loans. Grants are provided by Mines, by the State of Colorado (Colorado State Grants), and by the federal government (Pell Grants and Supplemental Educational Opportunity Grants).

Work Study funds also come from Mines, State of Colorado and the federal government. Students work between 8 and 10 hours a week, and typically earn between $500 to $1,500 to help pay for books, travel, and other personal expenses.

Student Loans may be offered from The Direct lending program through the federal government. Mines offers a limited amount of institutional loans to assist students during the summer.

Supplemental student loans may also be offered through private bank loan programs.

Merit-based assistance is offered to incoming freshmen to recognize them for their outstanding achievements. Awards to new freshmen students are made on the basis of their academic performance in high school as well as information on the admissions application such

as outside activities. New transfer students who are seeking their first degree may be eligible for a merit award if they belong to Phi Theta Kappa. Continuing students can receive departmental scholarships based on their academic performance at Mines, particularly in their major field of study, and on financial need.

Alumni Association Grants are awarded to students who are children of alumni who have been active in the Mines Alumni Association for the two years prior to the student's enrollment. The students may also receive a senior award, based on their academic scholarship, and the availability of funds.

Engineers' Day Scholarships are available to Colorado residents. Based on high school records, an essay, and other information, a committee of Mines' students selects the recipients for these four-year awards. Students will be informed of the application during the admission process.

Athletic scholarships may be awarded to promising student-athletes in sixteen men's and women's sports. The scholarships are renewable for up to three years, based on the recommendation of the Athletics Department.

Army ROTC scholarships are available from Mines and the U.S. Army for outstanding young men and women who are interested in a military career. The one, two, three, and four-year scholarships can provide up to full tuition and fees, a book allowance, and a monthly stipend for personal expenses. The Mines Military Science Department assists students in applying for these scholarships.

U.S. Navy Scholarships through the Civil Engineering Program, Nuclear Power Officer Program, and Baccalaureate Degree Completion Program are also available to Mines students. The local Navy Recruiting District Office provides information about these scholarships.

U.S. Air Force ROTC Scholarships are available from Mines and the U.S. Air Force. The three and four year scholarships can provide up to full tuition, fees, a book allowance, and a stipend. Further information is available through the Department of Aerospace Studies at the University of Colorado Boulder (the official home base for the Mines detachment).

In addition to scholarships through Mines, many students receive scholarships from their hometown civic, religious or other organizations. All students are urged to contact organizations with which they or their parents are affiliated to investigate such scholarships. The Financial Aid Office reserves the right, unless otherwise instructed by the student, to release the student's information to scholarship providers for the purpose of assisting students in obtaining scholarships.

Financial Aid Policies

General

Students are required to report to the Financial Aid Office all financial assistance offered or received from all sources, including Mines, immediately upon receipt or notification of such assistance. For the purpose of this paragraph, "financial assistance" shall include, but not be limited to, grants, scholarships, fellowships, or loans funded by public or private sources, as well as all income not considered taxable income by the Internal Revenue Service. Upon receipt of this information, Mines shall evaluate, and may adjust any financial assistance provided to the student from Mines, Colorado, or federal funds. No student shall receive financial assistance from Mines if such student's total assistance from all sources exceeds the total cost of the student's education. For the purpose of this paragraph, the "total cost of education" shall be defined to include the cost of tuition, fees, books, room and board, transportation, and personal expenses.

Funds for the Federal Pell Grant, Federal Supplemental Educational Opportunity Grant, Federal College Work-Study Program, Federal Direct Stafford Loan, and Federal Direct PLUS Loans are provided in whole or part by appropriations of the United States Congress. The Colorado General Assembly provides funds for the Colorado Grant and Colorado Work-Study programs. These programs are all subject to renewed funding each year.

Satisfactory Academic Progress

Mines students receiving scholarships must make satisfactory academic progress as specified in the rules and regulations for each individual scholarship.

Students receiving assistance from federal, Colorado or need-based Mines funds must make satisfactory academic progress toward their degree. Satisfactory progress is defined by maintaining adequate pace towards graduation and maintaining a 2.0 cumulative GPA at all times. Pace is measured by dividing the overall credit hours attempted by the overall credit hours completed. Students will be required to maintain a 75% completion rate at all times. Satisfactory standing is determined after each semester, including summer. If students are deficient in either the pace or grade average measure, they will receive a one semester warning period during which they must return to satisfactory standing.

If this is not done, their eligibility will be terminated until such time as they return to satisfactory standing. In addition, if students receive grades of F or INC in all of their courses, their future financial aid eligibility will be terminated without a warning period. Financial aid eligibility termination may be appealed to the Financial Aid Office on the basis of extenuating or special circumstances having negatively affected the student's academic performance. If approved, the student will receive a probationary period of one semester to regain satisfactory standing.

Study Abroad

Students wishing to pursue study abroad opportunities should contact the Office of International Programs (OIP), listed under the Services section of this Catalog. Colorado School of Mines encourages students to include an international study/work experience in their undergraduate education. Mines maintains student exchange programs with a wide variety of institutions. Courses successfully passed abroad can be substituted for their equivalent course at Mines. Overall GPA is not affected by courses taken abroad. A well-planned study abroad program will not delay graduation. In addition, study abroad can be arranged on an individual basis at universities throughout the world.

Financial aid and selected scholarships and grants can be used to finance approved study abroad programs where hours toward the student's program will be transferred to Mines. The OIP has developed a resource center for study abroad information, phone 303-384-2121. Students are invited to use the resource materials and meet with staff to discuss overseas study opportunities.

Withdrawals

We understand that unexpected events occur in life that will cause a student to withdraw from classes at Colorado School of Mines. Federal regulation requires financial aid to be awarded under the assumption that a student will attend the institution for the entire period in which federal assistance was disbursed. The following policies will help you

to understand the impact a withdrawal may have if you are receiving financial aid. The tuition and fees refund policy set by Mines is separate from the return calculation required by federal regulation.

An official withdrawal will be recorded once the withdrawal process has been completed by the student. Students who withdraw from the University should contact the financial aid office as part of the withdrawal process to determine what effect this will have on their financial aid. A withdrawal requires the financial aid office to determine how much of the federal, state and institutional financial aid the student has earned. Financial aid is not considered earned until the 60% point of the semester. The unearned portion will be returned to the program from which it came (i.e. student loans to the lender, Pell to the federal department of education, etc). Students need to be aware that they may owe Colorado School of Mines for unearned federal, state and/or institutional aid even if they are receiving a refund in tuition and fees.

Federal regulations consider a student to be an unofficial withdrawal if the student receives all failing grades for the term. If the student has not completely withdrawn and has failed to earn a passing grade in at least one class for the term, Mines is required to determine whether the student established eligibility for financial aid by attending at least one class or participating in any Mines academic-related activity. An unofficial withdrawal calculation will be performed and funds returned to their respective federal, state and/or institutional aid programs if there is not documentation supporting the student's last day of attendance, or the documentation indicates the student stopped attending prior to the 60% point of the semester.

State of Colorado Residency Qualifications

A student is classified as a resident or nonresident for tuition purposes at the time admission is granted and upon completion of the CSM Colorado Residency for Tuition Classification Form. The classification is based upon information furnished by the student. The student who, due to subsequent events, becomes eligible for resident tuition after enrolling at CSM must complete a petition through the Registrar's Office. More information on residency requirements and what petition to complete can be found on the residency website.

The final decision regarding tuition status rests with the Tuition Appeals Committee of Colorado School of Mines. A student who willfully gives wrong information to evade payment of nonresident tuition shall be subject to serious disciplinary action.

Petitioning for In-State Tuition Classification

The specific requirements for establishing residency for tuition classification purposes are prescribed by state law (Colorado Revised Statutes, Title 23, Article 7). Because Colorado residency status is governed solely by Colorado law, the fact that a student might not qualify for in-state status in any other state does not guarantee in-state status in Colorado. The tuition classification statute places the burden of proof on the student to provide clear and convincing evidence of eligibility.

There are three components to determining residency eligibility for undergraduate students:

- **Emancipation** means a student's parents have entirely surrendered care, custody, and support of the student. The student is able to independently support themselves. Support of any kind from family and/or friends does not make a student emancipated. Emancipation must occur at least one year before a student can establish domicile and intent.
- **Domicile** is a person's true, and permanent home and place of habitation and must be established at least one-year prior to the first day of classes.
- **Intent** are the legal ties a person has established to make Colorado their permanent home and must be established concurrently while establishing domicile.

To be able to establish domicile and intent, an undergraduate student must be a "qualified person" under one of the following categories: parent/legal guardian, adult (23 years old prior to the first day of classes), or if you are under 23 years old you must be legally emancipated. More information on how to qualify and petition for resident status, as well as deadlines, can be found on the residency website.

Residence Halls

Housing & Dining

Room and board charges are established by the Board of Trustees and are subject to change. Payment of room and board charges falls under the same guidelines as payment of tuition and fees. Rates for the 2021-2022 Academic Year can be found by going to: Residence Life Rates.

Housing Application

Information and application for residence hall space is included in the packet offering admission to the student. Colorado School of Mines has a First Year Residency Requirement. All housing assignments are based on the date of the enrollment deposit with Admissions.

After the first year, sophomore students are invited to live in our sophomore housing communities in Maple Hall and 1750 Jackson. Residence Life also encourages upper-class and graduate students to apply to the Apartments at Mines Park. Additionally, students associated with Fraternity & Sorority Life may apply for housing through Residence Life in partnership with Fraternity & Sorority Life (within SAIL). The submission of a room application for all housing areas can be done in Trailhead.

Contracts are issued for the full academic year and no cancellation will be accepted after an agreement has been submitted, except for those who decide not to attend Colorado School of Mines. Those contracts separately issued only for entering students second semester may be cancelled no later than December 1. After that date no cancellation will be accepted except for those who decide not to attend Mines.

Housing & Dining

Residence Halls

Residence hall living is an integral part of the Colorado School of Mines experience. All first-year students are required to live on campus in the residence halls, most sophomores and many upper-class students continue to live in Residence Life housing throughout their time at Mines.

The “Traditional” residence halls (Morgan, Thomas, Bradford, and Randall halls) house about 380 first-year students in single and double rooms on single gender floors, with a community-style bathroom facility on each floor. Weaver Towers has living space for 230 first-year students in suites with single and double rooms, a common living area, and two

single bathroom facilities. Maple Hall is a 290-bed suite-style facility with single and double bedrooms and a few triple rooms, Maple has a semi-private bathroom in each suite shared by one other room. Maple Hall houses both first-year and sophomore residents. Elm Hall is a neighborhood-style facility offering space for 210 students in mostly double rooms, with a limited number of single and triple rooms. Elm has several community bathrooms that offer private options on each floor. Spruce Hall is our newest residence hall, housing 400 first-year students, with single, double, and triple bedrooms in a traditional community style building with community bathrooms that are gender-inclusive. Elm Hall and Spruce Hall are both options for Gender Inclusive Housing.

All residence hall spaces have kitchens, study lounges, social lounges, laundry facilities, and a front desk to help with packages and to provide some services to our residents. All residence hall bedrooms are equipped with a twin extra-long, loftable bed, a desk, a chair, a dresser, and a closet space for each student, as well as wired and wireless internet connections, and unlimited laundry. Students are responsible for damage to the room or furnishings. Colorado School of Mines assumes no responsibility for loss or theft of personal belongings, and residents are strongly encouraged to carry personal property, or renters insurance.

Additionally, Residence Life offers students an option to live and learn within a Theme Learning Community that is a partnership between Residence Life, administrative departments, and faculty across campus. Theme Learning Communities consist of intentionally designed living experiences centered around a variety of educational, cultural, organizational, and personal interests. These communities allow students with common interests to live together and support each other through planned activities and informal interactions, and to build relationships with faculty outside the classroom through the Faculty Friend program. Communities include Adventure Leadership Community (Outdoor Recreation), Oredigger Leadership & Service Community, Visual and Performing Arts, Athleticism and Wellness, Nucleus Scholars, and Engineering Grand Challenges. For more information, please see the Theme Learning Community Web page.

For all Housing & Dining rates, please see the Housing Rates web page.

Mines Dining

Mines Dining operates a main dining hall, Mines Market, and five retail dining facilities on campus. Mines Market features all-you-care-to-eat dining, adjacent to Elm Hall. Additional retail dining facilities, including The Periodic Table (featuring Starbucks, WOW Café, and Habañeros) in the Student Center, Sub-Connection and Jamba in the Student Recreation Center, Blaster's Brew in Brown Hall, Einstein Bros. Bagels in CTLM, and Zime in the new residence hall Spruce Hall, take student meal plans, as well as cash or credit card. Residence hall students are required to maintain a resident meal plan. Meal plans are designed to be flexible in order to best serve our student's needs.

Students not living in a residence hall may purchase any one of several commuter, or voluntary, meal plans which best meets their individual needs. Dining options are limited during breaks (Thanksgiving, Fall, Winter and Spring Break). For more information and hours, go to Mines Dining.

For rates, please see the Residential Meal Plans page.

Housing beyond the first year in on campus apartments

Mines is proud to offer housing to students beyond their first year in a variety of locations and housing options.

1750 Jackson is a sophomore living apartment community on the east side of campus. 1750 Jackson houses 360 students in their second year, creating options for students to live independently while living with their friends in a Residence Life supported environment. 1750 Jackson has fully furnished apartments (Twin XL loftable bed and mattress, desk, chair, dresser, couch, chair, coffee tables, and stools) with kitchens for four students, living in either double or single bedrooms. There are also single studio apartments available in limited quantity. 1750 Jackson residents have wired and wireless internet connections and unlimited laundry on each floor, there are also indoor and outdoor common areas for studying, relaxing, and fun.

The Mines Park apartment complex is located west of the 6th Avenue and 19th Street intersection on 55 acres owned by Mines. The complex houses upper-class undergraduate students, graduate students, and students with families. Mines Park units are complete with refrigerators, stoves, dishwashers, wired and wireless internet connections, unlimited laundry, and a Mines Park parking pass, but are not furnished units. There are two community centers that contain laundry facilities, recreational and study space, and meeting rooms. For more information or to apply for apartment housing, go to the Mines Park webpage. Additionally, the Mines Park office is located within Community Center 2 for any additional assistance you may need.

Residents of our apartment communities must be full-time students to live in Residence Life Housing. Student and professional staff live within each community for any assistance, advice, support, and community building as well as emergency response.

For all Housing & Dining rates, please see the Housing Rates page.

Fraternities, Sororities

Any non-freshman student who is a member of one of the national Greek organizations with a house on campus is eligible to live in Fraternity or Sorority housing after their freshman year. Several of the Greek Houses are owned and operated by the School, while the remaining houses are owned and operated by the organizations. All full time, undergraduate students are eligible to join these organizations. For information, visit the Fraternity and Sorority Life office.

Undergraduate Information

Undergraduate CATALOG

It is the responsibility of the student to become informed and to observe all regulations and procedures required by the program the student is pursuing. Ignorance of a rule does not constitute a basis for waiving that rule. The Undergraduate Catalog, current at the time of the student's most recent admission, gives the academic requirements the student must meet to graduate. However, a student can change to the requirements in a later catalog published while the student is enrolled as an undergraduate. Changes to administrative policies and procedures become effective for all students as soon as the campus community is notified of the changes. The Undergraduate Catalog is available to students in electronic format. Electronic versions of the Undergraduate Catalog may be updated more frequently to reflect

changes approved by, and communicated to, the campus community. As such, students are encouraged to refer to the most recently available electronic version of the Undergraduate Catalog. This version is available at the Mines website. The electronic version of the Undergraduate Catalog is considered the official version of this document. In case of disagreement between the electronic and print versions (if available), the electronic version will take precedence.

Admission Requirements

Colorado School of Mines seeks to admit a diverse and dynamic student population representative of the state of Colorado, the nation and beyond. Mines admits students who have demonstrated the ability to accomplish classroom and laboratory work and benefit from our programs. The decision to admit a student is based on our confidence in one's ability to earn a degree at Mines. Criteria considered in evaluating students include:

1. pattern of course work in high school or college,
2. grades earned in those courses,
3. ACT or SAT test scores (if provided),
4. rank in class, and
5. other available test scores (if provided),
6. other factors and characteristics of a successful student.

No single criterion for admission is used.

The admission requirements below are minimum requirements for consideration and may change after a catalog has been finalized. Admission is competitive and not guaranteed. The Board of Trustees, Mines governing board, reserves the right to deviate from published admission requirements. In such cases, changes in admission policy would be widely publicized.

Freshmen

Admission is competitive. The minimum requirements for admission consideration for all high school graduates who have not attended a college or university are as follows:

1. An applicant must be a graduate of an accredited high school.
2. The following 17 units of secondary school work should be completed upon graduation from high school:

Algebra	2.0
Geometry	1.0
Advanced Mathematics (including Pre Calculus and/or Trigonometry)	1.0
English	4.0
History or Social Studies	3.0
Academic Elective (Computer Science if available)	2.0
Laboratory Science	3.0
Foreign Language	1.0
Total Semester Hrs	**17.0**

3. One unit of laboratory science must be either chemistry or physics. The second and third units may be chemistry, physics, biology, zoology, botany, geology, etc. with laboratory. Both physics and chemistry are recommended for two of the three required units. General Science is not acceptable as a science unit, however it is acceptable as an academic elective unit.
4. The 2 units of academic electives (computer science, social studies, mathematics, English, science, or foreign language) must be acceptable to the applicant's high school to meet graduation requirements. For applicants submitting GED Equivalency Diplomas, these units may be completed by the GED test.

Transfer Students

Admission is competitive. An applicant to Mines is considered to be a transfer student if he or she has enrolled in coursework at another college after graduating from high school. The minimum requirements for admission consideration for all transfer students are as follows:

1. Students transferring from another college or university must have completed the same high school course requirements as entering freshmen. A transcript of the applicant's high school record is required.
2. Applicants must present official college transcripts from all colleges attended. Applicants must have an overall, cumulative college grade point average of 2.75 or better. Students presenting a lower GPA will be given careful consideration and acted on individually.
3. An applicant who cannot re-enroll at the institution from which he or she wishes to transfer, or from any previously attended institution because of scholastic record or other reason will be evaluated on a case-by-case basis.
4. Completed or "in progress" college courses which meet Mines graduation requirements are eligible for transfer credit if the institution is regionally accredited, and the course is not remedial or vocational, and the grade earned is a "C" or better. For more information see: http://catalog.mines.edu/undergraduate/undergraduateinformation/academicregulations/ (p. 16)

Former Students

The minimum admission requirements for those students who have previously attended Mines are as follows:

1. Any student who has attended another college or university since last enrolling at Mines must re-apply for admission through the Admissions Office.
2. Any student who did not complete the semester immediately preceding the beginning of the period for which he or she wishes to enroll must be re-admitted to Mines by the Admissions Office.
3. A former student, returning after a period of suspension, must apply for admission to the Admissions Office and must furnish an approval for such re-enrollment from the Readmissions Committee of Colorado School of Mines. Appropriate forms to apply for admission may be obtained from the Admissions Office. Official transcripts for all coursework completed while away from Mines must be submitted to the Registrar's Office for review of transferability of the credit.

Exchange Students

All students participating in the Mines Exchange Program (coming to Mines and Mines students going abroad) must be enrolled in a minimum of 15 semester credit hours at Mines or the host university abroad. Contact Mines Education Abroad for further information about this requirement.

International Students

For purposes of admission, international applicants are students in a non-immigrant status who are not U.S. citizens or do not have approved and

finalized U.S. permanent residence, refugee status or political asylum. International students usually need an F1 or J1 visa to study in the United States.

Generally, international applicants seeking admission to Colorado School of Mines must meet the same academic standards for admission as those required of American applicants. Admission is competitive. There are wide variations, however, between educational systems throughout the world that make exact comparisons of educational standards difficult. International applicants are selected on the basis of their prior academic work, probability of success in the chosen curriculum (as evidenced by prior work in the academic area involved) and proof of English proficiency. After admission but prior to enrollment, certification of adequate financial resources is required.

International applicants must submit a completed application; a $50 nonrefundable international document processing fee; translated secondary schooling records, and/or a credentials evaluation report, and when applicable, translated college transcripts. After admissions but prior to enrollment, a credential evaluation performed by a NACES member and certification of adequate financial resources is required.

English Proficiency

Student applicants whose native language is not English (identified by the U.S. Department of State Bureau of Public Affairs), must prove proficiency in the English language by achieving one of the following:

1. A TOEFL (Test of English as a Foreign Language) score of 79 on the internet Based TOEFL (iBT).

Subject	Internet TOEFL (iBT)	Paper TOEFL (PBT)
Reading	20	54
Writing	17	55
Listening	21	55
Speaking	21	N/A
Total	79	550

2. An IELTS (International English Language Testing System) Score of 6.5, with no band below a 6.0.
3. Pearson Test of English/PTE Academic: Minimum overall score of 53 with no communicative skills score below 50.
4. Duolingo English Test - The Duolingo English Test is an acceptable test of English proficiency. A minimum overall score of 105, with no subscore below a 105 is required for all Fall 2021 applicants. We will evaluate our requirements in 2021 to determine 2022 requirements.
5. A bachelor's degree from a regionally accredited U.S. college or university.
6. Completion of four years of high school in a U.S. high school. These applicants are subject to high school competency requirements and ACT and/or SAT results.
7. Transferable credit from an accredited US institution of higher education equivalent to 30 credits or more including 6 credits of freshman English composition at a U.S. college or university with a cumulative GPA of 3.0 or higher.

The above English Proficiency requirement applies to students currently studying in the United States and for students outside the country.

Advanced Credit for International Evaluation

The following methods are used by Colorado School of Mines to validate the awarding of advanced standing credit for international students who have completed work in their home countries at the postsecondary level:

1. Credit is granted based upon recommendation by recognized academic publications, primarily provided by the American Association of Collegiate Registrars and Admissions Officers.
2. Courses are evaluated by a comparable credit-granting department at Colorado School of Mines.

Enrollment Requirement - English Language

All new students whose primary language is not English must demonstrate English Language proficiency before enrolling for the first time at the university. This requirement applies to international and non-international, permanent residents, immigrants, transfer and non-transfer students alike.

Enrollment Requirement - International Coursework

All new students who have taken courses during high school outside of the U.S. must submit their official high school transcripts in the original language, as well as a certified English translation and credential evaluation and designate Mines as a copy recipient of your evaluation. The preferred translation agencies are Educational Credential Evaluators (ECE) or World Education Services (WES). Other National Association of Credential Evaluation Services (NACES) will be considered on a case-by-case basis.

Enrollment Requirement - All Admitted Students

All admissions are ultimately contingent upon successful completion and submission of final transcripts reflecting academic achievement similar to assessment at the time of admission. Students are expected to continue to prepare at a similar level of academic rigor, and with similar or better results as the enrollment date approaches. If final transcripts/documents are received that reflect information different from the admission assessment, Colorado School of Mines reserves the right to review the admission offer again, and to take appropriate action. This may include a change in conditions or terms of admission, or a rescission of the admission offer.

Fraudulent Applications

Individuals who withhold or provide fraudulent information on applications for undergraduate admissions or readmissions are subject to immediate dismissal from the university. The decision for immediate dismissal will be made by the Associate Provost of Enrollment Management and/or the Executive Director of Admissions. This decision will be made after a complete and thorough review of the situation and an individual conference with the student involved. The individual dismissed has the right to appeal the decision to the committee on academic policy and procedure, whose decision will be final.

Nondegree Students

A nondegree student is one who has not applied to pursue a degree program at Mines but wishes to take courses regularly offered on campus. Such students may take any course for which they have the prerequisites as listed in the Mines catalog or have the permission of the instructor. Transcripts or evidence of the prerequisites are required. An

applicant for admission to the undergraduate school who does not meet admission requirements may not fulfill deficiencies through this means. Exception to this rule can be made only by the Associate Provost for Enrollment Management. A maximum of 12 hours of nondegree credit from Colorado School of Mines may be used toward an undergraduate degree program. A nondegree student who has completed a Bachelor degree or higher, regardless of course level in which one wishes to enroll, must utilize the graduate nondegree process. Courses completed as a non-degree student at the undergraduate level will be included in the overall undergraduate grade point average.

Academic Regulations

Deficiencies

The curricula at Colorado School of Mines have been especially designed so that the course work flows naturally from course to course and year to year. Thus, it is important that deficiencies in lower numbered courses be scheduled in preference to more advanced work.

Prerequisites

It is the responsibility of each student to make certain that the proper prerequisites for all courses have been met. Registration in a course without the necessary prerequisite may result in dismissal from the class or a grade of F (Failed) in the course.

Remediation

The Colorado Department of Higher Education specifies a remedial programs policy in which any first-time freshmen admitted to public institutions of higher education in Colorado with ACT (or equivalent) scores of less than 18 in reading or English, or less than 19 in mathematics, are required to participate in remedial studies. At the Colorado School of Mines, these remedial studies will be conducted through required tutoring in Nature and Human Values for reading and writing, and Calculus for Scientists and Engineers I for mathematics, and the consequent achievement of a grade of C or better.

Transfer Credit

In all cases, requests for transfer credit are processed by the Registrar. Credits must be submitted on an official transcript from a regionally accredited institution or if the institution is international, credit is only considered from institutions that are recognized by the Ministry of Education or other official accrediting or recognition body in the country of origin. Credits must be academic in nature. Vocational, CLEP, DSST, and theological credit is not accepted. No credit is granted for internships, co-ops, practicums, life experience courses, Independent Study, precalculus courses below Calculus I such as trigonometry and geometry, and non-calculus based general/introductory Physics courses.

Only courses completed with grades of "C" or better will be considered for acceptance. Credit that is recorded as “pass” “satisfactory” or “credit” at institutions that do not equate this classification to a C or better grade will not transfer.

Departments may stipulate a higher minimum grade.

Credit Conversion

Quarter credits are converted to semester credits upon transfer. This is done by multiplying the quarter credits by 0.67 (i.e. 4 quarter credits x 0.67 = 2.6 semester credits).

European Credit Transfer and Accumulation System (ECTS) credits are converted to semester credits by multiplying ECTS credits by 0.5 (i.e. 2 ECTS x 0.5 = 1 semester credit),

Other international credits are converted to the U.S. semester based system according to national standards set by AACRAO International Education Services.

New Transfer Students

Upon matriculation, a transfer student will receive the prescribed academic credit for courses taken at another institution if these courses are listed in a current articulation agreement and transfer guide between CSM and that institution. When an articulation agreement does not exist with another institution, the transfer student may receive credit for a course taken at another institution upon receipt of a certified copy of the student’s official transcript from the host institution. Courses may be subject to review by the appropriate CSM department head or designate to ensure course equivalency. Course materials, such as syllabi, exams, and notes may be requested for evaluation. Credits earned more than 10 years in advance of admission will not transfer.

Continuing Students

Students who are currently enrolled at CSM may transfer credit in required courses only in extenuating circumstances, upon the advance approval of the Registrar, the department head of the appropriate course, and the department head of the student’s option/major. Upon return, credit will be received subject to review by the Registrar. Physics courses are subject to post-approval from the department. Forms for this purpose are available in the Registrar’s Office, and the process is reviewed periodically by the Office of the Executive Vice President for Academic Affairs (EVPAA).

Returning Students

Students who have matriculated at CSM, withdrawn, applied for readmission and wish to transfer in credit taken at an institution while they were absent from CSM, must obtain approval, upon return, of the department head of the appropriate course, the department head of the student’s option/major, and the Registrar.

Prior Learning Credit

Colorado school of Mines makes no promises to prospective students regarding the acceptance of credit awarded by examination, credit for prior learning, or credit for transfer until these credits have been evaluated for applicability to a degree program. If prior learning credits are approved by Mines, up to a maximum of 56.0 semester hours of prior learning credit may be applied to an undergraduate degree based on course applicability for that degree.

Advanced Placement (AP) and International Baccalaureate (IB)

Course work completed for select subjects under the Advanced Placement Program in a high school may be accepted for college credit provided that the Advanced Placement Program Test grade is either a

5, 4, or 3 depending on the exam. See https://www.mines.edu/registrar/advanced-credits/ for specific information.

Course work completed for select subjects under the International Baccalaureate Program in high school may be accepted for college credit provided that the International Baccalaureate Program Exam grade in a 4, 5, 6, or 7 on selected standard and higher level exams. In some cases, departmental approval is required before credit is granted. More information on which subjects are accepted can be found on the web at https://www.mines.edu/registrar/advanced-credits/.

Challenge Exams

Qualified students may complete challenge exams to test out of and receive credit for the following foundational Core courses at Mines. Faculty in each department determine a student's eligibility for sitting for the exams and communicate eligibility requirements to the Registrar for the purposes of communication with the new incoming eligible students.

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0
PHGN100	PHYSICS I - MECHANICS	4.5
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	4.5

Incoming students in their first two semesters at CSM may be eligible for challenge exams based on AP scores or other factors as determined by the department offering the exam. Other classes/subjects may be considered on a case by case basis.

Challenge exams are provided at the department's option and discretion. Departments are not required to provide exams for all introductory and foundational Core courses.

Students must pass the challenge exam with the equivalent of a "C" grade or better as determined by the department in order to earn credit for the course. Passed exams are recorded as CSM transfer credit with a grade of "T". Challenge exams do not affect the student's grade point average at CSM.

Departments provide information about students who have passed exams to the Registrar's Office prior to Census Day in order to make necessary adjustments to the student's schedule.

Challenge exam credit may not be awarded if it is a repeat of already earned college-level credit.

Students will not be charged tuition but CSM reserves the right to charge an administrative fee to take an exam. No fees are required at this time.

Additional details about these exams can be found on the relevant department's website.

VETERANS

Colorado School of Mines is approved by the Colorado State Approving Agency for Veteran Benefits under chapters 30, 31, 32, 33, 35, 1606, and 1607. Undergraduate students must register for and maintain 12.0 credit hours, and graduate students must register for and maintain 9.0 credit hours of graduate work in any semester to be certified as a full-time student for full-time benefits. Any hours taken under the full-time category will decrease the benefits to 3/4 time, 1/2 time, or tuition payment only.

All changes in hours, program, addresses, marital status, or dependents are to be reported to the Veterans Certifying Officer as soon as possible so that overpayment or underpayment may be avoided. Veterans must see the Veteran's Certifying Officer each semester to be certified for any benefits for which they may be eligible. In order for veterans to continue to receive benefits, they must make satisfactory progress as defined by Colorado School of Mines.

An honorably or generally discharged military veteran providing a copy of his/her DD214 is awarded two credit hours to meet the physical education undergraduate degree requirement at Mines. Additionally, veterans may request substitution of a technical elective for the institution's core EDNS course requirement in all undergraduate degree programs.

Students who have served or are currently serving in the military are eligible for priority registration beginning Summer/Fall 2018. Proof of service needs to be provided to the Registrar's Office and may include (but is not limited) to a DD-214 for veterans and for active duty personnel current orders or other documents showing active duty status.

For more information, please visit the Veterans Services web page.

Military Credit Policy

The evaluation of previous postsecondary education and training is mandatory and required for VA beneficiaries. For students utilizing Veterans benefits who are approved for transfer credit as a result of this evaluation, the institution will grant appropriate credit, reduce the program length proportionately, notify the student and Veterans Affairs in writing of this decision, and adjust invoicing of the VA accordingly.

Colorado School of Mines reviews the Joint Service Transcript and other military documents for transfer credit on behalf of our newly admitted and first semester active duty military and veteran students. Academic coursework is considered for undergraduate credit from all branches of the military services including the United States Army, Navy, Air Force, Marines, and Coast Guard.

Credit is considered based on the submission of the Joint Services Transcript and the military form DD214 by the student as part of the student's admissions application submission. Consideration of credit is guided by the standards set forth in the American Council on Education (ACE) recommendations with final transferability and applicability determined by Colorado School of Mines. All courses will be verified using the Joint Services Transcript.

Only those courses that carry an academic designation will receive consideration for credit. Applicability of credit to a specific degree is determined based on the requirements of that degree. Most approved military credits will be free elective credits and will not be direct equivalents of courses offered at Colorado School of Mines. Be aware that if elective requirements are complete, this may limit the options for course selections during your program. This can be an issue for students who need to keep a full-time course load for Veterans benefits usage. Each student is encouraged to speak with the VA and Military Specialist in the Registrar's Office for further information about the regulations surrounding using VA benefits.

ELIGIBILITY

Within the guidelines of this policy, veteran students must meet the following criteria to be awarded transfer credit:

1. Admission to an undergraduate degree program at Colorado School of Mines.

2. Be a veteran with an honorable or general discharge, an active duty service member, or a member of the Reserves/National Guard.
3. Provide official military records including the DD214 (if applicable) and the Joint Services Transcript (JST) during the admission process.

TRANSFER CREDIT COMPONENTS

A student with military training entering Mines may be eligible for up to 14 semester credit hours depending on their completed military academic coursework. Applicability of transfer credit to graduation requirements will vary depending on the chosen degree.

1. Up to two credits of Physical Activity

Students with military training who are able to provide a DD214 showing an honorable or general discharge will be awarded 2 credits (equivalent of 4 separate semesters) of physical activity credit. This credit will meet the requirement for the complete Physical Activity Requirement at Mines.

2. Up to six credits of Design

Depending on the content and duration of training and academic coursework, a veteran or active service member may apply to the Engineering, Design and Society Program for consideration of the transcripted JST credit and copy of the DD214 form to be transferred as a portion or all of the required first-level design course. If approved, the student would be awarded either:

- two semester credits toward the degree and would be required to complete EDNS155 (1 credit) instead of the complete EDNS151 (3 credit) course, or
- three semester credits toward the degree and the completion of the full EDNS151 (3 credit) course.

3. Up to six credits of Humanities & Social Science

4. Up to six credits of Free Elective

Courses listed on the JST may be considered for up to a maximum of 6 credit hours of Free Elective. These courses must be academic in nature and not occupational or career-based training. Evaluations are based on ACE recommendations and internal Mines evaluation of coursework.

In all cases, acceptable course credit must be academic in nature and cannot repeat or overlap other courses for which the student has degree credit.

Military and EDNS 151/2XX Exemptions

Students who have technical experience outside of the classroom may be eligible to substitute a different technical elective course in place of EDNS151 and EDNS251. In order to pursue this course of action, the student must provide information and materials describing the experience and how it applies to the program to the EDNS program director. If approved, the student will complete the substitution form and turn it in to the Registrar's Office to be placed in the academic file.

Course Withdrawals, Additions and Drops

Courses may be added or dropped without fee or penalty during the first 11 school days of a regular academic term (first 4 school days of a 6-week field course or the first 6 school days of the 8-week summer term).

Continuing students may withdraw from any course after the eleventh day of classes through the thirteenth week for any reason with a grade of "W". After the thirteenth week, no withdrawals are permitted except in cases of complete withdrawal from school or for extenuating circumstances (medical or legal hardship) under the auspices of the Dean of Student's Office. In the case when a student completely withdraws after the stated deadline for course withdrawals, they may jeopardize their ability to immediately return to Mines the following semester (see Withdrawal from School, Mines Catalog). A grade of "F" will be given in courses which are withdrawn from after the deadline without approval.

Approval of a late withdrawal from a course can be given by the Registrar acting on behalf of the Office of Academic Affairs in accordance with Mines' refund policy, and in compliance with federal regulations. Requests should be initiated in the Registrar's Office.

All adds/drops are initiated in the Registrar's Office. To withdraw from a course (with a "W") a student can withdraw from a course in Trailhead by the thirteenth week deadline. If a student receives financial aid or Veteran's benefits, consult the Financial Aid Office and/or the VA representatives in the Registrar's Office prior to withdrawing from a course. Refer to the Academic Calendar for dates of specific deadlines.

Independent Study

For each semester credit hour awarded for independent study a student is expected to invest approximately 25 hours of effort in the educational activity involved. To register for independent study, a student should get from the Registrar's Office the form provided for that purpose, have it completed by the instructor involved and the appropriate department/division head, and return it to the Registrar's Office.

Off-Campus Study

A student must enroll in an official CSM course for any period of off-campus, course-related study, whether U.S. or foreign, including faculty-led short courses, study abroad, or any off-campus trip sponsored by CSM or led by a CSM faculty member. The registration must occur in the same term that the off-campus study takes place. In addition, the student must complete the necessary release, waiver, and emergency contact forms, transfer credit pre-approvals, and FERPA release, and provide adequate proof of current health insurance prior to departure. For additional information concerning study abroad requirements, contact the Office of International Programs at (303) 384-2121; for other information, contact the Registrar's Office.

Absenteeism

Class attendance is required of all undergraduates unless the student has an excused absence. Excused absences may be approved by individual faculty upon direct request by the student, by request and approval via the procedure below, or occasionally by Title IX and/or Disability Support Services based on special circumstances. Excused absences are granted for three general reasons:

1. Student is a varsity athlete and is representing the School in a varsity athletics activity.
2. Student is representing the School in an authorized activity related to a club or academic endeavor (academic competitions, student professional society conferences, club sport competition, program-sponsored competitions, etc.)
3. Student has a documented personal reason (illness, injury, jury duty, life-threatening illness or death in the immediate family, religious holiday or required observance, job interview [limitations apply] etc.)

Students who miss academic work (including but not limited to exams, homework, and labs) for one of the reasons listed above may be issued an excused absence. If an excused absence is granted, the student must be given the opportunity to make up the missed work in a reasonable period of time without penalty. While the student is not responsible for actually issuing the excused absence, the student is responsible for making sure documentation is submitted appropriately and for contacting his/her faculty member(s) to initiate arrangements for making up any missed work.

Varsity Athletics and Club sports Absences

The Athletics Department will authorize excused absences for all approved varsity athletics and club sports related absences. The Athletics Department will send notice of excused absences to faculty members on or before Census Day each semester. The student is responsible for contacting his/her faculty member(s) prior to the absence occurring to initiate arrangements for making up any missed work. The Faculty Oversight Committee on Sports and Athletics oversees the number of excused absences permitted per semester by varsity and club sports athletes.

Authorized Activity Absences

The Associate Vice President of Student Life or designee may authorize excused absences upon receipt of proper documentation of the school-sponsored activity. All excused absences for school-sponsored activities must be documented with the Associate Vice President of Student Life by Census Day of each semester. If the absence will occur prior to Census Day, then the documentation should be received at least two weeks prior to the absence. Once documentation has been received and approved, the Associate Vice President of Student Life will send notice of excused absences to faculty members. The student is responsible for contacting his/her faculty member(s) prior to the absence occurring to initiate arrangements for making up any missed work.

Requests for excused absence(s) related to an authorized activity received after Census Day may be denied or be documented as an excused or unexcused absence at the discretion of the faculty member.

Personal Reason Absences

The Associate Vice President of Student Life or designee may authorize excused absences upon receipt of proper documentation of the illness, injury, or other reason. The student must provide the documentation to the Associate Vice President of Student Life within one week of returning to class. In the case of religious holidays or required observances (not including weekly or daily activities), the student must submit the request at least three weeks in advance of the absence. Once documentation has been received and approved, the Associate Vice President of Student Life will send notice of excused absences to faculty members. The student is responsible for contacting his/her faculty member(s) to initiate arrangements for making up any missed work.

Important Note: Every effort will be made by the faculty to honor all excused absences. However, class attendance is essential for understanding of the material and for learning to take place. Excessive absence, regardless of reason, may result in a reduced or failing grade in the course based on course content and delivery. As content and delivery differ among the faculty and with each class, it is important for a student missing class to discuss the absences, excused or unexcused, with his/her faculty member(s) to determine what will be considered excessive.

Unexcused Absences

All absences that are not documented as excused absences are considered unexcused absences. Faculty members may deny a student the opportunity to make up some or all of the work missed due to unexcused absence(s). However, the faculty members do have the discretion to grant a student permission to make up any missed academic work for an unexcused absence. The faculty member may consider the student's class performance, as well as their attendance, in the decision.

Withdrawal from School

A student may officially withdraw from Mines - temporarily or permanently - by contacting the Dean of Students Office and completing the *Complete Withdrawal Request Form*.

Complete withdrawal requests may be submitted until close of business on the last day of scheduled classes for the term (Review Day is not a scheduled class day), and will result in "W's" assigned to all courses in progress.

Students may request a Hardship Withdrawal. Hardship Withdrawals may include medical matters but will also more appropriately account for withdrawals associated with natural disasters, financial hardship, family priorities, or anomalous documented considerations (i.e., significant personal circumstances). Hardship Withdrawals may be verified by corroborating documentation. Hardship Withdrawals will not be considered as part of the Maximum Withdrawal Policy calculations.

Guaranteed reentry to Mines for the term immediately following a complete withdrawal (Standard Withdrawal or Hardship Withdrawal) is only possible if a student completely withdraws by the Course Withdrawal Deadline - approximately 13 weeks into the term (as noted on the Mines' Academic Calendar).

If a student wishes to return to Mines for the immediate term following a complete withdrawal requested after the Course Withdrawal Deadline (e.g., Fall to Spring, Spring to Summer, Summer to Fall), a student must submit a complete petition to the Dean of Student's Office prior to the first scheduled class day of the immediate next academic term (noted as when "Class Start" on the Mines Academic Calendar). Petition instructions and form are available via the Student Life Website or Dean of Students Office.

A return petition will be reviewed by the Dean of Students Office (or Designated Representative). Approvals or denials of a student's petition may be decided by the Dean of Students. Students who wish to appeal a denial may do so with the VP of Student Life (or Designated Representative). Appeals are made by way of an email which asks for reconsideration of the denial, and must be requested within five business days of the denial.

A return petition may necessitate appropriate documentation which clearly supports a student's intention to return. When relevant, Mines will engage the institution's chosen clinician (medical or mental health) to help evaluate the student's readiness to return, in consultation with the Dean of Students Office, including reviewing any non-Mines clinician documentation provided.

Failure to officially withdraw will result in the grades of courses as earned, which may include a notation of “F”. Leaving the School without

having paid tuition and fees will result in a hold being placed against the transcript. Additionally, students may be sent to collections for failing to reconcile all outstanding debt to the institution. Either of these actions would make future enrollment at Mines or another college more difficult. Read more about withdrawing from Mines here.

Admissions Procedures

Please refer to our website for current undergraduate admissions policies and processes, found at https://www.mines.edu/undergraduate-admissions/

All Applicants

Documents received by Mines in connection with applications for admission or transfer of credit will not be duplicated, returned to the applicant, or forwarded to any agency or any other institution.

Timelines and deadlines for applications for undergraduate study are defined on the undergraduate Admissions website. Admission for any semester or term may close whenever Mines' budgeted number of students has been met.

High School Students

Applicants are encouraged to apply online at www.mines.edu. Questions can be directed to the Admissions Office via e-mail: admissions@mines.edu (admit@mines.edu); or via postal mail:

Admissions Office
Colorado School of Mines
1812 Illinois Street
Golden, CO 80401

A student may apply for admission any time after completing the 11th grade. Announcement of when the application will open for a given term will be posted on the Colorado School of Mines website. The application will be evaluated upon receipt of the completed application form, an official **or unofficial** high school transcript showing courses completed, courses remaining to be completed, ranking in class, other pertinent data, and SAT or ACT test scores. High school seniors are encouraged to apply early in the fall term of senior year. Please note: Official high school transcripts are required if a student is accepted and chooses to enroll at Mines.

Freshman admission is competitive.

Applicants who are admitted are subject to completion of all entrance requirements and high school graduation.

Transfer Students

Undergraduate students at another college or university who wish to transfer to Mines should apply online at www.mines.edu. Review the Colorado School of Mines' Admissions web pages for guidance on recommended coursework and timing of the admission application. Generally, a transfer student should apply for admission at the beginning of the final semester of attendance at his or her present college. The application will be evaluated upon receipt of the completed application form and application fee, official final high school transcript (or GED), official transcripts from each university or college attended, and a list of courses in progress. The Admissions Office will then notify the student of his or her admission status. Admission is subject to satisfactory completion of current courses in progress and submission of a final, official transcript(s).

Transfer admission is competitive

A non-refundable application fee is required of all transfer applicants.

Guaranteed Transfer of Credit

Colorado School of Mines is a signatory to the Colorado Statewide Engineering Articulation Agreement. Beginning with admissions in 2003–2004, this agreement determines transferability of coursework for engineering students in the State of Colorado. All students transferring into Mines under the terms of the statewide agreement are strongly encouraged to be advised by the Mines Registrar's Office on their planned course of study. Credits earned more than 10 years prior will not transfer.

Additionally, Colorado School of Mines has formal transfer articulation agreements with Red Rocks Community College (RRCC), Front Range Community College (FRCC), Community College of Denver (CCD), Community College of Aurora (CCA), Arapahoe Community College (ACC) and Pikes Peak Community College (PPCC). Students are encouraged to review the articulation information at https://www.mines.edu/undergraduate-admissions/transfer-students/.

Transfer of Credit by Review

College courses taken that are not part of an articulation agreement, are **NOT** guaranteed to transfer.

In all cases, requests for transfer credit are processed by the Registrar. Credits must be submitted on an official transcript from a regionally accredited institution or if the institution is international, credit is only considered from institutions that are recognized by the Ministry of Education or other official accrediting or recognition body in the country of origin. Credits must be academic in nature. Military, Vocational, CLEP, DSST, and theological credit is not accepted. No credit is granted for internships, co-ops, practicums, life experience courses, Independent Study, precalculus courses below Calculus I such as trigonometry and geometry, and non-calculus based general/introductory Physics courses.

Only courses completed with grades of "C" or better will be considered for acceptance. Credit that is recorded as “pass” “satisfactory” or “credit” at institutions that do not equate this classification to a C or better grade will not transfer.

Departments may stipulate a higher minimum grade.

Advanced Placement, International Baccalaureate, and A-Levels

Course work completed for select subjects under the **Advanced Placement** Program in high school may be accepted for college credit provided that the Advanced Placement Program Test grade meets currently evaluated outcomes. Advanced Placement credit is evaluated by Mines faculty every two years and credit will be transferred upon receipt of official test scores. See current Advanced Placement test score requirements for transfer credit at: https://www.mines.edu/registrar/advanced-credits/.

Course work completed for select subjects under the **International Baccalaureate** Program in high school may be accepted for college credit provided that the International Baccalaureate Program Exam grade meets currently evaluated outcomes. International Baccalaureate credit is

evaluated by Mines faculty every two years and credit will be transferred upon receipt of official exam scores. In some cases, departmental approval is required before credit is granted. See current International Baccalaureate exam score requirements for transfer credit at https://www.mines.edu/registrar/advanced-credits/.

Course work completed for select subjects within the **UK system (A or AS Exam):** A-Levels may be accepted for college credit provided the final grade meets currently evaluated outcomes. Generally, Advanced Levels (A-Levels) are reviewed on a course by course basis. However, some exams have been approved for the coming two years starting in the fall of 2016. See current A-Levels exam score requirements for transfer credit at: https://www.mines.edu/registrar/advanced-credits/.

All admission decisions are final, with one exception. If your admission to the Colorado School of Mines is denied based on information you provided regarding your criminal history, pending criminal charges, or disciplinary history at another academic institution, you have the right to an appeal. Appeals must be in writing and should be submitted to the Associate Provost for Enrollment Management at admissions@mines.edu within 14 days of receipt of the admissions decisions. Appeals should include all relevant information you would like the Associate Provost to consider. You will be notified of the outcome of your appeal within 14 days of receipt.

Undergraduate Non-Degree Students

Our undergraduate non-degree option is designed for students who are interested in taking courses at Mines, but do not plan on pursuing a degree at that time. Undergraduate non-degree applicants include individuals who have not completed a Bachelor's degree or higher. Individuals who have already completed a Bachelor's degree, Master's degree, PhD or Doctoral level degree, must submit a Graduate non-degree application. Registration in requested courses is based on availability (after all current students have registered for their courses), completion of the non-degree application, and proof of prerequisites, through the submission of official transcripts and/or test scores. A non-degree student is one who has not applied to pursue a degree program at Mines but wishes to take courses regularly offered on campus. Non-degree students pay all applicable tuition and student fees. Non-degree students are not eligible for financial aid. Only 12 hours of non-degree seeking courses may be applied towards a Mines degree. Applicants for admission to undergraduate programs whom do not meet admissions requirements may not fulfill deficiencies as a non-degree student.

Returning Mines students

Colorado School of Mines welcomes any previous Mines' student who left the University in good standing and wishes to resume their studies at Mines. Students must complete the returning student application and must provide official transcripts from other college and universities attended since last attending Mines.

If a student is required to see the Readmissions Committee before returning to Mines, the Undergraduate Admissions office will not process the returning student application until a decision has been rendered and communicated from the Readmissions Committee. Readmission is granted at the discretion of the University. Factors which may be considered when determining eligibility for readmission include, but are not limited to, registration or transcripts holds, previous academic achievement, length of absence, space availability, activities during the period of non-enrollment, and prior disciplinary action.

Declaration of Option (Major)

The curriculum during the first semester at Mines is generally the same across majors. Students are not required to choose a major before the end of the freshman year. All students must have declared a major by the beginning of the junior year.

Medical Record

A health history prepared by the student, a medical examination performed by the student's physician and an updated immunization record completed by the student and the physician, nurse or health authority comprise the medical record. A medical record is required for full time students entering Mines for the first time, or following an absence of more than 12 calendar months.

The medical record will be sent to the student after acceptance for admission. The medical record must be updated and completed and then returned to the Student Health Center before permission to enroll is granted. Proof of immunity consists of an official Certificate of Immunization signed by a physician, nurse, or public health official which documents measles, mumps and rubella immunity. The Certificate must specify the type of vaccine and the dates (month, day, year) of administration or written evidence of laboratory tests showing immunity to measles, mumps and rubella.

The completed medical record is confidential and will be kept in the Student Health Center. The record will not be released unless the student signs a written release.

Combined Undergraduate/ Graduate Degree Programs

A. Overview

Many degree programs offer Mines undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Master's Degree, Master's Degree, or Doctoral Degree while completing the requirements for their Bachelor's Degree. These combined Bachelors-Masters/Doctoral programs have been created by Mines faculty in those situations where they have deemed it academically advantageous to treat undergraduate and graduate degree programs as a continuous and integrated process. These are accelerated programs that can be valuable in fields of engineering and applied science where advanced education in technology and/or management provides the opportunity to be on a fast track for advancement to leadership positions. These programs also can be valuable for students who want to get a head start on graduate education.

The combined programs at Mines offer several advantages to students who choose to enroll in them:

1. Students can earn a graduate degree in their undergraduate major or in a field that complements their undergraduate major.
2. Students who plan to go directly into industry leave Mines with additional specialized knowledge and skills which may allow them to enter their career path at a higher level and advance more rapidly. Alternatively, students planning on attending graduate school can get a head start on their graduate education.
3. Students can plan their undergraduate electives to satisfy prerequisites, thus ensuring adequate preparation for their graduate program.

4. Early assignment of graduate advisors permits students to plan optimum course selection and scheduling in order to complete their graduate program quickly.
5. Early acceptance into a Combined Degree Program leading to a Graduate Degree assures students of automatic acceptance into full graduate status if they maintain good standing while in early-acceptance status.
6. In many cases, students will be able to complete both a Bachelor's and a Master's Degrees in five years of total enrollment at Mines.

Certain graduate programs may allow Combined Degree Program students to fulfill part of the requirements of their graduate degree by including up to six hours of specified course credits which also were used in fulfilling the requirements of their undergraduate degree. These courses; referred to as double counted courses, may be applied toward fulfilling many graduate degree requirements. Check the departmental section of the Catalog to determine which programs provide this opportunity and any limitations that might apply.

Double counted courses must:

- Meet all requirements for graduate credit, grades are included in calculating the graduate GPA.
- Some degree programs only allow students to double count 500 level courses (not 400 level), so please check the degree program for details.
- Must maintain grades according to undergraduate and graduate program requirements. Some degree programs have stricter limitations, so please check the degree program for details.

B. Admission Process

Students interested in applying into a graduate degree program as a Combined Degree Program student should first contact the department or division hosting the graduate degree program into which he/she wishes to apply.

- It is recommended that contact be made during the Sophomore year, but no later than the end of the Junior year.
- Graduate programs will provide initial counseling on degree application procedures, admissions standards and degree completion requirements.

Admission into a graduate degree program as a Combined Degree student may be granted after the student earns 60 undergraduate credits including transfer credit, and must be granted no later than the semester in which the student intends to apply to graduate with the bachelor's degree. For example, if a student intends to graduate in May, admission to the graduate program as a combined student must be granted for that same Spring semester. See the Graduate Admissions website for the appropriate deadlines for the semester in which admission is sought.

Once admitted into a graduate degree program, students may enroll in 500-level courses and apply these directly to their graduate degree. To apply, students must submit the standard graduate application package for the graduate portion of their Combined Degree Program. Upon admission into a graduate degree program, students are assigned graduate advisors. Prior to registration for the next semester, students and their graduate advisors should meet and plan a strategy for completing both the undergraduate and graduate programs as efficiently as possible. Until their undergraduate degree requirements are completed, students continue to have undergraduate advisors in the home department or division of their Bachelor's Degrees.

C. Requirements

Combined Degree Program students are considered undergraduate students until such time as they complete their undergraduate degree requirements. Combined Degree Program students who are still considered undergraduates by this definition have all of the privileges and are subject to all expectations of both their undergraduate and graduate programs. These students may enroll in both undergraduate and graduate courses (see section D below), may have access to departmental assistance available through both programs, and may be eligible for undergraduate financial aid as determined by the Office of Financial Aid. Upon completion of their undergraduate degree requirements, a Combined Degree Program student is considered enrolled full-time in his/her graduate program. Once having done so, the student is no longer eligible for undergraduate financial aid, but may now be eligible for graduate financial aid.

Once admitted into a graduate program, undergraduate Combined Program students must maintain good standing in the Combined Program by maintaining a minimum semester GPA of 3.0 in all courses taken. Students not meeting this requirement are deemed to be making unsatisfactory academic progress in the Combined Degree Program. Students for whom this is the case are subject to probation and, if occurring over two semesters, subject to discretionary dismissal from the graduate portion of their program as defined in the Unsatisfactory Academic Performance section of this Catalog.

Upon completion of the undergraduate degree requirements, Combined Degree Program students are subject to all requirements (e.g., course requirements, departmental approval of transfer credits, research credits, minimum GPA, etc.) appropriate to the graduate program in which they are enrolled.

D. Enrolling in Graduate Courses for a Combined Program

Undergraduate who have been granted admission through the Combined Degree Program into thesis-based degree programs (Masters or Doctoral) may, with graduate advisor approval, register for 700-level research credits.

700-level research credits are always applied to a student's graduate degree program.

As described in the Undergraduate Catalog, seniors may enroll in 500-level courses. In addition, undergraduate seniors who have been granted admission through the Combined Degree Program into thesis-based degree programs (Masters or Doctoral) may, with graduate advisor approval, register for 700-level research credits appropriate to Masters-level degree programs. With this single exception, while a Combined Degree Program student is still completing his/her undergraduate degree, all of the conditions described in the Undergraduate Catalog for undergraduate enrollment in graduate-level courses apply. 700-level research credits are always applied to a student's graduate degree program.

Undergraduate Seniors Enrolling in Graduate Courses

This policy was under review at the time of publication please see the catalog addendum page located at: Mines.edu/Registrar/program-changes

Core Requirements

Core Curriculum

The Core Curriculum at Mines forms the foundation for advanced study in the major fields. It is designed to give students the fundamental knowledge and skills they will need and put to use in their majors and in careers after graduation. Core courses provide students with fundamental technical, mathematical, and writing skills. In Core courses, students learn basic scientific procedures, principles, concepts, laws, and theories relevant to all applied sciences. In addition, Core courses in the humanities and social sciences help students develop interdisciplinary perspectives on the ethical, social, and cultural contexts within which engineering takes place.

The variety of courses in the Core Curriculum also provide students with opportunities to develop skills in problem solving, critical thinking, teamwork, design, and communication. Students who complete the Core are well prepared to be lifelong learners and leaders who can work effectively in an increasingly globalized world.

The Core Curriculum has three parts, the details of which can be found below. All CSM students complete the courses in the Common Core. Courses required in the Science Requirement and Engineering Requirement vary according to the major field of study. Finally, all students have a number of Free Elective courses. Free Electives are usually taken in the last two years.

Refer to the Degree Requirements section for each major program under Undergraduate Programs and Departments for a listing of Core courses students should take each semester.

Overview: Core Course Requirements

Core & distributed course requirements for Bachelor of Science degrees are comprised of the following four groups:

1. **Core Curriculum** - Students in all degree programs are required to complete all course requirements listed in this group.
2. **Humanities & Social Sciences (H&SS) Requirement** - Students in all degree programs are required to complete all course requirements listed in this group.
3. **Distributed Science Requirement** - Students in all degree programs are required to complete a minimum of three courses as prescribed by the specific degree program.
4. **Engineering Requirement** - Engineering Requirements are applicable to undergraduate students in engineering disciplines as specified by the degree program. See Department and Division program descriptions in this Catalog for specific courses required.

The Core Curriculum

Core requirements are applicable to all undergraduate students:

In Mathematics and the Basic Sciences		
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0
MATH225	DIFFERENTIAL EQUATIONS	3.0
CHGN121	PRINCIPLES OF CHEMISTRY I	4.0
PHGN100	PHYSICS I - MECHANICS	4.5
In Design		
EDNS151	DESIGN I	3.0
In Physical Activity (four separate semesters including the following) [*]		
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5
In Freshman Orientation & Success		
CSM101	FRESHMAN SUCCESS SEMINAR	0.5
Free Electives [**]		
Minimum of 9.0 Semester Hours		9.0
Total Semester Hrs		**38.0**

* A minimum of 2.0 credit hours. See the Physical Education and Athletics section for specifics.

** A minimum of 9.0 hours of Free Elective are included with each degree-granting program.

1. The choice must not be in conflict with any Graduation Requirements (p. 33).
2. Free electives to satisfy degree requirements may not exceed three semester hours (3.0) in activity courses such as band, choir, studio art, physical activity, and varsity athletics courses combined.
3. Transfer credits used for free electives must comply with the transfer credit guidelines.

Humanities & Social Sciences (H&SS) Requirement

All Mines undergraduate students are required to satisfy a Humanities & Social Sciences (H&SS) Core requirement as one component of Mines' Core Curriculum. The H&SS Core requirement includes 19 credit hours of courses ranging from first-year to senior-level and offered by a variety of academic units across campus. The H&SS Core includes both specified and restricted-elective course requirements as described below.

Core Required Courses*

HASS100	NATURE AND HUMAN VALUES	4.0
HASS200	GLOBAL STUDIES	3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0
MID-LEVEL ELECTIVE	Two courses from the approved list of requirements [**]	6.0
400-LEVEL ELECTIVE	One course at the 400-level from the approved list of requirements [**]	3.0
Total Semester Hrs		**19.0**

* These course requirements are modified for students in the following programs: Thorson Honors, McBride Honors, and Bachelor of Science in Engineering (BSE). Students in these programs can find program-specific requirements within the relevant program sections of this catalog.

** The additional 9 credit hours of mid-level and 400-level electives must meet the following requirements:

- At least 3 credit hours must be at the 400 level.
- At least 3 credit hours must have a HASS (Humanities, Arts, and Social Sciences) course code.
- No more than 6 credit hours can have the LIFL (Foreign Languages) course code.
- Courses with the LIMU (Music) course code cannot be used to satisfy this requirement.
- HASS498 special topic courses can be used to satisfy this requirement. EBGN498 and EDNS498 special topic courses will be determined to satisfy this requirement on a course-by-course basis, and that determination will be made prior to the beginning of the term the course is offered.
- Except for foreign languages, no AP or IB credit can be used to meet this requirement. (AP/IB credits will be applied as free electives.)
- Single majors in Economics cannot use courses with the EBGN course code to satisfy this requirement.

Courses that satisfy the Humanities & Social Sciences (H&SS) Core Restricted Electives requirement are offered by several academic units. The various course codes and their respective academic division or department can be found in the table below:

Course Code	Course Title
EBGN	Economics & Business
EDNS	Engineering, Design, and Society
HASS	Humanities, Arts, and Social Sciences
HNRS	Honors
LIFL	Foreign Language
PEGN	Petroleum Engineering

With the exception of HASS, LIFL and HNRS, not all courses with these codes count toward the Humanities & Social Sciences (H&SS) Core Restricted Electives requirement.

The table below includes the complete list of courses satisfying the Humanities & Social Sciences (H&SS) requirement:

HASSXXX	All HASS courses are eligible for Humanities and Social Sciences (H&SS) credit (see your advisor)	
LIFLXXX	All LIFL courses are eligible for Humanities and Social Sciences (H&SS) credit (see your advisor)	
HNRSXXX	All HNRS courses are eligible for Humanities and Social Sciences (H&SS) credit (see your advisor)	
EBGN301	INTERMEDIATE MICROECONOMICS	3.0
EBGN302	INTERMEDIATE MACROECONOMICS	3.0
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0
EBGN320	ECONOMICS AND TECHNOLOGY	3.0
EBGN330	ENERGY ECONOMICS	3.0
EBGN340	ENERGY AND ENVIRONMENTAL POLICY	3.0
EBGN401	ADVANCED TOPICS IN ECONOMICS	3.0
EBGN430	ADVANCED ENERGY ECONOMICS	3.0
EBGN434	PROPERTY RIGHTS AND NATURAL RESOURCES	3.0
EBGN437	REGIONAL ECONOMICS	3.0
EBGN441	INTERNATIONAL ECONOMICS	3.0
EBGN443	PUBLIC ECONOMICS	3.0
EBGN470	ENVIRONMENTAL ECONOMICS	3.0
EDNS315	ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY	3.0
EDNS375	ENGINEERING CULTURES	3.0
EDNS430	CORPORATE SOCIAL RESPONSIBILITY	3.0
EDNS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
EDNS477	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3.0
EDNS478	ENGINEERING AND SOCIAL JUSTICE	3.0
EDNS479	COMMUNITY-BASED RESEARCH	3.0
EDNS480	ANTHROPOLOGY OF DEVELOPMENT	3.0
MNGN335	COMMUNITIES AND NATURAL RESOURCE DEVELOPMENT	3.0
PEGN430	ENVIRONMENTAL LAW AND SUSTAINABILITY	3.0

Distributed Science Requirement

The Science Requirement is a minimum of three courses and is applicable to all undergraduate students as follows:

APPLIED MATH & STATISTICS		
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	
or CBEN110	FUNDAMENTALS OF BIOLOGY I	
or CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)	
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY	
BIOCHEMISTRY		
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)	
CBEN110	FUNDAMENTALS OF BIOLOGY I	
CHEMISTRY - See degree specialty listings to determine if CBEN110 **or** GEGN101 **are required**		
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)	
CBEN110	FUNDAMENTALS OF BIOLOGY I	
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	
CHEMICAL ENGINEERING		
CBEN110	FUNDAMENTALS OF BIOLOGY I	
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)	
CHEMICAL & BIOCHEMICAL ENGINEERING		
CBEN110	FUNDAMENTALS OF BIOLOGY I	

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)

CIVIL ENGINEERING

FOUR COURSES REQUIRED

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
or CBEN110	FUNDAMENTALS OF BIOLOGY I

COMPUTER SCIENCE

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CSCI101	INTRODUCTION TO COMPUTER SCIENCE
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS

ECONOMICS

CSCI101	INTRODUCTION TO COMPUTER SCIENCE
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS
CBEN110	FUNDAMENTALS OF BIOLOGY I
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
or PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
or CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY

ELECTRICAL ENGINEERING

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS

CHOOSE TWO FROM BELOW

CBEN110	FUNDAMENTALS OF BIOLOGY I
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY
CSCI101	INTRODUCTION TO COMPUTER SCIENCE

ENGINEERING

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CSCI101	INTRODUCTION TO COMPUTER SCIENCE
or MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS
or CBEN110	FUNDAMENTALS OF BIOLOGY I
or CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY
or CSCI101	INTRODUCTION TO COMPUTER SCIENCE
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS

ENVIRONMENTAL ENGINEERING

FOUR COURSES REQUIRED

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS

GEOLOGICAL ENGINEERING

GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY

GEOPHYSICAL ENGINEERING

CSCI101	INTRODUCTION TO COMPUTER SCIENCE
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS

MECHANICAL ENGINEERING

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY
CSCI101 & CSCI102	INTRODUCTION TO COMPUTER SCIENCE and INTRODUCTION TO COMPUTER SCIENCE - LAB

METALLURGICAL & MATERIALS ENGINEERING

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY
CBEN110	FUNDAMENTALS OF BIOLOGY I
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS

MINING ENGINEERING

GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)

PETROLEUM ENGINEERING

GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY

ENGINEERING PHYSICS

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY
CBEN110	FUNDAMENTALS OF BIOLOGY I

or GEGN101 EARTH AND ENVIRONMENTAL SYSTEMS
or CSCI101 INTRODUCTION TO COMPUTER SCIENCE

Engineering Requirement (see degree program listing)

Engineering Requirements are applicable to undergraduate students in engineering disciplines as specified by the degree program. See Department and Division program descriptions in this Catalog for specific courses required.

THE FRESHMAN YEAR

Freshmen in all programs normally take similar subjects. A sample first year schedule is listed below:

Freshman

Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
EBGN201	PRINCIPLES OF ECONOMICS*			3.0
HASS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN Elective	PHYSICAL ACTIVITY ELECTIVE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
EDNS151	DESIGN I**			3.0
PHGN100	PHYSICS I - MECHANICS			4.5
DIST SCI	Distributed Science Requirement*			4.0
PAGN Elective	PHYSICAL ACTIVITY ELECTIVE			0.5
				16.0

Total Semester Hrs: 32.0

* For scheduling purposes, registration in combinations of GEGN101, CBEN110, HASS100, EBGN201, MATH201, CSCI101, and EDNS151 will vary between the fall and spring semesters. Students admitted with acceptable advanced placement credits will be registered in accordance with their advanced placement status.

** Completion of EDNS155 in lieu of EDNS151 is by permission only and does not alter the total hours required for completion of the degree.

General Information

Academic Calendar

The academic year is based on the early semester system. The first semester begins in late August and closes in mid-December; the second semester begins in early January and closes in mid-May.

Classification of Students

Degree seeking undergraduates are classified as follows according to semester credit hours earned:

Undergraduate Year	Semester Credit Hours Earned
Freshman	0 to 29.9 semester credit hours
Sophomore	30 to 59.9 semester credit hours
Junior	60 to 89.9 semester credit hours
Senior	90 or more semester credit hours

Course Numbering & Subject Codes

Numbering of Courses

Course numbering is based on the content of material presented in courses:

Material	Level	Division
100-199	Freshman Level	Lower Division
200-299	Sophomore Level	Lower Division
300-399	Junior Level	Upper Division
400-499	Senior Level	Upper Division
500-599	Master's Level	
600-699	Doctoral Level	
Over 700	Graduate Research or Thesis Level	

Subject Codes:

Course Code	Course Title
AFGN	Air Force
AMFG	Advanced Manufacturing
BIOL	Biology
CBEN	Chemical & Biological Engineering
CEEN	Civil & Environmental Engineering
CHGC	Geochemistry
CHGN	Chemistry
CSCI	Computer Science
CSM	General Studies; Skills Courses
DSCI	Data Science
DTCN	Data Center Engineering
EBGN	Economics & Business
EDNS	Engineering, Design, and Society
EENG	Electrical Engineering
ENGY	Energy
FEGN	Finite Element Analysis
GEGN	Geological Engineering
GEGX	Geochemical Exploration (Geology)
GEOC	Oceanography (Geology)
GEOL	Geology
GOGN	Geo-Engineering (Mining)
GPGN	Geophysical Engineering
HASS	Humanities, Arts, and Social Sciences
HNRS	Honors Program
LICM	Communication
LIFL	Foreign Languages

LIMU	Music; Band; Choir
MATH	Mathematics
MEGN	Mechanical Engineering
MLGN	Materials Science
MNGN	Mining Engineering
MSGN	Military Science
MTGN	Metallurgical & Materials Engineering
NUGN	Nuclear Engineering
ORWE	Operations Research with Engineering
PAGN	Physical Education & Athletics
PEGN	Petroleum Engineering
PHGN	Physics
SPRS	Space Resources
SYGN	Core Sequence in Systems

Curriculum Changes

In accordance with the statement on Curriculum Changes, the Colorado School of Mines makes improvements in its curriculum from time to time. To confirm that they are progressing according to the requirements of the curriculum, students should consult their academic advisors on a regular basis, reference the online degree evaluation, and carefully consult any Catalog Addenda that may be published.

Part-Time Degree Students

A part-time degree student may enroll in any course for which he or she has the prerequisites or the permission of the department. Part-time degree students will be subject to all rules and regulations of Colorado School of Mines, but they may not:

1. Live in student housing;
2. Receive financial help in the form of School-sponsored scholarships or grants;
3. Participate in any School-recognized activity unless fees are paid;
4. Take advantage of activities provided by student fees unless such fees are paid.

Course work completed by a part-time degree student who subsequently changes to full-time status will be accepted as meeting degree requirements.

Seniors in Graduate Courses

With the consent of the student's department/division and the Dean of Graduate Studies, a qualified senior may enroll in 500-level courses without being a registered graduate student. At least a 2.5 GPA is required. The necessary forms for attending these courses are available in the Registrar's Office. Seniors may not enroll in 600-level courses. Credits in 500-level courses earned by seniors may be applied toward an advanced degree at CSM only if:

1. The student gains admission to the Graduate School.
2. The student's graduate committee agrees that these credits are a reasonable part of his graduate program.
3. The student provides proof that the courses in question were not counted toward those required for the Bachelor's Degree.
4. Graduate courses applied to a graduate degree may not count toward eligibility for undergraduate financial aid. This may only be done if a student has been admitted to a Combined BS/MS degree program and has received the appropriate prior approvals.

Undergraduate students enrolled in graduate-level courses (500-level) are graded using the graduate grading system. See the CSM Graduate Catalog for a description of the grading system used in graduate-level courses.

Course Substitution

To substitute credit for one course in place of another course required as part of the approved curricula in the catalog, a student must receive the approval of the Registrar, the heads of departments of the two courses, the head of the student's option department. There will be a periodic review by the Office of the Executive Vice President for Academic Affairs. Forms for this purpose are available in the Registrar's Office.

Change of Catalog

It is assumed that each student will graduate under the requirements of the catalog in effect at the time of most recent admission. However, it is possible to change to any subsequent catalog in effect while the student is enrolled in a regular semester.

To change catalogs, a form obtained from the Registrar's Office is presented for approval to the head of the student's option department. Upon receipt of approval, the form must be returned to the Registrar's Office.

Students' Use of English

All Mines students are expected to show professional facility in the use of the English language.

English skills are emphasized, but not taught exclusively, in most of the Humanities & Social Science (H&SS) courses and EPICS as well as in option courses in junior and senior years. Students are required to write reports, make oral presentations, and generally demonstrate their facility in the English language while enrolled in their courses.

The Writing Center is available to assist students with their writing. For additional information, contact Allyce Horan, Director of the Writing Center at 303-384-2265.

Summer Sessions

The summer term is divided into two independent units. Summer Session I is a 6-week period beginning on Monday following Spring Commencement. Summer Session II is either a 6-week or 8-week session which immediately follows Summer Session I.

Review Day

No required class meetings, examinations or activities may take place on the Friday immediately preceding final exams for the fall and spring terms. At their own discretion, faculty members may hold additional office hours or give a review session on Review Day provided these activities are strictly optional. This day has been created as a break from regularly scheduled and/or required academic activities to allow students to prepare for their final examinations as they see fit.

COMMON EXAMINATIONS POLICY

This policy covers out#of#class exams for all undergraduate and graduate level courses with the exception of take#home exams, as noted:

- The evening common exam period is Monday through Thursday evenings, with one exam period each evening from 7:30 pm to 9:00 pm. Exams are limited to these 90 minutes.
- No course may request more than 4 evening common exam periods in a single semester. (Final exams are not included as part of this limitation.)
- Generally only 100#level courses are allowed to schedule an exam on Wednesday evenings.
- Priority for limited space goes to courses (or courses bundled) with largest enrollment. Specific classes that are exempted from this policy are graduate courses that meet the following criteria: Graduate courses that are numbered 6XX or Graduate courses that have fewer than 20 registered students. For these courses, outside of normal class time exams should be specifically scheduled in the course syllabi that are provided to the students at the beginning of the semester. If the exam is not scheduled in the syllabus, it should be scheduled a minimum of three weeks in advance and be at a time that does not significantly inconvenience any of the students registered in the class.

Any graduate course that is co#taught with an undergraduate course and schedules examinations for both the undergraduate and graduate versions of the course at the same time is not exempted from this policy.

Course conflicts

Regularly scheduled evening courses that meet partially or completely during this time of 7:30pm – 9:00pm, Monday through Thursday, have priority over evening exams covered by this policy. Any course that schedules an out of class exam during the evening exam times assumes all responsibility for arranging make#up exams for students who have conflicts with regularly scheduled classes including courses that are part of the McBride Honors Program.

Exam conflicts

If a student is scheduled in two exams on the same evening, the course or bundle of courses with the lower total enrollment will be required to provide the make#ups for affected students. The Registrar's Office will provide a list of the students with two exams in one time slot to the professor of the course with the lower enrollment with the reminder that make#up exams are the responsibility of that professor.

For the complete Common Exam policy, please refer to: https://inside.mines.edu/UserFiles/File/registrar/Common_Exam_Policy_FINAL_7-8-15.pdf.

Final Examinations Policy

Final examinations are scheduled by the Registrar. With the exception of courses requiring a common time, all finals will be scheduled on the basis of the day and the hour the course is offered.

In general, all final examinations will be given only during the stated final examination period and are to appear on the Registrar's schedule. Faculty policy adopted in January 1976 provides that no exams (final or otherwise) may be scheduled during the week preceding final examinations week, with the possible exception of laboratory exams. The scheduling by an individual faculty member of a final exam during the week preceding final examinations week is to be avoided because it tends to hinder the students' timely completion of other course work and interfere with the schedules of other instructors. Faculty members should not override this policy, even if the students in the class vote to do so.

Students who have conflicts with the final exam schedule or have more than two exams on the same day should inform their instructors. The instructor of the highest numbered course is required to grant relief (e.g., an alternate time during exam week).

Academic activities that are explicitly disallowed by this policy include:

• Scheduling an in-class examination (final or otherwise, with the possible exception of laboratory exams) for any course during the week preceding final exams

• Scheduling an early make-up final examination - unless the student needs to miss the regularly scheduled final for school related business (athletics, school-related travel, etc…) and requested by the student and approved by the instructor.

• Assigning a take-home final examination for any course that is due during the week preceding final exams – unless the student needs to miss the regularly scheduled final for school related business (athletics, school-related travel, etc…) and requested by the student and approved by the instructor.

Academic activities that are allowable during the week preceding final exams include:

- The introduction of new materials
- Laboratory finals
- Required homework
- Required in-class assignments such as quizzes or worksheets (NO EXAMS)
  - Quizzes are shorter exercises which take place on a fairly regular basis (e.g. 15-30 minutes in duration, 6-10 times a semester).
  - Exams are major exercises which take place only a few times a semester (e.g. 50-120 minutes in duration, 2-4 times a semester).
- Major course assignments such as Final Presentations or Term Projects provided the assignment was assigned at least 4 weeks in advance or was clearly indicated in the course syllabus (Presentations must not be scheduled in conflict with regularly scheduled courses in departments outside of the one scheduling the presentation.)
- Take home finals (provided they are not due prior to finals week)
- Make-up exams for students who miss a scheduled exam in the prior week due to emergency, illness, athletic event, or other CSM sanctioned activity (provided this absence has been approved by the Dean of Student's Office)

(Note: These policies apply only to undergraduate courses. Students enrolled in graduate courses, are bound by policies outlined in the Graduate Catalogs.)

Full-time Enrollment

Full-time enrollment for certification for Veterans Benefits, athletics, loans, most financial aid, etc. is 12.0 credit hours per semester for the fall and spring semesters. Full-time enrollment for Summer Session I and Summer Session II combined is 12.0 credit hours.

Good Standing, Honor Roll & Dean's List, Graduation Awards, Probation & Suspension

Good Standing

A student is in Good Standing at CSM when he or she is enrolled in class(es) and is not on either academic or disciplinary probation, suspension, or dismissal.

Honor Roll & Dean's List

To be placed on the academic honor roll, a student must complete at least 14.0 semester hours with a 3.0-3.499 grade point for the semester, have no grade below C, and no incomplete grade. Those students satisfying the above criteria with a semester grade-point average of 3.5 or above are placed on the Dean's List.

Students are notified by the Dean of Students of the receipt of these honors. The Dean's List notation appears on the student's transcript.

Graduation Awards

Colorado School of Mines awards the designations of Cum Laude, Magna Cum Laude, and Summa Cum Laude upon graduation. These designations are based on the following overall grade-point averages:

Grade-point average	Designation
3.500 - 3.699	Cum Laude
3.700 - 3.899	Magna Cum Laude
3.900 - 4.000	Summa Cum Laude

Commencement ceremony awards are determined by the student's cumulative academic record at the end of the preceding semester. For example, the overall grade-point average earned at the end of the fall term determines the honor listed in the May commencement program.

Final honors designations are determined once final grades have been awarded for the term of graduation. The final honors designation appears on the official transcript and is inscribed on the metal diploma. Official transcripts are available approximately one to two weeks after the term grades have been finalized. Metal diplomas are sent to the student approximately two months after final grades are posted. Mailing arrangements are made during Graduation Salute.

Undergraduate students are provided one metal diploma at no cost. Additional metal diplomas and parchment diplomas can be ordered online at the Registrar's Office webpage for an additional charge. Graduating students should order these items before the end of the graduation term in order to ensure delivery approximately two months after final grades are awarded.

Academic Probation & Suspension

Probation

A student whose cumulative grade-point average falls below the minimum requirement of 2.0 will be placed on academic probation for the following semester. A student on probation is subject to the following restrictions:

1. The student may not register for more than 15.0 credit hours;
2. The student may be required to withdraw from intercollegiate athletics;
3. The student may not run for, or accept appointment to, any campus office or committee chairmanship. A student who is placed on probation while holding a position involving significant responsibility and commitment may be required to resign after consultation with the Dean of Student's Office or the President of Associated Students. A student will be removed from probation when the cumulative grade-point average is brought up to the minimum, as specified in the table below.

Suspension

A student whose cumulative grade-point average falls below the minimum requirement of 2.0 will be placed on academic probation for the following semester. A student who satisfies the current term grade period requirement but fails to achieve the required cumulative grade-point average will remain on probation. A student who fails to earn above a 2.0 GPA (current term and cumulative) while on probation will be suspended.

A first-year or transfer student who fails to make a grade-point average of 2.0 in the first grade period will be on Academic Probation for the following academic term. Additionally, the student will be required to meet with the Center for Academic Services and Advising (CASA) for counsel. Students may not continue their studies until meeting with CASA.

Suspension becomes effective immediately when it is imposed. Readmission after suspension requires written approval from the Readmissions Committee.

No student who is on suspension may enroll in any regular academic semester without the written approval of the Readmissions Committee. However, a student on suspension may enroll in a summer session (field camp, academic session, or both) with the permission of the Dean of Student's Office. Students on suspension who have been given permission to enroll in a summer session by the Dean may not enroll in any subsequent term at CSM without the written permission of the Readmissions Committee.

A student who intends to appear in person before the Readmissions Committee must contact the Dean of Student's Office at least one week prior to the desired appointment. Between regular meetings of the Committee, in cases where extensive travel would be required to appear in person, a student may petition in writing to the Committee, through the Dean of Student's Office.

Appearing before the Readmissions Committee by letter rather than in person will be permitted only in cases of extreme hardship. Such cases will include travel from a great distance, e.g. overseas, or travel from a distance which requires leaving a permanent job.

The Readmissions Committee meets on six separate occasions throughout the year. Students applying for readmission must appear at those times except under conditions beyond the control of the student. Such conditions include a committee appointment load, delay in producing notice of suspension, or weather conditions closing highways and airports.

All applications for readmission after a minimum period away from school, and all appeals of suspension or dismissal, must include a written statement of the case to be made for readmission.

A student who, after being suspended and readmitted twice, again fails to meet the academic standards shall be automatically dismissed. The Readmissions Committee will hear a single appeal of automatic dismissal. The appeal will only be heard after demonstration of substantial and significant changes. A period of time sufficient (i.e. one calendar year) to demonstrate such a change usually elapses prior to the student attempting to schedule this hearing. The decision of the Committee on that single appeal will be final and no further appeal will be permitted.

Readmission by the Committee does not guarantee that there is space available to enroll. A student must process the necessary papers with the Admissions Office prior to seeing the Committee.

Notification

Notice of probation, suspension, or dismissal will be mailed to each student who fails to meet catalog requirements.

Repeated Failure

A student who twice fails a required course at Colorado School of Mines and is not subject to academic suspension will automatically be placed on "special hold" status with the Registrar, regardless of the student's cumulative or semester GPA. The student must meet with the subject advisor and receive written permission to remove the hold before being allowed to register.

In the case of three or more Fs in the same course, the student must meet with the faculty Readmissions Committee and receive permission to remove the hold before being allowed to register.

Transfer credit from another school will not be accepted for a twice-failed course.

Multiple Withdrawal Policy

The total number of withdrawn course credits (e.g. courses resulting in a “W” grade) over a student’s academic career are tracked and counted at the end of each academic semester (Fall and Spring terms). When the following credit limits have been met, or surpassed, the associated academic standing provisions will result.

When a student has accumulated 20 or more withdrawn credits, the student will receive support including possible admission to the Bounce Back program and individual academic coaching and assistance.

When a student has accumulated 30 or more withdrawn credits, the student will receive a first (or greater) suspension for failing to meet academic performance standards. The student must meet with the Readmissions Committee and secure a majority vote in favor of their return.

When a student has accumulated 45 or more withdrawn credits, the student will receive a second (or greater) suspension for failing to meet academic performance standards. To return, the student must meet with the Readmissions Committee and secure a majority vote in favor of their return.

When a student has accumulated 60 or more withdrawn credits, the student will receive a third suspension resulting in dismissal or terminal dismissal for failing to meet academic performance standards.

Withdrawn credits resulting from a Hardship or Medical withdrawal will not count towards the total number of withdrawn credits for the purposes of this policy.

For further information, please contact the Office of the Dean of Students.

Grading System, Grade-Point Average (GPA), and Grade Appeals

Undergraduate grading system

Grades

When a student registers in a course, one of the following grades will appear on his/her academic record. If a student registered as NC (audit) fails to satisfy all conditions, no record of his registration in the course will be made. The assignment of the grade symbol is based on the level of performance, and represents the extent of the student's demonstrated mastery of the material listed in the course outline and achievement of the stated course objectives.

Symbol	Interpretation
A	Excellent
A-	
B+	
B	Good
B-	
C+	
C	Satisfactory
C-	
D+	
D	
D-	Poor (lowest passing)
F	Failed
S	Satisfactory, C or better, used at mid-term
U	Unsatisfactory, below C, used at mid-term
PRG	Satisfactory Progress
PRU	Unsatisfactory Progress

In addition to these performance symbols, the following is a list of registration symbols that may appear on a Mines transcript:

Symbol	Interpretation
WI	Involuntary Withdrawal
W	Withdrew, no penalty
T	Transfer Credit
INC	Incomplete
NC	Not for Credit (Audit)
Z	Grade not yet submitted

Incomplete Grade

An Incomplete ‘INC’ is a temporary grade which may be given at the instructor’s discretion to a student when illness, necessary absence, or other reasons beyond the control of the student prevent completion of course requirements by the end of the academic term. An ‘INC’ is restricted to cases in which the student satisfactorily completed

a significant amount of the course work, including attendance and participation.

The student and the instructor should discuss the terms for the incomplete before the end of the term. The instructor may grant up to one year, but the time limit may be less, to complete outstanding coursework. Any outstanding grade of 'INC' will be converted to an 'F' grade if it has not been updated by the instructor after one year. In the event that an 'INC' grade remains on the record at the completion of the degree, the 'INC' will be converted to an 'F' and included in the final GPA.

C Grade (Not for Credit or Audit)

A student may, for special reasons and with the instructor's permission, register in a course on the basis of NC (Not for Credit). To have the grade NC appear on his/her transcript, the student must enroll at registration time as a NC student in the course and comply with all conditions stipulated by the course instructor, except that if a student registered as NC fails to satisfy all conditions, no record of this registration in the course will be made. The Registration Action Form is used to request that a course be recorded as an audit. The form is available in the Registrar's Office.

Transfer Credit

Transfer credit earned at another institution will have a T grade assigned but no grade points will be recorded on the student's permanent record. Calculation of the grade-point average will be made only from the courses completed at Colorado School of Mines.

GPA Hours and Quality Points

For graduation a student must successfully complete a certain number of required semester hours and must maintain grades at a satisfactory level. The system for expressing the quality of a student's work is based on quality points and GPA hours. The numerical value associated with the specific grades are:

Grade	Numerical Value
A	4.000
A-	3.700
B+	3.300
B	3.000
B-	2.700
C+	2.300
C	2.000
C-	1.700
D+	1.300
D	1.000
D-	0.700
F	0.000

The number of quality points earned in any course is the number of semester hours assigned to that course multiplied by the numerical value of the grade received. To compute an overall or major grade-point average, the number of cumulative GPA hours is divided into the cumulative quality points received. Grades of W, WI, INC, PRG, PRU, or NC are not counted in quality hours.

Midterm Grading

Midterm grading is conducted using Satisfactory (S) and Unsatisfactory (U) grades. Certain foundational courses are required to be graded between the 6th and 8th weeks of the term to provide students an early warning with time to recover. If the midterm grade is blank in these specific courses, the grade for the student is Satisfactory (S) by default, or C- or better. Faculty will enter Unsatisfactory (U) grades for those students currently earning grades of D+ or lower.

Courses include: All Core Curriculum and Distributed Science Elective courses with the exception of H&SS Mid-Level Cluster and 400-Level. Additionally, the following courses will also be included: CEEN241 (Statics), CEEN311 (Mechanics of Materials), MEGN361 (Thermodynamics 1), CSCI261 (Programming Concepts), CHGN209 (Chemical Thermodynamics), and CBEN210 (Intro to Thermodynamics) as they are key pre-requisite courses for many students.

Semester Hours

The number of times a class meets during a week (for lecture, recitation, or laboratory) determines the number of semester hours assigned to that course. Class sessions are normally 50 minutes long and represent one hour of credit for each hour meeting. A minimum of three hours of laboratory work per week are equivalent to 1-semester hour of credit. For the average student, each hour of lecture and recitation requires at least two hours of preparation. No full-time undergraduate student may enroll for more than 19 credit hours in one semester. Physical education, advanced ROTC and Honors Program in Public Affairs courses are excepted. However, upon written recommendation of the faculty advisor, the better students may be given permission by the Registrar on behalf of Academic Affairs to take additional hours.

Grade-Point Averages

Grade-Point Averages shall be specified, recorded, reported, and used to three figures following the decimal point for any and all purposes to which said averages may apply.

Overall Grade-Point Average

If a course completed during the Fall 2007 term through Summer 2011 was a repeat of a course completed in any previous term and the course was not repeatable for credit, the grade and credit hours earned for the most recent occurrence of the course will count toward the student's grade-point average and the student's degree requirements. The most recent course occurrence must be an exact match to the previous course completed (subject and number). The most recent grade is applied to the overall grade-point average even if the previous grade is higher.

Only courses originally completed and subsequently repeated at Colorado School of Mines during Fall 2007 through Summer 2011 with the same subject code and number apply to this repeat policy.

Option (Major) Grade-Point Average

The grade-point average calculated for the option (major) is calculated in the same manner as the overall grade-point average. Starting Fall 2011 the repeat policy is no longer in effect and all attempts at major courses completed in the major department or division are included. However, the major grade point average includes only the most recent attempt of a repeated course if the most recent attempt of that course occurs from Fall 2007 through Summer 2011.

The major grade point average includes up to 5 ranges of courses within the department (e.g. SUBJ200-499) but not necessarily all courses (i.e. SUBJ 100-599Z), plus up to 10 single courses with different subject codes from outside of the department.

The minimum major grade-point average required to earn a Mines undergraduate degree is a 2.000. For specifics concerning major GPA, reference the department specific section of the catalog. Courses that comprise the major GPA are listed at the end of the degree requirement tables.

GPA Recovery Policy

All attempts at every Mines course will count in the overall grade-point average unless the student qualifies for GPA recovery. GPA recovery will only be possible if the most recent course grade was a “D” or an “F” (including plus and/or minus). As grades C or better are satisfactory from a degree attainment perspective, such grades do not qualify for GPA replacement. No classes taken before Fall 2020 qualify for GPA Recovery.

If the student takes the course for a second time or third time, the most recent grade will be the only grade used to calculate the grade-point average (even if the previous grade(s) was higher). There will be no option to repeat for GPA recovery beyond a third attempt (i.e., third and/or greater attempts all count toward the GPA). All records of grades earned, including those excluded from GPA calculations as well as attempts (i.e. “W’s”), will be recorded on the student’s transcript. All withdrawals are still subject to the maximum withdrawal policy.

Courses from other institutions transferred to Colorado School of Mines are not counted in any grade- point average and cannot be used under this repeat policy.

GRADE Changes

After the completion of final grading for a term, only corrections to errors in grading may be processed and they must be for grade improvements only. Corrections to errors in grading for all students will be accepted one year from the original grade entry. With the exception of punitive disciplinary actions, diminution of a grade is not allowed without approval of the Provost.

Grade Appeal Process

Mines faculty have the responsibility, and sole authority for, assigning grades. As instructors, this responsibility includes clearly stating the instructional objectives of a course, defining how grades will be assigned in a way that is consistent with these objectives, and then assigning grades. It is the student’s responsibility to understand the grading criteria and then maintain the standards of academic performance established for each course in which he or she is enrolled.

If a student believes he or she has been unfairly graded, the student may appeal this decision first to the instructor of the course, and if the appeal is denied, to the Academic Standards Committee of the Faculty Senate. The Academic Standards Committee is the faculty body authorized to review and modify course grades, in appropriate circumstances. Any decision made by the Academic Standards Committee is final. In evaluating a grade appeal, the Academic Standards Committee will place the burden of proof on the student. For a grade to be revised by the Academic Standards Committee, the student must demonstrate that the grading decision was unfair by documenting that one or more of the following conditions applied:

1. The grading decision was based on something other than course performance, unless the grade was a result of penalty for academic dishonesty.
2. The grading decision was based on standards that were unreasonably different from those applied to other students in the same section of that course.
3. The grading decision was based on standards that differed substantially and unreasonably from those previously articulated by the instructor.

To appeal a grade, the student should proceed as follows:

1. The student should prepare an appeal of the grade received in the course. This appeal must define the basis for the appeal and must present all relevant evidence supporting the student’s case.
2. After preparing the appeal, the student should deliver this appeal to the course instructor and attempt to resolve the issue directly with the instructor. Written grade appeals must be delivered to the instructor no later than 10 business days after the start of the regular (fall or spring) semester immediately following the semester in which the contested grade was received. In the event that the course instructor is unavailable because of leave, illness, sabbatical, retirement, or resignation from the university, the course coordinator (first) or the Department Head/Division Director (second) shall represent the instructor.
3. If after discussion with the instructor, the student is still dissatisfied, he or she can proceed with the appeal by emailing a copy of the appeal and a copy of a summary of the instructor/student meetings held in connection with the previous step to the Academic Standards Committee. All information must be submitted to the committee no later than 25 business days after the start of the semester immediately following the semester in which the contested grade was received.
4. On the basis of all information deemed pertinent to the grade appeal, the Academic Standards Committee will determine whether the grade should be revised. The decision rendered will be either:
   a. the original grading decision is upheld, or
   b. sufficient evidence exists to indicate a grade has been assigned unfairly.

In the latter case, the Academic Standards Committee will assign the student a new grade for the course. The Committee’s decision is final. The decision and supporting documentation will be delivered to the Faculty Senate, the office of the Executive Vice President for Academic Affairs, the student, the instructor, and the instructor’s Department Head/Division Director no later than 25 business days following the Faculty Senate’s receipt of the grade appeal.

The schedule, but not the process, outlined above may be modified upon mutual agreement of the student, the course instructor, and the Academic Standards Committee.

Class Rank

Colorado School of Mines does not calculate class rank. The Registrar's Office will provide a letter stating this fact upon request if necessary for the submission of scholarship applications.

Minor Programs / Areas of Special Interest (ASI)

Established Minor Programs/Areas of Special Interest (ASI) are offered by undergraduate degree-granting departments and the Military Science Department. Additionally Mines offers interdisciplinary minors and ASIs.

A Minor Program/Area of Special Interest declaration (which can be found in the Registrar's Office) should be submitted for approval at the time of application for graduation. If the minor or ASI is added after the application to graduate, it must be submitted to the Registrar's Office by the first day of the term in which the student is graduating.

Once the declaration form is submitted to the Registrar's Office, the student deciding not to complete the minor/ASI must officially drop the minor/ASI by notifying the Registrar's Office in writing. Should minor/ASI requirements not be complete at the time of graduation, the minor/ASI program will not be awarded. Minors/ASIs are not added after the BS degree is posted. Completion of the minor/ASI will be recorded on the student's official transcript. Students who return after completing a degree may not take courses solely to complete a minor with the expectation of having the minor added to the transcript. Minors/ASIs are not added after the BS degree is posted.

Please see the Department for specific course requirements. For questions concerning changes in the sequence of minor/ASI courses after the declaration form is submitted, contact the Registrar's Office for assistance.

No more than half of the hours used for the minor or ASI may be transferred from other colleges or universities including AP, IB, or other high school or non-Mines credit. Some minor/ASI programs, however, have been established in collaboration with other institutions through formal articulation agreements and these may allow transfer credit exceeding this limit. For additional information on program-specific transfer credit limits, refer to the programs section of this Catalog.

As a minimum, Mines requires that any course used to fulfill a minor/ASI requirement be completed with a passing grade. Some programs offering minors/ASIs may, however, impose higher minimum grades for inclusion of the course in the minor/ASI. In these cases, the program specified minimum course grades take precedence. For additional information on program-specific minimum course grade requirements, refer to the programs section of this Catalog. As a minimum, to be awarded a minor/ASI, Mines requires students obtain a cumulative GPA of 2.0 or higher in all minor/ASI courses completed at Mines. All attempts at required minor/ASI courses are used in computing this minor/ASI GPA. Some programs offering minors/ASIs may, however, require a higher minimum cumulative GPA. In these cases, the program specified GPA takes precedence. For additional information on program specific GPA requirements, refer to the programs section of this Catalog.

Each department or minor-oversight authority (in the case of interdisciplinary minors) defines a list of requirements that constitute a minor. The lists of requirements clearly delineate any specific courses needed for the minor, may include a set of courses from which the rest of the credits must be completed, and will clearly outline any other specific restrictions and/or requirements for obtaining the minor. Once recommended by Undergraduate Council and approved by Faculty Senate, the minor requirements will appear in the appropriate department or interdisciplinary sections of this catalog so that courses may be planned in advance in order for a student to receive a given minor/s.

The objective of a minor is to provide a depth of understanding and expertise to an area outside of, or complementary to, a student's degree. A minor is a thematically-related set of academic activities leading to a transcript designation in addition to but separate from that granted by the student's degree.

Minors

All minors are created and awarded based on the following minimum requirements and limitations:

Minimum Credit Hours - 18.0

Minimum Hours Outside of Degree Requirements - 9.0

At least 9.0 of the hours required for the minor must not be used for any part of the degree other than Free Electives.

Minimum GPA - 2.0

A 2.0 grade point average, including all Mines graded courses used for the minor, must be met in order to receive the minor designation on the transcript. Transfer credit hours do not factor into the minor grade point average.

Level - At least 9.0 credits must be at the 300-level or above.

Content

There must be sufficient distinction between a degree and a minor obtained by the same student. In general, students may earn minors offered by the same department as their degree program, but the minor may not have the same name as the degree. For example, an Electrical Engineering degree-seeking student may earn a minor in Computer Science. However, degree granting programs, with recommendation by Undergraduate Council and approval by Faculty Senate, may 1) specify minors that are excluded for their students due to insufficient distinction, and/or 2) add restrictions or additional requirements to the minimal requirements for their students to obtain a specific minor.

Areas of Special Interest (ASIs)

All ASIs are created and awarded based on the following minimum requirements and limitations:

Minimum Credit Hours - 12.0

Minimum Hours Outside of Degree Requirements - 9.0

At least 9.0 of the hours required for the ASI must not be used for any part of the degree other than Free Electives.

Minimum GPA - 2.0

A 2.0 grade point average, including all Mines graded courses used for the ASI, must be met in order to receive the ASI designation on the transcript. Transfer credit hours do not factor into the ASI grade point average.

Level - At least 9.0 credits must be at the 300-level or above.

Undergraduate Degree Requirements

Bachelor of Science Degree

Upon completion of the requirements and upon being recommended for graduation by the faculty, and approved by the Board of Trustees, the undergraduate receives one of the following degrees:

- Bachelor of Science (Applied Mathematics and Statistics)
- Bachelor of Science (Biochemistry)
- Bachelor of Science (Chemical Engineering)
- Bachelor of Science (Chemistry)
- Bachelor of Science (Civil Engineering)
- Bachelor of Science (Computer Science)
- Bachelor of Science (Economics)
- Bachelor of Science (Electrical Engineering)
- Bachelor of Science (Engineering)
- Bachelor of Science (Engineering Physics)
- Bachelor of Science (Environmental Engineering)
- Bachelor of Science (Geological Engineering)
- Bachelor of Science (Geophysical Engineering)
- Bachelor of Science (Mechanical Engineering)
- Bachelor of Science (Metallurgical & Materials Engineering)
- Bachelor of Science (Mining Engineering)
- Bachelor of Science (Petroleum Engineering)

Degree Retirement Notification

Admission into the following degree program is suspended after the Spring 2017 semester:

- Bachelor of Science (Chemical and Biochemical Engineering)

Program requirements for students admitted before Summer 2017 wishing to remain in the program are as defined in previous catalogs. For students wishing to pursue a similar degree, please see the Bachelor of Science (Chemical Engineering) - Biological Engineering Track.

Graduation Requirements

To qualify for a Bachelor of Science degree from Colorado School of Mines, all candidates must satisfy the following requirements:

1. A minimum cumulative grade-point average of 2.000 for all academic work completed in residence.
2. A minimum cumulative grade-point average of 2.000 for courses in the candidate's major.
3. A minimum of 30 hours credit in 300 and 400 series technical courses in residence, at least 15 of which are to be taken in the senior year.
4. A minimum of 19 hours in Humanities & Social Science (H&SS) courses.
5. The recommendation of their degree-granting department/ division to the faculty.
6. The certification by the Registrar that all required academic work is satisfactorily completed.
7. The recommendation of the faculty and approval of the Board of Trustees.

Seniors must submit an Application to Graduate upon completion of 90 hours (upon obtaining Senior class standing). Applications are completed online through the student's Trailhead account.

Completed Minor and ASI forms are normally due to the Registrar's Office at the same as the application to graduate. If the Minor or ASI is added later, it is due no later than the first day of the term in which the student is graduating.

It is the responsibility of students to monitor the progress of their degrees. It is also the student's responsibility to contact the Registrar's Office when there appears to be a discrepancy between the degree audit and the student's records.

No students, graduate or undergraduate, will receive diplomas until they have complied with all the rules and regulations of Colorado School of Mines and settled all accounts with the School. Transcript of grades and other records will not be provided for any student or graduate who has an unsettled obligation of any kind to the School.

Multiple Degrees

A student wishing to complete two Bachelor of Science degrees must complete the first degree plus a minimum of thirty hours specific to the second degree program. The thirty (or more) hours required for the second degree may not include free electives and may not be double counted with any credit used to complete the first degree. The degree plan for the second degree must be approved by the advisor, the department head, and the Registrar's Office representing Academic Affairs.

When two degrees are completed concurrently, the first degree is the one with fewer total hours required for graduation. In the case of a returning student, the first degree is the original completed degree. The two degrees may be in different colleges. The degree plan may include courses from multiple departments. Different catalogs may be used, one for each degree program. The student receives two separate diplomas. The transcript lists both degrees.

A student may not earn two degrees in the same content area because the course requirements, content, and titles do not significantly differ.

The following combinations are not allowable:

BS in Engineering, Mechanical Specialty & BS in Mechanical Engineering

BS in Engineering, Electrical Specialty & BS in Electrical Engineering

BS in Engineering, Environmental Specialty & BS in Environmental Engineering

BS in Engineering, Civil Specialty & BS in Civil Engineering

BS in Mathematics & Computer Science & BS in Applied Math and Statistics

BS in Mathematics & Computer Science & BS in Computer Science

BS in Chemical Engineering & BS in Chemical and Biochemical Engineering

Degree Posting and Grade Changes

Once the degree is posted, grade changes will be accepted for six weeks only. After six weeks has passed, no grade changes will be allowed for any courses on the official transcript.

Commencement Participation

To participate in May Commencement, no more than 6 semester credit hours can remain outstanding after the spring term. The student must show proof of summer registration for these 6 or fewer credits in order to be placed on the list for August completion. To participate in December convocation, the undergraduate student must be registered for all

courses that lead to completion of the degree at the end of the same fall term.

Courses Older Than 10 Years

For returning students who wish to use courses completed more than 10 years prior, contact the Registrar's Office. These courses will not apply to current degrees without special approval from the degree-granting department or division, and the department in which the course is taught.

Programs and Departments

Applied Mathematics & Statistics

Program Description

The Applied Mathematics and Statistics Department (AMS) offers an undergraduate degree in which students are exposed to a breadth of coursework in computational mathematics, applied mathematics, and statistics. In the senior year, students may choose an area of emphasis in either Computational and Applied Mathematics (CAM) or Statistics (STAT). Both options emphasize technical competence, problem-solving, teamwork, projects, relation to other disciplines, verbal, written, and graphical skills.

In a broad sense, these programs stress the development of practical applications and techniques to enhance the overall attractiveness of applied mathematics and statistics majors to a wide range of employers in industry and government. More specifically, AMS utilizes a modeling "field session" to introduce concepts and techniques in mathematical modeling and the senior capstone experiences in Computational and Applied Mathematics and Statistics to engage high-level undergraduate students in problems of practical applicability for potential employers. These courses are designed to simulate an industrial job or research environment. The close collaboration with potential employers and professors improves communication between our students and the private sector, and sponsors from other disciplines on campus.

Applied Mathematics and Statistics majors are encouraged to use free elective courses to gain knowledge in another discipline and incorporate either an Area of Special Interest (ASI) or a minor. This adds to the flexibility of the program and qualifies students for a wide variety of careers.

In addition to offering undergraduate and graduate degree programs, the Department provides the teaching skills and technical expertise to develop capabilities in computational mathematics, applied mathematics, and statistics for all Colorado School of Mines (CSM) students.

Program Educational Objectives

(Bachelor of Science in Applied Mathematics and Statistics)

In addition to contributing toward achieving the educational objectives described in the Mines Graduate Profile and the Accreditation Board for Engineering and Technology's (ABET) accreditation criteria, the Applied Mathematics and Statistics Program at Mines has established the following program educational objectives:

Students will demonstrate technical expertise within mathematics and statistics by:

- Designing and implementing solutions to practical problems in science and engineering; and,
- Using appropriate technology as a tool to solve problems in mathematics.

Students will demonstrate a breadth and depth of knowledge within mathematics by:

- Extending course material to solve original problems,
- Applying knowledge of mathematics to the solution of problems,
- Identifying, formulating and solving mathematics problems, and
- Analyzing and interpreting statistical data.

Students will demonstrate an understanding and appreciation for the relationship of mathematics to other fields by:

- Applying mathematics and statistics to solve problems in other fields,
- Working in cooperative multidisciplinary teams, and
- Choosing appropriate technology to solve problems in other disciplines.

Students will demonstrate an ability to communicate mathematics effectively by:

- Giving oral presentations,
- Completing written explanations,
- Interacting effectively in cooperative teams, and
- Understanding and interpreting written material in mathematics.

Curriculum

The calculus sequence emphasizes mathematics applied to problems students are likely to see in other fields. This supports the curricula in other programs where mathematics is important, and assists students who are under prepared in mathematics. Priorities in the mathematics curriculum include: applied problems in the mathematics courses and ready utilization of mathematics in the science and engineering courses.

This emphasis on the utilization of mathematics continues through the upper-division courses. Another aspect of the curriculum is the use of a spiraling mode of learning in which concepts are revisited to deepen the students' understanding.

The applications, teamwork, assessment and communications emphasis directly address ABET criteria and the Mines graduate profile. The curriculum offers the following two areas of emphases:

Degree Requirements (Applied Mathematics and Statistics)

Computational and Applied Mathematics (CAM) EMPHASIS

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, CBEN 110, CHGN 122, or CHGN 125	3.0		3.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
HASS100	NATURE AND HUMAN VALUES	4.0		4.0

MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
EDNS151	DESIGN I			3.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
PHGN100	PHYSICS I - MECHANICS	3.0	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CSCI261	PROGRAMMING CONCEPTS	3.0		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Spring		**lec**	**lab**	**sem.hrs**
HASS200	GLOBAL STUDIES	3.0		3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3.0
MATH332	LINEAR ALGEBRA or 342	3.0		3.0
CSCIxxx	COMPUTER ELECTIVE[1]	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
MATH300	FOUNDATIONS OF ADVANCED MATHEMATICS	3.0		3.0
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0		3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL ELECTIVE	3.0		3.0
MATH310	INTRODUCTION TO MATHEMATICAL MODELING			3.0
MATH	MATHEMATICS-CAM ELECTIVE[2]	3.0		3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
MATH301	INTRODUCTION TO ANALYSIS	3.0		3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0		3.0
MATH	MATHEMATICS-CAM ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL ELECTIVE	3.0		3.0
MATH331	MATHEMATICAL BIOLOGY			3.0
				15.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0		3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	4.0		4.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				16.0

Total Semester Hrs: 128.5

[1] May be satisfied by CSCI262 or any other approved computationally intensive course.

Mathematics-CAM elective list. CAM students must choose at least 2 electives from this list. [2]

MATH440	PARALLEL SCIENTIFIC COMPUTING	3.0
MATH454	COMPLEX ANALYSIS	3.0
MATH457	INTEGRAL EQUATIONS	3.0
MATH458	ABSTRACT ALGEBRA	3.0
MATH459	ASYMPTOTICS	3.0
MATH472	MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE	3.0
MATH500	LINEAR VECTOR SPACES	3.0
MATH501	APPLIED ANALYSIS	3.0
MATH514	APPLIED MATHEMATICS I	3.0
MATH515	APPLIED MATHEMATICS II	3.0
MATH550	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	3.0

MATH551	COMPUTATIONAL LINEAR ALGEBRA	3.0
MATH	Department approval required for courses not on this list.	

Mathematics-STAT Elective List. CAM students may choose up to 4 electives from this list to satisfy CAM/STAT Elective requirements. [2]

MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
MATH432	SPATIAL STATISTICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH437	MULTIVARIATE ANALYSIS	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH439	SURVIVAL ANALYSIS	3.0
MATH482	STATISTICS PRACTICUM (CAPSTONE)	4.0
MATH530	STATISTICAL METHODS I	3.0
MATH531	STATISTICAL METHODS II	3.0
MATH534	MATHEMATICAL STATISTICS I	3.0
MATH535	MATHEMATICAL STATISTICS II	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
CSCI406	ALGORITHMS	3.0
MATH	Department approval required for courses not on this list.	

Statistics (STATS) EMPHASIS

Freshman

Fall		**lec**	**lab**	**sem.hrs**
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, CBEN 110, CHGN 122, or CHGN 125	3.0		3.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
HASS100	NATURE AND HUMAN VALUES	4.0		4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
EDNS151	DESIGN I			3.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
PHGN100	PHYSICS I - MECHANICS	3.0	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CSCI261	PROGRAMMING CONCEPTS	3.0		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Spring		**lec**	**lab**	**sem.hrs**
CSCI262	DATA STRUCTURES	3.0		3.0
HASS200	GLOBAL STUDIES	3.0		3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3.0
MATH332	LINEAR ALGEBRA or 342	3.0		3.0
FREE	FREE ELECTIVE			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
MATH300	FOUNDATIONS OF ADVANCED MATHEMATICS	3.0		3.0
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0		3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0		3.0
MATH	MATHEMATICS-STAT ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL ELECTIVE	3.0		3.0
MATH310	INTRODUCTION TO MATHEMATICAL MODELING			3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
MATH301	INTRODUCTION TO ANALYSIS			3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0		3.0
MATH	MATHEMATICS-STAT ELECTIVE[2]	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL ELECTIVE	3.0		3.0
				15.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
CSCI403	DATA BASE MANAGEMENT			3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0		3.0
MATH	MATHEMATICS CAM/STAT ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL ELECTIVE	3.0		3.0

FREE	FREE ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				18.0
Spring		**lec**	**lab**	**sem.hrs**
MATH437	MULTIVARIATE ANALYSIS			3.0
MATH482	STATISTICS PRACTICUM (CAPSTONE) (STAT Capstone)	4.0		4.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				16.0

Total Semester Hrs: 128.5

Mathematics-STAT Elective List. STAT students must choose at least 2 electives from this list. [2]

MATH432	SPATIAL STATISTICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH439	SURVIVAL ANALYSIS	3.0
MATH530	STATISTICAL METHODS I	3.0
MATH531	STATISTICAL METHODS II	3.0
MATH534	MATHEMATICAL STATISTICS I	3.0
MATH535	MATHEMATICAL STATISTICS II	3.0
MATH	Department approval required for courses not on this list.	

Mathematics-CAM Elective List. STAT students may choose up to 4 electives from this list to satisfy CAM/STAT Elective requirements. [2]

MATH331	MATHEMATICAL BIOLOGY	3.0
MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0
MATH440	PARALLEL SCIENTIFIC COMPUTING	3.0
MATH454	COMPLEX ANALYSIS	3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH457	INTEGRAL EQUATIONS	3.0
MATH458	ABSTRACT ALGEBRA	3.0
MATH459	ASYMPTOTICS	3.0
MATH472	MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE	3.0
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	4.0
MATH500	LINEAR VECTOR SPACES	3.0
MATH501	APPLIED ANALYSIS	3.0
MATH514	APPLIED MATHEMATICS I	3.0
MATH515	APPLIED MATHEMATICS II	3.0
MATH550	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH551	COMPUTATIONAL LINEAR ALGEBRA	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI406	ALGORITHMS	3.0
MATH	Department approval required for courses not on this list.	

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- CSCI100 through CSCI799 inclusive
- MACS100 through MACS799 inclusive (Previous subject code)
- MATH100 through MATH799 inclusive

Overview

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13) section of the Mines Catalog (p. 2). The Department of Applied Mathematics and Statistics offers the following:

ASIs are available in:

Computational and Applied Mathematics (CAM)

Required Courses		
MATH225	DIFFERENTIAL EQUATIONS	3.0
or MATH235	DIFFERENTIAL EQUATIONS HONORS	
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0
MATH332	LINEAR ALGEBRA	3.0
or MATH342	HONORS LINEAR ALGEBRA	
Plus 3 hours of elective courses listed below.		

Statistics (STAT)

Required Courses		
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
Plus 3 hours of elective courses from the list below.		

Mathematical Sciences

Required Courses		
MATH225	DIFFERENTIAL EQUATIONS	3.0
Plus 9 hours of upper division or graduate level MATH courses. 3 of which must be at the 400-level.		

Minors are available in:

Computational and Applied Mathematics (CAM)

Required Courses		
MATH225	DIFFERENTIAL EQUATIONS	3.0
or MATH235	DIFFERENTIAL EQUATIONS HONORS	

MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0
MATH332	LINEAR ALGEBRA	3.0
or MATH342	HONORS LINEAR ALGEBRA	
Plus 9 hours of electives from the list below.		

Statistics (STAT)

Required Courses		
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
Plus 6 hours of electives from the list below		

Mathematical Sciences

Required Courses		
MATH225	DIFFERENTIAL EQUATIONS	3.0
Plus 15 hours of upper division or graduate level MATH courses. 3 of which must be at the 400-level.		

To complete a Minor/ASI in Computational and Applied Mathematics (CAM), students must choose 9 credits (Minor) or 3 credits (ASI) from the following elective list

MATH301	INTRODUCTION TO ANALYSIS	3.0
MATH310	INTRODUCTION TO MATHEMATICAL MODELING	3.0
MATH331	MATHEMATICAL BIOLOGY	3.0
MATH348	ADVANCED ENGINEERING MATHEMATICS	3.0
MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0
MATH437	MULTIVARIATE ANALYSIS	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH440	PARALLEL SCIENTIFIC COMPUTING	3.0
MATH454	COMPLEX ANALYSIS	3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH457	INTEGRAL EQUATIONS	3.0
MATH459	ASYMPTOTICS	3.0
MATH472	MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE	3.0
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	4.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI406	ALGORITHMS	3.0
CSCI441	COMPUTER GRAPHICS	3.0
CSCI444	ADVANCED COMPUTER GRAPHICS	3.0
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
CSCI474	INTRODUCTION TO CRYPTOGRAPHY	3.0
MATH3xx/4xx/5xx	Approved upper division or graduate course	

To complete a Minor/ASI in Statistics (STAT), students must choose 6 credits (Minor) or 3 credits (ASI) from the following elective list

MATH432	SPATIAL STATISTICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH437	MULTIVARIATE ANALYSIS	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH439	SURVIVAL ANALYSIS	3.0
MATH498	SPECIAL TOPICS	1-6
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
MATH3xx/4xx/5xx	Approved upper division or graduate course	

Courses

MATH100. INTRODUCTORY TOPICS FOR CALCULUS. 3.0 Semester Hrs.
(S) An introduction and/or review of topics which are essential to the background of an undergraduate student at CSM. This course serves as a preparatory course for the Calculus curriculum and includes material from Algebra, Trigonometry, Mathematical Analysis, and Calculus. Topics include basic algebra and equation solving, solutions of inequalities, trigonometric functions and identities, functions of a single variable, continuity, and limits of functions. Does not apply toward undergraduate degree or GPA. 3 hours lecture; 3 semester hours.

MATH111. CALCULUS FOR SCIENTISTS AND ENGINEERS I. 4.0 Semester Hrs.
(I, II, S) First course in the calculus sequence, including elements of plane geometry. Functions, limits, continuity, derivatives and their application. Definite and indefinite integrals; Prerequisite: precalculus. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH112. CALCULUS FOR SCIENTISTS AND ENGINEERS II. 4.0 Semester Hrs.
Equivalent with MATH122,
(I, II, S) Vectors, applications and techniques of integration, infinite series, and an introduction to multivariate functions and surfaces. Prerequisite: Grade of C- or better in MATH111. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH113. CALCULUS FOR SCIENTISTS AND ENGINEERS II - SHORT FORM. 1.0 Semester Hr.
(I, II) This is a bridge course for entering freshmen and new transfer students to CSM who have either a score of 5 on the BC AP Calculus exam or who have taken an appropriate Calculus II course at another institution (determined by a departmental review of course materials). Two, three and n-dimensional space, vectors, curves and surfaces in 3-dimensional space, polar, cylindrical and spherical coordinates, and applications of these topics. Prerequisite: Placement by Mines Transfer Specialist or AMS Department recommendation. 1 hour lecture; 1 semester hour.

MATH122. CALCULUS FOR SCIENTISTS AND ENGINEERS II HONORS. 4.0 Semester Hrs.
Equivalent with MATH112,
(I, II) Same topics as those covered in MATH112 but with additional material and problems. Prerequisites: Grade of C- or better in MATH111. 4 hours lecture; 4 semester hours.

MATH198. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MATH199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MATH201. PROBABILITY AND STATISTICS FOR ENGINEERS. 3.0 Semester Hrs.
Equivalent with MATH323,
(I,II,S) This course is an introduction to Probability and Statistics, including fundamentals of experimental design and data collection, the summary and display of data, elementary probability, propagation of error, discrete and continuous probability models, interval estimation, hypothesis testing, and linear regression with emphasis on applications to science and engineering. Prerequisites: MATH112, MATH122 or concurrent enrollment in MATH113. 3 hours lecture; 3 semester hours.

MATH213. CALCULUS FOR SCIENTISTS AND ENGINEERS III. 4.0 Semester Hrs.
(I, II, S) Multivariable calculus, including partial derivatives, multiple integrals, and vector calculus. Prerequisites: Grade of C- or better in MATH112 or MATH122 or Concurrent Enrollment in MATH113. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH214. CALCULUS FOR SCIENTIST AND ENGINEERS III - SHORT FORM. 1.0 Semester Hr.
(I, II) This is a bridge course for entering freshmen and new transfer students to CSM who have taken an appropriate Calculus III course at another institution (determined by a departmental review of course materials). Vector Calculus including line and surface integrals with applications to work and flux, Green's Theorem, Stokes' Theorem and the Divergence Theorem. 1 hour lecture; 1 semester hour.

MATH223. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS. 4.0 Semester Hrs.
(II) Same topics as those covered in MATH213 but with additional material and problems. Prerequisite: (Grade of B- or better in MATH112 or MATH113 or MATH122) OR (concurrent enrollment in MATH113 for new students with pending AP or transfer credit for Calculus II). 4 hours lecture; 4 semester hours.

MATH224. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS. 4.0 Semester Hrs.
(I, II) Early introduction of vectors, linear algebra, multivariable calculus. Vector fields, line and surface integrals. Prerequisite: (Grade of B- or better in MATH112 or MATH113 or MATH122) OR (concurrent enrollment in MATH113 for new students with pending AP or transfer credit for Calculus II). 4 hours lecture; 4 semester hours.

MATH225. DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.
(I, II, S) Classical techniques for first and higher order equations and systems of equations. Laplace transforms. Phase-plane and stability analysis of non-linear equations and systems. Applications from physics, mechanics, electrical engineering, and environmental sciences. Prerequisites: Grade of C- or better in MATH112 or MATH122 or Concurrent Enrollment in MATH113. 3 hours lecture; 3 semester hours.

MATH235. DIFFERENTIAL EQUATIONS HONORS. 3.0 Semester Hrs.
(I, II) Same topics as those covered in MATH225 but with additional material and problems. 3 hours lecture; 3 semester hours. Prerequisite: Grade of B- or better in MATH112 or MATH 113 or MATH122, or concurrent enrollment in MATH113 for new students with pending AP or transfer credit for Calculus II.

MATH298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MATH299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MATH300. FOUNDATIONS OF ADVANCED MATHEMATICS. 3.0 Semester Hrs.
(I) (WI) This course is an introduction to communication in mathematics. This writing intensive course provides a transition from the Calculus sequence to theoretical mathematics curriculum in CSM. Topics include logic and recursion, techniques of mathematical proofs, reading and writing proofs. Prerequisites: MATH112 or MATH122. 3 hours lecture; 3 semester hours.

MATH301. INTRODUCTION TO ANALYSIS. 3.0 Semester Hrs.
Equivalent with MATH401,
(II) This course is a first course in real analysis that lays out the context and motivation of analysis in terms of the transition from power series to those less predictable series. The course is taught from a historical perspective. It covers an introduction to the real numbers, sequences and series and their convergence, real-valued functions and their continuity and differentiability, sequences of functions and their pointwise and uniform convergence, and Riemann-Stieltjes integration theory. Prerequisite: MATH300. 3 hours lecture; 3 semester hours.

MATH307. INTRODUCTION TO SCIENTIFIC COMPUTING. 3.0 Semester Hrs.
Equivalent with CSCI407,MATH407,
(I, II, S) This course is designed to introduce scientific computing to scientists and engineers. Students in this course will be taught various numerical methods and programming techniques to solve basic scientific problems. Emphasis will be made on implementation of various numerical and approximation methods to efficiently simulate several applied mathematical models. Prerequisites: MATH213 or MATH223 or MATH224. Co-requisites: MATH225 or MATH235. 3 hours lecture; 3 semester hours.

MATH310. INTRODUCTION TO MATHEMATICAL MODELING. 3.0 Semester Hrs.
An introduction to modeling and communication in mathematics. A writing intensive course providing a transition from the core math sequence to the upper division AMS curriculum. Topics include a variety of mathematical and statistical modeling techniques. Students will formulate and solve applied problems and will present results orally and in writing. In addition, students will be introduced to the mathematics software that will be used in upper division courses. Prerequisite: MATH201, MATH225.

MATH332. LINEAR ALGEBRA. 3.0 Semester Hrs.
(I, II) Systems of linear equations, matrices, determinants and eigenvalues. Linear operators. Abstract vector spaces. Applications selected from linear programming, physics, graph theory, and other fields. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH334. INTRODUCTION TO PROBABILITY. 3.0 Semester Hrs.
(I) An introduction to the theory of probability essential for problems in science and engineering. Topics include axioms of probability, combinatorics, conditional probability and independence, discrete and continuous probability density functions, expectation, jointly distributed random variables, Central Limit Theorem, laws of large numbers. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture, 3 semester hours.

MATH335. INTRODUCTION TO MATHEMATICAL STATISTICS. 3.0 Semester Hrs.
(II) An introduction to the theory of statistics essential for problems in science and engineering. Topics include sampling distributions, methods of point estimation, methods of interval estimation, significance testing for population means and variances and goodness of fit, linear regression, analysis of variance. Prerequisite: MATH334. 3 hours lecture, 3 semester hours.

MATH340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I, II, S) (WI) Supervised, full-time engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions. Repeatable.

MATH342. HONORS LINEAR ALGEBRA. 3.0 Semester Hrs.
(II) Same topics as those covered in MATH332 but with additional material and problems as well as a more rigorous presentation. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH348. ADVANCED ENGINEERING MATHEMATICS. 3.0 Semester Hrs.
(I, II, S) Introduction to partial differential equations, with applications to physical phenomena. Fourier series. Linear algebra, with emphasis on sets of simultaneous equations. This course cannot be used as a MATH elective by MCS or AMS majors. Prerequisite: MATH225 or MATH235 and MATH213 or MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH398. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MATH399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MATH408. COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.
(I) This course is designed to introduce computational methods to scientists and engineers for developing differential equations based computer models. Students in this course will be taught various numerical methods and programming techniques to simulate systems of nonlinear ordinary differential equations. Emphasis will be on implementation of various numerical and approximation methods to efficiently simulate several systems of nonlinear differential equations. Prerequisite: MATH307. 3 hours lecture, 3 semester hours.

MATH424. INTRODUCTION TO APPLIED STATISTICS. 3.0 Semester Hrs.
(I) Linear regression, analysis of variance, and design of experiments, focusing on the construction of models and evaluation of their fit. Techniques covered will include stepwise and best subsets regression, variable transformations, and residual analysis. Emphasis will be placed on the analysis of data with statistical software. Prerequisites: MATH201 or MATH335 and MATH332 or MATH342. 3 hours lecture; 3 semester hours.

MATH431. MATHEMATICAL BIOLOGY. 3.0 Semester Hrs.
This course will discuss methods for building and solving both continuous and discrete mathematical models. These methods will be applied to population dynamics, epidemic spread, pharmacokinetics and modeling of physiologic systems. Modern Control Theory will be introduced and used to model living systems. Some concepts related to self-organizing systems will be introduced. Prerequisite: MATH307, MATH310, MATH332 or MATH342.

MATH432. SPATIAL STATISTICS. 3.0 Semester Hrs.
(I) Modeling and analysis of data observed in a 2- or 3-dimensional region. Random fields, variograms, covariances, stationarity, nonstationarity, kriging, simulation, Bayesian hierarchical models, spatial regression, SAR, CAR, QAR, and MA models, Geary/Moran indices, point processes, K-function, complete spatial randomness, homogeneous and inhomogeneous processes, marked point processes. Prerequisite: MATH335. Corequisite: MATH424. 3 hours lecture; 3 semester hours.

MATH436. ADVANCED STATISTICAL MODELING. 3.0 Semester Hrs.
(II) Modern methods for constructing and evaluating statistical models. Topics include generalized linear models, generalized additive models, hierarchical Bayes methods, and resampling methods. Time series models, including moving average, autoregressive, and ARIMA models, estimation and forecasting, confidence intervals. Prerequisites: MATH335 and MATH424. 3 hours lecture; 3 semester hours.

MATH437. MULTIVARIATE ANALYSIS. 3.0 Semester Hrs.
(II) Introduction to applied multivariate techniques for data analysis. Topics include principal components, cluster analysis, MANOVA and other methods based on the multivariate Gaussian distribution, discriminant analysis, classification with nearest neighbors. Prerequisites: MATH335 or MATH201 and MATH332 or MATH342. 3 hours lecture; 3 semester hours.

MATH438. STOCHASTIC MODELS. 3.0 Semester Hrs.
(II) An introduction to stochastic models applicable to problems in engineering, physical science, economics, and operations research. Markov chains in discrete and continuous time, Poisson processes, and topics in queuing, reliability, and renewal theory. Prerequisite: MATH334. 3 hours lecture, 3 semester hours.

MATH439. SURVIVAL ANALYSIS. 3.0 Semester Hrs.
(I) Basic theory and practice of survival analysis. Topics include survival and hazard functions, censoring and truncation, parametric and non-parametric inference, hypothesis testing, the proportional hazards model, model diagnostics. Prerequisite: MATH335. 3 hours lecture; 3 semester hours.

MATH440. PARALLEL SCIENTIFIC COMPUTING. 3.0 Semester Hrs.
Equivalent with CSCI440,
(I) This course is designed to facilitate students' learning of parallel programming techniques to efficiently simulate various complex processes modeled by mathematical equations using multiple and multi-core processors. Emphasis will be placed on implementation of various scientific computing algorithms in FORTRAN 90 and its variants using MPI and OpenMP. Prerequisites: MATH307 or CSCI407. 3 hours lecture; 3 semester hours.

MATH454. COMPLEX ANALYSIS. 3.0 Semester Hrs.
(II) The complex plane. Analytic functions, harmonic functions. Mapping by elementary functions. Complex integration, power series, calculus of residues. Conformal mapping. Prerequisite: MATH225 or MATH235 and MATH213 or MATH223 or MATH224. 3 hours lecture, 3 semester hours.

MATH455. PARTIAL DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.
(I, II) Linear partial differential equations, with emphasis on the classical second-order equations: wave equation, heat equation, Laplace's equation. Separation of variables, Fourier methods, Sturm-Liouville problems. Prerequisites: MATH225 or MATH235 and MATH213 or MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH457. INTEGRAL EQUATIONS. 3.0 Semester Hrs.
(I) This is an introductory course on the theory and applications of integral equations. Abel, Fredholm and Volterra equations. Fredholm theory: small kernels, separable kernels, iteration, connections with linear algebra and Sturm-Liouville problems. Applications to boundary-value problems for Laplace's equation and other partial differential equations. Prerequisites: MATH332 or MATH342, and MATH455. 3 hours lecture; 3 semester hours.

MATH458. ABSTRACT ALGEBRA. 3.0 Semester Hrs.
(I) This course is an introduction to the concepts of contemporary abstract algebra and applications of those concepts in areas such as physics and chemistry. Topics include groups, subgroups, isomorphisms and homomorphisms, rings, integral domains and fields. Prerequisites: MATH300. 3 hours lecture; 3 semester hours.

MATH459. ASYMPTOTICS. 3.0 Semester Hrs.
Equivalent with MATH559,
(I) Asymptotic methods are used to find approximate solutions to problems when exact solutions are unavailable or too complicated to be useful. A broad range of asymptotic methods is developed, covering algebraic problems, integrals and differential equations. Prerequisites: MATH213 and MATH225. 3 hours lecture; 3 semester hours.

MATH470. MATHEMATICAL MODELING OF SPATIAL PROCESSES IN BIOLOGY. 3.0 Semester Hrs.
This course is an introduction to mathematical modeling of spatial processes in biology. The emphasis is on partial differential equation models from a diverse set of biological topics such as cellular homeostasis, muscle dynamics, neural dynamics, calcium handling, epidemiology, and chemotaxis. We will survey a variety of models and analyze their results in the context of the biology. Mathematically, we will examine the diffusion equation, advection equation, and combinations of the two that include reactions. There will be a significant computational component to the course including bi-weekly computational labs; students will solve the model equations and perform computations using MATLAB. Prerequisite: MATH331, MATH455 or equivalent courses and familiarity with MATLAB.

MATH472. MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE. 3.0 Semester Hrs.
(II) This course will focus on mathematical and computational techniques applied to neuroscience. Topics will include nonlinear dynamics, hysteresis, the cable equation, and representative models such as Wilson-Cowan, Hodgkin-Huxley, and FitzHugh-Nagumo. Applications will be motivated by student interests. In addition to building basic skills in applied math, students will gain insight into how mathematical sciences can be used to model and solve problems in neuroscience; develop a variety of strategies (computational, theoretical, etc.) with which to approach novel mathematical situations; and hone skills for communicating mathematical ideas precisely and concisely in an interdisciplinary context. In addition, the strong computational component of this course will help students to develop computer programming skills and apply appropriate technological tools to solve mathematical problems. Prerequisite: MATH331. 3 hours lecture; 3 semester hours.

MATH482. STATISTICS PRACTICUM (CAPSTONE). 4.0 Semester Hrs.
This is the capstone course in the Statistics option. Students will apply statistical principles to data analysis through advanced work, leading to a written report and an oral presentation. Choice of project is arranged between the student and the individual faculty member who will serve as advisor. Prerequisite: MATH335, MATH424.

MATH484. MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE). 4.0 Semester Hrs.
This is the capstone course in the Computational and Applied Mathematics option. Students will apply computational and applied mathematics modeling techniques to solve complex problems in biological, engineering and physical systems. Mathematical methods and algorithms will be studied within both theoretical and computational contexts. The emphasis is on how to formulate, analyze and use nonlinear modeling to solve typical modern problems. Prerequisite: MATH331, MATH307, MATH455.

MATH491. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
(I) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

MATH492. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
(II) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: none. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

MATH498. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MATH499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Department Head

Greg Fasshauer, Professor

Professors

Mahadevan Ganesh

Paul A. Martin

Doug Nychka

Associate professors

Soutir Bandyopadhyay

Cecilia Diniz Behn

Dorit Hammerling

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Willy Hereman

Steven Pruess

Emeriti Associate Professors

Barbara B. Bath

Ruth Maurer

Chemical and Biological Engineering

Program Description

The Chemical and Biological Engineering Department offers a Bachelor of Science in Chemical Engineering, with optional Biological Engineering, Process Engineering, or Honors Research tracks.

Generally, the fields of chemical and biological engineering are extremely broad, and encompass all technologies and industries where chemical processing is utilized in any form. Students with baccalaureate (BS) Chemical Engineering degrees from Mines can find employment in many diverse fields, including: advanced materials synthesis and processing, product and process research and development, food and pharmaceutical processing and synthesis, biochemical and biomedical materials and products, microelectronics manufacturing, petroleum and petrochemical processing, and process and product design. Students in the Biological Engineering, Process Engineering, or Honors Research track take 12 credits of technical and chemical engineering electives designed to provide additional focus in these areas. The Biological and Process Engineering tracks are open to all students. The Honors Research track requires students to apply and be accepted. Alternatively students can earn their degree without being in a track, customizing their electives without any restrictions.

The practice of chemical engineering draws from the fundamentals of biology, chemistry, mathematics, and physics. Accordingly, undergraduate students must initially complete a program of study that stresses these basic fields of science. Chemical engineering coursework blends these four disciplines into a series of engineering fundamentals relating to how materials are produced and processed both in the laboratory and in large industrial-scale facilities. Courses such as fluid mechanics, heat and mass transfer, thermodynamics, reaction kinetics, and chemical process control are at the heart of the chemical engineering curriculum at Mines. In addition, it is becoming increasingly important for engineers to understand how biological and microscopic, molecular-level properties can influence the macroscopic behavior of materials, biological, and chemical systems. This somewhat unique focus is first introduced at Mines through the physical and organic chemistry sequences, and the theme is continued and developed within the chemical engineering curriculum via material and projects introduced in advanced courses. Our undergraduate program at Mines is exemplified by intensive integration of computer-aided simulation and computer-aided process modeling in the curriculum and by our unique approach to teaching of the unit operations laboratory sequence. The unit operations lab course is offered only in the summer as a 6-week intensive session. Here, the fundamentals of heat, mass, and momentum transfer and applied thermodynamics are reviewed in a practical, applications-oriented setting. The important skills of teamwork, critical thinking, time management, and oral and written technical communications skills are also stressed in this course.

Facilities for the study of chemical and biological engineering at the Colorado School of Mines are among the best in the nation. Specialized undergraduate laboratory facilities exist for studying polymer properties, measuring reaction kinetics, characterizing transport phenomena, and for studying several typical chemical unit operations. Our undergraduate research program is open to highly qualified students and provides our undergraduates with the opportunity to carry out independent research or to join a graduate research team. This program has been highly successful and our undergraduate chemical engineering students have won several national competitions and awards based on research conducted while pursuing their baccalaureate degrees. We also have a cooperative (Co-Op) education program in which students can earn course credit while gaining work experience in industry.

The programs leading to the degree of Bachelor of Science in Chemical Engineering and to the degree of Bachelor of Science in Chemical and Biochemical Engineering are both accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Please visit our website for contact points and more information on the degree program, including details on how to apply for the Honors Research track. https://chemeng.mines.edu

Program Educational Objectives (Bachelor of Science in Chemical Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Chemical and Biological Engineering Department at CSM has established 3 program educational objectives for all of its graduates. Our graduates within 3 to 5 years of completing their degree will:

- be in graduate school or in the workforce utilizing their education in chemical engineering fundamentals
- be applying their knowledge of and skills in engineering fundamentals in conventional areas of chemical engineering and in contemporary and growing fields
- have demonstrated both their commitment to continuing to develop personally and professionally and an appreciation for the ethical and social responsibilities associated with being an engineer and a world citizen

Combined Baccalaureate/Masters Degree Program

The Chemical and Biological Engineering Department offers the opportunity to begin work on a Master of Science (with or without thesis) degree while completing the requirements of the BS degree. These combined BS/MS degrees are designed to allow undergraduates engaged in research, or simply interested in furthering their studies beyond a BS degree, to apply their experience and interest to an advanced degree. Students enrolled within the combined program may choose up to six credits of CBEN coursework at the 400-level and above (that has been successfully completed with a grade of B or above) to “double-count”; that is, to apply towards the degree requirements for both their Bachelor of Science and their Master of Science, simultaneously. The requirements for the (non-thesis) MS degree consist of the four core graduate courses (which cannot be double-counted):

CBEN507	APPLIED MATHEMATICS IN CHEMICAL ENGINEERING	3.0
or CBEN420/505	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING	
CBEN509	ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS	3.0
CBEN516	ADVANCED TRANSPORT PHENOMENA	3.0
or CBEN430/530	TRANSPORT PHENOMENA	
CBEN518	REACTION KINETICS AND CATALYSIS	3.0
or CBEN519	ADVANCED TOPICS IN HETEROGENEOUS CATALYSIS	

ELECT	Approved Electives	18.0
Total Semester Hrs		**30.0**

It is expected that a student would be able to complete both degrees in 4 1/2 to 5 years. To take advantage of the combined program, students are encouraged to engage in research and take some graduate coursework during their senior year. The application process and requirements are identical to our normal MS degree programs. Applications may be completed online and require 3 letters of recommendation and a statement of purpose. For students who intend to begin the BS/MS program in Fall, applications are due by July 1st. The deadline is November 1st for students intending to enroll in the Spring semester. Students must have a GPA greater than 3.0 to be considered for the program. Interested students are encouraged to get more information from their advisor and/or the current faculty member in charge of Graduate Affairs.

Curriculum

The Chemical Engineering curriculum is structured according to the goals outlined above. Accordingly, the programs of study are organized to include 3 semesters of science and general engineering fundamentals followed by 5 semesters of chemical engineering fundamentals and applications.

A. Chemical Engineering Fundamentals

The following courses represent the basic knowledge component of the Chemical Engineering curriculum at Mines.

CBEN201	MATERIAL AND ENERGY BALANCES	3.0
CBEN307	FLUID MECHANICS	3.0
CBEN314	CHEMICAL ENGINEERING HEAT AND MASS TRANSFER	4.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS	3.0
CBEN375	CHEMICAL ENGINEERING SEPARATIONS	3.0

B. Chemical Engineering Applications

The following courses are applications-oriented courses that build on the student's basic knowledge of science and engineering fundamentals:

CBEN312	UNIT OPERATIONS LABORATORY	3.0
CBEN313	UNIT OPERATIONS LABORATORY	3.0
CBEN402	CHEMICAL ENGINEERING DESIGN	3.0
CBEN403	PROCESS DYNAMICS AND CONTROL	3.0
CBEN414	CHEMICAL PROCESS SAFETY	1.0
CBEN418	KINETICS AND REACTION ENGINEERING	3.0

Technical Electives for Chemical Engineering

C. Electives for Chemical Engineering

Chemical Engineering majors have elective credit requirements that may be fulfilled with several different courses. Technical Electives I and II are any upper division (300 level or higher) in any engineering or science designation. Humanities and Economics courses do not fulfill this requirement with the exception of EBGN321. CBEN electives are courses offered by the CBE department with engineering content, one of the two required classes must be at the 400 level. Lastly one CBEN/CHGN elective is required at the 300 level or higher. Some or all of these electives may be grouped together to earn a specialty track in chemical engineering as described below.

D. Specialty Tracks in Chemical Engineering

NOTE: Below is a suggested curriculum path. Electives may be taken any time they fit into your schedule, but note that not all courses are offered all semesters. Please refer to https://chemeng.mines.edu/undergraduate-program/ for the most updated flowsheet.

Degree Requirements (Chemical Engineering)

Freshman

Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
EDNS151	DESIGN I			3.0
HASS100	NATURE AND HUMAN VALUES			4.0
				16.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CBEN210	INTRO TO THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN200	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING			3.0
CBEN201	MATERIAL AND ENERGY BALANCES			3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0

PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
CBEN307	FLUID MECHANICS			3.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
HASS200	GLOBAL STUDIES			3.0
CBEN358	CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY			1.0
TECH	TECH ELECTIVE			3.0
				17.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN314	CHEMICAL ENGINEERING HEAT AND MASS TRANSFER			4.0
CBEN375	CHEMICAL ENGINEERING SEPARATIONS			3.0
CBEN403	PROCESS DYNAMICS AND CONTROL			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE	3.0		3.0
TECH	TECH ELECTIVE			3.0
				16.0

Summer		**lec**	**lab**	**sem.hrs**
CBEN312	UNIT OPERATIONS LABORATORY			3.0
CBEN313	UNIT OPERATIONS LABORATORY			3.0
				6.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
CBEN402	CHEMICAL ENGINEERING DESIGN			3.0
CBEN414	CHEMICAL PROCESS SAFETY			1.0
CBEN418	KINETICS AND REACTION ENGINEERING			3.0
CBEN ELECT	CHEMICAL ENGINEERING ELECTIVE			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE			3.0
				16.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN ELECT	400-LEVEL CHEMICAL ENGINEERING ELECTIVE			3.0
CHGN/CBEN ELECT	CHGN or CBEN Elective (300 or higher)*			3.0
FREE	FREE ELECTIVE			3.0
FREE	FREE ELECTIVE			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL RESTRICTED ELECTIVE			3.0
				15.0

Total Semester Hrs: 134.5

TECH Electives

Technical Electives are any upper division (300 level or higher) in any engineering or science designation. Humanities and Economics courses do not fulfill this requirement with the exception of EBGN321.

CBEN Electives

6 hours are required with 3 hours being at the 400-level.

CBEN250	INTRODUCTION TO CHEMICAL ENGINEERING ANALYSIS AND DESIGN	3.0
CBEN310	INTRODUCTION TO BIOMEDICAL ENGINEERING	3.0
CBEN315	INTRODUCTION TO ELECTROCHEMICAL ENGINEERING	3.0
CBEN340	COOPERATIVE EDUCATION	1-3
CBEN350	HONORS UNDERGRADUATE RESEARCH	1-3
CBEN360	BIOPROCESS ENGINEERING	3.0
CBEN365	INTRODUCTION TO CHEMICAL ENGINEERING PRACTICE	3.0
CBEN398	SPECIAL TOPICS	1-6
CBEN399	INDEPENDENT STUDY	1-6
CBEN401	PROCESS OPTIMIZATION	3.0
CBEN408	NATURAL GAS PROCESSING	3.0
CBEN409	PETROLEUM PROCESSES	3.0
CBEN413	QUANTITATIVE HUMAN BIOLOGY	3.0
CBEN415	POLYMER SCIENCE AND TECHNOLOGY	3.0
CBEN416	POLYMER ENGINEERING AND TECHNOLOGY	3.0
CBEN420	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING	3.0
CBEN422	CHEMICAL ENGINEERING FLOW ASSURANCE	3.0
CBEN426	ADVANCED FUNCTIONAL POROUS MATERIALS	3.0
CBEN432	TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS	3.0
CBEN435	INTERDISCIPLINARY MICROELECTRONICS	3.0
CBEN440	MOLECULAR PERSPECTIVES IN CHEMICAL ENGINEERING	3.0
CBEN469	FUEL CELL SCIENCE AND TECHNOLOGY	3.0
CBEN470	INTRODUCTION TO MICROFLUIDICS	3.0
CBEN472	INTRODUCTION TO ENERGY TECHNOLOGIES	3.0
CBEN480	NATURAL GAS HYDRATES	3.0
CBEN450	HONORS UNDERGRADUATE RESEARCH	1-3
CBEN498	SPECIAL TOPICS	1-6
CBEN499	INDEPENDENT STUDY	1-6

Degree Requirements (Biological Engineering Track)

Freshman

Fall		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
EDNS151	DESIGN I			3.0
HASS100	NATURE AND HUMAN VALUES			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		lec	lab	sem.hrs
CBEN210	INTRO TO THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
CBEN200	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING			3.0
CBEN201	MATERIAL AND ENERGY BALANCES			3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		lec	lab	sem.hrs
CBEN307	FLUID MECHANICS			3.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS			3.0
HASS200	GLOBAL STUDIES			3.0
CBEN358	CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY			1.0
CHGN428	BIOCHEMISTRY			3.0
FREE	FREE ELECTIVE			3.0
				16.0

Spring		lec	lab	sem.hrs
CBEN375	CHEMICAL ENGINEERING SEPARATIONS			3.0
CBEN314	CHEMICAL ENGINEERING HEAT AND MASS TRANSFER			4.0
CBEN403	PROCESS DYNAMICS AND CONTROL			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE	3.0		3.0
CBEN360	BIOPROCESS ENGINEERING			3.0
				16.0

Summer		lec	lab	sem.hrs
CBEN312	UNIT OPERATIONS LABORATORY			3.0
CBEN313	UNIT OPERATIONS LABORATORY			3.0
				6.0

Senior

Fall		lec	lab	sem.hrs
CBEN402	CHEMICAL ENGINEERING DESIGN			3.0
CBEN418	KINETICS AND REACTION ENGINEERING			3.0
CBEN414	CHEMICAL PROCESS SAFETY			1.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE II			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I			4.0
BIO TECH ELECT	BIO TECH ELECTIVE			3.0
				17.0

Spring		lec	lab	sem.hrs
BIO TECH ELECT	BIO TECH ELECTIVE			3.0
FREE	FREE ELECTIVE			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL RESTRICTED ELECTIVE			3.0
FREE	FREE ELECTIVE			3.0

CBEN ELECT	400-LEVEL CHEMICAL ENGINEERING ELECTIVE	3.0
		15.0

Total Semester Hrs: 134.5

* The CHGN/CBEN elective course may be any CBEN or CHGN course at the 300-or higher level.

TECH Electives

Technical Electives are any upper division (300 level or higher) in any engineering or science designation. Humanities and Economics courses do not fulfill this requirement with the exception of EBGN321.

Biological Tech Electives

Six elective credits are required.

CHGN429	BIOCHEMISTRY II	3.0
CHGN441	THE CHEMISTRY AND BIOCHEMISTRY OF PHARMACEUTICALS	3.0
CHGN462	MICROBIOLOGY	3.0
CBEN310	INTRODUCTION TO BIOMEDICAL ENGINEERING	3.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	INTRO TO GENETICS	4.0
CBEN324	INTRODUCTION TO BREWING SCIENCE	3.0
CBEN412	INTRODUCTION TO PHARMACOLOGY	3.0
CBEN413	QUANTITATIVE HUMAN BIOLOGY	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0
CBEN432	TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS	3.0
CBEN454	APPLIED BIOINFORMATICS	3.0
PHGN433	BIOPHYSICS	3.0

400-Level CBEN Electives

CBEN401	PROCESS OPTIMIZATION	3.0
CBEN408	NATURAL GAS PROCESSING	3.0
CBEN409	PETROLEUM PROCESSES	3.0
CBEN415	POLYMER SCIENCE AND TECHNOLOGY	3.0
CBEN416	POLYMER ENGINEERING AND TECHNOLOGY	3.0
CBEN420	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING	3.0
CBEN432	TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS	3.0
CBEN435	INTERDISCIPLINARY MICROELECTRONICS	3.0
CBEN440	MOLECULAR PERSPECTIVES IN CHEMICAL ENGINEERING	3.0
CBEN469	FUEL CELL SCIENCE AND TECHNOLOGY	3.0
CBEN470	INTRODUCTION TO MICROFLUIDICS	3.0
CBEN472	INTRODUCTION TO ENERGY TECHNOLOGIES	3.0
CBEN480	NATURAL GAS HYDRATES	3.0
CBEN450	HONORS UNDERGRADUATE RESEARCH	1-3
CBEN498	SPECIAL TOPICS	1-6
CBEN499	INDEPENDENT STUDY	1-6

Degree Requirements (Process Engineering Track)

Freshman

Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
EDNS151	DESIGN I			3.0
HASS100	NATURE AND HUMAN VALUES			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CBEN210	INTRO TO THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN200	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING			3.0
CBEN201	MATERIAL AND ENERGY BALANCES			3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior				
Fall		**lec**	**lab**	**sem.hrs**
CBEN307	FLUID MECHANICS			3.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
HASS200	GLOBAL STUDIES			3.0
CBEN358	CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY			1.0
CBEN365	INTRODUCTION TO CHEMICAL ENGINEERING PRACTICE			3.0
				17.0
Spring		**lec**	**lab**	**sem.hrs**
CBEN314	CHEMICAL ENGINEERING HEAT AND MASS TRANSFER			4.0
CBEN375	CHEMICAL ENGINEERING SEPARATIONS			3.0
CBEN403	PROCESS DYNAMICS AND CONTROL			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE	3.0		3.0
PROCESS TECH	PROCESS TECH ELECTIVE			3.0
				16.0
Summer		**lec**	**lab**	**sem.hrs**
CBEN312	UNIT OPERATIONS LABORATORY			3.0
CBEN313	UNIT OPERATIONS LABORATORY			3.0
				6.0
Senior				
Fall		**lec**	**lab**	**sem.hrs**
CBEN402	CHEMICAL ENGINEERING DESIGN			3.0
CBEN418	KINETICS AND REACTION ENGINEERING			3.0
CBEN414	CHEMICAL PROCESS SAFETY			1.0
FREE	FREE ELECTIVE			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE	3.0		3.0
EBGN321	ENGINEERING ECONOMICS			3.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
PROCESS ELECT	400-LEVEL PROCESS TECH ELECTIVE			3.0
CHGN/CBEN ELECT	CHGN or CBEN Elective (300 or higher)*			3.0
FREE	FREE ELECTIVE			3.0
FREE	FREE ELECTIVE			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL RESTRICTED ELECTIVE			3.0
				15.0

Total Semester Hrs: 134.5

* The CHGN/CBEN elective course may be any CBEN or CHGN course at the 300-or higher level.

TECH Electives

Technical Electives are any upper division (300 level or higher) in any engineering or science designation. Humanities and Economics courses do not fulfill this requirement.

Process Electives

Students are required to take 6 hours of the follow courses. 3 hours must be a 400-level CBEN course.

CBEN401	PROCESS OPTIMIZATION	3.0
CBEN408	NATURAL GAS PROCESSING	3.0
CBEN409	PETROLEUM PROCESSES	3.0
CBEN472	INTRODUCTION TO ENERGY TECHNOLOGIES	3.0
CBEN480	NATURAL GAS HYDRATES	3.0
EBGN553	PROJECT MANAGEMENT	3.0

Degree Requirements (Chemical Engineering Honors Research Track)

Registration into the Honors Research Track will be by application only. Applications will be due in the spring semester. The track is designed to fit sophomore-level applicants, though it can also be completed by junior-level students, especially if some research work has already been completed. In addition to the 12 hours of coursework, the following three requirements must be met to earn the Honors Research Track. Please see the CBE website for additional details.

1) Public dissemination of research work

2) Submission and acceptance of a written undergraduate thesis

3) Complete CBE degree with overall GPA greater than or equal to 3.5

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
EDNS151	DESIGN I			3.0
HASS100	NATURE AND HUMAN VALUES			4.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CBEN210	INTRO TO THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN200	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING			3.0
CBEN201	MATERIAL AND ENERGY BALANCES			3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
CBEN307	FLUID MECHANICS			3.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
HASS200	GLOBAL STUDIES			3.0
CBEN358	CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY			1.0
CBEN368	INTRODUCTION TO UNDERGRADUATE RESEARCH			1.0
CBEN350	HONORS UNDERGRADUATE RESEARCH, 351, 450, or 451			2.0
				17.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN314	CHEMICAL ENGINEERING HEAT AND MASS TRANSFER			4.0
CBEN375	CHEMICAL ENGINEERING SEPARATIONS			3.0
CBEN403	PROCESS DYNAMICS AND CONTROL			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE	3.0		3.0
CBEN351	HONORS UNDERGRADUATE RESEARCH, 350, 450, or 451			3.0
				16.0

Summer		**lec**	**lab**	**sem.hrs**
CBEN312	UNIT OPERATIONS LABORATORY			3.0
CBEN313	UNIT OPERATIONS LABORATORY			3.0
				6.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
CBEN402	CHEMICAL ENGINEERING DESIGN			3.0
CBEN414	CHEMICAL PROCESS SAFETY			1.0
CBEN418	KINETICS AND REACTION ENGINEERING			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE			3.0
CBEN430	TRANSPORT PHENOMENA			3.0
				16.0

Spring		**lec**	**lab**	**sem.hrs**
TECH	TECH ELECTIVE*			3.0
CBEN ELECT	500-LEVEL CHEMICAL ENGINEERING ELECTIVE			3.0
FREE	FREE ELECTIVE			3.0
FREE	FREE ELECTIVE			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL RESTRICTED ELECTIVE			3.0
				15.0

Total Semester Hrs: 134.5

TECH Electives

Technical Electives are any upper division (300 level or higher) in any engineering or science designation. Humanities and Economics courses do not fulfill this requirement with the exception of EBGN321.

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- CBEN100 through CBEN599 inclusive

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Biomedical Engineering Minor

To obtain a Biomedical Engineering (BME) minor, students must take at least 18 credits related to Biomedical Engineering. Two courses (8 credits) of biology are required. Two restricted requirements include Intro to Biomedical Engineering (required) and at least 3 credits of engineering electives related to BME. Two more courses (or at least 4 credits) may be chosen from the engineering and/or additional electives. The lists of electives will be modified as new related courses that fall into these categories become available.

REQUIRED courses (11 credits):

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
CBEN310	INTRODUCTION TO BIOMEDICAL ENGINEERING	3.0

Plus at least 3 credits of engineering electives:

CBEN35x/45x/x98/x99	HONORS UNDERGRADUATE RESEARCH, SPECIAL TOPICS, INDEPENDENT STUDY *	1-4
CBEN360	BIOPROCESS ENGINEERING	3.0
CBEN413	QUANTITATIVE HUMAN BIOLOGY	3.0
CBEN432	TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS	3.0
CBEN470	INTRODUCTION TO MICROFLUIDICS	3.0
CBEN555	POLYMER AND COMPLEX FLUIDS COLLOQUIUM	1.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
MEGN435	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0
or MEGN535	MODELING AND SIMULATION OF HUMAN MOVEMENT	
MEGN436	COMPUTATIONAL BIOMECHANICS	3.0
or MEGN536	COMPUTATIONAL BIOMECHANICS	
MTGN472	BIOMATERIALS I	3.0
MEGN531	PROSTHETIC AND IMPLANT ENGINEERING	3.0
MEGN532	EXPERIMENTAL METHODS IN BIOMECHANICS	3.0
MEGN537	PROBABILISTIC BIOMECHANICS	3.0

Plus at least 4 more credits from the list above and/or the list below:

Additional elective courses related to BME:

CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN305	ANATOMY AND PHYSIOLOGY LAB	1.0
CBEN306	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN	3.0
CBEN309	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN LABORATORY	1.0
CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	INTRO TO GENETICS	4.0
CBEN322	BIOLOGICAL PSYCHOLOGY	3.0
CBEN35x/45x/x98/x99	HONORS UNDERGRADUATE RESEARCH, SPECIAL TOPICS, INDEPENDENT STUDY	1-4
CBEN411	NEUROSCIENCE, MEMORY, AND LEARNING (NEUROSCIENCE, MEMORY, AND LEARNING)	3.0
CBEN412	INTRODUCTION TO PHARMACOLOGY (INTRODUCTION TO PHARMACOLOGY)	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0
or CBEN531	IMMUNOLOGY FOR SCIENTISTS AND ENGINEERS	
CBEN454	APPLIED BIOINFORMATICS	3.0
or CBEN554	APPLIED BIOINFORMATICS	
CHGN428	BIOCHEMISTRY	3.0
CHGN429	BIOCHEMISTRY II	3.0
CHGN441	THE CHEMISTRY AND BIOCHEMISTRY OF PHARMACEUTICALS	3.0
CHGN462	MICROBIOLOGY	3.0
MTGN472	BIOMATERIALS I	3.0
or MTGN572	BIOMATERIALS	
PHGN433	BIOPHYSICS	3.0

*As the content of these courses varies, the course must be noted as relevant to the BME minor to count toward the minor, and noted as having sufficient engineering content to count as an engineering elective course as the engineering electives.

Courses

CBEN110. FUNDAMENTALS OF BIOLOGY I. 4.0 Semester Hrs.
Equivalent with BIOL110,
(I, II) Fundamentals of Biology with Laboratory I. This course will emphasize the fundamental concepts of biology and use illustrative examples and laboratory investigations that highlight the interface of biology with engineering. The focus will be on (1) the scientific method; (2) structural, molecular, and energetic basis of cellular activities; (3) mechanisms of storage and transfer of genetic information in biological organisms; (4) a laboratory 'toolbox' that will carry them forward in their laboratory-based courses. This core course in biology will be interdisciplinary in nature and will incorporate the major themes and mission of this school - earth, energy, and the environment. Lecture Hours: 3; Lab Hours: 3; Semester Hours: 4.

CBEN120. FUNDAMENTALS OF BIOLOGY II. 4.0 Semester Hrs.
Equivalent with CBEN323,
This is the continuation of Fundamentals of Biology I. Emphasis in the second semester is placed on an examination of organisms as the products of evolution and the diversity of life forms. Special attention will be given to how form fits function in animals and plants and the potential for biomimetic applications. Prerequisite: CBEN110. Fundamentals of Biology I or equivalent. 3 hours lecture; 3 hours laboratory; 4 semester hours.

CBEN198. SPECIAL TOPICS. 6.0 Semester Hrs.
Topical courses in chemical engineering of special interest. Prerequisite: none; 1 to 6 semester hours. Repeatable for credit under different titles.

CBEN199. INDEPENDENT STUDY. 1-6 Semester Hr.
Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: submission of ?Independent Study? form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

CBEN200. COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING. 3.0 Semester Hrs.
(II) Fundamentals of mathematical methods and computer programming as applied to the solution of chemical engineering problems. Introduction to computational methods and algorithm development and implementation. Prerequisite: MATH112. Co-requisite: CBEN210. 3 hours lecture; 3 semester hours.

CBEN201. MATERIAL AND ENERGY BALANCES. 3.0 Semester Hrs.
Equivalent with CHEN201,
(II) Introduction to the formulation and solution of material and energy balances on chemical processes. Establishes the engineering approach to problem solving, the relations between known and unknown process variables, and appropriate computational methods. Prerequisites: CHGN122. Co-requisites: CBEN210, CBEN200, MATH213, MATH225. 3 hours lecture; 3 semester hours.

CBEN202. CHEMICAL PROCESS PRINCIPLES LABORATORY. 1.0 Semester Hr.
(II) Laboratory measurements dealing with the first and second laws of thermodynamics, calculation and analysis of experimental results, professional report writing. Introduction to computer-aided process simulation. Corequisites: CBEN210, CBEN201, MATH225, EDNS251. 3 hours lab; 1 semester hour.

CBEN210. INTRO TO THERMODYNAMICS. 3.0 Semester Hrs.
(I, II) Introduction to the fundamental principles of classical engineering thermodynamics. Application of mass and energy balances to closed and open systems including systems undergoing transient processes. Entropy generation and the second law of thermodynamics for closed and open systems. Introduction to phase equilibrium and chemical reaction equilibria. Ideal solution behavior. May not also receive credit for CHGN209, MEGN361, or GEGN330. Prerequisites: CHGN121, CHGN122, MATH111. Co-requisites: MATH112, PHGN100. 3 hours lecture; 3 semester hours.

CBEN250. INTRODUCTION TO CHEMICAL ENGINEERING ANALYSIS AND DESIGN. 3.0 Semester Hrs.
Introduction to chemical process industries and how analysis and design concepts guide the development of new processes and products. Use of simple mathematical models to describe the performance of common process building blocks including pumps, heat exchangers, chemical reactors, and separators. Prerequisites: Concurrent enrollment in CBEN210. 3 hours lecture; 3 semester hours.

CBEN298. SPECIAL TOPICS. 1-6 Semester Hr.
Topical courses in chemical engineering of special interest. Prerequisite: none; 1 to 6 semester hours. Repeatable for credit under different titles.

CBEN299. INDEPENDENT STUDY. 1-6 Semester Hr.
Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: submission of ?Independent Study? form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

CBEN304. ANATOMY AND PHYSIOLOGY. 3.0 Semester Hrs.
Equivalent with CBEN404,
This course will cover the basics of human anatomy and physiology of the cardiovascular system and blood, the immune system, the respiratory system, the digestive system, the endocrine system, the urinary system and the reproductive system. We will discuss the gross and microscopic anatomy and the physiology of these major systems. Where possible, we will integrate discussions of disease processes and introduce biomedical engineering concepts and problems. Check with department for semester(s) offered. 3 hours lecture; 3 semester hours. Prerequisite: General Biology I.

CBEN305. ANATOMY AND PHYSIOLOGY LAB. 1.0 Semester Hr.
Equivalent with CBEN405,
In this course we explore the basic concepts of human anatomy and physiology using simulations of the physiology and a virtual human dissector program. These are supplemented as needed with animations, pictures and movies of cadaver dissection to provide the student with a practical experience discovering principles and structures associated with the anatomy and physiology. Co-requisite: CBEN404.

CBEN306. ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN. 3.0 Semester Hrs.
Equivalent with CBEN406,
This course will cover the basics of human anatomy and physiology of the tissues, skeletal system, muscular system, central nervous system and peripheral nervous system. We will discuss the gross and microscopic anatomy and the physiology of these major systems. Where possible, we will integrate discussions of disease processes and introduce biomedical engineering concepts and problems. Prerequisite: General Biology I.

CBEN307. FLUID MECHANICS. 3.0 Semester Hrs.
(I) This course covers theory and application of momentum transfer and fluid flow. Fundamentals of microscopic phenomena and application to macroscopic systems are addressed. Course work also includes computational fluid dynamics. Prerequisites: MATH225, grade of C- or better in CBEN201. 3 hours lecture; 3 semester hours.

CBEN308. HEAT TRANSFER. 3.0 Semester Hrs.
(II) This course covers theory and applications of energy transfer: conduction, convection, and radiation. Fundamentals of microscopic phenomena and their application to macroscopic systems are addressed. Course work also includes application of relevant numerical methods to solve heat transfer problems. Prerequisites: MATH225, grade of C- or better in CBEN307. 3 hours lecture; 3 semester hours.

CBEN309. ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN LABORATORY. 1.0 Semester Hr.
Equivalent with CBEN407,
In this course we explore the basic concepts of human anatomy and physiology of the tissue types, skeletal system, muscular system, and nervous system using anatomical models and medical tissue microscope slides. These are supplemented as needed with pictures, chalk talks, handouts, ultrasound for muscle and skeleton, and EEG recording of brain waves to provide the student with a practical experience discovering principles and structures associated with the anatomy and physiology and to reinforce the material from the lecture course. Prerequisite: General Biology 1 [BIOL110]. Co-requisite: must either have taken or currently taking Anatomy and Physiology BMB [CBEN406].

CBEN310. INTRODUCTION TO BIOMEDICAL ENGINEERING. 3.0 Semester Hrs.
Introduction to the field of Biomedical Engineering including biomolecular, cellular, and physiological principles, and areas of specialty including biomolecular engineering, biomaterials, biomechanics, bioinstrumentation and bioimaging. Prerequisite: CBEN110, CBEN210 or CHGN209 or MEGN361.

CBEN311. INTRODUCTION TO NEUROSCIENCE. 3.0 Semester Hrs.
This course is the general overview of brain anatomy, physiology, and function. It includes perception, motor, language, behavior, and executive function. This course will review what happens with injury and abnormalities of thought. It will discuss the overview of brain development throughout one's lifespan. Prerequisite: CBEN110, CHGN121, CHGN122, PHGN100, PHGN200.

CBEN312. UNIT OPERATIONS LABORATORY. 3.0 Semester Hrs.
(S) Unit Operations Laboratory. This course covers principles of mass, energy, and momentum transport as applied to laboratory-scale processing equipment. Written and oral communications skills, teamwork, and critical thinking are emphasized. 9 hours lab; 3 semester hours. Prerequisite: CBEN201, CBEN202 OR CBEN200, CBEN307, CBEN308 OR CBEN314, CBEN357, CBEN375.

CBEN313. UNIT OPERATIONS LABORATORY. 3.0 Semester Hrs.
(S) Unit Operations Laboratory. This course covers principles of mass, energy, and momentum transport as applied to laboratory-scale processing equipment. Written and oral communications skills, teamwork, and critical thinking are emphasized. 9 hours lab; 3 semester hours. Prerequisite: CBEN201, CBEN202 OR CBEN200, CBEN307, CBEN308 OR CBEN314, CBEN357, CBEN375.

CBEN314. CHEMICAL ENGINEERING HEAT AND MASS TRANSFER. 4.0 Semester Hrs.
(II) This course covers theory and applications of energy transfer: conduction, convection, and radiation and mass transfer: diffusion and convection. Fundamentals of microscopic phenomena and their application to macroscopic systems are addressed. Course work also includes application of relevant numerical methods to solve heat and mass transfer problems. 4 hours lecture; 4 semester hours. Prerequisite: MATH225, CBEN 200, grade of C- or better in CBEN307.

CBEN315. INTRODUCTION TO ELECTROCHEMICAL ENGINEERING. 3.0 Semester Hrs.
(II) Introduction to the field of Electrochemical Engineering including basic electrochemical principles, electrode kinetics, ionic conduction, as applied to common devices such as fuel cells, electrolyzers, redox flow cells and batteries. Prerequisites: CBEN210. 3 hours lecture; 3 semester hours.

CBEN320. CELL BIOLOGY AND PHYSIOLOGY. 3.0 Semester Hrs.
Equivalent with CBEN410,
An introduction to the morphological, biochemical, and biophysical properties of cells and their significance in the life processes. Prerequisite: General Biology I or equivalent.

CBEN321. INTRO TO GENETICS. 4.0 Semester Hrs.
(II) A study of the mechanisms by which biological information is encoded, stored, and transmitted, including Mendelian genetics, molecular genetics, chromosome structure and rearrangement, cytogenetics, and population genetics. Prerequisite: General biology I or equivalent. 3 hours lecture, 3 hours laboratory; 4 semester hours.

CBEN322. BIOLOGICAL PSYCHOLOGY. 3.0 Semester Hrs.
This course relates the hard sciences of the brain and neuroscience to the psychology of human behavior. It covers such topics as decision making, learning, the brain's anatomy and physiology, psychopathology, addiction, the senses, sexuality, and brainwashing. It addresses the topics covered on the psychology section of the MCAT examination. Prerequisite: CBEN110, CHGN122, PHGN200.

CBEN323. GENERAL BIOLOGY II LABORATORY. 1.0 Semester Hr.
Equivalent with CBEN120,
(I, II) This Course provides students with laboratory exercises that complement lectures given in CBEN303, the second semester introductory course in Biology. Emphasis is placed on an examination of organisms as the products of evolution. The diversity of life forms will be explored. Special attention will be given to the vertebrate body (organs, tissues and systems) and how it functions. Co-requisite or Prerequisite: CBEN303 or equivalent. 3 hours laboratory; 1 semester hour.

CBEN324. INTRODUCTION TO BREWING SCIENCE. 3.0 Semester Hrs.
(II) Introduction to the field of Brewing Science including an overview of ingredients and the brewing process, the biochemistry of brewing, commercial brewing, quality control, and the economics of the brewing industry. Students will malt grain, brew their own beer, and analyze with modern analytical equipment. Prerequisites: CBEN110; Student must be at least 21 years of age at beginning of semester. 2 hours lecture; 3 hours lab; 3 semester hours.

CBEN325. MCAT REVIEW. 3.0 Semester Hrs.
(II) The MCAT Review course is specifically for preparation of the Medical College Admissions Test [MCAT]. It will look at test taking skills, the information required to study for the MCAT, and will go over in detail the psychology information and the critical analysis and reading skills sections of the exam as well as doing practice exams. Prerequisites: CBEN110, PHGN200, CHGN222. Co-requisites: CBEN120. 3 hours lecture; 3 semester hours.

CBEN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.
Cooperative work/education experience involving employment of a chemical engineering nature in an internship spanning at least one academic semester. Prerequisite: none. 1 to 3 semester hours. Repeatable to a maximum of 6 hours.

CBEN350. HONORS UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
Scholarly research of an independent nature. Prerequisite: Junior standing. 1 to 3 semester hours.

CBEN351. HONORS UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
Scholarly research of an independent nature. Prerequisite: junior standing. 1 to 3 semester hours.

CBEN357. CHEMICAL ENGINEERING THERMODYNAMICS. 3.0 Semester Hrs.
(I) Introduction to non-ideal behavior in thermodynamic systems and their applications. Phase and reaction equilibria are emphasized. Relevant aspects of computer-aided process simulation are incorporated. Prerequisites: CBEN210 (or equivalent), MATH225, grade of C- or better in CBEN201. 3 hours lecture; 3 semester hours.

CBEN358. CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY. 1.0 Semester Hr.
(I) This course includes hands-on laboratory measurements of physical data from experiments based on the principles of chemical engineering thermodynamics. Methods and concepts explored include calculation and analysis of physical properties, phase equilibria, and reaction equilibria and the application of these concepts in chemical engineering. Prerequisites: CBEN200 and CBEN210. 3 hours lab; 1 semester hour.

CBEN360. BIOPROCESS ENGINEERING. 3.0 Semester Hrs.
The analysis and design of microbial reactions and biochemical unit operations, including processes used in conjunction with bioreactors, are investigated in this course. Industrial enzyme technologies are developed and explored. A strong focus is given to the basic processes for producing fermentation products and biofuels. Biochemical systems for organic oxidation and fermentation and inorganic oxidation and reduction are presented. Computer-aided process simulation is incorporated. Prerequisites: CHGN428, CBEN201, CBEN358. 2 hours lecture; 3 hours lab; 3 semester hours.

CBEN365. INTRODUCTION TO CHEMICAL ENGINEERING PRACTICE. 3.0 Semester Hrs.
(I) Builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving approached in an integrated teamwork environment, and initial technical content specific to the Chemical Engineering degree program to solve a range of chemical process engineering problems. Technical content necessary for process analysis and design activity is presented. This course emphasizes steady-state design in areas such as fuels, food sciences, chemicals, and pharmaceuticals, wherein creative and critical thinking skills are necessary. Projects may involve computer-based optimization to obtain a solution. Prerequisites: EDNS151 or EDNS155, CBEN 200, CBEN201. 3 hours lecture; 3 semester hours.

CBEN368. INTRODUCTION TO UNDERGRADUATE RESEARCH. 1.0 Semester Hr.
Introduction to Undergraduate Research. This course introduces research methods and provides a survey of the various fields in which CBE faculty conduct research. Topics such as how to conduct literature searches, critically reading and analyzing research articles, ethics, lab safety, and how to write papers are addressed. Prerequisite: None.

CBEN375. CHEMICAL ENGINEERING SEPARATIONS. 3.0 Semester Hrs.
(II) This course covers fundamentals of stage-wise and diffusional mass transport with applications to chemical engineering systems and processes. Relevant aspects of computer-aided process simulation and computational methods are incorporated. Prerequisites: grade of C- or better in CBEN357. 3 hours lecture; 3 semester hours.

CBEN398. SPECIAL TOPICS. 1-6 Semester Hr.
Topical courses in chemical engineering of special interest. Prerequisite: none; 1 to 6 semester hours. Repeatable for credit under different titles.

CBEN399. INDEPENDENT STUDY. 1-6 Semester Hr.
Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: submission of ?Independent Study? form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

CBEN401. PROCESS OPTIMIZATION. 3.0 Semester Hrs.
This course introduces skills and knowledge required to develop conceptual designs of new processes and tools to analyze troubleshoot, and optimize existing processes. Prerequisite: CBEN201, CBEN308 or CBEN314, CBEN307, CBEN357, CBEN375, CBEN402.

CBEN402. CHEMICAL ENGINEERING DESIGN. 3.0 Semester Hrs.
(I) This course covers simulation, synthesis, analysis, evaluation, as well as costing and economic evaluation of chemical processes. Computer-aided process simulation to plant and process design is applied. Prerequisite: CBEN307, (CBEN308 or CBEN 314), CBEN357, CBEN358, CBEN375. Co-requisite: CBEN418. 3 hours lecture; 3 semester hours.

CBEN403. PROCESS DYNAMICS AND CONTROL. 3.0 Semester Hrs.
(II) Mathematical modeling and analysis of transient systems. Applications of control theory to response of dynamic chemical engineering systems and processes. Co-requisites: CBEN314 or CBEN308, CBEN375. Prerequisites: CBEN201, CBEN307, MATH225. 3 hours lecture; 3 semester hours.

CBEN408. NATURAL GAS PROCESSING. 3.0 Semester Hrs.
Application of chemical engineering principles to the processing of natural gas. Emphasis on using thermodynamics and mass transfer operations to analyze existing plants. Relevant aspects of computer-aided process simulation. Prerequisite: CHGN221, CBEN308 or CBEN314, CBEN375.

CBEN409. PETROLEUM PROCESSES. 3.0 Semester Hrs.
(I) Application of chemical engineering principles to petroleum refining. Thermodynamics and reaction engineering of complex hydro carbon systems. Relevant aspects of computer-aided process simulation for complex mixtures. 3 hours lecture; 3 semester hours. Prerequisite: CHGN221, CBEN375.

CBEN411. NEUROSCIENCE, MEMORY, AND LEARNING. 3.0 Semester Hrs.
Equivalent with CBEN511,
(II) This course relates the hard sciences of the brain and neuroscience to memory encoding and current learning theories. Prerequisites: CBEN110, CBEN120, CHGN221, CHGN222, PHGN100, PHGN200. 3 hours lecture, 3 semester hours.

CBEN412. INTRODUCTION TO PHARMACOLOGY. 3.0 Semester Hrs.
(II) This course introduces the concepts of pharmacokinetics and biopharmaceuticals. It will discuss the delivery systems for pharmaceuticals and how they change with disease states. It will cover the modeling of drug delivery, absorption, excretion, and accumulation. The course will cover the different modeling systems for drug delivery and transport. Prerequisites: CBEN110, CBEN120, CHGN121, CHGN122. 3 hours lecture; 3 semester hours.

CBEN413. QUANTITATIVE HUMAN BIOLOGY. 3.0 Semester Hrs.
This course examines the bioelectric implications of the brain, heart, and muscles from a biomedical engineering view point. The course covers human brain, heart, and muscle anatomy as well as the devices currently in use to overcome abnormalities in function. Prerequisite: CBEN 110, CBEN 120.

CBEN414. CHEMICAL PROCESS SAFETY. 1.0 Semester Hr.
(I) This course considers all aspects of chemical process safety and loss prevention. Students are trained for the identification of potential hazards and hazardous conditions associated with the processes and equipment involved in the chemical process industries, and methods of predicting the possible severity of these hazards and presenting, controlling or mitigating them. Quantitative engineering analysis training delivered by each of the CHEN core courses is applied: applications of mass and energy balances, fluid mechanics of liquid, gas, and two-phase flows, heat transfer, the conservation of energy, mass transfer, diffusion and dispersion under highly variable conditions, reaction kinetics, process control, and statistical analysis. Prerequisite: CBEN375. Corequisite: CBEN418. 1 hour lecture; 1 semester hour.

CBEN415. POLYMER SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.
Equivalent with CHGN430,MLGN530,
Chemistry and thermodynamics of polymers and polymer solutions. Reaction engineering of polymerization. Characterization techniques based on solution properties. Materials science of polymers in varying physical states. Processing operations for polymeric materials and use in separations. Prerequisite: CHGN221, MATH225, CBEN357. 3 hours lecture; 3 semester hours.

CBEN416. POLYMER ENGINEERING AND TECHNOLOGY. 3.0 Semester Hrs.
Polymer fluid mechanics, polymer rheological response, and polymer shape forming. Definition and measure ment of material properties. Interrelationships between response functions and correlation of data and material response. Theoretical approaches for prediction of polymer properties. Processing operations for polymeric materials; melt and flow instabilities. Prerequisite: CBEN307, MATH225. 3 hours lecture; 3 semester hours.

CBEN418. KINETICS AND REACTION ENGINEERING. 3.0 Semester Hrs.
This course emphasizes applications of the fundamentals of thermodynamics, physical chemistry, organic chemistry, and material and energy balances to the engineering of reactive processes. Key topics include reactor design, acquisition and analysis of rate data, and heterogeneous catalysis. Computational methods as related to reactor and reaction modeling are incorporated. Prerequisite: CBEN308 or CBEN314, CBEN357, MATH225, CHGN221. Co-requisite: CHGN351.

CBEN420. MATHEMATICAL METHODS IN CHEMICAL ENGINEERING. 3.0 Semester Hrs.
Formulation and solution of chemical engineering problems using numerical solution methods within the Excel and MathCAD environments. Setup and numerical solution of ordinary and partial differential equations for typical chemical engineering systems and transport processes. Prerequisite: MATH225, CHGN209 or CBEN210, CBEN307, CBEN357. 3 hours lecture; 3 semester hours.

CBEN422. CHEMICAL ENGINEERING FLOW ASSURANCE. 3.0 Semester Hrs.
(II) Chemical Engineering Flow Assurance will include the principles of the application of thermodynamics and mesocopic and microscopic tools that can be applied to the production of oil field fluids, including mitigation strategies for solids, including gas hydrates, waxes, and asphaltenes. Prerequisite: CBEN357. 3 hours lecture; 3 semester hours.

CBEN426. ADVANCED FUNCTIONAL POROUS MATERIALS. 3.0 Semester Hrs.
Nanomaterials synthesis, hierarchically ordered porous materials, functional applications, catalysis, separations, adsorption Prerequisite: CHGN122. Co-requisite: CHGN351.

CBEN430. TRANSPORT PHENOMENA. 3.0 Semester Hrs.
(I) This course covers theory and applications of momentum, energy, and mass transfer based on microscopic control volumes. Analytical and numerical solution methods are employed in this course. 3 hours lecture; 3 semester hours. Prerequisite: CBEN307, CBEN308 or CBEN314, CBEN357, CBEN375, MATH225.

CBEN431. IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS. 3.0 Semester Hrs.
This course introduces the basic concepts of immunology and their applications in engineering and science. We will discuss the molecular, biochemical and cellular aspects of the immune system including structure and function of the innate and acquired immune systems. Building on this, we will discuss the immune response to infectious agents and the material science of introduced implants and materials such as heart valves, artificial joints, organ transplants and lenses. We will also discuss the role of the immune system in cancer, allergies, immune deficiencies, vaccination and other applications such as immunoassay and flow cytometry. Prerequisite: CBEN110.

CBEN432. TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS. 3.0 Semester Hrs.
The goal of this course is to develop and analyze models of biological transport and reaction processes. We will apply the principles of mass, momentum, and energy conservation to describe mechanisms of physiology and pathology. We will explore the applications of transport phenomena in the design of drug delivery systems, engineered tissues, and biomedical diagnostics with an emphasis on the barriers to molecular transport in cardiovascular disease and cancer. Prerequisite: CBEN307.

CBEN435. INTERDISCIPLINARY MICROELECTRONICS. 3.0 Semester Hrs.
Equivalent with MLGN535,PHGN435,PHGN535,
(II) Application of science and engineering principles to the design, fabrication, and testing of microelectronic devices. Emphasis on specific unit operations and the interrelation among processing steps. Prerequisites: Senior standing in PHGN, CBEN, MTGN, or EGGN. Due to lab, space the enrollment is limited to 20 students. 1.5 hours lecture, 4 hours lab; 3 semester hours.

CBEN440. MOLECULAR PERSPECTIVES IN CHEMICAL ENGINEERING. 3.0 Semester Hrs.
Applications of statistical and quantum mechanics to understanding and prediction of equilibrium and transport properties and processes. Relations between microscopic properties of materials and systems to macroscopic behavior. 3 hours lecture; 3 semester hours. Prerequisite: CBEN307, CBEN308 or CBEN314, CBEN357, CBEN375, CHGN351 and CHGN353, CHGN221 and CHGN222, MATH225.

CBEN450. HONORS UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
Scholarly research of an independent nature. Prerequisite: senior standing. 1 to 3 semester hours.

CBEN451. HONORS UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
Scholarly research of an independent nature. Prerequisite: senior standing. 1 to 3 semester hours.

CBEN454. APPLIED BIOINFORMATICS. 3.0 Semester Hrs.
(II) In this course we will discuss the concepts and tools of bioinformatics. The molecular biology of genomics and proteomics will be presented and the techniques for collecting, storing, retrieving and processing such data will be discussed. Topics include analyzing DNA, RNA and protein sequences, gene recognition, gene expression, protein structure prediction, modeling evolution, utilizing BLAST and other online tools for the exploration of genome, proteome and other available databases. In parallel, there will be an introduction to the PERL programming language. Practical applications to biological research and disease will be presented and students given opportunities to use the tools discussed. Prerequisites: General Biology [BIOL110]. 3 hour lecture; 3 semester hours.

CBEN460. BIOCHEMICAL PROCESS ENGINEERING. 3.0 Semester Hrs.
(I) The analysis and design of microbial reactions and biochemical unit operations, including processes used in conjunction with bioreactors, are investigated in this course. Industrial enzyme technologies are developed and explored. A strong focus is given to the basic processes for producing fermentation products and biofuels. Biochemical systems for organic oxidation and fermentation and inorganic oxidation and reduction are presented. Prerequisites: CBEN375, CHGN428, CHGN462. 3 hours lecture; 3 semester hours.

CBEN461. BIOCHEMICAL PROCESS ENGINEERING LABORATORY. 1.0 Semester Hr.
(I) This course emphasizes bio-based product preparation, laboratory measurement, and calculation and analysis of bioprocesses including fermentation and bio-solids separations and their application to biochemical engineering. Computer-aided process simulation is incorporated. Prerequisites: CBEN375, CHGN428, CHGN462. Co-requisite: CBEN460, 3 hours laboratory, 1 semester hour.

CBEN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.
Equivalent with MEGN469,MTGN469,
(I) Investigate fundamentals of fuel-cell operation and electrochemistry from a chemical-thermodynamics and materials-science perspective. Review types of fuel cells, fuel-processing requirements and approaches, and fuel-cell system integration. Examine current topics in fuel-cell science and technology. Fabricate and test operational fuel cells in the Colorado Fuel Cell Center. Prerequisites: MEGN361 or CBEN357 or MTGN351. 3 hours lecture; 3 semester hours.

CBEN470. INTRODUCTION TO MICROFLUIDICS. 3.0 Semester Hrs.
This course introduces the basic principles and applications of microfluidic systems. Concepts related to microscale fluid mechanics, transport, physics, and biology are presented. To gain familiarity with small-scale systems, students are provided with the opportunity to design, fabricate, and test a simple microfluidic device. Prerequisites: CBEN307 or MEGN351. 3 hours lecture; 3 semester hours.

CBEN472. INTRODUCTION TO ENERGY TECHNOLOGIES. 3.0 Semester Hrs.
(II) In this course the student will gain an understanding about energy technologies including how they work, how they are quantitatively evaluated, what they cost, and what is their benefit or impact on the natural environment. There will be discussions about proposed energy systems and how they might become a part of the existing infrastructure. However, to truly understand the impact of proposed energy systems, the student must also have a grasp on the infrastructure of existing energy systems. Prerequisites: CBEN357 Chemical Engineering Thermodynamics (or equivalent). 3 lecture hours, 3 credit hours.

CBEN480. NATURAL GAS HYDRATES. 3.0 Semester Hrs.
The purpose of this class is to learn about clathrate hydrates, using two of the instructor's books, (1) Clathrate Hydrates of Natural Gases, Third Edition (2008) co-authored by C.A.Koh, and (2) Hydrate Engineering, (2000). Using a basis of these books, and accompanying programs, we have abundant resources to act as professionals who are always learning. 3 hours lecture; 3 semester hours.

CBEN498. SPECIAL TOPICS. 1-6 Semester Hr.
Topical courses in chemical engineering of special interest. Prerequisite: none; 1 to 6 semester hours. Repeatable for credit under different titles.

CBEN499. INDEPENDENT STUDY. 1-6 Semester Hr.
Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: none, submission of ?Independent Study? form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

Professors

Sumit Agarwal

Moises A. Carreon

Anuj Chauhan, Department Head

Andrew M. Herring

Carolyn A. Koh, William K. Coors Distinguished Chair of Chemical and Biological Engineering

David W. M. Marr, Gaylord & Phyllis Weaver Distinguished Professor, Chemical and Biological Engineering

Amadeu Sum

Colin A. Wolden

David Wu

Associate Professors

Melissa D. Krebs

Ning Wu

Assistant Professors

Nanette R. Boyle

Kevin J. Cash

Nikki Farnsworth

Diego A. Gómez-Gualdrón

Stephanie Kwon

Alexander Pak

Joseph R. Samaniuk

Teaching Professors

Jason C. Ganley

Tracy Q. Gardner

Teaching Associate Professors

Michael D.M. Barankin

Rachel M. Morrish, Assistant Department Head

Cynthia L. Norrgran

C. Joshua Ramey

Justin Shaffer

Professor of Practice

John L. Jechura

Professors Emeriti

Robert M. Baldwin

Annette L. Bunge

Anthony M. Dean

James F. Ely, University Professor Emeritus

J. Thomas McKinnon

Ronald L. Miller

E. Dendy Sloan, Jr., University Professor Emeritus

Charles Vestal

J. Douglas Way

Victor F. Yesavage

Civil and Environmental Engineering

Program Description

The Department of Civil & Environmental Engineering (CEE) offers design-oriented and student-centered undergraduate programs in Civil Engineering and Environmental Engineering. The degrees build upon fundamental engineering principles and provide specialization within Civil and Environmental Engineering. Graduates are positioned for a broad range of professional opportunities, and are well-prepared for an engineering career in a world of rapid technological change.

The Civil Engineering degree offers breadth in several Civil Engineering fields: Construction Engineering, Engineering Surveying, Environmental Engineering, Geotechnical Engineering, Structural Engineering, and Water Resources. Civil students can elect to further specialize in one or more of these areas by selecting related courses to fulfill their Civil Engineering Technical Electives.

The Environmental Engineering degree introduces students to the fundamentals of environmental engineering including the scientific and regulatory basis of public health and environmental protection. The degree is designed to prepare students to investigate and analyze environmental systems and assess risks to public health and ecosystems as well as evaluate and design natural and engineered solutions to mitigate risks and enable beneficial outcomes. Topics covered include water reclamation and reuse, hazardous waste management, contaminated site remediation, environmental science, water and wastewater treatment, and regulatory processes.

The programs leading to the degree Bachelor of Science in Civil Engineering and to the degree Bachelor of Science in Environmental Engineering are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

The department also offers two minors and two ASIs. Majors are encouraged to use free elective courses to gain knowledge in another discipline and incorporate either an Area of Special Interest (ASI) or a minor. This adds to the flexibility of the program and qualifies students for a wide variety of careers.

Program Educational Objectives

The Civil Engineering and Environmental Engineering programs contribute to the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria. Program Educational Objectives (PEOs) of these programs are as follows:

Within three years of attaining the Bachelor of Science in Civil Engineering, graduates will be situated in growing careers or will be successfully pursuing a graduate degree in Civil Engineering or a related field; advancing in their professional standing, generating new knowledge and/or exercising leadership in the field; and contributing to the needs of society through professional practice, research, and/or service.

Within three years of attaining the Bachelor of Science in Environmental Engineering, graduates will be situated in careers or will be successfully pursuing a graduate degree in Environmental Engineering or a related field; advancing in their professional standing, generating new knowledge and/or exercising leadership in their field; and contributing to the needs of society through professional practice, research, and/or service.

Curriculum

During the first two years at Colorado School of Mines, students complete a set of core courses that includes mathematics, basic sciences, and engineering sciences. Course work in mathematics gives engineering students tools for modeling, analyzing, and predicting physical and chemical phenomena. The basic sciences of physics and chemistry provide an appropriate foundation in the physical sciences; engineering science then builds upon these basic sciences and focuses on applications.

The core curriculum also includes an introduction to engineering design principles and practices. These courses emphasize design methodology and stress the creative and synthesis aspects of the engineering profession. The core curriculum also includes complementary courses in the humanities and social sciences which explore the links between the environment, human society, and engineering.

In the final two years, students complete discipline-specific advanced engineering courses. Civil Engineering students explore soil mechanics, structural theory, design of foundations, design of steel or concrete structures, and Civil Engineering technical electives. Environmental Engineering students explore water chemistry and water quality, air pollution, the fate and transport of chemicals in the environment (air, water, and soil), water resources, environmental policy, and Environmental Engineering technical electives. At the student's discretion, free electives (9 credits) can be used to either satisfy his/her personal interest in a topic or the credits can be used to pursue an "area of special interest" (12 semester hours) or a minor (at least 18 semester hours). All students complete a capstone engineering design course that is focused on an in-depth, realistic, and multi-disciplinary engineering project.

Students interested in a research experience, in addition to their undergraduate curriculum, are encouraged to work on an Independent Study project with one of the Civil & Environmental Engineering faculty. These projects can offer an applied experience that is relevant to future graduate studies and a professional career.

Bachelor of Science in Civil Engineering Degree Requirements:

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS or CBEN 110			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Spring		lec	lab	sem.hrs
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
EDNS151	DESIGN I			3.0
				16.0

Sophomore

Fall		lec	lab	sem.hrs
CEEN210	INTRODUCTION TO CIVIL INFRASTRUCTURE			1.5
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
CEEN241	STATICS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
HASS200	GLOBAL STUDIES			3.0
				16.5

Spring		lec	lab	sem.hrs
CEEN310	FLUID MECHANICS FOR CIVIL AND ENVIRONMENTAL ENGINEERING			3.0
CEEN267	DESIGN II: CIVIL ENGINEERING, EDNS 262, EDNS 261, or EDNS 251			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS			3.0
CSCI260	FORTRAN PROGRAMMING, 261, or MATH 307			2.0
CEEN3XX	Special Topics* Civil and Environmental Engineering Tools - contact department for information			1.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Summer		lec	lab	sem.hrs
CEEN331	ENGINEERING FIELD SESSION, CIVIL			3.0
				3.0

Junior

Fall		lec	lab	sem.hrs
CEEN350	CIVIL AND CONSTRUCTION ENGINEERING MATERIALS			3.0
CEEN314	STRUCTURAL THEORY			3.0
CEEN312	SOIL MECHANICS			3.0
CEEN312L	SOIL MECHANICS LABORATORY			1.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
				16.0

Spring		lec	lab	sem.hrs
CE BREADTH	Civil Engineering Breadth Elective*			3.0
CE BREADTH	Civil Engineering Breadth Elective*			3.0
CEEN415	FOUNDATION ENGINEERING			3.0
STR ELECT	Structural Design Elective**			3.0
MEGN315	DYNAMICS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
				18.0

Senior

Fall		lec	lab	sem.hrs
EDNS491	SENIOR DESIGN I			3.0
CE ELECT	Civil Engineering Technical Elective***			3.0
CE ELECT	Civil Engineering Technical Elective***			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
FREE	Free Elective			3.0
FREE	Free Elective			3.0
				18.0

Spring		lec	lab	sem.hrs
EDNS492	SENIOR DESIGN II			3.0
CE ELECT	Civil Engineering Technical Elective***			3.0
CE ELECT	Civil Engineering Technical Elective***			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective			3.0
FREE	Free Elective			3.0
				15.0

Total Semester Hrs: 135.5

*** *Civil Engineering Breadth Electives*** - Students must take a minimum of two courses from this list. These courses may count as Civil Engineering Technical Electives or Free Electives if not used to meet this requirement.

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER
CEEN360	INTRODUCTION TO CONSTRUCTION ENGINEERING
CEEN381	HYDROLOGY AND WATER RESOURCES ENGINEERING

***** Structural Design Elective*** - Students must take a minimum of one course from this list. These courses may count as Civil Engineering Technical Electives or Free Electives if not used to meet this requirement.

CEEN443	DESIGN OF STEEL STRUCTURES
CEEN445	DESIGN OF REINFORCED CONCRETE STRUCTURES

****** Civil Engineering Technical Electives*** - Students must take a minimum of four courses from this list. These courses may also count as Free Electives if not used to meet this requirement.

2 Electives must come from a CEEN Prefix:

CEEN302	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: AIR AND WASTE MANAGEMENT
CEEN303	ENVIRONMENTAL ENGINEERING LABORATORY
CEEN401	LIFE CYCLE ASSESSMENT
CEEN402	PROJECT ENGINEERING
CEEN405	NUMERICAL METHODS FOR ENGINEERS
CEEN406	FINITE ELEMENT METHODS FOR ENGINEERS
CEEN410	ADVANCED SOIL MECHANICS
CEEN411	UNSATURATED SOIL MECHANICS
CEEN421	HIGHWAY AND TRAFFIC ENGINEERING
CEEN423	SURVEYING FOR ENGINEERS AND INFRASTRUCTURE DESIGN PRACTICES
CEEN430	ADVANCED STRUCTURAL ANALYSIS
CEEN433	MATRIX STRUCTURAL ANALYSIS
CEEN441	INTRODUCTION TO THE SEISMIC DESIGN OF STRUCTURES
CEEN446	STRUCTURAL LOADS
CEEN460	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT
CEEN461	FUNDAMENTALS OF ECOLOGY
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES
CEEN471	WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN
CEEN472	ONSITE WATER RECLAMATION AND REUSE
CEEN475	SITE REMEDIATION ENGINEERING
CEEN477	SUSTAINABLE ENGINEERING DESIGN
CEEN479	AIR POLLUTION
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT
CEEN482	HYDROLOGY AND WATER RESOURCES LABORATORY
CEEN492	ENVIRONMENTAL LAW
EBGN321	ENGINEERING ECONOMICS
GEGN466	GROUNDWATER ENGINEERING
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION
MEGN416	ENGINEERING VIBRATION
MNGN321	INTRODUCTION TO ROCK MECHANICS
MNGN404	TUNNELING
MNGN405	ROCK MECHANICS IN MINING
MNGN406	DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

CEEN100 through CEEN499 inclusive

Bachelor of Science in Environmental Engineering Degree Requirements:

Freshman

Fall		**lec**	**lab**	**sem.hrs**
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Spring		**lec**	**lab**	**sem.hrs**
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
EDNS151	DESIGN I			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
CEEN241	STATICS			3.0
CSCI260	FORTRAN PROGRAMMING, 261, or MATH 307			2.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0

PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0
Spring		**lec**	**lab**	**sem.hrs**
MATH225	DIFFERENTIAL EQUATIONS			3.0
CEEN310	FLUID MECHANICS FOR CIVIL AND ENVIRONMENTAL ENGINEERING			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
EDNS251	DESIGN II, 261, 262, or CEEN 267			3.0
HASS200	GLOBAL STUDIES			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5
Junior				
Fall		**lec**	**lab**	**sem.hrs**
CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER			3.0
CEEN381	HYDROLOGY AND WATER RESOURCES ENGINEERING			3.0
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS, CBEN 210, or MEGN 361			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
BIOSCI ELECT	Bio-Science Elective*			3.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
CEEN302	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: AIR AND WASTE MANAGEMENT			3.0
CEEN303	ENVIRONMENTAL ENGINEERING LABORATORY			3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS			3.0
EVE ELECT	Environmental Engineering Elective**			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
FREE	Free Elective			3.0
				18.0
Summer		**lec**	**lab**	**sem.hrs**
CEEN330	ENGINEERING FIELD SESSION, ENVIRONMENTAL			3.0
				3.0
Senior				
Fall		**lec**	**lab**	**sem.hrs**
EDNS491	SENIOR DESIGN I			3.0
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES			3.0
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT			3.0
CEEN482	HYDROLOGY AND WATER RESOURCES LABORATORY			3.0
EVE ELECT	Environmental Engineering Elective**			3.0
FREE	Free Elective			3.0
				18.0
Spring		**lec**	**lab**	**sem.hrs**
EDNS492	SENIOR DESIGN II			3.0
EVE ELECT	Environmental Engineering Elective**			3.0
EVE ELECT	Environmental Engineering Elective**			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective			3.0
FREE	Free Elective			3.0
				15.0

Total Semester Hrs: 134.5

***Bio-science Elective Courses -** Students must take a minimum of one course from this list. If this requirement is met with BIOL110, then CEEN460, CEEN461 and CHGN462 may count as Environmental Engineering Electives or Free Electives. BIOL110 cannot count as an Environmental Engineering Elective.

CBEN110	FUNDAMENTALS OF BIOLOGY I
CEEN460	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT
CEEN461	FUNDAMENTALS OF ECOLOGY
CHGN462	MICROBIOLOGY

****Environmental Engineering Elective Courses -** Students must take a minimum of four courses from this list. These courses may count as Free Electives if not used to meet this requirement.

CEEN312	SOIL MECHANICS
CEEN405	NUMERICAL METHODS FOR ENGINEERS
CEEN401	LIFE CYCLE ASSESSMENT
CEEN402	PROJECT ENGINEERING
CEEN410	ADVANCED SOIL MECHANICS
CEEN460	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT
CEEN461	FUNDAMENTALS OF ECOLOGY
CEEN471	WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN
CEEN472	ONSITE WATER RECLAMATION AND REUSE
CEEN474	SOLID WASTE MINIMIZATION AND RECYCLING
CEEN475	SITE REMEDIATION ENGINEERING
CEEN476	POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE

CEEN477	SUSTAINABLE ENGINEERING DESIGN
CEEN479	AIR POLLUTION
CEEN492	ENVIRONMENTAL LAW
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY
CHGN462	MICROBIOLOGY
EBGN321	ENGINEERING ECONOMICS
ENGY320	INTRO TO RENEWABLE ENERGY
GEGN466	GROUNDWATER ENGINEERING
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

CEEN300 through CEEN499 inclusive

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Civil or Environmental Engineering Minor and ASI

ASI in Civil Engineering

Civil engineering is a closely related field to many majors on campus, including mechanical engineering, electrical engineering, petroleum engineering, geological engineering, and mining engineering. A background in civil engineering fundamentals bolsters students' credentials for careers in the construction industry, the mining industry, the energy sector, or public policy and service. This Area of Special Interest (ASI) has been carefully designed to introduce the fundamentals of the major subfields of civil engineering at Mines: structural engineering, geotechnical engineering, water resources and hydrology, environmental engineering, construction engineering, and surveying.

Students are encouraged to explore other courses relevant to this ASI and propose their own plan of study that would support the Area of Special Interest- Civil Engineering. For pre-approval on potential course substitutions to fulfill this ASI, please contact the Undergraduate Program Manager for Civil/Environmental Engineering.

Four courses (12.0 credit hours) are required for this ASI.

Required		**6.0**
CEEN312	SOIL MECHANICS	
CEEN314	STRUCTURAL THEORY	
Electives (See List)		6.0
Total Semester Hrs		**12.0**

Elective List: Select 2 of the following 4 courses:

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	3.0
CEEN331	ENGINEERING FIELD SESSION, CIVIL	3.0
CEEN360	INTRODUCTION TO CONSTRUCTION ENGINEERING	3.0
CEEN381	HYDROLOGY AND WATER RESOURCES ENGINEERING	3.0

Students that are majoring in Civil Engineering cannot complete this ASI. A student majoring in Environmental Engineering can complete this ASI by completing CEEN312, CEEN314, CEEN331, and CEEN360. Courses cannot be double-counted as Environmental Engineering Electives. Up to three of these courses may be double-counted towards the B.S. Environmental Engineering as Free Electives. This requirement ensures that there is sufficient distinction between the degree and the minor.

ASI in Environmental Engineering

Environmental engineering is at the forefront of solving the world's challenges related to earth, energy and environment. As such, an ability to apply environmental fundamentals to engineering practice within disciplines such as geological, mining, electrical, computational, mechanical, petroleum, and chemical processing industries as well as public policy and service bolsters students' credentials in those fields. This Area of Special Interest (ASI) has been carefully designed to introduce the fundamentals of environmental engineering at Mines: environmental science and chemistry, hydrology and water resources, water and wastewater treatment, and chemical implications, fate and transport to enable an understanding and application of these themes to practitioners across disciplines.

Students are encouraged to explore other courses relevant to this minor and propose their own plan of study that would support this Area of Special Interest (ASI). For pre-approval on potential course substitutions to fulfill this ASI, please contact the Undergraduate Program Manager for Civil/Environmental Engineering.

Four courses (12.0 credit hours) are required for this ASI.

Complete 4 of the following 5 courses:		12.0
CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	
CEEN302	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: AIR AND WASTE MANAGEMENT	
CEEN381	HYDROLOGY AND WATER RESOURCES ENGINEERING	
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES	
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT	

Students who are majoring in Environmental Engineering cannot complete this ASI. A student majoring in Civil Engineering can only earn this ASI by completing all 5 of the courses (15.0 credit hours total). Of those 5 courses, only 2 may be double-counted towards the major degree requirements. This additional requirement is necessary in order to ensure sufficient distinction between the degree and the ASI.

Minor in Structural Engineering

Structural engineering services are in high demand in virtually every engineering industry, spanning from construction to manufacturing to aerospace. This minor has been developed for students with an interest in the principles of solid mechanics that wish to learn how to design structures in practical applications. Topics covered in this minor include various methods and theories for structural analysis and design; finite element methods; design with steel, concrete, timber, and masonry; and an introduction to the seismic design of structures.

Students are encouraged to explore other courses relevant to this minor and propose their own plan of study that would support the Structural minor. For pre-approval on potential course substitutions to fulfill this minor, please contact the Undergraduate Program Manager for Civil/Environmental Engineering.

Six courses (18.0 credit hours) are required for this minor.

Required		**3.0**
CEEN314	STRUCTURAL THEORY [1]	
Electives (See List)		**15.0**
Total Semester Hrs		**18.0**

Elective List: Select 5 of the following 7 courses:

CEEN406	FINITE ELEMENT METHODS FOR ENGINEERS
CEEN430	ADVANCED STRUCTURAL ANALYSIS
CEEN433	MATRIX STRUCTURAL ANALYSIS
CEEN440	TIMBER AND MASONRY DESIGN
CEEN441	INTRODUCTION TO THE SEISMIC DESIGN OF STRUCTURES
CEEN443	DESIGN OF STEEL STRUCTURES
CEEN445	DESIGN OF REINFORCED CONCRETE STRUCTURES

In order to ensure sufficient distinction between the degree and the minor, Civil Engineering students must meet additional requirements to earn this minor. Courses that are required for the degree (CEEN314 and either CEEN443 or CEEN445) may not be double-counted towards the minor. Therefore, the remaining six courses on the list must be taken in order to earn the minor (CEEN406, CEEN430, CEEN440, CEEN443/CEEN445, CEEN441, and CEEN433). None of the six courses may be double-counted as Civil Engineering Technical Electives, but a maximum of three may be double-counted as Free Electives. The remaining courses used for the minor may not be applied to the B.S. Civil degree.

Students may also propose the substitution of other CEEN-prefixed structural engineering courses, such as 500-level graduate courses or approved Special Topics courses, at discretion of the approval of the department.

[1]The prerequisite to CEEN314, Structural Theory, is CEEN311 Mechanics of Materials. Students who have completed MEGN 312 Introduction to Solid Mechanics are encouraged to pursue a prerequisite override.

Minor in Water Sustainability

Assuring safe and sustainable water supplies is one of the world's most pressing challenges. Understanding the design and implementation of water systems and related infrastructure requires diverse knowledge within the water resources field but that knowledge also crosses into numerous engineering disciplines. Students that are pursuing careers in the mining industry, energy industry, manufacturing industry, chemical processing industry, and public policy sector can bolster their credentials with this minor. The Water Sustainability minor has been developed to expose students to the relevant subfields of water and environmental systems, including water chemistry, fluid mechanics, water resources and hydrology, fate and transport of chemicals in the environment, site remediation, and onsite water reclamation and reuse.

Students are encouraged to explore other courses relevant to this minor and propose their own plan of study that would support the Water Sustainability minor. For pre-approval on potential course substitutions to fulfill this minor, please contact the Undergraduate Program Manager for Civil/Environmental Engineering.

Six courses (18.0 credit hours) are required for this minor.

Required Courses		**12.0**
CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	
CEEN310	FLUID MECHANICS FOR CIVIL AND ENVIRONMENTAL ENGINEERING [1]	
CEEN381	HYDROLOGY AND WATER RESOURCES ENGINEERING	
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES	
Electives (See List)		**6.0**
Total Semester Hrs		**18.0**

Elective List: Select 2 of the following 6 courses:

CEEN471	WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN
CEEN472	ONSITE WATER RECLAMATION AND REUSE
CEEN475	SITE REMEDIATION ENGINEERING
CEEN477	SUSTAINABLE ENGINEERING DESIGN
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT
CEEN482	HYDROLOGY AND WATER RESOURCES LABORATORY

Civil Engineering and Environmental Engineering majors may not pursue this minor, as there is too much overlap between degree requirements and the minor. The combined (BS + MS) degree program may be a suitable option for Civil or Environmental majors that wish to focus in Sustainable Water Engineering.

[1] Students that have completed a different variation of a fluid mechanics are encouraged to pursue a course substitution request so that the completed course can be double-counted for the minor.

Courses

CEEN198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CEEN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CEEN210. INTRODUCTION TO CIVIL INFRASTRUCTURE. 1.5 Semester Hr.
(I) An introduction to civil infrastructure systems, including the analysis, design and management of infrastructure that supports human activity, including transportation (road, rail, aviation), water and wastewater, communications and power. 0.75 hours lecture; 2.25 hours lab; 1.5 semester hours.

CEEN241. STATICS. 3.0 Semester Hrs.
(I, II, S) Forces, moments, couples, equilibrium, centroids and second moments of areas, volumes and masses, hydrostatics, friction, virtual work. Applications of vector algebra to structures. Prerequisite: PHGN100 and credit or concurrent enrollment in MATH112 or MATH113. 3 hours lecture; 3 semester hours.

CEEN267. DESIGN II: CIVIL ENGINEERING. 3.0 Semester Hrs.
Equivalent with EPIC267,
Design II builds on the design processes introduced in Design I, focusing on open-ended problem solving in which students integrate teamwork and communication with the use of computer software, AutoCAD and Civil3D, as tools to solve engineering problems. Projects often include planning, due diligence, construction document preparation, and site certification processes in the context of land development projects. Prerequisite: EDNS151, EDNS155, EDNS192 or HNRS115.

CEEN298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CEEN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CEEN301. FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER. 3.0 Semester Hrs.
(I, II) This course introduces fundamentals of environmental science & engineering as applied to water resource management and environmental problem solving. Topics include environmental regulation, toxicology, material balance, applications in environmental chemistry, hydrology, water quality management, water supply and treatment, and wastewater treatment and reuse. Topical discussions will address major sources and concerns in measurement, practice and underlying theory in the field of environmental engineering. The course also includes field trips to local water and wastewater treatment facilities to integrate theory with practice. Prerequisites: CHGN122, PHGN100. 3 hours lecture; 3 semester hours.

CEEN302. FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: AIR AND WASTE MANAGEMENT. 3.0 Semester Hrs.
(I, II) Introductory level fundamentals in atmospheric systems, air pollution control, solid waste management, hazardous waste management, waste minimization, pollution prevention, role and responsibilities of public institutions and private organizations in environmental management (relative to air, solid and hazardous waste). Prerequisite: CHGN122, PHGN100 and MATH213 or consent of instructor. 3 hours lecture; 3 semester hours.

CEEN303. ENVIRONMENTAL ENGINEERING LABORATORY. 3.0 Semester Hrs.
Equivalent with ESGN355,
This course introduces the laboratory and experimental techniques used for generating and interpreting data in environmental science and engineering related to water, land, and environmental health. An emphasis is placed on quantitative chemical and microbiological analysis of water and soil samples relevant to water supply and wastewater discharge. Topics include basic water quality measurements (pH, conductivity, etc.) and quantitative analysis of chemicals by chromatographic and mass spectrometric techniques. Advanced topics include quantitative and qualitative analysis of bioreactor performance, bench testing for water treatment, and measurement and control of disinfection by-products. 1 hour lecture, 6 hours lab; 3 semester hours. Prerequisite: CEEN301 or CEEN302.

CEEN310. FLUID MECHANICS FOR CIVIL AND ENVIRONMENTAL ENGINEERING. 3.0 Semester Hrs.
(I, II) The study and application of principles of incompressible fluid mechanics. Topics include: hydrostatic forces on submerged surfaces, buoyancy, control volume analysis, conservation of mass, fluid motion, Bernoulli's equation and conservation of energy, momentum, dimensional analysis, internal flow (pipe systems), external flow (drag and lift), flow in open channels, and hydraulic jumps. The course will also introduce concepts about municipal water supply networks and storm water drainage and wastewater collection and treatment systems. May not also receive credit for PEGN251 or MEGN351. Prerequisites: PHGN100, CEEN241. 3 lecture hours, 3 semester hours.

CEEN311. MECHANICS OF MATERIALS. 3.0 Semester Hrs.
Fundamentals of stress, strain, deformation, and material properties. Mechanics of members subjected to axial, torsional, bending, and combined loads; beam deflection; static indeterminacy; Euler buckling; stress transformation and principal stresses; thermal stress, strain, and deformation; thin-walled pressure vessels; Allowable Stress Design; and stress concentrations. May not also receive credit for MEGN212. Prerequisite: CEEN241.

CEEN312. SOIL MECHANICS. 3.0 Semester Hrs.
(I, II) An introductory course covering the engineering properties of soil, soil phase relationships and classification. Principle of effective stress. Seepage through soils and flow nets. Soil compressibility, consolidation and settlement prediction. Shear strength of soils. Prerequisite: CEEN311. 3 hours lecture; 3 semester hours.

CEEN312L. SOIL MECHANICS LABORATORY. 1.0 Semester Hr.
(I, II) Introduction to laboratory testing methods in soil mechanics. Classification, permeability, compressibility, shear strength. Co-requisites: CEEN312. 3 hours lab; 1 semester hour.

CEEN314. STRUCTURAL THEORY. 3.0 Semester Hrs.
(I, II) Analysis of determinate and indeterminate structures for both forces and deflections. Influence lines, work and energy methods, moment distribution, matrix operations, computer methods. Prerequisite: CEEN311. 3 hours lecture; 3 semester hours.

CEEN315. CIVIL AND ENVIRONMENTAL ENGINEERING TOOLS. 1.5 Semester Hr.
Students in this project-based course will be introduced to and implement useful, industry standard tools from Civil and Environmental Engineering fields. Although unlimited, subjects presented may include: introduction to industry software, data analysis, materials testing, design preparation/ presentation, or hands-on exercises illustrating concepts presented in lecture. Content will be presented in modules that occur over three to five-week periods. Modules indicative of the breadth of the profession will be offered. Credit hours will be awarded based on the completion of least three modules encompassing 15 weeks. Co-requisite: CEEN310, CEEN311.

CEEN330. ENGINEERING FIELD SESSION, ENVIRONMENTAL. 3.0 Semester Hrs.
(S) The environmental module is intended to introduce students to laboratory and field analytical skills used in the analysis of an environmental engineering problem. Students will receive instruction on the measurement of water quality parameters (chemical, physical, and biological) in the laboratory and field. The student will use these skills to collect field data and analyze a given environmental engineering problem. Prerequisite: CEEN301, CEEN303. Three weeks in summer session. 9 hours lab; 3 semester hours.

CEEN331. ENGINEERING FIELD SESSION, CIVIL. 3.0 Semester Hrs.
(S) The theory and practice of modern surveying. Lectures and hands-on field work teaches horizontal, vertical, and angular measurements and computations using traditional and modern equipment. Subdivision of land and applications to civil engineering practice, GPS and astronomic observations. Prerequisite: EDNS251, ENDS261, EDNS262 or CEEN267. Three weeks (6 day weeks) in summer field session; 9 hours lab; 3 semester hours.

CEEN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I,II,S) Supervised full-time engineering-related employment in which specific educational objectives are set and achieved. The co-op differs from a typical internship in both the length and scope of responsibilities. Students must meet with the CEE Co-op Advisor prior to enrolling to determine the appropriateness of the engagement, clarify the educational objectives, set expectations, and receive written approval for their specific Co-op program. This prior approval of the CEE Co-op Advisor and completion of paperwork with the Career Center is required prior to beginning the work portion of the program. The co-op occurs during academic fall or spring semester(s) and may overlap with a summer session, with a typical length of six months total. 3.0 credit hours. This course is repeatable. Prerequisite: Second semester sophomore status or above and a cumulative grade-point average of at least 2.00.

CEEN350. CIVIL AND CONSTRUCTION ENGINEERING MATERIALS. 3.0 Semester Hrs.
This course deals with the nature and performance of civil engineering materials and evaluation of their physical and mechanical properties. This course focuses on materials used in construction and maintenance of building and infrastructure such as metals (steel and aluminum), aggregates, Portland cement, concrete, shotcrete, asphalt, wood, recycled materials, and composites. The course covers standards describing materials and tests for determining material properties and includes a lab component where students conduct tests, analyze the resulting data, and prepare technical reports. Laboratory tests include evaluation of behavior of civil engineering materials under a wide range of conditions. 2 hours lecture; 3 hours lab, 3 semester hours. Prerequisite: CEEN311.

CEEN360. INTRODUCTION TO CONSTRUCTION ENGINEERING. 3.0 Semester Hrs.
(II) Overview of the construction process for civil construction (spanning the building, transportation, and infrastructure sectors), including procurement methods and project delivery methods, codes, regulations, tests, standards, and Risk estimation and management. Construction methods and materials. Construction contracts, including drawings and specifications. Construction administration, including submittals, requests for information, change orders, special instructions, claims, disputes, arbitration, litigation, and project close-out. Project scheduling using the Critical Path Method. Construction project management. Construction safety and OSHA. Quantity takeoffs and construction estimating. Application of engineering analysis and design to construction projects. 3 hours lecture; 3 semester hours.

CEEN381. HYDROLOGY AND WATER RESOURCES ENGINEERING. 3.0 Semester Hrs.
Equivalent with CEEN481,ESGN459,
This course introduces the principles of physical hydrology and fundamentals of water resources engineering. Topics include groundwater, surface water, precipitation, infiltration, evapotranspiration, sediment transport, flood and drought analysis, lake and reservoir analysis, water-resources planning, water quality engineering, stormwater management, and engineering design problems. 3 hour lecture; 3 semester hours. Prerequisite: CEEN310.

CEEN398. SPECIAL TOPICS IN CIVIL AND ENVIRONMENTAL ENGINEERING. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CEEN399. INDEPENDENT STUDY. 1-6 Semester Hr.
Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Variable credit; 1 to 6 credit hours. Repeatable for credit. Prerequisite: Independent Study form must be completed and submitted to the Registrar.

CEEN401. LIFE CYCLE ASSESSMENT. 3.0 Semester Hrs.
Which is more sustainable: paper vs plastic, hybrid vs electric vehicles? LCA is a powerful tool used to answer these questions; LCA quantifies the environmental sustainability of a product or process. Students will learn to conduct an LCA during a semester-long project of their choosing. At the end of the course students should be able to sit for the ACLCA professional LCACP certification exam. Prerequisite: Junior standing.

CEEN402. PROJECT ENGINEERING. 3.0 Semester Hrs.
(I, II, S) Project Engineers - through their "big picture" understanding of overall project completion requirements, technical knowledge of the components that have to be coordinated & assembled, and application of people skills - get things done. This career-oriented course focuses on the roles & responsibilities, skills, and character of the Project Engineer as a problem-solver, integrator, and leader. Content, procedural, and relationship project needs essential for project execution success are identified. Practical instruction and exercises are given - formulated around industry documents and templates - on key project execution best practices such as estimating (cost, weight, etc.), scheduling, quality, earned value, constructability, risk management, and root-cause analysis. Emotional Intelligence is introduced along with identification of skills that are essential for leading projects and people to success. Management, leadership, and ethical principles and best practices are illustrated through case studies of complex, high-profile domestic and international projects. Prior to taking the course, design and analysis courses along with any project/construction management experience beneficial but not expected. Courses recommended concurrently include courses equivalent to CEEN591, CEEN594, EBGN553, and MNGN509 are advantageous but not required. 3 hours lecture; 3 semester hours. Prerequisite: CEEN360.

CEEN405. NUMERICAL METHODS FOR ENGINEERS. 3.0 Semester Hrs.
(S) Introduction to the use of numerical methods in the solution of problems encountered in engineering analysis and design, e.g. linear simultaneous equations (e.g. analysis of elastic materials, steady heat flow); roots of nonlinear equations (e.g. vibration problems, open channel flow); eigenvalue problems (e.g. natural frequencies, buckling and elastic stability); curve fitting and differentiation (e.g. interpretation of experimental data, estimation of gradients); integration (e.g. summation of pressure distributions, finite element properties, local averaging); ordinary differential equations (e.g. forced vibrations, beam bending). All course participants will receive source code consisting of a suite of numerical methods programs. Prerequisites: CSCI260 or CSCI261 or MATH307, MATH225. 3 hours lecture; 3 semester hours.

CEEN406. FINITE ELEMENT METHODS FOR ENGINEERS. 3.0 Semester Hrs.
A course combining finite element theory with practical programming experience in which the multidisciplinary nature of the finite element method as a numerical technique for solving differential equations is emphasized. Topics covered include simple structural elements, beams on elastic foundations, solid elasticity, steady state analysis and transient analysis. Some of the applications will lie in the general area of geomechanics, reflecting the research interests of the instructor. Prerequisite: CEEN311 or MEGN312 and MATH225.

CEEN410. ADVANCED SOIL MECHANICS. 3.0 Semester Hrs.
Advanced soil mechanics theories and concepts as applied to analysis and design in geotechnical engineering. Topics covered will include seepage, consolidation, shear strength and probabilistic methods. The course will have an emphasis on numerical solution techniques to geotechnical problems by finite elements and finite differences. 3 hour lectures; 3 semester hours. Fall even years. Prerequisite: CEEN312.

CEEN411. UNSATURATED SOIL MECHANICS. 3.0 Semester Hrs.
Equivalent with CEEN512,
Systematic introduction of soil mechanics under partially saturated conditions. Topics include principles of seepage under variably saturated conditions, principle of the effective stress, shear strength theory, and hydraulic and mechanical properties. When this course is cross-listed and concurrent with CEEN511, students that enroll in CEEN511 will complete additional and/or more complex assignments. Prerequisite: CEEN312.

CEEN415. FOUNDATION ENGINEERING. 3.0 Semester Hrs.
(I, II) Techniques of subsoil investigation, types of foundations and foundation problems, selection of basis for design of foundation types. Open-ended problem solving and decision making. Prerequisite: CEEN312. 3 hours lecture; 3 semester hours.

CEEN419. RISK ASSESSMENT IN GEOTECHNICAL ENGINEERING. 3.0 Semester Hrs.
Soil and rock are among the most variable of all engineering materials, and as such are highly amenable to a probabilistic treatment. Assessment of the probability of failure or inadequate performance is rapidly gaining ground on the traditional factor of safety approach as a more rational approach to design decision making and risk management. Probabilistic concepts are also closely related to system reliability and Load and Resistance Factor Design (LRFD). When probability is combined with consequences of failure, this leads to the concept of risk. This course is about the theory and application of various tools enabling risk assessment in engineering with an emphasis on geotechnical applications.

CEEN421. HIGHWAY AND TRAFFIC ENGINEERING. 3.0 Semester Hrs.
The emphasis of this class is on the multi-disciplinary nature of highway and traffic engineering and its application to the planning and design of transportation facilities. In the course of the class the students will examine design problems that will involve: geometric design, surveying, traffic operations, hydrology, hydraulics, elements of bridge design, statistics, highway safety, transportation planning, engineering ethics, soil mechanics, pavement design, economics, environmental science. 3 credit hours. Taught on demand.

CEEN423. SURVEYING FOR ENGINEERS AND INFRASTRUCTURE DESIGN PRACTICES. 3.0 Semester Hrs.
(I) Applications of civil engineering skills using the engineer's level, total station, GPS receiver, and commercial software for field data collection, design, and layout of civil infrastructure including survey control, roadways, intersections, and utilities such as water and sewer. The course includes basic road design, horizontal design, vertical design, centerline layout, slope/cross section staking, earthwork volume calculations, engineering astronomy, and preparation of plan/profile drawings. Some discussion of concepts and mathematics of applying GPS data to engineering projects and the principles of map projections (Mercator, Lambert, UTM, State Plane, etc.) and coordinate systems such as (North American Datum) NAD '27, NAD '83, and other reference networks is included. Prerequisite: CEEN331. 2 hours lecture; 8-9 field work days; 3 semester hours.

CEEN425. CEMENTITIOUS MATERIALS FOR CONSTRUCTION. 3.0 Semester Hrs.
Cementitious materials, as the most commonly used construction materials, are the main focus of this course and variety of cementitious materials including Portland and non-Portland cements, supplementary cementitious materials, concrete and sprayed concrete (shotcrete), and grouts with their needed additional constituents are covered in this course. This course provides a comprehensive treatment of engineering principles and considerations for proper design, production, placement and maintenance of high quality cementitious materials for infrastructure. In addition, cementitious materials and techniques used for ground improvement purposes are covered in this course. Prerequisite: CEEN 311.

CEEN430. ADVANCED STRUCTURAL ANALYSIS. 3.0 Semester Hrs.
(II) Introduction to advanced structural analysis concepts. Nonprismatic structures. Arches, Suspension and cable-stayed bridges. Structural optimization. Computer Methods. Structures with nonlinear materials. Internal force redistribution for statically indeterminate structures. Graduate credit requires additional homework and projects. Prerequisite: CEEN314. 3 hour lectures; 3 semester hours.

CEEN433. MATRIX STRUCTURAL ANALYSIS. 3.0 Semester Hrs.
Equivalent with CEEN533,
(II) Focused study on computer oriented methods for solving determinate and indeterminate structures such as trusses and frames. Classical stiffness based analysis method will be introduced with hands-on practice to develop customized matrix analysis program using Matlab. Commercial structural analysis programs will also be introduced during the class and practiced through class projects. When this course is cross-listed and concurrent with CEEN533, students that enroll in CEEN533 will complete additional and/or more complex assignments. Prerequisite: CEEN314. 3 lecture hours, 3 semester hours.

CEEN441. INTRODUCTION TO THE SEISMIC DESIGN OF STRUCTURES. 3.0 Semester Hrs.
(I) This course provides students with an introduction to seismic design as it relates to structures. Students will become familiar with the sources of seismic disturbances, the physics of seismic energy transmission, and the relationship between ground disturbance and the resulting forces experienced by structures. The theory and basis for existing building code provisions relating to seismic design of structures will be introduced. Building code requirements and design methodologies will be examined and applied. Prerequisites: CEEN443, or CEEN445, or CEEN440. 3 hours lecture; 3 semester hours.

CEEN442. TIMBER AND MASONRY DESIGN. 3.0 Semester Hrs.
The course develops the theory and design methods required for the use of timber and masonry as structural materials. The design of walls, beams, columns, beam-columns, shear walls, and structural systems are covered for each material. Gravity, wind, snow, and seismic loads are calculated and utilized for design. Prerequisite: CEEN311.

CEEN443. DESIGN OF STEEL STRUCTURES. 3.0 Semester Hrs.
(I, II) To learn application and use the American Institute of Steel Construction (AISC) Steel Construction Manual. Course develops an understanding of the underlying theory for the design specifications. Students learn basic steel structural member design principles to select the shape and size of a structural member. The design and analysis of tension members, compression members, flexural members, and members under combined loading is included, in addition to basic bolted and welded connection design. Prerequisite: CEEN314. 3 hours lecture; 3 semester hours.

CEEN445. DESIGN OF REINFORCED CONCRETE STRUCTURES. 3.0 Semester Hrs.
(I, II) This course provides an introduction to the materials and principles involved in the design of reinforced concrete. It will allow students to develop an understanding of the fundamental behavior of reinforced concrete under compressive, tensile, bending, and shear loadings, and gain a working knowledge of strength design theory and its application to the design of reinforced concrete beams, columns, slabs, and footings. Prerequisite: CEEN314. 3 hours lecture; 3 semester hours.

CEEN446. STRUCTURAL LOADS. 3.0 Semester Hrs.
(II) Students will be introduced to the load types and load combinations required to design structures in compliance with building code requirements. Students will learn the theory and methods to determine the magnitude and application of loads associated with structure self-weight and occupancy. Students will be introduced to the physics underlying the requirements for environmental loads and to the accepted methods used to calculate environmental loads due to wind, snow, rain, floods, and avalanches. Students will become familiar with the common approaches used to deal with tsunami loads and blast loads. Students will learn the importance of and to recognize the load paths required to transmit applied loads from the structure to the foundation. 3 hours lecture; 3 semester hours. Prerequisite: CEEN314.

CEEN460. MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT. 3.0 Semester Hrs.
(I) Essentially, this course will be an introduction to the field of environmental microbiology. Although not titled as such, we will focus on all aspects of environmental microbiology including those of engineered systems. We will be particularly considering things that pertain to life in all of its forms. Expect to engage in diverse conversations pertaining to life in any of its habitats. The class has THREE ESSENTIAL ELEMENTS. The first is the lectures and the material that I, or any of the guest speakers happen to cover. The second is the material that has been assigned in the textbook. Please read the assigned textbook sections thoroughly before coming to class. Also, at times, I will be assigning current papers to read, please read them as assigned. The third is YOUR PARTICIPATION in discussions. 3 hours lecture; 3 semester hours.

CEEN461. FUNDAMENTALS OF ECOLOGY. 3.0 Semester Hrs.
Biological and ecological principles discussed and industrial examples of their use given. Analysis of ecosystem processes, such as erosion, succession, and how these processes relate to engineering activities, including engineering design and plant operation. Criteria and performance standards analyzed for facility siting, pollution control, and mitigation of impacts. North American ecosystems analyzed. Concepts of forestry, range, and wildlife management integrated as they apply to all of the above. Three to four weekend trips will be arranged during the semester. Semester offering based on faculty availability.

CEEN470. WATER AND WASTEWATER TREATMENT PROCESSES. 3.0 Semester Hrs.
Equivalent with BELS453,EGGN453,ESGN453,
The goal of this course is to familiarize students with the unit operations and processes involved in water and wastewater treatment. This course will focus on the physical, chemical, and biological processes for water and wastewater treatment and reclamation. Treatment objectives, process theory, and practice are considered in detail. Prerequisite: CEEN301.

CEEN471. WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN. 3.0 Semester Hrs.
(II) The goal of this course is to familiarize students with the design of domestic and industrial water and wastewater treatment systems. This course will focus on the combination of physical, chemical, and biological processes and technologies to form a water or wastewater treatment system. Source water quality, treatment objectives, water reuse, multi-barrier approaches, and water and energy efficiency are considered in detail. Prerequisites: CEEN470, or CEEN570, or other water or wastewater treatment design courses (for graduate students enrolled in this course). 3 hours lecture; 3 semester hours.

CEEN472. ONSITE WATER RECLAMATION AND REUSE. 3.0 Semester Hrs.
(II). Appropriate solutions to water and sanitation in the U.S. and globally need to be effective in protecting public health and preserving water quality while also being acceptable, affordable and sustainable. Onsite and decentralized systems have the potential to achieve these goals in rural areas, peri-urban developments, and urban centers in small and large cities. Moreover they can improve water use efficiency, conserve energy and enable distributed energy generation, promote green spaces, restore surface waters and aquifers, and stimulate new green companies and jobs. A growing array of approaches, devices and technologies have evolved that include point-of-use water purification, waste source separation, conventional and advanced treatment units, localized natural treatment systems, and varied resource recovery and recycling options. This course will focus on the engineering selection, design, and implementation of onsite and decentralized systems for water reclamation and reuse. Topics to be covered include process analysis and system planning, water and waste stream attributes, water and resource conservation, confined unit and natural system treatment technologies, effluent collection and clustering, recycling and reuse options, and system management. Prerequisite: CEEN301. 3 hours lecture; 3 semester hours.

CEEN473. HYDRAULIC PROBLEMS. 3.0 Semester Hrs.
Review of fundamentals, forces on submerged surfaces, buoyancy and flotation, gravity dams, weirs, steady flow in open channels, backwater curves, hydraulic machinery, elementary hydrodynamics, hydraulic structures. Prerequisite: CEEN310.

CEEN475. SITE REMEDIATION ENGINEERING. 3.0 Semester Hrs.
This course describes the engineering principles and practices associated with the characterization and remediation of contaminated sites. Methods for site characterization and risk assessment will be highlighted while the emphasis will be on remedial action screening processes and technology principles and conceptual design. Common isolation and containment and in-situ and ex-situ treatment technology will be covered. Computerized decision-support tools will be used and case studies will be presented. Prerequisite: CHGN121.

CEEN477. SUSTAINABLE ENGINEERING DESIGN. 3.0 Semester Hrs.
(I) This course is a comprehensive introduction into concept of sustainability and sustainable development from an engineering point of view. It involves the integration of engineering and statistical analysis through a Life Cycle Assessment tool, allowing a quantitative, broad-based consideration any process or product design and their respective impacts on environment, human health and the resource base. The requirements for considering social implications are also discussed. Prerequisites: Senior or graduate standing; 3 hours lecture, 3 semester hours.

CEEN479. AIR POLLUTION. 3.0 Semester Hrs.
(II) This course familiarizes students with the basic physics, chemistry and biology of major air pollutants, related health impacts, and engineered approaches used to mitigate the effects of common air pollutants. This course is also designed to provide a solid foundation in air pollution topic areas found on the FEE or PE exam. Critical US air pollution legislation is discussed. The sources of particulate and gaseous pollutants from both stationary and mobile sources, associated key chemical reactions, and approaches for control are considered. Indoor air pollution and the Gaussian dispersion model for air pollutants are discussed. Prerequisite: CEEN302. 3 hours lecture; 3 semester hours.

CEEN480. CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT. 3.0 Semester Hrs.
Equivalent with ESGN440,
This course describes the environmental behavior of inorganic and organic chemicals in multimedia environments, including water, air, sediment and biota. Sources and characteristics of contaminants in the environment are discussed as broad categories, with some specific examples from various industries. Attention is focused on the persistence, reactivity, and partitioning behavior of contaminants in environmental media. Both steady and unsteady state multimedia environmental models are developed and applied to contaminated sites. The principles of contaminant transport in surface water, groundwater and air are also introduced. The course provides students with the conceptual basis and mathematical tools for predicting the behavior of contaminants in the environment. Prerequisite: CEEN301.

CEEN482. HYDROLOGY AND WATER RESOURCES LABORATORY. 3.0 Semester Hrs.
(I) This course introduces students to the collection, compilation, synthesis and interpretation of data for quantification of the components of the hydrologic cycle, including precipitation, evaporation, infiltration, and runoff. Students will use hydrologic variables and parameters to evaluate watershed processes and behavior. Students will also survey and apply measurement techniques necessary for watershed studies. Advanced topics include development, construction, and application of analytical models for selected problems in hydrology and water resources. Prerequisite: CEEN381. 2 hours lecture; 3 hours lab; 3 semester hours.

CEEN492. ENVIRONMENTAL LAW. 3.0 Semester Hrs.
Equivalent with CEEN592,PEGN530,
(I) Specially designed for the needs of the environmental quality engineer, scientist, planner, manager, government regulator, consultant, or advocate. Highlights include how our legal system works, environmental law fundamentals, all major US EPA/state enforcement programs, the National Environmental Policy Act, air and water pollutant laws, risk assessment and management, and toxic and hazardous substance laws (RCRA, CERCLA, TSCA, LUST, etc). Prerequisites: CEEN301 or CEEN302. 3 hours lecture; 3 semester hours.

CEEN498. SPECIAL TOPICS IN CIVIL AND ENVIRONMENTAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CEEN499. INDEPENDENT STUDY. 1-6 Semester Hr.
Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Variable credit; 1 to 6 credit hours. Repeatable for credit. Prerequisite: Independent Study form must be completed and submitted to the Registrar.

Professor and Department Head

Junko Munakata Marr

Professor and James R. Paden Distinguished Chair

Marte Gutierrez

Professor and Grewcock Distinguished Chair

Michael Mooney

Professor and AMAX Distinguished Chair

Tissa Illangasekare

Professors

Tzahi Cath

Linda Figueroa

D.V. Griffiths

Christopher Higgins

Terri Hogue

Paul C. Johnson

Amy Landis

Ning Lu

John McCray

Kamini Singha

John R. Spear

Timothy Strathmann

Associate Professors

Christopher Bellona

Shiling Pei

Jonathan O. Sharp

Assistant Professors

Reza Hedayat

Lori Tunstall

Teaching Professors

Joseph Crocker

Kristoph Kinzli

Susan Reynolds

Teaching Associate Professors

Andres Guerra

Jeffrey Holley

Hongyan Liu

Alexandra Wayllace

Teaching Assistant Professor

Chelsea Panos

University Emeritus Professor

Robert L. Siegrist

Emeriti Associate Professor

Ronald R. H. Cohen

Panos Kiousis

Emeritus Teaching Professor

Candace Sulzbach

Chemistry

Degrees Offered

Bachelor of Science in Chemistry (three tracks) certified by American Chemical Society (ACS)

- Chemistry
- Biochemistry
- Environmental Chemistry

Bachelor of Science in Biochemistry (non-ACS)

Program Description

Chemistry is the field of science associated with atoms and molecules, hence nanoscience and beyond. Overall, chemists focus their efforts to understand the behavior and properties of matter, the reactions and transformations that dictate chemical processes, and the creation of new substances. Chemistry is often considered the central science, linking the physical sciences with engineering, medicine, and life sciences. The subject of chemistry is typically organized into more focused subdisciplines, including organic chemistry, physical chemistry, inorganic chemistry, biochemistry, analytical chemistry, theoretical/computational chemistry, and materials chemistry. A degree in chemistry examines these topics to promote a fundamental understanding of the world and an application toward technological problems. Professional chemists apply their knowledge in many different areas ranging from environmental and biochemical processes to the development of new materials. They work in academic environments, high-tech start-ups, and research and development laboratories associated with practically every advanced technological field including medicine, energy, biotechnology, computing, and agriculture.

The B.S. degree program in chemistry is approved by the American Chemical Society (ACS) with a more traditional chemistry track that can be tailored to optimize preparation consistent with a student's individual career goals, offered along with specific curricular tracks emphasizing environmental chemistry or biochemistry. These degree tracks are designed to educate professionals for the varied career opportunities this central scientific discipline affords. The curricula are therefore founded in rigorous fundamental science complemented by application of these principles to the materials, energy, minerals, biochemical and/or environmental fields. For example, those aspiring to enter Ph.D. programs in chemistry or biochemistry are strongly advised to include undergraduate research among their elective hours. Others interested in industrial chemistry choose area of special interest courses, for example in chemical engineering or metallurgy. A number of students complete degrees in both chemistry and chemical engineering as an excellent preparation for industrial careers.

There is a separate B.S. degree in Biochemistry which is also offered. The B.S. degree program in biochemistry is designed to educate professionals for the varied career opportunities this scientific discipline affords. The curriculum is therefore founded in rigorous fundamental science complemented by application of these principles to the earth, environment and energy fields as the foundation for a Mines education.

Biochemistry is the field of science concerned with the chemical and physicochemical processes that occur within living organisms. It focuses on molecular genetics, protein science and metabolism. Almost all areas of the life sciences are being uncovered and developed by biochemical methodology and research. Biochemistry focuses on understanding how biological molecules give rise to the processes that occur within living cells and between cells, which in turn relates greatly to the study and understanding of tissues, organs, organism and microorganism structure and function.

A degree in biochemistry examines these topics to promote a fundamental understanding of the fusion of chemistry and biology and an application toward technological problems. Professional biochemists apply their knowledge in many different areas ranging from environmental processes to the development of new biomaterials and novel renewable energy. They work in academic environments, high-tech start-ups, and research and development laboratories associated with practically every advanced technological field including medicine, energy, biotechnology, computing, and agriculture.

The instructional and research laboratories located in Coolbaugh Hall are state-of-the-art facilities with modern instrumentation for synthesis and characterization of molecules and materials. Instrumentation includes: gas chromatographs (GC), high-performance liquid chromatographs (HPLC), inductively-coupled-plasma-atomic emission spectrometers (ICP-AES), field-flow fractionation (FFF) equipment, mass spectrometry equipment (MS, GC/MS, GC/MS/MS, PY/MS, PY/GC/MS, SFC/MS, MALDI-TOF), 400 MHz and 500 MHz nuclear magnetic resonance spectrometers (NMR), infrared spectrometers (FTIR), ultraviolet-visible (UV) spectrometers, thermogravimetric analyzers (TGA), differential scanning calorimeters (DSC), and others including equipment for microscopy, light scattering, and elemental analysis. In addition, the campus provides access to the Mines 2,144 core 23 teraflop supercomputer for computational research.

Program Educational Objectives (Bachelor of Science in Chemistry)

In addition to contributing toward achieving the educational objectives described in the Mines Graduate Profile and the ABET Accreditation Criteria, the BS curricula in chemistry are designed to:

- Impart mastery of chemistry fundamentals;
- Develop ability to apply chemistry fundamentals in solving open-ended problems;
- Impart knowledge of and ability to use modern tools of chemical analysis and synthesis;
- Develop ability to locate and use pertinent information from the chemical literature;
- Develop ability to interpret and use experimental data for chemical systems;
- Develop ability to effectively communicate in both written and oral formats;
- Prepare students for entry to and success in professional careers;
- Prepare students for entry to and success in graduate programs; and
- Prepare students for responsible contribution to society.

Curriculum

The BS chemistry curricula, in addition to the strong basis provided by the common core, contain three components: chemistry fundamentals, laboratory and communication skills, and applications courses.

Chemistry fundamentals

- Analytical chemistry - sampling, method selection, statistical data analysis, error sources, theory of operation of analytical instruments (atomic and molecular spectroscopy, mass spectrometry, nuclear magnetic resonance spectroscopy, chromatography and other

separation methods, electroanalytical methods, and thermal methods), calibration, standardization, stoichiometry of analysis, equilibrium and kinetic principles in analysis.

- Inorganic chemistry - atomic structure and periodicity, crystal lattice structure, molecular geometry and bonding (VSEPR, Lewis structures, VB and MO theory, bond energies and lengths), metals structure and properties, acid-base theories, main-group element chemistry, coordination chemistry, term symbols, ligand field theory, spectra and magnetism of complexes, organometallic chemistry, and nanomaterials chemistry and design.
- Organic chemistry - bonding and structure, structure- physical property relationships, reactivity-structure relationships, reaction mechanisms (nucleophilic and electrophilic substitution, addition, elimination, radical reactions, rearrangements, redox reactions, photochemical reactions, and metal-mediated reactions), chemical kinetics, catalysis, major classes of compounds and their reactions, and design of synthetic pathways.
- Physical chemistry - thermodynamics (energy, enthalpy, entropy, equilibrium constants, free energy, chemical potential, non-ideal systems, standard states, activity, phase rule, phase equilibria, phase diagrams), electrochemistry, kinetic theory (Maxwell-Boltzmann distribution, collision frequency, effusion, heat capacity, equipartition of energy), kinetics (microscopic reversibility, relaxation processes, mechanisms and rate laws, collision and absolute rate theories), quantum mechanics (Schroedinger equations, operators and matrix elements, particle-in-a-box, simple harmonic oscillator, rigid rotor, angular momentum, hydrogen atom, hydrogen wave functions, spin, Pauli principle, LCAO method, MO theory, bonding), spectroscopy (dipole selection rules, rotational spectra, term symbols, atomic and molecular electronic spectra, magnetic spectroscopy, Raman spectroscopy, multiphoton selection rules, lasers), statistical thermodynamics (ensembles, partition functions, Einstein crystals, Debye crystals), group theory, surface chemistry, X-ray crystallography, electron diffraction, dielectric constants, dipole moments, and elements of computational chemistry.

Laboratory and communication skills

- Analytical methods - gravimetry, titrimetry, sample dissolution, quantitative spectroscopy, GC, HPLC, GC/MS, potentiometry, NMR, AA, ICP-AES
- Synthesis techniques - batch reactor assembly, inert-atmosphere manipulations, vacuum line methods, high-temperature methods, high-pressure methods, distillation, recrystallization, extraction, sublimation, chromatographic purification, product identification
- Physical measurements - refractometry, viscometry, colligative properties, FTIR, NMR
- Information retrieval - Chemical Abstracts online searching, CA registry numbers, Beilstein, Gmelin, handbooks, organic syntheses, organic reactions, inorganic syntheses, primary sources, ACS Style Guide
- Reporting - lab notebook, experiment and research reports, technical oral reports
- Communication - scientific reviews, seminar presentations, publication of research results

Applications

- Elective courses - application of chemistry fundamentals in chemistry elective courses or courses in another discipline; e.g. chemical engineering, environmental science, materials science
- Internship - summer or semester experience in an industrial or governmental organization working on real-world problems
- Undergraduate research - open-ended problem solving in the context of a research project

Degree Requirements for Bachelor of Science in Chemistry

Degree Requirements (Chemistry Track)

Freshman

Fall		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
EDNS151	DESIGN I			3.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS or CBEN 110			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	2.0	4.0	4.5
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
HASS200	GLOBAL STUDIES			3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY		3.0	1.0

MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
CHGN336	ANALYTICAL CHEMISTRY	3.0		3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY		3.0	1.0
CHGN341	INORGANIC CHEMISTRY I	3.0		3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH		3.0	1.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2.0
CHGN428	BIOCHEMISTRY	3.0		3.0
TECH ELECT	Technical Elective*	3.0		3.0
TECH ELECT	Technical Elective*	3.0		3.0
				15.0

Summer		**lec**	**lab**	**sem.hrs**
CHGN490	CHEMISTRY FIELD SESSION		18.0	6.0
				6.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
CHGN ELECT	Chemistry Elective**			3.0
TECH ELECT	Technical Elective*	3.0		3.0
TECH ELECT	Technical Elective*	3.0		3.0
FREE	Free Elective	3.0		3.0
				15.0

Spring		**lec**	**lab**	**sem.hrs**
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective	3.0		3.0
CHGN401	INORGANIC CHEMISTRY II	3.0		3.0
CHGN ELECT	Chemistry Elective**			2.0
TECH ELECT	Technical Elective*	3.0		3.0
FREE	Free Elective	3.0		3.0
				14.0

Total Semester Hrs: 133.5

* Technical Electives are courses in any technical field. HASS, PAGN, Military Science, ROTC, McBride and the business courses of EBGN are ***not*** accepted technical electives. Examples of possible electives that will be recommended to students are:

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	3.0
CHGN411	APPLIED RADIOCHEMISTRY	3.0
CHGN430	INTRODUCTION TO POLYMER SCIENCE	3.0
CHGN462	MICROBIOLOGY	3.0
EBGN305	FINANCIAL ACCOUNTING	3.0
EBGN306	MANAGERIAL ACCOUNTING	3.0
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0
GEGN206	EARTH MATERIALS	3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH332	LINEAR ALGEBRA	3.0
MNGN210	INTRODUCTORY MINING	3.0
MTGN311	STRUCTURE OF MATERIALS	3.0
PEGN102	INTRODUCTION TO PETROLEUM INDUSTRY	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0

** Chemistry Electives are non-required courses taught within the Chemistry Department. In addition, graduate level Chemistry and Geochemistry courses taught within the Department are acceptable.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter Ph.D. programs in Chemistry or related fields are strongly advised to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495.

Degree Requirements (Environmental Chemistry Track)

Freshman

Fall		**lec**	**lab**	**sem.hrs**
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
EDNS151	DESIGN I			3.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS or CBEN 110			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0

PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0
Sophomore				
Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	2.0	4.0	4.5
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0
Spring		**lec**	**lab**	**sem.hrs**
HASS200	GLOBAL STUDIES			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY		3.0	1.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.5
Junior				
Fall		**lec**	**lab**	**sem.hrs**
CHGN336	ANALYTICAL CHEMISTRY	3.0		3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY	3.0	1.0	1.0
CHGN341	INORGANIC CHEMISTRY I	3.0		3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH	3.0	1.0	1.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
CHEV ELECT	Environmental Elective**	3.0		3.0
				18.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2.0
CHGN428	BIOCHEMISTRY	3.0		3.0
CHEV ELECT	Environmental Elective**	3.0		3.0
TECH ELECT	Technical Elective*	3.0		3.0
				15.0
Summer		**lec**	**lab**	**sem.hrs**
CHGN490	CHEMISTRY FIELD SESSION		18.0	6.0
				6.0
Senior				
Fall		**lec**	**lab**	**sem.hrs**
CHEV ELECT	Environmental Elective**	3.0		3.0
CHEV ELECT	Environmental Elective**	3.0		3.0
CHGN ELECT	Chemistry Elective**	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN410	SURFACE CHEMISTRY	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective	3.0		3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0		3.0
CHGN ELECT	Chemistry Elective**			2.0
FREE	Free Elective	3.0		3.0
				14.0

Total Semester Hrs: 133.5

* Technical Electives are courses in any technical field. HASS, PAGN, Military Science and ROTC, McBride and the business courses of EBGN are ***not*** accepted technical electives.

** Chemistry Electives are non-required courses taught within the Chemistry Department. In addition, graduate level Chemistry and Geochemistry courses taught within the Department are acceptable.

Environmental Electives are courses that are directly or indirectly related to Environmental Chemistry. Examples include environmental CEEN courses and CHGN462. Students can consult their advisors for further clarification.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter Ph.D. programs in Chemistry or related fields are strongly advised to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495.

Degree Requirements (Biochemistry Track)

Freshman

Fall		lec	lab	sem.hrs
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
EDNS151	DESIGN I			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	2.0	4.0	4.5
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
HASS200	GLOBAL STUDIES			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY		3.0	1.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.5

Junior

Fall		lec	lab	sem.hrs
TECH ELECT	Technical Elective*			4.0
CHGN336	ANALYTICAL CHEMISTRY	3.0		3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY		3.0	1.0
CHGN341	INORGANIC CHEMISTRY I	3.0		3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	4.0	4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH		3.0	1.0
				16.0

Spring		lec	lab	sem.hrs
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2.0
CHGN428	BIOCHEMISTRY	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
CBEN120	FUNDAMENTALS OF BIOLOGY II			4.0
				16.0

Summer		lec	lab	sem.hrs
CHGN490	CHEMISTRY FIELD SESSION		18.0	6.0
				6.0

Senior

Fall		lec	lab	sem.hrs
CHGN429	BIOCHEMISTRY II	3.0		3.0
CHGN ELECT	Chemistry Elective**			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
TECH ELECT	Technical Elective*	3.0		3.0
FREE	Free Elective	3.0		3.0
				15.0

Spring		lec	lab	sem.hrs
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective	3.0		3.0
CHGN401	INORGANIC CHEMISTRY II	3.0		3.0
CHGN ELECT	Chemistry Elective**			2.0
FREE	Free Elective	3.0		3.0

FREE	Free Elective	3.0	3.0
			14.0

Total Semester Hrs: 132.5

* Technical Electives are courses in any technical field. HASS, PAGN, Military Science and ROTC, McBride and the business courses of EBGN are ***not*** accepted technical electives. * Possible technical electives that will be recommended to students are:

CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0
CHGN462	MICROBIOLOGY	3.0
CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	INTRO TO GENETICS	4.0

** Chemistry Electives are non-required courses taught within the Chemistry Department. In addition, graduate level Chemistry and Geochemistry courses taught within the Department are acceptable.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter Ph.D. programs in Chemistry or related fields are strongly advised to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495.

Degree Requirements for Bachelor of Science in Biochemistry

Freshman

Fall		**lec**	**lab**	**sem.hrs**
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
EDNS151	DESIGN I			3.0
PAGN Elective	Physical Activity Course			0.5
				16.0
Spring		**lec**	**lab**	**sem.hrs**
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
PAGN Elective	Physical Activity Course			0.5
				17.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I			3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY			1.0
PAGN Elective	Physical Activity Course			0.5
				16.0
Spring		**lec**	**lab**	**sem.hrs**
MATH225	DIFFERENTIAL EQUATIONS			3.0
CHGN335	INSTRUMENTAL ANALYSIS			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
CHGN222	ORGANIC CHEMISTRY II			3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY			1.0
HASS200	GLOBAL STUDIES			3.0
PAGN Elective	Physical Activity Course			0.5
				16.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
CHGN428	BIOCHEMISTRY			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I			4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH			1.0
CHGN336	ANALYTICAL CHEMISTRY			3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY			1.0
TECH ELECT	Technical Elective			4.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN429	BIOCHEMISTRY II			3.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY			2.0
CHGN4XX	Biochemistry laboratory		1.0	1.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective I			3.0
CBEN120	FUNDAMENTALS OF BIOLOGY II			4.0
				13.0
Summer		**lec**	**lab**	**sem.hrs**
CHGN490	CHEMISTRY FIELD SESSION			6.0
				6.0

Senior				
Fall		**lec**	**lab**	**sem.hrs**
CHGN341	INORGANIC CHEMISTRY I			3.0
CHGN ELECT	Chemistry Elective			3.0
TECH ELECT	Technical Elective			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective II			3.0
FREE ELECT	Free Elective			3.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN ELECT	Chemistry Elective			3.0
CHGN ELECT	Chemistry Elective			3.0
HASS/EBGN				3.0
FREE Elect	Free Elective			3.0
FREE ELECT	Free Elective			3.0
				15.0

Total Semester Hrs: 130.5

CHGN Electives:

CHGN462	MICROBIOLOGY	3.0
CHGN4XX	Chemical Biology	3.0
CHGN311	INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY	3.0
CHGN4XX	Chemistry and Biochemistry of Pharmaceuticals	3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0
CHGN495	UNDERGRADUATE RESEARCH	1-5

Tech Electives:

CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN305	ANATOMY AND PHYSIOLOGY LAB	1.0
CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	INTRO TO GENETICS	4.0
CBEN322	BIOLOGICAL PSYCHOLOGY	3.0
CBEN411	NEUROSCIENCE, MEMORY, AND LEARNING	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- CHGC100 through CHGC599 inclusive
- CHGN100 through CHGN599 inclusive

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Chemistry Minor and ASI Programs

No specific course sequences are suggested for students wishing to include chemistry minors or areas of special interest in their programs. Rather, those students should consult with the Chemistry department head (or designated faculty member) to design appropriate sequences. For the purpose of completing a minor in Chemistry, the Organic Chemistry sequence is exempt from the 100-200 level limit.

ASI programs include Chemistry, Polymer Chemistry, Environmental Chemistry, and Biochemistry. Refer to the main ASI section of the Bulletin for applicable rules for Areas of Special Interest (p. 33).

Courses

CHGN111. INTRODUCTORY CHEMISTRY. 3.0 Semester Hrs.
(S) Introductory college chemistry. Elementary atomic structure and the periodic chart, chemical bonding, chemical reactions and stoichiometry of chemical reactions, chemical equilibrium, thermochemistry, and properties of gases. Must not be used for elective credit. Does not apply toward undergraduate degree or g.p.a. 3 hours lecture and 3 hours lab; 3 semester hours.

CHGN121. PRINCIPLES OF CHEMISTRY I. 4.0 Semester Hrs.
Study of matter and energy based on atomic structure, correlation of properties of elements with position in periodic chart, chemical bonding, geometry of molecules, phase changes, stoichiometry, solution chemistry, gas laws, and thermochemistry. 3 hours lecture, 3 hours lab; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-SC1.

CHGN122. PRINCIPLES OF CHEMISTRY II (SC1). 4.0 Semester Hrs.
(I, II, S) Continuation of CHGN121 concentrating on chemical kinetics, gas laws, thermodynamics, electrochemistry and chemical equilibrium (acid- base, solubility, complexation, and redox). Laboratory experiments emphasizing quantitative chemical measurements. Prerequisite: Grade of C- or better in CHGN121. 3 hours lecture; 3 hours lab, 4 semester hours.

CHGN125. MOLECULAR ENGINEERING & MATERIALS CHEMISTRY. 4.0 Semester Hrs.
(I,II) Studies of the interactions of matter and energy in chemical reactions and physical processes. Building on principles from CHGN121, the course systematically explores the relationships between processes, structures and properties, starting from the atomic and molecular level. It provides a framework to apply knowledge of chemical bonding and material properties to engineering design, with an emphasis on the Engineering Grand Challenges and the discovery of new process-structure-property relationships. There is a strong focus on the underlying principles of kinetics and equilibrium, and their general applicability, strongly rooted in the first and second law of thermodynamics. Examples of these principles come primarily from solid-state systems. Laboratory experiments emphasize conceptual understanding of structure-property relationships through both hands-on and computational analysis, reinforced by quantitative chemical measurements. Prerequisite: Grade of C- or better in CHGN121. 3 hours lecture; 3 hours lab; 4 semester hours.

CHGN198. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CHGN209. INTRODUCTION TO CHEMICAL THERMODYNAMICS. 3.0 Semester Hrs.
(I, II, S) Introduction to the fundamental principles of classical thermodynamics, with particular emphasis on chemical and phase equilibria. Volume-temperature-pressure relationships for solids, liquids, and gases; ideal and non-ideal gases. Introduction to kineticmolecular theory of ideal gases and the Maxwell-Boltzmann distributions. Work, heat, and application of the First Law to closed systems, including chemical reactions. Entropy and the Second and Third Laws; Gibbs Free Energy. Chemical equilibrium and the equilibrium constant; introduction to activities & fugacities. One- and two-component phase diagrams; Gibbs Phase Rule. May not also receive credit for CBEN210 or GEGN330. Prerequisites: CHGN121, CHGN122 or CHGN125, MATH111, MATH112, PHGN100. 3 hours lecture; 3 semester hours.

CHGN221. ORGANIC CHEMISTRY I. 3.0 Semester Hrs.
(I,S) Structure, properties, and reactions of the important classes of organic compounds, introduction to reaction mechanisms. Prerequisites: Grade of C- or better in CHGN122 or CHGN125. 3 hours lecture; 3 semester hours.

CHGN222. ORGANIC CHEMISTRY II. 3.0 Semester Hrs.
(II, S) Continuation of CHGN221. Prerequisites: Grade of C- or better in CHGN221. 3 hours lecture; 3 semester hours.

CHGN223. ORGANIC CHEMISTRY I LABORATORY. 1.0 Semester Hr.
(I,II, S) Laboratory exercises including purification techniques, synthesis, and characterization. Experiments are designed to support concepts presented in the CHGN221. Students are introduced to Green Chemistry principles and methods of synthesis and the use of computational software. Prerequisites: CHGN221 or concurrent enrollment. 3 hours laboratory, 1 semester hour.

CHGN224. ORGANIC CHEMISTRY II LABORATORY. 1.0 Semester Hr.
(II, S) Laboratory exercises using more advanced synthesis techniques. Experiments are designed to support concepts presented in CHGN222. Prerequisites: CHGN221, CHGN223, and CHGN222 or concurrent enrollment. 3 hours laboratory, 1 semester hour.

CHGN298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CHGN311. INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY. 3.0 Semester Hrs.
(II) The primary objective of this course is to provide all students a suitable background to understand the role nanotechnology will play in future technologies and the underpinning principals involved. 3 hours lecture; 3 semester hours. Prerequisite: CHGN121.

CHGN323. QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY. 2.0 Semester Hrs.
(II) Identification, separation and purification of organic compounds including use of modern physical and instrumental methods. Prerequisite: Grade of C- or better in CHGN222, CHGN224. 1 hour lecture; 3 hours lab; 2 semester hours.

CHGN335. INSTRUMENTAL ANALYSIS. 3.0 Semester Hrs.
(II) Principles of AAS, AES, Visible-UV, IR, NMR, XRF, XRD, XPS, electron, and mass spectroscopy; gas and liquid chromatography; data interpretation. Prerequisite: Grade of C- or better in CHGN122. 3 hours lecture; 3 semester hours.

CHGN336. ANALYTICAL CHEMISTRY. 3.0 Semester Hrs.
Theory and techniques of gravimetry, titrimetry (acid-base, complexometric, redox, precipitation), electrochemical analysis, chemical separations; statistical evaluation of data. Prerequisite: Grade of C- or better in both CHGN122 and CHGN221.

CHGN337. ANALYTICAL CHEMISTRY LABORATORY. 1.0 Semester Hr.
Laboratory exercises emphasizing sample preparation and instrumental methods of analysis. Prerequisite: CHGN221 (C- or better), CHGN 223. Co-requisite: CHGN336.

CHGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I, II, S) Supervised, full-time, chemistry-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

CHGN341. INORGANIC CHEMISTRY I. 3.0 Semester Hrs.
(I) The chemistry of the elements and periodic trends in reactivity is discussed. Particular concepts covered include group theory, symmetry, bonding in ionic and metallic crystal, acid-base theories, coordination chemistry, ligand field theory and radioactivity. 3 hours lecture; 3 semester hours. Prerequisite: CHGN222 and CHGN209 or CBEN210.

CHGN351. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I. 4.0 Semester Hrs.
(I,II,S) A study of chemical systems from a molecular physical chemistry perspective. Includes an introduction to quantum mechanics, atoms and molecules, spectroscopy, bonding and symmetry, and an introduction to modern computational chemistry. Prerequisite: MATH225; PHGN200; Grade of C- or better in CHGN 122 or CHGN 125; and Grade of C- or better in CHGN209 or CBEN210. 3 hours lecture; 3 hours lab; 4 semester hours.

CHGN353. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II. 4.0 Semester Hrs.
(II) A continuation of CHGN351. Includes statistical thermodynamics, chemical kinetics, chemical reaction mechanisms, electrochemistry, and selected additional topics. Prerequisite: CHGN351. 3 hours lecture; 3 hours laboratory; 4 semester hours.

CHGN395. INTRODUCTION TO UNDERGRADUATE RESEARCH. 1.0 Semester Hr.
(I) (WI) Introduction to Undergraduate Research is designed to introduce students to the research endeavor. Topics include ethics, hypothesis testing, critical evaluation of the scientific literature, scientific writing, bibliographic software, and proposal preparation. Prerequisites: Completion of the chemistry curriculum through the Spring semester of the sophomore year. Credit: 1 semester hour.

CHGN396. UNDERGRADUATE RESEARCH. 1-5 Semester Hr.
(I,II,S) Individual research project for freshman, sophomores or juniors under direction of a member of the departmental faculty. Prerequisites: None. Variable credit; 1 to 5 credit hours. Repeatable for credit. Seniors should take CHGN495 instead of CHGN396.

CHGN398. SPECIAL TOPICS IN CHEMISTRY. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CHGN401. INORGANIC CHEMISTRY II. 3.0 Semester Hrs.
(II) The chemistry of the elements and several applications are related to inorganic chemistry are considered in this course. Particular concepts covered include experimental techniques, chemistry specific to groups of elements, catalysis and industrial processes, inorganic materials and nanotechnology, and other applications of inorganic chemistry. Prerequisite: CHGN341. 3 hours lecture; 3 semester hours.

CHGN403. INTRODUCTION TO ENVIRONMENTAL CHEMISTRY. 3.0 Semester Hrs.
Equivalent with CHGC505,
(II) Processes by which natural and anthropogenic chemicals interact, react and are transformed and redistributed in various environmental compartments. Air, soil and aqueous (fresh and saline surface and groundwaters) environments are covered, along with specialized environments such as waste treatment facilities and the upper atmosphere. Prerequisites: CHGN209 or CBEN210. 3 hours lecture; 3 semester hours.

CHGN406. INTRODUCTION TO GEOCHEMISTRY. 3.0 Semester Hrs.
(II) A comprehensive introduction to the basic concepts and principles of geochemistry, coupled with a thorough overview of related principles of thermodynamics and kinetics. Topics covered include: chemical bonding, key chemical reactions, mineral chemistry, soils and nanogeoscience, differentiation of the earth, controls on natural waters, stable and radiogenic isotopes and organic and biogeochemistry. Prerequisites: CHGN121, CHGN122, and GEGN101. 3 hours lecture; 3 semester hours.

CHGN410. SURFACE CHEMISTRY. 3.0 Semester Hrs.
Equivalent with MLGN510,
(II) Introduction to colloid systems, capillarity, surface tension and contact angle, adsorption from solution, micelles and micro - emulsions, the solid/gas interface, surface analytical techniques, van der Waal forces, electrical properties and colloid stability, some specific colloid systems (clays, foams and emulsions). Students enrolled for graduate credit in MLGN510 must complete a special project. Prerequisite: CHGN209. 3 hours lecture; 3 semester hours.

CHGN411. APPLIED RADIOCHEMISTRY. 3.0 Semester Hrs.
(II) This course is designed for those who have a budding interest radiochemistry and its applications. A brief overview of radioactivity and general chemistry will be provided in the first three weeks of the course. Follow-on weeks will feature segments focusing on the radiochemistry in the nuclear fuel cycle, radioisotope production, nuclear forensics and the environment. Prerequisite: CHGN121 and CHGN122. 3 hours lecture, 3 semester hours.

CHGN422. POLYMER CHEMISTRY LABORATORY. 1.0 Semester Hr.
(I) Prerequisites: CHGN221, CHGN223. 3 hours lab; 1 semester hour.

CHGN428. BIOCHEMISTRY. 3.0 Semester Hrs.
(I) Introductory study of the major molecules of biochemistry: amino acids, proteins, enzymes, nucleic acids, lipids, and saccharides- their structure, chemistry, biological function, and biosynthesis. Stresses bioenergetics and the cell as a biological unit of organization. Discussion of classical genetics, molecular genetics, and protein synthesis. Prerequisite: CHGN222. 3 hours lecture; 3 semester hours.

CHGN429. BIOCHEMISTRY II. 3.0 Semester Hrs.
A continuation of CHGN428. Topics include: nucleotide synthesis; DNA repair, replication and recombination; transcription, translation and regulation; proteomics; lipid and amino acid synthesis; protein target and degradation; membranes; receptors and signal transduction. Prerequisite: CHGN428.

CHGN430. INTRODUCTION TO POLYMER SCIENCE. 3.0 Semester Hrs.
Equivalent with MLGN530,
(I) An introduction to the chemistry and physics of macromolecules. Topics include the properties and statistics of polymer solutions, measurements of molecular weights, molecular weight distributions, properties of bulk polymers, mechanisms of polymer formation, and properties of thermosets and thermoplastics including elastomers. Pre requisite: CHGN222. 3 hour lecture, 3 semester hours.

CHGN431. INTRODUCTORY BIOCHEMISTRY LABORATORY. 2.0 Semester Hrs.
The link between the structure of a material and its properties is ubiquitous across all fields. Throughout the Biochemistry lab course, we will have the opportunity to explore both protein and nucleic acids through various techniques and analyses that probe the structure-property relationship of biomolecules that subsequently allows us to tap into molecular function. The selection of experiments is intentionally designed to provide exposure to a broad range of modern experimental strategies to enrich and solidify material covered within the CHGN428/429 sequence. Prerequisite: CHGN428. Co-requisite: CHGN428.

CHGN441. THE CHEMISTRY AND BIOCHEMISTRY OF PHARMACEUTICALS. 3.0 Semester Hrs.
This course will examine a broad range of pharmaceuticals, including but not limited to controlled substances, treatments for cardiovascular, respiratory, and infectious diseases, as well as cannabinoids and performance-enhancing substances. The history, pharmacology, and, in some cases, the synthesis of these pharmaceuticals will be covered. Prerequisite: CHGN221, CHGN222, CHGN428.

CHGN445. CHEMICAL BIOLOGY. 3.0 Semester Hrs.
The analysis of biological systems from the perspective of organic/inorganic and physical chemistry, including chemical reactions for the synthetic preparation of biomolecules and the chemistry behind different biotechnological developments and tools. A strong emphasis on the mechanistic basis of biochemical transformations is included. Strategies for directing pharmaceuticals or diagnostics to different subcellular locales will be presented. A survey of key advancements in the field of chemical biology will be drawn from the primary literature. Prerequisite: CHGN221, CHGN222, CHGN428.

CHGN462. MICROBIOLOGY. 3.0 Semester Hrs.
Equivalent with CHGN562,
(II) This course will cover the basic fundamentals of microbiology, such as structure and function of prokaryotic versus eukaryotic cells; viruses; classification of microorganisms; microbial metabolism, energetics, genetics, growth and diversity, microbial interactions with plants, animals, and other microbes. Special focus will be on pathogenic bacteriology, virology, and parasitology including disease symptoms, transmission, and treatment. Prerequisite: none. 3 hours lecture, 3 semester hours.

CHGN475. COMPUTATIONAL CHEMISTRY. 3.0 Semester Hrs.
(II) This class provides a survey of techniques of computational chemistry, including quantum mechanics (both Hartree-Fock and density functional approaches) and molecular dynamics. Emphasis is given to the integration of these techniques with experimental programs of molecular design and development. Prerequisites: CHGN351, CHGN401. 3 hours lecture; 3 semester hours.

CHGN490. CHEMISTRY FIELD SESSION. 6.0 Semester Hrs.
(S) (WI) Professional-level chemistry experience featuring modules including organic/polymer synthesis and characterization, inorganic nanomaterial investigations, computational chemistry, environmental chemical analysis , biochemistry and technical report writing. Prerequisites: CHGN323, CHGN341, and CHGN353. 6-week summer session; 6 semester hours.

CHGN495. UNDERGRADUATE RESEARCH. 1-5 Semester Hr.
(I, II, S) (WI) Individual research project under direction of a member of the Departmental faculty. Prerequisites: selection of a research topic and advisor, preparation and approval of a research proposal, completion of chemistry curriculum through the junior year. Variable credit; 1 to 5 credit hours. Repeatable for credit.

CHGN497. INTERNSHIP. 1-6 Semester Hr.
(I, II, S) Individual internship experience with an industrial, academic, or governmental host supervised by a Departmental faculty member. Prerequisites: Completion of chemistry curriculum through the junior year. Variable credit; 1 to 6 credit hours.

CHGN498. SPECIAL TOPICS IN CHEMISTRY. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN499. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professors

Thomas Gennett, Department Head

Richard C. Holz, Provost

Mark P. Jensen, Grandey University Chair in Nuclear Science & Engineering

Daniel M. Knauss, Associate Dean of Energy and Materials

Matthew C. Posewitz

James F. Ranville

Ryan M. Richards

Alan S. Sellinger

Bettina M. Voelker

Kim R. Williams

David T. Wu

Associate Professors

Judith Klein-Seetharaman

Jenifer C. Shafer

Brian G. Trewyn

Assistant Professors

Dylan Domaille

C. Michael McGuirk

Christine Morrison

Svitlana Pylypenko

Shubham Vyas

Teaching Professors

Renee L. Falconer, Assistant Department Head

Mark R. Seger

Teaching Associate Professors

Allison G. Caster

Angela Sower

Teaching Assistant Professors

Christian Beren

Amanda Jameer

Jonathan Miorelli

Research Professor

Mark E. Eberhart

Research Assistant Professors

Jessica Jackson

Yuan Yang

Joint Appointees

Matthew Beard

Todd Deutsch

Justin Johnson

Calvin Mukarakate

Bryan Pivovar

Affiliated Faculty

Wade Braunecker

Samuel Bryan

Stosh Kozimor

Joseph Meyer

Kathleen Smith

Professors Emeriti

Scott W. Cowley

Stephen R. Daniel

Dean W. Dickerhoof

Mark E. Eberhart

Kenneth W. Edwards

Ronald W. Klusman

Donald Langmuir

Donald L. Macalady

Patrick MacCarthy

Michael J. Pavelich

E. Craig Simmons

Kent J. Voorhees

Thomas R. Wildeman

John T. Williams

Computer Science

Program Description

The Department of Computer Science develops graduates who can process information in digital computers, design computer hardware and software, and work successfully with several different computing applications. The Department offers the degree of Bachelor of Science in Computer Science. Within this degree, a student may choose (not required) one of six available emphasis areas in Business, Computer Engineering, Data Science, Research Honors, Robotics and Intelligent Systems, or Space.

BS in Computer Science

Computing is ubiquitous, impacting almost every aspect of modern life, and playing an important role in many technological advances. Computing jobs are among the highest paid, and computing professionals generally report high job satisfaction. Graduates from our program have found employment with many different types of companies including technology, engineering, and financial companies.

The CS degree at Mines is designed to be accessible to students with or without prior programming experience. The Introduction to Computer Science course introduces students to the building blocks of CS and provides a brief introduction to procedural programming in Python. The second computing course, Programming Concepts, emphasizes development of programming skills in an object-oriented language. The third introductory course, Data Structures, provides an understanding of the classic data representation schemes, algorithms, and algorithm analysis that form the foundation for all advanced work in computing.

Required CS courses provide the fundamental skills and knowledge that are critical to success in computing. These courses reflect a mixture of theory and practice, including discrete structures, design and analysis of algorithms, principles of programming languages, computer architecture, operating systems, software engineering, and database management. The capstone field session course provides students an opportunity to work in teams to create software products for real clients.

Elective courses in CS allow students to explore a variety of important computing topics, such as graphics and visualization, artificial intelligence, mobile applications, and web programming. Elective courses often relate to recent trends in computing, covering topics such as security, high performance computing, and machine learning.

Computing is a broad field with applicability to most science and engineering domains. The CS minor is designed for students in other disciplines to receive a solid grounding in the basics, which should enable them to apply their computing skills to solve problems in other domains.

PROGRAM EDUCATIONAL OBJECTIVES (BACHELOR OF SCIENCE IN COMPUTER SCIENCE)

In addition to contributing toward achieving the educational objectives described in the Mines' Graduate Profile, the Computer Science Program at Mines has established the following program educational objectives:

Students will demonstrate technical expertise within computer science by:

- Designing and implementing solutions to practical problems in science and engineering,
- Using appropriate technology as a tool to solve problems in computer science, and
- Creating efficient algorithms and well-structured computer programs.

Students will demonstrate a breadth and depth of knowledge within computer science by:

- Extending course material to solve original problems,
- Applying knowledge of computer science to the solution of problems, and
- Identifying, formulating and solving computer science problems.

Students will demonstrate an understanding and appreciation for the relationship of computer science to other fields by:

- Applying computer science to solve problems in other fields,
- Working in cooperative multidisciplinary teams, and
- Choosing appropriate technology to solve problems in other disciplines.

Students will demonstrate an ability to communicate computer science effectively by:

- Giving oral presentations,
- Completing written explanations,
- Interacting effectively in cooperative teams,
- Creating well-documented programs, and
- Understanding and interpreting written material in computer science.

Bachelor of Science in Computer Science Degree Requirements:

Freshman

Fall		**lec**	**lab**	**sem.hrs**
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE			3.0
HASS100	NATURE AND HUMAN VALUES			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
EDNS151	DESIGN I			3.0
CSCI261	PROGRAMMING CONCEPTS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
CSCI274	INTRODUCTION TO THE LINUX OPERATING SYSTEM			1.0
CSCI262	DATA STRUCTURES			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
MATH225	DIFFERENTIAL EQUATIONS			3.0
CSCI358	DISCRETE MATHEMATICS			3.0
CSCI341	COMPUTER ORGANIZATION			3.0
HASS200	GLOBAL STUDIES			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
Focus Area Course 1				3.0
				15.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
MATH332	LINEAR ALGEBRA			3.0
CSCI306	SOFTWARE ENGINEERING			3.0
FREE	Free Elective			3.0
Focus Area Course 2				3.0
Focus Area Course 3				3.0
				15.0

Spring		**lec**	**lab**	**sem.hrs**
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS			3.0
CSCI406	ALGORITHMS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
FREE	Free Elective			3.0
Focus Area Course 4				3.0
				15.0

Summer		**lec**	**lab**	**sem.hrs**
CSCI370	ADVANCED SOFTWARE ENGINEERING			4.5
				4.5

Senior

Fall		**lec**	**lab**	**sem.hrs**
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
CSCI400	PRINCIPLES OF PROGRAMMING LANGUAGES			3.0
Focus Area Course 5				3.0
Focus Area Course 6				3.0
Focus Area Course 7				3.0
				15.0

Spring		**lec**	**lab**	**sem.hrs**
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400 Level Restricted Elective			3.0
CSCI442	OPERATING SYSTEMS			3.0
Focus Area Course 8				3.0
Focus Area Course 9				3.0
Focus Area Course 10				3.0
				15.0

Total Semester Hrs: 127.0

Focus Areas

The Department of Computer Science offers seven focus areas:

1. Computer Science
2. CS + Business
3. CS + Computer Engineering
4. CS + Data Science
5. CS + Research Honors
6. CS + Robotics & Intelligent Systems
7. CS + Space

Computer Science Electives can be chosen from any CSCI400-level course, any CSCI500-level course (with advisor approval), MATH307, or EENG383. EDNS491 & EDNS492, when both courses are taken together, can both be counted as Computer Science Electives. In a given focus area, a required course for that focus area can not also be counted as a CSCI technical elective in that focus area.

Computer Science

FREE	Free Elective	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
FREE	Free Elective	3.0
CSCI ELECT	Computer Science Elective	3.0
CSCI ELECT	Computer Science Elective	3.0
CSCI ELECT	Computer Science Elective	3.0
FREE	Free Elective	3.0
CSCI ELECT	Computer Science Elective	3.0
CSCI ELECT	Computer Science Elective	3.0
FREE	Free Elective	3.0
Total Semester Hrs		**30.0**

CS + Business

CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
EBGN***	BS Elective #&	3.0
EBGN***	BS Elective #&	3.0
EBGN***	BS Elective #&	3.0
CSCI475	INFORMATION SECURITY AND PRIVACY	3.0
CSCI ELECT	Computer Science Elective	3.0
EBGN***	BS Elective #&	3.0
CSCI448	MOBILE APPLICATION DEVELOPMENT	3.0
or CSCI445	WEB PROGRAMMING	
or CSCI446	WEB APPLICATIONS	

FREE	Free Elective	3.0
Total Semester Hrs		**30.0**

Four unique Business Electives must be chosen from: EBGN230, EBGN320, EBGN321, EBGN345, EBGN346, EBGN360, EBGN425, EBGN460, EBGN485

& If Business Elective is used to satisfy H&SS Restricted Elective requirement, then an additional Business Elective or eligible Computer Science Elective must be substituted.

CS + Computer Engineering

CSCI250	PYTHON-BASED COMPUTING: BUILDING A SENSOR SYSTEM	3.0
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER #&	3-4
or EENG282	ELECTRICAL CIRCUITS	
or PHGN215	ANALOG ELECTRONICS	
EENG284	DIGITAL LOGIC #	3-4
or PHGN317	SEMICONDUCTOR CIRCUITS- DIGITAL	
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING	4.0
CSCI471	COMPUTER NETWORKS I	3.0
CSCI475	INFORMATION SECURITY AND PRIVACY	3.0
CSCI ELECT	Computer Science Elective	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
or CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	
or CSCI474	INTRODUCTION TO CRYPTOGRAPHY	
FREE	Free Elective	3.0
FREE	Free Elective	1.0
Total Semester Hrs		**29-31**

PHGN215 & PHGN317 provide similar content to EENG281 & EENG284 and both can be substituted together with preapproval.

& EENG282 may be substituted for EENG281

CS + Data Science

CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
MATH432	SPATIAL STATISTICS	3.0
or MATH436	ADVANCED STATISTICAL MODELING	
or MATH437	MULTIVARIATE ANALYSIS	
or MATH438	STOCHASTIC MODELS	
or MATH439	SURVIVAL ANALYSIS	
CSCI404	ARTIFICIAL INTELLIGENCE	3.0
or CSCI423	COMPUTER SIMULATION	
or CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	
or CSCI474	INTRODUCTION TO CRYPTOGRAPHY	
or CSCI475	INFORMATION SECURITY AND PRIVACY	
CSCI ELECT	Computer Science Elective	3.0
FREE	Free Elective	3.0
Total Semester Hrs		**30.0**

CS + Research Honors

FREE	Free Elective	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
HASS360	RESEARCH, VALUES, AND COMMUNICATION	3.0
CSCI ELECT	Computer Science Elective	3.0
CSCI480	COMPUTER SCIENCE HONORS THESIS	3.0
CSCI5**	Computer Science Honors Elective #	3.0
CSCI ELECT	Computer Science Elective	3.0
CSCI480	COMPUTER SCIENCE HONORS THESIS	3.0
CSCI5**	Computer Science Honors Elective #	3.0
CSCI ELECT	Computer Science Elective	3.0
Total Semester Hrs		**30.0**

Computer Science Honors Electives may be any CSCI500-level course approved by advisor.

CS + Robotics & Intelligent Systems

EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER #&	3-4
or EENG282	ELECTRICAL CIRCUITS	
or PHGN215	ANALOG ELECTRONICS	
FREE	Free Elective	3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
MEGN441	INTRODUCTION TO ROBOTICS	3.0
CSCI404	ARTIFICIAL INTELLIGENCE	3.0
CSCI437	INTRODUCTION TO COMPUTER VISION	3.0
or CSCI473	HUMAN-CENTERED ROBOTICS	
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
or CSCI534	ROBOT PLANNING AND MANIPULATION	
CSCI432	ROBOT ETHICS	3.0
or CSCI436	HUMAN-ROBOT INTERACTION	
CSCI473	HUMAN-CENTERED ROBOTICS	3.0
or CSCI432	ROBOT ETHICS	
or CSCI436	HUMAN-ROBOT INTERACTION	
or CSCI437	INTRODUCTION TO COMPUTER VISION	
or CSCI470	INTRODUCTION TO MACHINE LEARNING	
or CSCI534	ROBOT PLANNING AND MANIPULATION	
CSCI ELECT	Computer Science Elective	3.0
Total Semester Hrs		**30-31**

PHGN215 provides similar content to EENG281 and can be substituted with preapproval

& EENG282 may be substituted for EENG281

CS + Space

CSCI250	PYTHON-BASED COMPUTING: BUILDING A SENSOR SYSTEM	3.0

CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
or CSCI404	ARTIFICIAL INTELLIGENCE	
or CSCI475	INFORMATION SECURITY AND PRIVACY	
FREE	Free Elective	3.0
MEGN498	SPACE SYSTEMS ENGINEERING	
CSCI423	COMPUTER SIMULATION	3.0
MEGN408	INTRODUCTION TO SPACE EXPLORATION	3.0
CSCI410	ELEMENTS OF COMPUTING SYSTEMS	3.0
or CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	
or CSCI471	COMPUTER NETWORKS I	
CSCI404	ARTIFICIAL INTELLIGENCE	3.0
or CSCI303	INTRODUCTION TO DATA SCIENCE	
or CSCI410	ELEMENTS OF COMPUTING SYSTEMS	
or CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	
or CSCI471	COMPUTER NETWORKS I	
or CSCI475	INFORMATION SECURITY AND PRIVACY	
MEGN498	SPACE OPERATIONS	3.0
CSCI***	CS Elective	3.0
Total Semester Hrs		**27.0**

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- CSCI200 through CSCI799 inclusive, excluding CSCI*99

Computer Science

For an **Area of Special Interest in Computer Science**, the student should take:

CSCI262	DATA STRUCTURES	3.0
CSCI306	SOFTWARE ENGINEERING	3.0
CSCI358	DISCRETE MATHEMATICS	3.0
CSCI406	ALGORITHMS	3.0

or

CSCI262	DATA STRUCTURES	3.0
CSCI274	INTRODUCTION TO THE LINUX OPERATING SYSTEM	1.0
CSCI306	SOFTWARE ENGINEERING	3.0
CSCI341	COMPUTER ORGANIZATION	3.0
CSCI442	OPERATING SYSTEMS	3.0

For a **Minor in Computer Science,** the student should take:

CSCI261	PROGRAMMING CONCEPTS	3.0
CSCI262	DATA STRUCTURES	3.0
CSCI306	SOFTWARE ENGINEERING	3.0
CSCI406	ALGORITHMS	3.0
CSCI ELECT	Computer Science Elective *^	3.0
CSCI ELECT	Computer Science Elective *	3.0

* CSCI Electives can be chosen from any 400-level CSCI course, MATH307, and EENG383. Please see the Courses Tab for course listings.

^ CSCI358 may be substituted for one CSCI Elective if the student does not meet the pre-requisites for CSCI406

or

CSCI261	PROGRAMMING CONCEPTS	3.0
CSCI262	DATA STRUCTURES	3.0
CSCI274	INTRODUCTION TO THE LINUX OPERATING SYSTEM	1.0
CSCI341	COMPUTER ORGANIZATION	3.0
CSCI442	OPERATING SYSTEMS	3.0
CSCI ELECT	Computer Science Elective *	3.0
CSCI ELECT	Computer Science Elective *	3.0

* CSCI Electives can be chosen from any 400-level CSCI course, MATH307, and EENG383. Please see the Courses Tab for course listings.

Minor in Computer Engineering

To earn the Minor in Computer Engineering, a student must take at least 18 credit hours from the following list, at least 9 of which must be 300-level or above:

CSCI261	PROGRAMMING CONCEPTS	3.0
CSCI262	DATA STRUCTURES	3.0
CSCI341	COMPUTER ORGANIZATION	3.0
CSCI442	OPERATING SYSTEMS	3.0
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER ^	3.0
or EENG282	ELECTRICAL CIRCUITS	
EENG284	DIGITAL LOGIC *	4.0
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING	4.0

^ PHGN215 may be used in place of EENG281/282 with pre-approval by the student's major program director.

* PHGN317 may be used in place of EENG284 with pre-approval by the student's major program director.

If a student is in a major that does not require CSCI261, then the student must take only three of the four CSCI courses listed.

At most 6.0 credits of this minor can be counted toward another minor degree program.

Minor in Data Science

Complete one of the following sets of courses:

CSCI261	PROGRAMMING CONCEPTS	3.0
CSCI262	DATA STRUCTURES	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0

MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
Choose 2 of		
CSCI403	DATA BASE MANAGEMENT	6.0
or CSCI404	ARTIFICIAL INTELLIGENCE	
or CSCI470	INTRODUCTION TO MACHINE LEARNING	
Total Semester Hrs		**18.0**

Or

CSCI261	PROGRAMMING CONCEPTS	3.0
CSCI262	DATA STRUCTURES	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
Total Semester Hrs		**18.0**

Minor in Robotics and Intelligent Systems

Complete the following courses:

CSCI261	PROGRAMMING CONCEPTS	3.0
CSCI262	DATA STRUCTURES	3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MEGN441	INTRODUCTION TO ROBOTICS	3.0
CSCI404	ARTIFICIAL INTELLIGENCE	3.0
or CSCI437	INTRODUCTION TO COMPUTER VISION	
or CSCI470	INTRODUCTION TO MACHINE LEARNING	
CSCI473	HUMAN-CENTERED ROBOTICS	3.0
or CSCI436	HUMAN-ROBOT INTERACTION	
or CSCI534	ROBOT PLANNING AND MANIPULATION	
Total Semester Hrs		**18.0**

Courses

CSCI101. INTRODUCTION TO COMPUTER SCIENCE. 3.0 Semester Hrs.
(I, II) An introductory course to the building blocks of Computer Science. Topics include conventional computer hardware, data representation, the role of operating systems and networks in modern computing, algorithm design, privacy and information security, data science, artificial intelligence, and computer ethics. A popular procedural programming language will be learned by students and programming assignments will explore ideas in algorithm development, optimization, and data manipulation. 3 hours lecture; 3 semester hours.

CSCI102. INTRODUCTION TO COMPUTER SCIENCE - LAB. 1.0 Semester Hr.
This course is a 1-credit hour optional lab course for CSCI 101 that offers an opportunity for new programmers to learn the Python programming language. Python is a powerful interpreted programming language with a simple syntax and a large set of libraries. While Python is an easy language for beginner programmers to learn, it is a language that is widely used in many scientific areas (e.g., data science). This lab course will introduce students to basic programming concepts: conditionals, loops, lists, strings, file input/output, functions, and objects. Take this course with CSCI 101 to either create a 4-credit hour distributed science elective or gain more experience with algorithmic design/programming in Python.

CSCI198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CSCI199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CSCI250. PYTHON-BASED COMPUTING: BUILDING A SENSOR SYSTEM. 3.0 Semester Hrs.
(I, II) This course will teach students the skills needed for data collection, analysis, and visualization on a small embedded device (e.g., Raspberry Pi). Students will learn basic Linux, Python, and the programming skills needed to control the hardware and associated sensors. This hands-on course includes a baseline project, four introductory projects (e.g., acoustic, acceleration, magnetic field, optical), and a final Capstone project. The Capstone project will have students create their own application using the techniques learned during the first half of the semester; students will then present their Capstone project through a formal presentation, write-up, and demonstration. We suggest the student take "Introduction to Computer Science" before this course. Co-requisite: MATH213, PHGN200. 3 hours lecture; 3 semester hours.

CSCI260. FORTRAN PROGRAMMING. 2.0 Semester Hrs.
(I) Computer programming in Fortran90/95 with applications to science and engineering. Program design and structure, problem analysis, debugging, program testing. Language skills: arithmetic, input/output, branching and looping, functions, arrays, data types. Introduction to operating systems. Prerequisite: none. 2 hours lecture; 2 semester hours.

CSCI261. PROGRAMMING CONCEPTS. 3.0 Semester Hrs.
This course introduces fundamental computer programming concepts using a high-level language and a modern development environment. Programming skills include sequential, selection, and repetition control structures, functions, input and output, primitive data types, basic data structures including arrays and pointers, objects, and classes. Software engineering skills include problem solving, program design, and debugging practices. Prerequisite: CSCI101.

CSCI262. DATA STRUCTURES. 3.0 Semester Hrs.
(I, II, S) Defining and using data structures such as linked lists, stacks, queues, binary trees, binary heap, and hash tables. Introduction to algorithm analysis, with emphasis on sorting and search routines. Language skills: abstract data types, templates, and inheritance. 3 hours lecture; 3 semester hours. Prerequisite: CSCI261 with a grade of C- or higher.

CSCI274. INTRODUCTION TO THE LINUX OPERATING SYSTEM. 1.0 Semester Hr.
(I, II) Introduction to the Linux Operating System will teach students how to become proficient with using a Linux operating system from the command line. Topics will include: remote login (ssh), file system navigation, file commands, editors, compilation, execution, redirection, output, searching, processes, usage, permissions, compression, parsing, networking, and bash scripting. Prerequisite: CSCI261. 1 hour lecture; 1 semester hour.

CSCI290. PROGRAMMING CHALLENGES I. 1.0 Semester Hr.
This course is the first of three courses in the Programming Challenges sequence which covers problem solving patterns and paradigms found in technical interviews and programming competitions. The students will learn more advanced data structures and algorithms while focusing on algorithmic complexity to solve problems in a finite amount of time. Co-requisite: CSCI262.

CSCI295. INDUSTRY EXPLORATION I. 1.0 Semester Hr.
Industry Exploration I provides 1st and 2nd year students an opportunity to explore different career paths in computer science. Each week students meet (over Zoom) with a company that hires a number of computer scientists. Prior to the meeting, students research the company and determine 1-2 specific question(s) to ask during the meeting (i.e., questions specific to the company). During the meeting, students talk with employees at the company to learn more about the types of computer science jobs that exist. After the meeting, students reflect on what was learned during the meeting. At the end of the semester, students have a better understanding of different types of jobs in computer science and what they may want to do in their future careers.

CSCI298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CSCI299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CSCI303. INTRODUCTION TO DATA SCIENCE. 3.0 Semester Hrs.
This course will teach students the core skills needed for gathering, cleaning, organizing, analyzing, interpreting, and visualizing data. Students will learn basic SQL for working with databases, basic Python programming for data manipulation, and the use and application of statistical and machine learning toolkits for data analysis. The course will be primarily focused on applications, with an emphasis on working with real (non-synthetic) datasets. Prerequisite: CSCI101 or CSCI102 or CSCI261.

CSCI306. SOFTWARE ENGINEERING. 3.0 Semester Hrs.
(I, II) Introduction to software engineering processes and object-oriented design principles. Topics include the Agile development methodology, test-driven development, UML diagrams, use cases and several object-oriented design patterns. Course work emphasizes good programming practices via version control and code reviews. Prerequisite: CSCI262 with grade of C- or higher. 3 hours lecture; 3 semester hours.

CSCI340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I, II, S) (WI) Supervised, full-time engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions. Repeatable.

CSCI341. COMPUTER ORGANIZATION. 3.0 Semester Hrs.
(I, II) Covers the basic concepts of computer architecture and organization. Topics include machine level instructions and operating system calls used to write programs in assembly language, computer arithmetics, performance, processor design, and pipelining techniques. This course provides insight into the way computers operate at the machine level. Prerequisite: CSCI261. Co-requisites: CSCI262. 3 hours lecture; 3 semester hours.

CSCI358. DISCRETE MATHEMATICS. 3.0 Semester Hrs.
(I, II) This course is an introductory course in discrete mathematics and algebraic structures. Topics include: formal logic; proofs, recursion, analysis of algorithms; sets and combinatorics; relations, functions, and matrices; Boolean algebra and computer logic; trees, graphs, finite-state machines, and regular languages. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

CSCI370. ADVANCED SOFTWARE ENGINEERING. 4.5 Semester Hrs.
(I, S) (WI) This capstone course has three primary goals: (1) to enable students to apply their course work knowledge to a challenging applied problem for a real client, (2) to enhance students' verbal and written communication skills, and (3) to provide an introduction to ethical decision making in computer science. Ethics and communication skills are emphasized in a classroom setting. The client work is done in small teams, either on campus or at the client site. Faculty advisors provide guidance related to the software engineering process, which is similar to Scrum. By the end of the course students must have a finished product with appropriate documentation. Prerequisite: CSCI306. 13.5 hours lab; 4.5 semester hours.

CSCI390. PROGRAMMING CHALLENGES II. 1.0 Semester Hr.
This course is the second of three courses in the Programming Challenges sequence which covers problem solving patterns and paradigms found in technical interviews and programming competitions. The students will learn more advanced set, counting, & number theory and algorithms while focusing on algorithmic complexity to solve problems in a finite amount of time. Prerequisite: CSCI290. Co-requisite: CSCI358.

CSCI395. INDUSTRY EXPLORATION II. 1.0 Semester Hr.
Industry Exploration II provides 3rd and 4th year students an opportunity to explore different career paths in computer science. Each week students visit a company that hires a number of computer scientists at the company?s office. Prior to the visit, students research the company and determine 1-2 specific question(s) to ask during the meeting (i.e., questions specific to the company). During the visit, students are provided a tour of the company?s office and the opportunity to talk to employees and learn more about the types of computer science jobs that exist. After the visit, students reflect on what was learned during the visit. At the end of the semester, students have a better understanding of different types of jobs in computer science and what they may want to do in their future careers.

CSCI398. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CSCI399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CSCI400. PRINCIPLES OF PROGRAMMING LANGUAGES. 3.0 Semester Hrs.
This course takes a broad view of programming languages, focusing on the fundamental abstractions and principles of language design that transcend the specifics of any particular programming language. The course will emphasize functional programming, develop experience via programming projects, and cover topics such as lambda calculus, higher-order functions, induction, persistence, type systems, syntax, and evaluation. Ultimately, students will have an opportunity to improve programming skills, and develop a deeper understanding of how programming languages are designed and implemented. Prerequisite: CSCI306, CSCI358.

CSCI403. DATA BASE MANAGEMENT. 3.0 Semester Hrs.
(I, II) Design and evaluation of information storage and retrieval systems, including defining and building a database and producing the necessary queries for access to the stored information. Relational database management systems, structured query language, and data storage facilities. Applications of data structures such as lists, inverted lists and trees. System security, maintenance, recovery and definition. Interfacing host languages to database systems and object-relational mapping tools. NoSQL databases and distributed databases. Prerequisite: CSCI262 with a grade of C- or higher. 3 hours lecture; 3 semester hours.

CSCI404. ARTIFICIAL INTELLIGENCE. 3.0 Semester Hrs.
(II) General investigation of the Artificial Intelligence field. Several methods used in artificial intelligence such as search strategies, knowledge representation, logic and probabilistic reasoning are developed and applied to practical problems. Fundamental artificial intelligence techniques are presented, including neural networks, genetic algorithms, and fuzzy sets. Selected application areas, such as robotics, natural language processing and games, are discussed. Prerequisite: CSCI262 with a grade of C- or higher and MATH201. 3 hours lecture; 3 semester hours.

CSCI406. ALGORITHMS. 3.0 Semester Hrs.
Equivalent with MATH406,
(I, II) Reasoning about algorithm correctness (proofs, counterexamples). Analysis of algorithms: asymptotic and practical complexity. Review of dictionary data structures (including balanced search trees). Priority queues. Advanced sorting algorithms (heapsort, radix sort). Advanced algorithmic concepts illustrated through sorting (randomized algorithms, lower bounds, divide and conquer). Dynamic programming. Backtracking. Algorithms on unweighted graphs (traversals) and weighted graphs (minimum spanning trees, shortest paths, network flows and bipartite matching); NP-completeness and its consequences. Prerequisite: CSCI262 with a grade of C- or higher, (MATH213 or MATH223 or MATH224), and (MATH300 or MATH358 or CSCI358). 3 hours lecture; 3 semester hours.

CSCI410. ELEMENTS OF COMPUTING SYSTEMS. 3.0 Semester Hrs.
(I, II) This comprehensive course will help students consolidate their understanding of all fundamental computer science concepts. Topics include symbolic communication, Boolean logic, binary systems, logic gates, computer architecture, assembly language, assembler construction, virtual machines, object-oriented programming languages, software engineering, compilers, language design, and operating systems. Using a hardware simulator and a programming language of their choice, students construct an entire modern computer from the ground up, resulting in an intimate understanding of how each component works. Prerequisites: CSCI341 or EENG383. 3 lecture hours, 3 credit hours.

CSCI422. USER INTERFACES. 3.0 Semester Hrs.
(I) User Interface Design is a course for programmers who want to learn how to create more effective software. This objective will be achieved by studying principles and patterns of interaction design, critiquing existing software using criteria presented in the textbooks, and applying criteria to the design and implementation of one larger product. Students will also learn a variety of techniques to guide the software design process, including Cognitive Walkthrough, Talk-aloud and others. Prerequisite: CSCI262. 3 hours lecture; 3 semester hours.

CSCI423. COMPUTER SIMULATION. 3.0 Semester Hrs.
A first course in computer simulation using formal learning groups and emphasizing the rigorous development of simulation applications. Topics will include random number generation, Monte Carlo simulation, discrete event simulation, and the mathematics behind their proper implementation and analysis (random variates, arrival time modeling, infinite horizon statistics, batch means and sampling techniques). The course uses learning group assignments, quizzes, programming projects (using Linux) and exams for assessment. Prerequisite: CSCI274, CSCI306, MATH201.

CSCI425. COMPILER DESIGN. 3.0 Semester Hrs.
An introductory course to the design and construction of compilers. Topics include scanning (lexical analysis), context free grammars, recursive descent (top-down) parsing, LR (bottom up) parsing, syntax directed translation, syntax trees, expression trees, parse trees, intermediate representation, register allocation and target code generation. Students will construct their own tool chain for compiling a simple language, tracking the relevant course topics as they are covered. Prerequisite: CSCI274, CSCI306, CSCI341.

CSCI432. ROBOT ETHICS. 3.0 Semester Hrs.
(II) (WI) This course explores ethical issues arising in robotics and human-robot interaction through philosophical analysis, behavioral and psychological analysis, research ethics education, and the integration of social and ethical concerns in scientific experimentation and algorithm design. Topics include case studies in lethal autonomous weapon systems, autonomous cars, and social robots, as well as higher-level concerns including economics, law, policy, and discrimination. Prerequisite: CSCI262 and MATH201.

CSCI436. HUMAN-ROBOT INTERACTION. 3.0 Semester Hrs.
Human-Robot Interaction is an interdisciplinary field at the intersection of Computer Science, Robotics, Psychology, and Human Factors, that seeks to answer a broad set of questions about robots designed to interact with humans (e.g., assistive robots, educational robots, and service robots), such as: (1) How does human interaction with robots differ from interaction with other people? (2) How does the appearance and behavior of a robot change how humans perceive, trust, and interact with that robot? And (3) How can we design and program robots that are natural, trustworthy, and effective? Accordingly, In this course, students will learn (1) how to design interactive robots, (2) the algorithmic foundations of interactive robots; and (3) how to evaluate interactive robots. To achieve these learning objectives, students will read and present key papers from the HRI literature, and complete a final project in which they will design, pilot, and evaluate novel HRI experiments in small groups, with in-class time expected to be split between lecture by the instructor, presentations by students, and either collaborative active learning activities or discussions with researchers in the field. Prerequisite: CSCI262, MATH201.

CSCI437. INTRODUCTION TO COMPUTER VISION. 3.0 Semester Hrs.
Equivalent with CSCI512,EENG507,EENG512,
(I) Computer vision is the process of using computers to acquire images, transform images, and extract symbolic descriptions from images. This course provides an introduction to this field, covering topics in image formation, feature extraction, location estimation, and object recognition. Design ability and hands-on projects will be emphasized, using popular software tools. The course will be of interest both to those who want to learn more about the subject and to those who just want to use computer imaging techniques. Prerequisites: MATH201 or EENG311, MATH332, CSCI261, Senior level standing. 3 hours lecture; 3 semester hours.

CSCI440. PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS. 3.0 Semester Hrs.
Equivalent with MATH440,
(II) This course is designed to introduce the field of parallel computing to all scientists and engineers. The students will be taught how to solve scientific problems using parallel computing technologies. They will be introduced to basic terminologies and concepts of parallel computing, learn how to use MPI to develop parallel programs, and study how to design and analyze parallel algorithms. Prerequisite: CSCI262 with a grade of C- or higher, CSCI341. 3 hours lecture; 3 semester hours.

CSCI441. COMPUTER GRAPHICS. 3.0 Semester Hrs.
Equivalent with MATH441,
(I) This class focuses on the basic 3D rendering and modeling techniques. In particular, it covers the graphics pipeline, elements of global illumination, modeling techniques based on polynomial curves and patches, and shader programming using the GPU. Prerequisites: CSCI262 with a grade of C- or higher, MATH332. 3 hours lecture; 3 semester hours.

CSCI442. OPERATING SYSTEMS. 3.0 Semester Hrs.
(I, II) Introduces the essential concepts in the design and implementation of operating systems: what they can do, what they contain, and how they are implemented. Despite rapid OS growth and development, the fundamental concepts learned in this course will endure. We will cover the following high-level OS topics, roughly in this order: computer systems, processes, processor scheduling, memory management, virtual memory, threads, and process/thread synchronization. This course provides insight into the internal structure of operating systems; emphasis is on concepts and techniques that are valid for all computers. Prerequisite: CSCI262 with a grade of C- or higher, CSCI274, CSCI341. 3 hours lecture; 3 semester hours.

CSCI443. ADVANCED PROGRAMMING CONCEPTS USING JAVA. 3.0 Semester Hrs.
(I, II) This course will quickly review programming constructs using the syntax and semantics of the Java programming language. It will compare the constructs of Java with other languages and discuss program design and implementation. Object oriented programming concepts will be reviewed and applications, applets, servlets, graphical user interfaces, threading, exception handling, JDBC, and network - ing as implemented in Java will be discussed. The basics of the Java Virtual Machine will be presented. 3 hours lecture, 3 semester hours Prerequisite: CSCI306.

CSCI444. ADVANCED COMPUTER GRAPHICS. 3.0 Semester Hrs.
Equivalent with MATH444,
(II) This is an advanced computer graphics course, focusing on modern rendering and geometric modeling techniques. Students will learn a variety of mathematical and algorithmic techniques that can be used to develop high-quality computer graphic software. Runtime performance will be evaluated to create optimized real-time graphics applications. In particular, the course will cover global illumination, GPU programming, and virtual and augmented reality. Prerequisites: CSCI441. 3 hours lecture; 3 semester hours.

CSCI445. WEB PROGRAMMING. 3.0 Semester Hrs.
(I) Web Programming is a course for programmers who want to develop web-based applications. It covers basic website design extended by client-side and server-side programming. Students should acquire an understanding of the role and application of web standards to website development. Topics include Cascading Style Sheets (CSS), JavaScript, PHP and database connectivity. At the conclusion of the course students should feel confident that they can design and develop dynamic Web applications on their own. Prerequisite: CSCI262. Co-requisite: CSCI403. 3 hours lecture; 3 semester hours.

CSCI446. WEB APPLICATIONS. 3.0 Semester Hrs.
(II) In Web Applications students will learn how to build effective web-based applications. At the completion of this course, students should know HTTP, Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Ajax, and RESTful architectures. Additionally students should have considered a variety of issues related to web application architecture, including but not limited to security, performance, web frameworks and cloud-based deployment environments. Prerequisites: CSCI262. Co-requisites: CSCI403. 3 hours lecture; 3 semester hours.

CSCI447. SCIENTIFIC VISUALIZATION. 3.0 Semester Hrs.
Equivalent with MATH447,
(I) Scientific visualization uses computer graphics to create visual images which aid in understanding of complex, often massive numerical representation of scientific concepts or results. The main focus of this course is on modern visualization techniques applicable to spatial data such as scalar, vector and tensor fields. In particular, the course will cover volume rendering, texture based methods for vector and tensor field visualization, and scalar and vector field topology. Basic understanding of computer graphics and analysis of algorithms required. Prerequisites: CSCI262 and MATH441. 3 lecture hours, 3 semester hours.

CSCI448. MOBILE APPLICATION DEVELOPMENT. 3.0 Semester Hrs.
(II) This course covers basic and advanced topics in mobile application development. Topics include the mobile application lifecycle, user interface components and layouts, storing persistent data, accessing network resources, using location and sensor APIs including GPS and accelerometer, starting and stopping system services, and threading. This is a project-based course where students will design and develop complete applications. Prerequisite: CSCI306 with a grade of C- or higher. 3 hours lecture; 3 semester hours.

CSCI455. GAME THEORY AND NETWORKS. 3.0 Semester Hrs.
Equivalent with CSCI555,
(I) An introduction to fundamental concepts of game theory with a focus on the applications in networks. Game theory is the study that analyzes the strategic interactions among autonomous decision-makers. Originated from economics. Influenced many areas in Computer Science, including artificial intelligence, e-commerce, theory, and security and privacy. Provides tools and knowledge for modeling and analyzing real-world problems. Prerequisites: CSCI358, CSCI406. 3 hours lecture; 3 semester hours.

CSCI470. INTRODUCTION TO MACHINE LEARNING. 3.0 Semester Hrs.
(I) The goal of machine learning is to build computer systems that improve automatically with experience, which has been successfully applied to a variety of application areas, including, for example, gene discovery, financial forecasting, and credit card fraud detection. This introductory course will study both the theoretical properties of machine learning algorithms and their practical applications. Students will have an opportunity to experiment with machine learning techniques and apply them to a selected problem in the context of term projects. Prerequisite: CSCI101 or CSCI102 or CSCI 261, MATH201, MATH332.

CSCI471. COMPUTER NETWORKS I. 3.0 Semester Hrs.
(I) This introduction to computer networks covers the fundamentals of computer communications, using TCP/IP standardized protocols as the main case study. The application layer and transport layer of communication protocols will be covered in depth. Detailed topics include application layer protocols (HTTP, FTP, SMTP, and DNS), transport layer protocols (reliable data transfer, connection management, and congestion control), network layer protocols, and link layer protocols. In addition, students will program client/server network applications. Prerequisites: CSCI262, CSCI274. 3 hours lecture; 3 semester hours.

CSCI473. HUMAN-CENTERED ROBOTICS. 3.0 Semester Hrs.
Equivalent with CSCI573,
(II) Human-centered robotics is an interdisciplinary area that bridges research and application of methodology from robotics, machine vision, machine learning, human-computer interaction, human factors, and cognitive science. Students will learn about fundamental research in human-centered robotics, as well as develop computational models for robotic perception, internal representation, robotic learning, human-robot interaction, and robot cognition for decision making. Prerequisites: CSCI262 and MATH201. 3 hours lecture; 3 semester hours.

CSCI474. INTRODUCTION TO CRYPTOGRAPHY. 3.0 Semester Hrs.
Equivalent with MATH474,
(II) This course is primarily oriented towards the mathematical aspects of cryptography, but is also closely related to practical and theoretical issues of computer security. The course provides mathematical background required for cryptography, including relevant aspects of number theory and mathematical statistics. The following aspects of cryptography will be covered: symmetric and asymmetric encryption, computational number theory, quantum encryption, RSA and discrete log systems, SHA, steganography, chaotic and pseudo-random sequences, message authentication, digital signatures, key distribution and key management, and block ciphers. Many practical approaches and most commonly used techniques will be considered and illustrated with real-life examples. Prerequisites: CSCI262, CSCI358, MATH334 or MATH335 or MATH201. 3 hours lecture; 3 semester hours.

CSCI475. INFORMATION SECURITY AND PRIVACY. 3.0 Semester Hrs.
(I) Information Security and Privacy provides a hands-on introduction to the principles and best practices in information and computer security. Lecture topics will include basic components of information security including threat assessment and mitigation, policy development, forensics investigation, and the legal and political dimensions of information security. Prerequisite: CSCI 262 and CSCI 341 (required); CSCI 274 (recommended). 3 hours lecture; 3 semester hours.

CSCI477. ELEMENTS OF GAMES AND GAME DEVELOPMENT. 3.0 Semester Hrs.
(II) This course provides an overview of computer and video game development along with practical game projects designed to introduce the student to the computer entertainment industry. Topics will include the nature of games, the game player, game play, game design, game mechanics, story and character, game worlds, interface and the game development process. Students will be required to develop code both in C++ and with the use of a game engine. Prerequisite: CSCI262. 3 hours lecture; 3 semester hours.

CSCI478. INTRODUCTION TO BIOINFORMATICS. 3.0 Semester Hrs.
Bioinformatics is the theory, application and development of computing tools to solve problems and create hypotheses in all areas of biological sciences, which has contributed to advances in biology by providing tools that handle datasets too large and/or complex for manual analysis. This course focuses on an introduction to computational analysis of genetic variation and computational interdisciplinary research in genetics. The topics of this course include introduction to genetics, identification of genes involved in disease, inferring human population history, technologies for obtaining genetic information, and genetic sequencing, with an emphasis on formulating interdisciplinary problems as computational problems and then solving those problems using computational techniques from statistics and computer science. Prerequisite: CSCI101 or CSCI102 or CSCI261.

CSCI480. COMPUTER SCIENCE HONORS THESIS. 3.0 Semester Hrs.
(I, II) Prerequisite: CSCI306. 3 hours research; 3 semester hours. Repeatable for credit up to 6 semester hours.

CSCI490. PROGRAMMING CHALLENGES III. 1.0 Semester Hr.
This course is the third of three courses in the Programming Challenges sequence which covers problem solving patterns and paradigms found in technical interviews and programming competitions. The students will learn more advanced dynamic programming, graph theory, and algorithms while focusing on algorithmic complexity to solve problems in a finite amount of time. Prerequisite: CSCI390. Co-requisite: CSCI406.

CSCI498. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CSCI499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professor and Department Head

Tracy Camp

Professors

Qi Han

Dinesh Mehta

Associate Professors

Hua Wang

Bo Wu

Dejun Yang

Chuan Yue

Hao Zhang

Assistant Professors

Mehmet Belviranli

Neil Dantam

Jedidiah McClurg

Thomas Williams

Teaching Professors

Vibhuti Dave

Christopher Painter-Wakefield

Teaching Associate Professors

Wendy Fisher, Assistant Department Head

Jeffrey Paone

Teaching Assistant Professor

Amelia Read

Professor of practice

Mark Baldwin

Phil Romig

Emeriti Professor

William Hoff, Emeritus Associate Professor

Cyndi Rader, Emeritus Teaching Professor

Economics and Business

Degrees Offered:

- Bachelor of Science in Economics
- Bachelor of Science in Business Engineering and Management Science

Program Description

The economy is becoming increasingly global and dependent on advanced technology. In such a world, private companies and public organizations need leaders and managers who understand economics and business, as well as science and technology.

Programs in the Division of Economics and Business are designed to bridge the gap that often exists between economists and managers, on the one hand, and engineers and scientists, on the other. All Mines undergraduate students are introduced to economic principles in a required course, and many pursue additional course work in minor programs or elective courses. The courses introduce undergraduate students to economic and business principles so that they will understand the economic and business environments, both national and global, in which they will work and live.

In keeping with the mission of the Colorado School of Mines, the Division of Economics and Business offers a Bachelor of Science in Economics. Most economics degrees at other universities are awarded as a Bachelor of Arts, with a strong liberal arts component. Our degree is grounded in mathematics, engineering and the sciences. We graduate technologically literate economists with quantitative economics and business skills that give them a competitive advantage in today's economy.

Economics majors have a range of career options following their undergraduate studies. Some pursue graduate degrees in economics, business, or law. Others begin careers as managers, economic advisors, and financial officers in business or government, often in organizations that deal with engineering, applied science, and advanced technology.

Bachelor of Science in Economics

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the educational objectives of the undergraduate program in economics and business are:

1. To provide students with a strong foundation in economic theory and analytical techniques, taking advantage of the mathematical and quantitative abilities of CSM undergraduate students; and
2. To prepare students for the work force, especially in organizations in CSM's areas of traditional strength (engineering, applied science, mathematics and computer science), and for graduate school, especially in economics, business, and law.

Curriculum

All economics majors take forty-five percent of their courses in math, science, and engineering, including the same core required of all CSM undergraduates. Students take another forty percent of their courses in economics and business. The remaining fifteen percent of the course work can come from any field. Many students complete minor programs in a technical field, such as computer science, engineering, geology or environmental science. A number of students pursue double majors.

To complete the economics major, students must take 45 hours of 300 and 400 level economics and business courses. Of these, 18 hours must be at the 400 level. At least 30 of the required 45 hours must be taken in residence in the home department. For students participating in an approved foreign study program, up to 19 hours of the 30 hours in residence requirement may be taken abroad.

Degree Requirements in Economics

Freshman

Fall		**lec**	**lab**	**sem.hrs**
DIST SCI	Distributed Science*	4.0		4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
EDNS151	DESIGN I			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
PHGN100	PHYSICS I - MECHANICS	4.5		4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0		3.0
HASS100	NATURE AND HUMAN VALUES			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
HASS200	GLOBAL STUDIES			3.0
FREE	Free Elective	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				13.5

Spring		**lec**	**lab**	**sem.hrs**
EBGN301	INTERMEDIATE MICROECONOMICS	3.0		3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
FREE	Free Elective			3.0
EBGN	EBGN Elective I**	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		lec	lab	sem.hrs
EBGN302	INTERMEDIATE MACROECONOMICS	3.0		3.0
EBGN425	BUSINESS ANALYTICS			3.0
EBGN	EBGN Elective II**	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				15.0

Spring		lec	lab	sem.hrs
EBGN303	ECONOMETRICS	3.0		3.0
EBGN321	ENGINEERING ECONOMICS	3.0		3.0
EBGN409	MATHEMATICAL ECONOMICS*** or EBGN Elective III**	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				15.0

Summer		lec	lab	sem.hrs
EBGN403	FIELD SESSION	3.0		3.0
				3.0

Senior

Fall		lec	lab	sem.hrs
EBGN401	ADVANCED TOPICS IN ECONOMICS	3.0		3.0
EBGN455	LINEAR PROGRAMMING*** or EBGN Elective III**	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective	3.0		3.0
EBGN	EBGN Elective IV**	3.0		3.0
FREE	Free Elective	3.0		3.0
				15.0

Spring		lec	lab	sem.hrs
EBGN	EBGN Elective V**	3.0		3.0
EBGN	EBGN Elective VI**	3.0		3.0
EBGN	EBGN Elective VII**	3.0		3.0
FREE	Free Electives	3.0		3.0
FREE	Free Electives	3.0		3.0
				15.0

Total Semester Hrs: 124.0

* Students in all degree options (majors) are required to complete a minimum of three out of five courses from the list of Distributed Science Requirements. For Economics Majors, students must take CSCI101 and MATH201 and one of the following: CBEN110, GEGN101, PHGN200, CHGN122, or CHGN125.

** At least 2 EBGN elective courses must be at the 400-level or above.

*** Students must take either EBGN409 or EBGN455.

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- EBGN100 through EBGN599 inclusive

Bachelor of Science in BUSINESS ENGINEERING AND MANAGEMENT SCIENCE

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile, the Division of Economics and Business has established the following program educational objectives for the BS in Business Engineering and Management Science:

Upon completion of the Business Engineering and Management Science degree, students will be able to:

1. Identify, access, validate, and visualize relevant data to inform business decisions.
2. Demonstrate proficiency with deterministic and stochastic analytical tools.
3. Demonstrate mastery of basic business principles.
4. Build models and apply quantitative tools to inform decisions about business strategy and operations.
5. Communicate effectively in a professional context in a variety of formats.
6. Identify and propose solutions to ethical issues in business decision-making.
7. Demonstrate expertise in their track areas of choice.

Curriculum

The BS in Business Engineering and Management Science develops graduates with applied quantitative skills that Mines is known for including data science, data analytics, and operations research. This degree lies at the intersection of technical skills and business training and enables students to develop leadership skills and passion that are needed in today's rapidly changing, technology-focused business world.

The Business Engineering and Management Science degree provides comprehensive training in two core areas: Data Analytics and Operations Research, and Business Principles. The Data Analytics and Operations Research core includes courses in data science, mathematics, applied statistics, and optimization modeling. The Business Principles core includes accounting, finance, marketing, communications, and management. In addition to these core courses, students specialize in tracks that allow them to deepen their knowledge of specific application areas. Students choose two 4-course tracks from a selection of Business Analytics, Financial Engineering, Artificial Intelligence and Machine Learning, Advanced Manufacturing, and Technology Management.

Degree Requirements in Business Engineering and Management Science

Freshman

Fall		lec	lab	sem.hrs
CSCI101 & CSCI102				4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
				16.5

Spring		lec	lab	sem.hrs
PHGN100	PHYSICS I - MECHANICS			4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
EDNS151	DESIGN I			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS			3.0
HASS200	GLOBAL STUDIES			3.0
EBGN305	FINANCIAL ACCOUNTING			3.0
EBGN307	BUSINESS COMMUNICATION*			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.5

Spring		lec	lab	sem.hrs
MATH225	DIFFERENTIAL EQUATIONS			3.0
CSCI303	INTRODUCTION TO DATA SCIENCE			3.0
EBGN303	ECONOMETRICS			3.0
DISTRIBUTED SCIENCE				4.0
FREE: Free Elective				3.0
PAGN Elective: PHYSICAL ACTIVITY COURSE				0.5
				16.5

Junior

Fall		lec	lab	sem.hrs
EBGN308	PRINCIPLES OF MARKETING*			3.0
EBGN345	PRINCIPLES OF CORPORATE FINANCE			3.0
MATH332	LINEAR ALGEBRA			3.0
TRACK 1 TECHNICAL ELECTIVE #1				3.0
TRACK 2 TECHNICAL ELECTIVE #1				3.0
ELECTIVE	H&SS Mid-Level Restricted Elective			3.0
				18.0

Spring		lec	lab	sem.hrs
EBGN455	LINEAR PROGRAMMING or MEGN 486			3.0
EBGN453	PROJECT MANAGEMENT			3.0
EBGN461	STOCHASTIC MODELS IN MANAGEMENT SCIENCE			3.0
TRACK 1 TECHNICAL ELECTIVE #2				3.0
TRACK 2 TECHNICAL ELECTIVE #2				3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Senior

Fall		lec	lab	sem.hrs
EBGN425	BUSINESS ANALYTICS			3.0
TRACK1 TECHNICAL ELECTIVE #3				3.0
TRACK 2 TECHNICAL ELECTIVE #3				3.0
ELECTIVE	H&SS Mid-Level Restricted Elective			3.0
FREE	Free Elective			3.0
				15.0

Spring		lec	lab	sem.hrs
EBGN485	BUSINESS STRATEGY			3.0
TRACK 1 TECHNICAL ELECTIVE #4				3.0
TRACK 2 TECHNICAL ELECTIVE #4				3.0
ELECTIVE	H&SS 400-Level Restricted Elective			3.0
FREE	Free Elective			3.0
				15.0

Total Semester Hrs: 128.0

* New Courses

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Minor Program in Economics

The minor in Economics requires that students complete 6 courses from the Division of Economics and Business, for a total of 18.0 credit hours. Minors are required to take Principles of Economics (EBGN201) and either Intermediate Microeconomics (EBGN301) or Intermediate Macroeconomics (EBGN302). Students must complete 4 additional EBGN courses. Up to 9 of the 18 hours required for the Economics minor may be used for other degree requirements including Humanities & Social Science (H&SS) electives. At least 9.0 of the hours required for the Economics minor must not be used for any part of the degree other than Free Electives.

Program Requirements:

EBGN201	PRINCIPLES OF ECONOMICS	3.0
EBGN301	INTERMEDIATE MICROECONOMICS	3.0
or EBGN302	INTERMEDIATE MACROECONOMICS	

EBGNXXX	Economics Electives	12.0
Total Semester Hrs		**18.0**

Minor in Business and Entrepreneurship

The Minor in Business and Entrepreneurship provides the opportunity for students to gain skills and knowledge in business and entrepreneurship. The minor requires that students complete 6 business courses for a total of 18.0 credit hours. Requirements as follows:

Required		
EBGN201	PRINCIPLES OF ECONOMICS	3.0
EBGN321	ENGINEERING ECONOMICS	3.0
Select 4 of the following:		
EBGN230	INTRODUCTION TO BUSINESS	3.0
EBGN304	PERSONAL FINANCE	3.0
EBGN305	FINANCIAL ACCOUNTING	3.0
EBGN345	PRINCIPLES OF CORPORATE FINANCE	3.0
EBGN346	INTRODUCTION TO INVESTMENTS	3.0
EBGN360	INTRODUCTION TO ENTREPRENEURSHIP	3.0
EBGN425	BUSINESS ANALYTICS	3.0
EBGN453	PROJECT MANAGEMENT	3.0
EBGN460	BUSINESS MODEL DEVELOPMENT	3.0
EBGN485	BUSINESS STRATEGY	3.0

At least 9.0 of the hours required for the Business and Entrepreneurship minor must not be used for any part of the degree other than Free Electives.

Area of Special Interest in Economics

The area of special interest in Economics requires that students complete Principles of Economics (EBGN201) and 3 other EBGN courses for a total of 12 credit hours. Except for Principles of Economics (EBGN201), EBGN courses taken to complete the ASI in Economics must not be used for any part of the degree other than Free Electives.

EBGN201	PRINCIPLES OF ECONOMICS	3.0
EBGNXXX	Economics Electives	9.0
Total Semester Hrs		**12.0**

Area of Special Interest in Entrepreneurship

The objective of the Area of Special Interest in Entrepreneurship is to supplement an engineering or applied science education with tools and processes to recognize and evaluate entrepreneurial opportunities.
These tools include financial forecasting, business models and the interrelationships of business functions including accounting, marketing, finance, human resources and operations. The processes include developing feasibility studies and business plans.

The area of Special Interest in Entrepreneurship requires that students complete Principles of Economics (EBGN201), Introduction to Entrepreneurship (EBGN360), Business Model Development (EBGN460), and one additional business course for a total of 12 credit hours.

EBGN201	PRINCIPLES OF ECONOMICS	3.0
EBGN360	INTRODUCTION TO ENTREPRENEURSHIP	3.0
EBGN460	BUSINESS MODEL DEVELOPMENT	3.0
Select 1 of the following:		
EBGN304	PERSONAL FINANCE	3.0
EBGN321	ENGINEERING ECONOMICS	3.0
EBGN345	PRINCIPLES OF CORPORATE FINANCE	3.0
EBGN346	INTRODUCTION TO INVESTMENTS	3.0
EBGN425	BUSINESS ANALYTICS	3.0
EBGN485	BUSINESS STRATEGY	3.0

Courses

EBGN198. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EBGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EBGN201. PRINCIPLES OF ECONOMICS. 3.0 Semester Hrs.
(I,II,S) Introduction to microeconomics and macroeconomics. This course focuses on applying the economic way of thinking and basic tools of economic analysis. Economic effects of public policies. Analysis of markets for goods, services and resources. Tools of cost-benefit analysis. Measures of overall economic activity. Determinants of economic growth. Monetary and fiscal policy. Prerequisites: None. 3 hours lecture; 3 semester hours.

EBGN230. INTRODUCTION TO BUSINESS. 3.0 Semester Hrs.
An introduction to everything business. In this class, you will explore why businesses are formed, what gives them a competitive advantage in the market, and how businesses report information to the public. You will also learn best practices for individual behavior and success when operating in a business environment, including what makes for a good business presentation, leading and communicating with teams, and project decision analysis. Being business smart is the foundation of every career path moving forward.

EBGN298. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EBGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EBGN301. INTERMEDIATE MICROECONOMICS. 3.0 Semester Hrs.
Equivalent with EBGN411,
This course introduces the theoretical and analytical foundations of microeconomics and applies these models to the decisions and interactions of consumers, producers and governments. Develops and applies models of consumer choice and production with a focus on general equilibrium results for competitive markets. Examines the effects of market power and market failures on prices, allocation of resources and social welfare. Prerequisite: EBGN201 and MATH213.

EBGN302. INTERMEDIATE MACROECONOMICS. 3.0 Semester Hrs.
Equivalent with EBGN412,
Intermediate macroeconomics provides a foundation for analyzing both short-run and long-run economic performance across countries and over time. The course discusses macroeconomic data analysis (including national income and balance of payments accounting), economic fluctuations and the potentially stabilizing roles of monetary, fiscal and exchange rates policies, the role of expectations and intertemporal considerations, and the determinants of long-run growth. The effects of external and internal shocks (such as oil price shocks, resource booms and busts) are analyzed. Prerequisite: EBGN201 and MATH213.

EBGN303. ECONOMETRICS. 3.0 Semester Hrs.
Equivalent with EBGN390,
Introduction to econometrics, including ordinary least-squares and single- equation models; two-stage least-squares and multiple-equation models; specification error, serial correlation, heteroskedasticity, and other problems; distributive-lag models and other extensions, hypothesis testing and forecasting applications. Prerequisite: EBGN201 and MATH201.

EBGN304. PERSONAL FINANCE. 3.0 Semester Hrs.
The management of household and personal finances. Overview of financial concepts with special emphasis on their application to issues faced by individuals and households: budget management, taxes, savings, housing and other major acquisitions, borrowing, insurance, investments, meeting retirement goals, and estate planning. Survey of principles and techniques for the management of a household's assets and liabilities. Study of financial institutions and their relationship to households, along with a discussion of financial instruments commonly held by individuals and families.

EBGN305. FINANCIAL ACCOUNTING. 3.0 Semester Hrs.
Survey and evaluation of balance sheets and income and expense statements, origin and purpose. Evaluation of depreciation, depletion, and reserve methods for tax and internal management purposes. Cash flow analysis in relation to planning and -decision making. Inventory methods and cost controls related to dynamics of production and processing. Prerequisite: EBGN201.

EBGN306. MANAGERIAL ACCOUNTING. 3.0 Semester Hrs.
Introduction to cost concepts and principles of management accounting including cost accounting. The course focuses on activities that create value for customers and owners of a company and demonstrates how to generate cost-accounting information to be used in management decision making. Prerequisite: EBGN201, EBGN305.

EBGN310. ENVIRONMENTAL AND RESOURCE ECONOMICS. 3.0 Semester Hrs.
(I) (WI) Application of microeconomic theory to topics in environmental and resource economics. Topics include analysis of pollution control, benefit/cost analysis in decision-making and the associated problems of measuring benefits and costs, non-renewable resource extraction, measures of resource scarcity, renewable resource management, environmental justice, sustainability, and the analysis of environmental regulations and resource policies. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

EBGN315. THE ECONOMICS OF STRATEGY. 3.0 Semester Hrs.
An introduction to game theory and industrial organization (IO) principles at a practical and applied level. Topics include economies of scale and scope, the economics of the make-versus-buy decision, market structure and entry, dynamic pricing rivalry, strategic positioning, and the economics of organizational design. Prerequisite: EBGN201.

EBGN320. ECONOMICS AND TECHNOLOGY. 3.0 Semester Hrs.
(II) The theoretical, empirical and policy aspects of the economics of technology and technological change. Topics include the economics of research and development, inventions and patenting, the Internet, e-commerce, and incentives for efficient implementation of technology. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

EBGN321. ENGINEERING ECONOMICS. 3.0 Semester Hrs.
Equivalent with CHEN421,
Time value of money concepts of present worth, future worth, annual worth, rate of return and break-even analysis applied to after-tax economic analysis of mineral, petroleum and general investments. Related topics on proper handling of (1) inflation and escalation, (2) leverage (borrowed money), (3) risk adjustment of analysis using expected value concepts, (4) mutually exclusive alternative analysis and service producing alternatives. Prerequisite: EBGN201.

EBGN330. ENERGY ECONOMICS. 3.0 Semester Hrs.
Equivalent with ENGY330,
Study of economic theories of optimal resource extraction, market power, market failure, regulation, deregulation, technological change and resource scarcity. Economic tools used to analyze OPEC, energy mergers, natural gas price controls and deregulation, electric utility restructuring, energy taxes, environmental impacts of energy use, government R&D programs, and other energy topics. Prerequisite: EBGN201.

EBGN340. ENERGY AND ENVIRONMENTAL POLICY. 3.0 Semester Hrs.
This course considers the intersection of energy and environmental policy from an economic perspective. Policy issues addressed include climate change, renewable resources, externalities of energy use, transportation, and economic development and sustainability. Prerequisites: EBGN201. 3 hours lecture; 3 semester hours.

EBGN345. PRINCIPLES OF CORPORATE FINANCE. 3.0 Semester Hrs.
(II) Introduction to corporate finance, financial management, and financial markets. Time value of money and discounted cash flow valuation, risk and returns, interest rates, bond and stock valuation, capital budgeting and financing decisions. Introduction to financial engineering and financial risk management, derivatives, and hedging with derivatives. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

EBGN346. INTRODUCTION TO INVESTMENTS. 3.0 Semester Hrs.
This course is an introduction to the principles of investment in competitive financial markets. The course will provide an overview to: 1) the structure of capital markets, 2) theories and practice of portfolio construction and management, 3) asset pricing theories used to analyze securities, 4) equity and debt securities, and 4) derivative instruments. 3 hours lecture; 3 semester hours. Prerequisite: EBGN201.

EBGN360. INTRODUCTION TO ENTREPRENEURSHIP. 3.0 Semester Hrs.
This course introduces students to the entrepreneurial process, focusing on the concepts, practices, and tools of the entrepreneurial world. This will be accomplished through a combination of readings, cases, speakers, and projects designed to convey the unique environment of entrepreneurship and new ventures. The mastery of concepts covered in this course will lead to an initial evaluation of new venture ideas. In this course students will interact with entrepreneurs, participate in class discussion, and be active participants in the teaching/learning process. 3 hours lecture; 3 semester hours.

EBGN398. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EBGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EBGN401. ADVANCED TOPICS IN ECONOMICS. 3.0 Semester Hrs.
(I) Application of economic theory to microeconomic and macroeconomic problems. This course will involve both theoretical and empirical modeling. Specific topics will vary by semester depending on faculty and student interest. Topics may include general equilibrium modeling, computational economics, game theory, the economics of information, intertemporal allocations, economic growth, microfoundations of macroeconomic models and policy simulation. Prerequisites: EBGN301, EBGN302 and EBGN303. 3 hours lecture; 3 semester hours.

EBGN403. FIELD SESSION. 3.0 Semester Hrs.
Equivalent with EBGN402,
An applied course for students majoring in economics. The field session may consist of either participation in a computer simulation or an independent research project under the supervision of a faculty member. In the computer simulation, students work as part of the senior executive team of a company and are responsible for developing and executing a strategy for their company with on-going decisions on everything from new product development, to marketing, to finance and accounting. Prerequisite: EBGN301, EBGN302, EBGN303.

EBGN409. MATHEMATICAL ECONOMICS. 3.0 Semester Hrs.
Application of mathematical tools to economic problems. Coverage of mathematics needed to read published economic literature and to do graduate study in economics. Topics from differential and integral calculus, matrix algebra, differential equations, and dynamic programming. Applications are taken from mineral, energy, and environmental issues, requiring both analytical and computer solutions using programs such as GAMS and MATHEMATICA. Prerequisite: MATH213, EBGN301, EBGN302.

EBGN425. BUSINESS ANALYTICS. 3.0 Semester Hrs.
With the increasing availability of large volumes of raw business data, the process of converting it into meaningful insights has become critical for organizations to stay competitive. Driven by massive volumes of business data, business analytics has become instrumental in unveiling such managerial practices which guide the decision making process in companies at every operational stage. This course includes various descriptive, predictive and prescriptive business analytics strategies. It provides fundamental skills using quantitative tools to organize, process, and critically interpret business data, as well as key concepts in quantitative decision making to model and solve real-world problems. Prerequisite: EBGN201, MATH112.

EBGN430. ADVANCED ENERGY ECONOMICS. 3.0 Semester Hrs.
(I) (WI) Application of economic models to understand markets for oil, gas, coal, electricity, and renewable energy resources. Models, modeling techniques and applications include market structure, energy efficiency, demand-side management, energy policy and regulation. The emphasis in the course is on the development of appropriate models and their application to current issues in energy markets. Prerequisites: EBGN301, EBGN330. 3 hours lecture; 3 semester hours.

EBGN434. PROPERTY RIGHTS AND NATURAL RESOURCES. 3.0 Semester Hrs.
When choosing how to allocate our scarce resources, institutions serve as constraints at any given time. Over time, these institutions form and evolve when it appears profitable to do so. This course focuses on the North American story of resource use and draws on economics, law, and history to understand those processes and their implications. The course will provide a framework to understand why certain institutions were adopted and how they now shape our economic decisions today. Prerequisite: EBGN201.

EBGN435. ECONOMICS OF WATER RESOURCES. 3.0 Semester Hrs.
This course seeks to develop the underlying economic problems of water use and how policy impacts the allocation of water in our economy. Water is a critical input for a number of sectors; from our basic sustenance to agriculture production, from industrial processes to ecological services, and from mineral extraction to energy production. Meanwhile, the supply of water is highly variable across space and through time while pollutants can further diminish the useable extent, making the policies to allocate and manage the resource central to understanding how the resource is utilized. The course will survey topics across sectors and water sources while applying economic theory and empirical/policy analysis. Prerequisite: EBGN409 or MATH213.

EBGN437. REGIONAL ECONOMICS. 3.0 Semester Hrs.
(II) (WI) Analysis of the spatial dimension of economies and economic decisions. Interregional capital and labor mobility. Location decisions of firms and households. Agglomeration economies. Models of regional economic growth. Measuring and forecasting economic impact and regional growth. Local and regional economic development policy. Urban and regional spatial structure. Emphasis on application of tools and techniques of regional analysis. Prerequisite: EBGN301 or EBGN302. 3 hours lecture; 3 semester hours.

EBGN441. INTERNATIONAL ECONOMICS. 3.0 Semester Hrs.
Theories and determinants of international trade, including static and dynamic comparative advantage and the gains from trade. The history of arguments for and against free trade. The political economy of trade policy in both developing and developed countries. Prerequisite: EBGN301.

EBGN443. PUBLIC ECONOMICS. 3.0 Semester Hrs.
This course covers public-sector economics, including the fundamental institutions and relationships between the government and private decision makers. It covers the fundamental generalequilibrium welfare theorems and their interaction with government policy instruments that affect efficiency and distribution. Normative topics include an intensive study of the causes and consequences of, and policy prescriptions for, market failure due to public goods, or other problems associated with externalities and income distribution. Positive analysis focuses on policy formation in the context of political- economy and public choice theories. Prerequisite: EBGN301.

EBGN444. INNOVATE X. 3.0 Semester Hrs.
Innovate X introduces concepts and tools to accelerate the design, validation and adoption of innovations in support of creative problem solving. Using an entrepreneurial mindset, we learn how to identify and frame problems that beneficiaries and stakeholders face. We attempt to design and test practical solutions to those problems in collaboration with those who experience the problems. We apply beneficiary discovery, pretotyping, business model design (social, economic and environmental), constrained creativity, efficient experimentation, and rapid iteration. While resolving challenges involves technical solutions, an important aspect of this course is directly engaging beneficiaries and stakeholders in social contexts to develop solutions with strong impact potential. Innov8x is grounded in collaborative creativity theory at the intersection of organizational behavior (social psychology), design principles, entrepreneurship and innovation management.

EBGN453. PROJECT MANAGEMENT. 3.0 Semester Hrs.
Project management has evolved into a business process broadly used in organizations to accomplish goals and objectives through teams. This course covers the essential principles of traditional project management consistent with professional certification requirements (the Project Management Institute's PMP certification) as well as an introduction to current agile project management methodologies. The traditional project management phases of project initiation, planning, execution, monitoring and control, and project closure are covered including related scheduling, estimating, risk assessment and other analytical tools. Students will gain experience using Microsoft Project. Organizational structure and culture issues are analyzed to understand how they can impact project management success, and the concepts of project portfolios and project programs are applied from the organizational perspective. Agile project management methodologies are introduced, including adaptive and iterative processes, scrum, lean and other Agile tools and techniques. By the end of the course, students will understand how traditional and agile project differ.

EBGN455. LINEAR PROGRAMMING. 3.0 Semester Hrs.
This course addresses the formulation of linear programming models, examines linear programs in two dimensions, covers standard form and other basics essential to understanding the Simplex method, the Simplex method itself, duality theory, complementary slackness conditions, and sensitivity analysis. As time permits, multi-objective programming, an introduction to linear integer programming, and the interior point method are introduced. Applications of linear programming models discussed in this course include, but are not limited to, the areas of manufacturing, finance, energy, mining, transportation and logistics, and the military. Prerequisite: MATH332 or MATH348 or EBGN409.

EBGN459. SUPPLY CHAIN MANAGEMENT. 3.0 Semester Hrs.
As a quantitative managerial course, the course will explore how firms can better organize their operations so that they more effectively align their supply with the demand for their products and services. Supply Chain Management (SCM) is concerned with the efficient integration of suppliers, factories, warehouses and retail-stores (or other forms of distribution channels) so that products are provided to customers in the right quantity and at the right time. Topics include managing economies of scale for functional products, managing market- mediation costs for innovative products, make-to order versus make-to-stock systems, quick response strategies, risk pooling strategies, supply-chain contracts and revenue management. Additional "special topics" will also be introduced, such as reverse logistics issues in the supply-chain or contemporary operational and financial hedging strategies. Prerequisite: None.

EBGN460. BUSINESS MODEL DEVELOPMENT. 3.0 Semester Hrs.
(II) This course leads students through the process of developing and validating a business model for an innovative product or service by a start-up or an established organization. The creation of a business model can be challenging, frustrating, fascinating and fulfilling. Building on skills learned in EBGN360, students explore ways to sustain and scale a promising new product or service in any context: commercial/for-profit, social/non-profit or government. It is an iterative process that involves uncovering beneficiary needs and leads to an in-depth understanding of how value is delivered, differentiated and captured. Students work in teams since new ventures are started by teams with complementary skills and a shared purpose. This is a demanding, hands-on course that integrates knowledge from entrepreneurship, business, economics and engineering classes. Students are expected to initiate and drive an intense beneficiary discovery process that involves reaching out to beneficiaries and engaging them outside class. Prerequisite: EBGN360. 3 hours lecture; 3 semester hours.

EBGN461. STOCHASTIC MODELS IN MANAGEMENT SCIENCE. 3.0 Semester Hrs.
As a quantitative managerial course, the course is an introduction to the use of probability models for analyzing risks and economic decisions and doing performance analysis for dynamic systems. The difficulties of making decisions under uncertainty are familiar to everyone. We will learn models that help us quantitatively analyze uncertainty and how to use related software packages for managerial decision-making and to do optimization under uncertainty. Illustrative examples will be drawn from many fields including marketing, finance, production, logistics and distribution, energy and mining. The main focus of the course is to see methodologies that help to quantify the dynamic relationships of sequences of "random" events that evolve over time.

EBGN470. ENVIRONMENTAL ECONOMICS. 3.0 Semester Hrs.
(II) (WI) This course considers the role of markets as they relate to the environment. Topics discussed include environmental policy and economic incentives, market and non-market approaches to pollution regulation, property rights and the environment, the use of benefit/cost analysis in environmental policy decisions, and methods for measuring environmental and nonmarket values. Prerequisite: EBGN301. 3 hours lecture; 3 semester hours.

EBGN474. INVENTING, PATENTING AND LICENSING. 3.0 Semester Hrs.
(S) (WI) This course provides an introduction to the legal framework of inventing and patenting and addresses practical issues facing inventors. The course examines patent law, inventing and patenting in the corporate environment, patent infringement and litigation, licensing, and the economic impact of patents. Methods and resources for market evaluation, searching prior art, documentation and disclosure of invention, and preparing patent applications are presented. Prerequisite: None. 3 hours lecture; 3 semester hours.

EBGN485. BUSINESS STRATEGY. 3.0 Semester Hrs.
Business strategy is focused on formulating and implementing the major goals of the firm in relation to changing competitive environmental conditions, firm resources, and individuals' motives and values. This course is about the issues and challenges of running a firm in a competitive environment from the perspective of a senior manager. The challenge for senior managers goes well beyond applying an appropriate formula to a problem because to date there are not any universal formulas for successful companies. Rather, senior managers must be able to identify that a problem exists and then to bring resolution, despite partial information. This course requires identifying, analyzing, and solving firm problems with original thinking and execution. A key instructional objective of this course is to help you develop a rigorous approach for addressing complex business problems. Prerequisite: EBGN321 or EBGN345 or EBGN346.

EBGN495. ECONOMIC FORECASTING. 3.0 Semester Hrs.
An introduction to the methods employed in business and econometric forecasting. Topics include time series modeling, Box- Jenkins models, vector autoregression, cointegration, exponential smoothing and seasonal adjustments. Covers data collection methods, graphing, model building, model interpretation, and presentation of results. Topics include demand and sales forecasting, the use of anticipations data, leading indicators and scenario analysis, business cycle forecasting, GNP, stock market prices and commodity market prices. Includes discussion of links between economic forecasting and government policy. Prerequisite: EBGN301, EBGN302, EBGN303.

EBGN498. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 0.5-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EBGN499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professor

Roderick G. Eggert , Viola Vestal Coulter Professor, Deputy Director, Critical Materials Institute

Associate Professors

Jared C. Carbone

Michael B. Heeley

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Assistant professors

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Teaching Professors

Scott Houser, Interim Department Head

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Teaching Associate Professors

Andrew Pederson

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Professor of Practice

David Culbreth

Patrick Leach

Paul Zink

Professors Emeriti

Carol A. Dahl

John E. Tilton

Graham Davis

Franklin J. Stermole

Michael R. Walls

Engineering, Design, and Society

Program Description

The Division of Engineering, Design, and Society (EDS) engages in research, education, and outreach that inspires and empowers engineers and applied scientists to become innovative and impactful leaders. Our specialization is in socio-technical design, problem definition, and problem solution, and we seek to educate future leaders who will address the challenges of attaining a thriving, sustainable global society.

EDS is home to:

Bachelor of Science in Engineering: The BSE is an interdisciplinary design engineering degree that focuses on the creation of innovative solutions to the challenging problems facing people, societies, and the world. Through a sequence of Integrated Design Studios that bridge first-year Cornerstone Design and senior-year Capstone Design, students become experts in design methods that deploy engineering principles to address human problems in real-world contexts. The BSE provides the flexibility for students to create specialized focus areas that suit their individual career and personal interests, and it ensures they gain practical engineering experience throughout their education at Mines.

Humanitarian Engineering: Mines' Humanitarian Engineering (HE) program is recognized internationally for its research, education, and outreach in socially responsible engineering. At the undergraduate level, HE includes two minors, Engineering for Community Development and Leadership in Social Responsibility, along with a range of electives courses open to all Mines students. At the graduate level, our new interdisciplinary Humanitarian Engineering and Science program offers MS thesis and non-thesis degree options as well as a graduate certificate. HE enables Mines students to understand how engineering can contribute to co-creating just and sustainable solutions to the problems faced by communities globally.

Cornerstone Design@Mines: Cornerstone encompasses Design I (EDNS151) and Design II (EDNS251 or a similar second-year course). Design I, taken by all first-year Mines students, teaches open-ended problem solving, project management, professional communications, and teaming skills—all within a human-centered design framework. Design II, taken by approximately half of Mines sophomore engineering students, applies and advances lessons from Design I by responding to real-world engineering challenges.

Capstone Design@Mines: Capstone entails a culminating two-semester senior design sequence for most engineering students at Mines, including Civil Engineering, Electrical Engineering, Environmental Engineering, Mechanical Engineering, and the general Engineering degree programs. The Capstone program provides a unique client-sponsored, hands-on, interdisciplinary engineering project experience for Mines students.

Programs

Bachelor of Science in Engineering

The Bachelor of Science in Engineering (BSE) is a new design-focused engineering degree program at Mines that offers a rigorous, flexible, creative, interdisciplinary program of study. The BSE integrates:

1) The strength of Mines' traditions in **engineering**, built upon the fundamentals of mathematics, science, and engineering analysis

2) The inspiration and applied skills of studio-based **design education** focusing on innovation, creativity, and technological advance

3) The insights and analytic perspectives of the **humanities, arts, and social sciences** to focus attention on the right problems and the best overall solutions

The BSE curriculum revolves around hands-on, project-based design studios every semester, culminating in Capstone Design. We offer a unique approach to design engineering through our Integrative Design Studios, which bridge technical, social, and creative approaches to problem definition and solution. Additionally, the BSE allows students to specialize in a Focus Area of their choice, enabling students to pursue depth of study in an area of personal interest. Focus areas span emerging technologies, the application of technology to underserved user groups, and the creation of new technology-driven startups. BSE program details and course offerings are included under the Major tab above.

Humanitarian Engineering (HE)

HE connects students with a passion for contributing to social and environmental problem solving to Mines faculty who lead the field of applying engineering to pressing social, environmental, and community challenges. Integrating engineering with social sciences and design, the HE program includes minors, BSE focus areas, and elective courses that teach students how to work *with* the communities they seek to serve by co-creating solutions that promote justice, responsibility, and sustainability. HE serves students from a wide range of disciplines and who have diverse career goals spanning NGOs, government agencies and research groups, start-up businesses, and established companies. Seminar-style courses offered by the Engineering, Design, and Society Division and the Humanities, Arts, and Social Sciences Division, along with selected technical electives offered by other academic units across campus, provide students a balance of breadth and depth in areas related to Humanitarian Engineering. Students may also wish to pursue one of the two minors in Humanitarian Engineering or a related BSE Focus Area in Community Development or Corporate Sustainability. Program details and course listings are available under the Minor tab above.

ENGINEERING FOR COMMUNITY DEVELOPMENT

The Minor in Engineering for Community Development (ECD) is an evolution of the country's first minor in Humanitarian Engineering created by Mines in 2003. Designed specifically for engineers and applied scientists who want to serve communities, the ECD minor prepares students to become leaders in community development through engineering.

Graduates with the ECD minor can work at the US Peace Corps (see Mines Peace Corps Prep Program), community service NGOs, international organizations, or a range of companies hosting projects related to community development. The knowledge and skills learned through the ECD minor prepares graduates for any engineering job involving community engagement, cross-cultural work environments, or human-centered design.

The ECD minor is designed to fit with any degree program on campus. Please contact Professor Juan Lucena (jlucena@mines.edu) to sign up for the minor or for advice on course selection.

LEADERSHIP IN SOCIAL RESPONSIBILITY

The Minor in Leadership in Social Responsibility (LSR) is the country's first undergraduate minor in social responsibility designed specifically

for engineers and applied scientists. The LSR minor prepares Mines students to become leaders in promoting shared social, environmental, and economic value for companies and their stakeholders.

Graduates of the LSR minor are sought by corporate employers that desire engineers who are prepared to factor public perception and community acceptance into the decisions they make and the technologies and processes they design. Graduates will also be prepared to take jobs that focus on corporate social responsibility, stakeholder engagement, and sustainability.

The LSR minor is designed to fit with any degree program on campus. Please contact Professor Jessica Smith (jmsmith@mines.edu) to sign up for the minor or for advice on course selection.

Cornerstone Design@Mines

Cornerstone Design teaches students how to solve complex, open-ended problems using design methods, critical thinking, and professional workplace skills. Students work in multidisciplinary teams to learn through doing, with an emphasis on defining and iterating problems through a holistic lens of technology, people, and environment. Students apply a human-centered design methodology to understand a problem from multiple perspectives before attempting to solve it. Instruction is hands-on and experimental, with the instructor serving as both teacher and mentor.

Design I (EDNS151) has students working in teams on a semester-long project, learning to communicate technical ideas and solutions visually, orally, in writing, and through prototype demonstrations. Design I introduces students to the human-centered design process, which includes exploration, ideation, solution concept development, and validation, while also ensuring their solutions are viable, desirable, feasible, and sustainable.

Design II (EDNS251 and related courses) builds on the foundation of Design I by having student teams manage a client relationship and use commercial design software to model, predict, and analyze solution concepts. Students should check with their degree program to determine whether Design II is stipulated or permissible for satisfying program requirements.

Capstone Design@Mines

The Capstone Design sequence offers a one-of-a-kind, creative, multidisciplinary, team-based design experience emerging from combined efforts in civil, electrical, mechanical, environmental, and general engineering. It is increasingly recognized within the engineering community that many of the grand challenges facing society today will only be met by multidisciplinary approaches. Capstone Design embraces the uniqueness of each disciplinary approach while enabling students to address real-world, interdisciplinary challenges. Capstone Design is comprised by a two-semester, senior-year course sequence: Senior Design I (EDNS491) and Senior Design II (EDNS492).

Capstone Design addresses ABET accreditation guidelines for the engineering design component of engineering program curricula:

- Use of open-ended problems
- Formulation of design problem statements and specifications
- Consideration of multiple alternative solutions for a given challenge
- Assessment of the desirability, feasibility, and viability of proposed solutions

The **Capstone Design Showcase** celebrates the engineering educational achievements of participating students. This twice-yearly, campus-wide celebration offers students an opportunity to present the real-world, client-driven project work they have completed over the course of their senior year.

Bachelor of Science in Engineering

The Bachelor of Science in Engineering (BSE) is a flexible, interdisciplinary program of study combining:

1. The strength of a Mines' technical degree with fundamentals coursework in mathematics, science, and engineering
2. An integrated educational experience spanning engineering, design, innovation, social sciences, and the humanities and
3. A Focus Area allowing for a depth of study in an area of personal or career interest, such as innovation and emerging technologies, sustainability and socially responsible applications of engineering, or an individualized focus area at the intersection of technology and society.

These three components are brought together via:

4. A unique set of six Integrative Design Studios, culminating in the two-semester Capstone Design Studio.

The Integrative Design Studios teach students how to respond to authentic, open-ended problems by integrating diverse skills, perspectives, and disciplinary approaches. They also provide a broad set of design competencies that are applicable to solving problems in any domain. Students work on a wide variety of hands-on projects, individually and in teams, mastering the capacity to move creatively from ill-structured problems to concrete, innovative, human-centered solutions. Through this journey, students also develop a diverse project portfolio, illustrating their unique skills and individual identity as a design engineer.

In parallel with the experiential design approach of the integrative design studios, students have great flexibility in selecting engineering fundamentals and electives courses from a wide variety of engineering disciplines. This flexibility allows students to prepare for their chosen Focus Area or to chart their own engineering, innovation, or design pathways.

The program also includes a design practicum experience (EDNS392) for students to develop real-world work experience prior to their senior year and the selection of their Capstone Design@Mines project. This opportunity encourages students to explore career options early. It also helps them better understand how their individual design expertise can contribute to a variety of engineering problems, organizational needs, and multidisciplinary teams. Together, the key components of the program promote a “design early, design often, design real” approach to engineering education.

Program Educational Outcomes

Within several years of completing the degree, graduates with a Bachelor of Science in Engineering will be engaged in progressively more responsible positions as:

Innovators who are comfortable taking risks and who are energized by the belief that engineers help make the world a better place by improving people’s lives through technologies designed with and for people and the planet.

Design Thinkers who confidently approach engineering problems from a human and nature-centric perspective and identify multiple design

solutions before converging on improvements and results that balance technical, economic, environmental, and societal goals.

Impact Makers who are much more than "just" engineers, with a broad perspective to responsibly envision, design, and implement new technologies that make a positive impact on people, organizations, the environment, and society.

Student Outcomes

Graduates of the program will have attained ABET Student Outcomes 1-7.

Curriculum

The curriculum comprises six groups of coursework and experiential learning for a total of 133.5 credits:

Group 1		
The Core Curriculum		
Mathematics and the Basic Sciences		23.5
Physical Activity		2.0
Freshman Orientation and Success		0.5
Free Electives		9.0
Group 2		
Humanities & Social Science (H&SS) Requirement		
Communication		3.0
Economics		3.0
Humanities & Social Science (H&SS) Mid-Level Electives		6.0
Humanities & Social Science (H&SS) 400-Level Elective		3.0
Group 3		**10.5**
Distributed Science Requirement		
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	4.5
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0
or MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	
CBEN110	FUNDAMENTALS OF BIOLOGY I	3.0 - 4.0
or CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)	
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY	
or CSCI101	INTRODUCTION TO COMPUTER SCIENCE	
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	
or MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	
Group 4		**30.0**
Engineering Coursework Requirements		
Engineering Fundamentals (Statics, Circuits, Fluid Mechanics, Thermodynamics, Materials)		15.0
Engineering Electives		15.0
Group 5		**19.0**
Integrative Design Studios		
Freshman Design Studio		7.0
Sophomore Design Studio		6.0
Junior Design Studio		3.0
Junior Field Session		3.0
Group 6		**24.0**
Focus Area and Capstone Design		
Focus Area Coursework		18.0
Capstone Senior Design Studio		6.0

The BSE degree program offers students a combination of courses that includes core mathematics, basic and advanced sciences, engineering fundamentals, and foundational studies in the social sciences and humanities throughout the freshman and sophomore years.

There is strong alignment of the initial course sequence between this degree program and other engineering degree programs at Mines, allowing smooth entry into the Bachelor of Science in Engineering degree program at any time during the first two years.

In the junior and senior years, students complete fundamental engineering courses across the breadth of traditional engineering disciplines and pursue advanced disciplinary studies through additional engineering electives, emphasizing engineering's breadth as well as commonalities among different engineering disciplines. Integrated with their technical studies, students learn about the many human dimensions of defining and solving problems using perspectives and approaches from the social sciences, humanities, and design, including the creative, social, cultural, political (including policy), economic, and business components critical for understanding the big challenges facing society and the environment today.

A central component of this degree program is the extensive application of technical and non-technical skillsets in response to real-world problems throughout the Integrative Design Studios. This approach increases and solidifies students' understanding of the content from their other courses. The Integrative Design Studio culminates in the Capstone Design Studio sequence, where students draw together the entirety of their educational experience to solve client-sponsored engineering problems in specific areas of student interest.

Bachelor of Science in Engineering: Degree Requirements

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
EDNS200	COMMUNICATION			3.0
EDNS191	INTEGRATIVE DESIGN STUDIO IA*			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0
Spring		**lec**	**lab**	**sem.hrs**
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5

CSCI101	INTRODUCTION TO COMPUTER SCIENCE or MATH 201**#			3.0
EDNS192	INTEGRATIVE DESIGN STUDIO IB			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS**			4.5
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS, CBEN 110, CHGN 122, CHGN 125, CSCI 101, or GEGN 101**#			3.0
EDNS291	INTEGRATIVE DESIGN STUDIO IIA			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective##			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				18.0

Spring		**lec**	**lab**	**sem.hrs**
MATH225	DIFFERENTIAL EQUATIONS			3.0
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS, CBEN 210, or MEGN 361#			3.0
CEEN241	STATICS#			3.0
EDNS292	INTEGRATIVE DESIGN STUDIO IIB			3.0
ENGR	ENGINEERING ELECTIVE###			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
MTGN202	ENGINEERED MATERIALS or CEEN 311#			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER or 282#			3.0
ENGR	ENGINEERING ELECTIVE###			3.0
EDNS391	INTEGRATIVE DESIGN STUDIO IIIA			3.0
FOCUS	FOCUS AREA####			3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
PEGN251	FLUID MECHANICS, CBEN 307, CEEN 310, GEGN 351, or MEGN 351#			3.0
ENGR	ENGINEERING ELECTIVE###			3.0
ENGR	ENGINEERING ELECTIVE###			3.0
EDNS392	INTEGRATIVE DESIGN STUDIO IIIB			3.0
FOCUS	FOCUS AREA####			3.0
FREE	FREE ELECTIVE			3.0
				18.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
ENGR	ENGINEERING ELECTIVE###			3.0
EDNS491	SENIOR DESIGN I			3.0
FOCUS	FOCUS AREA####			3.0
FOCUS	FOCUS AREA####			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective##			3.0
FREE	FREE ELECTIVE			3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
EDNS492	SENIOR DESIGN II			3.0
FOCUS	FOCUS AREA####			3.0
FOCUS	FOCUS AREA####			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective##			3.0
FREE	FREE ELECTIVE			3.0
				15.0

Total Semester Hrs: 133.5

* The INTEGRATIVE DESIGN STUDIO IA and INTEGRATIVE DESIGN STUDIO IB course sequence satisfies parallel Humanities & Social Science (H&SS) plus EDNS151 requirements needed for other engineering degrees at Mines. Students may satisfy these requirements by separately taking HASS100 and EDNS151.

** A minimum of 10.5 credits of Core Distributed Science courses are required. Students must take PHGN200 (PHYSICS II – ELECTROMAGNETISM AND OPTICS) and two of the common distributed science courses: CBEN110, CHGN122 or CHGN125, CSCI101, GEGN101, and MATH201. One of CSCI101 (INTRODUCTION TO COMPUTER SCIENCE) or MATH201 (PROBABILITY AND STATISTICS FOR ENGINEERS) must be taken from this list, and both can be taken depending on student preference. Note that PHGN200 is 4.5 credit hours, the math and computer science courses are each 3.0 credit hours, and the remaining courses are each 4.0 credit hours.

**# Students have limited flexibility as to when to take two of their Core Distributed Science courses starting in their freshman year into early junior year, and should be decided in consultation with student's advisor to accommodate prerequisite requirements.

*** The EDNS291 INTEGRATIVE DESIGN STUDIO IIA and EDNS292 INTEGRATIVE DESIGN STUDIO IIB course sequence substitutes for HASS200 GLOBAL STUDIES and any one of the EDNS2XX DESIGN II courses or MEGN200 for this degree only. MEGN200 does not substitute for EDNS2XX DESIGN II credit in any other degree program at this time. Additionally, the INTEGRATIVE DESIGN STUDIO II sequence does not count toward MEGN200 credit for students transferring out of the BSE program into Mechanical Engineering at this time.

ENGINEERING FUNDAMENTALS courses are: (1) one of the **thermodynamics** courses CHGN209, CBEN210, or MEGN361; (2) **statics** CEEN241; (3) one of the **circuits** courses EENG281 or EENG282; (4) one of the **materials** courses MTGN202, CEEN311, or MEGN312; and (5) one of the **fluid mechanics** courses PEGN251, CBEN307,CEEN310, GEGN351, or MEGN351. Prerequisites may apply.

Humanities & Social Science (H&SS) Restricted Elective courses, a minimum of 9 credit hours of upper level coursework, as described in the Humanities, Arts, and Social Sciences section of the catalog. Focus Areas may list recommended courses to use for these electives.

ENGINEERING ELECTIVES are purposefully drawn from course offerings provided through other engineering programs. Details are provided in the following section. Some of the Focus Areas identify specific courses from the list of allowed engineering electives that must be taken to satisfy the requirements of the Focus Area. Those engineering elective courses are identified in the Focus Area description as being outside of the 18 credit hours allocated to Focus Area Coursework.

Focus Area courses are a coherent set of required and suggested elective offerings around a particular topic. Details are given the Focus Area Requirements section below.

Bachelor of Science in Engineering: Engineering Coursework Requirements:

A minimum of 30 credit hours of Engineering Coursework (designated as ENGR in the Bachelor of Science in Engineering Degree Requirements listing above) are required (typically ten courses). 15 credit hours (typically five courses) are prescribed ENGINEERING FUNDAMENTALS courses as noted in footnote # above. The additional 15 credit hours are ENGINEERING ELECTIVES. The requirement of 30 credits of Engineering Coursework may include engineering courses taken as a part of a student's Focus Areas (Focus Areas may require specific engineering courses be taken – see footnote ### above). This Engineering Coursework requirement combined with specific engineering content in the six INTEGRATIVE DESIGN STUDIOs (allocating 11 credit hours of the 18 credit hours for the design studios) and the Capstone Senior Design sequence (EDNS491 and EDNS492) produces 47 credit hours of engineering course work for this degree program. Note that certain ENGINEERING FUNDAMENTALS may also be prescribed by a Focus Area in order to satisfy prerequisite requirements. Likewise, students are encouraged to select ENGINEERING ELECTIVES to reinforce and complement the courses in the student's chosen Focus Area. ENGINEERING ELECTIVES must be chosen from the list below, or select 400-level courses discussed with and approved by the student's advisor. Finally, note that students must have at least 9 credit hours at or above the 300-level with a common theme or subject area within the group of courses that make up the required 30 credit hours of Engineering Coursework to ensure a reasonable level of disciplinary depth in a single field of engineering. Furthermore, students must have at least 9 credit hours at or above the 400-level plus the 6 credit hours of capstone senior design course and project work (EDNS491 and EDNS492).

The complexity of integrating various department curriculum, the potential for missing prerequisites, and the need to follow an expected course sequence requires that students develop a 2nd, 3rd and 4th year plan with their advisor during the first semester of their sophomore year course of study, and to collaboratively work with their advisor and Program Director for curricular assessment and approval prior to registration for every semester. The course plan is expected to be a dynamic roadmap for a student's particular degree curriculum.

The following engineering-content courses are used to satisfy the 15-credit hour requirement for ENGINEERING ELECTIVES. Please be aware of course prerequisites, reviewed with the student's advisor.

Chemical Engineering		
CBEN201	MATERIAL AND ENERGY BALANCES	3.0
CBEN308	HEAT TRANSFER	3.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS	3.0
CBEN375	CHEMICAL ENGINEERING SEPARATIONS	3.0
Civil & Environmental Engineering		
CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	3.0
CEEN312	SOIL MECHANICS	3.0
CEEN312L	SOIL MECHANICS LABORATORY	1.0
CEEN314	STRUCTURAL THEORY	3.0
CEEN360	INTRODUCTION TO CONSTRUCTION ENGINEERING	3.0
CEEN381	HYDROLOGY AND WATER RESOURCES ENGINEERING	3.0
Electrical Engineering & Electronics		
PHGN215	ANALOG ELECTRONICS	4.0
EENG284	DIGITAL LOGIC	4.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
PHGN317	SEMICONDUCTOR CIRCUITS- DIGITAL	3.0
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING	4.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS	3.0
Geological Engineering		
GEGN203	ENGINEERING TERRAIN ANALYSIS	2.0
GEGN204	GEOLOGIC PRINCIPLES AND PROCESSES	2.0
GEGN206	EARTH MATERIALS	3.0
GEGN307	PETROLOGY	3.0
GEGN342	ENGINEERING GEOMORPHOLOGY	3.0
Geology		
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY	3.0
GEOL310	EARTH MATERIALS	3.0
GEOL311	MINING GEOLOGY	3.0
GEOL315	SEDIMENTOLOGY AND STRATIGRAPHY	3.0
GEOL321	MINERALOGY AND MINERAL CHARACTERIZATION	3.0

Mechanical Engineering		
MEGN315	DYNAMICS	3.0
MEGN416	ENGINEERING VIBRATION	3.0
MEGN451	FLUID MECHANICS II - AERODYNAMICS	3.0
MEGN461	THERMODYNAMICS II	3.0
MEGN471	HEAT TRANSFER	3.0
Mining		
MNGN210	INTRODUCTORY MINING	3.0
MNGN316	COAL MINING METHODS	3.0
MNGN317	DYNAMICS FOR MINING ENGINEERS	1.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	3.0
Metallurgical and Materials Engineering		
MTGN311	STRUCTURE OF MATERIALS	3.0
MTGN311L	STRUCTURE OF MATERIALS LABORATORY	1.0
MTGN334	CHEMICAL PROCESSING OF MATERIALS	3.0
MTGN348	MICROSTRUCTURAL DEVELOPMENT	3.0
MTGN351	METALLURGICAL AND MATERIALS THERMODYNAMICS	3.0
MTGN352	METALLURGICAL AND MATERIALS KINETICS	3.0
MTGN381	INTRODUCTION TO PHASE EQUILIBRIA IN MATERIALS SYSTEMS	2.0
Petroleum Engineering		
PEGN305	COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING	2.0
PEGN308	RESERVOIR ROCK PROPERTIES	3.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS	3.0

Bachelor of Science in Engineering: Focus Areas

Focus Areas are a compilation of prescribed and suggested courses and topical projects that have been reviewed by a broad spectrum of faculty from multiple programs/departments and of varied professional background who assess the collection of content to encompass *technical, innovation, design, social/cultural, and environmental* pillars needed by students who plan to pursue a career in that focus area.

All Focus Areas require a minimum of 18 credit hours of course work which may include prescribed or recommended engineering courses. In addition to the directed Focus Area coursework, certain HASS and engineering electives may be suggested as supporting the Focus Area. Students should work closely with their advisor to select their electives in a way that complements their Focus Area studies.

In addition to coursework specific to their Focus Area, students must also complete a 6-credit hour, two-semester capstone senior design project. This project is the culmination of the student's studies and brings together content learned through the three previous years of Integrative Design Studios, science, mathematics, engineering coursework, and Focus Area coursework.

A limited number of Focus Areas are currently defined. New Focus Areas will be added periodically, depending on student and faculty interest, as described in a separate BSE Program Management document.

Current Focus Areas:

- **Energy Studies** (global energy development, sustainable energy, energy policy)
- **Robotics and Automation**
- **Water Security** (water quality, storage and management, efficient utilization, policy, law)
- **Music, Audio Engineering, and Recording Arts**
- **Corporate Sustainability**
- **Community Development**
- **STEM Teaching**
- **Individualized** (customized course of study)

Focus Area Requirements:

Focus Area – Energy Studies:

Students must take the following courses:

ENGY200	INTRODUCTION TO ENERGY	3.0
ENGY340	NUCLEAR ENERGY	3.0
ENGY350	GEOTHERMAL ENERGY	3.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0
PEGN450	ENERGY ENGINEERING *	3.0

* PEGN450 is also listed in the ENGINEERING ELECTIVE list of courses. Students may not count PEGN450 as an ENGINEERING ELECTIVE credit.

Students must also select one of the following courses:

EBGN330	ENERGY ECONOMICS	3.0
HASS486	SCIENCE AND TECHNOLOGY POLICY **	3.0
HASS490	ENERGY AND SOCIETY **	3.0

** HASS486 and HASS490, if used for Focus Area credits, may not also count toward the 9 credit hours of required Humanities & Social Science (H&SS) Restricted Electives.

Focus Area – Robotics and Automation:

Students must take the following courses:

MEGN315	DYNAMICS *	3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS *	3.0
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING *	4.0
MEGN441	INTRODUCTION TO ROBOTICS	3.0

* MEGN315, EENG307, and EENG383 are also listed in the ENGINEERING ELECTIVE list of courses. Students may not count these three courses as ENGINEERING ELECTIVE credits.

Students must also select two of the following courses:

CSCI404	ARTIFICIAL INTELLIGENCE	3.0
CSCI473	HUMAN-CENTERED ROBOTICS	3.0
MEGN481	MACHINE DESIGN	3.0
CSCI507	INTRODUCTION TO COMPUTER VISION	3.0

Focus Area – Water Security:

(Note - this Focus Area requires 20 credits of topical coursework.) For their ENGINEERING FUNDAMENTALS courses in fluids and materials students must select GEGN351 and CEEN311.

Students must take the following courses:

GEGN203	ENGINEERING TERRAIN ANALYSIS *	2.0
CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER *	3.0
CEEN381	HYDROLOGY AND WATER RESOURCES ENGINEERING *	3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0

* GEGN203, CEEN301, and CEEN381 are also listed in the ENGINEERING ELECTIVE list of courses. Students may not also count these three courses as ENGINEERING ELECTIVE courses.

Students must also select one of the following courses (both are recommended):

CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES	3.0
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT	3.0

Students must also select two of the following courses:

EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0
HASS486	SCIENCE AND TECHNOLOGY POLICY **	3.0
HASS488	GLOBAL WATER POLITICS AND POLICY **	3.0

** HASS486 and HASS488, if used for Focus Area credits, may not also count toward the 9 credit hours of Humanities & Social Science (H&SS) Restricted Electives.

Focus Area – Music, Audio Engineering, and Recording Arts:

Students must take the following courses**:

HASS324	AUDIO/ACOUSTICAL ENGINEERING AND SCIENCE	3.0
HASS326	MUSIC THEORY	3.0
HASS327	MUSIC TECHNOLOGY	3.0
HASS429	REAL WORLD RECORDING/RESEARCH	3.0

** HASS324, HASS326, HASS327, and HASS429 may not also count toward the required 9 credit hours of Humanities & Social Science (H&SS) Restricted Electives.

Students must also select 2 of the following courses:

MEGN315	DYNAMICS *	3.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS *	4.0
MEGN416	ENGINEERING VIBRATION *	3.0

* MEGN315, EENG385, and MEGN416, if used for Focus Area credits, may not also be used for ENGINEERING ELECTIVE credits.

It is also suggested that students participate in **Performance Enhancement** (3 credit hours total taken as Free Elective):

LIMU	ENSEMBLE	
LIMU189	INDIVIDUAL INSTRUMENTAL OR VOCAL MUSIC INSTRUCTION	1.0

Focus Area – Community Development:

Students must take the following courses:

EDNS315	ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY	3.0
EDNS477	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3.0
EDNS478	ENGINEERING AND SOCIAL JUSTICE *	3.0
EDNS479	COMMUNITY-BASED RESEARCH *	3.0

* EDNS477 EDNS478, and EDNS479 may not also count toward the 9 credit hours of Humanities & Social Science (H&SS) Restricted Electives.

Students must also select one of the following cross-cultural skills courses:

HASS425	INTERCULTURAL COMMUNICATION **	3.0
EDNS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD **	3.0

** HASS425 and EDNS475, if used for Focus Area credits, may not also count toward the 9 credit hours of Humanities & Social Science (H&SS) Restricted Electives.

Students must also select one of the following courses:

CEEN472	ONSITE WATER RECLAMATION AND REUSE	3.0
CEEN475	SITE REMEDIATION ENGINEERING	3.0

Focus Area – Corporate Sustainability:

Students must take the following courses:

EDNS315	ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY	3.0
ENGR	Any course(s) from the Engineering Coursework Requirements list *	3.0
EDNS430	CORPORATE SOCIAL RESPONSIBILITY	3.0
HASS448	GLOBAL ENVIRONMENTAL ISSUES **	3.0
EDNS479	COMMUNITY-BASED RESEARCH	3.0
EDNS480	ANTHROPOLOGY OF DEVELOPMENT	3.0

* ENGR must be a course other than any used for the 30 credit hours of ENGINEERING FUNDAMENTALS or ENGINEERING ELECTIVES.

** EDNS430, HASS448, EDNS479, and EDNS480 may not also count toward the 9 credit hours of Humanities & Social Science (H&SS) Restricted Electives.

Focus Area - STEM Teaching:

Students must take the following courses:

SCED262	K-12 FIELD EXPERIENCE AND BUILDING STUDENT RELATIONSHIPS	3.0

SCED333	EDUCATIONAL PSYCHOLOGY AND ASSESSMENT *	3.0
SCED363	DYNAMIC TEACHING: MOTIVATION, CLASSROOM MANAGEMENT, AND DIFFERENTIATION OF INSTRUCTION *	3.0

* SCED 333 and SCED 363 may not double-count for both the Focus Area and the Humanities & Social Science (H&SS) Restricted Electives

Students must also select one of the following courses:

MAED405	MATHEMATICAL PRACTICES AND THE SOCIAL CONTEXT OF MATHEMATICS	3.0
SCED415	SCIENTIFIC PRACTICES VS ENGINEERING DESIGN AND THE NATURE OF SCIENCE	3.0

Students must also select one of the following courses:

MAED425	PRE-ALGEBRA AND ALGEBRA TEACHING TECHNIQUES	3.0
MAED435	COMPUTER SCIENCE TEACHING TECHNIQUES	3.0
SCED445	PHYSICS AND CHEMISTRY TEACHING TECHNIQUES	3.0

Students must also select one of the following courses:

MAED464	CAPSTONE CURRICULUM DESIGN I	3.0
SCED464	CAPSTONE CURRICULUM DESIGN I	3.0

If students choose to use either SCED333 or SCED363 to fulfill part of their 9 required H&SS Restricted Electives, they then must also select one of the following variable credit courses to fulfill the remaining Focus Area credit hours:

MAED465	CAPSTONE CURRICULUM DESIGN II	3.0-12.0
SCED465	CAPSTONE CURRICULUM DESIGN II	3.0-12.0

Focus Area – Individualized Focus Areas:

An Individualized Focus Area (IFA) is a customized course of study along with an associated senior design capstone experience that is agreed upon by the student, advisor, and BSE Program Director. Typically, an IFA is defined for a student whose interests and passions are not represented by the existing predefined Focus Areas. The advisor and BSE Program Director are responsible for ensuring an IFA meets the same standards as any of the predefined Focus Areas in the BSE program, as described below in the Program Management section, including having at least three faculty mentors. The transcripts of students who follow an IFA will be denoted as “Individualized Focus Area” without further reference to the focus topic.

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree’s GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree’s GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- EPIC100 through EPIC599
- EDNS100 through EDNS599

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Minor in Engineering for Community Development

Program requirements (18 credit hours)

Introductory Course (3 credits required):		
EDNS315	ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY	3.0
Area 1 - Engineers and Development (6 credits from this list):		
EDNS477	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3.0
EDNS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
EDNS478	ENGINEERING AND SOCIAL JUSTICE	3.0
EDNS479	COMMUNITY-BASED RESEARCH	3.0
EDNS480	ANTHROPOLOGY OF DEVELOPMENT	3.0
Area 2 - Community-Centered Design (6 credits from this list):		
EDNS301	HUMAN-CENTERED PROBLEM DEFINITION	3.0
EDNS401	PROJECTS FOR PEOPLE	3.0
Or an EDNS2XX course with project directly related to community development		
Capstone Design (3 credits from this list):		
EDNS492	SENIOR DESIGN II ((for students in majors in the College of Engineering and Computational Sciences, CECS, and with an identified HE component to the project) or)	3.0
CEEN477	SUSTAINABLE ENGINEERING DESIGN ((for students in majors outside of CECS))	3.0

Minor in Leadership in Social Responsibility

The Minor in Leadership in Social Responsibility will prepare CSM students to become leaders in identifying and promoting the role that engineers can play in advancing social responsibility inside corporations. Graduates will be able to articulate the strategic value of social responsibility for business, particularly in achieving and maintaining the social license to operate, and the role engineering itself can play in advancing a firm’s social responsibility program, including community engagement.

For CSM students to “solve the world’s challenges related to the earth, energy and the environment,” they must also be able to navigate the increasingly complex social, political, and economic contexts that shape those challenges. Achieving the social license to operate, for example, is recognized as necessary for developing mineral resources in the US and abroad. Stewardship of the earth, development of materials, overcoming the earth’s energy challenges, and fostering environmentally sound and sustainable solutions – the bedrock of the Mines vision articulated in the Strategic Plan – requires engineers and applied scientists who are able to work in local and global contexts that are shaped by the sometimes conflicting demands of stakeholders, governments, communities and

corporations. Reasoning through and managing these competing demands is at the core of social responsibility.

Minor in Leadership in Social Responsibility (18 credits required)

Three required courses (9 credits):

EDNS315	ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY	3.0
EDNS430	CORPORATE SOCIAL RESPONSIBILITY	3.0
EDNS479	COMMUNITY-BASED RESEARCH	3.0

One cross-cultural competency course (3 credits):

EDNS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
HASS325	CULTURAL ANTHROPOLOGY	3.0
HASS425	INTERCULTURAL COMMUNICATION	3.0
EDNS480	ANTHROPOLOGY OF DEVELOPMENT	3.0

Two electives, at least one of which must be an engineering course (related to Leadership and/or Corporate Social Responsibility topics, approved by program director) (6 credits):

1. Approved Petroleum Engineering course, such as

PEGN350	SUSTAINABLE ENERGY SYSTEMS	3.0
PEGN430	ENVIRONMENTAL LAW AND SUSTAINABILITY	3.0
PEGN481	PETROLEUM SEMINAR	2.0

2. Approved Mining Engineering course, such as

MNGN308	MINE SAFETY	1.0
MNGN427	MINE VALUATION	2.0
MNGN470	SAFETY AND HEALTH MANAGEMENT IN THE MINING INDUSTRY	3.0
MNGN510	FUNDAMENTALS OF MINING AND MINERAL RESOURCE DEVELOPMENT	3.0

3. Approved Environmental Engineering course, such as

CEEN472	ONSITE WATER RECLAMATION AND REUSE	3.0
CEEN475	SITE REMEDIATION ENGINEERING	3.0
CEEN477	SUSTAINABLE ENGINEERING DESIGN	3.0

4. Approved Economics & Business course, such as

EBGN340	ENERGY AND ENVIRONMENTAL POLICY	3.0
EBGN443	PUBLIC ECONOMICS	3.0
EBGN567	BUSINESS LAW AND ETHICS	3.0

5. Approved Humanities & Social Science (H&SS) courses are to be determined. Additional courses can be approved by the Program Director.

Area of Special Interest in Humanitarian Engineering (12 credit hours)

Intro Course		**3.0**
EDNS315	ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY	
Select one of the following:		**3.0**
EDNS301	HUMAN-CENTERED PROBLEM DEFINITION	
EDNS401	PROJECTS FOR PEOPLE	
EDNS430	CORPORATE SOCIAL RESPONSIBILITY	
Select two of the following:		**6.0**
EDNS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	
EDNS477	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	
EDNS478	ENGINEERING AND SOCIAL JUSTICE	
EDNS479	COMMUNITY-BASED RESEARCH	
EDNS480	ANTHROPOLOGY OF DEVELOPMENT	
HASS325	CULTURAL ANTHROPOLOGY	
HASS425	INTERCULTURAL COMMUNICATION	
CEEN477	SUSTAINABLE ENGINEERING DESIGN	

Courses

EDNS151. DESIGN I. 3.0 Semester Hrs.
Equivalent with EPIC151,
(I, II, S) Design I teaches students how to solve open-ended problems in a hands-on manner using critical thinking and workplace skills. Students work in multidisciplinary teams to learn through doing, with emphasis on defining and diagnosing the problem through a holistic lens of technology, people and culture. Students follow a user-centered design methodology throughout the process, seeking to understand a problem from multiple perspectives before attempting to solve it. Students learn and apply specific skills throughout the semester, including: communication (written, oral, graphical), project management, concept visualization, critical thinking, effective teamwork, as well as building and iterating solutions. 2 hours lecture, 3 hours lab; 3 semester hours.

EDNS155. DESIGN I: GRAPHICS. 1.0 Semester Hr.
Equivalent with EPIC155,
(I ,II, S) Design I: Graphics teaches students conceptualization and visualization skills, and how to represent ideas graphically, both by hand and using computer aided design (CAD). 1 hour lecture, 1 hour lab; 1 semester hour.

EDNS156. AUTOCAD BASICS. 1.0 Semester Hr.
(I, II) This course explores the two- and three-dimensional viewing and construction capabilities of AutoCAD. Students will learn to use AutoCAD for modeling (2D line drawing, 3D construction, Rendering, Part Assembly) and will develop techniques to improve speed and accuracy. The AutoCAD certification exam will not be offered as part of this course; however, the professor will provide instructions on accessing certification options, which generally have their own fees associated with them. 3 hours lab; 1 semester hour.

EDNS157. SOLIDWORKS BASICS (FOR CERTIFICATION). 1.0 Semester Hr.
(I, II) Students will become familiar and confident with Solidworks CAD program and be able to use most of the basic functions well, including Parts, Assemblies, and Drawing Layouts. The Associate-level certification exam will be offered at the end of the course, and while there are no guarantees for students becoming certified, students will have gained the necessary skills to try. 3 hours lab; 1 semester hour.

EDNS191. INTEGRATIVE DESIGN STUDIO IA. 4.0 Semester Hrs.
(I) (WI) Introduces students to human-centered design methodologies relative to open-ended problem solving using socially relevant challenges. Students in this first design studio course utilize a range of resources to explore ethical implications and test the logic of arguments for/against proposed design solutions. Hands-on activities and graphical visualization are utilized to approach the design process in a collaborative team environment. Students begin compiling a personal design portfolio that carries through their undergraduate studies for the Bachelor of Science in Engineering degree. 3 hours lecture; 3 hours lab; 4 semester hours.

EDNS192. INTEGRATIVE DESIGN STUDIO IB. 3.0 Semester Hrs.
(II) (WI) Students explore and participate in design activities as a member of a multi-year, multi-discipline client project, or work on an individual or smaller team project such as the design of experiential activities or community projects. Students are challenged to evaluate the history of science and engineering and its impact on social and political systems as a foundation for creating smarter designs. Prototyping skills are utilized to explore design functionality and potential alternatives. The course continues an emphasis on technical writing along with developing other communication formats. Prerequisite: EDNS191. 2 hours lecture; 3 hours lab; 3 semester hours.

EDNS198. SPECIAL TOPCS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EDNS199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EDNS199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EDNS200. COMMUNICATION. 3.0 Semester Hrs.
(I, II) (WI) This course introduces future engineers to why communication matters in engineering and involves collaborative effort to convey technical details in socially embedded and socially transformative contexts. The course approach provides exposure to how engineers communicate a range and depth of sociotechnical content to varied audiences, in writing, orally, visually, electronically, and via contextual listening, and shows students ways in which communication functions via diverse genres, to multiple audiences, and for different purposes. With structured opportunity for feedback and revision, students both study and produce communication artifacts that aim to meet or exceed criteria for what constitutes legitimate evidence and context within and beyond diverse engineering fields. 3 hours lecture; 3 semester hours.

EDNS205. PROGRAMMING CONCEPTS AND ENGINEERING ANALYSIS. 3.0 Semester Hrs.
(I,II) This course provides an introduction to techniques of scientific computation that are utilized for engineering analysis, with the software package MATLAB as the primary computational platform. The course focuses on methods data analysis and programming, along with numerical solutions to algebraic and differential equations. Engineering applications are used as examples throughout the course. 3 hours lecture; 3 semester hours.

EDNS251. DESIGN II. 3.0 Semester Hrs.
Equivalent with EPIC251,
(I, II, S) Design II builds on the design process introduced in Design I, which focuses on open-ended problem solving in which students integrate teamwork and communications with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Teams analyze team dynamics through weekly team meetings and progress reports. The course emphasizes oral presentations and builds on written communications techniques introduced in Design I. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: EDNS151, EDNS155, EDNS192, or HNRS115.

EDNS261. DESIGN II: GIS. 3.0 Semester Hrs.
Equivalent with EPIC261,
(I,II,S) The Design II: GIS builds on the design process learned in Design I, which focuses on open-ended problem solving where students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Design II: GIS incorporates instruction and hands-on exercises in ArcGIS, a geographic information system software package, to enable students to capture, manage, analyze and display spatial data in maps and charts, to solve problems that depend on spatial analysis and orientation GIS for their design solutions. 2 hours lecutre, 3 hours lab; 3 semester hours. Prerequisite: EDNS151, EDNS155, EDNS192, or HNRS115.

EDNS262. DESIGN II: AUTOCAD. 3.0 Semester Hrs.
Equivalent with EPIC262,
(I) Design II: AutoCAD builds on the design process from Design I, which focuses on open-ended problem solving where students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Design II: AutoCAD incorporates instruction in 3-D AutoCAD computer-aided drawing of elemental designs (structure and mechanical) and geo-spatial designs and analyses to solve problems and publish outcomes. Students are introduced to digital terrain modeling and geo-referencing concepts using AutoCAD Civil3D and raster satellite imagery. Students studying Civil Engineering, Environmental Engineering, and Mining Engineering might consider registering for this course. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: EDNS151, EDNS155, EDNS192, or HNRS115.

EDNS263. DESIGN II: MATERIALS. 3.0 Semester Hrs.
Equivalent with EPIC271,
(II) Design II: Materials builds on the design process introduced in Design I, which focuses on open-ended problem solving where students integrate teamwork and communication with the use of computer software as tools to solve materials engineering problems. The Design II: Materials curriculum matches the standard Design II deliverables but with a focus on Metallurgical and Materials Engineering (MME) based projects. Previous projects have utilized areas such as mechanical testing, bio-materials, semiconductors, ceramics, and non destructive examination to address industrial, environmental, research and geopolitical open-ended problems. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: EDNS151, EDNS155, EDNS192, or HNRS115.

EDNS264. DESIGN II: GEOLOGY GIS. 3.0 Semester Hrs.
Equivalent with EPIC264,
(WI) Design II: GIS builds on the design process introduced in Design I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. There are typically eight geology-based projects in the course, based on the needs of multiple outside clients. Many of the course deliverables are maps with associated data sets. Check with department for semester(s) offered. Prerequisite: EDNS151, EDNS155, EDNS192 or HNRS115.

EDNS269. DESIGN II: ENGINEERING PHYSICS. 3.0 Semester Hrs.
Equivalent with EPIC269,
(I, II, S) Design II: Engineering Physics builds on the design process introduced in Design I, and focuses on open-ended problem solving in which students use teamwork to develop computer software as a tool to solve problems related to engineering physics. Students will learn basic programming skills and apply them to projects that relate to current research and applications of physics. Projects are selected to represent real world physics problems wherein creative and critical thinking skills are necessary. These projects often involve computer-based optimization to obtain a solution. Students will learn how to analyze errors in data, and their effects on data interpretation and decision-making. Engineering Physics majors are encouraged to take this course in the sophomore year. It is open to other students on a space-available basis. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: EDNS151, EDNS155, EDNS192, or HNRS115.

EDNS291. INTEGRATIVE DESIGN STUDIO IIA. 3.0 Semester Hrs.
(I) Students work on an entrepreneurial or client project that may be a short-duration project or continuation of a multi-year, multi-discipline project with teams consisting of freshman to possibly senior students working on the same project, and typically student-lead designs. The course focuses on technical open-ended problem solving in which students integrate teamwork and communications with the use of computer software tools and inclusion of the greater social, political, cultural, and economic factors that ultimately determine if a design is successful. Case studies or other illustrative approaches are used to facilitate discussions on what constitutes effective or harmful designs in areas of earth, energy and environment. Information gathering and modeling are used to support problem assessment and solution exploration. Prerequisites: EDNS192 or HNRS115 or CSM192 or HASS100 and EDNS151. 3 hours lecture; 3 semester hours.

EDNS292. INTEGRATIVE DESIGN STUDIO IIB. 3.0 Semester Hrs.
(II) Students focus on significant contribution to a design project, building proficiency as they incorporate their core and distributed science studies, and begin to integrate their studies in distributed engineering as may be appropriate to the project. Communication of the design approach is emphasized. Prerequisite: EDNS291. 3 hours lecture; 3 semester hours.

EDNS298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EDNS299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Variable credit; 1 to 6 credit hours. Repeatable for credit. Prerequisite: Independent Study form must be completed and submitted to the Registrar.

EDNS301. HUMAN-CENTERED PROBLEM DEFINITION. 3.0 Semester Hrs.
(I, II) This class will equip students with the knowledge, skills and attitudes needed to identify, define, and begin solving real problems for real people, within the socio-technical ambiguity that surrounds all engineering problems. The course will focus on problems faced in everyday life, by people from different backgrounds and in different circumstances, so that students will be able to rise to the occasion presented by future workplace challenges. By the end of this course, students will be able to recognize design problems around them, determine whether they are worth solving, and employ a suite of tools to create multiple solutions. The follow up course --"Design for People" -- will enable students to take the best solutions to the prototype phase. 3 hours lecture; 3 semester hours.

EDNS315. ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY. 3.0 Semester Hrs.
(I, II) (WI) This course explores how engineers think about and practice environmental and social responsibility, and critically analyzes codes of ethics before moving to a deeper focus on macroethical topics with direct relevance to engineering practice, environmental sustainability, social and environmental justice, social entrepreneurship, corporate social responsibility, and engagement with the public. These macroethical issues are examined through a variety of historical and contemporary case studies and a broad range of technologies. Prerequisite: HASS100, and EDNS151 or EDNS192. 3 hours lecture; 3 semester hours.

EDNS375. ENGINEERING CULTURES. 3.0 Semester Hrs.
Equivalent with LAIS375,
This course seeks to improve students? abilities to understand and assess engineering problem solving from different cultural, political, and historical perspectives. An exploration, by comparison and contrast, of engineering cultures in such settings as 20th century United States, Japan, former Soviet Union and presentday Russia, Europe, Southeast Asia, and Latin America. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

EDNS391. INTEGRATIVE DESIGN STUDIO IIIA. 3.0 Semester Hrs.
(I) (WI) Design Practicum augments the engineering core and addresses content and depth that students may not have otherwise acquired through separate Engineering Core courses. This design studio is intended as preparation for the Design Practicum/Field Session studio EGGN392 and includes modules on technical engineering drawings, system simulation and optimization. Project management skills are emphasized. Prerequisites: EDNS292 or LAIS 200 and any EPIC 200 Level or MEGN200 or GPGN268, and EDNS200. 3 hours lecture; 3 semester hours.

EDNS392. INTEGRATIVE DESIGN STUDIO IIIB. 3.0 Semester Hrs.
(II) (WI) Students in Design Practicum incorporate instruction from their Engineering Core to drive technical feasibility assessment of a project for a client. This studio serves as the Field Session experience for students in the BSE program and places students in a professional practice experiential environment. Teaming and leadership skills are emphasized. This course also places strong emphasis on the economic and business aspects of a project, including development of a detailed techno-economic assessment. Prerequisites: EDNS391, PHGN200, and MATH225. 3 hours lecture; 3 semester hours.

EDNS398. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EDNS399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EDNS401. PROJECTS FOR PEOPLE. 3.0 Semester Hrs.
(I, II) Work with innovative organizations dedicated to community development to solve major engineering challenges. This course is open to juniors and seniors interested in engaging a challenging design problem and learning more about Human Centered Design (HCD). The course will be aimed at developing engineering solutions to real problems affecting real people in areas central to their lives. 3 hours lecture; 3 semester hours.

EDNS430. CORPORATE SOCIAL RESPONSIBILITY. 3.0 Semester Hrs.
Equivalent with LAIS430,
Businesses are largely responsible for creating the wealth upon which the well-being of society depends. As they create that wealth, their actions impact society, which is composed of a wide variety of stakeholders. In turn, society shapes the rules and expectations by which businesses must navigate their internal and external environments. This interaction between corporations and society (in its broadest sense) is the concern of Corporate Social Responsibility (CSR). This course explores the dimensions of that interaction from a multi-stakeholder perspective using case studies, guest speakers and field work. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

EDNS475. ENGINEERING CULTURES IN THE DEVELOPING WORLD. 3.0 Semester Hrs.
Equivalent with LAIS475,
An investigation and assessment of engineering problem-solving in the developing world using historical and cultural cases. Countries to be included range across Africa, Asia, and Latin America. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

EDNS477. ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT. 3.0 Semester Hrs.
(I, II) This course is an introduction to the relationship between engineering and sustainable community development (SCD) from historical, political, ideological, ethical, cultural, and practical perspectives. Students will study and analyze different dimensions of community and sustainable development and the role that engineering might play in them. Also students will critically explore strengths and limitations of dominant methods in engineering problem solving, design, and research for working in SCD. Students will learn to research, describe, analyze and evaluate case studies in SCD and develop criteria for their evaluation. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

EDNS478. ENGINEERING AND SOCIAL JUSTICE. 3.0 Semester Hrs.
Equivalent with LAIS478,
(II) This course offers students the opportunity to explore the relationships between engineering and social justice. The course begins with students? exploration of their own social locations, alliances and resistances to social justice through critical engagement of interdisciplinary readings that challenge engineering mindsets. Then the course helps students to understand what constitutes social justice in different areas of social life and the role that engineers and engineering might play in these. Finally, the course gives students an understanding of why and how engineering has been aligned and/or divergent from social justice issues and causes. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

EDNS479. COMMUNITY-BASED RESEARCH. 3.0 Semester Hrs.
Engineers and applied scientists face challenges that are profoundly socio-technical in nature, and communities are increasingly calling for greater participation in the decisions that affect them. Understanding the diverse perspectives of communities and being able to establish positive working relationships with their members is therefore crucial to the socially responsible practice of engineering and applied science. This course provides students with the conceptual and methodological tools to conduct community-based research. Students will learn ethnographic field methods and participatory research strategies, and critically assess the strengths and limitations of these through a final original research project. Prerequisite: HASS100 or graduate student standing. Co-requisite: HASS200 or graduate student standing.

EDNS480. ANTHROPOLOGY OF DEVELOPMENT. 3.0 Semester Hrs.
Equivalent with LAIS480,
Engineers and applied scientists face challenges that are profoundly socio-technical in nature, ranging from controversies surrounding new technologies of energy extraction that affect communities to the mercurial "social license to operate" in locations where technical systems impact people. Understanding the perspectives of communities and being able to establish positive working relationships with their members is therefore crucial to the socially responsible practice of engineering and applied science. This course provides students with the conceptual and methodological tools to engage communities in respectful and productive ways. Students will learn ethnographic field methods and participatory research strategies, and critically assess the strengths and limitations of these through a final original research project. Prerequisite: HASS200. Co-requisite: EDNS477 or HASS325.

EDNS491. SENIOR DESIGN I. 3.0 Semester Hrs.
Equivalent with EGGN491,
(I, II) (WI) This course is the first of a two-semester capstone course sequence giving the student experience in the engineering design process. Realistic open-ended design problems are addressed for real world clients at the conceptual, engineering analysis, and the synthesis stages and include economic and ethical considerations necessary to arrive at a final design. Students are assigned to interdisciplinary teams and exposed to processes in the areas of design methodology, project management, communications, and work place issues. Strong emphasis is placed on this being a process course versus a project course. This is a writing-across-the-curriculum course where students' written and oral communication skills are strengthened. The design projects are chosen to develop student creativity, use of design methodology and application of prior course work paralleled by individual study and research. 2 hours lecture; 3 hours lab; 3 semester hours. Prerequisite: For BSME students, completion of MEGN301; for BSCE students, completion of Engineering Field Session, Civil, CEEN 331; for BSENV completion of Engineering Field Session, Environmental, CEEN 330; and for all other students completion of Field Session appropriate to the student's specialty and consent of instructor. Co-requisite: For BSME students, MEGN481; for BSCE students, any one of CEEN443, CEEN445, CEEN440, or CEEN415; for BSEE students, EENG 350 and EENG 389 plus any one of EENG 391, EENG 392, EENG 393, or EENG 394; for BSE students, EDNS392.

EDNS492. SENIOR DESIGN II. 3.0 Semester Hrs.
(I, II) (WI) This course is the second of a two-semester sequence to give the student experience in the engineering design process. Design integrity and performance are to be demonstrated by building a prototype or model, or producing a complete drawing and specification package, and performing pre-planned experimental tests, wherever feasible, to verify design compliance with client requirements. Prerequisite: EGGN491. 1 hour lecture; 6 hours lab; 3 semester hours.

EDNS498. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EDNS499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Director

Dean Nieusma, Division Director

Professors

Kevin Moore, Executive Director of Humanitarian Engineering

Juan Lucena, Humanitarian Engineering Director of Undergraduate Programs and Outreach

Associate Professor

Jessica Smith, Humanitarian Engineering Director of Graduate Programs and Research

Assistant Professor

Elizabeth Reddy

Teaching Associate Professors

Yosef Allam, Director of Cornerstone Design@Mines

Robin Bullock

Alina Handorean

Leslie Light

Mirna Mattjik

Carrie McClelland

Chelsea Salinas, Assistant Division Director

Teaching Assistant Professor

Lauren Shumaker, Director of Thorson First-Year Honors Experience

Staff

Monica Kurtz, Stakeholder Relations Manager

Julia Roos, Associate Director of Humanitarian Engineering

Kimberly Walker, Program Assistant

Electrical Engineering

Program Description

The Department of Electrical Engineering at Mines strives to produce leaders who serve the profession, the global community, and society. In addition to the program's ABET-accredited undergraduate curriculum, students attain technical expertise while completing course work and projects reflective of modern technology trends. Students consider the broader impacts of engineering solutions on society and human lives. Fundamental and applied engineering research in power and renewable energy, data sciences and control systems, and RF and wireless communications are offered which support the university's mission of "earth, energy, and environment."

At the undergraduate level, the department focuses on a select number of subareas in electrical engineering; specifically,

(1) energy systems and power electronics (ESPE),
(2) integrated circuits, computer engineering and electronic systems (ICE),
(3) information and systems sciences (ISS), and
(4) antennas and wireless communications (AWC).

At the graduate level, the department provides educational and research opportunities in three selected topical areas:

(1) compressive sensing, data analysis, control and optimization;
(2) energy systems, electric power, power electronics, renewable energy, machines and drives,
(3) antennas, RF and microwaves, wireless communications, and computational electromagnetics.

Both undergraduate and graduate programs are characterized by strong ties with industrial partners (locally and nationally) that provide resources for students, laboratories, research projects, and ultimately career paths for our students.

BS in Electrical Engineering

PROGRAM EDUCATIONAL OBJECTIVES

The Electrical Engineering program contributes to the educational objectives described in the Mines' Graduate Profile. In addition, the Electrical Engineering Program at Mines has established the following program educational objectives:

Within three years of attaining the BSEE degree:

1. Graduates will be applying their professional Electrical Engineering skills and training in their chosen field or will be successfully pursuing a degree.
2. Graduates will be situated in growing careers, generating new knowledge and exercising professional leadership.
3. Graduates will be contributing to the needs of society through professional practice, research and service.

Bachelor of Science in Electrical Engineering Degree Requirements:

Freshman

Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS, CBEN 110, CHGN 122, or CHGN 125 (Distributed Science 1)			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Spring		**lec**	**lab**	**sem.hrs**
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
EDNS151	DESIGN I			3.0
PHGN100	PHYSICS I - MECHANICS			4.5
CSCI101	INTRODUCTION TO COMPUTER SCIENCE (Distributed Science 2)			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
HASS200	GLOBAL STUDIES			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS (Distributed Science 3)			4.5
CSCI261	PROGRAMMING CONCEPTS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Spring		**lec**	**lab**	**sem.hrs**
MATH225	DIFFERENTIAL EQUATIONS			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
EENG284	DIGITAL LOGIC			4.0
EENG282	ELECTRICAL CIRCUITS			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				14.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
MATH332	LINEAR ALGEBRA			3.0

EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS			3.0
EENG310	INFORMATION SYSTEMS SCIENCE I			4.0
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING			4.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY			4.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
EENG385	ELECTRONIC DEVICES AND CIRCUITS			4.0
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS			3.0
EENG311	INFORMATION SYSTEMS SCIENCE II			3.0
Emphasis Area Elective	Emphasis Area Elective (Students pursuing an emphasis area should take a course within their declared emphasis area. Students NOT pursuing an emphasis area must take one of these Thermodynamics/Statics courses instead: MEGN361, CEEN241, CHGN209, CBEN210, or GEGN 330)*			3.0
EENG350	SYSTEMS EXPLORATION AND ENGINEERING DESIGN LAB			2.0
EENG391	FE ON ENERGY SYSTEMS AND POWER ELECTRONICS, 391, 393, or 394			1.0
EENG392	FE ON INFORMATION AND SYSTEMS SCIENCES, 391, 393, or 394			1.0
				17.0

Senior				
Fall		**lec**	**lab**	**sem.hrs**
H&SS Elective	Humanities & Social Science (H&SS) Mid-Level Restricted Elective			3.0
H&SS Elective	Humanities & Social Science (H&SS) Mid-Level Restricted Elective			3.0
EDNS491	SENIOR DESIGN I			3.0
EE Elective	Electrical Engineering Elective (Students pursuing an emphasis area should take a course within their declared emphasis area)*			3.0
EE Elective	Electrical Engineering Elective (Students pursuing an emphasis area should take a course within their declared emphasis area)*			3.0
				15.0

Spring		**lec**	**lab**	**sem.hrs**
H&SS Elective	Humanities & Social Science (H&SS) 400-Level Restricted Elective			3.0
EDNS492	SENIOR DESIGN II			3.0
EE Elective	Electrical Engineering Elective (Students pursuing an emphasis area should take a course within their declared emphasis area)*			3.0
FREE	Free Elective			3.0
FREE	Free Elective			3.0
FREE	Free Elective			3.0
				18.0

Total Semester Hrs: 129.5

* Electrical Engineering students are required to take three Electrical Engineering Electives from an approved list. Requirements vary for students that wish to have an emphasis area listed on their official transcript. See below for guidelines and the list of Electrical Engineering Electives:

Electrical Engineering Electives:

Organized by emphasis area.

- No Emphasis Area: Complete 9 credits of Electrical Engineering Electives from any of the emphasis areas or the general list below, and complete a Thermodynamics or Statics course.

- Emphasis Area: Complete 12 credits in one emphasis area and declare emphasis area with the Registrar. Students with an emphasis area should replace the Thermodynamics/Statics course requirement with an emphasis area course.

Information and Systems Sciences		
EENG411	DIGITAL SIGNAL PROCESSING	3.0
EENG413	ANALOG AND DIGITAL COMMUNICATION SYSTEMS	4.0
EENG415	DATA SCIENCE FOR ELECTRICAL ENGINEERING	3.0
EENG417	MODERN CONTROL DESIGN	3.0
EENG427	WIRELESS COMMUNICATIONS	3.0
EENG437	INTRODUCTION TO COMPUTER VISION	3.0
MEGN441	INTRODUCTION TO ROBOTICS	3.0
Energy Systems and Power Electronics		
EENG390	ENERGY, ELECTRICITY, RENEWABLE ENERGY, AND ELECTRIC POWER GRID	3.0
EENG470	INTRODUCTION TO HIGH POWER ELECTRONICS	3.0
EENG475	INTERCONNECTION OF RENEWABLE ENERGY, INTEGRATED POWER ELECTRONICS, POWER SYSTEMS, AND POWER QUALITY	3.0
EENG480	POWER SYSTEMS ANALYSIS	3.0
EENG481	ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS	3.0
EENG489	COMPUTATIONAL METHODS IN ENERGY SYSTEMS AND POWER ELECTRONICS	3.0
Antennas and Wireless Communications		

EENG425	INTRODUCTION TO ANTENNAS	3.0
EENG427	WIRELESS COMMUNICATIONS	3.0
EENG428	COMPUTATIONAL ELECTROMAGNETICS	3.0
EENG429	ACTIVE RF & MICROWAVE DEVICES	3.0
EENG430	PASSIVE RF & MICROWAVE DEVICES	3.0
EENG486	ELECTROMAGNETIC FIELDS AND WAVES	3.0
Integrated Circuits and Electronics		
EENG411	DIGITAL SIGNAL PROCESSING	3.0
EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0
EENG423	INTRODUCTION TO VLSI DESIGN	3.0
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3.0
Electrical Engineering General		
CEEN405	NUMERICAL METHODS FOR ENGINEERS	3.0
CSCI341	COMPUTER ORGANIZATION	3.0
CSCI410	ELEMENTS OF COMPUTING SYSTEMS	3.0
CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	3.0
CSCI442	OPERATING SYSTEMS	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS	4.0
PHGN440	SOLID STATE PHYSICS	3.0
PHGN441	SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA	3.0
PHGN462	ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS	3.0

*Additional EENG or CSCI 400-level and graduate level classes taught by faculty in the EE department may be considered as Electrical Engineering Electives. Talk to your advisor for further guidance. 300-level or higher courses from other departments may be considered by the Department Head.

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- EENG100 through EENG699 inclusive
- EDNS491 (EGGN491)
- EDNS492 (EGGN492)

Combined BS/MS in Electrical Engineering

The Department of Electrical Engineering offers a combined Bachelor of Science/Master of Science program in Electrical Engineering that enables students to work on a Bachelor of Science and a Master of Science simultaneously. This allows undergraduate students to take courses that will count for their graduate degree requirements, while still finishing their undergraduate degree requirements. This will be especially attractive to students who intend to go on to the graduate program, yet have availability in their schedules even while fulfilling the undergraduate requirements. Another advantage is an expedited graduate school application process, as described below.

Students must be admitted into the Combined BS/MS degree program prior to the close of registration of the term in which any course toward the MS degree will be applied. Typically this is the beginning of the student's Senior year, but students may apply as early as the first semester of their Junior year. Admissions must be granted no later than the end of registration in the last semester of the Senior year. In order to apply for the combined program, a pro forma graduate school application is submitted, and as long as the undergraduate portion of the program is successfully completed and the student has a GPA above 3.0, the student is admitted to the non#thesis Master of Science degree program in Electrical Engineering.

Students are required to take an additional 30 credit hours for the M.S. degree. Up to nine of the 30 credit hours beyond the undergraduate degree requirements can be 400-level courses. The remainder of the courses will be at the graduate level (500-level and above). There is no limit on the number of graduate level (500#level and above) courses a student may take beyond the undergraduate degree requirements, but a student must complete at least one semester as a registered graduate student after completion of the undergraduate degree before being awarded a graduate degree. Students must declare graduate courses through the Registrar's Office at time of registration. Grades count toward the graduate GPA and must meet the minimum grade requirements (C# or higher) to be counted toward graduation requirements. Courses may not be used to meet undergraduate financial aid requirements. Students will declare course work as regular graduate courses on Admission to Candidacy Form. Students should follow the MS Non#Thesis degree requirements based on their track in selecting appropriate graduate degree courses. Students may switch from the combined program which includes a non-thesis Master of Science degree to an M.S. degree with a thesis optional, however, if students change degree programs they must satisfy all degree requirements for the M.S. with thesis degree.

Combined Engineering Physics Baccalaureate and Electrical Engineering Masters Degrees

The Department of Electrical Engineering, in collaboration with the Department of Physics, offers a five-year program in which students have the opportunity to obtain specific engineering skill to complement their physics background. Physics students in this program fill in their technical and free electives over their standard four year Engineering Physics B.S. program with a reduced set of Electrical Engineering classes. At the end of the fourth year, the student is awarded an Engineering Physics B.S degree. Course schedules for this five-year program can be obtained in the Physics Departmental Offices.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Electrical Engineering

ASI in Electrical Engineering

The following twelve credit sequence is required for an ASI in Electrical Engineering, The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3.0
or PHGN215	ANALOG ELECTRONICS	
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0

Complete remaining requirements by taking 6.0 credits of any EENG 300 or 400 level course.

Minor in Electrical Engineering

A minimum of eighteen credits are required for a Minor in Electrical Engineering as follows. (See Minor/ASI section of the Bulletin for all rules for minors at Mines.)

Students must complete an eighteen credit hour sequence as described below for a minor in EE. All students seeking a minor in EE will need to take one of two possible versions of Electrical Circuits and EENG 307 (3 credits) after which they can pick an emphasis area to complete the remaining minor requirements. The four emphasis areas are as follows

1. Information Systems and Science (ISS), 18 or 20 credits

EENG282	ELECTRICAL CIRCUITS	4.0
or EENG281 & MEGN300	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER and INSTRUMENTATION & AUTOMATION	
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG310	INFORMATION SYSTEMS SCIENCE I	4.0
EENG311	INFORMATION SYSTEMS SCIENCE II	3.0

2. Energy Systems and Power (ESPE), 18 credits

EENG282	ELECTRICAL CIRCUITS	4.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS	3.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0

3. Digital Systems, 18 or 20 credits

EENG282	ELECTRICAL CIRCUITS	4.0
or EENG281 & MEGN300	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER and INSTRUMENTATION & AUTOMATION	
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING	4.0
EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0
or EENG423	INTRODUCTION TO VLSI DESIGN	

4. General Electrical Engineering, 19 or 21 credits

EENG282	ELECTRICAL CIRCUITS	4.0
or EENG281 & MEGN300	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER and INSTRUMENTATION & AUTOMATION	
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG310	INFORMATION SYSTEMS SCIENCE I	4.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0

Courses

EENG198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EENG199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG281. INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER. 3.0 Semester Hrs.
(I, II) This course provides an engineering science analysis of electrical circuits. DC and single-phase AC networks are presented. Transient analysis of RC, RL, and RLC circuits is studied as is the analysis of circuits in sinusoidal steady-state using phasor concepts. The following topics are included: DC and single-phase AC circuit analysis, current and charge relationships. Ohm?s Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchhoff?s Laws, Thevenin and Norton equivalent circuits, superposition and source transformation, power and energy, maximum power transfer, first order transient response, algebra of complex numbers, phasor representation, time domain and frequency domain concepts, and ideal transformers. The course features PSPICE, a commercial circuit analysis software package. May not also receive credit for EENG282. Prerequisite: PHGN200. 3 hours lecture; 3 semester hours.

EENG282. ELECTRICAL CIRCUITS. 4.0 Semester Hrs.
(I,II) This course provides an engineering science analysis of electrical circuits. DC and AC (single-phase and three-phase) networks are presented. Transient analysis of RC and RL circuits is studied as is the analysis of circuits in sinusoidal steady-state using phasor concepts. The following topics are included: DC and AC circuit analysis, current and charge relationships. Ohm's Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchhoff's Laws, Thevenin and Norton equivalent circuits, superposition and source transformation, power and energy, maximum power transfer, first order transient response, algebra of complex numbers, phasor representation, time domain and frequency domain concepts, and steady-state analysis of single-phase and three-phase ac power circuits. May not also receive credit for EENG281. Prerequisites: PHGN200. 3 hours lecture; 3 hours lab; 4 semester hours.

EENG284. DIGITAL LOGIC. 4.0 Semester Hrs.
(I, II) Fundamentals of digital logic design. Covers combinational and sequential logic circuits, programmable logic devices, hardware description languages, and computer-aided design (CAD) tools. Laboratory component introduces simulation and synthesis software and hands-on hardware design. 3 hours lecture; 3 hours lab; 4 semester hours. Prerequisite: CSCI261 (C- or better). Co-requisite: EENG282 or EENG281 or PHGN215.

EENG298. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EENG299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG307. INTRODUCTION TO FEEDBACK CONTROL SYSTEMS. 3.0 Semester Hrs.
(I, II) System modeling through an energy flow approach is presented, with examples from linear electrical, mechanical, fluid and/or thermal systems. Analysis of system response in both the time domain and frequency domain is discussed in detail. Feedback control design techniques, including PID, are analyzed using both analytical and computational methods. 3 hours lecture; 3 semester hours. Prerequisite: EENG281 or EENG282 or PHGN215 (C- or better) and MATH225.

EENG310. INFORMATION SYSTEMS SCIENCE I. 4.0 Semester Hrs.
Equivalent with EENG388,
(I, II) The interpretation, representation and analysis of time-varying phenomena as signals which convey information and noise; applications are drawn from filtering, audio and image processing, and communications. Topics include convolution, Fourier series and transforms, sampling and discrete-time processing of continuous-time signals, modulation, and z-transforms. 3 hours lecture; 1 hour recitation, 4 semester hours. Prerequisite: EENG281 or EENG282 or PHGN215 (C- or better) and MATH225.

EENG311. INFORMATION SYSTEMS SCIENCE II. 3.0 Semester Hrs.
(I,II) This course covers signals and noise in electrical systems. Topics covered include information theory, signal to noise ratio, random variables, probability density functions, statistics, noise, matched filters, coding and entropy, power spectral density, and bit error rate. Applications are taken from radar, communications systems, and signal processing. Prerequisite: EENG310. 3 hours lecture; 3 semester hours.

EENG340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I,II,S) Supervised, full-time engineering related employment for a continuous six-month period in which specific educational objectives are achieved. Students must meet with the Department Head prior to enrolling to clarify the educational objectives for their individual Co-op program. Prerequisites: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 3 semester hours credit will be granted once toward degree requirements. Credit earned in EENG340, Cooperative Education, may be used as free elective credit hours if, in the judgment of the Department Head, the required term paper adequately documents the fact that the work experience entailed high-quality application of engineering principles and practice. Applying the credits as free electives requires the student to submit a Declaration of Intent to Request Approval to Apply Co-op Credit toward Graduation Requirements form obtained from the Career Center to the Department Head.

EENG350. SYSTEMS EXPLORATION AND ENGINEERING DESIGN LAB. 2.0 Semester Hrs.
(I, II) This laboratory is a semester-long design and build activity centered around a challenge problem that varies from year to year. Solving this problem requires the design and prototyping of a complex system and utilizes concepts from multiple electrical engineering courses. Students work in intra-disciplinary teams, with students focusing on either embedded systems or control systems. Prerequisite: EENG307 and EENG383. 1 hour lecture; 3 hours lab; 2 semester hours.

EENG383. MICROCOMPUTER ARCHITECTURE AND INTERFACING. 4.0 Semester Hrs.
(I, II) Microprocessor and microcontroller architecture focusing on hardware structures and elementary machine and assembly language programming skills essential for use of microprocessors in data acquisition, control, and instrumentation systems. Analog and digital signal conditioning, communication, and processing. A/D and D/A converters for microprocessors. RS232 and other communication standards. Laboratory study and evaluation of microcomputer system; design and implementation of interfacing projects. 3 hours lecture; 3 hours lab; 4 semester hours. Prerequisite: EENG281 or EENG282 or PHGN215 (C-or better) and EENG284 or PHGN317 (C-or better).

EENG385. ELECTRONIC DEVICES AND CIRCUITS. 4.0 Semester Hrs.
(I, II) Semiconductor materials and characteristics, junction diode operation, bipolar junction transistors, field effect transistors, biasing techniques, four layer devices, amplifier and power supply design, laboratory study of semiconductor circuit characteristics. Prerequisite: EENG307. 3 hours lecture; 3 hours lab; 4 semester hours.

EENG386. FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS. 3.0 Semester Hrs.
(I, II) This course provides an introduction to electromagnetic theory as applied to electrical engineering problems in wireless communications, transmission lines, and high-frequency circuit design. The theory and applications are based on Maxwell's equations, which describe the electric and magnetic force-fields, the interplay between them, and how they transport energy. Matlab and PSPICE will be used in homework assignments, to perform simulations of electromagnetic interference, electromagnetic energy propagation along transmission lines on printed circuit boards, and antenna radiation patterns. Prerequisites: EENG281 (C- or better) or EENG282 (C- or better), and MATH225. 3 hours lecture; 3 semester hours.

EENG389. FUNDAMENTALS OF ELECTRIC MACHINERY. 4.0 Semester Hrs.
(I, II) This course provides an engineering analysis of electrical machines. The following topics are included: review of three-phase AC circuit analysis, magnetic circuit concepts and materials, transformer analysis and operation, modelling, steady-state analysis of rotating machines, synchronous and poly-phase induction motors, and DC machines and laboratory study of external characteristics of machines and transformers. Prerequisite: EENG281 (C- or better) or EENG282 (C- or better). 3 hours lecture, 3 hours lab; 4 semester hours.

EENG390. ENERGY, ELECTRICITY, RENEWABLE ENERGY, AND ELECTRIC POWER GRID. 3.0 Semester Hrs.
(I) (WI) Fundamentals and primary sources of energy; Energy conversion; Comprehensive energy picture in USA and the world; Generation of electric power today; Understanding of the electric power grid and how it works; Renewable energy resources and distributed generation; Wind and PV power generation; Future trend in electricity delivery; Energy sustainability. Prerequisites: EENG281 or EENG282 or PHGN215. 3 hours lecture; 3 semester hours.

EENG391. FE ON ENERGY SYSTEMS AND POWER ELECTRONICS. 1.0 Semester Hr.
(II) This course focuses on learning industrial automation, PLC (Programmable Logic Controller), control and interfacing of Variable Frequency Drives (VFD), circuitry to field devices (input/output connections to the real world), industrial field-bus networking, allowing the automation of industrial environments. Students will work on industrial controllers and learn techniques for industrial automation. A component of this course is how ethics and Professional Responsibilities of being an "Engineer" shapes a Global Society, and how working professionals interact with other persons in a global and pluralistic society. Students should take at least two FE modules in the same semester. 1 hour lecture; 2 hours lab; 1 semester hour. Prerequisite: EENG385, EENG389, EENG284, EENG282, EENG307. Co-requisite: EENG392 or EENG393 or EENG394.

EENG392. FE ON INFORMATION AND SYSTEMS SCIENCES. 1.0 Semester Hr.
(II) The course will present hardware and software solutions for the purpose of creating customized instrumentation and control systems. Concepts presented include 1) User Interface Design: controls, indicators, dialogs, graphs, charts, tab controls, user interface best practices 2) Software Development: basic software architecture, loops, arrays, binary logic, mathematics, data management 3) Instrumentation basics: connecting sensors to hardware, acquiring data, analyzing instrumentation accuracy, examining resolution and noise characteristics of a signal 4) Control basics: create pulse-width modulated (PWM) signals for controlling motors, servos, amplifiers, and heaters. Create a PID control algorithm to control a dynamic system. Prerequisite: (EENG281 or EENG282) and CSCI261. Co-requisite: EENG307. 1 hour lecture; 2 hours lab; 1 semester hour.

EENG393. FE ON INTEGRATED CIRCUITS AND ELECTRONICS PRACTICUM. 1.0 Semester Hr.
(I) Students will learn how to design, fabricate, and solder a printed circuit board (PCB) from concept to implementation. In addition to teaching best design practices, the course will address the variety of real-world constraints that impact the manufacturing of electrical circuits on PCBs. Prerequisite: EENG383 or EENG385. 1 hour lecture; 2 hours lab; 1 semester hour.

EENG394. FE ON ANTENNAS AND WIRELESS COMMUNICATIONS. 1.0 Semester Hr.
(I) This course provides the basic theories of electromagnetics, antennas, and wireless communications. Hands on experience will be developed during the projects assigned in the class to design antennas and passive microwave devices. 0.5 hours lecture; 1.5 hours lab; 1 semester hour.

EENG395. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
(I, II) Individual research project for freshman, sophomores or juniors under direction of a member of the departmental faculty. Written report required for credit. Seniors should take EENG495 instead of EENG395. Repeatable for credit. Variable credit; 1 to 3 semester hours.

EENG398. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EENG399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG411. DIGITAL SIGNAL PROCESSING. 3.0 Semester Hrs.
(II) This course introduces the mathematical and engineering aspects of digital signal processing (DSP). An emphasis is placed on the various possible representations for discrete-time signals and systems (in the time, z-, and frequency domains) and how those representations can facilitate the identification of signal properties, the design of digital filters, and the sampling of continuous-time signals. Advanced topics include sigma-delta conversion techniques, multi-rate signal processing, and spectral analysis. The course will be useful to all students who are concerned with information bearing signals and signal processing in a wide variety of application settings, including sensing, instrumentation, control, communications, signal interpretation and diagnostics, and imaging. Prerequisite: EENG310. 3 hours lecture; 3 semester hours.

EENG413. ANALOG AND DIGITAL COMMUNICATION SYSTEMS. 4.0 Semester Hrs.
(II) Signal classification; Fourier transform; filtering; sampling; signal representation; modulation; demodulation; applications to broadcast, data transmission, and instrumentation. Prerequisite: EENG310. 3 hours lecture; 3 hours lab; 4 semester hours.

EENG415. DATA SCIENCE FOR ELECTRICAL ENGINEERING. 3.0 Semester Hrs.
This course presents a comprehensive exposition of the theory, methods, and algorithms for data analytics as related to power and energy systems. It will focus on (1) techniques for performing statistical inference based on data, (2) methods for predicting future values of data, (3) methods for classifying data instances into relevant classes and clusters, (4) methods for building, training and testing artificial neural networks, and (5) techniques for evaluating the effectiveness and quality of a data analytics model. Prerequisite: EENG311.

EENG417. MODERN CONTROL DESIGN. 3.0 Semester Hrs.
(I) Control system design with an emphasis on observer-based methods, from initial open-loop experiments to final implementation. The course begins with an overview of feedback control design technique from the frequency domain perspective, including sensitivity and fundamental limitations. State space realization theory is introduced, and system identification methods for parameter estimation are introduced. Computerbased methods for control system design are presented. Prerequisite: EENG307. 3 lecture hours, 3 semester hours.

EENG421. SEMICONDUCTOR DEVICE PHYSICS AND DESIGN. 3.0 Semester Hrs.
(I) This course will explore the field of semiconductors and the technological breakthroughs which they have enabled. We will begin by investigating the physics of semiconductor materials, including a brief foray into quantum mechanics. Then, we will focus on understanding pn junctions in great detail, as this device will lead us to many others (bipolar transistors, LEDs, solar cells). We will explore these topics through a range of sources (textbooks, scientific literature, patents) and discuss the effects they have had on Western society. As time allows, we will conclude with topics of interest to the students (possibilities include quantum devices, MOSFETs, lasers, and integrated circuit fabrication techniques). Prerequisite: PHGN200. 3 hours lecture; 3 semester hours.

EENG423. INTRODUCTION TO VLSI DESIGN. 3.0 Semester Hrs.
(II) This is an introductory course that will cover basic theories and techniques of digital VLSI (Very Large Scale Integrated Circuits) design and CMOS technology. The objective of this course is to understand the theory and design of digital systems at the transistor level. The course will cover MOS transistor theory, CMOS processing technology, techniques to design fast digital circuits, techniques to design power efficient circuits, standard CMOS fabrications processes, CMOS design rules, and static and dynamic logic structures. Prerequisites: EENG281 (C- or better) or EENG282 (C- or better), and EENG284 (C- or better). 3 hours lecture; 3 semester hours.

EENG425. INTRODUCTION TO ANTENNAS. 3.0 Semester Hrs.
(II) This course provides an introduction to antennas and antenna arrays. Theoretical analysis and use of computer programs for antenna analysis and design will be presented. Experimental tests and demonstrations will also be conducted to complement the theoretical analysis. Students are expected to use MATLAB to model antennas and their performance. Prerequisites: EENG386.

EENG427. WIRELESS COMMUNICATIONS. 3.0 Semester Hrs.
(I, II, S) This course provides the tools needed to analyze and design a wireless system. Topics include link budgets, satellite communications, cellular communications, handsets, base stations, modulation techniques, RF propagation, coding, and diversity. Students are expected to complete an extensive final project. Prerequisites: EENG311 or MATH201 and EENG310. 3 hours lecture; 3 semester hours.

EENG428. COMPUTATIONAL ELECTROMAGNETICS. 3.0 Semester Hrs.
(I) This course provides the basic formulation and numerical solution for static electric problems based on Laplace, Poisson and wave equations and for full wave electromagnetic problems based on Maxwell's equations. Variation principles methods, including the finite-element method and method of moments will be introduced. Field to circuit conversion will be discussed via the transmission line method. Numerical approximations based on the finite difference and finite difference frequency domain techniques will also be developed for solving practical problems. Prerequisite: EENG386. 3 hours lecture; 3 semester hours.

EENG429. ACTIVE RF & MICROWAVE DEVICES. 3.0 Semester Hrs.
(II) This course introduces the basics of active radio-frequency (RF) and microwave circuits and devices which are the building blocks of modern communication and radar systems. The topics that will be studied are RF and microwave circuit components, resonant circuits, matching networks, noise in active circuits, switches, RF and microwave transistors and amplifiers. Additionally, mixers, oscillators, transceiver architectures, RF and monolithic microwave integrated circuits (RFICs and MMICs) will be introduced. Moreover, students will learn how to model active devices using professional CAD software, how to fabricate printed active microwave devices, how a vector network analyzer (VNA) operates, and how to measure active RF and microwave devices using VNAs. Prerequisites: EENG385. 3 hours lecture; 3 semester hours.

EENG430. PASSIVE RF & MICROWAVE DEVICES. 3.0 Semester Hrs.
(I) This course introduces the basics of passive radio-frequency (RF) and microwave circuits and devices which are the building blocks of modern communication and radar systems. The topics that will be studied are microwave transmission lines and waveguides, microwave network theory, microwave resonators, power dividers, directional couplers, hybrids, RF/microwave filters, and phase shifters. Students will also learn how to design and analyze passive microwave devices using professional CAD software. Moreover, students will learn how to fabricate printed passive microwave devices and test them using a vector network analyzer. Prerequisites: EENG386. 3 hours lecture; 3 semester hours.

EENG437. INTRODUCTION TO COMPUTER VISION. 3.0 Semester Hrs.
(I) Computer vision is the process of using computers to acquire images, transform images, and extract symbolic descriptions from images. This course provides an introduction to this field, covering topics in image formation, feature extraction, location estimation, and object recognition. Design ability and hands-on projects will be emphasized, using popular software tools. The course will be of interest both to those who want to learn more about the subject and to those who just want to use computer imaging techniques. Prerequisites: MATH201 or EENG311, MATH332, CSCI261, Senior level standing. 3 hours lecture; 3 semester hours.

EENG470. INTRODUCTION TO HIGH POWER ELECTRONICS. 3.0 Semester Hrs.
(I) Power electronics are used in a broad range of applications from control of power flow on major transmission lines to control of motor speeds in industrial facilities and electric vehicles, to computer power supplies. This course introduces the basic principles of analysis and design of circuits utilizing power electronics, including AC/DC, AC/AC, DC/DC, and DC/AC conversions in their many configurations. Prerequisite: EENG282. 3 hours lecture; 3 semester hours.

EENG475. INTERCONNECTION OF RENEWABLE ENERGY, INTEGRATED POWER ELECTRONICS, POWER SYSTEMS, AND POWER QUALITY. 3.0 Semester Hrs.
(I, II, S) (WI) This course focus on interconnection issues and power/voltage quality impacts of distributed generation resources at the power distribution level, or industrial sites. Students will have a clear understanding of the challenges associated with the integration of distributed generation resources (renewable and non-renewable) with the current distribution power grid. The impact of these resources on feeder voltage and power will be discussed in details, with mitigation techniques analyzed. Hands-on simulation-based case studies will help the participants examine the covered topics on realistic power system models and understand how renewable energy interconnection issues affect power and voltage quality. The course consists of a mathematical and analytical understanding of relevant electrical energy conversion systems analysis and modeling issues. A problem and project-based oriented design of small renewable energy systems will make possible the energy storage integration, in stand-alone, as well as connected to the utility grid, with all interconnections requirements for hardware, software and real-time implementation. Prerequisite: EENG282. 4 hours lecture, 4 hours lab, 4 hours other; 3 semester hours.

EENG480. POWER SYSTEMS ANALYSIS. 3.0 Semester Hrs.
(I) 3-phase power systems, per-unit calculations, modeling and equivalent circuits of major components, voltage drop, fault calculations, symmetrical components and unsymmetrical faults, system grounding, power-flow, selection of major equipment, design of electric power distribution systems. Prerequisite: EENG389. 3 hours lecture; 3 semester hours.

EENG481. ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS. 3.0 Semester Hrs.
(II) The course investigates the design, operation and analysis of complex interconnected electric power grids, the basis of our electric power infrastructure. Evaluating the system operation, planning for the future expansion under deregulation and restructuring, ensuring system reliability, maintaining security, and developing systems that are safe to operate has become increasingly more difficult. Because of the complexity of the problems encountered, analysis and design procedures rely on the use of sophisticated power system simulation computer programs. The course features some commonly used commercial software packages. Prerequisites: EENG480. 2 Lecture Hours, 3 Laboratory Hours, 3 Semester Hours.

EENG486. ELECTROMAGNETIC FIELDS AND WAVES. 3.0 Semester Hrs.
(I) This course provides an introduction to electromagnetic fields and waves and their applications in antennas, radar, high-frequency electronics, and microwave devices. The time-varying form of electromagnetic fields and the use of sinusoidal time sources to create time-harmonic electromagnetic fields will be covered first, followed by coverage of plane electromagnetic waves formulation and reflection and transmission from different surfaces. Finally, the application of guided electromagnetic waves will be covered through the study of transmission lines, waveguides, and their applications in microwave systems. Prerequisite: EENG386. 3 hours lecture; 3 semester hours.

EENG489. COMPUTATIONAL METHODS IN ENERGY SYSTEMS AND POWER ELECTRONICS. 3.0 Semester Hrs.
(II) The course presents a unified approach for understanding and applying computational methods, computer-aided analysis and design of electric power systems. Applications will range from power electronics to power systems, power quality, and renewable energy. Focus will be on how these seemingly diverse applications all fit within the smart-grid paradigm. This course builds on background knowledge of electric circuits, control of dc/dc converters and inverters, energy conversion and power electronics by preparing students in applying the computational methods for multi-domain simulation of energy systems and power electronics engineering problems. Prerequisites: EENG282 or EENG382. 1 hour lecture, 2 lab hours, 3 semester hours.

EENG495. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
(I, II) Individual research project under direction of a member of the departmental faculty. Written report required for credit. Prerequisites: senior-level standing based on credit hours. Variable credit; 1 to 3 semester hours. Repeatable for credit.

EENG498. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EENG499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professor and Department Head

Peter Aaen

Professors

Atef Elsherbeni, Dobelman Chair

Randy Haupt

Tyrone Vincent

Michael Wakin

Associate professors

Kathryn Johnson

Salman Mohagheghi

Gongguo Tang

Assistant professor

Payam Nayeri

Teaching Professors

Abd Arkadan

Chris Coulston

Research Professor

Mohammed Hadi

Emeritus Professor

Ravel Ammerman

Emerita Professor

Catherine Skokan

Geology and Geological Engineering

Program Description

A Bachelor of Science degree in Geological Engineering is the basis for careers concentrating on the interaction of humans and the earth. Geological Engineers deal with a wide variety of the resource and environmental problems that come with accommodating more and more people on a finite planet. Geologic hazards and conditions must be recognized and considered in the location and design of foundations for buildings, roads and other structures; waste disposal facilities must be properly located, designed and constructed; contaminated sites and ground water must be accurately characterized before cleanup can be accomplished; water supplies must be located, developed and protected; and new mineral and energy resources must be located and developed in an environmentally sound manner. Geological Engineers are the professionals trained to meet these challenges.

The Geological Engineering curriculum provides a strong foundation in the basic sciences, mathematics, geological science and basic engineering along with specialized upper level instruction in integrated applications to real problems. Engineering design is integrated throughout the four year program, beginning in Design I (Freshman year) and ending with the capstone design courses in the senior year.

The program leading to the degree of Bachelor of Science in Geological Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Students have the background to take the Fundamentals of Engineering Exam, the first step in becoming a registered Professional Engineer.

Graduates follow five general career paths:

Engineering Geology and Geotechnics. Careers in site investigation, design and stabilization of foundations and slopes; site characterization, design, construction and remediation of waste disposal sites or contaminated sites; and assessment of geologic hazards for civil, mining or environmental engineering projects.

Ground-Water Engineering. Careers in assessment and remediation of ground-water contamination, design of ground-water control facilities for geotechnical projects and exploration for and development of ground-water supplies.

Petroleum Exploration and Development Engineering. Careers in search for and development of oil and gas and their efficient extraction.

Mineral Exploration and Development Engineering. Careers in search for and development of natural deposits of metals, industrial materials and rock aggregate.

Geological Science. Students are also well prepared to pursue careers in basic geoscience. Graduates have become experts in fields as divergent as global climate change, the early history of the Earth, planetary science, fractal representation of ground-water flow and simulation of sedimentary rock sequences, to name a few. Careers are available in research and education.

The curriculum may be followed along two concentration paths with slightly different upper division requirements. Both concentrations are identical in the first two years as students study basic science, mathematics, engineering science, and geological science. In the junior year those students pursuing careers in ground-water engineering, engineering geology and geotechnics, or geoenvironmental engineering applications follow the Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration. Students anticipating careers in resource exploration and development or who expect to pursue graduate studies in geological sciences follow the Mineral and Petroleum Exploration Engineering Concentration.

At all levels the Geological Engineering Program emphasizes laboratory and field experience. All courses have a laboratory session, and after the junior year students participate in a field course, which is six weeks of geologic and engineering mapping and direct observation. The course involves considerable time outdoors in the mountains and canyons of Utah and southwestern Colorado.

At the senior level, students begin to focus on a career path by taking course sequences in at least two areas of geological engineering specialization. The course sequences begin with a 4 unit course in the fundamentals of a field of geological engineering which is followed by a 3 unit design-oriented course that emphasizes experience in direct application of principles through design projects.

Combined Undergraduate/Graduate Programs

Several degree programs offer CSM undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Degree, or Master Degree while completing the requirements for their Bachelor Degree. These programs can give students a head start on graduate education. An overview of these combined programs and description of the admission process and requirements are found in the Graduate Degrees and Requirements section of the Graduate Catalog.

Program Educational Objectives (Bachelor of Science in Geological Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Geological Engineering Program at CSM has established the following program educational objectives, which students are expected to attain within a few years of graduation:

1. Demonstrate a high level of technical competence
2. Demonstrate prowess in written, oral and graphical communication
3. Experience good teamwork and leadership practices

Program Requirements

In order to achieve the program goals listed above, every student working toward the Bachelor of Science Degree in Geological Engineering must complete the following requirements:

Degree Requirements (Geological Engineering)

Following the sophomore year, Geological Engineering students choose from one of two concentrations:

1. Minerals and Petroleum Exploration Engineering
2. Environmental, Engineering Geology and Geotechnics, and Ground-water Engineering

Minerals and Petroleum Exploration Engineering Concentration

Recommended for students intending careers in exploration and development of mineral and fuels resources, or intending careers in geoscience research and education.

Freshman

Fall		lec	lab	sem.hrs
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	3.0	3.0	4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
EDNS151	DESIGN I			3.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125	3.0	3.0	4.0
HASS100	NATURE AND HUMAN VALUES			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		lec	lab	sem.hrs
GEGN203	ENGINEERING TERRAIN ANALYSIS	2.0		2.0
GEGN204	GEOLOGIC PRINCIPLES AND PROCESSES	2.0		2.0
GEGN205	ADVANCED PHYSICAL GEOLOGY LABORATORY		3.0	1.0
CEEN241	STATICS	3.0		3.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
HASS200	GLOBAL STUDIES			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5		0.5
				14.5

Spring		lec	lab	sem.hrs
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
CEEN311	MECHANICS OF MATERIALS	3.0		3.0
GEGN212	PETROLOGY FOR GEOLOGICAL ENGINEERS	3.0	3.0	4.0
GEGN217	GEOLOGIC FIELD METHODS (GEOLOGIC FIELD METHODS)	1.0	8.0	2.0
EDNS264	DESIGN II: GEOLOGY GIS	2.0	3.0	3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5		0.5
				17.0

Junior

Fall		lec	lab	sem.hrs
GEOL309	STRUCTURAL GEOLOGY AND TECTONICS	3.0	3.0	4.0
GEOL321	MINERALOGY AND MINERAL CHARACTERIZATION	2.0	3.0	3.0
GEGN330	GEOSCIENTISTS THERMODYNAMICS, CHGN 209, or MEGN 361			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
CEEN312	SOIL MECHANICS or MNGN 321			3.0
				16.0

Spring		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
GEGN432	GEOLOGICAL DATA MANAGEMENT			3.0
GEGN351	GEOLOGICAL FLUID MECHANICS	3.0		3.0
GEGN307	PETROLOGY	2.0	3.0	3.0
GEOL314	STRATIGRAPHY	3.0	3.0	4.0
GEGN317	GEOLOGIC FIELD SKILLS (GEOLOGIC FIELD SKILLS)	1.0	4.0	1.0
				18.0

Summer		lec	lab	sem.hrs
GEGN316	FIELD GEOLOGY		6.0	6.0
				6.0

Senior

Fall		lec	lab	sem.hrs
GEGN ELECT	GEGN4xx Option Elective	3.0	3.0	4.0
GEGN ELECT	GEGN4xx Option Elective	3.0	3.0	4.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
FREE	Free Elective			3.0
				17.0

Spring		lec	lab	sem.hrs
GEGN403	MINERAL EXPLORATION DESIGN			3.0
GEGN439	PETROLEUM EXPLORATION DESIGN			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective	3.0		3.0
FREE	Free Elective			4.0

FREE	Free Elective	3.0
		16.0

Total Semester Hrs: 137.5

* Technical Elective: MNGN321 or CEEN312.
Geologic Science and Engineering Elective: An elective must be selected from a department list of approved courses. The elective must total 3 hours of math and basic sciences or engineering topics.

Option Electives

Student must take TWO of the following four courses:		8.0
GEGN401	MINERAL DEPOSITS	
GEGN438	PETROLEUM GEOLOGY	
GEGN467	GROUNDWATER ENGINEERING	
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	

Design Electives

Students must take TWO of the following design courses, corresponding in subject area to the Option Elective:		6.0
GEGN403	MINERAL EXPLORATION DESIGN	
GEGN439	PETROLEUM EXPLORATION DESIGN	
GEGN469	ENGINEERING GEOLOGY DESIGN	
GEGN470	GROUND-WATER ENGINEERING DESIGN	

Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration

Recommended for students intending careers in geotechnical engineering, hydrogeology, or other environmental engineering careers.

Freshman

Fall		lec	lab	sem.hrs
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	3.0	3.0	4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
EDNS151	DESIGN I			3.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125	3.0	3.0	4.0
HASS100	NATURE AND HUMAN VALUES			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		lec	lab	sem.hrs
MATH225	DIFFERENTIAL EQUATIONS			3.0
CEEN241	STATICS	3.0		3.0
GEGN203	ENGINEERING TERRAIN ANALYSIS	2.0		2.0
GEGN204	GEOLOGIC PRINCIPLES AND PROCESSES	2.0		2.0
GEGN205	ADVANCED PHYSICAL GEOLOGY LABORATORY		3.0	1.0
HASS200	GLOBAL STUDIES			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				14.5

Spring		lec	lab	sem.hrs
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
CEEN311	MECHANICS OF MATERIALS	3.0		3.0
GEGN212	PETROLOGY FOR GEOLOGICAL ENGINEERS			4.0
GEGN217	GEOLOGIC FIELD METHODS			2.0
EDNS264	DESIGN II: GEOLOGY GIS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Junior

Fall		lec	lab	sem.hrs
CEEN312	SOIL MECHANICS			3.0
CEEN312L	SOIL MECHANICS LABORATORY			1.0
GEGN330	GEOSCIENTISTS THERMODYNAMICS, CHGN 209, or MEGN 361			3.0
GEOL309	STRUCTURAL GEOLOGY AND TECTONICS	3.0	3.0	4.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
				18.0

Spring		lec	lab	sem.hrs
GEGN432	GEOLOGICAL DATA MANAGEMENT			3.0
GEGN351	GEOLOGICAL FLUID MECHANICS	3.0		3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	2.0	3.0	3.0
GEOL314	STRATIGRAPHY	3.0	3.0	4.0
GEGN317	GEOLOGIC FIELD SKILLS	1.0	4.0	1.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
				17.0

Summer		lec	lab	sem.hrs
GEGN316	FIELD GEOLOGY		6.0	6.0
				6.0

Senior

Fall		lec	lab	sem.hrs
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	3.0	3.0	4.0
GEGN467	GROUNDWATER ENGINEERING	3.0	3.0	4.0
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				17.0

Spring		lec	lab	sem.hrs
GEGN469	ENGINEERING GEOLOGY DESIGN	3.0		3.0
GEGN470	GROUND-WATER ENGINEERING DESIGN	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				15.0

Total Semester Hrs: 137.5

Students in the Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration may further specialize by utilizing their free elective courses to emphasize a specific specialty. Suggested courses are presented below and should be selected in consultation with the student's advisor. The emphasis area is an informal designation only and it will not appear on the transcript.

Engineering Geology and Geotechnics Emphasis

CEEN415	FOUNDATION ENGINEERING	3.0
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0
EBGN321	ENGINEERING ECONOMICS	3.0
GEGN399	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6
GEGN499	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6
GEGN307	PETROLOGY	3.0
GEOL321	MINERALOGY AND MINERAL CHARACTERIZATION	3.0
CSCI261	PROGRAMMING CONCEPTS	3.0
MNGN404	TUNNELING	3.0
MNGN408	UNDERGROUND DESIGN AND CONSTRUCTION	2.0
MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0
MNGN445/545	ROCK SLOPE ENGINEERING	3.0

Water Engineering Emphasis

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	3.0
CEEN302	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: AIR AND WASTE MANAGEMENT	3.0
CEEN461	FUNDAMENTALS OF ECOLOGY	3.0
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES	3.0
CEEN471	WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN	3.0
CEEN475	SITE REMEDIATION ENGINEERING	3.0
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT	3.0
CSCI260	FORTRAN PROGRAMMING	2.0
CSCI261	PROGRAMMING CONCEPTS	3.0
EBGN321	ENGINEERING ECONOMICS	3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0
CEEN492	ENVIRONMENTAL LAW	3.0
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0
GEGN481	ANALYTICAL HYDROLOGY	3.0
GEGN483	MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS	3.0
GEGN499	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6
GEOL321	MINERALOGY AND MINERAL CHARACTERIZATION	3.0
HASS487	ENVIRONMENTAL POLITICS AND POLICY	3.0
HASS488	GLOBAL WATER POLITICS AND POLICY	3.0
MATH332	LINEAR ALGEBRA	3.0
MEGN451	FLUID MECHANICS II - AERODYNAMICS	3.0

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- GEGN100 through GEGN599 inclusive
- GEGX100 through GEGX599 inclusive
- GEOC100 through GEOC599 inclusive
- GEOL100 through GEOL599 inclusive

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Geological Engineering Minor and Area of Special Interest

To receive a minor or ASI, a student must take at least 12 (ASI) or 18 (minor) hours of a logical sequence of courses. This may include GEGN101 (4 hours) and up to 4 hours at the 200-level.

Students must consult with the Department to have their sequence of courses approved before embarking on a minor program.

Courses

GEGN101. EARTH AND ENVIRONMENTAL SYSTEMS. 4.0 Semester Hrs.
Equivalent with SYGN101,
(I, II, S) Fundamental concepts concerning the nature, composition and evolution of the lithosphere, hydrosphere, atmosphere and biosphere of the earth integrating the basic sciences of chemistry, physics, biology and mathematics. Understanding of anthropological interactions with the natural systems, and related discussions on cycling of energy and mass, global warming, natural hazards, land use, mitigation of environmental problems such as toxic waste disposal, exploitation and conservation of energy, mineral and agricultural resources, proper use of water resources, biodiversity and construction. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEGN203. ENGINEERING TERRAIN ANALYSIS. 2.0 Semester Hrs.
(I) Analysis of landforms, geologic processes, principles of geomorphology, mapping, air photo and map interpretation, and engineering uses of geologic information.. Geomorphology of glacial, volcanic, arid, karst, and complex geological landscapes. Introduction to weathering, soils, hillslopes, and drainage systems. Prerequisite: GEGN101. Must be taken concurrently with GEGN204 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

GEGN204. GEOLOGIC PRINCIPLES AND PROCESSES. 2.0 Semester Hrs.
(I) Introduction to advanced concepts of physical and historical geology from a scientific perspective. Development of the geologic time scale, relative time, and geochronology. Chemical composition and cycling of elements in the Earth. Plate tectonics and how tectonics influence sea-level history and sedimentation patterns. Evolution and the fossil record. Critical events in Earth history with a focus on North America and Colorado geology. Prerequisite: GEGN101. Must be taken concurrently with GEGN203 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

GEGN205. ADVANCED PHYSICAL GEOLOGY LABORATORY. 1.0 Semester Hr.
(I) Basic geologic mapping and data gathering skills, with special emphasis on air photos and topographic and geologic maps. Course will include fieldwork in geomorphic regions of Colorado, with analysis of landforms and geologic processes. Applications of geologic information to solve geologic engineering problems. Prerequisite: GEGN101. Must be taken concurrently with GEGN203 and GEGN204 for GE majors. 3 hours laboratory, 1 semester hour.

GEGN206. EARTH MATERIALS. 3.0 Semester Hrs.
(II) Introduction to Earth Materials, emphasizing the structure, composition, formation, and behavior of minerals. Laboratories emphasize the recognition, description, and engineering evaluation of earth materials. Prerequisite: GEGN101, GEGN203, GEGN204, GEGN205. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN212. PETROLOGY FOR GEOLOGICAL ENGINEERS. 4.0 Semester Hrs.
Introduction to Earth materials. This course will teach foundations of mineralogy and petrology in lecture, including an introduction to crystal chemistry and mineral classification schemes and the concepts of rock forming processes as a basis for rock classification. Students will be able to link chemistry, mineralogy, and tectonic processes to rock forming processes and the associated rock classification. The associated laboratory will focus on practical skills used to identify minerals and rocks in hand sample. Prerequisite: CHGN122 or CHGN125. Co-requisite: GEGN217.

GEGN217. GEOLOGIC FIELD METHODS. 2.0 Semester Hrs.
Methods and techniques of geologic field observations and interpretations. Lectures in field techniques and local geology. Laboratory and field project in diverse sedimentary, igneous, metamorphic, structural, and surficial terrains using aerial photographs and topographic maps. Geologic cross sections, maps, and reports. Weekend exercises required. Prerequisite: GEGN203, GEGN204 and GEGN205.

GEGN298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEGN299. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEGN307. PETROLOGY. 3.0 Semester Hrs.
Equivalent with GEOL307,
An introduction to igneous, sedimentary and metamorphic processes, stressing the application of chemical and physical mechanisms to study the origin, occurrence, and association of rock types. Emphasis on the megascopic and microscopic classification, description, and interpretation of rocks. Analysis of the fabric and physical properties. Prerequisite: GEOL321, GEGN330 or CHGN209 or MEGN361.

GEGN316. FIELD GEOLOGY. 6.0 Semester Hrs.
(S) Six weeks of field work, stressing geology of the Southern Rocky Mountain Province. Mapping of igneous, metamorphic, and sedimentary terrain using air photos, topographic maps, and other methods. Diversified individual problems in petroleum geology, mining geology, engineering geology, structural geology, and stratigraphy. Formal reports submitted on several problems. Frequent evening lectures and discussion sessions. Field trips emphasize regional geology as well as mining, petroleum, and engineering projects. Prerequisites: GEGN203, GEGN204, GEGN205, GEGN206, GEGN212 or GEGN307, GEOL314, GEOL309, and GEGN317. 6 semester hours (Summer Term).

GEGN317. GEOLOGIC FIELD SKILLS. 1.0 Semester Hr.
Advanced methods and techniques of geologic field observations and interpretations. Field mapping projects in diverse sedimentary, igneous, metamorphic, structural, and surficial terrains using aerial photographs and topographic maps. Geologic cross sections, maps, and reports. Weekend exercises required. Course includes an introduction to camping skills and working in remote field locations. Prerequisite: GEGN217, GEGN212, GEOL309. Co-requisite: GEOL314.

GEGN330. GEOSCIENTISTS THERMODYNAMICS. 3.0 Semester Hrs.
(I) Introduction to fundamental principles of thermodynamics applied to geosciences and geoengineering. Thermodynamics are used as a tool for evaluating the stability and chemical transformation of minerals and rocks, evolution of vapors and liquids and their reaction paths when subjected to different P-T geological regimes. The course will focus on basic principles of thermodynamics and make use of examples relevant to geoscientists encompassing: i) calculation of thermodynamic properties (volume, heat capacity, enthalpy and entropy) as a function of pressure, temperature and composition, ii) the study of heat transfer and volume change associated to chemical reactions and iii) evaluation of phase stabilities using Gibbs energy minimization and law of mass action. Introduction to pure phase properties, ideal and non-ideal solutions, activities, equilibrium constants, chemical potential, electrolytes, phase rule and Gibbs energy function. Prerequisites: CHGN121, CHGN122 or CHGN125, MATH111, MATH112, GEGN206. May not also receive credit for CHGN209 or CBEN210. 3 hours lecture; 3 semester hours.

GEGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 1 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions. Repeatable.

GEGN342. ENGINEERING GEOMORPHOLOGY. 3.0 Semester Hrs.
(I) Study of interrelationships between internal and external earth processes, geologic materials, time, and resulting landforms on the Earth?s surface. Influences of geomorphic processes on design of natural resource exploration programs and siting and design of geotechnical and geohydrologic projects. Laboratory analysis of geomorphic and geologic features utilizing maps, photo interpretation and field observations. Prerequisite: GEGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN351. GEOLOGICAL FLUID MECHANICS. 3.0 Semester Hrs.
(II) Properties of fluids; Bernoulli's energy equation, the momentum and mass equations; laminar and turbulent flow in pipes, channels, machinery, and earth materials; subcritical and supercritical flow in channels; Darcy's Law; the Coriolis effect and geostrophic flow in the oceans and atmosphere; sediment transport. Prerequisite: CEEN241. 3 hours lecture; 3 semester hours.

GEGN398. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEGN399. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEGN401. MINERAL DEPOSITS. 4.0 Semester Hrs.
(I) Introductory presentation of magmatic, hydrothermal, and sedimentary metallic ore deposits. Chemical, petrologic, structural, and sedimentological processes that contribute to ore formation. Description of classic deposits representing individual deposit types. Review of exploration sequences. Laboratory consists of hand specimen study of host rock-ore mineral suites and mineral deposit evaluation problems. Prerequisite: GEGN330 or CHGN209, GEGN307, and GEGN316. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN403. MINERAL EXPLORATION DESIGN. 3.0 Semester Hrs.
(II) (WI) Exploration project design: commodity selection, target selection, genetic models, alternative exploration approaches and associated costs, exploration models, property acquisition, and preliminary economic evaluation. Lectures and laboratory exercises to simulate the entire exploration sequence from inception and planning through implementation to discovery, with initial ore reserve calculations and preliminary economic evaluation. Prerequisite: GEGN401 and EDNS251. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN404. ORE MICROSCOPY. 3.0 Semester Hrs.
(II) Identification of ore minerals using reflected light microscopy, micro-hardness, and reflectivity techniques. Interpretation of common ore mineral textures, including those produced by magmatic segregation, open space filling, replacement, exsolution, and recrystallization. Guided research on the ore mineralogy and ore textures of classical ore deposits. Prerequisite: GEOL321, GEGN401. 6 hours lab; 3 semester hours.

GEGN432. GEOLOGICAL DATA MANAGEMENT. 3.0 Semester Hrs.
(I, II, S) Techniques for managing and analyzing geological data, including statistical analysis procedures and computer programming. Topics addressed include elementary probability, populations and distributions, estimation, hypothesis testing, analysis of data sequences, mapping, sampling and sample representativity, linear regression, and overview of univariate and multivariate statistical methods. Practical experience with principles of software programming and statistical analysis for geological applications via suppled software and data sets from geological case histories. Prerequisites: Junior standing in Geological Engineering. 2 hours lecture; 3 hours lab; 3 semester hours.

GEGN438. PETROLEUM GEOLOGY. 4.0 Semester Hrs.
(I) Source rocks, reservoir rocks, types of traps, temperature and pressure conditions of the reservoir, theories of origin and accumulation of petroleum, geology of major petroleum fields and provinces of the world, and methods of exploration for petroleum. Term report required. Laboratory consists of study of well log analysis, stratigraphic correlation, production mapping, hydrodynamics and exploration exercises. Prerequisite: GEOL308 or GEOL309 and GEOL314 or GEOL315; and GEGN316 or GPGN486 or PEGN316. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN439. PETROLEUM EXPLORATION DESIGN. 3.0 Semester Hrs.
Equivalent with PEGN439,
(II) (WI) This is a multi-disciplinary design course that integrates fundamentals and design concepts in geology, geophysics, and petroleum exploration. Students work both individually and in teams on multiple open-ended design problems in oil and gas exploration, including integration of well and seismic reflection databases, seismic interpretation in different tectonostratigraphic settings, and the development of a prospects in a variety of exploration plays. Several detailed written and oral presentations are made throughout the semester. Prerequisites: GEOL309, GEOL314, GEGN438, and EDNS264. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN466. GROUNDWATER ENGINEERING. 3.0 Semester Hrs.
(I) Theory of groundwater occurrence and flow. Relation of groundwater to surface; potential distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Prerequisites: Calc III (MATH213 or MATH223 or MATH224) and DiffEQ (MATH225 or MATH235) and GEGN351 or MEGN351. 3 hours lecture, 3 semester hours.

GEGN467. GROUNDWATER ENGINEERING. 4.0 Semester Hrs.
(I) Theory of groundwater occurrence and flow. Relation of groundwater to surface water; potential distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Laboratory sessions on water budgets, water chemistry, properties of porous media, solutions to hydraulic flow problems, analytical and digital models, and hydrogeologic interpretation. Prerequisites: Calc III (MATH213, MATH223 or MATH224) and DiffEQ (MATH225 or MATH235) and GEGN351 or MEGN351. 3 hours lecture, 3 hours lab, 4 semester hours.

GEGN468. ENGINEERING GEOLOGY AND GEOTECHNICS. 4.0 Semester Hrs.
(I) Application of geology to evaluation of construction, mining, and environmental projects such as dams, water ways, tunnels, highways, bridges, buildings, mine design, and land-based waste disposal facilities. Design projects including field, laboratory, and computer analysis are an important part of the course. Prerequisite: MNGN321 and CEEN312/CEEN312L. 3 hours lecture, 3 hours lab, 4 semester hours.

GEGN469. ENGINEERING GEOLOGY DESIGN. 3.0 Semester Hrs.
(II) (WI) This is a capstone design course that emphasizes realistic engineering geologic/geotechnics projects. Lecture time is used to introduce projects and discussions of methods and procedures for project work. Several major projects will be assigned and one to two field trips will be required. Students work as individual investigators and in teams. Final written design reports and oral presentations are required. Prerequisite: GEGN468 and EDNS264. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN470. GROUND-WATER ENGINEERING DESIGN. 3.0 Semester Hrs.
(II) (WI) Application of the principles of hydrogeology and ground-water engineering to water supply, geotechnical, or water quality problems involving the design of well fields, drilling programs, and/or pump tests. Engineering reports, complete with specifications, analysis, and results, will be required. Prerequisite: GEGN467 or equivalent and EPIC264. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN473. GEOLOGICAL ENGINEERING SITE INVESTIGATION. 3.0 Semester Hrs.
Methods of field investigation, testing, and monitoring for geotechnical and hazardous waste sites, including: drilling and sampling methods, sample logging, field testing methods, instrumentation, trench logging, foundation inspection, engineering stratigraphic column and engineering soils map construction. Projects will include technical writing for investigations (reports, memos, proposals, workplans). Class will culminate in practice conducting simulated investigations (using a computer simulator).

GEGN475. APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS. 3.0 Semester Hrs.
(II) An introduction to Geographic Information Systems (GIS) and their applications to all areas of geology and geological engineering. Lecture topics include: principles of GIS, data structures, digital elevation models, data input and verification, data analysis and spatial modeling, data quality and error propagation, methods of GIS projects, as well as video presentations. Prerequisite: GEGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN481. ANALYTICAL HYDROLOGY. 3.0 Semester Hrs.
Equivalent with GEGN581,
(I) Introduction to the theory, and hydrological application of, probability, statistics, linear algebra, differential equations, numerical analysis, and integral transforms. Prerequisites: GEGN467. 3 hours lecture; 3 semester hours.

GEGN483. MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS. 3.0 Semester Hrs.
(II) Lectures, assigned readings, and direct computer experience concerning the fundamentals and applications of analytical and finite-difference solutions to ground water flow problems as well as an introduction to inverse modeling. Design of computer models to solve ground water problems. Prerequisites: Familiarity with computers, mathematics through differential and integral calculus, and GEGN467. 3 hours lecture; 3 semester hours.

GEGN498. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEGN499. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEOC407. ATMOSPHERE, WEATHER AND CLIMATE. 3.0 Semester Hrs.
(II) An introduction to the Earth?s atmosphere and its role in weather patterns and long term climate. Provides basic understanding of origin and evolution of the atmosphere, Earth?s heat budget, global atmospheric circulation and modern climatic zones. Long- and short-term climate change including paleoclimatology, the causes of glacial periods and global warming, and the depletion of the ozone layer. Causes and effects of volcanic eruptions on climate, El Nino, acid rain, severe thunderstorms, tornadoes, hurricanes, and avalanches are also discussed. Microclimates and weather patterns common in Colorado. Prerequisite: Completion of CSM freshman technical core, or equivalent. 3 hours lecture; 3 semester hours. Offered alternate years.

GEOC408. INTRODUCTION TO OCEANOGRAPHY. 3.0 Semester Hrs.
(II) An introduction to the scientific study of the oceans, including chemistry, physics, geology, biology, geophysics, and mineral resources of the marine environment. Lectures from pertinent disciplines are included. Recommended background: basic college courses in chemistry, geology, mathematics, and physics. 3 hours lecture; 3 semester hours. Offered alternate years.

GEOL102. INTRODUCTION TO GEOLOGICAL ENGINEERING. 1.0 Semester Hr.
(II) Presentations by faculty members and outside professionals of case studies to provide a comprehensive overview of the fields of Geology and Geological Engineering and the preparation necessary to pursue careers in those fields. A short paper on an academic professional path will be required. Prerequisite: GEGN101 or concurrent enrollment. 1 hour lecture; 1 semester hour.

GEOL198. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEOL199. INDEPENDENT STUDY IN GEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEOL201. PLATE TECTONICS. 3.0 Semester Hrs.
(II) An introduction to the theory of plate tectonics as a first-order framework with which the temporal and spatial evolution of the Earth?s surface and interior may be described and understood. Key topics include the mechanisms of mountain building, crustal growth and destruction, volcanism and seismicity in intraplate and plate-margin settings, and secular changes in plate tectonic processes and products over geological time. Laboratory exercises will involve individual and group exercises that utilize qualitative and quantitative analysis of geophysical, geochemical, geochronological, and petrological datasets to constrain the large-scale dynamics of the Earth. Prerequisite: GEGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEOL298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEOL308. INTRODUCTORY APPLIED STRUCTURAL GEOLOGY. 3.0 Semester Hrs.
(II) Nature and origin of structural features of Earth?s crust emphasizing structural controls on oil and gas entrapment. Structural patterns and associations are discussed in context of plate tectonic theories, using examples from across the globe. In class exercises and field projects in structural geometry, mapping and cross section construction and seismic reflection data interpretation. Course required of all PEGN and GPGN students. Prerequisite: GEGN101. 3 hours lecture; 3 semester hours.

GEOL309. STRUCTURAL GEOLOGY AND TECTONICS. 4.0 Semester Hrs.
(I) (WI) Recognition, habitat, and origin of deformational structures related to stresses and strains (rock mechanics and microstructures) and plate tectonics. Structural development of mountain belts, rift, strike-slip and salt systems. Comprehensive field and laboratory projects use descriptive geometry, stereographic projection, structural contours, map and cross section construction, air photo interpretation, and seismic reflection data analysis. Required of Geological Engineers. Prerequisite: GEGN101, GEGN203, GEGN204, GEGN205 and GEGN206 or GPGN200. 3 hours lecture, 3 hours lab; 4 semester hours.

GEOL310. EARTH MATERIALS. 3.0 Semester Hrs.
(I) Introduction to Earth Materials, emphasizing the structure, formation, distribution and engineering behavior of minerals and rocks. Structural features and processes are related to stress/strain theory and rock mechanics principles. Laboratories and field exercises emphasize the recognition, description and engineering evaluation of natural materials. Lectures and case study exercises present the knowledge of natural materials and processes necessary for mining engineering careers. Prerequisites: GEGN101. 2 hours lecture; 3 hours lab; 3 semester hours.

GEOL311. MINING GEOLOGY. 3.0 Semester Hrs.
(II) Introduction to Mining Geology, emphasizing the formation, distribution, engineering behavior, exploration for and geological aspects of development of ore materials. Laboratories emphasize the recognition, description and engineering evaluation of ores and their hosts. Lectures and case study exercises present the knowledge of ores and ore-forming processes necessary for mining engineering careers. Prerequisites: GEGN101 and GEOL310 or MNGN310. 2 hours lecture; 3 hours lab; 3 semester hours.

GEOL314. STRATIGRAPHY. 4.0 Semester Hrs.
(II) Lectures and laboratory and field exercises in concepts of stratigraphy and biostratigraphy, facies associations in various depositional environments, sedimentary rock sequences and geometries in sedimentary basins, and geohistory analysis of sedimentary basins. Prerequisites: GEGN101, GEGN203 or GEGN204, GEGN205. 3 hours lecture, 3 hours lab; 4 semester hours.

GEOL315. SEDIMENTOLOGY AND STRATIGRAPHY. 3.0 Semester Hrs.
(I) Integrated lecture, laboratory and field exercises on the genesis of sedimentary rocks as related to subsurface porosity and permeability development and distribution for non-geology majors. Emphasis is placed on siliciclastic systems of varying degrees of heterogeneity. Topics include diagenesis, facies analysis, correlation techniques, and sequence and seismic stratigraphy. Application to hydrocarbon exploitation stressed throughout the course. Required of all PEGN students. Prerequisite: GEGN101, PEGN308. 2 hours lecture, 3 hours lab; 3 semester hours.

GEOL321. MINERALOGY AND MINERAL CHARACTERIZATION. 3.0 Semester Hrs.
(I) Principles of mineralogy and mineral characterization. Crystallography of naturally occurring materials. Principles of crystal chemistry. Interrelationships among mineral structure, external shape, chemical composition, and physical properties. Introduction to mineral stability. Laboratories emphasize analytical methods, including X-ray diffraction, scanning electron microscopy, and optical microscopy. Prerequisite:GEGN101, CHGN122 or CHGN125, GEGN206. 2 hours lecture, 3 hours lab: 3 semester hours.

GEOL398. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEOL399. INDEPENDENT STUDY IN GEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

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(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

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GEOL399. INDEPENDENT STUDY IN GEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEOL410. PLANETARY GEOLOGY. 3.0 Semester Hrs.
Introduction to the geology of planets, moons, and other bodies within and beyond our solar system. Focusing on topics such as (a) the origin and composition of our solar system and its constituent materials, (b) geologic processes occurring on planetary surfaces (e.g. cratering) and shallow and deep interiors (e.g. volcanism, mantle convection), (c) methods of solar system exploration, and potential for resource discovery and utilization on near-neighbors and asteroids, and (d) comparative planetology (thermal histories, evidence for plate tectonics, origin and retention of atmospheres, exobiology).

GEOL443. UNDERGRADUATE FIELD SEMINAR. 1-3 Semester Hr.
Special advanced classroom and field programs emphasizing detailed study of some aspects of the geology of an area or region. Field studies normally conducted away from the Golden campus. Classroom course content dependent on area of study. Fees assessed for field and living expenses and transportation. 1 to 3 semester hours; may be repeated for credit.

GEOL444. INVERTEBRATE PALEONTOLOGY. 3.0 Semester Hrs.
(II) Fossils are the basis for establishing global correlation among Phanerozoic sedimentary rocks, and thus are critical to the reconstruction of the past 550 million years of Earth history. This is a lecture elective course that will aid in rounding out undergraduate Earth science/ engineering geological knowledge. Fossil preservation, taphonomy, evolution, mass extinctions, biostratigraphy, graphic correlation, invertebrate phyla and their geologic history and evolution. Prerequisites: GEGN204, GEGN205, GEGN206. 3 hours lecture; 3 semester hours.

GEOL470. APPLICATIONS OF SATELLITE REMOTE SENSING. 3.0 Semester Hrs.
(II) Students are introduced to geoscience applications of satellite remote sensing. Introductory lectures provide background on satellites, sensors, methodology, and diverse applications. One or more areas of application are presented from a systems perspective. Guest lecturers from academia, industry, and government agencies present case studies focusing on applications, which vary from semester to semester. Students do independent term projects, under the supervision of a faculty member or guest lecturer, that are presented both written and orally at the end of the term. Prerequisites: PHGN200 and MATH225. 3 hours lecture; 3 semester hours.

GEOL498. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEOL499. INDEPENDENT STUDY IN GEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professor and Department Head

Wendy Bohrson

Professors

David A. Benson

Zhaoshan Chang, Charles F. Fogarty Endowed Chair

Alexei Milkov, Director of Potential Gas Agency

Thomas Monecke, Co-Director of CMRS

Piret Plink-Bjorklund

Paul M. Santi, Director of CMS

Kamini Singha, Associate Dean of ESP

Stephen A. Sonnenberg, Charles Boettcher Distinguished Chair in Petroleum Geology

Lesli J. Wood, Associate Department Head, Weimer Distinguished Chair

Associate Professors

Yvette Kuiper

Bruce Trudgill

Alexis Navarre-Sitchler, Ben Fryrear Endowed Chair for Innovation and Excellence

Wendy Zhou

Assistant Professors

Kevin Cannon

Danica Roth

Gabriel Walton

Research Professors

Marsha French

Richard Goldfarb

Zane Jobe, Director of the Chevron Center of Research Excellence

David Leach

Reed M. Maxwell

J. Fredrick Sarg

Research Assistant Professor

Mary Carr

Research Associate Professor

Katharina Pfaff

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Christian V. Shorey

Professors Emerita

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John B. Curtis

Thomas L.T. Grose

John D. Haun

Jerry D. Higgins

Murray W. Hitzman

Neil F. Hurley

Keenan Lee

Samuel B. Romberger

Keith A. Turner

John E. Warme

Robert J. Weimer

Richard F. Wendlandt

Associate Professors Emeriti

L. Graham Closs

Timothy A. Cross

Gregory S. Holden

Geophysics

Program Description

Founded in 1926, the Department of Geophysics at Colorado School of Mines is recognized and respected around the world for its programs in applied geophysical research and education. With 12 full-time faculty and small class sizes, students receive individualized attention in a close-knit department. The mission of the geophysical engineering program is to educate undergraduates in the application of geophysics to help meet global needs for energy, water, food, minerals, and the mitigation of natural hazards by exploring and illuminating the dynamic processes of the Earth, oceans, atmosphere and solar system.

Geophysicists study the Earth's interior through physical measurements collected at the Earth's surface, in boreholes, from aircraft, or from satellites. Using a combination of mathematics, physics, geology, chemistry, hydrology, and computer science, both geophysicists and geophysical engineers analyze these measurements to infer properties and processes within the Earth's complex interior. Noninvasive imaging beneath the surface of Earth and other planets by geophysicists is much like noninvasive imaging of the interior of the human body by medical specialists.

The Earth supplies the materials needed by our society, serves as the repository for used products, and provides a home to all its inhabitants. Geophysics and geophysical engineering have important roles to play in the solution of challenging problems facing the inhabitants of this planet, such as providing fresh water, food, and energy for Earth's growing population, evaluating sites for underground construction and containment of hazardous waste, monitoring the aging infrastructures of developed nations, mitigating the threat of geohazards (earthquakes, volcanoes, landslides, avalanches) to populated areas, contributing to homeland security (including detection and removal of unexploded ordnance and land mines), evaluating changes in climate and managing humankind's response to them, and exploring other planets.

Energy companies and mining firms employ geophysicists to explore for hidden resources around the world. Engineering firms hire geophysical engineers to assess sites that are chosen for large construction projects and waste-management operations. Environmental organizations use geophysics to conduct groundwater surveys and to track the flow of contaminants. On the global scale, geophysicists employed by universities and government agencies (such as the United States Geological Survey and NASA) try to understand such Earth processes as heat flow, gravitational, magnetic, electric, thermal, and stress fields within the Earth's interior. For the past decade, nearly all Mines geophysics graduates have found employment in their chosen field, with about half of them choosing to pursue graduate studies.

The program leading to the degree of Bachelor of Science in Geophysical Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Bachelor of Science Program in Geophysical Engineering

Geophysical Engineering undergraduates who may have an interest in professional registration as engineers are encouraged to take the Engineer in Training (EIT)/Fundamentals of Engineering (FE) exam as seniors. The Geophysical Engineering Program has the following objectives and associated outcomes:

Program Educational Objective 1: Graduates will be competent professionals who are capable of independent and innovative problem solving, are skilled in scientific computing and are working to address important Earth, energy, and /or environmental problems.

Program Educational Objective 2: Graduates will be effective oral and written communicators with exceptional team skills which will allow them to grow in their careers and in professional societies.

Program Educational Objective 3: Graduates will recognize economic and social impacts of their work and will have the ability to communicate this to a range of stakeholders (e.g. management, public, peers)

Student Outcomes (from ABET Criterion 3):

a. An ability to apply knowledge of mathematics, science, and engineering.

b. An ability to design and conduct experiments, as well as to analyze and interpret data.

c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health, safety, manufacturability, and sustainability.

d. An ability to function on multidisciplinary teams.

e. An ability to identify, formulate, and solve engineering problems.

f. An understanding of professional and ethical responsibility.

g. An ability to communicate effectively.

h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

i. A recognition of the need for, and an ability to engage in life-long learning.

j. Knowledge of contemporary issues.

k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Program Specific Outcomes

1. Expanded perspective of applied geophysics as a result of participating in employment or research.

2. An ability to analyze, quantitatively, the errors, limitations, and uncertainties in data.

Geophysics Field Camp

Each summer, a base of field operations is set up for four weeks, usually in the mountains of Colorado, for students who have completed their junior year. Students prepare geological maps and cross sections and then use these as the basis for conducting seismic, gravimetric, magnetic, electrical, and electromagnetic surveys. After acquiring these various geophysical datasets, the students process the data and develop an interpretation that is consistent with all the information. In addition to the required four-week program, students can also participate in other diverse field experiences. In recent years these have included cruises on seismic ships in the Gulf of Mexico, studies at an archeological site,

investigations at environmental sites, and a ground-penetrating radar survey on an active volcano in Hawaii.

Study Abroad

The Department of Geophysics encourages its undergraduates to spend one or two semesters studying abroad. At some universities, credits can be earned that substitute for course requirements in the geophysical engineering program at Mines. Information on universities that have established formal exchange programs with Mines can be obtained from the Office of Global Initiatives.

Combined BS/MS Program

Undergraduate students in the Geophysical Engineering program who are interested in continuing directly into the Master of Science program in Geophysics or Geophysical Engineering are encouraged to meet with their advisor or department head as early as possible in their undergraduate program. Students enrolled in the Mines Combined Undergraduate/Graduate Program may double count up to six hours of credits which were used in fulfilling the requirements of their undergraduate degree at Mines, towards their graduate program. Any courses that count towards the graduate degree requirements as either "Required Coursework" or "Elective Coursework", as defined below, may be used for the purposes of double counting at the discretion of the advisor (MS Non-Thesis) or thesis committee (MS Thesis or Ph.D.). These courses must have been passed with a "B-" or better and meet all other University, Department, Division, and Program requirements for graduate credit.

Summer Jobs in Geophysics

In addition to the summer field camp experience, students have opportunities every summer throughout their undergraduate career to work as summer interns within industry, at Mines, or for government agencies such as the U.S. Geological Survey.

Undergraduate Research

Students are encouraged to try their hand at research by working on a project with a Mines faculty member, either during the semester, or during the summer. As an alternative to a summer internship, students may wish to participate in a Research Experience for Undergraduates (REU), either at Mines or at another university. REU's are typically sponsored by the National Science Foundation (NSF) and are listed on the NSF website.

The Cecil H. and Ida Green Graduate and Professional Center

The meeting rooms, laboratories, and computer-aided instruction areas of the Department of Geophysics are all located in Green Center. The Department is home to one of only two campus Linux-only computing labs. The Department also maintains equipment for conducting geophysical field measurements, including magnetometers, gravity meters, ground-penetrating radar, and instruments for recording seismic waves. Students may request access to the Department petrophysics laboratory for measuring properties of porous rocks, or study one of the world's largest repositories of core samples in the Core Lab.

Curriculum

Geophysics is an applied and interdisciplinary science; therefore, students must have a strong foundation in physics, mathematics, geology, and computer sciences. Included in this foundation is a comprehensive body of courses on the theory and practice of geophysical methods. As geophysics and geophysical engineering involve the study and exploration of the entire earth, our graduates have great opportunities to work anywhere on, and even off, the planet. Therefore, the curriculum includes electives in the Humanities & Social Science (H&SS) that give students an understanding of international issues and different cultures. Every student who obtains a Bachelor's Degree in Geophysical Engineering completes the Mines Core Curriculum plus the program-specific courses, all outlined below. We recommend students download the current curriculum flowchart from the Departmental webpage, https://geophysics.mines.edu/undergraduate-program/.

Degree Requirements (Geophysical Engineering)

Freshman

Fall		lec	lab	sem.hrs
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	3.0	3.0	4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
CSCI101	INTRODUCTION TO COMPUTER SCIENCE			3.0
				16.0

Spring		lec	lab	sem.hrs
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
EDNS151	DESIGN I			3.0
HASS100	NATURE AND HUMAN VALUES	4.0		4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Sophomore

Fall		lec	lab	sem.hrs
GPGN228	INTRODUCTION TO ROCK PHYSICS			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
GEGN205	ADVANCED PHYSICAL GEOLOGY LABORATORY			1.0
GEGN204	GEOLOGIC PRINCIPLES AND PROCESSES or 203			2.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Spring		lec	lab	sem.hrs
GPGN268	GEOPHYSICAL DATA ANALYSIS			3.0
GPGN229	MATHEMATICAL GEOPHYSICS			3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
HASS200	GLOBAL STUDIES			3.0
GEGN/GEOL	GEOLOGY ELECTIVE[1]			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				18.5

Junior

Fall		lec	lab	sem.hrs
GPGN328	PHYSICS OF THE EARTH - I	3.0		3.0
GPGN350	SCIENCE AND COMMUNICATION SKILLS	3.0		3.0
MATH332	LINEAR ALGEBRA			3.0
CSCI250	PYTHON-BASED COMPUTING: BUILDING A SENSOR SYSTEM			3.0
FREE	FREE ELECTIVE	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective[2]			3.0
				18.0

Spring		lec	lab	sem.hrs
GPGN404	DIGITAL SIGNAL PROCESSING			3.0
GPGN329	PHYSICS OF THE EARTH - II			3.0
GPGN314	APPLIED GEOPHYSICS			4.0
FREE	FREE ELECTIVE	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective[2]			3.0
				16.0

Summer		lec	lab	sem.hrs
GPGN486	GEOPHYSICS FIELD CAMP		4.0	4.0
				4.0

Senior

Fall		lec	lab	sem.hrs
GPGN435	GEOPHYSICAL COMPUTING			3.0
GPGN409	INVERSION			3.0
GP ELECT	GPGN Advanced Elective[3]	3.0	3.0	3.0
GP ELECT	GPGN Advanced Elective[3]	3.0	3.0	3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective[2]	3.0		3.0
				15.0

Spring		lec	lab	sem.hrs
GPGN438	GEOPHYSICS PROJECT DESIGN			3.0
CSCI303	INTRODUCTION TO DATA SCIENCE			3.0
GP ELECT	GPGN Advanced Elective[3]	3.0		3.0
GP ELECT	GPGN Advanced Elective[3]			3.0
FREE	FREE ELECTIVE	3.0		3.0
				15.0

Total Semester Hrs: 133.5

1 Students must take at least 3 credits of GEGN or GEOL electives.

2 Within these 9 Humanities & Social Science (H&SS) electives, students must take at least 3 credits at the 400-level.

3 Students must take 12 credits of advanced GPGN elective courses at the 400- or 500-level.

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- GPGN100 through GPGN599 inclusive

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Minor in Geophysics/Geophysical Engineering

Geophysics plays an important role in many aspects of civil engineering, petroleum engineering, mechanical engineering, and mining engineering, as well as mathematics, physics, geology, chemistry, hydrology, and computer science. Given the natural connections between these various fields and geophysics, it may be of interest for students in other majors to consider choosing to minor in geophysics, or to choose geophysics as an area of specialization. The core set of courses required for a GP minor are as follows:

GPGN229	MATHEMATICAL GEOPHYSICS	3.0
GPGN328	PHYSICS OF THE EARTH - I	3.0
GPGN329	PHYSICS OF THE EARTH - II	3.0
GPGN314	APPLIED GEOPHYSICS	4.0

The remaining 5 hours can be satisfied by a combination of other geophysics courses, as well as courses in geology, mathematics, and computer science depending on the student's major. Students must consult with the Department of Geophysics to have these remaining courses approved. Previous or concurrent experience in programming is strongly recommended but not required.

Courses

GPGN101. INTRODUCTION TO GEOPHYSICS: GEOPHYSICS AND SOCIETY. 3.0 Semester Hrs.
(I) This is a discovery course designed to introduce freshmen to the science of geophysics in the context of society and humans' interaction with the Earth. Students will explore geophysical measurements and characterization of earth properties and processes that have the greatest impact on the development of human civilization. Examples include characterizing earthquakes and volcanic eruptions, imaging energy resources deep within the earth, measuring the impacts of climate change on the ice sheets, and evaluation of water resources. 3 hours lecture; 3 semester hours.

GPGN198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GPGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GPGN228. INTRODUCTION TO ROCK PHYSICS. 3.0 Semester Hrs.
(I) Introduction to sediment and rock properties, their measurements, and geophysical operations. Course will introduce physical and mathematical framework, quantitative interpretations, and provide framework for multi-physics approaches, data interpretation, and data inversion to help us understand the physical properties of the subsurface. Topics covered will include mineralogy, porosity, density, pore shape/size, pore fluids, permeability, compressibility, stress, and strength and how they can be measured with experiments and approximated with geophysical techniques. 2 hours lecture; 3 hours lab; 3 semester hours.

GPGN229. MATHEMATICAL GEOPHYSICS. 3.0 Semester Hrs.
(II) This course will address how specific mathematical approaches are used to understand and to solve geophysical problems. Topics that will be used in a geophysical context include continuum mechanics, linear algebra, vector calculus, complex variables, Fourier series, partial differential equations, probability, the wave equation, and the heat equation. Prerequisites: MATH111, MATH112, MATH213, PHGN100, PHGN200. Corequisites: MATH225. 3 hours lecture; 3 semester hours.

GPGN268. GEOPHYSICAL DATA ANALYSIS. 3.0 Semester Hrs.
Equivalent with EPIC268,
(II) Geophysical Data Analysis focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Students work on projects from the geophysical engineering practice in which they analyze (process, model, visualize) data. In their projects, students encounter limitations and uncertainties in data and learn quantitative means for handling them. They learn how to analyze errors in data, and their effects on data interpretation and decision making. 3 lecture hours; 3 semester hours.

GPGN298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GPGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GPGN314. APPLIED GEOPHYSICS. 4.0 Semester Hrs.
(II) Applied Geophysics is an introductory course on the theory and application of gravity, magnetic, electrical, electromagnetic, and seismic methods for imaging the Earth's subsurface. These tools are employed in various geotechnical and environmental engineering problems, resource exploration and production monitoring, geothermal site characterization, hazards, and humanitarian efforts. Through the combination of three one-hour lectures and one three-hour lab each week, the students are provided with the fundamental theory and hands on field experiments for each of these techniques including the principles, instrumentation, and procedures of data acquisition, analysis, and interpretation. Prerequisite: MATH213, MATH225, GPGN328. Co-requisite: GPGN329. 3 hours lecture; 3 hours lab; 4 semester hours.

GPGN328. PHYSICS OF THE EARTH - I. 3.0 Semester Hrs.
(I) This course is the first part of a two-course sequence on Physics of the Earth and will introduce the static fields including the electrostatics, steady state current flow in conductive media, magnetostatics, and gravitational field as used in probing the interior of the Earth and physical processes therein. The spatial context will be earth?s lithosphere and the associated geoscientific problems arise from a wide range of disciplines including environmental problems, hydrology, minerals and energy exploration, hydrology, tectonics, and climate science. The course will discuss static field theory, their interaction with different physical properties of earth materials, and the use of these fields in imaging, characterizing, and monitoring structures and processes in the earth lithosphere and on the interface between atmosphere and crust. Prerequisites: PHGN200, GPGN229. 3 hours lecture; 3 semester hours.

GPGN329. PHYSICS OF THE EARTH - II. 3.0 Semester Hrs.
(II) The second half of Physics of the Earth will aim to give a global perspective to Earth?s formation and evolution. Starting from conservation laws and continuum mechanics, Earth?s dynamic fields (theory of seismic and electromagnetic wave propagation) will be covered in the context of solid-Earth geophysics and integrated with various geophysical observations & measurements; the Earth seen by the waves, inferring the structure and composition of the interior of planetary bodies from crust to core, physical & thermo-chemical processes in mantle and core shaping Earth?s surface and magnetic field, planetary cooling, ?hot topics? and current challenges in illuminating Earth?s deep structure, modern computational techniques that are used to improve our understanding of Earth?s interior and history. Prerequisites: PHGN200, MATH225, GPGN229, GPGN328. 3 hours lecture; 3 semester hours.

GPGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

GPGN350. SCIENCE AND COMMUNICATION SKILLS. 3.0 Semester Hrs.
(I) (WI) This class covers the basic skills needed for research and for communicating the results of the research. The class covers hands-on elements of doing research, such as choosing a research topic, generating research questions, making a work plan, dealing with the ambiguity and hurdles of research, research ethics, as well as publishing scientific papers, scientific writing, giving oral communications, and writing research proposals. In addition, the class covers career-oriented topics such as choosing a program for graduate studies, working with an advisor, and applying for a job. Students acquire hands-on experience by choosing a research project, making a work plan, writing a proposal, and presenting that proposal. 3 hours lecture; 3 semester hours.

GPGN398. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GPGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GPGN404. DIGITAL SIGNAL PROCESSING. 3.0 Semester Hrs.
(II) The fundamentals of 1-D digital signal processing as applied to geophysical investigations are studied. Students explore the mathematical background and practical consequences of Fourier series and 1D/2D Fourier transforms, linear time-invariant (LTI) systems, convolution and deconvolution, properties of discrete systems, sampling theorem and signal reconstruction, Z-Transform, discrete-time Fourier transform, discrete Fourier series and discrete Fourier transform, windowing and spectrograms, realization of digital filters, FIR filter design and IIR filter design Emphasis is placed on applying the knowledge gained in lecture to exploring practical signal processing issues.
This is done through homework and in-class practicum assignments requiring the programming and testing of algorithms discussed in lecture. Prerequisite: CSCI250. 2 hours lecture; 3 hours lab; 3 semester hours.

GPGN409. INVERSION. 3.0 Semester Hrs.
(I) A study of the fundamentals of inverse problem theory as applied to geophysics. The inversion technology has applicability in all fields of geophysical application, regardless of the physics employed, as well as in non-geophysical data analysis. The course covers fundamental concepts of inversion in the probabilistic and deterministic frameworks, as well as practical methods for solving discrete inverse problems. Topics studied include model discretization, Bayesian inversion, optimization criteria and methods, regularization techniques, error and resolution analysis. Weekly homework assignments addressing either theoretical or numerical problems through programming assignments illustrate the concepts discussed in class. Knowledge of the Python programming language is assumed. Prerequisite: GPGN229, MATH332, GPGN404, CSCI250. Co-requisite: GPGN435. 3 hours lecture; 3 semester hours.

GPGN411. GRAVITY AND MAGNETIC METHODS. 3.0 Semester Hrs.
Equivalent with GPGN414,
(I) Instrumentation for land surface, borehole, sea floor, sea surface, and airborne operations. Reduction of observed gravity and magnetic values. Theory of potential field effects of geologic distributions. Methods and limitations of interpretation. Prerequisite: GPGN314. 3 hours lecture; 3 semester hours.

GPGN419. INTRODUCTION TO FORMATION EVALUATION AND WELL LOGGING. 3.0 Semester Hrs.
(I, II) An introduction to well logging methods, including the relationship between measured properties and reservoir properties. Analysis of log suites for reservoir size and content. Graphical and analytical methods will be developed to allow the student to better visualize the reservoir, its contents, and its potential for production. Use of the computer as a tool to handle data, create graphs and log traces, and make computations of reservoir parameters is required. Prerequisite: GPGN314. 3 hours lecture; 3 semester hours.

GPGN420. ELECTRICAL AND ELECTROMAGNETIC METHODS. 3.0 Semester Hrs.
Equivalent with GPGN422,
(II) In-depth study of the application of electrical and electromagnetic methods to crustal studies, minerals exploration, oil and gas exploration, and groundwater. Laboratory work with mathematical models coupled with field work over areas of known geology. Prerequisite: GPGN314. 3 hours lecture; 3 semester hours.

GPGN435. GEOPHYSICAL COMPUTING. 3.0 Semester Hrs.
(I) This course develops the principles of geophysical computing in the context of simulating and validating numerical solutions to geophysical data processing challenges (e.g., interpolation, regression, numerical quadrature and differentiation) and partial differential equations commonly found in geophysical investigations (e.g., Laplace/Poisson equation, heat flow/diffusion equation, acoustic wave equation). Students learn how algorithms from applied linear algebra can be leveraged to efficiently generate numerical solutions to multidimensional geophysical problems using both self-developed and existing numerical libraries. Prerequisite: CSCI250.

GPGN436. GEOPHYSICAL COMPUTING. 3.0 Semester Hrs.
Equivalent with GPGN435,
This course develops the principles of geophysical computing in the context of simulating and validating numerical solutions to geophysical data processing challenges (e.g., interpolation, regression, numerical quadrature and differentiation) and partial differential equations commonly found in geophysical investigations (e.g., Laplace/Poisson equation, heat flow/diffusion equation, acoustic wave equation). Students learn how algorithms from applied linear algebra can be leveraged to efficiently generate numerical solutions to multidimensional geophysical problems using both self-developed and existing numerical libraries. Offered concurrently with GPGN536. Prerequisite: CSCI250 or instructor consent.

GPGN438. GEOPHYSICS PROJECT DESIGN. 3.0 Semester Hrs.
(II) (WI) Complementary design course for geophysics restricted elective course(s). Application of engineering design principles to geophysics through advanced work, individual in character, leading to an engineering report or senior thesis and oral presentation thereof. Choice of design project is to be arranged between student and individual faculty member who will serve as an advisor, subject to department head approval. Prerequisites: GPGN314, GPGN329, GPGN404. 1 hour lecture; 6 hours lab; 3 semester hours.

GPGN455. EARTHQUAKE SEISMOLOGY. 3.0 Semester Hrs.
Equivalent with GPGN555,
(I) Earthquakes are amongst the most significant natural hazards faced by mankind, with millions of fatalities forecast this century. They are also our most accessible source of information on Earth's structure, rheology and tectonics, which are what ultimately govern the distribution of its natural resources. This course provides an overview of how earthquake seismology, complemented by geodesy and tectonic geomorphology, can be used to determine earthquake locations, depths and mechanisms; understand Earth's tectonics and rheology; establish long-term earthquake histories and forecast future recurrence; mitigate against seismic hazards; illuminate large- and fine-scale features of Earth's interior using earthquake data. Students will also cover the recent developments in 3D numerical earthquake source and wave propagation modelling as well as common & modern seismic data formats and processing/visualization tools and techniques used in earthquake seismology. 3 hours lecture; 3 semester hours. Prerequisite: PHGN200, GPGN229.

GPGN458. SEISMIC INTERPRETATION. 3.0 Semester Hrs.
(II) This course will give the participants a unique hands-on experience in seismic interpretation working with several sets of field data and industry standard interpretation software. The course will provide valuable knowledge and information in professional career development. The course involves lectures and labs on seismic interpretation on data sets from a variety of petroleum provinces from around the world. Potential projects for interpretation can be from Gulf of Mexico, North Sea and US land and can have time-lapse and multi-component data types. The class is based on completion and presentation of assignments, exams and final project. Final project will be presentation of the prospect as developed by a group of students. 2 hours lecture; 3 hours lab; 3 semester hours.

GPGN461. SEISMIC DATA PROCESSING. 4.0 Semester Hrs.
Equivalent with GPGN452,
(I) This course covers the basic processing steps required to create images of the earth using 2D and 3D reflection seismic data. Topics include data organization and domains, signal processing to enhance temporal and spatial resolution, identification and suppression of incoherent and coherent noise, velocity analysis, near-surface statics, datuming, normal- and dip-moveout corrections, common-midpoint stacking, principles and methods used for poststack and prestack time and depth imaging, migration velocity analysis and post-imaging enhancement techniques. Realistic synthetic examples and field data sets are extensively used throughout the course. A three-hour lab introduces the student to hands-on data processing using Seismic Unix software package. The final exam consists of processing a 2D seismic line with oral presentation of the results. Prerequisites: GPGN404, GPGN329, GPGN314. 3 hours lecture; 3 hours lab; 4 semester hours.

GPGN470. APPLICATIONS OF SATELLITE REMOTE SENSING. 3.0 Semester Hrs.
(I) An introduction to geoscience applications of satellite remote sensing of the Earth and planets. The lectures provide background on satellites, sensors, methodology, and diverse applications. Topics include visible, near infrared, and thermal infrared passive sensing, active microwave and radio sensing, and geodetic remote sensing. Lectures and labs involve use of data from a variety of instruments, as several applications to problems in the Earth and planetary sciences are presented. Students will complete independent term projects that are presented both written and orally at the end of the term. 3 hours lecture; 3 semester hours.

GPGN471. GEODYNAMICS AND GEOLOGY. 2.0 Semester Hrs.
(I) Earth?s evolving internal dynamics and properties have controlled time-varying crustal geologic processes and their products. All terrestrial planets fractionated synchronously with accretion, but only Earth continued strongly active. Much geology, from ancient granite and greenstone to recently enabled plate-tectonics, will be illustrated in the context of coevolving deep and shallow processes. Integration of geophysics, geology, and planetology will allow evaluation of popular and alternative explanations, but the sum will be contrarian, not conventional. Math and specialist vocabularies will be minimized. PREREQUISITES: CHGN121, PHGN100, PHGN200, and GEGN101. 2 lecture hours, 2 semester hours.

GPGN474. HYDROGEOPHYSICS. 3.0 Semester Hrs.
(II) Application of geophysical methods to problems in hydrology. The course will consider both groundwater and surface water problems from the micro to basin scale. Topics may include characterizing groundwater surface water interaction, critical zone evaluation and weathering processes, snow and ice as a water resource, large scale imaging of aquifer systems, in situ estimation of aquifer parameters, evaluation of groundwater resources, delineation of thermal and chemical pollution of groundwater, and mapping of saltware intrusion. Readings and discussions will touch on social and political issues surrounding water use and the critical role that physical characterization plays in understanding water resources. Prerequisite: GPGN314. 2 hours lecture; 3 hours lab; 3 semester hours.

GPGN486. GEOPHYSICS FIELD CAMP. 4.0 Semester Hrs.
(S) (WI) Introduction to geological and geophysical field methods. The program includes exercises in geological surveying, stratigraphic section measurements, geological mapping, and interpretation of geological observations. Students conduct geophysical surveys related to the acquisition of seismic, gravity, magnetic, and electrical observations. Students participate in designing the appropriate geophysical surveys, acquiring the observations, reducing the observations, and interpreting these observations in the context of the geological model defined from the geological surveys. Prerequisite: GPGN268, GPGN314, GPGN329, GPGN404, GEGN203 or GEGN204, GEGN205. 12 hours lab; 4 semester hours.

GPGN498. SPECIAL TOPICS IN GEOPHYSICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GPGN498. SPECIAL TOPICS IN GEOPHYSICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GPGN498. SPECIAL TOPICS IN GEOPHYSICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GPGN499. GEOPHYSICAL INVESTIGATION. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

SYGN498. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

Professors

John H. Bradford, Vice President for Global Initiatives

Yaoguo Li

Manika Prasad

Paul C. Sava, Interim Department Head, C.H. Green Chair of Exploration Geophysics

Roelof K. Snieder, Keck Foundation Professor of Professional Development Education

Ilya D. Tsvankin

Ali Tura

Associate Professors

Brandon Dugan, Associate Department Head, Baker Hughes Chair of Petrophysics and Borehole Geophysics

Jeffrey C. Shragge

Assistant Professors

Ebru Bozdag

Ge Jin

Matthew Siegfried

Professors Emeriti

Norman Bleistein

Thomas L. Davis

Dave Hale

Alexander A. Kaufman

Kenneth L. Larner

Gary R. Olhoeft

Phillip R. Romig, Jr.

Terence K. Young

Emeritus Associate Professor

Thomas M. Boyd

Research Professor

Jeffrey Lee

Research Associate Professor

James L. Simmons

Research Assistant Professors

Jyoti Behura

Richard Krahenbuhl

Mathias Pohl

Adjunct Faculty

Timothy Collett, Senior Scientist, US Geological Survey

Gavin P. Hayes, NEIC Reseach Seismologist, US Geological Survey

Morgan Moschetti, Research Geophysicist, US Geological Survey

Ryan North, Principal Geophysicist, Olson Engineering

Nathaniel Putzig, Senior Scientist, Planetary Science Institute

Andreas Rueger, Chief Geophysicist, Digital Geo Specialists

Humanities, Arts, and Social Sciences

Program Description

As the 21st century unfolds, individuals, communities, and nations face major challenges in energy, natural resources, and the environment. While these challenges demand practical ingenuity from engineers and applied scientists, solutions must also take into account social, political, economic, cultural, ethical, and global contexts. Mines students, as citizens and future professionals, confront a rapidly changing society that demands core technical skills complemented by flexible intelligence, original thought, and cultural sensitivity.

Starting in January 2017 the Liberal Arts and International Studies (LAIS) Division became the Humanities, Arts, and Social Sciences (HASS) Division.

Courses in Humanities, Arts, and Social Sciences Division (HASS) expand students' professional and personal capacities by providing opportunities to explore the humanities, social sciences, and fine arts. Our curricula encourage the development of critical thinking skills that will help students make more informed choices as national and world citizens - promoting more complex understandings of justice, equality, culture, history, development, and sustainability. Students, for example, study ethical reasoning, compare and contrast different economies and cultures, develop arguments from data, and interrogate globalization. HASS courses also foster creativity by offering opportunities for self-discovery. Students conduct literary analyses, improve communication skills, play music, learn media theory, and write poetry. These experiences foster intellectual agility, personal maturity, and respect for the complexity of our world.

Undergraduate Humanities and Social Science

Educational Objectives

In addition to contributing to the educational objectives described in the Mines Graduate Profile and the ABET Accreditation Criteria, the coursework in the Division of Humanities, Arts, and Social Sciences is designed to help Mines develop in students the ability to engage in life-long learning and recognize the value of doing so by acquiring the broad education necessary to

1. Understand the impact of engineering solutions in contemporary, global, international, societal, political, and ethical contexts;
2. Understand the role of Humanities and Social Sciences in identifying, formulating, and solving engineering problems;
3. Prepare to live and work in a complex world;
4. Understand the meaning and implications of “stewardship of the Earth”; and
5. Communicate effectively in writing and orally.

Music (LIMU)

Courses in Music do not count toward the Humanities,Arts, & Social Sciences General Education restricted elective requirement, but may be taken for **Free Elective credit only.** **A maximum of 3.0 semester hours of concert band, chorus, physical education, athletics or other activity credit combined may be used toward free elective credit in a degree granting program.**

Foreign Language (LIFL)

Typically, several foreign languages are taught through the Division. In order to gain basic proficiency from their foreign language study, students are encouraged to enroll for at least two semesters in whatever language(s) they elect to take. **No student is permitted to take a foreign language that is either his/her native language or second language.**

Undergraduate Minors

At the undergraduate level, Humanities,Arts, & Social Sciences offers minors in Culture, Creativity, and Communication; Environment and Sustainability Studies; Global Politics and Society; Music, Audio Engineering, and Recording Arts; and an Individualized Undergraduate minor. See the minor tab for details.

Graduate Degree and Programs

At the graduate level, Humanities,Arts, & Social Sciences offers a 30-hour degree. It also offers Graduate Certificates and Graduate Minors in Natural Resources and Energy Policy (NREP). See the Graduate catalog for details.

Hennebach Program in the Humanities

The Hennebach Program in the Humanities, supported by a major endowment from Ralph Hennebach (CSM Class of 1941), sponsors a regular series of Visiting Professors and the general enhancement of the Humanities on campus. Recent visiting professors have included scholars in Classics, Creative Writing, Environmental Studies, Ethics, History, Literature, Philosophy, and Social Theory as well as the interdisciplinary fields of Environmental Policy, and Science, Technology, and Society Studies. The Program is dedicated to enriching the lives of both students and faculty through teaching and research, with visiting scholars offering courses, giving lectures, conducting workshops, and collaborating on projects. In addition, the Hennebach Program is exploring opportunities for meeting the needs of Undergraduate students who would especially benefit from more focused study in the Humanities that would appropriately complement technical degree curricula.

Humanities & Social Sciences (H&SS) Requirement

All Mines undergraduate students are required to satisfy a Humanities & Social Sciences (H&SS) Core requirement as one component of Mines' Core Curriculum. The H&SS Core requirement includes 19 credit hours of courses ranging from first-year to senior-level and offered by a variety of academic units across campus. The H&SS Core includes both specified and restricted-elective course requirements as described below.

Core Required Courses*

HASS100	NATURE AND HUMAN VALUES	4.0
HASS200	GLOBAL STUDIES	3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0
MID-LEVEL ELECTIVE	Two courses from the approved list of requirements **	6.0

400-LEVEL ELECTIVE	One course at the 400-level from the approved list of requirements **	3.0
Total Semester Hrs		**19.0**

* These course requirements are modified for students in the following programs: Thorson Honors, McBride Honors, and Bachelor of Science in Engineering (BSE). Students in these programs can find program-specific requirements within the relevant program sections of this catalog.

** The additional 9 credit hours of mid-level and 400-level electives must meet the following requirements:

- At least 3 credit hours must be at the 400 level.
- At least 3 credit hours must have a HASS (Humanities, Arts, and Social Sciences) course code.
- No more than 6 credit hours can have the LIFL (Foreign Languages) course code.
- Courses with the LIMU (Music) course code cannot be used to satisfy this requirement.
- HASS498 special topic courses can be used to satisfy this requirement. EBGN498 and EDNS498 special topic courses will be determined to satisfy this requirement on a course-by-course basis, and that determination will be made prior to the beginning of the term the course is offered.
- Except for foreign languages, no AP or IB credit can be used to meet this requirement. (AP/IB credits will be applied as free electives.)
- Single majors in Economics cannot use courses with the EBGN course code to satisfy this requirement.

Courses that satisfy the Humanities & Social Sciences (H&SS) Core Restricted Electives requirement are offered by several academic units. The various course codes and their respective academic division or department can be found in the table below:

Course Code	Course Title
EBGN	Economics & Business
EDNS	Engineering, Design, and Society
HASS	Humanities, Arts, and Social Sciences
HNRS	Honors
LIFL	Foreign Language
PEGN	Petroleum Engineering

With the exception of HASS, LIFL and HNRS, not all courses with these codes count toward the Humanities & Social Sciences (H&SS) Core Restricted Electives requirement.

The table below includes the complete list of courses satisfying the Humanities & Social Sciences (H&SS) requirement:

HASSXXX	All HASS courses are eligible for Humanities and Social Sciences (H&SS) credit (see your advisor)	
LIFLXXX	All LIFL courses are eligible for Humanities and Social Sciences (H&SS) credit (see your advisor)	
HNRSXXX	All HNRS courses are eligible for Humanities and Social Sciences (H&SS) credit (see your advisor)	
EBGN301	INTERMEDIATE MICROECONOMICS	3.0
EBGN302	INTERMEDIATE MACROECONOMICS	3.0
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0
EBGN320	ECONOMICS AND TECHNOLOGY	3.0
EBGN330	ENERGY ECONOMICS	3.0
EBGN340	ENERGY AND ENVIRONMENTAL POLICY	3.0
EBGN401	ADVANCED TOPICS IN ECONOMICS	3.0
EBGN430	ADVANCED ENERGY ECONOMICS	3.0
EBGN434	PROPERTY RIGHTS AND NATURAL RESOURCES	3.0
EBGN437	REGIONAL ECONOMICS	3.0
EBGN441	INTERNATIONAL ECONOMICS	3.0
EBGN443	PUBLIC ECONOMICS	3.0
EBGN470	ENVIRONMENTAL ECONOMICS	3.0
EDNS315	ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY	3.0
EDNS375	ENGINEERING CULTURES	3.0
EDNS430	CORPORATE SOCIAL RESPONSIBILITY	3.0
EDNS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
EDNS477	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3.0
EDNS478	ENGINEERING AND SOCIAL JUSTICE	3.0
EDNS479	COMMUNITY-BASED RESEARCH	3.0
EDNS480	ANTHROPOLOGY OF DEVELOPMENT	3.0
MNGN335	COMMUNITIES AND NATURAL RESOURCE DEVELOPMENT	3.0
PEGN430	ENVIRONMENTAL LAW AND SUSTAINABILITY	3.0

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Minor Programs

The Division of Humanities, Arts, and Social Sciences Studies (HASS) offers several minor programs. Students who elect to pursue a minor **usually** will satisfy the Humanities & Social Science (H&SS) requirements; however, the Music Technology ASI will not satisfy these requirements. Students will need to use their free elective hours to complete a minor.

A minor requires a minimum of 18 credit-hours; an area of special interest (ASI) requires a minimum of 12 credit hours. No more than half the credits to be applied towards a Humanities, Arts, & Social Sciences minor or ASI may be transfer credits. The Humanities, Arts, & Social Sciences Undergraduate Faculty Advisor must approve all transfer credits that will be used for a Humanities, Arts, & Social Sciences minor or ASI.

The student must fill out a Minor/Area of Special Interest Declaration (available in the Registrar's Office) and obtain approval signatures from the student's Mines advisor, from the Head or Director of the student's major department or division, and from the Humanities, Arts, & Social Sciences Faculty Undergraduate Advisor. Students should consult the listed Program Directors for the specific requirements of each minor.

The available minors or ASI's are listed below and the Program Directors are:

Culture, Creativity, and Communication (CCC) Program Director: Paul Farca, Environment and Sustainability Studies, (ESS) Program Co-Directors: Tina Gianquitto/Sandy Woodson, Global Politics and Society(GPS) Program Director Kathleen Hancock

Minor in Culture, Creativity, and Communication

Given the diverse disciplinary and interdisciplinary interests of Mines students, the Culture, Creativity, Communication minor provides a flexible, interdisciplinary range of options so students can follow particular passions bolstered by distinctive, signature experiences. Students will take courses below as part of a pathway in Literature and Creative Writing, a pathway in Communication Studies, or an intellectually coherent pathway in both.

The CCC minor elevates student capacity for empathy, contextual understanding, intellectual versatility, creative cognition, and expressive clarity. This minor will help students who feel a passion for culture and the arts, and who yearn to explore diverse fields of literary studies, creative writing, and communication studies.

Students in the Culture, Creativity, Communication minor must complete 18 hours of coursework, selected with the guidance of a faculty advisor, from the courses below.

Midlevel courses:

HASS201	WORKSHOP FOUNDATIONS: THE ART AND CRAFT OF CREATIVE WRITING	3.0
HASS300	CREATIVE WRITING: FICTION	3.0
HASS301	CREATIVE WRITING: POETRY I	3.0
HASS305	AMERICAN LITERATURE: COLONIAL PERIOD TO THE PRESENT	3.0
HASS307	EXPLORATIONS IN COMPARATIVE LITERATURE	3.0
HASS309	LITERATURE AND SOCIETY	3.0
HASS320	ETHICS	3.0
HASS323	INTRODUCTION TO SCIENCE COMMUNICATION	3.0

400-level courses (minimum of two):

HASS400	ADVANCED SHORT FICTION WRITING WORKSHOP	3.0
HASS401	CREATIVE WRITING: POETRY II	3.0
HASS404	WOMEN, LITERATURE, AND SOCIETY	3.0
HASS406	THE LITERATURE OF WAR AND REMEMBRANCE	3.0
HASS407	SCIENCE IN LITERATURE	3.0
HASS408	LIFE STORIES	3.0
HASS409	SHAKESPEAREAN DRAMA	3.0
HASS410	CRITICAL PERSPECTIVES ON 20TH CENTURY LITERATURE	3.0
HASS411	LITERATURES OF THE AFRICAN WORLD	3.0
HASS412	LITERATURE AND THE ENVIRONMENT	3.0
HASS415	MASS MEDIA STUDIES	3.0
HASS416	FILM STUDIES	3.0
HASS418	NARRATING THE NATION	3.0
HASS419	ENVIRONMENTAL COMMUNICATION	3.0
HASS423	ADVANCED SCIENCE COMMUNICATION	3.0
HASS425	INTERCULTURAL COMMUNICATION	3.0
HASS426	SCIENTIFIC CONTROVERSIES	3.0
HASS433	SHAKESPEARE AND THE SCIENTIFIC REVOLUTION	3.0

Minor in Environment and Sustainability Studies

Environmental Studies is an interdisciplinary field that examines human interactions with the natural environment from the perspective of the Humanities & Social Science (H&SS). The Minor provides political, social, cultural, economic, and historical perspectives on modern environmental challenges, complementing student expertise in science and engineering. This strengthens their capacity for advanced analysis environmental issues, and prepares them for career opportunities in environmental health and safety, policy, design, and consulting.

The Minor in Environment and Sustainability Studies requires 18 hours of course work, including 12 credit hours in Humanities & Social Science (H&SS) electives, 3 credit hours in restricted environmental science and engineering electives, and a required capstone class. No more than 9 of the 18 hours required can apply towards degree requirements other than free electives.

The HASS curriculum of Environment and Sustainability Studies is designed to provide students with an interdisciplinary perspective on human interaction with the environment from the perspective of the Humanities & Social Science (H&SS).

The Environment and Sustainability Studies Minor is designed to strengthen interdisciplinary collaboration across campus, in order to provide students with an enhanced capacity to recognize the connections between technical and non-technical courses. Students completing the Minor are required to take 3 credits in an upper-division course on environmental science and engineering. Faculty involved in the Environment and Sustainability Studies Minor will work with colleagues across campus to identify upper-division electives in environmental science and engineering that can fulfill this requirement.

Capstone

Students taking the ESS minor will be required to take a capstone course, HASS448. This course requires students to examine contemporary environmental challenges in a wide array of real world contexts relevant to their majors, and articulate innovative solutions to those challenges through advanced academic research, persuasive written arguments, and innovative public presentations. Although a member of the ESS faculty will serve as primary instructor and coordinator, a significant portion of class time devoted to invited guest lectures and discussions from other HASS faculty, alumni, industry practitioners, and STEM faculty from across campus.

Minor requirements

ELECT XXX	Humanities & Social Science (H&SS)	12.0
ELECT XXX	Restricted Environmental Science and Engineering Elective	3.0
HASS448	GLOBAL ENVIRONMENTAL ISSUES	3.0
Total Semester Hrs		**18.0**

Minor in Global Politics and Society (GPS)

The GPS Minor (18 credit hours) prepares engineers and scientists with the knowledge and experience they need to tackle complex global issues and become leaders in their professional and personal lives, within their own countries and in the global community. Drawing primarily

from the social sciences, our classes link theories with real-world problems, while enhancing students' analytical and communication skills. Courses provide the political, social, and historical contexts to better understand world regions, particularly ones with significant natural resource endowments. Topics include war, trade, energy, corruption, and religion. Fitting the Mines' mission, our courses bring a stronger focus to natural resources and energy issues than similar programs at other universities.

Required Course: One of the following two courses

HASS460	GEOPOLITICS OF NATURAL RESOURCES	3.0
HASS344	INTERNATIONAL RELATIONS	3.0

Electives

The remaining credits must come from the following courses. AT LEAST one must be a 400-level class.

Regional Focus		
HASS337	ASIA: POLITICS & SOCIETY	3.0
HASS339	MIDDLE EAST: POLITICS & SOCIETY	3.0
HASS341	AFRICA: POLITICS & SOCIETY	3.0
HASS411	LITERATURES OF THE AFRICAN WORLD	3.0
HASS437	ASIAN DEVELOPMENT	3.0
HASS439	MIDDLE EAST DEVELOPMENT	3.0
HASS441	AFRICAN DEVELOPMENT	3.0
HASS442	NATURAL RESOURCES AND WAR IN AFRICA	3.0
HASS456	POWER AND POLITICS IN EURASIA	3.0
Global Focus		
HASS307	EXPLORATIONS IN COMPARATIVE LITERATURE	3.0
HASS431	MORAL PSYCHOLOGY, RELIGION, AND AMERICAN SOCIETY	3.0
HASS542	NATURAL RESOURCES AND WAR IN AFRICA	3.0
HASS490	ENERGY AND SOCIETY	3.0
Politics and Policy Focus		
HASS486	SCIENCE AND TECHNOLOGY POLICY	3.0
HASS488	GLOBAL WATER POLITICS AND POLICY	3.0
HASS491	ENERGY POLITICS	3.0
HASS492	ENERGY AND SECURITY POLICY	3.0
Foreign Languages		
LIFL1XX	Foreign Language Up to six hours	3-6

Minor in Music, Audio Engineering, and the Recording Arts

Program Advisor: Robert Klimek. Program Co-Advisor: Jonathan Cullsion.

The Music, Audio Engineering, and the Recording Arts Minor is designed for students interested in the crossover field between music and related technical skills. Technical emphasis within this minor creates an opportunity for the student to research/experience the impact of their specific majors upon both music as an art form and music as an industry. Throughout the minor, students are exposed to the refinements and developments that technology has created in the field of recording, production, sound reinforcement and product design, as well as, the interplay between the arts and technology. The discovery of connections between current music and sound engineering practices is stressed. The final outcome is a skilled and informed studio musician/technician in present day studio conditions. Finally, this minor is not designed to expand any current engineering curriculum, but to complement a student's education.

Students desiring a Music, Audio Engineering, and the Recording Arts Minor must complete 18 hours of courses as follows:

Four *required* music courses (12 credit-hours):

HASS324	AUDIO/ACOUSTICAL ENGINEERING AND SCIENCE	3.0
HASS327	MUSIC TECHNOLOGY	3.0
HASS315	MUSICAL TRADITIONS OF THE WESTERN WORLD	3.0
HASS330	MUSIC TECHNOLOGY CAPSTONE	3.0
Total Semester Hrs		**12.0**

One 400 level *required* course (3 credit hours):

HASS429	REAL WORLD RECORDING/RESEARCH	3.0

Three additional credit-hours:

HASS326	MUSIC THEORY	3.0
Performance Enhancement (3 credit hours total)		
LIMU	ENSEMBLE Two semesters	
LIMU189	INDIVIDUAL INSTRUMENTAL OR VOCAL MUSIC INSTRUCTION One semester	

Individualized Undergraduate Minor

Program Advisor: Prof. Sandy Woodson. Students declaring an Undergraduate Individual Minor in LAIS must choose 18 restricted elective hours in LAIS with a coherent rationale reflecting some explicit focus of study that the student wishes to pursue. A student desiring this minor must design it in consultation with a member of the LAIS faculty who approves the rationale and the choice of courses, eg., pre-law or pre-med courses.

Area of Special Interest in Music Technology

Program Advisor: Prof. Bob Klimek. The Area of Special Interest in Music Technology is comprised of a sequence of courses that allows students to combine interests and abilities in both the science and theory of music production. Completion of this ASI will train students in the technical aspects of the music recording industry, including sound and video recording, sound effects, and software design.

Courses

HASS100. NATURE AND HUMAN VALUES. 4.0 Semester Hrs.
Equivalent with HNRS105,LAIS100,
Nature and Human Values will focus on diverse views and critical questions concerning traditional and contemporary issues linking the quality of human life and Nature, and their interdependence. The course will examine various disciplinary and interdisciplinary approaches regarding two major questions: 1) How has Nature affected the quality of human life and the formulation of human values and ethics? (2) How have human actions, values, and ethics affected Nature? These issues will use cases and examples taken from across time and cultures. Themes will include but are not limited to population, natural resources, stewardship of the Earth, and the future of human society. This is a writing-intensive course that will provide instruction and practice in expository writing, using the disciplines and perspectives of the Humanities and Social Sciences. 4 hours lecture/seminar; 4 semester hours.

HASS101. ACADEMIC ENGLISH PROFICIENCY. 3.0 Semester Hrs.
Academic English Proficiency will help non-native English speakers understand and apply advanced reading and writing skills required for success at the university level. Working with content from a wide range of academic and professional disciplines, students will master advanced grammar, inference, analysis, and vocabulary. The course will teach students how to incorporate complex sentence structure, diverse clauses, and word forms to improve their composition abilities in multiple writing contexts. To support these components, students will also improve their reading fluency and comprehension through academic texts specifically chosen to engage English language learners. Content and coursework will promote critical thinking and responses in English. Overall, students will learn about the cultural expectations associated with academic writing in American universities.

HASS198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS200. GLOBAL STUDIES. 3.0 Semester Hrs.
Equivalent with LAIS200,SYGN200,
(I, II, S) Part of the Mines core curriculum, following the first-year requirement of HASS 100 (Nature and Human Values). Modern scientists and engineers operate in an increasingly interconnected world. This course is designed to enhance student capacity to understand, appreciate, and critically analyze the global contexts in which they will live and work. Course material examines the modern world through specific thematic lenses, with an emphasis on the major patterns of cultural, political, and/or environmental change. Students will develop original analysis through comparative empirical research on diverse societies and regions, and will communicate this analysis orally and in writing. Prerequisite: HASS100. 3 hours lecture; 3 semester hours.

HASS201. WORKSHOP FOUNDATIONS: THE ART AND CRAFT OF CREATIVE WRITING. 3.0 Semester Hrs.
Equivalent with LAIS201,
(I, II, S) (WI) This course examines the major patterns of modern and contemporary written forms. Topics analyzed include poetics, prose and creative nonfiction, and the personal or lyric essay. Poetics will focus on writing from imagism to modernism to beat and hippy writing, up to contemporary and postmodern poetry. Prose writing will examine the development of the shorts story from inception to contemporary approaches. Analysis of historical trends and change will also serve as a basis for developing student writing habits and strategies. Over the course of the semester, these subjects will be addressed through seminars, readings, workshops, and in-class discussion and activities. Prerequisites: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS202. TECHNICAL COMMUNICATION. 3.0 Semester Hrs.
(I) Technical Communication introduces students to the written and oral communication of technical information, and prepares students for effective professional communication. The course covers workplace writing, such as memos, proposals, and reports, visual communication, best practices for layout and design, ethical practices in the workplace, multimodal communication technologies, and oral presentations. 3 hours lecture; 3 semester hours.

HASS220. INTRODUCTION TO PHILOSOPHY. 3.0 Semester Hrs.
Equivalent with LAIS220,
A general introduction to philosophy that explores historical and analytic traditions. Historical exploration may compare and contrast ancient and modern, rationalist and empiricist, European and Asian approaches to philosophy. Analytic exploration may consider such basic problems as the distinction between illusion and reality, the one and the many, the structure of knowledge, the existence of God, the nature of mind or self. Prerequisite: HASS 100. Corequisite: HASS 200. 3 hours lecture; 3 credit hours.

HASS221. INTRODUCTION TO RELIGIONS. 3.0 Semester Hrs.
Equivalent with LAIS221,
This course has two focuses. We will look at selected religions emphasizing their popular, institutional, and contemplative forms; these will be four or five of the most common religions: Hinduism, Buddhism, Judaism, Christianity, and/or Islam. The second point of the course focuses on how the Humanities and Social Sciences work. We will use methods from various disciplines to study religion-history of religions and religious thought, sociology, anthropology and ethnography, art history, study of myth, philosophy, analysis of religious texts and artifacts (both contemporary and historical), analysis of material culture and the role it plays in religion, and other disciplines and methodologies. We will look at the question of objectivity; is it possible to be objective? We will approach this methodological question using the concept ?standpoint.? For selected readings, films, and your own writings, we will analyze what the ?standpoint? is. Prerequisite: HASS 100. Corequisite: HASS 200. 3 hours lecture; 3 semester hours.

HASS226. BEGINNING CLASS PIANO AND FUNDAMENTALS OF MUSIC. 3.0 Semester Hrs.
Equivalent with LAIS226,
(I, II, S) HASS 226 is a beginning keyboard class. Students will learn to read music, develop fundamental keyboard skills, grasp basic music theory and history concepts, and understand the communal nature of music through ensemble preparation and public performance. Assessment will be based on class participation, written exams, student reflection papers, written and aural homework assignments, and public performances in class. The course will be a recommended, but not required, prerequisite for HASS 326 (Music Theory) and HASS 328 (Basic Music Composition and Arranging). Prerequisite: HASS100. Corequisite: HASS 200. 3 hours lecture; 3 semester hours.

HASS227. BEGINNING ORCHESTRAL STRINGS AND FUNDAMENTALS OF MUSIC. 3.0 Semester Hrs.
HASS 227 is a beginning orchestral ensemble class. Students will learn to read music, develop fundamental playing skills on one of four instruments available (violin, viola, cello, or bass), grasp basic music theory and history concepts, and understand the communal nature of music through ensemble participation and public performance. Assessment will be based on in-class peer and instructor critique, written exams, daily journal assignments, written, aural, and playing homework assignments, and public performances in class. Prerequisite: HASS100. Co-requisite: HASS200.

HASS286. GLOBAL POLITICS & SOCIETY. 3.0 Semester Hrs.
Equivalent with LAIS286,
(I, II, S) This is a beginning- level course intended to familiarize students with the study of politics across societies. The method is comparative in that it approaches the task of studying the world's different political systems by contrasting and comparing them along different dimensions, and by seeking generalizations about them. The class focuses on cases, topics, and methodologies in American and comparative politics. The course is part of the Global Politics & Society Minor. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS298. SPECIAL TOPICS. 6.0 Semester Hrs.
Equivalent with LAIS298B,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS298. SPECIAL TOPICS. 6.0 Semester Hrs.
Equivalent with LAIS298C,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS299. INDEPENDENT STUDY. 1-6 Semester Hr.
Equivalent with LAIS299B,
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS299. INDEPENDENT STUDY. 1-6 Semester Hr.
Equivalent with LAIS299C,
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS299. INDEPENDENT STUDY. 1-6 Semester Hr.
Equivalent with LAIS299D,
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS300. CREATIVE WRITING: FICTION. 3.0 Semester Hrs.
Equivalent with LAIS300,
Students will write weekly exercises and read their work for the pleasure and edification of the class. The midterm in this course will be the production of a short story. The final will consist of a completed, revised short story. The best of these works may be printed in a future collection. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS301. CREATIVE WRITING: POETRY I. 3.0 Semester Hrs.
Equivalent with LAIS301,
This course focuses on reading and writing poetry. Students will learn many different poetic forms to compliment prosody, craft, and technique. Aesthetic preferences will be developed as the class reads, discusses, and models some of the great American poets. Weekly exercises reflect specific poetic tools, encourage the writing of literary poetry, and stimulate the development of the student?s craft. The purpose of the course is to experience the literature and its place in a multicultural society, while students ?try on? various styles and contexts in order to develop their own voice. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS305. AMERICAN LITERATURE: COLONIAL PERIOD TO THE PRESENT. 3.0 Semester Hrs.
Equivalent with LAIS305,
This course offers an overview of American literature from the colonial period to the present. The texts of the class provide a context for examining the traditions that shape the American nation as a physical, cultural and historical space. As we read, we will focus on the relationships between community, landscape, history, and language in the American imagination. We will concentrate specifically on conceptions of the nation and national identity in relation to race, gender, and class difference. Authors may include: Rowlandson, Brown, Apess, Hawthorne, Douglass, Melville, Whitman, James, Stein, Eliot, Hemingway, Silko, and Auster. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS307. EXPLORATIONS IN COMPARATIVE LITERATURE. 3.0 Semester Hrs.
Equivalent with LAIS307,
This course examines major figures and themes in the modern literatures of Africa, the Caribbean, and Latin America. Reading, discussion and writing will focus on fiction and poetry representing Francophone, Arabic, and Hispanophone traditions within these world regions. Engaging these texts will foster understanding of some of the pivotal philosophical, political, and aesthetic debates that have informed cultural practices in diverse colonial territories and nation-states. Thematic and stylistic concerns will include imperialism, nationalism, existentialism, Orientalism, negritude, and social and magical realisms. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS309. LITERATURE AND SOCIETY. 3.0 Semester Hrs.
Equivalent with LAIS309,
Before the emergence of sociology as a distinct field of study, literary artists had long been investigating the seemingly infinite complexity of human societies, seeking to comprehend the forces shaping collective identities, socio-cultural transformations, technological innovations, and political conflicts. Designed to enrich recognition and understanding of the complex interplay of artistic creativity and social inquiry over time, this course compares influential literary and social-scientific responses to the Enlightenment, the Industrial Revolution, and other dynamic junctures integral to the forging of "modernity" and the volatile world we inhabit today. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS315. MUSICAL TRADITIONS OF THE WESTERN WORLD. 3.0 Semester Hrs.
Equivalent with LAIS315,
An introduction to music of the Western world from its beginnings to the present. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS316. JAZZ AND AMERICAN POPULAR MUSIC. 3.0 Semester Hrs.
(I, II, S) This upper-level HASS course explores the American musical style called Jazz, as well as examining the evolution and development of popular music in America. The shared history, background, differences and similarities of these artistic areas will be examined for a deeper understanding of the impact they had in the modern world. Topics analyzed include: regional influences, evolution in thematic material, technological development, important artistic contributions, political and societal factors, and music as a product vs an art form. Analysis of historical trends and change will also serve as a framework for student opinions. Over the course of the semester, these subjects will be addressed through lectures, seminars, readings, and in-class discussion and activities. Students will develop their own analytical skills, which will be demonstrated in written opinion responses, in-class discussions, and musical analysis projects. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS320. ETHICS. 3.0 Semester Hrs.
Equivalent with LAIS320,
A general introduction to ethics that explores its analytic and historical traditions. Reference will commonly be made to one or more significant texts by such moral philosophers as Plato, Aristotle, Augustine, Thomas Aquinas, Kant, John Stuart Mill, and others. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS323. INTRODUCTION TO SCIENCE COMMUNICATION. 3.0 Semester Hrs.
Equivalent with LAIS323,
This course will explore the relationship between science and the public through an examination of science writing and communication on current events. Students will study various forms of science communication, including essays, blogs, news segments, media clips, and radio programs in order to understand the ways in which science is communicated beyond the lab or university and into the public consciousness. Science writing often explores the human condition, reflects on hopes and worries about technology, and informs our collective knowledge about the world. Students will discuss the implications of this kind of communication, analyze breakdowns in communication through case studies, and write for peer and popular audiences, including turning a lab report into a short feature article and writing a science essay. Prerequisite: HASS100. Corequisite HASS200. 3 hours lecture; 3 semester hours.

HASS324. AUDIO/ACOUSTICAL ENGINEERING AND SCIENCE. 3.0 Semester Hrs.
Equivalent with LAIS324,
(I) Audio/acoustical engineering and science teaches concepts surrounding the production, transmission, manipulation and reception of audible sound. These factors play a role in many diverse areas such as the design of modern music technology products, recording studios and loudspeakers, civil engineering and building design, and industrial safety. This course will explore and concepts of this field and the physics/mechanics that are involved, as well as aesthetic impacts related to the subject matter. Discussion of human anatomy and psycho acoustic phenomena are also presented. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS325. CULTURAL ANTHROPOLOGY. 3.0 Semester Hrs.
Equivalent with LAIS325,
A study of the social behavior and cultural devel opment of humans. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS326. MUSIC THEORY. 3.0 Semester Hrs.
Equivalent with LAIS326,
(I) The course begins with the fundamentals of music theory and moves into more complex applications. Music of the common practice period (18th century) and beyond is considered. Aural and visual recognition of harmonic material is emphasized. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS327. MUSIC TECHNOLOGY. 3.0 Semester Hrs.
Equivalent with LAIS327,
(I, II) An introduction to the physics of music and sound. The history of music technology from wax tubes to synthesizers. Construction of instruments and studio. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS328. BASIC MUSIC COMPOSITION AND ARRANGING. 1.0 Semester Hr.
Equivalent with LAIS328,
(I) This course begins with the fundamentals of music composition and works towards basic vocal and instrumental arrangement skills. Upon completion of this course the student should: 1) Demonstrate basic knowledge of (music) compositional techniques; 2) Demonstrate primary concepts of vocal and instrumental ensemble arrangement; 3) Demonstrate an ability to use notational software and Midi station hardware. Prerequisite: HASS100. Corequisite: HASS200. Repeatable for credit. 1 hour lecture; 1 semester hour.

HASS330. MUSIC TECHNOLOGY CAPSTONE. 3.0 Semester Hrs.
Equivalent with LAIS330,
(II) Project-based course designed to develop practical technological and communication skills for direct application to the music recording. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS337. ASIA: POLITICS & SOCIETY. 3.0 Semester Hrs.
Equivalent with LAIS337,
(I, II, S) (WI) A broad survey of the interrelationship between the state and economy in East and Southeast Asia as seen through an examination of critical contemporary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics of interstate relationships between the developed North and the developing South. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS339. MIDDLE EAST: POLITICS & SOCIETY. 3.0 Semester Hrs.
Equivalent with LAIS339,
(I, II, S) (WI) A broad survey of the interrelationships between the state and market in the Middle East as seen through an examination of critical contemporary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics between the developed North and the developing South. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS341. AFRICA: POLITICS & SOCIETY. 3.0 Semester Hrs.
Equivalent with LAIS341,
(I, II, S) (WI) A broad survey of the interrelationships between the state and market in Africa as seen through an examination of critical contem porary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics between the developed North and the developing South. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS344. INTERNATIONAL RELATIONS. 3.0 Semester Hrs.
Equivalent with LAIS344,
This course surveys major topics and theories of international relations. Students will evaluate diverse perspectives and examine a variety of topics including war and peace, economic globalization, human rights and international law, international environmental issues, and the role of the US as the current superpower. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS360. RESEARCH, VALUES, AND COMMUNICATION. 3.0 Semester Hrs.
This 3-credit class, which is one of the HASS electives, helps students prepare to be effective in research in science or engineering, for communicating research to an intended audience, and for developing ethical standards that are grounded in personal values. The class covers elements of doing research, such as choosing a research topic, generating research questions, making a work plan, dealing with the ambiguity and hurdles of research, research ethics, broader social and ethical impacts of research, as well as publishing scientific papers, scientific writing, giving oral communications, and writing research proposals. Students acquire hands-on experience by choosing a research project, performing a literature search, develop critical thinking, making a work plan, writing a proposal, and presenting that proposal. The proposal can be the upbeat to a senior design project.

HASS365. HISTORY OF WAR. 3.0 Semester Hrs.
Equivalent with LAIS365,
History of War looks at war primarily as a significant human activity in the history of the Western World since the times of Greece and Rome to the present. The causes, strategies, results, and costs of various wars will be covered, with considerable focus on important military and political leaders as well as on noted historians and theoreticians. The course is primarily a lecture course with possible group and individual presentations as class size permits. Tests will be both objective and essay types. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS366. DIVIDED STATES OF AMERICA. 3.0 Semester Hrs.
This course explores the historical underpinnings of contested developments in recent U.S. history. Students will learn about various social movements, economic changes, and political developments that have created fractures in contemporary American society. Through readings, writings, and discussions, students will develop analytical tools for identifying and assessing differing economic, political, environmental, and social contexts within the United States. The course further emphasizes the application of critical skills for assessing conflicting evidence and interpretations. Topics include economic growth and change, government power and policy, social movements across the political spectrum, wars and international relations, political parties and movements, and racial, class, gender, regional, and religious influences on American life. Prerequisite: HASS100. Co-requisite: HASS200 (although HASS200 can also be taken as a pre-requisite).

HASS370. HISTORY OF SCIENCE. 3.0 Semester Hrs.
Equivalent with LAIS370,
An introduction to the social history of science, exploring significant people, theories, and social practices in science, with special attention to the histories of physics, chemistry, earth sciences, ecology, and biology. Prerequisite: HASS100. Corequisite HASS200. 3 hours lecture; 3 semester hours.

HASS372. HISTORY OF MEDICINE. 3.0 Semester Hrs.
This class explores the history of western medicine from antiquity to modernity, examining both how western ideas about the causes and cures of human ailments have changed overtime, how culture and society informed these ideas, and how disease has shaped human history. In addition to this, topics to be covered include how the medical profession and identity of medical professionals evolved overtime, the histories of psychiatry, hospitals, surgery, public health, and tropical medicine, and how medicine intersects with power and discrimination.

HASS376. COMMUNITY ENGAGEMENT THROUGH SERVICE LEARNING. 3.0 Semester Hrs.
Equivalent with LAIS376,
(II) Community Engagement through Service Learning combines a traditional classroom environment with an off campus learning experience with a local non-profit or community organization. Students spend 3-4 hours per week serving the organization they choose and meet in class once per week to discuss reading assignments, present research findings, and share experiences and insights about the course material. Instructors may choose to focus on a particular topic or social issue, such as poverty and privilege, or may engage with community issues more broadly. The course focuses on several aspects of a student?s learning, including intra- and interpersonal learning, discovering community, and developing communication skills and critical and interdisciplinary approaches. Course work will focus on critical reading, group discussion and deliberation, oral presentations of research, and writing assignments. Prerequisites: HASS100. Corequisite: HASS200. 2 hours lecture; 3 hours lab; 3 semester hours.

HASS398. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS398. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS398B,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS398. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS398C,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS398. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS398D,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS399. INDEPENDENT STUDY. 1-6 Semester Hr.
Equivalent with LAIS399B,
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS399. INDEPENDENT STUDY. 1-6 Semester Hr.
Equivalent with LAIS399C,
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS399. INDEPENDENT STUDY. 1-6 Semester Hr.
Equivalent with LAIS399D,
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS399. INDEPENDENT STUDY. 1-6 Semester Hr.
Equivalent with LAIS399E,
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HASS400. ADVANCED SHORT FICTION WRITING WORKSHOP. 3.0 Semester Hrs.
(II) (WI) This upper-level HASS course examines the major patterns of modern and contemporary written forms of fiction, and asks students to apply what they learn in their own writing. Topics analyzed include: prose and narrative theory, organizational approaches to fiction, plot, character, setting, and all the many aspects of professional creative writing. Critical prose writing by the students will examine the development of the short story from inception to contemporary approaches. Analysis of historical trends and change will also serve as a basis for developing student writing habits and strategies. Over the course of the semester, these subjects will be addressed through seminars, readings, workshops, and in-class discussion and activities. Students will advance their own fiction-writing skills, which will be demonstrated in two new short stories over the course of the semester, and will turn in a final portfolio and critical paper to show their growth. Prerequisites: HASS100, HASS200. Corequisites: HASS300, HASS301, and HASS401. 3 hours seminar; 3 semester hours.

HASS401. CREATIVE WRITING: POETRY II. 3.0 Semester Hrs.
Equivalent with LAIS401,
This course is a continuation of HASS 301 for those interested in developing their poetry writing further. It focuses on reading and writing poetry. Students will learn many different poetic forms to compliment prosody, craft, and technique. Aesthetic preferences will be developed as the class reads, discusses, and models some of the great American poets. Weekly exercises reflect specific poetic tools, encourage the writing of literary poetry, and simulate the development of the student? s craft. The purpose of the course is to experience the literature and its place in a multicultural society, while students ?try on? various styles and contexts in order to develop their own voice. Prerequisite: HASS100, HASS301. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS404. WOMEN, LITERATURE, AND SOCIETY. 3.0 Semester Hrs.
Equivalent with LAIS404,
This reading and writing intensive course examines the role that women writers have played in a range of literary traditions. Far from residing in the margins of key national debates, women writers have actively contributed their voices to demands for social, racial, economic, and artistic equality. We will examine the writing produced by women from a diversity of racial, ethnic, and social backgrounds, as we examine the ways in which women writers respond to the various pressures placed on them as artists and activists. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS406. THE LITERATURE OF WAR AND REMEMBRANCE. 3.0 Semester Hrs.
Equivalent with LAIS406,
In "The Literature of War and Remembrance," students survey poetry, prose, and film ranging from classicial to contemporary war literature. The course considers literary depictions of the individual and society in war and its aftermath. Critical reading and writing skills are demonstrated in creative presentations and analytical essays. Students will investigate war literature and commemorative art inspired by recent world conflicts, and place a contemporary work into the thematic structure of the course. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS407. SCIENCE IN LITERATURE. 3.0 Semester Hrs.
Equivalent with LAIS407,
Science fiction often serves as a cautionary tale that deals with the darker side of humanity's desires in order to find a better understanding of who we are and what we hope to become. This class examines scientific and social progress as it is imagined by some of the greatest authors of the genre. We will examine the current events that may have influenced the writing and position our lens to the scientific and technological breakthroughs, as well as the social, cultural, and political state of the world at the time of our readings. This course focuses on classic science fiction from the late 1800's to the present which may include: Jules Verne, H.G. Wells, Sir Arthur Conan Doyle, Jack Williamson, Isaac Asimov, Robert Heinlein, Alfred Bester, Philip Jose Farmer, Marion Zimmer Bradley, Ray Bradbury, Philip K. Dick, William Gibson, Arthur C. Clarke, Ursula K. LeGuin and Mary Doria Russell, among others. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS408. LIFE STORIES. 3.0 Semester Hrs.
Equivalent with LAIS408,
Using texts by published authors and members of the class, we will explore the pleasures and challenges of creating and interpreting narratives based on "real life." The class will consider critical theories about the relationship between the self and the stories we tell. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS409. SHAKESPEAREAN DRAMA. 3.0 Semester Hrs.
Equivalent with LAIS409,
Shakespeare, the most well known writer in English and perhaps the world, deals with universal themes and the ultimate nature of what it is to be a human being. His plays are staged, filmed, and read around the globe, even after 400 years. This seminar will explore why Shakespeare? s plays and characters have such lasting power and meaning to humanity. The seminar will combine class discussion, lecture, and video. Grades will be based on participation, response essays, and a final essay. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS410. CRITICAL PERSPECTIVES ON 20TH CENTURY LITERATURE. 3.0 Semester Hrs.
Equivalent with LAIS410,
This course introduces students to texts and cultural productions of the 20th Century literature. We will examine a diverse collection of materials, including novels and short stories, poems, plays, films, painting, and sculpture. Science, technology, violence, history, identity, language all come under the careful scrutiny of the authors we will discuss in this course, which may include Conrad, Fanon, Achebe, Eliot, Kafka, Barnes, Camus, Borges, and Marquez, among others. We will also screen films that comment upon the fragility of individual identity in the face of modern technology. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS411. LITERATURES OF THE AFRICAN WORLD. 3.0 Semester Hrs.
Equivalent with LAIS411,
This course examines wide-ranging writers' depictions of collective transformations and conflicts integral to the making and remaking of African and Afro-diasporic communities worldwide. Fiction, poetry, and essays representing diverse linguistic, aesthetic, and philosophical traditions will constitute the bulk of the reading. Alongside their intrinsic expressive values, these texts illuminate religious and popular cultural practices important to social groups throughout much of sub-Saharan Africa, the Caribbean, Latin America, and the United States. Primary socio-historical themes may include the slave trade, plantation cultures, generational consciousness, ethnicity, gender relations, urbanization, and collective violence. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS412. LITERATURE AND THE ENVIRONMENT. 3.0 Semester Hrs.
Equivalent with LAIS412,
This reading and writing intensive course investigates the human connection to the environment in a broad range of literary materials. Discussions focus on the role of place - of landscape as physical, cultural, moral, historical space - and on the relationship between landscape and community, history, and language in the environmental imagination. Readings include texts that celebrate the natural world, those that indict the careless use of land and resources, and those that predict and depict the consequences of that carelessness. Additionally, we investigate philosophical, legal, and policy frameworks that shape approaches to environmental issues. Prerequisite: HASS100. Corequesite HASS200. 3 hours seminar; 3 semester hours.

HASS415. MASS MEDIA STUDIES. 3.0 Semester Hrs.
Equivalent with LAIS415,
This introduction to mass media studies is designed to help students become more active interpreters of mass media messages, primarily those that emanate from television, radio, the Internet, sound recordings (music), and motions pictures (film, documentary, etc.). Taking a broad rhetorical and sociological perspective, the course examines a range of mass media topics and issues. Students should complete this course with enhanced rhetorical and sociological understandings of how media shapes individuals, societies, and cultures as well as how those groups shape the media. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS416. FILM STUDIES. 3.0 Semester Hrs.
Equivalent with LAIS416,
This course introduces students to the basics of film history, form, and criticism. Students will be exposed to a variety of film forms, including documentary, narrative, and formalist films, and will be encouraged to discuss and write about these forms using critical film language. Students will have an opportunity to work on their own film projects and to conduct research into the relationship between films and their historical, cultural, and ideological origins. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS418. NARRATING THE NATION. 3.0 Semester Hrs.
Equivalent with LAIS418,
The novel, nationalism, and the modern nation-state share the same eighteenth and nineteenth-century roots. Relationships between the works of novelists, local nationalisms, and state politics have, however, always been volatile. These tensions have assumed particularly dramatic expressive and political forms in Latin America and postcolonial South Asia and Africa. This course examines the inspirations, stakes, and ramifications of celebrated novelists' explorations of the conflicted and fragmentary character their own and/or neighboring nationstates. Beyond their intrinsic literary values, these texts illuminate distinctive religious, ritual, and popular cultural practices that have shaped collective imaginings of the nation, as well as oscillations in nationalist sentiment across specific regions and historical junctures. Studies in relevant visual media -films, paintings, and telenovelas - will further our comparative inquiry into the relationships between artistic narrative and critical perspectives on "the nation." Alongside the focal literary and visual texts, the course will address major historians' and social theorists' accounts of the origins, spread, and varied careers of nationalist thought and practice across our modern world. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS419. ENVIRONMENTAL COMMUNICATION. 3.0 Semester Hrs.
Equivalent with LAIS419,
(I, II, S) (WI) This course explores the ways that messages about the environment and environmentalism are communicated in the mass media, fine arts, and popular culture. The course will introduce students to key readings in environmental communication, media studies, and cultural studies in order to understand the many ways in which the images, messages, and politics of environmentalism and the natural world are constructed and contested. Students will critically analyze their roles as science and/or technology communicators in the context of environmental issues and will apply their skills to creating communications projects for diverse audiences. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS421. ENVIRONMENTAL PHILOSOPHY AND POLICY. 3.0 Semester Hrs.
Equivalent with LAIS421,
A critical examination of environmental ethics and the philosophical theories on which they depend. Topics may include preservation/conservation, animal welfare, deep ecology, the land ethic, eco-feminism, environmental justice, sustainability, or non-western approaches. This class may also include analyses of select, contemporary environmental issues. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS422. ART AND ENVIRONMENTALISM. 3.0 Semester Hrs.
This course introduces students to the basics of art history and criticism with a focus on how environmental philosophies manifest in works of art. Students will be exposed to a variety of art forms, including painting, photography, and sculpture, and will be encouraged to discuss and write about these forms using the language of visual analysis. Students will have an opportunity to work on their own art projects and to conduct research into the relationship between art objects and their historical, cultural, and ideological origins. Prerequisite: HASS200.

HASS423. ADVANCED SCIENCE COMMUNICATION. 3.0 Semester Hrs.
Equivalent with LAIS423,
This course will examine historical and contemporary case studies in which science communication (or miscommunication) played key roles in shaping policy outcomes and/or public perceptions. Examples of cases might include the recent controversies over hacked climate science emails, nuclear power plant siting controversies, or discussions of ethics in classic environmental cases, such as the Dioxin pollution case. Students will study, analyze, and write about science communication and policy theories related to scientific uncertainty; the role of the scientist as communicator; and media ethics. Students will also be exposed to a number of strategies for managing their encounters with the media, as well as tools for assessing their communication responsibilities and capacities. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS425. INTERCULTURAL COMMUNICATION. 3.0 Semester Hrs.
Equivalent with LAIS425,
(I, II) The course examines intercultural communication theory and practice. In particular, the course provides students with a window into how intercultural (mis)communication cases arise, evolve, and are resolved. Students investigate communication cases and issues across a broad range of cultural divides, such as national, ethnic, gender, and social class cultures. Some case studies are situated in engineering and applied science contexts. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS426. SCIENTIFIC CONTROVERSIES. 3.0 Semester Hrs.
Equivalent with LAIS426,
(I, II) Examines national and international, historical and contemporary scientific and engineering controversies. In particular, the course provides students with a window into how scientific controversies arise, evolve, and are resolved both within scientific circles and in the public arena. By exploring case studies of such controversies, students gain a better understanding about how scientific controversies shape and are shaped by communication as well as by public policy. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture, 3 semester hours.

HASS427. RISK COMMUNICATION. 3.0 Semester Hrs.
How do people perceive risk, as well as make decisions and communicate under conditions of uncertainty and risk? This course explores multiple perspectives on that overarching question. Although risk perception, risk management, and risk communication are three major course components, they are not treated separately but in terms of how they interrelate. Case studies include engineers and applied scientists coping with complex forms of uncertainty and risk, communicating in organizational and public sphere contexts with multiple audiences via the press and directly to the public, stockholders, co-workers, local communities, and more. In addition, students will critically reflect on the social consequences of living with risk in our contemporary moment. Prerequisite: HASS100. Co-requisite: HASS200.

HASS429. REAL WORLD RECORDING/RESEARCH. 3.0 Semester Hrs.
Equivalent with LAIS429,
(WI) This reading and writing-intensive course explores the acoustical, musical, and technical aspects of recording a variety of live ethno-musicological music genres and/or performances, towards the purpose of learning how to research, document and capture the most accurate and authentic recording. Historical research, non-traditional recording techniques; archival documentation, and editing will all be a part of this course. Prerequisites: HASS100 and HASS315 or HASS327. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS431. MORAL PSYCHOLOGY, RELIGION, AND AMERICAN SOCIETY. 3.0 Semester Hrs.
Equivalent with LAIS431,
(I, II, S) (WI) This course introduces intersections of moral psychology, religion in American society. Course begins with an understanding of religion in the United States and how religion has influenced foreign affairs throughout history (national security). Course introduces insights from moral psychology to shed light on the political spectrum in American political life. The course then explores how faith-based organizations make decisions on when and how to enter American political life for social change (intrasecurity). Finally, the course explores the connections between religion and terrorism that have seen some rise in the early 21st century (national security). Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS432. ROBOT ETHICS. 3.0 Semester Hrs.
(II) This course explores ethical issues arising in robotics and human-robot interaction through philosophical analysis, behavioral and psychological analysis, research ethics education, and the integration of social and ethical concerns in scientific experimentation and algorithm design. Topics include case studies in lethal autonomous weapon systems, autonomous cars, and social robots, as well as higher-level concerns including economics, law, policy, and discrimination. Prerequisite: HASS200.

HASS433. SHAKESPEARE AND THE SCIENTIFIC REVOLUTION. 3.0 Semester Hrs.
Equivalent with LAIS433,
(I, II, S) (WI) This course investigates ways in which William Shakespeare, a contemporary of Galileo, reflects in his work scientific theories and discoveries emerging during the Renaissance that transformed long-held world views. Shakespeare presents characters encountering unprecedented challenges interpreting their own relationship to the natural world and the political world, the spiritual world and the New World, the world of arts and the human imagination. Because the Renaissance concept of science is so broad and multi-disciplinary, students will be able to pursue individual interests in their research for this course. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS435. LATIN AMERICAN DEVELOPMENT. 3.0 Semester Hrs.
Equivalent with LAIS435,
A seminar designed to explore the political economy of current and recent past development strategies, models, efforts, and issues in Latin America, one of the most dynamic regions of the world today. Development is understood to be a nonlinear, complex set of processes involving political, economic, social, cultural, and environmental factors whose ultimate goal is to improve the quality of life for individuals. The role of both the state and the market in development processes will be examined. Topics to be covered will vary as changing realities dictate but will be drawn from such subjects as inequality of income distribution; the role of education and health care; region-markets; the impact of globalization, institution-building, corporate-community-state interfaces, neoliberalism, privatization, democracy, and public policy formulation as it relates to development goals. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS437. ASIAN DEVELOPMENT. 3.0 Semester Hrs.
Equivalent with LAIS437,
This international political economy seminar deals with the historical development of Asia Pacific from agrarian to post-industrial eras; its economic, political, and cultural transformation since World War II, contemporary security issues that both divide and unite the region; and globalization processes that encourage Asia Pacific to forge a single trading bloc. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS439. MIDDLE EAST DEVELOPMENT. 3.0 Semester Hrs.
Equivalent with LAIS439,
This internationa political economy seminar analyzes economic, political and social dynamics that affect the progress and direction of states, markets, and peoples of the region. It examines the development of the Middle East from agrarian to post-industrial societies; economic, political and cultural transformations since World War II; contemporary security issues that both divide and unite the region; and the effects of globalization processes on economies and societies in the Middle East. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS441. AFRICAN DEVELOPMENT. 3.0 Semester Hrs.
Equivalent with LAIS441,
This course provides a broad overview of the political economy of Africa. Its goal is to give students an understanding of the possibilities of African development and the impediments that currently block its economic growth. Despite substantial natural resources, mineral reserves, and human capital, most African countries remain mired in poverty. The struggles that have arisen on the continent have fostered thinking about the curse of natural resources where countries with oil or diamonds are beset with political instability and warfare. Readings give first an introduction to the continent followed by a focus on the specific issues that confront African development today. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS442. NATURAL RESOURCES AND WAR IN AFRICA. 3.0 Semester Hrs.
Equivalent with LAIS442,
Africa possesses abundant natural resources yet suffers civil wars and international conflicts based on access to resource revenues. The course examines the distinctive history of Africa, the impact of the resource curse, mismanagement of government and corruption, and specific cases of unrest and war in Africa. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS446. GLOBALIZATION. 3.0 Semester Hrs.
Equivalent with LAIS446,
This international political economy seminar is an historical and contemporary analysis of globalization processes examined through selected issues of world affairs of political, economic, military, and diplomatic significance. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS448. GLOBAL ENVIRONMENTAL ISSUES. 3.0 Semester Hrs.
Equivalent with LAIS448,
Critical examination of interactions between development and the environment and the human dimensions of global change; social, cpolitical, economic, and cultural responses to the management and preservation of natural resources and ecosystems on a global scale. Exploration of the meaning and implications of ?Stewardship of the Earth? and ?Sustainable Development.? Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS450. POLITICAL RISK ASSESSMENT. 3.0 Semester Hrs.
Equivalent with LAIS450,
This course will review the existing methodologies and techniques of risk assessment in both country-specific and global environments. It will also seek to design better ways of assessing and evaluating risk factors for business and public diplomacy in the increasingly globalized context of economy and politics wherein the role of the state is being challenged and redefined. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS452. CORRUPTION AND DEVELOPMENT. 3.0 Semester Hrs.
Equivalent with LAIS452,
(I, II, S) (WI) This course addresses the problem of corruption and its impact on development. Readings are multi disciplinary and include policy studies, economics, and political science. Students will acquire an understanding of what constitutes corruption, how it negatively affects development, and what they, as engineers in a variety of professional circumstances, might do in circumstances in which bribe paying or bribe taking might occur. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS453. ETHNIC CONFLICT IN GLOBAL PERSPECTIVE. 3.0 Semester Hrs.
Equivalent with LAIS453,
Many scholars used to believe that with modernization, racial, religious, and cultural antagonisms would weaken as individuals developed more rational outlooks and gave primacy to their economic concerns. Yet, with the waning of global ideological conflict of the left-right nature, conflict based on cultural and "civilization" differences have come to the fore in both developing and developed countries. This course will examine ethnic conflict, broadly conceived, in a variety of contexts. Case studies will include the civil war in Yugoslavia, the LA riots, the antagonism between the Chinese and "indigenous' groups in Southeast, the so-called war between the West and Islam, and ethnic relations in the U.S. We will consider ethnic contention in both institutionalized, political processes, such as the politics of affirmative action, as well as in non-institutionalized, extra-legal settings, such as ethnic riots, pogroms, and genocide. We will end by asking what can be done to mitigate ethnic conflict and what might be the future of ethnic group identification. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS456. POWER AND POLITICS IN EURASIA. 3.0 Semester Hrs.
Equivalent with LAIS456,
This seminar covers the major internal and international issues confronting the fifteen states that once comprised the Soviet Union. After an overview of the USSR and its collapse in 1991, the course explores subsequent economic and security dilemmas facing the "new" nations of Eurasia. Special attention will be paid to oil, natural gas, and other energy sectors in the region. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS458. NATURAL RESOURCES AND DEVELOPMENT. 3.0 Semester Hrs.
(I, II, S) (WI) This course examines the relationship between natural resources and development. It begins by discussing theories of development and how those theories account for specific choices among resource abundant countries. From the theoretical readings, students examine sector specific topics in particular cases. These subjects include oil and natural gas in African and Central Asian countries; hard rock mining in West Africa and East Asia; gemstone mining in Southern and West Africa; contracting in the extractive industries; and corporate social responsibility. Readings are multidisciplinary and draw from policy studies, economics, and political science to provide students an understanding of different theoretical approaches from the social sciences to explain the relationship between abundant natural resources and development. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS460. GEOPOLITICS OF NATURAL RESOURCES. 3.0 Semester Hrs.
Equivalent with LAIS460,
(I, II, S) (WI) This seminar examines geopolitical competition between great and aspiring powers for influence, control over land and natural resources, critical geo-strategic trade routes, or even infrastructure. Using empirical evidence from case studies, students develop a deeper understanding of the interconnections between the political, economic, social, cultural and geographic dimensions of foreign policies, as well as issues of war and peace. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS463. HISTORY OF EPIDEMICS. 3.0 Semester Hrs.
This course explores how epidemics and pandemics have shaped human history, from the Plague of Athens in 430 BCE to the HIV/AIDS crisis. Prerequisite: HASS200.

HASS464. HISTORY OF ENERGY AND THE ENVIRONMENT. 3.0 Semester Hrs.
Equivalent with LAIS464,
(II) This course examines the major patterns of human energy use and interaction with the natural environment on a global scale from the origins of civilization to the present day. Topics analyzed include the dynamics of historical change in energy and resource use, the ways in which energy and the environment have shaped the development of past societies, cultural perceptions of energy and the environment during different historical eras, and the impact of past human activities on natural systems. Analysis of historical trends will also serve as a basis for discussions related to current issues in energy and the environment. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS466. SCIENCE, TECHNOLOGY, AND CONFUCIAN ETHICS. 3.0 Semester Hrs.
This course examines the ethical ideas in classical Confucianism (e.g., Confucius, Mencius) and how these ethical ideas can shape the ways in which scientific and technological problems are defined and solved. Students in this class will be expected to read both classical Confucian texts such as Analects and Mencius and works by contemporary authors that examine the social, ethical, and political issues in scientific and technological domains such as gene editing technology, robotics, social media technology, and engineering through the lens of Confucian ethics. A major goal of this course is to help students challenge some prevalent ideologies in Western ethics such as autonomous individualism (e.g., individuals are understood as merely rights-bearing persons). It also helps students cultivate a cultural sensitivity toward scientific and technological practice in a global context. Our exploration in this class will help students develop their ?self-knowledge? that has been extensively missing in current engineering education system. Students are encouraged to think reflectively and critically about why they are engineers, for those benefit they want to work, and the kind of world they want to design and live in by using the powerful technologies they create. Prerequisite: HASS200.

HASS467. HISTORY OF EARTH AND ENVIRONMENTAL SCIENCES. 3.0 Semester Hrs.
Equivalent with LAIS467,
This course provides an overview of the history of some of the key sciences that help us understand the world we inhabit: geology, climatology, evolutionary biology, and ecology. As we investigate key scientific discoveries of the modern era, we will also consider the philosophical and cultural impacts of those scientific discoveries. Thus, our reading will include not only original texts by scientists, but also key literary, historical and other texts inspired by those discoveries. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS468. ENVIRONMENTAL JUSTICE. 3.0 Semester Hrs.
This course explores the history of the environmental justice movement, current and emerging environmental justice issues, and the application of environmental justice concepts and theories to environmental decision-making. Course content and activities are designed to enrich student understanding of how environmental injustice is produced (locally, regionally, and globally), how environmental justice issues are measured and analyzed, and how environmentally just outcomes can be achieved. Prerequisite: HASS100. Co-requisite: HASS200.

HASS484. US WATER POLITICS AND POLICY. 3.0 Semester Hrs.
(I) (WI) This interdisciplinary seminar course engages the complexities of contemporary water governance in the United States, with an emphasis on the arid American West, including the state of Colorado. It engages with governance questions such as how we are to share over-allocated water resources, how we are to engage with increasingly unpredictable hydrologic dynamics, and how changes in water science, engineering, and values shape policy and politics and vice versa. The course engages with concepts in ethics, economics, history, law, and policy, and puts them in conversation with dynamics in hydrology, engineering, and social-ecological systems theory. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS485. CONSTITUTIONAL LAW AND POLITICS. 3.0 Semester Hrs.
Equivalent with LAIS485,
This course presents a comprehensive survey of the U.S. Constitution with special attention devoted to the first ten Amendments, also known as the Bill of Rights. Since the Constitution is primarily a legal document, the class will adopt a legal approach to constitutional interpretation. However, as the historical and political context of constitutional interpretation is inseparable from the legal analysis, these areas will also be covered. Significant current developments in constitutional jurisprudence will also be examined. The first part of the course deals with Articles I through III of the Constitution, which specify the division of national governmental power among the executive, legislative, and judicial branches of government. Additionally, the federal nature of the American governmental system, in which governmental authority is apportioned between the national government and the state governments, will be studied. The second part of the course examines the individual rights specifically protected by the amendments to the Constitution, principally the First, Fourth, Fifth, Sixth, Eighth, and Fourteenth Amendments. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS486. SCIENCE AND TECHNOLOGY POLICY. 3.0 Semester Hrs.
Equivalent with LAIS486,
An examination of current issues relating to science and technology policy in the United States and, as appropriate, in other countries. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS487. ENVIRONMENTAL POLITICS AND POLICY. 3.0 Semester Hrs.
Equivalent with LAIS487,
Seminar on environmental policies and the political and governmental processes that produce them. Group discussion and independent research on specific environmental issues. Primary but not exclusive focus on the U.S. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS488. GLOBAL WATER POLITICS AND POLICY. 3.0 Semester Hrs.
Equivalent with LAIS488,
(II) (WI) This interdisciplinary seminar course analyzes how droughts, floods, water management, global trading system, and climate change affect the hydrological and food systems that are critically important for economic prosperity and political stability. It addresses water policy at scales that range from community level to global governance regimes. It uses relevant analytical perspectives of, for example, psychology, political economy, development studies, and institutional approaches in economic geography to help students understand how certain transboundary water conflicts have emerged, their national and regional implications, and policies and institutions that can be used to resolve them. Prerequisite: HASS100. Corequisite: HASS200. 3 hours seminar; 3 semester hours.

HASS490. ENERGY AND SOCIETY. 3.0 Semester Hrs.
Equivalent with ENGY490,LAIS490,MNGN490,
(I,II) An interdisciplinary capstone seminar that explores a spectrum of approaches to the understanding, planning, and implementation of energy production and use, including those typical of diverse private and public (national and international) corporations, organizations, states, and agencies. Aspects of global energy policy that may be considered include the historical, social, cultural, economic, ethical, political, and environmental aspects of energy together with comparative methodologies and assessments of diverse forms of energy development as these affect particular communities and societies. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS491. ENERGY POLITICS. 3.0 Semester Hrs.
(I, II, S) (WI) We will use political science approaches, theories, and methods to investigate the global, regional, state, and local politics of renewable and non-renewable energy, spanning all uses: transportation, heating and cooling, and electricity. We will look at the politics behind energy in a subset of countries to be chosen by the class, such as China, Brazil, India, Austria, Spain, Venezuela, and Germany. We will then focus on energy in Colorado and other US states, conducting primary research on the stakeholders and the relevant political outcomes. We will hear from energy companies, non-governmental organizations, university and research entities, government representatives, legislators, and local activists. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS492. ENERGY AND SECURITY POLICY. 3.0 Semester Hrs.
(I, II, S) (WI) This course applies a social science lens to understanding the intersections between national and international security concerns and energy. We will examine these intersections through a case study approach that includes directed readings, such as books and peer-reviewed journal articles, that incorporate student-led discussions and research projects. By exploring various energy security scenarios, such as restricted access to oil and gas, students will gain a comprehensive understanding of the energy-security nexus and the role governments and policies play in enhancing or limiting security. Prerequisite: HASS100. Corequisite: HASS200. 3 hours lecture; 3 semester hours.

HASS498. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS498. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS498B,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS498. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS498C,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS498. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS498D,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS498. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS498E,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS498. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS498F,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS498. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS498G,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS498. SPECIAL TOPICS. 1-6 Semester Hr.
Equivalent with LAIS498H,
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: HASS100. Corequisite: HASS200. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

HASS499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

HNRS105. INNOVATION AND DISCOVERY IN ENGINEERING, ARTS, AND SCIENCES I. 3.5 Semester Hrs.
(I) (WI) "Innovation and Discovery in Engineering, Arts, and Sciences" (IDEAS) applies honors pedagogies in a multidisciplinary, integrated environment that highlights the seamless boundaries between science and engineering, design, ethics, and the arts as a path toward making value-informed technical decisions. In addition to developing foundational skills in engineering design and problem-solving, students examine place, identity, citizenship, and community in various contexts as they learn what it means to be an engaged and mindful citizen and professional. IDEAS poses ethical problems and hands-on design challenges from a multitude of lenses. It incorporates experiential learning, team-based projects, and seminar discussions to encourage students to think both critically and creatively about their world. Students must pass both HNRS105 and HNRS 115 to meet degree requirements. If students drop either of these courses, they must take both LAIS100 and EPIC151 or their equivalents in order to graduate. 3 hours lecture; 1.5 hours lab; 3.5 semester hours.

HNRS115. INNOVATION AND DISCOVERY IN ENGINEERING, ARTS, AND SCIENCES II. 3.5 Semester Hrs.
(II) (WI) "Innovation and Discovery in Engineering, Arts, and Sciences" (IDEAS) applies honors pedagogies in a multidisciplinary, integrated environment that highlights the seamless boundaries between science and engineering, design, ethics, and the arts as a path toward making value-informed technical decisions. Students examine place, identity, citizenship, and community in various contexts as they learn what it means to be an engaged and mindful citizen and professional. IDEAS poses ethical problems and hands-on design challenges from a multitude of lenses. It incorporates experiential learning, team-based projects, and seminar discussions to encourage students to think both critically and creatively about their world. Students must pass both HNRS105 and HNRS115 to meet degree requirements. If students drop either of these courses, they must take both LAIS100 and EPIC151 or their equivalents in order to graduate. 3 hours lecture; 1.5 hours lab; 3.5 semester hours. Prerequisite: C- or better in HNRS105.

HNRS198. SPECIAL TOPICS. 6.0 Semester Hrs.
A Special Topics course will be a pilot course in the UHSP curriculum or will be offered as an enhancement to regularly-scheduled UHSP seminars. Special Topics courses in the UHSP curriculum will not be offered more than twice. Variable credit: 1 - 6 semester hours. Repeatable for credit under different titles.

HNRS199. INDEPENDENT STUDY. 1-6 Semester Hr.
Under special circumstances, a UHSP student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled UHSP curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

HNRS298. SPECIAL TOPICS. 1-6 Semester Hr.
A Special Topics course will be a pilot course in the UHSP curriculum or will be offered as an enhancement to regularly-scheduled UHSP seminars. Special Topics courses in the UHSP curriculum will not be offered more than twice. Variable credit: 1 - 6 semester hours. Repeatable for credit under different titles.

HNRS299. INDEPENDENT STUDY. 1-6 Semester Hr.
Under special circumstances, a UHSP student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled UHSP curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

HNRS305. EXPLORATIONS IN MODERN AMERICA. 3.0 Semester Hrs.
(I, II) (WI) Honors core course that develops student skills in reading, writing, critical thinking, and oral communication. skills through the exploration of selected topics related to the social, cultural, and political ideas and events that have shaped the development of the modern United States and its role in the world. Prerequisite: Admission to the Program and HASS100. 3 lecture hours, 3 credit hours.

HNRS315. EXPLORATIONS IN THE MODERN WORLD. 3.0 Semester Hrs.
(I, II) (WI) Honors core course that develops student writing skills and critical thinking abilities through the exploration of selected topics related to the social, cultural, and political ideas and developments that have shaped the modern world. Prerequisite: Admission to the Program and HASS100. 3 lecture hours, 3 credit hours.

HNRS398. SPECIAL TOPICS IN THE UNIVERSITY HONORS AND SCHOLARS PROGRAM. 1-6 Semester Hr.
A Special Topics course will be a pilot course in the University Honors & Scholars Programs curriculum or will be offered as an enhancement to regularly-scheduled UHSP seminars. Special Topics courses in the UHSP curriculum will not be offered more than twice.

HNRS399. INDEPENDENT STUDY. 1-6 Semester Hr.
Under special circumstances, a UHSP student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled UHSP curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

HNRS405. MCBRIDE PRACTICUM. 1-3 Semester Hr.
(I, II) (WI) With approval of the Program, a McBride student may enroll in an individualized study project which substitutes for or enhances the regularly-scheduled McBride curriculum seminars. This option may be used to pursue an approved foreign study program, service learning program, international internship, undergraduate research project, or other authorized experiential learning program of study. Students must also prepare a faculty-guided major research paper that integrates the experience with the goals, objectives, and focus of the Honors Program in Public Affairs. 1-3 semester hours. Repeatable up to 6 hours.

HNRS425. EXPLORATIONS IN POLITICS, POLICY, AND LEADERSHIP. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to policy, politics, and/or leadership through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in The Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS430. EXPLORATIONS IN IDEAS, ETHICS, AND RELIGION. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to ideas, ethics, and/or religion through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS435. EXPLORATIONS IN CULTURE, SOCIETY, AND CREATIVE ARTS. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to culture, society, and/or the creative arts through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS440. EXPLORATIONS IN INTERNATIONAL STUDIES & GLOBAL AFFAIRS. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to international studies and/or global affairs through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS445. EXPLORATIONS IN SCIENCE, TECHNOLOGY, AND SOCIETY. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to the relationships between science, technology, and society through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS450. EXPLORATIONS IN EARTH, ENERGY, AND ENVIRONMENT. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to earth, energy, and/or the environment through case studies, readings, research, and writing. This course may focus on the human dimensions or broader impacts of science, technology, engineering, or mathematics. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS476. COMMUNITY ENGAGEMENT THROUGH SERVICE LEARNING. 3.0 Semester Hrs.
(II) Community Engagement through Service Learning combines a traditional classroom environment with an off campus learning experience with a local non-profit or community organization. Students spend 3-4 hours per week serving the organization they choose and meet in class once per week to discuss reading assignments, present research findings, and share experiences and insights about the course material. Instructors may choose to focus on a particular topic or social issue, such as poverty and privilege, or may engage with community issues more broadly. The course focuses on several aspects of a student?s learning, including intra- and interpersonal learning, discovering community, and developing communication skills and critical and interdisciplinary approaches. Course work will focus on critical reading, group discussion and deliberation, oral presentations of research, and writing assignments. Prerequisites: none. 2 hours lecture; 3-4 hours lab; 3.0 semester hours.

HNRS498. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS. 1-6 Semester Hr.
A Special Topics course will be a pilot course in the McBride curriculum or will be offered as an enhancement to regularly-scheduled McBride seminars. Special Topics courses in the McBride curriculum will not be offered more than twice. Variable credit: 1 - 6 semester hours. Repeatable for credit under different titles.

HNRS499. INDEPENDENT STUDY. 1-6 Semester Hr.
Under special circumstances, a McBride student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled McBride curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

LICM198. SPECIAL TOPICS. 0.5-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LICM298. SPECIAL TOPICS. 0.5-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIFL113. SPANISH I. 3.0 Semester Hrs.
Fundamentals of spoken and written Spanish with an emphasis on vocabulary, idiomatic expressions of daily conversation, and Spanish American culture. 3 semester hours.

LIFL114. ARABIC I. 3.0 Semester Hrs.
Fundamentals of spoken and written Arabic with an emphasis on vocabulary, idiomatic expressions of daily conversation, and culture of Arabic-speaking societies. 3 semester hours.

LIFL115. GERMAN I. 3.0 Semester Hrs.
Fundamentals of spoken and written German with an emphasis on vocabulary, idiomatic expressions of daily conversation, and German culture. 3 semester hours.

LIFL119. FRENCH I. 3.0 Semester Hrs.
(I) French I provides basic instruction in speaking, reading, listening, and writing the French language, with emphasis in class on communicating through speaking and listening skills. French and francophone culture will also be studied. Successful completion of French I will allow students to further their french studies in level 2. 3 hours lecture, 3 semester hours.

LIFL123. SPANISH II. 3.0 Semester Hrs.
Continuation of Spanish I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and Spanish American culture. 3 semester hours.

LIFL124. ARABIC II. 3.0 Semester Hrs.
Continuation of Arabic I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and culture of Arabic speaking societies. 3 semester hours.

LIFL125. GERMAN II. 3.0 Semester Hrs.
Continuation of German I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and German culture. 3 semester hours.

LIFL129. FRENCH II. 3.0 Semester Hrs.
(II) French 2 provides continued instruction in speaking, reading, listening, and writing the French language, with emphasis in class on communicating through speaking and listening skills. French and francophone culture will also be studied. Prerequisites: LIFL119. 3 hours lecture.

LIFL198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIFL199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

LIFL213. SPANISH III. 3.0 Semester Hrs.
Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Spanish American culture. 3 semester hours.

LIFL298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIFL299. INDEPENDENT STUDY. 6.0 Semester Hrs.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

LIFL398. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIFL399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

LIFL498. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIFL499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

LIMU101. CSM CONCERT/MARCH BAND-FRESHMAN. 1.0 Semester Hr.
Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU102. COLORADO SCHOOL OF MINES SYMPHONY ORCHESTRA - FRESHMAN. 1.0 Semester Hr.
(I, II, S) The Colorado School of Mines Symphony Orchestra is a full orchestra including strings, woodwinds, brass, and percussion. The orchestra studies a wide range of repertoire including standard orchestral works in addition to popular selections, film soundtracks, and chamber ensemble pieces. Performances include formal concerts, silent film soundtrack productions, and chamber music recitals; while performance frequency varies by semester, there are typically one to two large-ensemble performances per semester and one to three chamber performances per semester. Grading is based on individual participation and preparation. Offered every other year. 3 hours lab; 1 semester hour.

LIMU111. CSM CONCERT CHOIR - FRESHMAN. 1.0 Semester Hr.
Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU112. CSM CONCERT CHOIR - FRESHMAN. 1.0 Semester Hr.
Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU121. GUITAR ENSEMBLE. 1.0 Semester Hr.
(I, II, S) Students will learn the basics of classical guitar playing in a non-threatening environment. Utilizing beginning to intermediate classical guitar tunes, students will advance the fundamental guitar technique as well as the music reading skill on classical guitar. Reading skill is the foundation of students? future engagement with all forms of music, therefore considerable amount of class resources will be devoted to this particular discipline. Participation in the departmental concert at the end of the semester is mandatory. Offered every other year. 3 hours lab; 1 semester hour.

LIMU189. INDIVIDUAL INSTRUMENTAL OR VOCAL MUSIC INSTRUCTION. 1.0 Semester Hr.
(I, II) The course affords the student an opportunity to study privately with CSM music faculty on a wide range of instruments including guitar, piano, bass guitar, voice, saxophone, flute, drums and world instruments. Students will be required to practice regularly and demonstrate proficiency on their instrument/voice. Topics of this class will include performance etiquette, musicianship, musical styles, stylistic vocabulary, foreign language and basic music theory. 1 credit hour.

LIMU198. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIMU199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

LIMU201. CSM CONCERT/MARCH BAND-SOPHOMORE. 1.0 Semester Hr.
Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU202. COLORADO SCHOOL OF MINES SYMPHONY ORCHESTRA - SOPHOMORE. 1.0 Semester Hr.
(II) The Colorado School of Mines Symphony Orchestra is a full orchestra including strings, woodwinds, brass, and percussion. The orchestra studies a wide range of repertoire including standard orchestral works in addition to popular selections, film soundtracks, and chamber ensemble pieces. Performances include formal concerts, silent film soundtrack productions, and chamber music recitals; while performance frequency varies by semester, there are typically one to two large-ensemble performances per semester and one to three chamber performances per semester. Grading is based on individual participation and preparation. Offered every other year. 3 hours lab; 1 semester hour.

LIMU211. csm CONCERT CHOIR - SOPHOMORE. 1.0 Semester Hr.
Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU212. CSM CONCERT CHOIR - SOPHOMORE. 1.0 Semester Hr.
Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIMU299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

LIMU301. CSM CONCERT/MARCH BAND-JUNIOR. 1.0 Semester Hr.
Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU302. COLORADO SCHOOL OF MINES SYMPHONY ORCHESTRA - JUNIOR. 1.0 Semester Hr.
(II) The Colorado School of Mines Symphony Orchestra is a full orchestra including strings, woodwinds, brass, and percussion. The orchestra studies a wide range of repertoire including standard orchestral works in addition to popular selections, film soundtracks, and chamber ensemble pieces. Performances include formal concerts, silent film soundtrack productions, and chamber music recitals; while performance frequency varies by semester, there are typically one to two large-ensemble performances per semester and one to three chamber performances per semester. Grading is based on individual participation and preparation. Offered every other year. 3 hours lab; 1 semester hour.

LIMU311. CSM CONCERT CHOIR - JUNIOR. 1.0 Semester Hr.
Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU312. CSM CONCERT CHOIR - JUNIOR. 1.0 Semester Hr.
Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU398. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIMU399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

LIMU401. CSM CONCERT/MARCH BAND-SENIOR. 1.0 Semester Hr.
(I) The Colorado School of Mines Symphony Orchestra is a full orchestra including strings, woodwinds, brass, and percussion. The orchestra studies a wide range of repertoire including standard orchestral works in addition to popular selections, film soundtracks, and chamber ensemble pieces. Performances include formal concerts, silent film soundtrack productions, and chamber music recitals; while performance frequency varies by semester, there are typically one to two large-ensemble performances per semester and one to three chamber performances per semester. Grading is based on individual participation and preparation. 3 hours lab; 1 semester hour.

LIMU402. COLORADO SCHOOL OF MINES SYMPHONY ORCHESTRA - SENIOR. 1.0 Semester Hr.
(II) The Colorado School of Mines Symphony Orchestra is a full orchestra including strings, woodwinds, brass, and percussion. The orchestra studies a wide range of repertoire including standard orchestral works in addition to popular selections, film soundtracks, and chamber ensemble pieces. Performances include formal concerts, silent film soundtrack productions, and chamber music recitals; while performance frequency varies by semester, there are typically one to two large-ensemble performances per semester and one to three chamber performances per semester. Grading is based on individual participation and preparation. Offered every other year. 3 hours lab; 1 semester hour.

LIMU411. CSM CONCERT CHOIR - SENIOR. 1.0 Semester Hr.
Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU412. CSM CONCERT CHOIR - SENIOR. 1.0 Semester Hr.
Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU421. JAZZ ENSEMBLE. 1.0 Semester Hr.
FALL The Jazz Ensemble provides an opportunity for students to participate in a musical ensemble in the jazz big band format. Jazz music is a unique American art form. The big band jazz format is an exciting way for students to experience the power, grace and beauty of this art form and music in general. The class will consist of regular weekly rehearsals and one or more concert performance (s). 1 semester hour. Repeatable for credit. See rules limiting the number of hours applicable to a degree above.

LIMU422. JAZZ ENSEMBLE - SPRING. 1.0 Semester Hr.
SPRING The Jazz Ensemble provides an opportunity for students to participate in a musical ensemble in the jazz big band format. Jazz music is a unique American art form. The big band jazz format is an exciting way for students to experience the power, grace and beauty of this art form and music in general. The class will consist of regular weekly rehearsals and one or more concert performance(s). 1 semester hour. Repeatable for credit. See rules limiting the number of hours applicable to a degree above.

LIMU423. JAZZ LAB. 1.0 Semester Hr.
The Jazz Lab provides an opportunity for students to participate in a musical ensemble in the jazz combo format. Jazz music is a unique American art form. The jazz combo format is an exciting way for students to experience the joy and sense of achievement of performing this great American music form. The class will consist of regular weekly rehearsals and one or more concert performance(s). 1 semester hour. Repeatable for credit. See rules limiting the number of hours applicable to a degree above.

LIMU450. MUSIC TECHNOLOGY CAPSTONE COURSE. 3.0 Semester Hrs.
Project-based course designed to develop practical technological and communication skills for direct application to the music recording. Prerequisite: LIMU340 and LIMU350. 3 hours seminar; 3 semester hours.

LIMU498. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

LIMU499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professors

Hussein A. Amery , Department Head

Elizabeth Van Wie Davis

Jon Leydens

Kenneth Osgood

Associate Professors

Tina L. Gianquitto

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James D. Straker

Assistant Professors

Adrianne Kroepsch

Qin Zhu

Teaching Professors

Cortney Holles

Jonathan Cullison

Paula A. Farca

Robert Klimek, Music Program Director

Toni Lefton, Director, University Honors and Scholars Programs

Sandy Woodson, Undergraduate Advisor

Teaching Associate Professors

Melanie Brandt, Director of McBride Program

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Maggie Greenwood

Joseph Horan, Associate Department Head

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Shannon Davies Mancus

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Arthur B. Sacks

Associate Professors Emeriti

Betty J. Cannon

Kathleen H. Ochs

Laura J. Pang

Karen B. Wiley

Teaching Professor Emeriti

James Jesudason

Mechanical Engineering

Program Description

The Mechanical Engineering Department offers a design-oriented undergraduate program that emphasizes fundamental engineering principles. Students receive a strong foundation in mechanical engineering disciplines, and a working knowledge of modern engineering tools. Many courses are augmented through hands-on and project-based experiences. Successful graduates are well-prepared for a mechanical engineering career in a world of rapid technological change.

The program leading to the degree of Bachelor of Science in Mechanical Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Bachelor of Science in Mechanical Engineering

The Mechanical Engineering program intentionally embeds several professional and technical skills, e.g. working on teams, engineering design, technical communication and programming, throughout the Mechanical Engineering curriculum. During the freshman and sophomore years, students complete a set of core courses that include mathematics, basic sciences, and fundamental engineering disciplines. This includes early open-ended design experiences in Introduction to Design (EDNS151), Introduction to Mechanical Engineering: Programming and Hardware Interface (MEGN200), and Introduction to Mechanical Engineering: Design and Fabrication (MEGN201). Additionally, courses in Humanities & Social Science (H&SS) allow students to explore the linkages between the environment, human society, and engineered systems.

In the middle years, Mechanical Engineering offers a four course project-based design sequence to learn engineering tools, including MATLAB, SolidWorks, and LabVIEW, to solve engineering problems in a hands-on environment. This experience teaches design methodology and stresses the creative aspects of the mechanical engineering profession. This course sequence helps prepare students for open-ended, industry-based project in the senior design experience.

In the junior and senior years, students complete an advanced mechanical engineering core that includes fluid mechanics, thermodynamics, heat transfer, numerical methods, control systems, machine design, computer-aided engineering, and manufacturing processes. This engineering core is complemented by courses in economics and electives in Humanities & Social Science (H&SS). Students must also take three advanced technical electives and three additional free electives to explore specific fields of interest. In the senior year, all students must complete a capstone design course focused on a multidisciplinary engineering project.

Students in mechanical engineering spend considerable time with design and testing equipment available in the CECS Garage, a large machine shop, and automation spaces for prototyping and testing equipment. Students are also encouraged to get involved in research with our faculty in the Department of Mechanical Engineering. These research areas include: biomechanics; solid mechanics and materials; thermal-fluid systems; and robotics. Our students also find internship opportunities to gain practical experience and explore the many industries under the mechanical engineering umbrella.

There are plenty of opportunities outside of the curriculum for students to explore their passions. We have an active Mines Maker Space, Robotics Club, and Abilities Research & Design Group, a group of students enabling those with disabilities to try new activities or advance their performance in a given sport. These are just a few of the clubs and societies where students engage with the community or compete in design challenges nation-wide.

Program Educational Objectives (Bachelor of Science in Mechanical Engineering)

The Mechanical Engineering program contributes to the educational objectives described in the Mines' Graduate Profile and the ABET Accreditation Criteria. Accordingly, the Mechanical Engineering Program at Mines has established the following program educational objectives for the B.S. in Mechanical Engineering degree:

Within three to five years of completing their degree, graduates will be:

- Applying their Mechanical Engineering education as active contributors in the workforce or graduate school;
- Effective at communicating technical information in a diverse and globally integrated society;
- Demonstrating their commitment to continued professional development through training, coursework, and/or professional society involvement;
- Exemplifying ethical and social responsibility in their professional activities.

Bachelor of Science in Mechanical Engineering Degree Requirements:

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
HASS100	NATURE AND HUMAN VALUES			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
EDNS151	DESIGN I			3.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
PHGN100	PHYSICS I - MECHANICS			4.5
CSCI101	INTRODUCTION TO COMPUTER SCIENCE			3.0

CSCI102	INTRODUCTION TO COMPUTER SCIENCE - LAB			1.0
				17.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CEEN241	STATICS			3.0
HASS200	GLOBAL STUDIES			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
MEGN200	INTRODUCTION TO MECHANICAL ENGINEERING: PROGRAMMING AND HARDWARE INTERFACE			3.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				18.0

Spring		**lec**	**lab**	**sem.hrs**
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
MEGN361	THERMODYNAMICS I			3.0
MEGN212	INTRODUCTION TO SOLID MECHANICS			3.0
MTGN202	ENGINEERED MATERIALS			3.0
MEGN201	INTRODUCTION TO MECHANICAL ENGINEERING: DESIGN & FABRICATION			3.0
				18.0

Junior

Fall		**lec**	**lab**	**sem.hrs**
EBGN201	PRINCIPLES OF ECONOMICS			3.0
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING			3.0
MEGN315	DYNAMICS			3.0
MEGN324	INTRODUCTION TO FINITE ELEMENT ANALYSIS			3.0
MEGN300	INSTRUMENTATION & AUTOMATION			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Spring		**lec**	**lab**	**sem.hrs**
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
MEGN381	MANUFACTURING PROCESSES			3.0
MEGN481	MACHINE DESIGN			3.0
MEGN301	MECHANICAL INTEGRATION & DESIGN			2.0
MEGN351	FLUID MECHANICS			3.0
				17.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
EDNS491	SENIOR DESIGN I			3.0
MEGN471	HEAT TRANSFER			3.0
FREE	Free Elective			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
MECH ELECT	Mechanical Engineering Elective*			3.0
MECH ELECT	Mechanical Engineering Elective*			3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
EDNS492	SENIOR DESIGN II			3.0
FREE	Free Elective			3.0
FREE	Free Elective			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective			3.0
MECH ELECT	Mechanical Engineering Elective*			3.0
				15.0

Total Semester Hrs: 134.5

* Mechanical Engineering students are required to take three Mechanical Engineering elective courses. At least one of these courses must be from the Advanced Engineering Sciences list. The remaining must be from either the Advanced Engineering Sciences list or the Mechanical Engineering Electives list.

Advanced Engineering Sciences:

MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
MEGN416	ENGINEERING VIBRATION	3.0
MEGN451	FLUID MECHANICS II - AERODYNAMICS	3.0
MEGN461	THERMODYNAMICS II	3.0

Mechanical Engineering Electives:

CEEN405	NUMERICAL METHODS FOR ENGINEERS	3.0
CEEN406	FINITE ELEMENT METHODS FOR ENGINEERS	3.0
EBGN321	ENGINEERING ECONOMICS	3.0
EDNS401	PROJECTS FOR PEOPLE	3.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0
EENG390	ENERGY, ELECTRICITY, RENEWABLE ENERGY, AND ELECTRIC POWER GRID	3.0
EENG417	MODERN CONTROL DESIGN	3.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
MEGN391	AUTOMOTIVE DESIGN: SAE COLLEGIATE DESIGN SERIES (FORMULA SAE)	1.0

MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
MEGN435	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0
MEGN436	COMPUTATIONAL BIOMECHANICS	3.0
MEGN441	INTRODUCTION TO ROBOTICS	3.0
MEGN466	INTRODUCTION TO INTERNAL COMBUSTION ENGINES	3.0
MEGN469	FUEL CELL SCIENCE AND TECHNOLOGY	3.0
MEGN485	MANUFACTURING OPTIMIZATION WITH NETWORK MODELS	3.0
MEGN486	LINEAR OPTIMIZATION	3.0
MEGN487	NONLINEAR OPTIMIZATION	3.0
MEGN488	INTEGER OPTIMIZATION	3.0
MEGN498	SPECIAL TOPICS IN MECHANICAL ENGINEERING (SPECIAL TOPICS)	1-6
MEGN5XX	ANY 500-LEVEL MEGN COURSE	3.0
MTGN311	STRUCTURE OF MATERIALS	3.0
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0
MTGN463	POLYMER ENGINEERING	3.0
MTGN464	FORGING AND FORMING	2.0
MTGN475	METALLURGY OF WELDING	2.0
NUGN520	INTRODUCTION TO NUCLEAR REACTOR THERMAL-HYDRAULICS	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
PHGN350	INTERMEDIATE MECHANICS	4.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0
AMFG401	ADDITIVE MANUFACTURING	3.0
AMFG421	DESIGN FOR ADDITIVE MANUFACTURING	3.0
or AMFG521	DESIGN FOR ADDITIVE MANUFACTURING	
AMFG422	LEAN MANUFACTURING	3.0
AMFG4XX	Not Including 499	3.0
AMFG531	MATERIALS FOR ADDITIVE MANUFACTURING	3.0
AMFG511	DATA DRIVEN ADVANCED MANUFACTURING	3.0
CSCI261	PROGRAMMING CONCEPTS	3.0
CSCI306	SOFTWARE ENGINEERING	3.0
CSCI341	COMPUTER ORGANIZATION	3.0
CSCI442	OPERATING SYSTEMS	3.0
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING	4.0
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
CSCI437	INTRODUCTION TO COMPUTER VISION	3.0
CSCI404	ARTIFICIAL INTELLIGENCE	3.0
CSCI473	HUMAN-CENTERED ROBOTICS	3.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS	3.0
EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0
EENG310	INFORMATION SYSTEMS SCIENCE I	4.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0
EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0
MATH332	LINEAR ALGEBRA	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
MATH432	SPATIAL STATISTICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MEGN4XX	Mechanical Tech Elective (not including 499 & required 400-level courses)	3.0
CSCI5XX	Non-project and research credit	
EENG5XX	Non-seminar and research credit	
FEGN5XX	Non-project and research credit	
MATH5XX	Non-project and research credit	

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- CEEN241
- EENG281
- EENG307
- EGGN205
- EGGN250
- EGGN350
- EGGN450
- EGGN491
- EGGN492
- EDNS491
- EDNS491
- MEGN100 through MEGN699 inclusive

Combined Mechanical Engineering Baccalaureate and Masters Degrees

Mechanical Engineering offers a five year combined program in which students have the opportunity to obtain specific engineering skills supplemented with graduate coursework in mechanical engineering. Upon completion of the program, students receive two degrees, the Bachelor of Science in Mechanical Engineering and the Master of Science in Mechanical Engineering.

Admission into a graduate degree program as a Combined Undergraduate/Graduate degree student may occur as early as the first semester Junior year and *must be granted no later than the end of registration the last semester Senior year*. Students must meet minimum GPA admission requirements for the graduate degree.

Students are required to take an additional thirty credit hours for the M.S. degree. Up to nine of the 30 credit hours beyond the undergraduate degree requirements can be 400-level courses. The remainder of the courses will be at the graduate level (500-level and above). The

Mechanical Engineering Graduate Bulletin provides detail into the graduate program and includes specific instructions regarding required and elective courses. Students may switch from the combined program, which includes a non-thesis Master of Science degree to a M.S. degree with a thesis option; however, if students change degree programs they must satisfy all degree requirements for the M.S. with thesis degree.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Mechanical Engineering Areas of Special Interest (ASI) and Minor Programs

General Requirements

The Mechanical Engineering Department offers minor and ASI programs. Students who elect an ASI or minor, must fulfill all prerequisite requirements for each course in a chosen sequence. Students in the sciences or mathematics must be prepared to meet prerequisite requirements in fundamental engineering and engineering science courses. Students in engineering disciplines are better positioned to meet the prerequisite requirements for courses in the minor and ASI Mechanical Engineering program. (See Minor/ASI section of the Bulletin for all requirements for a minor/ASI at CSM.)

For an Area of Special Interest in Mechanical Engineering, the student must complete a minimum of 12 hours from the following:

MEGN212	INTRODUCTION TO SOLID MECHANICS	3.0
MEGN315	DYNAMICS	3.0
MEGN351	FLUID MECHANICS	3.0
MEGN361	THERMODYNAMICS I	3.0

For a Minor in Mechanical Engineering, the student must complete a minimum of 18 hours from the following:

1. Required Courses (choose three, 9 credit hours)		
MEGN212	INTRODUCTION TO SOLID MECHANICS	3.0
MEGN315	DYNAMICS	3.0
MEGN351	FLUID MECHANICS	3.0
MEGN361	THERMODYNAMICS I	3.0
2. Tracks (choose one track):		
Robotics, Automation & Design Track (10 credit hours)		
MEGN324	INTRODUCTION TO FINITE ELEMENT ANALYSIS	3.0
MEGN481	MACHINE DESIGN	3.0
MEGN381	MANUFACTURING PROCESSES	3.0
or MEGN441	INTRODUCTION TO ROBOTICS	
or MEGN416	ENGINEERING VIBRATION	
or MEGN485	MANUFACTURING OPTIMIZATION WITH NETWORK MODELS	
Solid Materials Track (9 credit hours)		
MEGN324	INTRODUCTION TO FINITE ELEMENT ANALYSIS	3.0
MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
MEGN416	ENGINEERING VIBRATION	3.0
Thermal-Fluids Track (9 credit hours)		
MEGN451	FLUID MECHANICS II - AERODYNAMICS	3.0
MEGN461	THERMODYNAMICS II	3.0
MEGN471	HEAT TRANSFER	3.0

Biomechanical Engineering Minor

General Requirements

To obtain a Biomechanical Engineering Minor, students must take at least 18.0 credits from the courses listed below. Fundamentals of Biology I (CBEN110) and Introduction to Biomechanical Engineering (MEGN330) are required (7.0 credits). Three more courses may be chosen from the proposed list of electives. The list of electives will be modified as new related courses become available.

Required Courses (11.0 credits)

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0

Biomechanical Engineering Elective Courses

MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
MEGN435	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0
or MEGN535	MODELING AND SIMULATION OF HUMAN MOVEMENT	
MEGN436	COMPUTATIONAL BIOMECHANICS	3.0
or MEGN536	COMPUTATIONAL BIOMECHANICS	
MEGN531	PROSTHETIC AND IMPLANT ENGINEERING	3.0
MEGN532	EXPERIMENTAL METHODS IN BIOMECHANICS	3.0
MEGN537	PROBABILISTIC BIOMECHANICS	3.0
MEGN553	INTRODUCTION TO COMPUTATIONAL TECHNIQUES FOR FLUID DYNAMICS AND TRANSPORT PHENOMENA	3.0
MEGN x98, x99	SPECIAL TOPICS *	3.0
MTGN472	BIOMATERIALS I	3.0
or MTGN572	BIOMATERIALS	
MTGN570	BIOCOMPATIBILITY OF MATERIALS	3.0
CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0
CBEN306	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN	3.0
CBEN309	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN LABORATORY	1.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN454	APPLIED BIOINFORMATICS	3.0
or CBEN554	APPLIED BIOINFORMATICS	
PHGN433	BIOPHYSICS	3.0
CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0

* As the content of these courses varies, the course must be noted as relevant to the biomechanical engineering minor.

Minor and ASI in Advanced Manufacturing

The interdisciplinary Advanced Manufacturing program will prepare undergraduates to meet the challenges of careers in advanced manufacturing. Undergraduate students have the following degree options:

- Area of Special Interest (12 credit hours)
  - Requirements: AMFG401 and 9 credit hours of electives (see Table 1)
- Minor (18 credit hours)
  - Requirements: AMFG401 and one other core course to be determined and 12 credit hours of electives (see Table 1)

Table 1: Undergraduate elective courses, listed by specialty area (AMFG531, AMFG 511 and FEGN 526 require approval by appropriate program directors)

Additive Manufacturing of Structural Materials		
MEGN381	MANUFACTURING PROCESSES	3.0
MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
AMFG421	DESIGN FOR ADDITIVE MANUFACTURING	3.0
AMFG531	MATERIALS FOR ADDITIVE MANUFACTURING	3.0
AMFG498	SPECIAL TOPICS IN ADVANCED MANUFACTURING	1-6
AMFG511	DATA DRIVEN ADVANCED MANUFACTURING	3.0
FEGN525	ADVANCED FEA THEORY & PRACTICE	3.0
FEGN526	STATIC AND DYNAMIC APPLICATIONS IN FEA	3.0

Aerospace Engineering Minor

The Aerospace Engineering minor includes six required courses listed below. Four of the courses currently exist in the mechanical engineering curriculum, and two are new courses. Courses in this minor, some developed in conjunction with industry, will help prepare Mines students for a career in aerospace industries.

MEGN408	INTRODUCTION TO SPACE EXPLORATION	3.0
MEGN413	AEROSPACE STRUCTURES	3.0
MEGN414	MECHANICS OF COMPOSITE MATERIALS	3.0
MEGN451	FLUID MECHANICS II - AERODYNAMICS	3.0
MEGN498	AEROSPACE SYSTEMS ENGINEERING	3.0
MEGN498	SPACE OPERATIONS	3.0
Total Semester Hrs		**18.0**

ASI in Aerospace Engineering

For an Area of Special Interest in Aerospace Engineering, the student must complete a minimum of 12 credit hours from the following:

MEGN451	FLUID MECHANICS II - AERODYNAMICS	3.0
MEGN471	HEAT TRANSFER	3.0
MEGN414	MECHANICS OF COMPOSITE MATERIALS	3.0
MEGN4XX	AEROSPACE STRUCTURES	3.0

Courses

MEGN200. INTRODUCTION TO MECHANICAL ENGINEERING: PROGRAMMING AND HARDWARE INTERFACE. 3.0 Semester Hrs.
Equivalent with LAIS200,
This course introduces programming skills using Matlab as a means to collect and analyze data and utilizes Arduinos as a platform for prototyping circuits and designs. This course reinforces the engineering design process through problem definition and identifying constraints and criteria, encouraging multiple solutions, and introducing analysis in design through prototyping. Prerequisite: EDNS151 or EDNS155 or HNRS105 or HNRS115, CSCI101, CSCI102.

MEGN201. INTRODUCTION TO MECHANICAL ENGINEERING: DESIGN & FABRICATION. 3.0 Semester Hrs.
(I, II, S) This course reinforces basic drawing skills from Cornerstone Design, introduces SolidWorks tools to advance modeling skills, introduces machine shop skills (including safety and use of mill, lathe and CNC) and introduces GDnT practices important in fabrication and manufacturing, and prob-stats relevant to manufacturing. 3 hours lecture; 3 semester hours. Prerequisite: EDNS151 or EDNS155.

MEGN212. INTRODUCTION TO SOLID MECHANICS. 3.0 Semester Hrs.
Equivalent with MEGN312,
This course introduces students to the principles of Solid Mechanics. Upon completion, students will be able to apply Solid Mechanics theories to analyze and design machine elements and structures using isotropic materials. The skills and knowledge learned in this course form the required foundation for Intro to Finite Element Analysis, Advanced Mechanics of Material, Machine Design and other advanced topics in engineering curricula. Practically, it enables students to solve real-world mechanical behavior problems that involve structural materials. This courses places an early focus on ensuring students have mastered the creation of free body diagrams given a mechanical system, then moves on to introduce and reinforce learning of stress and strain transformations, and failure theories. In practicing this knowledge, students will be able to analyze and design machine elements and structures of homogenous and heterogeneous geometries under axial, torsional, bending, transverse shear, internal pressure loads, and non-uniform loads. Students will be able to quantitatively communicate the outcomes. May not also receive credit for CEEN311. Prerequisite: CEEN241 (C- or better).

MEGN298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MEGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MEGN300. INSTRUMENTATION & AUTOMATION. 3.0 Semester Hrs.
This course will explore instrumentation and automation of electro-mechanical systems. Students will utilize LabView and electro-mechanical instrumentation to solve advanced engineering problems. Class activities and projects will highlight the utility of LabView for real-time instrumentation and control. Prerequisite: MEGN200 (C- or better), MEGN201 (C- or better).

MEGN301. MECHANICAL INTEGRATION & DESIGN. 2.0 Semester Hrs.
Students will utilize the engineering design process and knowledge in systems level design to produce a mechanical product/process. Students will reverse engineer a product/process to emphasize the steps in the design process. Students will select a longer course project, which is intended to reinforce engineering skills from other courses. The project topics would parallel one of the four research disciplines in ME, and students would be able to choose a topic pathway that emphasizes opportunities for mechanical engineering graduates. Prerequisite: MEGN200 (C- or better), MEGN201 (C- or better), MEGN300 (C- or better).

MEGN315. DYNAMICS. 3.0 Semester Hrs.
This course will cover particle kinematics (including 2-D motion in x-y coordinates, normal-tangential coordinates, & polar coordinates), rigid body kinematics (Including relative velocities and accelerations), rigid body kinetics (including the equation of motion, work and energy, linear impulse-momentum, & angular momentum), and introduction to vibrations. Prerequisite: CEEN241 (C- or better) and MATH225 (C- or better). Co-requisite: MATH307 (only required for Mechanical Engineering Majors).

MEGN324. INTRODUCTION TO FINITE ELEMENT ANALYSIS. 3.0 Semester Hrs.
This course aims to teach basic proficiency with Finite Element Analysis (FEA), which is the most widely used computer aided engineering tool in industry, academia, and government. Fundamentals of FEA theory are introduced, but the majority of the course is spent learning practical skills with commercial FEA software. Students will work interactively with the instructor and with their peers to complete hands-on FEA examples based primarily on problems in structural mechanics. Applications of FEA for heat conduction, natural frequency analysis, and design optimization are covered briefly. The course will conclude with a mini project on which students use FEA skills for engineering analysis and design. The importance of verification and validation (V&V) for critical evaluation of FEA predictions is emphasized, and students will make frequent use of statics and solid mechanics principles to corroborate their FEA results. Prerequisite: MEGN212 (C- or better) or CEEN311 (C- or better).

MEGN330. INTRODUCTION TO BIOMECHANICAL ENGINEERING. 3.0 Semester Hrs.
(I) The application of mechanical engineering principles and techniques to the human body presents many unique challenges. The discipline of Biomedical Engineering (more specifically, Biomechanical Engineering) has evolved over the past 50 years to address these challenges. Biomechanical Engineering includes such areas as biomechanics, biomaterials, bioinstrumentation, medical imaging, and rehabilitation. This course is intended to provide an introduction to, and overview of, Biomechanical Engineering and to prepare the student for more advanced Biomechanical coursework. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply various mechanical engineering principles to the human body. 3 hours lecture; 3 semester hours. Prerequisite: CEEN311 and PHGN200. Co-requisite: MEGN315.

MEGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I,II,S) Supervised, full-time engineering related employment for a continuous six-month period in which specific educational objectives are achieved. Students must meet with the Department Head prior to enrolling to clarify the educational objectives for their individual Co-op program. Prerequisites: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 3 semester hours credit will be granted once toward degree requirements. Credit earned in MEGN340, Cooperative Education, may be used as free elective credit hours if, in the judgment of the Department Head, the required term paper adequately documents the fact that the work experience entailed high-quality application of engineering principles and practice. Applying the credits as free electives requires the student to submit a Declaration of Intent to Request Approval to Apply Co-op Credit toward Graduation Requirements form obtained from the Career Center to the Department Head.

MEGN351. FLUID MECHANICS. 3.0 Semester Hrs.
This course wil cover principles of fluid properties, fluid statics, control-volume analysis, Bernoulli equation, differential analysis and Navier-Stokes equations, dimensional analysis, internal flow, external flow, open-channel flow, and turbomachinery. May not also receive credit for CEEN310 or PEGN251. Prerequisite: CEEN241 (C- or better) or MNGN317 (C- or better).

MEGN361. THERMODYNAMICS I. 3.0 Semester Hrs.
This course is a comprehensive treatment of thermodynamics from a mechanical engineering point of view. Topics include: Thermodynamic properties of substances inclusive of phase diagrams, equations of state, internal energy, enthalpy, entropy, and ideal gases; principles of conservation of mass and energy for steady-state and transient analyses; First and Second Law of thermodynamics, heat engines, and thermodynamic efficiencies; Application of fundamental principles with an emphasis on refrigeration and power cycles. May not also receive credit for CBEN210. Prerequisite: MATH213 (C- or better).

MEGN381. MANUFACTURING PROCESSES. 3.0 Semester Hrs.
Equivalent with MEGN380,
Manufacturing Processes is a survey course, that introduces a wide variety of traditional and advanced manufacturing processes with emphasis on process selection and hands-on experiences. Students are expected to have basic knowledge in material science, basic machining and GD&T before entering the class. Throughout the course students analyze the relationships between material properties, process variables and product functionality. Students design and evaluate processes for identifying value while eliminating waste using learned skill-sets including lean methodologies, six-sigma and statistical process control. Quality, cost, standards and ethics related to manufacturing are discussed throughout the semester. Prerequisite: MEGN201 and MTGN202.

MEGN391. AUTOMOTIVE DESIGN: SAE COLLEGIATE DESIGN SERIES (FORMULA SAE). 3.0 Semester Hrs.
This course introduces students to automotive design and fabrication. Students will design, fabricate, test, and analyze a formula style race car for the Formula SAE Collegiate Design Series international competition. Provide engineering students an opportunity to develop engineering skills beyond the classroom in a team oriented, competitive, and hands-on environment. Students will learn about a broad range of automobile design topics to include vehicle dynamics, propulsion, chassis design, electrical systems and aerodynamic devices. Both theoretical and hands-on skills will be exercised. Additionally, students will learn basic mechanical drawing, analysis and fabrication skills. Special emphasis will be placed on workplace safety, teamwork and peer leadership. Finally, students will gain experience in program management to include budgeting, resource management, scheduling and solving real world open-ended problems. Prerequisite: MEGN200.

MEGN398. SPECIAL TOPICS IN MECHANICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MEGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MEGN408. INTRODUCTION TO SPACE EXPLORATION. 3.0 Semester Hrs.
Overview of extraterrestrial applications of science and engineering by covering all facets of human and robotic space exploration, including its history, current status, and future opportunities in the aerospace and planetary science fields. Subtopics include: the space environment, space transportation systems, destinations (Low-Earth orbit, Moon, Mars, asteroids, other planets), current research, missions, and projects, the international and commercial perspectives, and discussion of potential career opportunities. This seminar style class is taught by CSM faculty, engineers and scientists from space agencies and research organizations, aerospace industry experts, and visionaries and entrepreneurs of the private space commerce sector.

MEGN412. ADVANCED MECHANICS OF MATERIALS. 3.0 Semester Hrs.
This Advanced Mechanics of Materials course builds upon the learning outcomes of the pre-requisite Mechanics of Materials (Solid Mechanics) course to teach students the fundamentals of elastic deformations. Introduction to energy methods, strain and stress transformations, constitutive relations for isotropic and orthotropic materials, and to fracture mechanics is realized through theory development, application examples, and numerical solutions. Knowledge from this course will enable students to work on variety of engineering applications in Mechanical, Materials, Aerospace, Civil and related engineering fields. Prerequisite: MEGN212 (C- or better) or CEEN311 (C- or better).

MEGN414. MECHANICS OF COMPOSITE MATERIALS. 3.0 Semester Hrs.
Introductory course on the mechanics of fiber-reinforced composite materials. The focus of the course is on the determination of stress and strain in a fiber-reinforced composite material with an emphasis on analysis, design, failure by strength-based criteria, and fracture of composites. Anisotropic materials are discussed from a general perspective then the theory is specialized to the analysis of fiber-reinforced materials. Both thermal and hygroscopic sources of strain are introduced. Classical laminated plate theory is next developed, and design of laminated composite structures is introduced. The analysis of helically reinforced composite tubes concludes the course. Prerequisite: MEGN212 (C- or better).

MEGN416. ENGINEERING VIBRATION. 3.0 Semester Hrs.
This course introduces linear theory of mechanical vibrations as applied to single- and multi-degree-of-freedom systems. Specifically, students learn to analyze and measure free and forced vibrations of spring-mass-damper systems in response to different types of loading including harmonic, impulse, and general transient loading. Force balance and energy methods are introduced as means to create models of vibrating mechanical components. Ultimately, students learn to apply these theories to design vibration isolators and dampers for machines subject to translational and rotational vibrations, including machines with rotating unbalances and two or more vibrating masses. Prerequisite: MEGN315 (C- or better).

MEGN417. VEHICLE DYNAMICS & POWERTRAIN SYSTEMS. 3.0 Semester Hrs.
This course offers an introduction to automotive engineering with a focus on vehicle design, suspension, powertrain and aerodynamics. The course is designed to introduce students to both theoretical and practical concepts of vehicle design with applications in increasing fuel efficiency and vehicle performance. The study of automotive engineering is of increasing importance as new technologies emerge and advances continue to be made to existing designs to create the ultimate driving experience; while having minimal impact on the environment by reducing tailpipe gas emissions, noise pollution, and waste material during manufacturing of new vehicles. Prerequisite: MEGN315, MEGN324, MEGN361.

MEGN430. MUSCULOSKELETAL BIOMECHANICS. 3.0 Semester Hrs.
(II) This course is intended to provide mechanical engineering students with a second course in musculoskeletal biomechanics. At the end of the semester, students should have in-depth knowledge and understanding necessary to apply mechanical engineering principles such as statics, dynamics, and mechanics of materials to the human body. The course will focus on the biomechanics of injury since understanding injury will require developing an understanding of normal biomechanics. 3 hours lecture; 3 semester hours. Prerequisite: MEGN330 (C- or better).

MEGN435. MODELING AND SIMULATION OF HUMAN MOVEMENT. 3.0 Semester Hrs.
Introduction to modeling and simulation in biomechanics. The course includes a synthesis of musculoskeletal properties, interactions with the environment, and computational optimization to construct detailed computer models and simulations of human movement. Prerequisite: MEGN315, MEGN330.

MEGN436. COMPUTATIONAL BIOMECHANICS. 3.0 Semester Hrs.
Computational Biomechanics provides an introduction to the application of computer simulation to solve fundamental problems in biomechanics and bioengineering. Musculoskeletal biomechanics, joint kinematics, medical image reconstruction, hard and soft tissue modeling, and medical device design are considered in the context of a semester-long project to develop and evaluate an artificial knee implant. Leading commercial software tools are introduced with hands-on exercises. An emphasis is placed on understanding the limitations of the computer model as a predictive tool and the need for rigorous verification and validation of all modeling tasks. Clinical application of biomechanical modeling tools is highlighted and impact on patient quality of life is discussed. Prerequisite: MEGN324, MEGN330.

MEGN441. INTRODUCTION TO ROBOTICS. 3.0 Semester Hrs.
(I, II) Overview and introduction to the science and engineering of intelligent mobile robotics and robotic manipulators. Covers guidance and force sensing, perception of the environment around a mobile vehicle, reasoning about the environment to identify obstacles and guidance path features and adaptively controlling and monitoring the vehicle health. A lesser emphasis is placed on robot manipulator kinematics, dynamics, and force and tactile sensing. Surveys manipulator and intelligent mobile robotics research and development. Introduces principles and concepts of guidance, position, and force sensing; vision data processing; basic path and trajectory planning algorithms; and force and position control. EENG307 is recommended to be completed before this course. Prerequisites: CSCI261 and EENG281 or EENG282 or PHGN215. 2 hours lecture; 3 hours lab; 3 semester hours.

MEGN451. FLUID MECHANICS II - AERODYNAMICS. 3.0 Semester Hrs.
Review of elementary fluid mechanics and engineering; Two-dimensional external flows, boundary layers, and flow separation; Gas dynamics and compressible flow: Isentropic flow, normal and oblique shocks, rocket propulsion, Prandtl-Meyer expansion fans; Application of computational fluid dynamics. Prerequisite: MEGN351(C- or better).

MEGN461. THERMODYNAMICS II. 3.0 Semester Hrs.
This course extends the subject matter of Thermodynamics I (MEGN361) to include the study of exergy, ideal gas mixture properties, psychrometrics and humid air processes, chemical reactions, and the 1st, 2nd and 3rd Laws of Thermodynamics as applied to reacting systems. Chemical equilibrium of multi-component systems, and simultaneous chemical reactions of real combustion and reaction processes are studied. Concepts of the above are explored through the analysis of advanced thermodynamic systems. 3 hours lecture; 3 semester hours. Prerequisite: MEGN351 (C- or better), MEGN361 (C- or better).

MEGN466. INTRODUCTION TO INTERNAL COMBUSTION ENGINES. 3.0 Semester Hrs.
Introduction to Internal Combustion Engines (ICEs); with a specific focus on Compression Ignition (CI) and Spark Ignition (SI) reciprocating engines. This is an applied thermo science course designed to introduce students to the fundamentals of both 4-stroke and 2-stroke reciprocating engines ranging in size from model airplane engines to large cargo ship engines. Course is designed as a one-semester course for students without prior experience with IC engines, however, the course will also include advanced engine technologies designed to deliver more horsepower, utilize less fuel, and meet stringent emission regulations. Discussion of advancements in alternative fueled engines will be covered as well. This course also includes an engine laboratory designed to provide hands-on experience and provide further insight into the material covered in the lectures. Prerequisite: MEGN351, MEGN361. Co-requisite: MEGN471.

MEGN467. PRINCIPLES OF BUILDING SCIENCE. 3.0 Semester Hrs.
This course covers the fundamentals of building heating, ventilation, and air conditioning (HVAC) systems and the use of numerical heat and moisture transfer models to analyze or design different building envelope and HVAC systems. Prerequisite: MEGN351, MEGN361. Co-requisite: MEGN471.

MEGN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.
Equivalent with CBEN469,MTGN469,
(I) Investigate fundamentals of fuel-cell operation and electrochemistry from a chemical-thermodynamics and materials- science perspective. Review types of fuel cells, fuel-processing requirements and approaches, and fuel-cell system integration. Examine current topics in fuel-cell science and technology. Fabricate and test operational fuel cells in the Colorado Fuel Cell Center. Prerequisites: MEGN361 or CBEN357 or MTGN351. 3 hours lecture; 3 semester hours.

MEGN471. HEAT TRANSFER. 3.0 Semester Hrs.
(I, II) Engineering approach to conduction, convection, and radiation, including steadystate conduction, nonsteady-state conduction, internal heat generation conduction in one, two, and three dimensions, and combined conduction and convection. Free and forced convection including laminar and turbulent flow, internal and external flow. Radiation of black and grey surfaces, shape factors and electrical equivalence. Prerequisite: MEGN351 (C- or better), MEGN361 (C- or better), and MATH307. 3 hours lecture; 3 semester hours.

MEGN481. MACHINE DESIGN. 3.0 Semester Hrs.
(I, II) In this course, students develop their knowledge of machine components and materials for the purpose of effective and efficient mechanical design. Emphasis is placed on developing analytical methods and tools that aid the decision making process. The course focuses on determination of stress, strain, and deflection for static, static multiaxial, impact, dynamic, and dynamic multiaxial loading. Students will learn about fatigue failure in mechanical design and calculate how long mechanical components are expected to last. Specific machine components covered include shafts, springs, gears, fasteners, and bearings. 3 hours lecture; 3 semester hours. Prerequisite: MEGN315 (C- or better) or PHGN350 (C- or better), and MEGN324 (C- or better).

MEGN485. MANUFACTURING OPTIMIZATION WITH NETWORK MODELS. 3.0 Semester Hrs.
Equivalent with EBGN456,
(I) We examine network flow models that arise in manufacturing, energy, mining, transportation and logistics: minimum cost flow models in transportation, shortest path problems in assigning inspection effort on a manufacturing line, and maximum flow models to allocate machine-hours to jobs. We also discuss an algorithm or two applicable to each problem class. Computer use for modeling (in a language such as AMPL) and solving (with software such as CPLEX) these optimization problems is introduced. Prerequisites: MATH111. 3 hours lecture; 3 semester hours.

MEGN486. LINEAR OPTIMIZATION. 3.0 Semester Hrs.
(I) This course addresses the formulation of linear programming models, linear programs in two dimensions, standard form, the Simplex method, duality theory, complementary slackness conditions, sensitivity analysis, and multi-objective programming. Applications of linear programming models include, but are not limited to, the areas of manufacturing, energy, mining, transportation and logistics, and the military. Computer use for modeling (in a language such as AMPL) and solving (with software such as CPLEX) these optimization problems is introduced. Offered every other year. Prerequisite: MATH332 or EBGN509. 3 hours lecture; 3 semester hours.

MEGN487. NONLINEAR OPTIMIZATION. 3.0 Semester Hrs.
Equivalent with MEGN587,
(I) This course addresses both unconstrained and constrained nonlinear model formulation and corresponding algorithms (e.g., Gradient Search and Newton?s Method, and Lagrange Multiplier Methods and Reduced Gradient Algorithms, respectively). Applications of state-of-the-art hardware and software will emphasize solving real-world engineering problems in areas such as manufacturing, energy, mining, transportation and logistics, and the military. Computer use for modeling (in a language such as AMPL) and solving (with an algorithm such as MINOS) these optimization problems is introduced. Offered every other year. Prerequisite: MATH111. 3 hours lecture; 3 semester hours.

MEGN488. INTEGER OPTIMIZATION. 3.0 Semester Hrs.
Equivalent with MEGN588,
(I) This course addresses the formulation of integer programming models, the branch-and-bound algorithm, total unimodularity and the ease with which these models are solved, and then suggest methods to increase tractability, including cuts, strong formulations, and decomposition techniques, e.g., Lagrangian relaxation, Benders decomposition. Applications include manufacturing, energy, mining, transportation and logistics, and the military. Computer use for modeling (in a language such as AMPL) and solving (with software such as CPLEX) these optimization problems is introduced. Offered every other year. Prerequisite: MATH111. 3 hours lecture; 3 semester hours.

MEGN498. SPECIAL TOPICS IN MECHANICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MEGN499. INDEPENDENT STUDY. 1-6 Semester Hr.
Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Note that MEGN499 does not count as an MEGN Teachnical Elective, though the course does count as a Free Elective. Prerequisite: Independent Study form must be completed and submitted to the Registrar.

Professor and Department Head

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Professors

Robert Braun, Rowlinson Professor of Mechanical Engineering

Cristian Ciobanu

Greg Jackson

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Alexandra Newman

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Associate professors

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Assistant professors

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Emeriti Professors

Joan Gosink

Robert King

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Emeriti Associate Professor

David Munoz

John Steele

Research Associate Professors

Sandrine Ricote

Huayang Zhu

Research Assistant Professors

Behnam Aminahmedi

Seongmook Cho

Carolina Herradon Hernandez

Garrison Hommer

Stelios Koumlis

Amy Schweikert

Metallurgical and Materials Engineering

Program Description

Metallurgical and Materials Engineering plays a role in all manufacturing processes which convert raw materials into useful products adapted to human needs. The primary goal of the Metallurgical and Materials Engineering program is to provide undergraduates with a fundamental knowledge base associated with materials-processing, their properties, and their selection and application. Upon graduation, students will have the necessary background and skills for successful careers in materials related industries; or for pursuit of graduate education in materials research and technology development and related fields.

The emphasis in the Department is on materials design and processing, which encompass: the conversion of mineral and chemical resources into metallic and ceramic/semiconducting materials; the engineering and synthesis of new materials; refining and processing to produce high performance materials for applications from consumer products to aerospace and electronics; the characterization and modification through processing of mechanical, chemical and physical properties of materials; and the selection of materials for specific applications.

The metallurgical and materials engineering discipline is founded on fundamentals in chemistry, mathematics and physics. These underlie the knowledge base and the skills for the processing of materials so as to achieve superior performance in application and enabling of new technologies. The engineering principles in this discipline include: crystal structure and structural analysis, thermodynamics of materials, reaction kinetics, transport phenomena, phase equilibria, phase transformations, microstructural evolution, mechanical behavior, and how the electronic and physical properties of materials can be designed and optimized.

The core-discipline fundamentals are applied to a broad range of materials processes including extraction and refining of materials, alloy development, casting, mechanical working, joining and forming, ceramic particle processing, sintering, high temperature reactions, and synthesis of engineered materials. The relationship of microchemistries, microstructures, and controlled defect structures or their elimination on materials properties and performance in all types of applications are emphasized.

The Metallurgical and Materials Engineering Undergraduate Program places particular emphasis on hands-on experimental work in addition to classroom learning. Laboratories, located in Nathaniel Hill Hall, are among the finest in the nation and are being continuously upgraded to support more relevant and advanced learning by students. The laboratories combined with classroom instruction, provide for a well-integrated education of the undergraduates. These facilities are well equipped and dedicated to: particulate and chemical/extraction, metallurgical and materials processing, corrosion and hydro/electro-metallurgical studies, physical and mechanical metallurgy, welding and joining, forming, processing and testing of ceramic materials. Mechanical testing facilities include computerized machines for tension, compression, torsion, toughness, fatigue and thermo-mechanical testing. In particular the “Hot Shop” has been established with professional supervision, providing opportunities for hands-on creation of items using our foundry, forging, welding, and glass facilities. These are available both for class-related and general access and are used by our bladesmithing, glass blowing, and other activities such as senior design projects.

Undergraduate students are encouraged to become involved in faculty research as opportunities permit. Such research is intended to be equivalent to graduate-level work and can make use of our advanced characterization facilities. These include: vapor deposition, and both plasma and high-temperature reaction systems; analytical laboratories for microstructural and microchemical analysis using techniques such as electron microscopy and various spectroscopies.

The Metallurgical and Materials Engineering undergraduate degree is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Metallurgical and Materials Engineering (MME) Program Educational Objectives

The Metallurgical and Materials Engineering (MME) program emphasizes the structure, properties, processing and performance of materials. Program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. The Metallurgical and Materials Engineering program at Mines prepares graduates who:

1. obtain a range of positions in industry or positions in government facilities or pursue graduate education in engineering, science, or other fields;
2. demonstrate advancement in their chosen careers;
3. engage in appropriate professional societies and continuing education activities.

The three MME program educational objectives were determined by using inputs from program constituencies (faculty, students, visiting committee, industry recruiters and alumni). These objectives are consistent with those of the Colorado School of Mines. Mines is an engineering and applied science institution, dedicated to the education and training of students who will be stewards of the earth's resources.

Curriculum

The Metallurgical and Materials Engineering (MME) curriculum is organized to educate students in the fundamentals of materials (MME Basics) and their applications (MME Applications) with the option of pursuing a track in one of four focus areas.

A. MME Basics: The basic curriculum in the Metallurgical and Materials Engineering program will provide a background in the following topic areas:

1. Crystal Structures and Structural Analysis: crystal systems; symmetry elements and Miller indices; atomic bonding; metallic, ceramic and polymeric structures; x-ray and electron diffraction; stereographic projection and crystal orientation; long range order; defects in materials.
2. Thermodynamics of Materials: heat and mass balances; thermodynamic laws; chemical potential and chemical equilibrium; solution thermodynamics & solution models; partial molar and excess quantities; solid state thermodynamics; thermodynamics of surfaces; electrochemistry.
3. Transport Phenomena and Kinetics: Heat, mass and momentum transport; transport properties of fluids; diffusion mechanisms; reaction kinetics; nucleation and growth kinetics.
4. Phase Equilibria: phase rule; binary and ternary systems; microstructural evolution; defects in crystals; surface phenomena; phase transformations: eutectic, eutectoid, martensitic, nucleation

and growth, recovery; microstructural evolution; strengthening mechanisms; quantitative stereology; heat treatment.

5. Properties of Materials: mechanical properties; chemical properties (oxidation and corrosion); electrical, magnetic and optical properties: failure analysis.

B. MME Applications: The course content in the Metallurgical and Materials Engineering program emphasizes the following applications:

1. Materials Processing: particulate processing; thermo- and electro-chemical materials processing; hydrometallurgical processing; synthesis of materials; deformation processing; solidification and casting; welding and joining.
2. Design and Application of Materials: materials selection; ferrous and nonferrous metals; ceramics; polymers; composites; electronic materials.
3. Statistical Process Control and Design of Experiments: statistical process control; process capability analysis; design of experiments.

C. MME Curriculum Requirements: The Metallurgical and Materials Engineering course sequence is designed to fulfill the program goals and to satisfy the curriculum requirements. The time sequence of courses organized by degree program, year and semester, is listed below.

Degree Requirements (Bachelor of Science in Metallurgical and Materials Engineering)

Freshman

Fall		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
EDNS151	DESIGN I			3.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS, GEGN 101, or CBEN 110			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Spring		lec	lab	sem.hrs
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Summer		lec	lab	sem.hrs
MTGN272	MME FIELD SESSION			3.0
				3.0

Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
MTGN202	ENGINEERED MATERIALS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
HASS200	GLOBAL STUDIES			3.0
MTGN251	METALLURGICAL AND MATERIALS THERMODYNAMICS			3.0
				18.0

Spring		lec	lab	sem.hrs
MATH225	DIFFERENTIAL EQUATIONS			3.0
CEEN241	STATICS			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
MTGN211	STRUCTURE OF MATERIALS			3.0
MTGN281	INTRODUCTION TO PHASE EQUILIBRIA IN MATERIALS SYSTEMS			2.0
EDNS263	DESIGN II: MATERIALS, 251, 261, 262, 263, 264, CEEN 267, or EDNS 269			3.0
				17.5

Junior

Fall		lec	lab	sem.hrs
CEEN311	MECHANICS OF MATERIALS			3.0
MTGN352	METALLURGICAL AND MATERIALS KINETICS			3.0
TECH ELECT	Restricted Technical Elective**			3.0
MTGN314	PROPERTIES AND PROCESSING OF CERAMICS			2.0
MTGN314L	PROPERTIES AND PROCESSING OF CERAMICS LABORATORY			1.0
MTGN350	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS			3.0
				15.0

Spring		lec	lab	sem.hrs
MTGN334	CHEMICAL PROCESSING OF MATERIALS			3.0
MTGN334L	CHEMICAL PROCESSING OF MATERIALS LABORATORY			1.0
MTGN348	MICROSTRUCTURAL DEVELOPMENT			3.0
MTGN348L	MICROSTRUCTURAL DEVELOPMENT LABORATORY			1.0
FREE	Free Elective			3.0

ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
MTGN315	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS			3.0
				17.0

Senior				
Fall		**lec**	**lab**	**sem.hrs**
MTGN445	MECHANICAL PROPERTIES OF MATERIALS			3.0
MTGN445L	MECHANICAL PROPERTIES OF MATERIALS LABORATORY			1.0
MTGN	MTGN Elective			3.0
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
FREE	Free Elective			3.0
MTGN467	MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION			2.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
MTGN	MTGN Elective			3.0
MTGN	MTGN Elective			3.0
MTGN	MTGN Elective			3.0
FREE	Free Elective			3.0
MTGN468	MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION			2.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective			3.0
				17.0

Total Semester Hrs: 137.5

**** Restricted Technical Electives:**

CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	3.0
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS	3.0
or CBEN210	INTRO TO THERMODYNAMICS	
CHGN221	ORGANIC CHEMISTRY I	3.0
CHGN335	INSTRUMENTAL ANALYSIS	3.0
CHGN336	ANALYTICAL CHEMISTRY	3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	4.0
CSCI261	PROGRAMMING CONCEPTS	3.0
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3.0
ENGY200	INTRODUCTION TO ENERGY	3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH332	LINEAR ALGEBRA	3.0
MATH348	ADVANCED ENGINEERING MATHEMATICS	3.0
PHGN215	ANALOG ELECTRONICS	4.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- MTGN100 through MTGN599 inclusive

Five Year Combined Metallurgical and Materials Engineering Baccalaureate and Master of Engineering in Metallurgical and Materials Engineering, with an Electronic-Materials Emphasis.*

The Departments of Metallurgical and Materials Engineering and Physics collaborate to offer a five-year program designed to meet the needs of the electronics and similar high-tech industries. Students who satisfy the requirements of the program obtain an undergraduate degree in either Engineering Physics or in Metallurgical and Materials Engineering in four years and a Master of Engineering degree in Metallurgical and Materials Engineering at the end of the fifth year. The program is designed to provide a strong background in science fundamentals, as well as specialized training in the materials-science and processing needs of these industries. Thus, the educational objective of the program is to provide students with the specific educational requirements to begin a career in microelectronics and, at the same time, a broad and flexible background necessary to remain competitive in this exciting and rapidly changing industry. The undergraduate electives which satisfy the requirements of the program and an overall curriculum need to be discussed with the student's advisor and approved by the Physics or Metallurgical and Materials Engineering Departments. A Program Mentor in each Department can also provide counseling on the program.

Application for admission to this program should be made during the first semester of the sophomore year (in special cases, later entry may be approved, upon review, by one of the program mentors). Undergraduate students admitted to the program must maintain a 3.0 grade-point average or better. The graduate segment of the program requires a case study report, submitted to the student's graduate advisor. Additional details on the Master of Engineering can be found in the Graduate Degree and Requirements section of the Graduate Bulletin. The case study is started during the student's senior design-project and completed during the year of graduate study. A student admitted to the program is expected to select a graduate advisor, in advance of the graduate-studies final year, and prior to the start of their senior year. The case-study topic is then identified and selected in consultation with the graduate advisor. A formal application, during the senior year, for admission to the graduate

program in Metallurgical and Materials Engineering must be submitted to the Graduate School. Students who have maintained all the standards of the program requirements leading up to this step, can expect to be admitted.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Minor in Metallurgical and Materials Engineering

A minor program in metallurgical and materials engineering consists of a minimum of 18 credit hours of a logical sequence of courses. Students majoring in metallurgical and material engineering are not eligible to earn a minor in the department.

A minor program declaration (available in the Registrar's Office) must be submitted for approval prior to the student's completion of half of the hours proposed to constitute the program. Approvals are required from the department head of metallurgical and materials engineering, the student's advisor, and the department head or division director in the department or division in which the student is enrolled.

Recommended Courses: The following courses are recommended for students seeking to earn a minor in metallurgical and materials engineering:

MTGN202	ENGINEERED MATERIALS	3.0
MTGN311	STRUCTURE OF MATERIALS	3.0
MTGN311L	STRUCTURE OF MATERIALS LABORATORY	1.0
MTGN348	MICROSTRUCTURAL DEVELOPMENT	3.0
MTGN348L	MICROSTRUCTURAL DEVELOPMENT LABORATORY	1.0
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0
MTGN445L	MECHANICAL PROPERTIES OF MATERIALS LABORATORY	1.0
300- or 400- level course in metallurgical and materials engineering		3.0
Total Semester Hrs		**18.0**

Other sequences are permissible to suit the special interests of individual students. These other sequences need to be discussed and approved by the department head in metallurgical and materials engineering.

Courses

MTGN198. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Semester Hr.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: none. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN199. INDEPENDENT STUDY. 1-3 Semester Hr.
(I, II, S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic; Independent Study Form must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

MTGN202. ENGINEERED MATERIALS. 3.0 Semester Hrs.
Equivalent with SYGN202,
(I, II, S) Introduction to the Metallurgical and Materials Engineering paradigm: processing, structure, and properties. The course will relate technologically significant processing procedures to resultant structures. The material structure will be examined to determine its effect upon material properties. Students will study materials engineering methodologies and learn terminology. Prerequisites: CHGN122 or CHGN125, MATH112, and PHGN100. 3 hours lecture; 3 semester hours.

MTGN211. STRUCTURE OF MATERIALS. 3.0 Semester Hrs.
(II) Principles of atomic bonding, crystallography, and amorphous structures. ii) Symmetry relationships to material properties. iii) Atomic structure determination through diffraction techniques. Prerequisite: MTGN202. Corequisite: PHGN200. 3 hours lecture; 3 semester hours.

MTGN219. ART AND SCIENCE OF GLASSBLOWING. 3.5 Semester Hrs.
Explore the science of glass by learning artistic glassblowing. Lectures will cover basic glass network structure, melt processing and viscosity, forming and cold working, as well as optical and mechanical properties. Over the course of the semester, laboratory exercises will train students in basic glassblowing and safe use of a hot glass shop. Students who pass the course with a B or better will be certified to use the Hill Hall hot glass shop during open shop hours. Due to the limited capacity of this course, registration opportunities are determined each semester by a random lottery. Details are announced via the Daily Blast a couple of weeks prior to registration begins.

MTGN251. METALLURGICAL AND MATERIALS THERMODYNAMICS. 3.0 Semester Hrs.
(I) Applications of thermodynamics in extractive and physical metallurgy and materials science. Thermodynamics of solutions including solution models and thermodynamic properties of alloys and slags. Reaction equilibria with examples in alloy systems and slags. Phase stability analysis. Thermodynamic properties of binary alloys in the solid state, defect equilibrium, and interactions. Prerequisites: MATH112, CHGN122 or CHGN125, and PHGN100. 3 hours lecture; 3 semester hours.

MTGN272. MME FIELD SESSION. 3.0 Semester Hrs.
(S) Introduction to the field of Metallurgical and Materials Engineering. Overview of opportunities, expectations, and practices within the MME department and the broader materials community. Introduction to bonding, crystal and grain structure, application space, and Structure-Property-Processing relationships. Laboratory projects and plant visits. Prerequisites: MATH112, PHGN100. 9 hours lab; 3 semester hours.

MTGN281. INTRODUCTION TO PHASE EQUILIBRIA IN MATERIALS SYSTEMS. 2.0 Semester Hrs.
(II) Review of the concepts of chemical equilibrium and derivation of the Gibbs phase rule. Application of the Gibbs phase rule to interpreting one, two and three component phase equilibrium diagrams. Application to alloy and ceramic materials systems. Emphasis on the evolution of phases and their amounts and the resulting microstructural development. Prerequisites: MTGN202, and MTGN251 or MTGN351. 2 hours lecture; 2 semester hours.

MTGN298. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 3.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: none. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN298. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 3.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: none. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN299. INDEPENDENT STUDY. 1-3 Semester Hr.
(I, II, S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic; Independent Study Form must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

MTGN300. FOUNDRY METALLURGY. 2.0 Semester Hrs.
(II) Design and metallurgical aspects of casting, patterns, molding materials and processes, solidification processes, risers and gating concepts, casting defects and inspection, melting practice, cast alloy selection. Corequisite: MTGN300L. 2 hours lecture; 2 semester hours.

MTGN300L. FOUNDRY METALLURGY LABORATORY. 1.0 Semester Hr.
Equivalent with MTGN302,
(II) Experiments in the foundry designed to supplement the lectures of MTGN300. Corequisite: MTGN300. 3 hours lab; 1 semester hour.

MTGN311. STRUCTURE OF MATERIALS. 3.0 Semester Hrs.
(I) Principles of crystallography and crystal chemistry. Characterization of crystalline materials using X-ray diffraction techniques. Applications to include compound identification, lattice parameter measurement, orientation of single crystals, and crystal structure determination. Prerequisites: PHGN200 and MTGN202. Co-requisite: MTGN311L. 3 hours lecture; 3 semester hours.

MTGN311L. STRUCTURE OF MATERIALS LABORATORY. 1.0 Semester Hr.
(I) (WI) Experiments in structure of materials to supplement the lectures of MTGN311. Co-requisite: MTGN311. 3 hours lab; 1 semester hour.

MTGN314. PROPERTIES AND PROCESSING OF CERAMICS. 2.0 Semester Hrs.
(I) Application of engineering principles and fundamental structure-processing-property relationship to inorganic non-metallic materials. Emergence of macroscopic characteristics and functional properties from bonding, structure, symmetry, and defects. Applications of basic thermodynamic and kinetic principles to powder-based processing. Corequisites: MTGN314L, MTGN202, and MTGN251 or MTGN351. 2 hours lecture; 2 semester hours.

MTGN314L. PROPERTIES AND PROCESSING OF CERAMICS LABORATORY. 1.0 Semester Hr.
(I) Laboratory for MTGN314. Corequisite: MTGN314. 3 hours lab; 1 semester hour.

MTGN315. ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS. 3.0 Semester Hrs.
(II) Survey of the electrical properties of materials, and the applications of materials as electrical circuit components. The effects of chemistry, processing and microstructure on the electrical properties. Functions, performance requirements and testing methods of material for each type of circuit component. General topics covered are conductors, resistors, insulators, capacitors, energy converters, magnetic materials and integrated circuits. Prerequisite: PHGN200. Corequisite: MTGN211 or MTGN311. 3 hours lecture; 3 semester hours.

MTGN333. INTRODUCTION TO BLADESMITHING. 3.0 Semester Hrs.
(I, II, S) An introduction to the metallurgy and art of bladesmithing. The course covers ferrous metallurgy with a focus on tools steels used for creating edged tools. Students will learn and execute techniques for alloy selection, shaping, profiling, beveling, heat treating, and sharpening knives. Students will complete at least two knives, one specified by the instructor, and one of the students own design. Co-requisite: MTGN348 or permission of instructor. 1 hour lecture; 2 hours lab; 3 semester hours.

MTGN334. CHEMICAL PROCESSING OF MATERIALS. 3.0 Semester Hrs.
(II) Development and application of fundamental principles related to the processing of metals and materials by thermochemical and aqueous and fused salt electrochemical/chemical routes. The course material is presented within the framework of a formalism that examines the physical chemistry, thermodynamics, reaction mechanisms and kinetics inherent to a wide selection of chemical processing systems. The general formalism provides for a transferable knowledge-base to other systems not specifically covered in the course. Prerequisites: MTGN272, MTGN351, and CEEN267 or EDNS251 or EDNS261 or EDNS262 or EDNS264 or EDNS269. Corequisite: MTGN334L. 3 hours lecture, 3 semester hours.

MTGN334L. CHEMICAL PROCESSING OF MATERIALS LABORATORY. 1.0 Semester Hr.
(II) Experiments in chemical processing of materials to supplement the lectures of MTGN334. Corequisite: MTGN334. 3 hours lab; 1 semester hour.

MTGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. 1 to 3 semester hours. Cooperative education credit does not count toward graduation except under special conditions. Repeatable.

MTGN348. MICROSTRUCTURAL DEVELOPMENT. 3.0 Semester Hrs.
(II) An introduction to the relationships between microstructure and properties of materials, with emphasis on metallic and ceramic systems; Fundamentals of imperfections in crystalline materials on material behavior; recrystallization and grain growth; strengthening mechanisms: grain refinement, solid solution strengthening, precipitation strengthening, and microstructural strengthening; and phase transformations. Prerequisites: MTGN211 or MTGN311, and MTGN251 or MTGN351. Corequisites: MTGN281 or MTGN381, and MTGN348L. 3 hours lecture, 3 semester hours.

MTGN348L. MICROSTRUCTURAL DEVELOPMENT LABORATORY. 1.0 Semester Hr.
(II) Experiments in microstructural development of materials to supplement the lectures of MTGN348. Corequisite: MTGN348. 3 hours lab; 1 semester hour.

MTGN350. STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS. 3.0 Semester Hrs.
(I) Introduction to statistical process control, process capability analysis and experimental design techniques. Statistical process control theory and techniques developed and applied to control charts for variables and attributes involved in process control and evaluation. Process capability concepts developed and applied to the evaluation of manufacturing processes. Theory of designed experiments developed and applied to full factorial experiments, fractional factorial experiments, screening experiments, multilevel experiments and mixture experiments. Analysis of designed experiments by graphical and statistical techniques. Introduction to computer software for statistical process control and for the design and analysis of experiments. 3 hours lecture, 3 semester hours.

MTGN351. METALLURGICAL AND MATERIALS THERMODYNAMICS. 3.0 Semester Hrs.
(I) Applications of thermodynamics in extractive and physical metallurgy and materials science. Thermodynamics of solutions including solution models, calculation of activities from phase diagrams, and measurements of thermodynamic properties of alloys and slags. Reaction equilibria with examples in alloy systems and slags. Phase stability analysis. Thermodynamic properties of phase diagrams in material systems, defect equilibrium and interactions. Prerequisite: CHGN209 or CBEN210. 3 hours lecture; 3 semester hours.

MTGN352. METALLURGICAL AND MATERIALS KINETICS. 3.0 Semester Hrs.
(I) Introduction to reaction kinetics: chemical kinetics, atomic and molecular diffusion, surface thermodynamics and kinetics of interfaces and nucleation-and-growth. Applications to materials processing and performance aspects associated with gas/solid reactions, precipitation and dissolution behavior, oxidation and corrosion, purification of semiconductors, carburizing of steel, formation of p-n junctions and other important materials systems. Prerequisite: MTGN272. Corequisite: MTGN251 or MTGN351. 3 hours lecture; 3 semester hours.

MTGN381. INTRODUCTION TO PHASE EQUILIBRIA IN MATERIALS SYSTEMS. 2.0 Semester Hrs.
(I) Review of the concepts of chemical equilibrium and derivation of the Gibbs phase rule. Application of the Gibbs phase rule to interpreting one, two and three component phase equilibrium diagrams. Application to alloy and ceramic materials systems. Emphasis on the evolution of phases and their amounts and the resulting microstructural development. Prerequisite/Co-requisite: MTGN351. 2 hours lecture; 2 semester hours.

MTGN398. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Semester Hr.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: none. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN399. INDEPENDENT STUDY. 1-3 Semester Hr.
(I, II, S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic; Independent Study Form must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

MTGN403. SENIOR THESIS. 3.0 Semester Hrs.
(I, II,S) Two-semester individual research under the direction of members of the MME faculty. Work may include library and laboratory research on topics of relevance. Oral presentation will be given at the end of the second semester and written thesis submitted to committee of evaluation. 3 hours research; 3 semester hours.

MTGN407. STEEL BAR MANUFACTURING. 1.0 Semester Hr.
(I) Facilities and metallurgical principles for manufacturing carbon and low alloy steel bars that are further transformed into high performance parts. Discussion of steel melting, ladle refining, casting, hot rolling, heat treatment, final processing, inspection and testing methods. Implications of process design and control on chemical uniformity, macrostructure, microstructure, internal quality, surface quality, mechanical properties and residual stresses. Review of customer processes and requirements for manufacturing parts from bars by hot or cold forging, machining, surface treating, and heat treating. Applications include crankshafts, gears, axles, drive shafts, springs, bearings, rails, line pipe, oil well casing, etc. Prerequisite: MTGN348. 1 hour lecture; 1.0 semester hour.

MTGN412. CERAMIC ENGINEERING. 3.0 Semester Hrs.
(I) Application of engineering principles to nonmetallic and ceramic materials. Processing of raw materials and production of ceramic bodies, glazes, glasses, enamels, and cements. Firing processes and reactions in glass bonded as well as mechanically bonded systems. Prerequisite: MTGN348. 3 hours lecture; 3 semester hours.

MTGN414. ADVANCED PROCESSING AND SINTERING OF CERAMICS. 3.0 Semester Hrs.
(II) Principles of ceramics processing and the relationship between processing and microstructure, with a focus on advanced microstructural control using thermal and athermal energy input in single and multiphase systems. Principles will be illustrated using case studies on specific ceramic materials. A project to design a ceramic fabrication process is required. Prerequisite: MTGN314. 3 hours lecture; 3 semester hours.

MTGN415. ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS. 3.0 Semester Hrs.
(II) Survey of the electrical properties of materials, and the applications of materials as electrical circuit components. The effects of chemistry, processing and microstructure on the electrical properties. Functions, performance requirements and testing methods of materials for each type of circuit component. General topics covered are conductors, resistors, insulators, capacitors, energy converters, magnetic materials and integrated circuits. Prerequisites: PHGN200 and MTGN311. 3 hours lecture; 3 semester hours.

MTGN419. NON-CRYSTALLINE MATERIALS. 3.0 Semester Hrs.
(I, II, S) Introduction to the principles of glass science and engineering and non-crystalline materials in general. Glass formation, structure, crystallization and properties will be covered, along with a survey of commercial glass compositions, manufacturing processes and applications. Prerequisites: MTGN211 or MTGN311, and MTGN412 or MTGN314. 3 hours lecture; 3 semester hours.

MTGN429. METALLURGICAL ENVIRONMENT. 3.0 Semester Hrs.
(I) Examination of the interface between metallurgical process engineering and environmental engineering. Wastes, effluents and their point sources in metallurgical processes such as mineral concentration, value extraction and process metallurgy are studied in context. Fundamentals of metallurgical unit operations and unit processes with those applicable to waste and effluent control, disposal and materials recycling are covered. Engineering design and engineering cost components are also included for selected examples. Fundamentals and applications receive equal coverage. Prerequisites: MTGN334. 3 hours lecture; 3 semester hours.

MTGN430. PHYSICAL CHEMISTRY OF IRON AND STEELMAKING. 3.0 Semester Hrs.
(I, II, S) Physical chemistry principles of blast furnace and direct reduction production of iron and refining of iron to steel. Discussion of raw materials, productivity, impurity removal, deoxidation, alloy additions, and ladle metallurgy. Offered every other year. Prerequisites: MTGN334, and MTGN251 or MTGN351. 3 hours lecture; 3 semester hours.

MTGN431. HYDRO- AND ELECTRO-METALLURGY. 3.0 Semester Hrs.
(I, II, S) Physicochemical principles associated with the extraction and refining of metals by hydro- and electrometallurgical techniques. Discussion of unit processes in hydrometallurgy, electrowinning, and electrorefining. Analysis of integrated flowsheets for the recovery of nonferrous metals. Offered every other year. Prerequisites: MTGN334, MTGN352, and MTGN351 or MTGN251. Corequisite: MTGN461, MTGN461L. 3 hours lecture; 3 semester hours.

MTGN432. PYROMETALLURGY. 3.0 Semester Hrs.
(II) Extraction and refining of metals including emerging practices. Modifications driven by environmental regulations and by energy minimization. Analysis and design of processes and the impact of economic constraints. Prerequisite: MTGN334. 3 hours lecture; 3 semester hours.

MTGN442. ENGINEERING ALLOYS. 3.0 Semester Hrs.
(I, II, S) This course is intended to be an important component of the physical metallurgy sequence, to reinforce and integrate principles from earlier courses, and enhance the breadth and depth of understanding of concepts in a wide variety of alloy systems. Metallic systems considered include iron and steels, copper, aluminum, titanium, superalloys, etc. Phase stability, microstructural evolution and structure/property relationships are emphasized. Offered every other year. Prerequisite: MTGN348. 3 hours lecture; 3 semester hours.

MTGN445. MECHANICAL PROPERTIES OF MATERIALS. 3.0 Semester Hrs.
(I) Mechanical properties and relationships. Plastic deformation of crystalline materials. Relationships of microstructures to mechanical strength. Fracture, creep, and fatigue. Prerequisite: MTGN348. Corequisite: MTGN445L. 3 hours lecture, 3 semester hours.

MTGN445L. MECHANICAL PROPERTIES OF MATERIALS LABORATORY. 1.0 Semester Hr.
(I) Laboratory sessions devoted to advanced mechanical-testing techniques to illustrate the application of the fundamentals presented in the lectures of MTGN445. Corequisite: MTGN445. 3 hours lab; 1 semester hour.

MTGN450. STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS. 3.0 Semester Hrs.
(I) Introduction to statistical process control, process capability analysis and experimental design techniques. Statistical process control theory and techniques developed and applied to control charts for variables and attributes involved in process control and evaluation. Process capability concepts developed and applied to the evaluation of manufacturing processes. Theory of designed experiments developed and applied to full factorial experiments, fractional factorial experiments, screening experiments, multilevel experiments and mixture experiments. Analysis of designed experiments by graphical and statistical techniques. Introduction to computer software for statistical process control and for the design and analysis of experiments. Prerequisite: none. 3 hours lecture, 3 semester hours.

MTGN451. CORROSION ENGINEERING. 3.0 Semester Hrs.
(I, II, S) Principles of electrochemistry. Corrosion mechanisms. Methods of corrosion control including cathodic and anodic protection and coatings. Examples, from various industries, of corrosion problems and solutions. Prerequisite: MTGN251 or MTGN351. 3 hours lecture; 3 semester hours.

MTGN456. ELECTRON MICROSCOPY. 2.0 Semester Hrs.
(I, II, S) Introduction to electron optics and the design and application of transmission and scanning electron microscopes. Interpretation of images produced by various contrast mechanisms. Electron diffraction analysis and the indexing of electron diffraction patterns. Prerequisites: MTGN211 or MTGN311. Corequisite: MTGN456L. 2 hours lecture; 2 semester hours.

MTGN456L. ELECTRON MICROSCOPY LABORATORY. 1.0 Semester Hr.
Equivalent with MTGN458,
(I, II, S) Laboratory exercises to illustrate specimen preparation techniques, microscope operation, and the interpretation of images produced from a variety of specimens, and to supplement the lectures in MTGN456. Corequisite: MTGN456. 3 hours lab; 1 semester hour.

MTGN461. TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS. 3.0 Semester Hrs.
(I) Introduction to the conserved-quantities: momentum, heat, and mass transfer, and application of chemical kinetics to elementary reactor-design. Examples from materials processing and process metallurgy. Molecular transport properties: viscosity, thermal conductivity, and mass diffusivity of materials encountered during processing operations. Uni-directional transport: problem formulation based on the required balance of the conserved- quantity applied to a control-volume. Prediction of velocity, temperature and concentration profiles. Equations of change: continuity, motion, and energy. Transport with two independent variables (unsteady-state behavior). Interphase transport: dimensionless correlations friction factor, heat, and mass transfer coefficients. Elementary concepts of radiation heat-transfer. Flow behavior in packed beds. Design equations for: continuous- flow/batch reactors with uniform dispersion and plug flow reactors. Digital computer methods for the design of metallurgical systems. Prerequisite: MATH225, MTGN334, and MTGN352. 3 hours lecture; 3 semester hours.

MTGN461L. TRANSPORT PHENOMENA AND REACTOR DESIGN LABORATORY. 1.0 Semester Hr.
(II) Experiments in transport phenomena and reactor design to supplement the lectures of MTGN461. Co-requisite: MTGN431, MTGN461. 3 hours lab; 1 semester hour.

MTGN462. SOLID WASTE MINIMIZATION AND RECYCLING. 3.0 Semester Hrs.
(I) This course will examine, using case studies, how industry applies engineering principles to minimize waste formation and to meet solid waste recycling challenges. Both proven and emerging solutions to solid waste environmental problems, especially those associated with metals, will be discussed. Prerequisites: CEEN301, CEEN302, and CHGN403. 3 hours lecture; 3 semester hours.

MTGN463. POLYMER ENGINEERING. 3.0 Semester Hrs.
(I, II, S) An introduction to the structure and properties of polymeric materials, their deformation and failure mechanisms, and the design and fabrication of polymeric end items. The molecular and crystallographic structures of polymers will be developed and related to the elastic, viscoelastic, yield, and fracture properties of polymer solids and reinforced polymer composites. Emphasis will be placed on forming and joining techniques for end item fabrication including: extrusion, injection molding, reaction injection molding, thermoforming, and blow molding. The design of end items will be considered in relation to: materials selection, manufacturing engineering, properties and applications. Offered every other year. 3 hours lecture; 3 semester hours.

MTGN464. FORGING AND FORMING. 2.0 Semester Hrs.
Introduction to plasticity. Survey and analysis of working operations of forging, extrusion, rolling, wire drawing and sheet-metal forming. Metallurgical structure evolution during working. Prerequisite: MTGN381 or CEEN311, MTGN348. Co-requisite: MTGN464L.

MTGN464L. FORGING AND FORMING LABORATORY. 1.0 Semester Hr.
(II) Experiments in forging and forming to supplement the lectures of MTGN464. Corequisite: MTGN464. 3 hours lab; 1 semester hour.

MTGN465. MECHANICAL PROPERTIES OF CERAMICS. 3.0 Semester Hrs.
(II) Mechanical properties of ceramics and ceramic-based composites; brittle fracture of solids; toughening mechanisms in composites; fatigue, high-temperature mechanical behavior, including fracture and creep deformation. Offered every other year. Prerequisites: MTGN211 or MTGN311, and MTGN314 or MTGN412. 3 hours lecture; 3 semester hours.

MTGN466. MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION. 3.0 Semester Hrs.
(II) (WI) Application of fundamental materials-engineering principles to the design of systems for extraction and synthesis, and to the selection of materials. Systems covered range from those used for metallurgical processing to those used for processing of emergent materials. Microstructural design, characterization and properties evaluation provide the basis for linking synthesis to applications. Selection criteria tied to specific requirements such as corrosion resistance, wear and abrasion resistance, high temperature service, cryogenic service, vacuum systems, automotive systems, electronic and optical systems, high strength/weight ratios, recycling, economics and safety issues. Materials investigated include mature and emergent metallic, ceramic and composite systems used in the manufacturing and fabrication industries. Student-team designactivities including oral- and written? reports. Prerequisite: MTGN351, MTGN352, MTGN445 and MTGN461. 1 hour lecture, 6 hours lab; 3 semester hours.

MTGN467. MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION. 2.0 Semester Hrs.
(I) Application of fundamental materials engineering principles to the design of systems, processes, and/or components for extraction, synthesis, operation and/or selection of materials in open-ended projects with realistic constraints. Project topics range from processes used for metallurgical processing and extraction to design and development of emergent materials to process/component analysis and (re)design. Chemical and microstructural characterization and property measurements provide the basis for linking synthesis to application and/or process to product. Selection criteria tied to specific requirements drive design under realistic constraints that include an appropriate mix of technical, economic, safety, and other considerations. Activities are carried out in teams in collaboration with project sponsors/clients. Prerequisite: MTGN348. Corequisites: MTGN461, MTGN445. 1 hour lecture, 3 hours lab; 2 semester hours.

MTGN468. MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION. 2.0 Semester Hrs.
(II) Application of fundamental materials engineering principles to the design of systems, processes, and/or components for extraction, synthesis, operation and/or selection of materials in open-ended projects with realistic constraints. Project topics range from processes used for metallurgical processing and extraction to design and development of emergent materials to process/component analysis and (re)design. Chemical and microstructural characterization and property measurements provide the basis for linking synthesis to application and/or process to product. Selection criteria tied to specific requirements drive design under realistic constraints that include an appropriate mix of technical, economic, safety, and other considerations. Activities are carried out in teams in collaboration with project sponsors/clients. Prerequisite: MTGN352. Corequisites: MTGN348, MTGN334. 1 hour lecture, 3 hours lab; 2 semester hours.

MTGN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.
(I) Fuel cells provide one of the most efficient means for converting the chemical energy stored in a fuel to electrical energy. Fuel cells offer improved energy efficiency and reduced pollution compared to heat engines. While composed of no (or very few) moving parts, a complete fuel cell system amounts to a small chemical plant for the production of power. This course introduces students to the fundamental aspects of fuel cell systems, with emphasis placed on proton exchange membrane (PEM) and solid oxide fuel cells (SOFC). Students will learn the basic principles of electrochemical energy conversion while being exposed to relevant topics in materials science, thermodynamics, and fluid mechanics. Offered every other year. Prerequisites: PHGN200, MATH315, and MTGN251 or MTGN351 or CHGN209 or CHGN210 or MEGN361. 3 hours lecture; 3 semester hours.

MTGN472. BIOMATERIALS I. 3.0 Semester Hrs.
(I) This course introduces biomaterials by combining materials engineering principles with understanding of aspects of molecular and cellular biology so that students learn how materials interact with biological systems, particularly for medical use. The course is organized around four main topics: 1) fundamental properties of biomaterials; 2) fundamental concepts in biology relevant to biomaterials; 3) interactions of physiological systems with biomaterials, and 4) processing of biopolymers, bioceramics and glasses, biometals and composites. Key topics covered include processing of materials to achieve specific biological responses, surface energy and surface modification; protein adsorption; cell adhesion, spreading and migration; biomaterials implantation and acute inflammation; blood-materials interactions; biofilms and biomaterials degradation; and clinical applications of biomaterials. Offered every other year. Prerequisite: MTGN202. 3 hours lecture; 3 semester hours.

MTGN473. COMPUTATIONAL MATERIALS. 3.0 Semester Hrs.
(II) Computational Materials is a course designed as an introduction to computational approaches used in modern materials science and engineering, and to provide the hands-on experience in using massively parallel supercomputers and executing popular materials software packages. The main goal is to provide exposure to students to the growing and highly interdisciplinary field of computational materials science and engineering, through a combination of lectures, hands-on exercises and a series of specifically designed projects. The course is organized to cover different length scales including: atomistic (electronic structure) calculations, molecular dynamics, and phase equilibria modeling. The emerging trends in data driven materials discovery and design are also covered. Particular emphasis is placed on the validation of computational results and recent trends in integrating theory, computations and experiment. 3 hours lecture; 3 semester hours.

MTGN475. METALLURGY OF WELDING. 2.0 Semester Hrs.
(I, II, S) Introduction to welding processes; thermal aspects; selection of filler metals; stresses; stress relief and annealing; pre- and postweld heat treating; weld defects; welding ferrous and nonferrous alloys; weld metal phase transformations; metallurgical evaluation of resulting weld microstructures and properties; and welding tests. Offered every other year. Prerequisite: MTGN348. Corequisite: MTGN475L. 2 hours lecture; 2 semester hours.

MTGN475L. METALLURGY OF WELDING LABORATORY. 1.0 Semester Hr.
Equivalent with MTGN477,
(I, II, S) Experiments designed to supplement the lectures in MTGN475. Offered every other year. Corequisite: MTGN475. 3 hours lab; 1 semester hour.

MTGN497. SUMMER PROGRAMS. 0.0 Semester Hrs.
(S) Summer registration. Repeatable.

MTGN498. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 3.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: none. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN499. INDEPENDENT STUDY. 1-3 Semester Hr.
(I, II, S) Independent advanced-work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Selection of problem is arranged between student and a specific Department faculty-member. Prerequisite: Selection of topic; Independent Study Form must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit to a maximum of 6 hours.

Professors

Kip O. Findley

Brian P. Gorman

Michael J. Kaufman, Office of Research and Technology Transfer

Suveen N. Mathaudhu

Ryan P. O'Hayre

Ivar E. Reimanis, Herman F. Coors Distinguished Professor of Ceramics

Angus A. Rockett, Department Head

John G. Speer, American Bureau of Shipping Endowed Chair in Metallurgical and Materials Engineering

Associate Professors

Geoff L. Brennecka, Fryrear Chair for Innovation and Excellence

Amy Clarke

Emmanuel De Moor

Jeffrey C. King

Corinne E. Packard

Zhenzhen Yu

Assistant Professors

Kester Clarke, FIERF Professor

Jonah Klemm-Toole

Vladen Stevanovic

Teaching Professor

Gerald Bourne, Assistant Department Head

Research Faculty

Lawrence Cho

Robert Cryderman

Prashun Gorai

Peter Green

Terry Lowe

Juan Carlos Madeni

Steve Midson

Michael Sanders

Andriy Zakutayev

Affiliate Faculty

Corby G. Anderson, Harrison Western Professor

Grover Coors

Adam Creuziger

Ron Goldfarb

Sridhar Seetharaman

Erik Spiller

Patrick R. Taylor, George S. Ansell Distinguished Professor of Chemical Metallurgy

Terry Totemeier

James Williams

Emeriti Professors

Glen R. Edwards, University Professor Emeritus

John P. Hager, University Professor Emeritus

George Krauss, University Professor Emeritus

Stephen Liu, University Professor Emeritus, Inaugural American Bureau of Shipping Chair Professor

Gerard P. Martins, Professor Emeritus

David K. Matlock, University Professor Emeritus

Brajendra Mishra, University Professor Emeritus

John J. Moore, Professor Emeritus

David L. Olson, University Professor Emeritus

Dennis W. Readey, Universtiy Professor Emeritus

Chester J. Van Tyne, Professor Emeritus

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Mining Engineering

Program Description

Mining engineering is a broad profession, which embraces all required activities to facilitate the recovery of valuable minerals and products from the earth's crust for the benefit of humanity. It is one of the oldest engineering professions, which continues to grow in importance. It has often been said: "If it can't be grown then it must be mined." An adequate supply of mineral products at competitive prices is the life-blood of the continuing growth of industrialized nations and the foundation of the progress for the developing countries.

The function of the mining engineer is to apply knowledge of pertinent scientific theory, engineering fundamentals, and improved technology to recover natural resources. Mining is a world-wide activity involving the extraction of non-metallics, metal ores of all kinds, and solid fuel and energy sources such as coal and nuclear materials. In addition to mineral extraction, the skills of mining engineers are also needed in a variety of fields where the earth's crust is utilized, such as the underground construction industry. The construction industry, with its requirements of developing earth (rock) systems, tunnels and underground chambers, and the hazardous waste disposal industry are examples of such applications. These are expanding needs, with a shortage of competent people; the mining engineer is well qualified to meet these needs.

The importance of ecological and environmental planning is recognized and given significant attention in all aspects of the mining engineering curriculum.

Mines mining engineering students study the principles and techniques of mineral exploration, and underground and surface mining operations, as well as, mineral processing technologies. Studies include rock mechanics, rock fragmentation, plant and mine design, mine ventilation, surveying, valuation, industrial hygiene, mineral law, mine safety, computing, mineral processing, solution mining and operations research. Throughout the mining engineering curriculum, a constant effort is made to maintain a balance between theoretical principles and their engineering applications. The mining engineering graduate is qualified for positions in engineering, supervision, and research.

The Department recognizes the high expectations that industry has for our graduates as well as the responsibility we have to prepare our students for successful professional careers. To be successful, it is imperative that mining graduates possess an ever-growing set of technical skills, knowledge, and expertise. Beyond the technical aspects of basic sciences, engineering fundamentals, and problem-solving, mining engineering graduates must also acquire a host of other skills which are essential in today's global economy.

These include:

- The ability to work in interdisciplinary teams and communicate effectively to different types of audiences,
- An appreciation of the social, political, and economic realities of different cultures, countries, and indigenous peoples,
- An understanding of the global role mineral extraction and resource development have on local, regional, and international levels,
- The desire for continuing and life-long education, intellectual and professional development, analysis, and creativity,
- The need to maintain high professional and ethical standards,
- The importance of self-confidence, conviction, and compassion, and
- The skills critical to leadership and supervision.

Put simply, our vision for the Mining Engineering Department is to be internationally recognized as the World's premiere center for education and applied research in the diverse fields of mining and underground construction and tunneling. This vision spans across numerous interdisciplinary areas of study. Through collaborations with other Mines departments, academic institutions, government agencies, and industry, we are committed to expanding the international reputation of the Department for excellence in education, research, industry service, and community outreach.

The Mining Engineering Department's program objectives are:

1. Have knowledge of, and skills in, engineering fundamentals to solve complex and open-ended mining and earth systems-related problems.
2. Demonstrate teamwork and leadership skills relevant to their chosen profession.
3. Several years after leaving Mines, our graduates will achieve professional growth.

The program leading to the degree of Bachelor of Science in Mining Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Program Educational Objectives (Bachelor of Science in Mining Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate profile and the ABET Accreditation Criteria, the educational objectives which the Mining Engineering Department aspires to accomplish can be seen in the attributes of our graduates. The graduate is equipped with:

- A sound knowledge in the required basic sciences and engineering fundamentals;
- Knowledge and experience in the application of engineering principles to the exploitation of earth's resources and construction of earth (rock) systems in an engineering systems orientation and setting;
- Ability to solve complex mining and earth systems related problems;
- Capability for team work and decision making;
- Appreciation of the global role of minerals in the changing world;
- Desire for continuing education, intellectual and professional development, analysis and creativity;
- Self confidence and articulation, with high professional and ethical standards.

Curriculum

The mining engineering curriculum is devised to facilitate the widest employability of CSM graduates. The curriculum is based on scientific engineering and geologic fundamentals and the application of these fundamentals to design and operate mines and to create structures in rock and prepare mine products for the market. To achieve this goal, the curriculum is designed to ensure that the graduates:

- become broad based mining engineers who can tackle the problems of both hard and soft rock mining, regardless of whether the mineral deposit requires surface or underground methods of extraction,

- have an opportunity, through elective courses, to specialize in one or more aspects of the mining engineering profession,
- are interested in an academic or research career, or wish to pursue employment in related fields, have a sufficiently sound scientific and engineering foundation to do so effectively.

This purpose permeates both the lower and upper division courses. Another important aspect of the curriculum is the development of the students' capabilities to be team members, with the added objective of preparing them for leadership in their professional life. The curriculum focuses on the application of engineering principles to solving problems, in short, engineering design in an earth systems approach.

Degree Requirements (Mining Engineering)

Freshman

Fall		**lec**	**lab**	**sem.hrs**
HASS100	NATURE AND HUMAN VALUES			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
EDNS151	DESIGN I			3.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0
Spring		**lec**	**lab**	**sem.hrs**
PHGN100	PHYSICS I - MECHANICS			4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
MNGN310	EARTH MATERIALS			3.0
CEEN241	STATICS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0
Spring		**lec**	**lab**	**sem.hrs**
MATH225	DIFFERENTIAL EQUATIONS			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
MNGN210	INTRODUCTORY MINING			3.0
MNGN311	MINING GEOLOGY			3.0
MNGN317	DYNAMICS FOR MINING ENGINEERS			1.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.5
Summer		**lec**	**lab**	**sem.hrs**
MNGN300	SUMMER FIELD SESSION			3.0
MNGN308	MINE SAFETY			1.0
				4.0

Junior

Fall		**lec**	**lab**	**sem.hrs**
EDNS251	DESIGN II			3.0
MNGN309	MINE SAFETY AND OPERATIONS			2.0
MNGN312	SURFACE MINE DESIGN			3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS			3.0
HASS200	GLOBAL STUDIES			3.0
FREE	Free Elective			3.0
				17.0
Spring		**lec**	**lab**	**sem.hrs**
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3.0
MNGN314	UNDERGROUND MINE DESIGN			3.0
MEGN351/ PEGN251	FLUID MECHANICS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE			3.0
FREE	Free Elective			3.0
				15.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
MNGN322	INTRODUCTION TO MINERAL PROCESSING AND LABORATORY			3.0
MNGN414	MINE PLANT DESIGN			3.0
MNGN428	MINING ENGINEERING EVALUATION AND DESIGN REPORT I			1.0
MNGN438	GEOSTATISTICS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL RESTRICTED ELECTIVE			3.0
FREE	Free Elective			3.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
MNGN429	MINING ENGINEERING EVALUATION AND DESIGN REPORT II			2.0
MNGN433	MINE SYSTEMS ANALYSIS I			3.0
MNGN427	MINE VALUATION			2.0

MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0
MNGN425	MINE VENTILATION AND THERMODYNAMICS	4.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL RESTRICTED ELECTIVE	3.0
		16.0

Total Semester Hrs: 132.5

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- MNGN100 through MNGN599 inclusive

Minor Programs

The Mining Engineering Department offers three minor programs; the traditional mining engineering program for non-mining majors, underground construction and tunneling and explosive engineering.

Mining Engineering Minor

The minor program in mining engineering requires students to take:

MNGN210	INTRODUCTORY MINING	3.0
Select two of the following:		6.0
MNGN312	SURFACE MINE DESIGN	
MNGN314	UNDERGROUND MINE DESIGN	
MNGN316	COAL MINING METHODS	
Other courses from mining engineering		9.0
Total Semester Hrs		**18.0**

The list of available courses can be found in the mining engineering department office.

Explosive Engineering Minor

Program Advisor: Dr. Mark Kuchta

There are very few academic explosive engineering programs world wide. In fact, Colorado School of Mines is the only educational institution that offers an explosive engineering minor program in the U.S.A. Developed in the CSM tradition of combining academic education with hands-on experience, this minor program will prepare students for new and developing applications involving the use of explosives in the mining and materials engineering, underground construction, oil and gas operations, demolition, homeland security, military, forensic investigations, manufacturing and material synthesis.

With the proper program development of courses and basic knowledge in explosive engineering, students enrolled in this program will discover and gain insight into the exciting industrial applications of explosives, selection of explosives, and the correct and safe use of the energetic materials. With the help of the program advisor, the students will design and select the proper course sequence and complete a hands-on research project under the supervision of a faculty advisor.

An explosives minor requires 18 credit hours of specially selected courses. The list of available courses can be found in the mining engineering department office.

Space Mining Minor

Students enrolled in this program will gain insight into the basic knowledge in planetary geology, exploration methods, and resource/reserve estimation and valuation. In addition, they will also gain practical knowledge in applications of various equipment necessary for excavation and the production of basic materials needed to build sustainable habitats and infrastructures. Program advisors include the faculty members of the Mining Engineering Department and those of the Center for Space Resources (CSR). They will advise students in the selection of a proper course sequence and guide them to complete projects.

A total of 6 courses or 18 credit hours is required to complete a Minor in Space Mining in the Department of Mining Engineering. This minor program will prepare students to further specialize in ISRU engineering. The first three required courses will provide the students with basic knowledge related to space resources. The subsequent courses will give students applied knowledge in more focused areas in space mining.

Required for all students:		9.0
MNGN210	INTRODUCTORY MINING	
GEOL410	PLANETARY GEOLOGY	
SPRS401	SPACE RESOURCES FUNDAMENTALS	
At least three courses from the list below		9.0
Total Semester Hrs		**18.0**

At least three of courses from the following list are needed to complete a minor in Space Mining:		**9.0**
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	
EBGN321	ENGINEERING ECONOMICS	
EDNS430	CORPORATE SOCIAL RESPONSIBILITY	
GEGN403	MINERAL EXPLORATION DESIGN	
GEOL470	APPLICATIONS OF SATELLITE REMOTE SENSING	
MNGN312	SURFACE MINE DESIGN	
MNGN321	INTRODUCTION TO ROCK MECHANICS	
MNGN322	INTRODUCTION TO MINERAL PROCESSING AND LABORATORY	
MNGN333	EXPLOSIVES ENGINEERING I	
MNGN335	COMMUNITIES AND NATURAL RESOURCE DEVELOPMENT	
MNGN407	ROCK FRAGMENTATION	
MNGN427	MINE VALUATION	
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS	
MTGN462	SOLID WASTE MINIMIZATION AND RECYCLING	
MNGN470	SAFETY AND HEALTH MANAGEMENT IN THE MINING INDUSTRY	

MNGN498	DATA ANALYTICS FOR RESOURCES ENGINEERING
MNGN567	SUSTAINABLE DEVELOPMENT AND EARTH RESOURCES
MNGN570	SAFETY AND HEALTH MANAGEMENT IN THE MINING INDUSTRY
MEGN408	INTRODUCTION TO SPACE EXPLORATION
MNGN598	GEOSPATIAL BIG DATA ANALYTICS (ONLINE)
MEGN441	INTRODUCTION TO ROBOTICS

Courses

MNGN198. SPECIAL TOPICS IN MINING ENGINEERING. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MNGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) (WI) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MNGN210. INTRODUCTORY MINING. 3.0 Semester Hrs.
INTRODUCTORY MINING (I, II) Survey of mining and mining economics. Topics include mining law, exploration and sampling, reserve estimation, project evaluation, basic unit operations including drilling, blasting, loading and hauling, support, shaft sinking and an introduction to surface and underground mining methods. Prerequisite: None. 3 hours lecture; 3 semester hours.

MNGN222. INTRODUCTION TO EXPLOSIVES ENGINEERING. 3.0 Semester Hrs.
(S) A basic introduction to explosives engineering and applied explosives science for students that recently completed their freshman or sophomore years at CSM. Topics covered will include safety and explosives regulations, chemistry of explosives, explosives physics, and detonation properties. The course features a significant hands-on practical laboratory learning component with several sessions held at the Explosives Research Laboratory (ERL) in Idaho Springs. Students completing this course will be well prepared for more advanced work in MNGN333 and MNGN444. Prerequisites: PHGN100, CHGN121, CHGN122, MATH111, and MATH112. 2 hours lecture; 3 hours lab; 3 semester hours.

MNGN298. SPECIAL TOPICS IN MINING ENGINEERING. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MNGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) (WI) Individual research or special problem projects supervised by a faculty member. When a student and instructor agree on a subject matter, content, method of assessment, and credit hours, it must be approved by the Department Head. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MNGN300. SUMMER FIELD SESSION. 3.0 Semester Hrs.
(S) Classroom and field instructions in the theory and practice of surface and underground mine surveying. Introduction to the application of various computer-aided mine design software packages incorporated in upper division mining courses. Prerequisite: completion of sophomore year; Duration: first three weeks of summer term; 3 semester hours.

MNGN308. MINE SAFETY. 1.0 Semester Hr.
(I) Causes and prevention of accidents. Mine safety regulations. Mine rescue training. Safety management and organization. Prerequisite: MNGN210. 1 hour lecture; 1 semester hour. Taken as the first week of summer session.

MNGN309. MINE SAFETY AND OPERATIONS. 2.0 Semester Hrs.
(I, II) Training in practical mine labor functions including: operation of jackleg drills, jumbo drills, muckers, and LHD machines. Training stresses safe operation of equipment and safe handling of explosives. Introduction to front-line management techniques. 2 semester hours. Prerequisite: MNGN210 and MSHA part 48, 40-hour training and 5000.23 certificate.

MNGN310. EARTH MATERIALS. 3.0 Semester Hrs.
(I) Introduction to Earth Materials, emphasizing the structure, formation, distribution and engineering behavior of minerals and rocks. Structural features and processes are related to stress/strain theory and rock mechanics principles. Laboratories and field exercises emphasize the recognition, description and engineering evaluation of natural materials. Lectures and case study exercises present the knowledge of natural materials and processes necessary for mining engineering careers. Prerequisites: GEGN101. 2 hours lecture; 3 hours lab; 3 semester hours.

MNGN311. MINING GEOLOGY. 3.0 Semester Hrs.
(II) Introduction to Mining Geology, emphasizing the formation, distribution, engineering behavior, exploration for and geological aspects of development of ore materials. Laboratories emphasize the recognition, description and engineering evaluation of ores and their hosts. Lectures and case study exercises present the knowledge of ores and ore-forming processes necessary for mining engineering careers. Prerequisites: GEGN 101, (GEOL310 or MNGN310). 2 hours lecture; 3 hours lab: 3 semester hours.

MNGN312. SURFACE MINE DESIGN. 3.0 Semester Hrs.
Analysis of elements of surface mine operation and design of surface mining system components with emphasis on minimization of adverse environmental impact and maximization of efficient use of mineral resources. Ore and coal estimates, unit operations, equipment selection, final pit determinations, short- and longrange planning, road layouts, dump planning, and cost estimation. Prerequisite: MNGN210.

MNGN314. UNDERGROUND MINE DESIGN. 3.0 Semester Hrs.
(II) Selection, design, and development of most suitable underground mining methods based upon the physical and the geological properties of mineral deposits (coal, metallics and nonmetallics), conservation considerations, and associated environmental impacts. Reserve estimates, development and production planning, engineering drawings for development and extraction, underground haulage systems, and cost estimates. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: MNGN210.

MNGN316. COAL MINING METHODS. 3.0 Semester Hrs.
(II) (WI) Devoted to surface and underground coal mining methods and design. The surface mining portion emphasizes area-mining methods, including pertinent design-related regulations, and overburden removal systems. Pit layout, sequencing, overburden equipment selection and cost estimation are presented. The underground mining portion emphasizes general mine layout; detailed layout of continuous, conventional, longwall, and shortwall sections. General cost and manning requirements; and production analysis. Federal and state health and safety regulations are included in all aspects of mine layout. Pre - requisite: MNGN210. 2 hours lecture, 3 hours lab, 3 semester hours.

MNGN317. DYNAMICS FOR MINING ENGINEERS. 1.0 Semester Hr.
(II) For mining engineering majors only. Absolute and relative motions, kinetics, work-energy, impulse-momentum and angular impulse-momentum. Prerequisite: MATH213/223, CEEN241. 1 hour lecture; 1 semester hour.

MNGN321. INTRODUCTION TO ROCK MECHANICS. 3.0 Semester Hrs.
Physical properties of rock, and fundamentals of rock substance and rock mass response to applied loads. Principles of elastic analysis and stress-strain relationships. Elementary principles of the theoretical and applied design of underground openings and pit slopes. Emphasis on practical applied aspects. Prerequisite: CEEN241 or MNGN317. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN322. INTRODUCTION TO MINERAL PROCESSING AND LABORATORY. 3.0 Semester Hrs.
(I) Principles and practice of crushing, grinding, size classification; mineral concentration technologies including magnetic and electrostatic separation, gravity separation, and flotation. Sedimentation, thickening, filtration and product drying as well as tailings disposal technologies are included. The course is open to all CSM students. Prerequisite: PHGN200/ 210, MATH213/223. 2 hours lecture; 3 hours lab; 3 semester hours.

MNGN333. EXPLOSIVES ENGINEERING I. 3.0 Semester Hrs.
(I) This course gives students in engineering and applied sciences the opportunity to examine and develop a fundamental knowledge including terminology and understanding of explosives science and engineering concepts. Student learning will be demonstrated by assignments, quizzes, and exams. Learning assistance will come in the form of multidisciplinary lectures complemented by a few lectures from experts from government, industry and the explosives engineering community. Pre-requisites: None. 2 hours lecture; 3 hours lab. 3 semester hours.

MNGN335. COMMUNITIES AND NATURAL RESOURCE DEVELOPMENT. 3.0 Semester Hrs.
This course examines the relationship between humans and their environment across space and time. In particular, it focuses on the intersections between natural resource developments and communities. By incorporating theoretical perspectives from environmental anthropology, it draws from frameworks of political ecology, social and environmental justice, indigenous rights, disasters, vulnerability, natural resource management, unequal development, and environmental futures. Drawing from case studies from mining, oil and gas, and energy developments, students will gain knowledge and skills in evaluating how natural resource developments and communities coexist.

MNGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

MNGN350. INTRODUCTION TO GEOTHERMAL ENERGY. 3.0 Semester Hrs.
Geothermal energy resources and their utilization, based on geoscience and engineering perspectives. Geoscience topics include world wide occurrences of resources and their classification, heat and mass transfer, geothermal reservoirs, hydrothermal geochemistry, exploration methods, and resource assessment. Engineering topics include thermodynamics of water, power cycles, electricity generation, drilling and well measurements, reservoir-surface engineering, and direct utilization. Economic and environmental considerations and case studies are also presented. Prerequisites: ENGY200. 3 hours lecture; 3 semester hours.

MNGN398. SPECIAL TOPICS IN MINING ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MNGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) (WI)) Individual research or special problem projects supervised by a faculty member. When a student and instructor agree on a subject matter, content, method of assessment, and credit hours, it must be approved by the Department Head. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MNGN404. TUNNELING. 3.0 Semester Hrs.
(I) Modern tunneling techniques. Emphasis on evaluation of ground conditions, estimation of support requirements, methods of tunnel driving and boring, design systems and equipment, and safety. Prerequisite: none. 3 hours lecture; 3 semester hours.

MNGN405. ROCK MECHANICS IN MINING. 3.0 Semester Hrs.
(I) The course deals with the rock mechanics aspect of design of mine layouts developed in both underground and surface. Underground mining sections include design of coal and hard rock pillars, mine layout design for tabular and massive ore bodies, assessment of caving characteristics or ore bodies, performance and application of backfill, and phenomenon of rock burst and its alleviation. Surface mining portion covers rock mass characterization, failure modes of slopes excavated in rock masses, probabilistic and deterministic approaches to design of slopes, and remedial measures for slope stability problems. Prerequisite: MN321 or equivalent. 3 hours lecture; 3 semester hours.

MNGN406. DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS. 3.0 Semester Hrs.
Design of underground excavations and support. Analysis of stress and rock mass deformations around excavations using analytical and numerical methods. Collections, preparation, and evaluation of in situ and laboratory data for excavation design. Use of rock mass rating systems for site characterization and excavation design. Study of support types and selection of support for underground excavations. Use of numerical models for design of shafts, tunnels and large chambers. Prerequisite: none. 3 hours lecture; 3 semester hours. Offered in odd years.

MNGN407. ROCK FRAGMENTATION. 3.0 Semester Hrs.
(II) Theory and application of rock drilling, rock boring, explosives, blasting, and mechanical rock breakage. Design of blasting rounds, applications to surface and underground excavation. Prerequisite: CEEN241, concurrent enrollment. 3 hours lecture; 3 semester hours.

MNGN408. UNDERGROUND DESIGN AND CONSTRUCTION. 2.0 Semester Hrs.
(I) Soil and rock engineering applied to underground civil works. Tunneling and the construction of underground openings for power facilities, water conveyance, transportation, and waste disposal; design, excavation and support of underground openings. Emphasis on consulting practice, case studies, geotechnical design, and construction methods. Prerequisite: CEEN312 OR MNGN321. 2 hours of lecture; 2 semester hours.

MNGN410. EXCAVATION PROJECT MANAGEMENT. 2.0 Semester Hrs.
(II) Successful implementation and management of surface and underground construction projects, preparation of contract documents, project bidding and estimating, contract awarding and notice to proceed, value engineering, risk management, construction management and dispute resolution, evaluation of differing site conditions claims. Prerequisite: MNGN 210, 2-hour lecture, 2 semester hours.

MNGN414. MINE PLANT DESIGN. 3.0 Semester Hrs.
(I) Analysis of mine plant elements with emphasis on design. Materials handling, dewatering, hoisting, belt conveyor and other material handling systems for underground mines. Prerequisite: MNGN312 and MNGN314. 2 hours lecture, 3 hours lab; 3 semester hour.

MNGN418. ADVANCED ROCK MECHANICS. 3.0 Semester Hrs.
Equivalent with MNGN508,
Analytical and numerical modeling analysis of stresses and displacements induced around engineering excavations in rock. In-situ stress. Rock failure criteria. Complete load deformation behavior of rocks. Measurement and monitoring techniques in rock mechanics. Principles of design of excavation in rocks. Analytical, numerical modeling and empirical design methods. Probabilistic and deterministic approaches to rock engineering designs. Excavation design examples for shafts, tunnels, large chambers and mine pillars. Seismic loading of structures in rock. Phenomenon of rock burst and its alleviation. Prerequisite: MNGN321. 3 hours lecture; 3 semester hours.

MNGN421. DESIGN OF UNDERGROUND EXCAVATIONS. 3.0 Semester Hrs.
(II) Design of underground openings in competent and broken ground using rock mechanics principles. Rock bolting design and other ground support methods. Coal, evaporite, metallic and nonmetallic deposits included. Prerequisite: MNGN321, concurrent enrollment. 3 hours lecture; 3 semester hours.

MNGN422. FLOTATION. 2.0 Semester Hrs.
Science and engineering governing the practice of mineral concentration by flotation. Interfacial phenomena, flotation reagents, mineral-reagent interactions, and zeta-potential are covered. Flotation circuit design and evaluation as well as tailings handling are also covered. The course also includes laboratory demonstrations of some fundamental concepts. 3 hours lecture; 3 semester hours.

MNGN423. FLOTATION LABORATORY. 1.0 Semester Hr.
(I) Experiments to accompany the lectures in MNGN422. Co-requisite: MNGN421. 3 hours lab; 1 semester hour.

MNGN424. MINE VENTILATION. 3.0 Semester Hrs.
(II) Fundamentals of mine ventilation, including control of gas, dust, temperature, and humidity; ventilation network analysis and design of systems. Prerequisites: PEGN251 or MEGN351, CHGN209 or MEGN361, and MNGN314. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN425. MINE VENTILATION AND THERMODYNAMICS. 4.0 Semester Hrs.
Fundamentals of mine ventilation and thermodynamics, including heat transfer, flow and control of gas, dust, temperature, and humidity; ventilation network analysis and design of mine ventilation systems. Prerequisite: MNGN314, EGGN351 or PEGN251 or instructor consent.

MNGN427. MINE VALUATION. 2.0 Semester Hrs.
(II) Course emphasis is on the business aspects of mining. Topics include time valuation of money and interest formulas, cash flow, investment criteria, tax considerations, risk and sensitivity analysis, escalation and inflation and cost of capital. Calculation procedures are illustrated by case studies. Computer programs are used. Prerequisite: Senior in Mining, graduate status. 2 hours lecture; 2 semester hours.

MNGN428. MINING ENGINEERING EVALUATION AND DESIGN REPORT I. 1.0 Semester Hr.
(I) (WI) Preparation of Phase I engineering report based on coordination of all previous work. Includes mineral deposit selection, geologic description, mining method selection, ore reserve determination, and permit process outline. Emphasis is on detailed mine design and cost analysis evaluation in preparation for MNGN429. Prerequisites: MNGN210, MNGN300, MNGN308, MNGN312, MNGN314, MNGN309, MNGN321, MNGN316, GEOL310 or MNGN310, GEOL311 or MNGN311. Co-requisites: MNGN438. 1 hour lecture; 1 semester hour.

MNGN429. MINING ENGINEERING EVALUATION AND DESIGN REPORT II. 2.0 Semester Hrs.
(II) (WI) Preparation of formal engineering report based on all course work in the mining option. Emphasis is on mine design, equipment selection, production scheduling, evaluation and cost analysis. Prerequisite: MNGN428, MNGN210, MNGN300, MNGN308, MNGN312, MNGN314, MNGN309, MNGN321, MNGN316, GEOL310 or MNGN310, GEOL311 or MNGN311, MNGN438, MNGN414. Co-requisites: MNGN322 or MNGN323, MNGN427, and MNGN433. 2 hours lecture; 2 semester hours.

MNGN431. MINING AND METALLURGICAL ENVIRONMENT. 3.0 Semester Hrs.
This course covers studies of the interface between mining and metallurgical process engineering and environmental engineering areas. Wastes, effluents and their point sources in mining and metallurgical processes such as mineral concentration, value extraction and process metallurgy are studied in context. Fundamentals of unit operations and unit processes with those applicable to waste and effluent control, disposal and materials recycling are covered. Engineering design and engineering cost components are also included for some examples chosen. The ratio of fundamentals applications coverage is about 1:1. Prerequisite: none. 3 hours lecture; 3 semester hours.

MNGN433. MINE SYSTEMS ANALYSIS I. 3.0 Semester Hrs.
(II) Application of statistics, systems analysis, and operations research techniques to mineral industry problems. Laboratory work using computer techniques to improve efficiency of mining operations. Prerequisite: Senior or graduate status. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN434. PROCESS ANALYSIS. 1.0 Semester Hr.
Projects to accompany the lectures in MNGN422. Prerequisite: MNGN422. 3 hours lab; 1 semester hour.

MNGN436. UNDERGROUND COAL MINE DESIGN. 3.0 Semester Hrs.
(II) Design of an underground coal mine based on an actual coal reserve. This course shall utilize all previous course material in the actual design of an underground coal mine. Ventilation, materials handling, electrical transmission and distribution, fluid mechanics, equipment selection and application, mine plant design. Information from all basic mining survey courses will be used. Prerequisite: MNGN316, MNGN321, MNGN414, EGGN329 and MNGN381 or MNGN384. 3 hours lecture, 3 hours lab; 3 semester hours.

MNGN438. GEOSTATISTICS. 3.0 Semester Hrs.
(I) Introduction to elementary probability theory and its applications in engineering and sciences; discrete and continuous probability distributions; parameter estimation; hypothesis testing; linear regression; spatial correlations and geostatistics with emphasis on applications in earth sciences and engineering. Prerequisites: MATH112. 2 hours of lecture and 3 hours of lab. 3 semester hours.

MNGN440. EQUIPMENT REPLACEMENT ANALYSIS. 2.0 Semester Hrs.
(I) Introduction to the fundamentals of classical equipment replacement theory. Emphasis on new, practical approaches to equipment replacement decision making. Topics include: operating and maintenance costs, obsolescence factors, technological changes, salvage, capital investments, minimal average annual costs, optimum economic life, infinite and finite planning horizons, replacement cycles, replacement vs. expansion, maximization of returns from equipment replacement expenditures. Prerequisite: MNGN427, senior or graduate status. 2 hours lecture; 2 semester hours.

MNGN444. EXPLOSIVES ENGINEERING II. 3.0 Semester Hrs.
(II) This course gives students in engineering and applied sciences the opportunity to acquire the fundamental concepts of explosives engineering and science applications as they apply to industry and real life examples. Students will expand upon their MNGN333 knowledge and develop a more advanced knowledge base including an understanding of the subject as it applies to their specific project interests. Assignments, quizzes, concept modeling and their project development and presentation will demonstrate student's progress. Prerequisite: MNGN333. 2 hours lecture, 3 hours lab, 3 semester hours.

MNGN445. ROCK SLOPE ENGINEERING. 3.0 Semester Hrs.
Introduction to the analysis and design of slopes excavated in rock. Rock mass classification and strength determinations, geological structural parameters, properties of fracture sets, data collection techniques, hydrological factors, methods of analysis of slope stability, wedge intersections, monitoring and maintenance of final pit slopes, classification of slides. Deterministic and probabilistic approaches in slope design. Remedial measures. Laboratory and field exercise in slope design. Collection of data and specimens in the field for deterring physical properties required for slope design. Application of numerical modeling and analytical techniques to slope stability determinations for hard rock and soft rock environments. Prerequisite: none. 3 hours lecture; 3 semester hours.

MNGN452. SOLUTION MINING AND PROCESSING OF ORES. 3.0 Semester Hrs.
(II) Theory and application of advanced methods of extracting and processing of minerals, underground or in situ, to recover solutions and concentrates of value-materials, by minimization of the traditional surface processing and disposal of tailings to minimize environmental impacts. Prerequisite: Senior or graduate status; none. 3 hours lecture; 3 semester hours. Offered in spring.

MNGN460. INDUSTRIAL MINERALS PRODUCTION. 3.0 Semester Hrs.
(II) This course describes the engineering principles and practices associated with quarry mining operations related to the cement and aggregates industries. The course will cover resource definition, quarry planning and design, extraction, and processing of material for cement and aggregate production. Permitting issues and reclamation, particle sizing and environmental practices, will be studied in depth. Prerequisite: MNGN312, MNGN322, MNGN323. 3 hours lecture; 3 semester hours. Offered in spring.

MNGN470. SAFETY AND HEALTH MANAGEMENT IN THE MINING INDUSTRY. 3.0 Semester Hrs.
(I) Fundamentals of managing occupational safety and health at a mining operation. Includes tracking of accident and injury statistics, risk management, developing a safety and health management plan, meeting MSHA regulatory requirements, training, safety audits and accident investigations. 3 hours lecture; 3 semester hours.

MNGN482. MINE MANAGEMENT. 3.0 Semester Hrs.
(II) Basic principles of successful mine management including supervision skills, administrative policies, industrial and human relations, improvement engineering, risk management, conflict resolution and external affairs. Prerequisite: Senior or graduate status. 2 hours lecture and 1 hour case study presentation and discussion per week; 3 hours lecture; 3 semester hours.

MNGN490. ENERGY AND SOCIETY. 3.0 Semester Hrs.
Equivalent with ENGY490,LAIS490,
(II). A transdisciplinary capstone seminar that explores a spectrum of approaches to the understanding, planning, and implementation of energy production and use, including those typical of diverse private and public (national and international) corporations, organizations, states, and agencies. Aspects of global energy policy that may be considered include the historical, social, cultural, economic, ethical, political, and environmental aspects of energy together with comparative methodologies and assessments of diverse forms of energy development. Prerequisites: ENGY330/EBGN330 and one of either ENGY310, ENGY320, or ENGY340. 3 hours lecture/seminar; 3 semester hours.

MNGN498. SPECIAL TOPICS IN MINING ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MNGN499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) (WI) Individual research or special problem projects supervised by a faculty member. When a student and instructor agree on a subject matter, content, method of assessment, and credit hours, it must be approved by the Department Head. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Department Head

M. Stephen Enders

Associate Department Head

Jürgen Brune

Professors

Corby Anderson

Kadri Dagdelen

H. Sebnem Düzgün

Linda Figueroa

Priscilla P. Nelson

Patrick R. Taylor

Associate Professors

Veronica Eliasson

Elizabeth Holley

Hugh B. Miller

Masami Nakagawa

Jamal Rostami

Assistant Professors

Rennie Kaunda

Nicole Smith

Gabriel Walton

Professors of Practice

Jürgen Brune

Research Professor

D. Erik Spiller

Adjunct Faculty

Anthony Konya

Petroleum Engineering

Program Description

The primary objectives of petroleum engineering are the safe and environmentally sound exploration, evaluation, development, and recovery of oil, gas, geothermal, and other fluids in the earth. Skills in this branch of engineering are needed to meet the world's ever-increasing demand for hydrocarbon fuel, thermal energy and waste and pollution management.

Graduates of our program are in solid demand, with the petroleum industry offering a wide range of employment opportunities for Petroleum Engineering students during summer breaks and after graduation. Exciting experiences range from field work in drilling and producing oil and gas fields, to office jobs in small towns or large cities. Worldwide travel and overseas assignments are available for interested students.

One of our objectives in the Petroleum Engineering Department is to prepare students to succeed in an energy industry that is evolving into an industry working with many energy sources. In addition to developing technical competence in petroleum engineering, you will learn how your education can help you contribute to the development of alternative energy sources such as geothermal. Alternative careers exist outside of the petroleum industry too and many petroleum engineering graduates find rewarding careers in the environmental arena, law, medicine, business, and many other walks of life.

The department offers semester-abroad opportunities through formal exchange programs with the Petroleum Engineering Department at the Montanuniversität Leoben in Austria, Technical University in Delft, Holland, the University of Adelaide, Adelaide, Australia, and the Petroleum Institute in Abu Dhabi, UAE. Qualified undergraduate and graduate students from each school can attend the other for one semester and receive full transfer credit back at the home university.

The program leading to the degree of Bachelor of Science in Petroleum Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Graduate courses emphasize the research aspects of the profession, as well as advanced engineering applications. Qualified students may continue their education and earn a Master of Science, Master of Engineering, and Doctor of Philosophy degrees.

To facilitate classroom instruction and the learning experience, the Petroleum Engineering faculty recommend that all petroleum engineering students have notebook computers. Recommended specifications for the computer can be obtained from the CSM Academic Computing & Networking web site.

The Petroleum Engineering Department encourages student involvement with the Society of Petroleum Engineers, the American Association of Drilling Engineers, and the American Rock Mechanics Association. The department provides some financial support for students attending the annual technical conferences for these professional societies.

Marquez (pronounced "Marcus") Hall is home to the Petroleum Engineering Department. A prominent campus landmark, Marquez Hall showcases Mines' longstanding strengths in its core focus areas and our commitment to staying at the forefront of innovation. The building is designed using aggressive energy saving strategies and is LEED certified. Marquez Hall is the first building on the Colorado School of Mines Campus that is funded entirely by private donations.

New laboratory and computer equipment added to Marquez Hall include:

Computer Laboratory

This computer laboratory is available for general use and classroom instruction. It is continuously open for student use. Software includes more than $5.0 million in donated industry software used by oil and gas companies and research labs around the world.

Drilling Simulator Laboratory

Rare on university campuses, this lab contains an up-to-date computer controlled, full-scale, graphic intensive drilling rig simulator. It includes drilling controls that can be used to simulate onshore and offshore drilling operations and well control situations. This lab also has three small scale drilling rig simulators, identical to those used in industrial well control training facilities.

Reservoir Characterization Laboratory

Rock properties are measured that affect economic development of reservoir resources of oil and gas. Measured properties include permeability, porosity, and relative permeability. "Hands on" experiences with simple and sophisticated equipment are provided.

Drilling Fluids Laboratory

Modern equipment found on drilling rigs world-wide enables students to evaluate and design fluid systems required in drilling operations.

Fluids Characterization Laboratory

A variety of properties of fluids from oil and gas reservoirs are measured for realistic conditions of elevated temperature and pressure. This laboratory accentuates principles studied in lectures.

Petroleum Engineering Summer Sessions

Two summer sessions, one after the completion of the sophomore year and one after the junior year, are important parts of the educational experience. The first is a session designed to introduce the student to the petroleum industry. Various career opportunities are highlighted, as well as showing petroleum field and office operations and geology. In addition, students are indoctrinated in health, safety, and environmental awareness. Petroleum Engineering, a truly unique and exciting engineering discipline, can be experienced by visiting petroleum operations. Historically, the areas visited have included Europe, Alaska, Canada, the U.S. Gulf Coast, California, the Midcontinent, the Northeast US, and the Rocky Mountain Region.

The second two-week session, after the junior year, is an in-depth study of the Rangely Oil Field and surrounding geology in Western Colorado. The Rangely Oil Field is the largest oil field in the Rocky Mountain region and has undergone primary, secondary, and enhanced recovery processes. Field work in the area provides the setting for understanding the complexity of geologic systems and the environmental and safety issues in the context of reservoir development and management.

Other Opportunities

It is recommended that all students considering majoring or minoring in Petroleum Engineering sign up for the Introductory course PEGN201, Petroleum Engineering Fundamentals. Also, seniors may take 500-level graduate courses that include topics such as drilling, reservoir, and

production engineering; reservoir simulation and characterization, and economics and risk analysis with instructor concurrence (see the CSM Graduate Catalog for course offerings).

Program Educational Objectives (Bachelor of Science in Petroleum Engineering)

The Mission of the Petroleum Engineering Program continues to evolve over time in response to the needs of the graduates and industry; in concert with the Colorado School of Mines Institutional Mission Statement and the Profile of the Future Graduate; and in recognition of accreditation requirements specified by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET). The Mission of the Petroleum Engineering Program is:

Our mission is to provide the necessary skills at the undergraduate, graduate, and continuing education levels to serve the world in developing conventional and unconventional hydrocarbon resources, water resources, and geothermal energy, while promoting cutting-edge research to improve resource recovery, advancing technologies to combat environmental problems, such as carbon sequestration and other earth disposal processes, and to foster the socially responsible development of Earth's resources.

As part of that process, the faculty of the department has objectives that they want to see their alumni accomplish within three to five years from graduation. The Petroleum Engineering Department's faculty and other constituents have affirmed the following Program Educational Objectives:

- Obtain an industry, government, or academic position in petroleum engineering, or a related field, or be pursuing a graduate education in petroleum engineering or in a related field;
- Demonstrate advancement in their chosen careers and exercising leadership in the area of petroleum engineering;
- Continue to develop personally and professionally, and serve others, through continuing education, professional societies, educational institutions, community groups, and other organizations; and,
- Identify the ethical implications and social impacts of engineering decisions.

To accomplish these objectives, the Petroleum Engineering program has, in addition to the school's Graduate Profile and the overall objectives, certain student objectives particular to the Department and based on the ABET student outcomes including:

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design and conduct experiments, as well as to analyze and interpret data
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an ability to function on multidisciplinary teams
- an ability to identify, formulate, and solve engineering problems
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- a recognition of the need for, and an ability to engage in life-long learning
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice..

These program educational objectives and student outcomes can be found on the Petroleum Engineering Department's website under the Colorado School of Mines website. These are also found publicly posted in the ABET bulletin board outside the department offices.

Curriculum

All disciplines within petroleum engineering are covered to great depth at the undergraduate and graduate levels, both in the classroom and laboratory instruction, and in research. Specific areas include fundamental fluid and rock behavior, drilling, formation evaluation, well completions and stimulation, well testing, production operations and artificial lift, reservoir engineering, supplemental and enhanced oil recovery, economic evaluation of petroleum projects, environmental and safety issues, and the computer simulation of most of these topics.

The Petroleum Engineering student studies mathematics, computer science, chemistry, physics, general engineering, geology, the humanities, technical communication (including researching subjects, report writing, oral presentations, and listening skills), and environmental topics. A unique aspect is the breadth and depth of the total program structured in a manner that prepares each graduate for a successful career from the standpoints of technical competence, managerial abilities, and multidisciplinary experiences. The needs for continued learning and professionalism are stressed.

The strength of the program comes from the high quality of students and professors. The faculty has expertise in teaching and research in all the major areas of petroleum engineering listed above. Additionally, the faculty members have significant industrial backgrounds that lead to meaningful design experiences for the students. Engineering design is taught throughout the curriculum including a senior design course on applying the learned skills to real world reservoir development and management problems.

As of August 2012 the program has new facilities and equipment for laboratory instruction and experimental research. To maintain leadership in future petroleum engineering technology, decision making, and management, computers are incorporated into every part of the program, from undergraduate instruction through graduate student and faculty research.

The department is close to oil and gas field operations, petroleum companies, research laboratories, and geologic out-crops of nearby producing formations. There are many opportunities for short field trips and for summer and part-time employment in the oil and gas industry.

Degree Requirements (Petroleum Engineering)

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS			4.0

MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
EDNS151	DESIGN I			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0
Spring		**lec**	**lab**	**sem.hrs**
PHGN100	PHYSICS I - MECHANICS			4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0
Sophomore				
Fall		**lec**	**lab**	**sem.hrs**
EBGN201	PRINCIPLES OF ECONOMICS			3.0
CEEN241	STATICS			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
PEGN201	PETROLEUM ENGINEERING FUNDAMENTALS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				18.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
PEGN251	FLUID MECHANICS			3.0
PEGN308	RESERVOIR ROCK PROPERTIES			3.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
HASS200	GLOBAL STUDIES			3.0
				18.0
Summer		**lec**	**lab**	**sem.hrs**
PEGN315	SUMMER FIELD SESSION I	1.0		1.0
				1.0
Junior				
Fall		**lec**	**lab**	**sem.hrs**
GEOL315	SEDIMENTOLOGY AND STRATIGRAPHY			3.0
PEGN305	COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING			2.0
PEGN311	DRILLING ENGINEERING			4.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS			3.0
PEGN282	PROFESSIONAL SKILLS 1			1.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.5
Spring		**lec**	**lab**	**sem.hrs**
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY			3.0
PEGN361	COMPLETION ENGINEERING			3.0
PEGN411	MECHANICS OF PETROLEUM PRODUCTION			3.0
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION			3.0
PEGN438	PETROLEUM DATA ANALYTICS			3.0
FREE	Free Elective			3.0
				18.0
Summer		**lec**	**lab**	**sem.hrs**
PEGN316	SUMMER FIELD SESSION II	2.0		2.0
				2.0
Senior				
Fall		**lec**	**lab**	**sem.hrs**
PEGN382	PROFESSIONAL SKILLS 2			1.0
PEGN423	PETROLEUM RESERVOIR ENGINEERING I			3.0
PEGN414	WELL TESTING AND ANALYSIS			3.0
PEGN422	ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
FREE	Free Elective			3.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
PEGN424	PETROLEUM RESERVOIR ENGINEERING II			3.0
PEGN426	FORMATION DAMAGE AND STIMULATION			3.0
PEGN439	MULTIDISCIPLINARY PETROLEUM DESIGN			3.0
PEGN482	PROFESSIONAL SKILLS 3			1.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective			3.0
FREE	Free Elective			3.0
				16.0

Total Semester Hrs: 138.5

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- PEGN100 through PEGN599 inclusive

Five Year Combined Baccalaureate and Masters Degree

The Petroleum Engineering Department offers the opportunity to begin work on a Master of Engineering or Master of Science Degree while completing the requirements for the Bachelor's Degree. These degrees are of special interest to those planning on studying abroad or wanting to get a head start on graduate education. These combined programs are individualized and a plan of study should be discussed with the student's academic advisor any time after the Sophomore year.

The Petroleum Engineering Department offers the following minor programs:

1. Petroleum Engineering
2. Petroleum Data Analytics

Petroleum Engineering Minor

The PE department tailors the student's minor to correlate with their interests in the petroleum industry. For example, students majoring in mechanical, civil, and electrical engineering, the focus typically would be in operations. For students majoring in chemical engineering, geologists and geophysicists, the focus is typically in reservoir engineering. The choice is left to the student which area of interest they wish to follow.

For a minor in Petroleum Engineering, the student must complete a minimum of 18 credit hours from the following:

Required Course:

PEGN308	RESERVOIR ROCK PROPERTIES	3.0

For a minor with an operations focus, 15 hours of the following:

PEGN201	PETROLEUM ENGINEERING FUNDAMENTALS	3.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS	3.0
PEGN311	DRILLING ENGINEERING	4.0
PEGN361	COMPLETION ENGINEERING	3.0
PEGN411	MECHANICS OF PETROLEUM PRODUCTION	3.0
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	3.0
PEGN426	FORMATION DAMAGE AND STIMULATION	3.0

For a minor with a reservoir focus, 15 hours of the following:

PEGN201	PETROLEUM ENGINEERING FUNDAMENTALS	3.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS	3.0
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	3.0
PEGN423	PETROLEUM RESERVOIR ENGINEERING I	3.0
PEGN424	PETROLEUM RESERVOIR ENGINEERING II	3.0
PEGN414	WELL TESTING AND ANALYSIS	3.0
PEGN439	MULTIDISCIPLINARY PETROLEUM DESIGN	3.0

Minor in Petroleum Data Analytics

Program Advisor: Dr. Alfred Eustes

The purpose of this minor is to enhance data analysis skills and to show potential opportunities of data, give students the skill-set to manage and analyze the data and use their knowledge of petroleum engineering to make petroleum resource acquisition more economical, safe and environmentally sound.

Objectives:
By the end of the minor program, students will be able to:
• Collect and pre-process typical petroleum data and to rearrange for use in analysis
• Apply standard probability and statistics methodology to various data constructs
• Analyze data to determine which various regression and prediction techniques would be applicable and to use that analysis process
• To build system algorithms for data information insight
• Use various data analytics analysis and visualization software for the petroleum industry

Minor Requirements

To obtain a Petroleum Data Analytics Minor, students must take a minimum of 18 credits related to Data Analytics. Six courses (18 credits) are required. Petroleum Engineering students can use any of their free elective classes and take their PEGN438 required course as part of the normal PEGN credit hour requirements. See CSM minor requirements here (p. 33). Students should begin their classes for this minor by the fall semester of their junior year in order to graduate in four years.

Pre-requisite classes

The following classes are required before the students can take Petroleum Data Analytics Minor:
• MATH112. CALCULUS FOR SCIENTISTS AND ENGINEERS II or

• MATH122. CALCULUS FOR SCIENTISTS AND ENGINEERS II HONORS

• EBGN201. PRINCIPLES OF ECONOMICS

Required Courses (18 credit hours)

MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
CSCI261	PROGRAMMING CONCEPTS	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
EBGN425	BUSINESS ANALYTICS	3.0
or EBGN525	BUSINESS ANALYTICS	
PEGN438	PETROLEUM DATA ANALYTICS	3.0
PEGN440	PETROLEUM DATA ANALYSIS	3.0

Courses

PEGN198. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PEGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PEGN201. PETROLEUM ENGINEERING FUNDAMENTALS. 3.0 Semester Hrs.
This course provides an introduction to the oil and gas industry and the various areas associated with petroleum engineering. Topics covered include exploration, development, drilling, production, stimulation, reservoir management, processing, transportation, engineering ethics and professionalism. This course is required for petroleum engineering majors and is open to those interested in petroleum engineering as a minor, and for any other interested students.

PEGN251. FLUID MECHANICS. 3.0 Semester Hrs.
Introductory and fundamental course in engineering fluid flow. Properties of fluids and fluid flow, fluid statics, mass and momentum balance, differential equations, dimensional analysis, laminar and turbulent flow in pipes, and two-phase flow. Lecture format with demonstrations and practical problem solving. May not also receive credit for MEGN351 or CEEN310. Co-requisite: CEEN241.

PEGN282. PROFESSIONAL SKILLS 1. 1.0 Semester Hr.
This course is the first in a three-course series designed for petroleum engineering students to develop skills in oral and written communication, professionalism, diversity and ethics. The course is designed as a discussion based seminar course and will focus on critical thinking and problem solving. Assignments will be based on technical and non-technical material relating to earth, energy, and the environment. Students will work individually and in multicultural teams on assignments throughout the semester.

PEGN298. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PEGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PEGN305. COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING. 2.0 Semester Hrs.
(I) This course is an introduction to computers and computer programming applied to petroleum engineering. Emphasis will be on learning Visual Basic programming techniques to solve engineering problems. A toolbox of fluid property and numerical techniques will be developed. Prerequisite: MATH213. 2 hours lecture; 2 semester hours.

PEGN308. RESERVOIR ROCK PROPERTIES. 3.0 Semester Hrs.
(I, II) (WI) Introduction to basic reservoir rock properties and their measurements. Topics covered include: porosity, saturations, volumetric equations, land descriptions, trapping mechanism, pressure and temperature gradient, abnormally pressured reservoirs. Darcy's law for linear horizontal and tilted flow, radial flow for single phase liquids and gases, multiphase flow (relative permeability). Capillary pressure and formation compressibility are also discussed. Co-requisites: CEEN241, PEGN251. 2 hours lecture; 3 hours lab; 3 semester hours.

PEGN311. DRILLING ENGINEERING. 4.0 Semester Hrs.
(I) Study of drilling operations, fluid design, hydraulics, drilling contracts, rig selection, rotary system, well control, bit selection, drill string design, directional drilling, and casing seat selection. Prerequisites: PEGN251 (grade of C or higher), PEGN315, CEEN241. Co-requisites: PEGN305. 3 hours lecture; 3 hours lab; 4 semester hours.

PEGN312. PROPERTIES OF PETROLEUM ENGINEERING FLUIDS. 3.0 Semester Hrs.
(I) (WI) Properties of fluids encountered in petroleum engineering including reservoir, drilling, and completion fluids, and oilfield waters. Phase behavior, density, viscosity, interfacial tension, and composition of oil, gas, and brine systems. Interpreting lab data for engineering applications. Flash calculations with k-values and equation of state. Introduction to fluid properties software. Laboratory experimentation of fluid properties. Prerequisites: PEGN308 (C or better), CHGN209 (C or better). 2 hours lecture; 3 hours lab; 3 semester hours.

PEGN315. SUMMER FIELD SESSION I. 1.0 Semester Hr.
(S) This 8 day course taken after the completion of the sophomore year is designed to introduce the student to oil and gas field and other engineering operations. Engineering design problems are integrated throughout the 8 day session. On-site visits to various oil field operations in the past included the Rocky Mountain region, the U.S. Gulf Coast, California, Alaska, Canada and Europe. Topics covered include drilling, completions, stimulations, surface facilities, production, artificial lift, reservoir, geology and geophysics. Also included are environmental and safety issues as related to the petroleum industry. Prerequisite: PEGN308 (grade C or better). 3 hours lab; 1 semester hour.

PEGN316. SUMMER FIELD SESSION II. 2.0 Semester Hrs.
(S) This two week course is taken after the completion of the junior year. Emphasis is placed on the multidisciplinary nature of reservoir management. Field trips in the area provide the opportunity to study eolian, fluvial, lacustrine, near shore, and marine depositional systems. These field trips provide the setting for understanding the complexity of each system in the context of reservoir development and management. Petroleum systems including the source, maturity, and trapping of hydrocarbons are studied in the context of petroleum exploration and development. Geologic methods incorporating both surface and subsurface data are used extensively. Prerequisites: PEGN315, PEGN419, GEOL308, and GEOL315. 6 hours lab; 2 semester hours.

PEGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

PEGN350. SUSTAINABLE ENERGY SYSTEMS. 3.0 Semester Hrs.
(I or II) A sustainable energy system is a system that lets us meet present energy needs while preserving the ability of future generations to meet their needs. Sustainable Energy Systems introduces undergraduate students to sustainable energy systems that will be available in the 21st century. The course focuses on sustainable energy sources, especially renewable energy sources and nuclear energy (e.g., fusion). Students are introduced to the existing energy infrastructure, become familiar with finite energy sources, and learn from a study of energy supply and demand that sustainable energy systems are needed. The ability to improve energy use efficiency and the impact of energy sources on the environment are discussed. Examples of sustainable energy systems and their applicability to different energy sectors are presented. The course is recommended for students who plan to enter the energy industry or students who would like an introduction to sustainable energy systems. Prerequisites: EDNS151. 3 hours lecture; 3 semester hours.

PEGN361. COMPLETION ENGINEERING. 3.0 Semester Hrs.
(II) (WI) This class is a continuation from drilling in PEGN311 into completion operations. Topics include casing design, cement planning, completion techniques and equipment, tubing design, wellhead selection, and sand control, and perforation procedures. 3 hours lecture; 3 semester hours. Prerequisite: PEGN311 and CEEN311.

PEGN382. PROFESSIONAL SKILLS 2. 1.0 Semester Hr.
This course is the second in a three-course series designed for petroleum engineering students to develop skills in oral and written communication, professionalism, diversity and ethics. The course is designed as a discussion based seminar course and will focus on oral and written communication skills. Assignments will be based on technical and non-technical material relating to earth, energy, and the environment. Students will work individually and in multicultural teams on assignments throughout the semester.

PEGN398. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PEGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PEGN411. MECHANICS OF PETROLEUM PRODUCTION. 3.0 Semester Hrs.
(II) Nodal analysis for pipe and formation deliverability including single and multiphase flow. Natural flow and design of artificial lift methods including gas lift, sucker rod pumps, electrical submersible pumps, and hydraulic pumps. 3 hours lecture; 3 semester hours. Prerequisite: PEGN251, PEGN308 (grade of C or better), PEGN311, and PEGN312.

PEGN414. WELL TESTING AND ANALYSIS. 3.0 Semester Hrs.
(I) Solution to the diffusivity equation. Transient well testing: build-up, drawdown, multi-rate test analysis for oil and gas. Flow tests and well deliverabilities. Type curve analysis. Super position, active and interference tests. Well test design. Prerequisites: MATH225 and PEGN419. 3 hours lecture; 3 semester hours.

PEGN419. WELL LOG ANALYSIS AND FORMATION EVALUATION. 3.0 Semester Hrs.
Equivalent with GPGN419,
(II) An introduction to well logging methods, including the relationship between measured properties and reservoir properties. Analysis of log suites for reservoir size and content. Graphical and analytical methods will be developed to allow the student to better visualize the reservoir, its contents, and its potential for production. Use of the computer as a tool to handle data, create graphs and log traces, and make computations of reservoir parameters is required. Prerequisites: GEOL315, PHGN 200 (grade of C or better). 3 hours lecture; 3 semester hours.

PEGN422. ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS. 3.0 Semester Hrs.
(I) Project economics for oil and gas projects under conditions of certainty and uncertainty. Topics include time value of money concepts, discount rate assumptions, measures of project profitability, costs, taxes, expected value concept, decision trees, gambler?s ruin, and Monte Carlo simulation techniques. 3 hours lecture; 3 semester hours.

PEGN423. PETROLEUM RESERVOIR ENGINEERING I. 3.0 Semester Hrs.
(I) Data requirements for reservoir engineering studies. Material balance calculations for normal gas, retrograde gas condensate, solution-gas and gas-cap reservoirs with or without water drive. Primary reservoir performance. Forecasting future recoveries by incremental material balance. 3 hours lecture; 3 semester hours. Prerequisite: PEGN419, PEGN316 and MATH 225 or MATH235.

PEGN424. PETROLEUM RESERVOIR ENGINEERING II. 3.0 Semester Hrs.
(II) Reservoir engineering aspects of supplemental recovery processes. Introduction to liquid-liquid displacement processes, gas-liquid displacement processes, and thermal recovery processes. Introduction to numerical reservoir simula tion, history matching and forecasting. Prerequisite: PEGN423 and PEGN438. 3 hours lecture; 3 semester hours.

PEGN426. FORMATION DAMAGE AND STIMULATION. 3.0 Semester Hrs.
Skin damage associated with formation damage, well deviation, and perforating. Formation damage mechanisms and causes. Stimulation techniques, including acidizing and fracturing. Calculation of matrix and fracturing rates and pressures. Design of matrix acidizing treatments. Selection/determination of hydraulic fracturing components including rock mechanical properties, in-situ stresses, proppants, fluid types, and diversion. Reservoir considerations in fracture propagation and design. Stimulation diagnostics and their application. Prerequisite: PEGN361 and PEGN411.

PEGN428. ADVANCED DRILLING ENGINEERING. 3.0 Semester Hrs.
(II) Rotary drilling systems with emphasis on design of drilling programs, directional and horizontal well planning. This elective course is recommended for petroleum engineering majors interested in drilling. Prerequisite: PEGN311, PEGN361. 3 hours lecture; 3 semester hours.

PEGN430. ENVIRONMENTAL LAW AND SUSTAINABILITY. 3.0 Semester Hrs.
(II) (WI) In this course students will be introduced to the fundamental legal principles that are relevant to sustainable engineering project development. General principles of United States (U.S.) environmental regulation pertaining to air quality, water quality, waste management, hazardous substances remediation, regulation of chemical manufacture and distribution, natural resources, and energy will be discussed in parallel with international laws pertaining to environmental protection and human rights. In the context of engineering project design, students will explore legal, societal, and ethical risks, and risk mitigation methodologies. 3 hours lecture; 3 semester hours.

PEGN438. PETROLEUM DATA ANALYTICS. 3.0 Semester Hrs.
(II) Introduction to elementary probability theory and its applications in engineering and sciences; discrete and continuous probability distributions; parameter estimation; hypothesis testing; linear regression; spatial correlations and geostatistics with emphasis on applications in earth sciences and engineering. Prerequisites: MATH112. 2 hours lecture; 3 hours lab; 3 semester hours.

PEGN439. MULTIDISCIPLINARY PETROLEUM DESIGN. 3.0 Semester Hrs.
Equivalent with GEGN439,GPGN439,
(II) (WI) This is a multi-disciplinary design course that integrates fundamentals and design concepts in geology, geophysics, and petroleum engineering. Students work in integrated teams consisting of students from each of the disciplines. Multiple open-ended design problems in oil and gas exploration and field development, including the development of a prospect in an exploration play and a detailed engineering field study are assigned. Several detailed written and oral presentations are made throughout the semester. Project economics including risk analysis are an integral part of the course. Prerequisites: GEOL308, PEGN316. Co-requisites: PEGN426. 2 hours lecture, 3 hours lab; 3 semester hours.

PEGN440. PETROLEUM DATA ANALYSIS. 3.0 Semester Hrs.
Capstone course for Petroleum Data Analytics minor. The course starts with an introduction to data analysis and visualization packages. The course then has three projects to include drilling, production, and reservoir data analysis along with data visualization techniques. The student will be required to prepare both oral and written and oral project updates and final results. Prerequisite: CSCI303, PEGN438.

PEGN450. ENERGY ENGINEERING. 3.0 Semester Hrs.
(I or II) Energy Engineering is an overview of energy sources that will be available for use in the 21st century. After discussing the history of energy and its contribution to society, we survey the science and technology of energy, including geothermal energy, fossil energy, solar energy, nuclear energy, wind energy, hydro energy, bio energy, energy and the environment, energy and economics, the hydrogen economy, and energy forecasts. This broad background will give you additional flexibility during your career and help you thrive in an energy industry that is evolving from an industry dominated by fossil fuels to an industry working with many energy sources. Prerequisite: MATH213, PHGN200. 3 hours lecture; 3 semester hours.

PEGN460. FLOW IN PIPE NETWORKS. 3.0 Semester Hrs.
(II) This course will provide an introduction to single and two phase hydraulics phenomena and modeling approaches to calculate pressure/temperature profile, losses along and flow rates along a production system. Furthermore, topics related to pipeline flow control and maintenance such as leak detection, damage prevention, integrity and pipe repairs will be covered. Finally, Federal Pipeline Safety Regulations and Health, Safety, and the Environment (HSE) regulations for the transportation of gas and hazardous liquids by pipeline will be discussed. In addition, this course will provide an introduction in transient theoretical modeling and design applications. OLGA transient multiphase flow simulator will be introduced and used to complete homework and final project. Industrial practices and operational problem related to transient production design will be covered. Prerequisites: PEGN251, CHGN209 , MATH225, and PEGN305. 3 hours lecture; 3 semester hours.

PEGN461. SURFACE FACILITIES DESIGN AND OPERATION. 3.0 Semester Hrs.
(I) This course will cover surface facilities typically required in the oil and gas industry. The course provides basic operation, design and evaluation of individual equipment such as Control equipment (control valve, pressure/level/flow rate/temperature), Liquid/gas Separators, Flowmeters, Boosting Equipment (pumps, compressors), Heaters, and Storage. Basic principles are described to design and evaluate different midstream processes such as Oil/water treating, Gas/liquid and liquid/liquid separation, Crude oil stabilization, Gas handling facilities, Dehydration, Gas Sweetening, Liquefied Natural Gas (LNG), Gas to Liquids (GTL). Furthermore, potential operation problems and piping and instrumentation diagram/drawing (P&ID) related to this processes will be discussed. Calculation examples and a design project can be given to integrate all acquired knowledge. Furthermore, ASME and API norms related to material selection, equipment selection, operation and maintenance will be discussed. Finally, Health, Safety, and the Environment (HSE) regulations for midstream operations will be discussed. Course objectives include learning how to select and operate different surface equipment required in the oil and natural gas industry, learning how to monitor, troubleshoot and optimize the operation of different surface equipment required in the oil and natural gas industry. Prerequisites: PEGN251, CHGN209, MATH225, PEGN305. 3 hours lecture; 3 semester hours.

PEGN462. FLOW ASSURANCE. 3.0 Semester Hrs.
(I) This course will cover hydrocarbon production including design and operational issues. Major subjects to be covered include the prediction of hydrates formation, paraffin, asphaltene, scale and sand deposition, and remedial actions. In addition, operational problems such as slugging, emulsions and corrosion will be covered. This course will provide to student's strong background on hydraulic modeling. Prerequisites: PEGN251, CHGN209, MATH225, and PEGN305. 3 hours lecture; 3 semester hours.

PEGN463. PETROLEUM MIDSTREAM DESIGN. 3.0 Semester Hrs.
(II) This course will cover the development of an integrated project in the midstream area. In this the students will integrate the knowledge from the midstream classes to solve a given problem with consideration of social responsibility and societal impacts. The objective is to work with several companies from the midstream sector to solve field problems. Furthermore, in this class, we will have some classes to cover more specific subjects with different presenters (i.e. safety, regulations, marketing, environment, new technologies for pipe repairs or inspections, software, process to sell/buy oil, etc), field visits, etc. 3 hours lecture; 3 semester hours. Prerequisite: PEGN460, PEGN461, PEGN462. Co-requisite: PEGN460.

PEGN481. PETROLEUM SEMINAR. 2.0 Semester Hrs.
(I) (WI) Written and oral presentations by each student on current energy topics. This course is designated as a writing intensive course (WI). Prerequisite: none. 2 hours lecture; 2 semester hours.

PEGN482. PROFESSIONAL SKILLS 3. 1.0 Semester Hr.
This course is the third in a three-course series designed for petroleum engineering students to develop skills in oral and written communication, professionalism, diversity and ethics. The course is designed as a discussion based seminar course and will focus on oral and written communication skills, professionalism, diversity and ethics. Assignments will be based on technical and non-technical material relating to earth, energy, and the environment. Students will work individually and in multicultural teams on assignments throughout the semester.

PEGN490. RESERVOIR GEOMECHANICS. 3.0 Semester Hrs.
(I) The course provides an introduction to fundamental rock mechanics and aims to emphasize their role in oil and gas exploration, drilling, completion and production engineering operations. Deformation as a function of stress, elastic moduli, in situ stress, stress magnitude and orientation, pore pressure, strength and fracture gradient, rock characteristic from field data (seismic, logging, drilling, production), integrated wellbore stability analysis, depletion and drilling induced fractures, compaction and associated changes in rock properties, hydraulic fracturing and fracture stability are among the topics to be covered. Pre-requisites: CEEN311. 3 hours lecture; 3 hours lab, 3 semester hours.

PEGN498. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PEGN499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professors

Hossein Kazemi, Chesebro' Distinguished Chair

Jennifer L. Miskimins, Department Head, F.H. "Mick" Merelli/Cimarex Energy Distinguished Department Head

Erdal Ozkan

Yu-Shu Wu

Associate Professors

Xiaolong Yin, Associate Department Head

Luis E. Zerpa

Assistant Professors

Yilin Fan

Teaching Professor

Linda A. Battalora

Teaching Associate Professors

Mansur Ermila

Mark G. Miller

Research Associate Professors

Alfred W. Eustes III

Philip H. Winterfeld

Professor of Practice

Jim Crompton

Elio S. Dean

William W. Fleckenstein

Adjunct Professor

Trent Green

Professor Emeritus

Ramona M. Graves, Professor and Dean Emeritus

Bill Scoggins, President Emeritus

Craig W. Van Kirk, Professor Emeritus

Associate Professor Emeritus

Richard Christiansen, Associate Professor Emeritus

Physics

Program Description - Engineering Physics

Physics provides the foundation for most applied science and engineering disciplines. It attracts those who wish to understand nature at its most fundamental level. The engineering physics program at Mines is interdisciplinary in nature, taking basic undergraduate physics subjects further with direct applications to engineering. ABET, the Accreditation Board for Engineering and Technology (http://www.abet.org), accredits the degree to provide graduates the first step towards professional licensure.

At Mines, the required engineering physics curriculum includes the requisite undergraduate physics courses that form rigorous study at any 4-year university. In addition to these core courses, Mines requirements include pre-engineering and engineering classes that physics majors at other universities would not ordinarily take. These courses include immersions in engineering science, engineering design, systems, a summer field session practicum, and a capstone senior design sequence culminating in a senior thesis.

The unique blend of physics and engineering makes it possible for a Mines engineering physics graduate to work at the interface between science and technology where new discoveries are made and continually being put into practice. While engineering physicists are proficient applying existing technologies, they are also willing to explore novel approaches and capable of developing new technologies. The excitement and fulfillment of working on innovative challenges make a Mines engineering physics degree attractive to many students.

With the flexibility of our degree, our undergraduates find themselves following a variety of career paths. Many find employment in fields as diverse as aerospace engineering, biomedical science, computational modeling of physical systems, device manufacturing and semiconductor processing, geophysics, materials development, nanotechnology, nuclear science and engineering, renewable and conventional energy industries, semiconductor manufacturing and processing, energy, and even entertainment enterprises that place high demands on animation, audio, special effects, and visualization talents. More than half of our seniors pursue graduate studies in physics or a closely related field of engineering. Some take their undergraduate training into post-graduate professional studies in business, law, management, medicine, or quantum engineering.

Mines physics faculty and staff maintain modern, state-of-the-art laboratories for general physics, modern physics, electronics, and advanced investigations. There are research laboratories for the study of condensed matter, materials science, nuclear physics, optics, and quantum physics & computing. The department maintains well-equipped, professionally staffed, electronic labs and machine shops to help students and faculty accomplish their curriculum, project, and research goals. The department also nurtures strong ties with national laboratories and local engineering design firms that provide students with authentic collaboration opportunities.

Program Educational Objectives (Bachelor of Science in Engineering Physics)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile, the Physics Department is dedicated to additional educational objectives.

The program prepares graduates who, based on factual knowledge and other skills necessary to construct an appropriate understanding of physical phenomena in applied contexts, will:

1. Obtain a range of positions in industry or positions in government facilities or pursue graduate education in engineering, science or related fields;
2. Communicate and perform effectively within the criteria of their chosen careers;
3. Engage in appropriate professional societies and continuing education activities;
4. Participate ethically as members of the global society.

Degree Requirements (Engineering Physics)

Freshman

Fall		lec	lab	sem.hrs
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS, CBEN 110, or CSCI101 AND CSCI102[If student chooses to complete CSCI101 (3 credits) for the Distributed Science requirement, they must also take CSCI102 (1 credit) lab course to meet the 4 total hours required.]			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Spring		lec	lab	sem.hrs
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
EDNS151	DESIGN I			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.5
EDNS269	DESIGN II: ENGINEERING PHYSICS, 251, 261, 262, 263, 264, CEEN 267, or GPGN 268			3.0
HASS200	GLOBAL STUDIES			3.0

PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0
Spring		**lec**	**lab**	**sem.hrs**
CSCI250	PYTHON-BASED COMPUTING: BUILDING A SENSOR SYSTEM			3.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
MATH332	LINEAR ALGEBRA			3.0
PHGN310	HONORS PHYSICS III-MODERN PHYSICS or 300			3.0
PHGN215	ANALOG ELECTRONICS			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.5
Summer		**lec**	**lab**	**sem.hrs**
PHGN384	FIELD SESSION TECHNIQUES IN PHYSICS			6.0
				6.0
Junior				
Fall		**lec**	**lab**	**sem.hrs**
PHGN315	ADVANCED PHYSICS LAB I			2.0
PHGN311	INTRODUCTION TO MATHEMATICAL PHYSICS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
PHGN317	SEMICONDUCTOR CIRCUITS-DIGITAL			3.0
PHGN350	INTERMEDIATE MECHANICS			4.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
PHGN361	INTERMEDIATE ELECTROMAGNETISM			3.0
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS			4.0
PHGN326	ADVANCED PHYSICS LAB II			2.0
PHGN341	THERMAL PHYSICS			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
				15.0
Senior				
Fall		**lec**	**lab**	**sem.hrs**
PHGN471	SENIOR DESIGN PRINCIPLES I			0.5
PHGN481	SENIOR DESIGN PRACTICE			2.5
PHGN462	ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) Mid-Level Restricted Elective			3.0
FREE	Free Elective I			3.0
FREE	Free Elective II			3.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
PHGN472	SENIOR DESIGN PRINCIPLES II			0.5
PHGN482	SENIOR DESIGN PRACTICE			2.5
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-Level Restricted Elective			3.0
ENG SCI	Engineering Science Elective			3.0
FREE	Free Elective III			3.0
FREE	Free Elective IV			3.0
				15.0

Total Semester Hrs: 130.5

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

PHGN100 through PHGN599 inclusive

Combined Baccalaureate/Masters and Baccalaureate/Doctoral Degree Programs

The Physics Department offers combined BS/MS degree programs in which students obtain an undergraduate degree in Engineering Physics, in as few as four years, as well as a masters degree in Applied Physics, in an Engineering discipline, in Technology Management, in Materials Science, or in Mathematics, after an additional year of study. There are engineering tracks, physics tracks, a management track, a materials science track, and a mathematics track. These programs emphasize a strong background in fundamentals of science, in addition to practical experience within an applied science, engineering, or mathematics discipline. Many of the undergraduate electives of students involved in each track are specified. For this reason, students are expected to apply to the program during the first semester of their sophomore year (in special cases late entry can be approved by the program mentors). A 3.0 grade point average must be maintained to guarantee admission into the physics, engineering, and materials science graduate programs. A 3.3 grade point average must be maintained to guarantee admission into the mathematics graduate program.

Students in the engineering tracks must complete a report or case study during the last year. Students in the physics, materials science, and mathematics tracks must complete a master's thesis. Students in the nuclear engineering program can choose between thesis and non-thesis options. The case study or thesis should begin during the senior year as part of the Senior Design experience. Participants must identify an engineering or physics advisor as appropriate prior to their senior year who will assist in choosing an appropriate project and help coordinate the senior design project with the case study or thesis completed in the last year.

It is also possible for undergraduate students to begin work on a doctoral degree in Applied Physics while completing the requirements for their bachelor's degree. Students in this combined baccalaureate/doctoral

program may fulfill part of the requirements of their doctoral degree by including up to six hours of specified course credits that are also used to fulfill the requirements of their undergraduate degree. These courses may only be applied toward fulfilling doctoral degree requirements. Courses must meet all requirements for graduate credit, but their grades are not included in calculating the graduate GPA.

Interested students can obtain additional information and detailed curricula from the Physics Department or from the participating engineering departments.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Minor and Area of Special Interest

The department offers a Minor and Area of Special Interest for students not majoring in physics. The requirements are as follows:

Area of Special Interest (12 semester hours minimum)		
PHGN100	PHYSICS I - MECHANICS	4.5
or PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	
Minor (18 semester hours minimum)		
PHGN100	PHYSICS I - MECHANICS	4.5
or PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
or PHGN310	HONORS PHYSICS III-MODERN PHYSICS	
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS	4.0
Select one of the following:		3-4
PHGN341	THERMAL PHYSICS	
PHGN350	INTERMEDIATE MECHANICS	
PHGN361	INTERMEDIATE ELECTROMAGNETISM	

Selected courses to complete the Minor: Upper division (400-level) and/or graduate (500-level) courses which form a logical sequence in a specific field of study as determined in consultation with the Physics Department and the student's option department.

Biophysics Minor

To obtain a Biophysics Minor, students must take at least 18.0 credits related to Biophysics. Two courses (8.0 credits) of Biology are required. Two additional requirements include Biophysics (PHGN433) and Laser Physics (PHGN480). Two more courses (or at least 4.0 credits) may be chosen from the list below. The list of electives will be modified as new related courses that fall into these categories become available. While the current emphasis of the Biophysics Minor is on optical techniques, we intend to add alternative tracks, for example radiologic (nuclear) techniques.

Required Courses (14.0 Credits)

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
PHGN433	BIOPHYSICS	3.0
PHGN480	LASER PHYSICS	3.0

Two Elective courses (at least 4.0 credits) from the list below:

PHGN466	MODERN OPTICAL ENGINEERING	3.0
or PHGN566	MODERN OPTICAL ENGINEERING	
PHGN570	FOURIER AND PHYSICAL OPTICS	3.0
CBEN310	INTRODUCTION TO BIOMEDICAL ENGINEERING	3.0
CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0
or CBEN531	IMMUNOLOGY FOR SCIENTISTS AND ENGINEERS	
CBEN454	APPLIED BIOINFORMATICS	3.0
or CBEN554	APPLIED BIOINFORMATICS	
MATH331	MATHEMATICAL BIOLOGY	3.0
NUGN535	INTRODUCTION TO HEALTH PHYSICS	3.0
PHGN504	RADIATION DETECTION AND MEASUREMENT	3.0
CHGN428	BIOCHEMISTRY	3.0
MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
CBEN470	INTRODUCTION TO MICROFLUIDICS	3.0
MEGN436	COMPUTATIONAL BIOMECHANICS	3.0
or MEGN536	COMPUTATIONAL BIOMECHANICS	

Courses

PHGN100. PHYSICS I - MECHANICS. 4.5 Semester Hrs.
(I,II,S) A first course in physics covering the basic principles of mechanics using vectors and calculus. The course consists of a fundamental treatment of the concepts and applications of kinematics and dynamics of particles and systems of particles, including Newton's laws, energy and momentum, rotation, oscillations, and waves. Prerequisite: MATH111. Co-requisites: MATH112 or MATH113 or MATH122. 2 hours lecture; 4 hours studio; 4.5 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-SC1.

PHGN198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Prerequisite: none. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

PHGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I,II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PHGN200. PHYSICS II-ELECTROMAGNETISM AND OPTICS. 4.5 Semester Hrs.
(I, II, S) Continuation of PHGN100. Introduction to the fundamental laws and concepts of electricity and magnetism, electromagnetic devices, electromagnetic behavior of materials, applications to simple circuits, electromagnetic radiation, and an introduction to optical phenomena. Prerequisite: Grade of C- or higher in PHGN100, concurrent enrollment in MATH213 or MATH214 or MATH223. 2 hours lecture; 4 hours studio; 4.5 semester hours.

PHGN215. ANALOG ELECTRONICS. 4.0 Semester Hrs.
(II) Introduction to analog devices used in modern electronics and basic topics in electrical engineering. Introduction to methods of electronics measurements, particularly the application of oscilloscopes and computer based data acquisition. Topics covered include circuit analysis, electrical power, diodes, transistors (FET and BJT), operational amplifiers, filters, transducers, and integrated circuits. Laboratory experiments in the use of basic electronics for physical measurements. Emphasis is on practical knowledge gained in the laboratory, including prototyping, troubleshooting, and laboratory notebook style. Prerequisite: PHGN200. 3 hours lecture, 3 hours lab; 4 semester hours.

PHGN298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Prerequisite: none. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

PHGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I,II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PHGN300. PHYSICS III-MODERN PHYSICS I. 3.0 Semester Hrs.
Equivalent with PHGN310,
(I) Our technical world is filled with countless examples of modern physics. This course will discuss some historic experiments that led to the key discoveries, and the basic concepts, theories, and models behind some of our present day technologies. Topics may include special relativity, quantum physics, atomic and molecular physics, solid-state physics, semiconductor theory and devices, nuclear physics, particle physics and cosmology. Prerequisite: PHGN200; Concurrent enrollment in MATH225. 3 hours lecture; 3 semester hours.

PHGN310. HONORS PHYSICS III-MODERN PHYSICS. 3.0 Semester Hrs.
Equivalent with PHGN300,
(II) The third course in introductory physics with in depth discussion on special relativity, wave-particle duality, the Schroedinger equation, electrons in solids, quantum tunneling, nuclear structure and transmutations. Registration is strongly recommended for declared physics majors and those considering majoring or minoring in physics. Prerequisite: PHGN200; Concurrent enrollment in MATH225. 3 hours lecture; 3 semester hours.

PHGN311. INTRODUCTION TO MATHEMATICAL PHYSICS. 3.0 Semester Hrs.
(I) Demonstration of the unity of diverse topics such as mechanics, quantum mechanics, optics, and electricity and magnetism via the techniques of linear algebra, complex variables, Fourier transforms, and vector calculus. Prerequisites: PHGN300 or PHGN310, MATH225, MATH332, and CSCI250. 3 hours lecture; 3 semester hours.

PHGN315. ADVANCED PHYSICS LAB I. 2.0 Semester Hrs.
(I) (WI) Introduction to laboratory measurement techniques as applied to modern physics experiments. Experiments from optics and atomic physics. A writing-intensive course with laboratory and computer design projects based on applications of modern physics. Prerequisite: PHGN300/310, PHGN384. 1 hour lecture, 3 hours lab; 2 semester hours.

PHGN317. SEMICONDUCTOR CIRCUITS- DIGITAL. 3.0 Semester Hrs.
(I) Introduction to digital devices used in modern electronics. Topics covered include logic gates, flip-flops, timers, counters, multiplexing, analog-to-digital and digital-to-analog devices. Emphasis is on practical circuit design and assembly. Prerequisite: PHGN215 and CSCI250. 2 hours lecture; 3 hours lab; 3 semester hours.

PHGN320. MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS. 4.0 Semester Hrs.
(II) Introduction to the Schroedinger theory of quantum mechanics. Topics include Schroedinger's equation, quantum theory of measurement, the uncertainty principle, eigenfunctions and energy spectra, anular momentum, perturbation theory, and the treatment of identical particles. Example applications taken from atomic, molecular, solid state or nuclear systems. Prerequisites: PHGN300 or PHGN310 and PHGN311. 4 hours lecture; 4 semester hours.

PHGN324. INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS. 3.0 Semester Hrs.
(II) Celestial mechanics; Kepler's laws and gravitation; solar system and its contents; electromagnetic radiation and matter; stars: distances, magnitudes, spectral classification, structure, and evolution. Variable and unusual stars, pulsars and neutron stars, supernovae, black holes, and models of the origin and evolution of the universe. Prerequisite: PHGN200. 3 hours lecture; 3 semester hours.

PHGN326. ADVANCED PHYSICS LAB II. 2.0 Semester Hrs.
(II) (WI) Continuation of PHGN315. A writing-intensive course which expands laboratory experiments to include nuclear and solid state physics. Prerequisite: PHGN315. 1 hour lecture, 3 hours lab; 2 semester hours.

PHGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 1 to 3 semester hours. Repeatable up to 3 credit hours.

PHGN341. THERMAL PHYSICS. 3.0 Semester Hrs.
(II) An introduction to statistical physics from the quantum mechanical point of view. The microcanonical and canonical ensembles. Heat, work and the laws of thermodynamics. Thermodynamic potentials; Maxwell relations; phase transformations. Elementary kinetic theory. An introduction to quantum statistics. Prerequisite: CHGN122 or CHGN125 and PHGN311. 3 hours lecture; 3 semester hours.

PHGN350. INTERMEDIATE MECHANICS. 4.0 Semester Hrs.
(I) Begins with an intermediate treatment of Newtonian mechanics and continues through an introduction to Hamilton's principle and Hamiltonian and Lagrangian dynamics. Includes systems of particles, linear and driven oscillators, motion under a central force, two-particle collisions and scattering, motion in non-inertial reference frames and dynamics of rigid bodies.Prerequisite:PHGN200. Corequisite: PHGN311. 4 hours lecture; 4 semester hours.

PHGN361. INTERMEDIATE ELECTROMAGNETISM. 3.0 Semester Hrs.
(II) Theory and application of the following: static electric and magnetic fields in free space, dielectric materials, and magnetic materials; steady currents; scalar and vector potentials; Gauss' law and Laplace's equation applied to boundary value problems; Ampere's and Faraday's laws. Prerequisite: PHGN200 and PHGN311. 3 hours lecture; 3 semester hours.

PHGN384. FIELD SESSION TECHNIQUES IN PHYSICS. 1-6 Semester Hr.
(S) Introduction to the design and fabrication of engineering physics apparatus. Intensive individual participation in the design of machined system components, vacuum systems, electronics, optics, and application of computer interfacing systems and computational tools. Supplementary lectures on safety, laboratory techniques and professional development. Visits to regional research facilities and industrial plants. Prerequisites: PHGN300 or PHGN310, PHGN215, CSCI250. 6 semester hours.

PHGN398. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Prerequisite: none. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

PHGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I,II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PHGN401. PHYSICS SEMINAR. 1.0 Semester Hr.
Students will attend the weekly physics seminar. Students will be responsible for presentation and discussion. Co-requisite: PHGN300 or PHGN310.

PHGN417. FUNDAMENTALS OF QUANTUM INFORMATION. 3.0 Semester Hrs.
This course serves as a broad introduction to quantum information science, open to students from many backgrounds. The basic structure of quantum mechanics (Hilbert spaces, operators, wavefunctions, entanglement, superposition, time evolution) is presented, as well as a number of important topics relevant to current quantum hardware (including oscillating fields, quantum noise, and more). Finally, we will survey the gate model of quantum computing, and study the critical subroutines which provide the promise of a quantum speedup in future quantum computers. Prerequisite: MATH332 or MATH342.

PHGN418. GENERAL RELATIVITY. 3.0 Semester Hrs.
(II) Introduction to Einstein's theory of gravitation. Requisite mathematics introduced and developed including tensor calculus and differential geometry. Formulation of Einstein field and geodesic equations. Development and analysis of solutions including stellar, black hole and cosmological geometries. Prerequisite: PHGN350. 3 hours lecture; 3 semester hours.

PHGN419. PRINCIPLES OF SOLAR ENERGY SYSTEMS. 3.0 Semester Hrs.
Review of the solar resource and components of solar irradiance; principles of photovoltaic devices and photovoltaic system design; photovoltaic electrical energy production and cost analysis of photovoltaic systems relative to fossil fuel alternatives; introduction to concentrated photovoltaic systems and manufacturing methods for wafer-based and thin film photovoltaic panels. Prerequisite: PHGN200 and MATH225. 3 hours lecture; 3 semester hours.

PHGN422. NUCLEAR PHYSICS. 3.0 Semester Hrs.
Introduction to subatomic (particle and nuclear) phenomena. Characterization and systematics of particle and nuclear states; symmetries; introduction and systematics of the electromagnetic, weak, and strong interactions; systematics of radioactivity; liquid drop and shell models; nuclear technology. Prerequisite: PHGN300/310. 3 hours lecture; 3 semester hours.

PHGN423. PARTICLE PHYSICS. 3.0 Semester Hrs.
(II) Introduction to the Standard Model of particle physics including: experimental methods, motivation and evaluation of amplitudes from Feynman diagrams with applications to scattering cross-sections and decay rates, organization of interactions based on underlying gauge-symmetry principles, Dirac equation and relativistic spinors, C, P and T symmetries, renormalization, spontaneous symmetry breaking and the Higgs mechanism for mass generation. Prerequisites: PHGN350. Co-requisites: PHGN320. 3 hour lecture.

PHGN424. ASTROPHYSICS. 3.0 Semester Hrs.
(II) A survey of fundamental aspects of astrophysical phenomena, concentrating on measurements of basic stellar properties such as distance, luminosity, spectral classification, mass, and radii. Simple models of stellar structure evolution and the associated nuclear processes as sources of energy and nucleosynthesis. Introduction to cosmology and physics of standard big-bang models. Prerequisite: PHGN300/310. 3 hours lecture; 3 semester hours.

PHGN433. BIOPHYSICS. 3.0 Semester Hrs.
Equivalent with PHGN333,
(II) This course is designed to show the application of physics to biology. It will assess the relationships between sequence structure and function in complex biological networks and the interfaces between physics, chemistry, biology and medicine. Topics include: biological membranes, biological mechanics and movement, neural networks, medical imaging basics including optical methods, MRI, isotopic tracers and CT, biomagnetism and pharmacokinetics. Prerequisites: CBEN110. 3 hours lecture; 3 semester hours.

PHGN435. INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY. 3.0 Semester Hrs.
Equivalent with
CBEN435,CBEN535,CHEN435,CHEN535,MLGN535,PHGN535,
Application of science and engineering principles to the design, fabrication, and testing of microelectronic devices. Emphasis on specific unit operations and the interrelation among processing steps. Prerequisites: Senior standing in PHGN, CHGN, MTGN, or EGGN. 1.5 hours lecture, 4 hours lab; 3 semester hours.

PHGN440. SOLID STATE PHYSICS. 3.0 Semester Hrs.
An elementary study of the properties of solids including crystalline structure and its determination, lattice vibrations, electrons in metals, and semiconductors. (Graduate students in physics may register only for PHGN440.) Prerequisite: PHGN320. 3 hours lecture; 3 semester hours.

PHGN441. SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA. 3.0 Semester Hrs.
Continuation of PHGN440/ MLGN502 with an emphasis on applications of the principles of solid state physics to practical properties of materials including: optical properties, superconductivity, dielectric properties, magnetism, noncrystalline structure, and interfaces. (Graduate students in physics may register only for PHGN441.) Prerequisite: PHGN440 or MLGN502. 3 hours lecture; 3 semester hours.

PHGN450. COMPUTATIONAL PHYSICS. 3.0 Semester Hrs.
Introduction to numerical methods for analyzing advanced physics problems. Topics covered include finite element methods, analysis of scaling, efficiency, errors, and stability, as well as a survey of numerical algorithms and packages for analyzing algebraic, differential, and matrix systems. The numerical methods are introduced and developed in the analysis of advanced physics problems taken from classical physics, astrophysics, electromagnetism, solid state, and nuclear physics. Prerequisites: Introductory-level knowledge of C, Fortran, or Basic; and PHGN311. 3 hours lecture; 3 semester hours.

PHGN462. ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS. 3.0 Semester Hrs.
(I) Solutions to the electromagnetic wave equation are studied, including plane waves, guided waves, refraction, interference, diffraction and polarization; applications in optics; imaging, lasers, resonators and wave guides. Prerequisite: PHGN361. 3 hours lecture; 3 semester hours.

PHGN466. MODERN OPTICAL ENGINEERING. 3.0 Semester Hrs.
Provides students with a comprehensive working knowledge of optical system design that is sufficient to address optical problems found in their respective disciplines. Topics include paraxial optics, imaging, aberration analysis, use of commercial ray tracing and optimization, diffraction, linear systems and optical transfer functions, detectors and optical system examples. Prerequisite: PHGN462. 3 hours lecture; 3 semester hours.

PHGN471. SENIOR DESIGN PRINCIPLES I. 0.5 Semester Hrs.
(I) (WI) The first of a two semester sequence covering the principles of project design. Class sessions cover effective team organization, project planning, time management, literature research methods, record keeping, fundamentals of technical writing, professional ethics, project funding and intellectual property. Prerequisites: PHGN384 and PHGN326. Co-requisites: PHGN481 or PHGN491. 1 hour lecture in 7 class sessions; 0.5 semester hours.

PHGN472. SENIOR DESIGN PRINCIPLES II. 0.5 Semester Hrs.
(II) (WI) Continuation of PHGN471. Prerequisite: PHGN384 and PHGN326. Co-requisite: PHGN482 or PHGN492. 1 hour lecture in 7 class sessions; 0.5 semester hours.

PHGN480. LASER PHYSICS. 3.0 Semester Hrs.
(I) Theory and application of the following: Interaction of light with atoms: absorption, gain, rate equations and line broadening. Propagation, control and measurement of light waves: Gaussian beams, optical resonators and wave guides, interferometers. Laser design and operation: pumping, oscillation, and dynamics (Q-switching and mode-locking). Introduction to ultrafast optics. Laboratory: alignment and characterization of laser systems. Prerequisites: PHGN320. Co-requisites: PHGN462. 3 hours lecture; 3 semester hours.

PHGN481. SENIOR DESIGN PRACTICE. 2.5 Semester Hrs.
(I) (WI) The first of a two semester program covering the full spectrum of project design, drawing on all of the student's previous course work. At the beginning of the first semester, the student selects a research project in consultation with the Senior Design Oversight Committee (SDOC) and the Project Mentor. The objectives of the project are given to the student in broad outline form. The student then designs the entire project, including any or all of the following elements as appropriate: literature search, specialized apparatus or algorithms, block-diagram electronics, computer data acquisition and/or analysis, sample materials, and measurement and/or analysis sequences. The course culminates in a formal interim written report. Prerequisite: PHGN384 and PHGN326. Co-requisite: PHGN471. 6 hour lab; 2.5 semester hours.

PHGN482. SENIOR DESIGN PRACTICE. 2.5 Semester Hrs.
(II) (WI) Continuation of PHGN481. The course culminates in a formal written report and poster. Prerequisite: PHGN384 and PHGN326. Co-requisite: PHGN472. 6 hour lab; 2.5 semester hours.

PHGN491. HONORS SENIOR DESIGN PRACTICE. 2.5 Semester Hrs.
(I) (WI) Individual work on an advanced research topic that involves more challenging demands than a regular senior design project. Honors students will devote more time to their project, and will produce an intermediate report in a more advanced format. Prerequisite: PHGN384 and PHGN326. Corequisite: PHGN471. 7.5 hour lab; 2.5 semester hours.

PHGN492. HONORS SENIOR DESIGN PRACTICE. 2.5 Semester Hrs.
(II) (WI) Continuation of PHGN481 or PHGN491. The course culminates in a formal written report and poster. The report may be in the form of a manuscript suitable for submission to a professional journal. Prerequisite: PHGN481 or PHGN491. Corequisite: PHGN472. 7.5 hour lab; 2.5 semesterhours.

PHGN498. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Prerequisite: none. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

PHGN498. SPECIAL TOPICS. 1-6 Semester Hr.
This course is designed for anyone interested in teaching physics at either the college or high school level. Topics include teaching methods for class time, recitation, labs, and homework. Students will engage directly with these methods as well as read the literature supporting each. Additionally time will be spent on assessment, both formative and summative; how to probe student thinking, what they are learning each class period, and what they have learned by the end of the term.

PHGN499. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I,II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professors

Lincoln D. Carr

Charles G. Durfee III

Uwe Greife

Mark T. Lusk

Frederic Sarazin, Department Head

Jeff A. Squier

Lawrence R. Wiencke

Associate Professors

Eliot Kapit

Timothy R. Ohno

Eric S. Toberer, Director of the Materials Science Program

Assistant Professors

Daniel Adams

Serena M. Eley

Zhexuan Gong

Kyle G. Leach

Susanta K. Sarkar

Meenakshi Singh

Jeramy D. Zimmerman

Teaching Professors

Kristine E. Callan

Alex T. Flournoy

Patrick B. Kohl

H. Vincent Kuo, Assistant Department Head

Todd G. Ruskell

Charles A. Stone

Teaching Assistant Professor

Emily M. Smith

Research Associate Professor

Wendy Adams Spencer

Research Assistant Professors

P. David Flammer

Laith Haddad

Lakshmi Krishna

Lokender Kumar

Nitin Kumar

K. Xerxes Steirer

Professors Emeriti

F. Edward Cecil

Reuben T. Collins

Thomas E. Furtak

Frank V. Kowalski

John Scales

P. Craig Taylor

John Trefny, President Emeritus

Don L. Williamson

Associate Professors Emeriti

David M. Wood

Additional Programs

Aerospace Studies

Air Force ROTC (AFROTC)

The Department of Aerospace Studies offers programs leading to an officer's commission in the Air Force in conjunction with an undergraduate or graduate degree.

Aerospace science courses are designed to supplement a regular degree program by offering practical leadership and management experience. The Aerospace Studies Program at Colorado School of Mines (MINES) is offered in conjunction with the University of Colorado at Boulder (CUB).

Four-Year Program

The four-year program consists of two phases: the general military course (freshman and sophomore years) and the professional officer course (junior and senior years). This program is designed for incoming freshmen or any student with four years remaining until degree completion. It consists of three parts: the General Military Course (GMC) for lower division (normally freshmen and sophomore) students; the Professional Officer Course (POC) for upper division students (normally juniors and seniors); and Leadership Laboratory (LLAB-attended by all cadets). Completion of a four-week summer training course is required prior to commissioning.

Leadership Lab

All AFROTC cadets must attend Leadership Lab (2 hours per week). The laboratory involves a study of Air Force customs and courtesies, drill and ceremonies, career opportunities, and the life and work of an Air Force officer.

General Military Course (GMC)

The basic course covers Air Force history and organization as well as military leadership and management. Laboratory sessions provide the opportunity to apply leadership skills while learning basic military skills. Enrollment in the basic course incurs no military obligation except for Air Force scholarship recipients.

Professional Officer Course (POC)

The advanced course covers military officership, leadership and unit operations, training techniques, military law, and professional ethics, and includes a leadership practicum each semester. A Field Training encampment provides challenging leadership training and is a prerequisite for commissioning. Advanced course students must have completed the basic course and obtain permission from the Professor of Aerospace Studies (PAS) to enroll in the POC.

Three-Year Program

The three-year program consists of the first two years of GMC courses taken concurrently in one year. The student then attends a Field Training encampment, and completes two years of advanced POC courses.

Scholarship Programs

Two-year, Three-year and Four-year college scholarships are available to eligible high school seniors, who apply before December 1 of their senior year. Scholarship students receive tuition assistance and mandatory laboratory fees, a book allowance, and a monthly stipend. Students interested in the scholarship program should contact the AFROTC Unit Admissions Officer no later than the beginning of the spring semester to apply for the following academic year. A complete listing of all available AFROTC scholarships is available at www.afrotc.com.

Registration and Credits

Air Force ROTC serves as free-elective credit in most departments. Elective course credit toward your degree for AFROTC classes will be determined by your individual academic advisor. Students who wish to register for Air Force ROTC classes do so through the normal course registration process at Mines. AFROTC classes begin with the AFGN prefix. For more information about AFROTC, contact the Detachment 105 Air Force ROTC Unit at 303-492-8278, or the department on campus directly at 303-273-3380. The department is located in the Military Science building at 1020 19th Street.

Other AFROTC Programs

Other programs are frequently available based on current Air Force needs. Contact a Detachment 105 representative at 303-492-8278.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Aerospace Studies Minor

Air Force ROTC cadets desiring to receive a minor in Aerospace Studies must complete at least 20 hours of Aerospace Studies courses as follows:

AFGN101	HERITAGE AND VALUES I	1.5
AFGN102	HERITAGE AND VALUES II	1.5
AFGN201	TEAM AND LEADERSHIP FUNDAMENTALS I	1.5
AFGN202	TEAM AND LEADERSHIP FUNDAMENTALS II	1.5
AFGN301	LEADING PEOPLE AND EFFECTIVE COMMUNICATION I	3.5
AFGN302	LEADING PEOPLE AND EFFECTIVE COMMUNICATION II	3.5
AFGN401	NATIONAL SECURITY, LEADERSHIP RESPONSIBILITIES, COMMISSIONING PREPARATION I	3.5
AFGN402	NATIONAL SECURITY, LEADERSHIP RESPONSIBILITIES, COMMISSIONING PREPARATION II	3.5
Total Semester Hrs		**20.0**

Courses

AFGN101. HERITAGE AND VALUES I. 1.5 Semester Hr.
This course provides an introduction to the Air Force, encourages students to pursue an AF career or seek additional information to be better informed about the role of the USAF. The course allows students to examine general aspects of the Department of the Air Force, AF Leadership, Air Force benefits, and opportunities for AF officers. The course also lays the foundation for becoming an Airman by outlining our heritage and values. Weekly Leadership Lab for this course (to be taken in conjunction with AFGN101 and 102) is a weekly laboratory that touches on the topics of Air Force customs and courtesies, health and physical fitness, and drill and ceremonies.

AFGN102. HERITAGE AND VALUES II. 1.5 Semester Hr.
A continuation of AFGN101. This course provides a historical perspective including lessons on war and the US military, AF operations, principles of war, and airpower. This course also provides students with an understanding for the employment of air and space power, from an institutional, doctrinal, and historical perspective. The students are introduced to the Air Force way of life and gain knowledge on what it means to be an Airman. Weekly Leadership Lab for this course (to be taken in conjunction with AFGN101 and 102) is a weekly laboratory that touches on the topics of Air Force customs and courtesies, health and physical fitness, and drill and ceremonies.

AFGN201. TEAM AND LEADERSHIP FUNDAMENTA. 1.5 Semester Hr.
This course is designed to provide a fundamental understanding of both leadership and team building. This course teaches students that there are many layers to leadership, including aspects that are not always obvious. Such things include listening, understanding themselves, being a good follower, and problem solving efficiently. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AFGN201 and 202) provides you with the opportunity to demonstrate fundamental management skills and prepares you for Field Training.

AFGN202. TEAM AND LEADERSHIP FUNDAMENTALS II. 1.5 Semester Hr.
A continuation of AFGN201. This course is designed to discuss different leadership perspectives when completing team building activities and discussing things like conflict management. This course also provides students with the ability of demonstrating their basic verbal and written communication skills. Active cadets will apply these lessons at Field Training, which follows the AFGN200 level. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AFGN201 and 202) provides you with the opportunity to demonstrate fundamental management skills and prepares you for Field Training.

AFGN301. LEADING PEOPLE AND EFFECTIVE COMMUNICATION I. 3.5 Semester Hrs.
This course is designed to build on the leadership fundamentals taught in the AFGN200 level. The cadets will have the opportunity to utilize their skills as they begin a broader leadership role in the detachment. The goal is for cadets and students to have a more in-depth understanding of how to effectively lead people and provide them with the tools to use throughout their detachment leadership roles. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AFGN301 and 302) provides you the opportunity to develop your fundamental management skills while planning and conducting cadet activities.

AFGN302. LEADING PEOPLE AND EFFECTIVE COMMUNICATION II. 3.5 Semester Hrs.
A continuation of AFGN301. This course is designed to help cadets hone their writing and briefing skills. The course continues into advanced skills and ethics training that will prepare them for becoming an officer and a supervisor. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AFGN301 and 302) provides you the opportunity to develop your fundamental management skills while planning and conducting cadet activities.

AFGN401. NATIONAL SECURITY, LEADERSHIP RESPONSIBILITIES, COMMISSIONING PREPARATION I. 3.5 Semester Hrs.
This course is designed to address the basic elements of national security policy and process. The cadet will comprehend the air and space power operations as well as understand selected roles of the military in society and current domestic and international issues affecting the military profession. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AFGN401 and 402) provides you with the opportunity to use your leadership skills in planning and conducting cadet activities. It prepares you for commissioning and entry into the active-duty Air Force.

AFGN402. NATIONAL SECURITY, LEADERSHIP RESPONSIBILITIES, COMMISSIONING PREPARATION II. 3.5 Semester Hrs.
A continuation of AFGN401. This course is designed to prepare cadets for life as a second lieutenant. Cadets should comprehend the responsibility, authority, and functions of an Air Force commander and selected provisions of the military justice system. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AFGN401 and 402) provides you with the opportunity to use your leadership skills in planning and conducting cadet activities. It prepares you for commissioning and entry into the active-duty Air Force.

Military Science

Army ROTC-AROTC

The Department of Military Science offers programs leading to an officer's commission in the active Army, Army Reserve, or National Guard in conjunction with an undergraduate or graduate degree. Military science courses are designed to supplement a regular degree program by offering practical leadership and management experience. The Military Science Program at the Colorado School of Mines (Mines) is offered in conjunction with the University of Colorado at Boulder (CU-B). Students attend classes at the Colorado School of Mines in Golden.

Four-Year Program

The four-year program consists of two phases: the basic course (freshman and sophomore years) and the advanced course (junior and senior years).

Basic course (MS I and MS II)

The basic course offers a 2- or 3-credit course each semester, covering Army history and organization as well as military leadership and management. Laboratory sessions provide the opportunity to apply leadership skills while learning basic military skills. Enrollment in the basic course incurs no military obligation except for Army scholarship recipients.

Advanced course (MS III and MS IV)

The advanced course covers leadership, tactics and unit operations, training techniques, military law, and professional ethics, and includes a leadership practicum each semester. A 33-day Cadet Summer Training at Fort Knox, Kentucky, provides challenging leadership training and is a prerequisite for commissioning. Advanced course students must have completed the basic course and obtain permission from the Professor of Military Science (PMS).

Two-Year Program

The two-year program consists of the advanced course, preceded by attending the Cadet Summer Training at Ft. Knox, Kentucky. Veterans, or Active Army Reserve/Army National Guard Soldiers, or students who have participated in three years of Junior ROTC or Civil Air Patrol, may be eligible to enroll in the advanced course without attendance at basic camp or completion of the basic course. Advanced course students must obtain permission from the Professor of Military Science (PMS) at 303-492-6495.

Scholarship Programs

Three-year and Four-year college scholarships are available to eligible high school seniors, who apply before December 1 of their senior year. Competition for two- and three- year scholarships is open to all university students. Scholarship students receive full tuition and mandatory laboratory fees, a book allowance, and an allowance of $300- $500 per month during the academic year. Students interested in the scholarship program should contact the AROTC Enrollment and Scholarship Officer at 303-492-3549 no later than the beginning of the spring semester to apply for the following academic year.

Simultaneous Membership Program

Students currently in the Army Reserves or Army National Guard and entering either the second year of the basic course or the advanced course may participate in the Simultaneous Membership Program (SMP). Students participating in this program will receive $450 to $500 monthly stipend plus their unit pay at the E-5 grade. SMP participants may be eligible for Army Reserve or Army National Guard tuition assistance benefits.

Leadership Laboratories

Leadership labs provide cadets with practical leadership experience and performance-oriented, hands-on instruction outside the classroom.. Diagnostic evaluations of cadets in leadership roles are frequently administered. Leadership labs are compulsory for enrolled cadets. Physical training is conducted three times a week with the purpose of developing muscular strength, endurance, and cardio-respiratory endurance.

Veterans

Veterans who have served on active duty or in the Army Reserve/ National Guard are also eligible for the ROTC program. Although veterans are not required to take the Basic Course, they are encouraged to do so. A minimum of 60 credit hours are required prior to enrolling in the Advanced Course.

Registration and Credits

Army ROTC serves as free-elective credit in most departments. Elective course credit toward your degree for AROTC classes will be determined by your individual academic advisor. Students who wish to register for Army ROTC classes do so through the normal course registration process at CSM. AROTC classes begin with the MSGN prefix.

For more information about AROTC, contact:

the Army ROTC Enrollment and Scholarship Officer at:
303-492-3549 or 303-492-6495

or the department on campus directly at:
303-273-3380

The department is located in the Military Science building, 1020 19th Street

You can also go to https://rotc.mines.edu/

For information about ROTC at MINES, call 303-273-3398 or 303-273-3380.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Military Science Minor

Army ROTC cadets desiring to receive a minor in Military Science must complete at least 22 hours of Military Science courses as follows:

MSGN103	ADVENTURES IN LEADERSHIP I	2.0
MSGN104	ADVENTURES IN LEADERSHIP II	2.0
MSGN203	METHODS OF LEADERSHIP AND MANAGEMENT I	2.0
MSGN204	METHODS OF LEADERSHIP AND MANAGEMENT II	2.0
MSGN301	MILITARY OPERATIONS AND TRAINING I	3.0
MSGN302	MILITARY OPERATIONS AND TRAINING II	3.0
MSGN303	LEADERSHIP LABORATORY	0.5

MSGN304	LEADERSHIP LABORATORY	0.5
MSGN401	OFFICER LEADERSHIP AND DEVELOPMENT I	3.0
MSGN402	OFFICER LEADERSHIP AND DEVELOPMENT II	3.0
MSGN403	LEADERSHIP LABORATORY	0.5
MSGN404	LEADERSHIP LABORATORY	0.5
Total Semester Hrs		**22.0**

Note: In order to Commission as a 2nd Lieutenant in the US Army, completion of a Military History Course (HASS365) is also required.

Courses

MSGN103. ADVENTURES IN LEADERSHIP I. 2.0 Semester Hrs.
(I) Introduces fundamentals of leadership and the United States Army. Examines its organization, customs, and history as well as its current relevance and purpose. Students also investigate basic leadership and management skills necessary to be successful in both military and civilian settings. Includes fundamentals of Army leadership doctrine, teambuilding concepts, time and stress management, an introduction to cartography and land navigation, marksmanship, briefing techniques, and some basic military tactics. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Fall).

MSGN104. ADVENTURES IN LEADERSHIP II. 2.0 Semester Hrs.
(II) Continues the investigation of leadership in small organizations. Covers selected topics such as basic troop leading procedures, military first aid and casualty evacuation concepts, creating ethical work climates, an introduction to Army organizations and installations, and a further examination of basic military tactics. Introduces students to effective military writing styles. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Spring).

MSGN198. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MSGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MSGN203. METHODS OF LEADERSHIP AND MANAGEMENT I. 2.0 Semester Hrs.
(I) Comprehensively reviews advanced leadership and management concepts including motivation, attitudes, communication skills, problem solving, human needs and behavior, and leadership self development. Students continue to refine effective written and oral communications skills and to explore topics such as the basic branches of the Army, and officer and NCO duties. Students conduct classroom and practical exercises in small unit light infantry tactics and are prepared to perform as midlevel leaders in the cadet organization. Lab fee: 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours.

MSGN204. METHODS OF LEADERSHIP AND MANAGEMENT II. 2.0 Semester Hrs.
(II) Focuses on leadership and management functions in military and corporate environments. Studies various components of Army leadership doctrine to include the four elements of leadership, leadership principles, risk management and planning theory, the be-know-do framework, and the Army leadership evaluation program. Continue to refine communication skills. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80hours field training; 2 semester hours. (Spring).

MSGN298. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MSGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MSGN301. MILITARY OPERATIONS AND TRAINING I. 3.0 Semester Hrs.
(I) Further explores the theory of managing and leading small military units with an emphasis on practical applications at the squad and platoon levels. Students examine various leadership styles and techniques as they relate to advanced small unit tactics. Familiarizes students with a variety of topics such as cartography, land navigation, field craft, and weapons systems. Involves multiple, evaluated leadership opportunities in field settings and hands-on experience with actual military equipment. Students are given maximum leadership opportunities in weekly labs. Prerequisite: none. Lab Fee. 3 hours lecture; 3 semester hours. (Fall).

MSGN302. MILITARY OPERATIONS AND TRAINING II. 3.0 Semester Hrs.
(II) Studies theoretical and practical applications of small unit leadership principles. Focuses on managing personnel and resources, the military decision making process, the operations order, and oral communications. Exposes the student to tactical unit leadership in a variety of environments with a focus on preparation for the summer advance camp experience. Prerequisite: none. Lab Fee. 3 hours lecture; 3 semester hours. (Spring).

MSGN303. LEADERSHIP LABORATORY. 0.5 Semester Hrs.
(I) Development of military leadership techniques to include preparation of operation plans, presentation of instruction, and supervision of underclass military cadets. Instruction in military drill, ceremonies, and customs and courtesies of the Army. Must be taken in conjunction with MSGN301. Prerequisite: none. Lab Fee. 2 hours lab, 3 hours PT, 80 hours field training; .5 semester hour. (Fall).

MSGN304. LEADERSHIP LABORATORY. 0.5 Semester Hrs.
(II) Continued development of military leadership techniques with the major emphasis on leading an Infantry Squad. Training is "handson." Practical exercises are used to increase understanding of the principles of leadership learned in MSGN302. Must be taken in conjunction with MSGN302. Prerequisite: none. Lab Fee. 2 hours lab, 3 hours PT, 80 hours field training; .5 semester hour. (Spring).

MSGN398. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MSGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MSGN401. OFFICER LEADERSHIP AND DEVELOPMENT I. 3.0 Semester Hrs.
(I) Examines management and leadership concepts and techniques associated with planning and executing military training and operations at company and higher echelons. Includes analyses of professional ethics and values, effective training principles and procedures, subordinate counseling, and effective staff officer briefing techniques. Also investigates other subjects such as counter terrorism, modern peacekeeping missions, and the impact of the information revolution on the art of land warfare. Conducted both in and out of classroom setting and with multiple practical leadership opportunities to organize cadet training and activities. Prerequisite: none. Lab Fee. 3 hours lecture; 3 semester hours. (Fall).

MSGN402. OFFICER LEADERSHIP AND DEVELOPMENT II. 3.0 Semester Hrs.
(II) Continues MSGN401 study of management and leadership concepts and techniques, providing practical leadership experiences in the classroom and during multiple cadet-run activities. Also examines varied topics such as theory and practice of the military justice system, law of war, military-media relations, support mechanisms for soldiers and their families, operational security considerations, and historical case studies in military leadership in the context of 21st century land warfare. Prerequisite: none. Lab Fee. 3 hours lecture; 3 semester hours. (Spring).

MSGN403. LEADERSHIP LABORATORY. 0.5 Semester Hrs.
(I) Continued development of leadership techniques by assignment in the command and staff positions in the Cadet Battalion. Cadets are expected to plan and execute much of the training associated with the day-to-day operations within the cadet battalion. Utilizing the troop leading and management principles learned in previous classes, cadets analyze the problems which the battalion faces, develop strategies, brief recommendations, and execute the approved plan. Prerequisite: none. Lab Fee. 2 hours lab, 3 hours PT, and 80 hours field training; .5 semester hour. (Fall).

MSGN404. LEADERSHIP LABORATORY. 0.5 Semester Hrs.
(II) Continued leadership development by serving in the command and staff positions in the Cadet Battalion. Cadets take a large role in determining the goals and direction of the cadet organization, under supervision of the cadre. Cadets are required to plan and organize cadet outings and much of the training of underclassmen. Lab Fee. Prerequisite: none. Lab Fee. 2 hours lab, 3 hours PT, and 80 hours field training; .5 semester hour. (Spring).

MSGN498. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MSGN499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Physical Education and Athletics

The Department of Physical Education and Athletics offers a four-fold physical education and athletics program which includes:

1. Required physical education classes;
2. Intercollegiate athletics;
3. Intramural athletics and club sports; and
4. Recreational athletics.

A large number of students use the institution's facilities for recreational purposes, including swimming, tennis, soccer, basketball, volleyball, weight lifting, softball, and racquetball.

Russell H. Volk Gymnasium

A tri-level complex containing a NCAA regulation basketball arena, two racquetball/handball courts, Jack Hancock Wrestling Center, weight training facility, locker space, and offices for the Athletics Department.

Steinhauer Field House

A facility of 35,000-sq. ft., which provides for the needs of intercollegiate athletics and physical education classes.

Darden Baseball Field

With dugouts, fencing, 10 inning score-board, netted backstop, press-box and lights for night games. Located west of Stermole Soccer Stadium and has seating accommodations for 500 spectators.

Softball Field

With dugouts, batting cage, perimeter fencing, sound system and an irrigation system. Located west of Darden Field seating for 200 people.

Marv Kay Stadium at Harry D. Campbell Field

Opened in 2015, the state-of-the-art Marv Kay Stadium features seating for 4,090, fan-friendly amenities, and lights for night games and practices. The playing field is a synthetic surface named in honor of Harry D. Campbell, Class of 1939.

Korell Athletic Center

Attached to Marv Kay Stadium, the Korell Athletic Center houses weight training and sports medicine facilities for Mines Athletics, as well as locker rooms and coaching staff offices for football, track & field, and cross country. The second floor includes flexible meeting and classroom space.

Tennis Courts

The Department maintains four tennis courts.

Student Recreation Center

A three-level, 108,000 square foot facility that features an 8 lane, 25 yard swimming pool with 2 diving boards and a 14 person hot tub. There are men's and women's locker rooms, a 4,000 square foot climbing wall, a full service juice bar, an elevated jogging track, a 5,500 square foot fitness area, 2 multi-purpose rooms, a recreational gym and an arena that seats 3,000 for varsity athletic contests.

Swenson Intramural Complex

Two fields are available for intramural/recreation sports.

Stermole Track and Field Complex

Nine lane metric track with all field event components necessary to host NCAA, RMAC sanctioned events. Seating for 800 spectators.

Stermole Soccer Stadium

Synthetic surface which provides a practice and playing venue for men's and women's NCAA soccer. The stadium seats 500 and features a support building with locker rooms, meeting space, and a press box.

Required Physical Activity

Each student at Colorado School of Mines is required to complete four separate semesters of Physical Activity classes (PAGN) of their choice. Each semester must carry at least 0.5 credit hours for a minimum total of 2.0 credit hours.

Exceptions:

1. A medical excuse verified by a physician;
2. Veterans, honorably or generally discharged from the armed forces (Student needs to provide Form DD-214 to the Registrar's Office.);
3. New students entering CSM for the first time who are 26 years or older prior to the first day of class;
4. Students holding a Bachelor’s degree.

Normally, the Physical Activity requirement is fulfilled during the first two years of attendance. Transfer students should check with the Registrar's Office regarding applicable courses in physical activity. Participation in intercollegiate athletics or club sports may be used for required semesters and hours of physical activity on a one-to-one basis. ROTC students may use their ROTC registration to meet the physical education requirement, where one semester of ROTC will meet one semester of the PAGN requirement.

Students who wish to continue taking physical activity after completing PAGN requirements may continue to apply PAGN credit towards their Free Elective. However, a maximum of 3.0 activity credits in total may apply toward Free Elective.

Some of the 200-level courses may require off campus transportation, please check with Department of Athletics. All students enrolled in physical activity shall provide their own gym uniform, athletic shoes, sunscreen or swimming suit. Lockers are available by request in the administrative offices on the third floor of Volk Gym.

Intercollegiate Athletics

The School is a charter member of the Rocky Mountain Athletic Conference (RMAC) and the National Collegiate Athletic Association (NCAA). Sports offered include: football, men’s and women’s basketball, wrestling, men’s and women’s track, men’s and women’s cross country, baseball, men’s golf, men’s and women’s swimming, men’s and women’s soccer, and women’s volleyball and softball. An athlete can register each semester for one hour physical activity credit to meet their graduation requirements.

Through a required athletic fee, all full-time students attending Mines become members of the Mines Athletic Association, which financially supports the intercollegiate athletic program. With this fee, each Mines

student receives free admission to all home athletic events. The Director of Athletics administers this program.

Intramural and Club Sports

The intramural program features a variety of activities ranging from those offered in the intercollegiate athletic program to more recreational type activities. They are governed by the Mines Rec. Sports Department. All activities are offered in the following categories: men, women and co-ed.

The club sport program is governed by the Mines Sport Club Council. There are 14 competitive groups currently under this umbrella. Some teams engage in intercollegiate competition at the non-varsity level, some serve as instructional/recreational entities, and some as strictly recreational interest groups. They are funded through ASCSM. Some of the current organizations are Cycling, Ice Hockey, Lacrosse, Men's Rugby, Women's Rugby, Ski Team, Men's Soccer, Women's Soccer, Men's Ultimate Frisbee, Women's Ultimate Frisbee, Men's Volleyball, Women's Volleyball, Water Polo, Bowling and In-Line Hockey.

Courses

PAGN101. PHYSICAL EDUCATION. 0.5 Semester Hrs.
(I) A general overview of life fitness basics which includes exposure to educational units of Nutrition, Stress Management, Drug and Alcohol Awareness. Instruction in Fitness units provides the student an opportunity for learning and the beginning basics for a healthy life style. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN102. PHYSICAL EDUCATION. 0.5 Semester Hrs.
(II) Sections in physical fitness and team sports, relating to personal health and wellness activities. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN133. OUTDOOR LEADERSHIP. 0.5 Semester Hrs.
(I, II) This Outdoor Leadership course is set to involve many students in experiencing outdoors and leadership in a combined manner. Outdoor programs require a high level of skill development, team work, real-time feedback loops, planning, monitoring of team members and outdoor conditions. Outdoor skills allow people access to more opportunities for relaxation, travel, personal exploration. Leadership and followership skills come through working with other people, time management, forming alternate plans, and then evaluating decisions. Repeatable for credit. 1.50 hours lab; .50 semester hours.

PAGN151. VARSITY BASEBALL. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of baseball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN153. VARSITY MEN'S BASKETBALL. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of men's basketball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN154. VARSITY WOMEN'S BASKETBALL. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of women's basketball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN157. VARSITY CROSS COUNTRY. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of cross country in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN159. VARSITY FOOTBALL. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of football in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN161. VARSITY GOLF. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of golf in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN167. VARSITY MEN'S SOCCER. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of men's soccer in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN168. VARSITY WOMEN'S SOCCER. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of women's soccer in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN169. VARSITY SWIMMING. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of swimming and diving in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN173. VARSITY TRACK AND FIELD. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of track and field in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN175. VARSITY WRESTLING. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of wrestling in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN177. VARSITY VOLLEYBALL. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of volleyball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN179. VARSITY SOFTBALL. 1.0 Semester Hr.
(I, II) Instruction and practice in fundamentals and mechanics of softball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. 3 hours lab; 1 semester hour. Repeatable for credit.

PAGN198. SPECIAL TOPICS. 0.5-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PAGN201. PERSONAL WELLNESS. 0.5 Semester Hrs.
(I, II) Provides an overview of the 5 Dimensions of Wellness: Physical, Social, Emotional, Intellectual and Spiritual. Students will take a proactive approach to developing strategies for optimum wellness including goal setting and application of wellness principles through assignments and group in-class work. 2 hours lecture; 0.5 semester hours. Not repeatable for credit.

PAGN202. INDOOR SOCCER. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN203. TECHNIQUES OF RELAXATION. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; .5 semester hours. Repeatable for credit.

PAGN205. BEGINNING KARATE. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN206. INTERMEDIATE KARATE. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN207. TRAIL RUNNING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN209. AIKIDO. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN210. HIKING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN211. BEGINNING SWIMMING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN212. INTERMEDIATE SWIMMING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN221. BEGINNING WEIGHT TRAINING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN222. ADVANCED WEIGHT TRAINING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN223. DISTANCE RUNNING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN232. YOGA. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN233. OUTDOOR LEADERSHIP ADVANCED. 0.5 Semester Hrs.
(I, II) This Outdoor Leadership course is set to involve many students in experiencing outdoors and leadership in a combined manner. Outdoor programs require a high level of skill development, team work, real-time feedback loops, planning, monitoring of team members and outdoor conditions. Outdoor skills allow people access to more opportunities for relaxation, travel, personal exploration. Leadership and followership skills come through working with other people, time management, forming alternate plans, and then evaluating decisions. Repeatable for credit. 1.50 hours lab; .50 semester hours.

PAGN241. WOMEN'S WEIGHT TRAINING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN242. WOMEN'S RAQUETBALL. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN245. SLACKLINE. 0.5 Semester Hrs.
Students enrolling in these courses may be required to furnish their own equipment. Repeatable for credit.

PAGN251. GOLF. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN257. INTRODUCTION TO ROCK CLIMBING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN258. WOMEN'S ROCK CLIMBING. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN273. BEGINNING BASKETBALL. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN274. ADVANCED BASKETBALL. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN275. VOLLEYBALL. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN277. BEGINNING RACQUETBALL. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN279. HANDBALL. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN280. CLUB SPORTS. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN281. ADVANCED HANDBALL. 0.5 Semester Hrs.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN282. INTRAMURAL SPORTS. 0.5 Semester Hrs.
Students enrolling in these courses may be required to furnish their own equipment.

PAGN285. PHYSICAL ACTIVITY. 0.5 Semester Hrs.
(S) Physical activity instruction by permission only. 2 hours lab; 0.5 semester hours. Repeatable for credit.

PAGN286. SRC - GROUP FITNESS. 0.5 Semester Hrs.
Students enrolling in these courses may be required to furnish their own equipment. Repeatable for credit.

PAGN287. SRC - WORKOUTS. 0.5 Semester Hrs.
Students enrolling in these courses may be required to furnish their own equipment. Repeatable for credit.

PAGN298. SPECIAL TOPICS. 0.5-6 Semester Hr.
(I,II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Variable credit; 0.5 to 6 semester hours. Repeatable for credit under different titles.

PAGN299. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II) Students enrolling in these courses may be required to furnish their own equipment. Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ? Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PAGN398. SPECIAL TOPICS. 0.5-6 Semester Hr.
(I,II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Variable credit; 0.5 to 6 credit hours. Repeatable for credit under different titles.

PAGN498. SPECIAL TOPICS. 0.5-6 Semester Hr.
(I,II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Variable credit; 0.5 to 6 credit hours. Repeatable for credit under different titles.

Faculty & Staff

Please see our staff directory: https://minesathletics.com/staff-directory

Quantitative Biosciences and Engineering

Degrees Offered:

- BS in Quantitative Biosciences and Engineering

Program Requirements

Student admissions to the QBE major will have the same requirements as admissions to Colorado School of Mines. There will be no additional requirements.

Program Description

We envision an integrative undergraduate program in Quantitative Biosciences and Engineering (QBE) that will provide rigorous training with an interface between biology and mathematics, computer sciences, and chemistry; establishing a new hallmark for Colorado School of Mines (Mines). The students in the major will complete a core course program that includes the general Mines core, plus a set of additional required courses we deem important to educate an individual in quantitative bioscience and engineering along with an approved stream of biology electives that lead to a BS degree. Electives are designed to support students with an interest in a particular area of biology [e.g., pre-med, ecology, systems, molecular] along with critical quantitative skills. Enhanced skill development and research opportunities through independent study credit will be offered in partnership with several research labs across campus.

Admission Requirements

Student admissions to the QBE major will have the same requirements as admissions to Colorado School of Mines. There will be no additional requirements.

Specialized Accreditation

The QBE bachelor's degree is not accredited through ABET, but through the American Society for Biochemistry and Molecular Biology [ASBMB]. The formal accreditation process occurs after the bachelor's program has been running for two years.

Bachelor of Science in Quantitative Biosciences and Engineering Degree Requirements:

Biology Core Requirements

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
BIOL300	INTRO TO QUANTITATIVE BIOLOGY	3.0
BIOL301	INTRO TO QUANTITATIVE BIOLOGY II	3.0
CBEN321	INTRO TO GENETICS	4.0
CHGN428	BIOCHEMISTRY	3.0
CHGN431	INTRODUCTORY BIOCHEMISTRY LABORATORY	2.0
CHGN462	MICROBIOLOGY	3.0
or CEEN460	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT	
BIOLXXX	FIELD SESSION	6.0
BIOLXXX	ENTREPRENEURSHIP SEMINAR	1.0

Fundamental Science and General Requirements

MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0
MATH225	DIFFERENTIAL EQUATIONS	3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
CHGN121	PRINCIPLES OF CHEMISTRY I	4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)	4.0
CHGN221	ORGANIC CHEMISTRY I	3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY	1.0
CHGN222	ORGANIC CHEMISTRY II	3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0
EDNS151	DESIGN I	3.0
HASS100	NATURE AND HUMAN VALUES	4.0
HASS200	GLOBAL STUDIES	3.0
ELECTIVE	Humanities & Social Sciences (H&SS) mid-level courses	
ELECTIVE	Humanities & Social Sciences (H&SS) 400-level courses	
PHGN100	PHYSICS I - MECHANICS	4.5
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	4.5
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
PAGN	Physical Activity Courses (4 electives)	
CSM101	FRESHMAN SUCCESS SEMINAR	0.5

The core course work totals 95.5 credits.

Free electives

9 credits of free electives. These can be used to cover prerequisites if necessary.

Technical Electives available

Technical electives with emphasis on biology-related courses, chosen from the following:

CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN305	ANATOMY AND PHYSIOLOGY LAB	1.0
CBEN310	INTRODUCTION TO BIOMEDICAL ENGINEERING	3.0
CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0
CBEN322	BIOLOGICAL PSYCHOLOGY	3.0
CBEN412	INTRODUCTION TO PHARMACOLOGY	3.0
CBEN413	QUANTITATIVE HUMAN BIOLOGY	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0
CBEN4XX	CAPSTONE	

CHGN429	BIOCHEMISTRY II	3.0
CHGN441	THE CHEMISTRY AND BIOCHEMISTRY OF PHARMACEUTICALS	3.0
MATH431	MATHEMATICAL BIOLOGY	3.0
CHGN445	CHEMICAL BIOLOGY	3.0
CHGN4XX	BIOINORGANIC CHEMISTRY	
CEEN461	FUNDAMENTALS OF ECOLOGY	3.0
PHGN433	BIOPHYSICS	3.0
BIOL499	INDEPENDENT STUDIES (up to 6 credits)	

Free Technical Elective totals 28 credit hours

Freshman

Fall		**lec**	**lab**	**sem.hrs**
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
EDNS151	DESIGN I			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
HASS100	NATURE AND HUMAN VALUES			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				17.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
CSCI101	INTRODUCTION TO COMPUTER SCIENCE			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		**lec**	**lab**	**sem.hrs**
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
BIOL300	INTRO TO QUANTITATIVE BIOLOGY I*			3.0
CSCI303	INTRODUCTION TO DATA SCIENCE			3.0
CBEN120	FUNDAMENTALS OF BIOLOGY II			4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
CHGN428	BIOCHEMISTRY			3.0
CHGN431	INTRODUCTORY BIOCHEMISTRY LABORATORY			2.0
HASS200	GLOBAL STUDIES			3.0
BIOL301	INTRO TO QUANTITATIVE BIOLOGY II*			3.0
TECH	TECH ELECTIVE INTERDISCIPLINARY BIO TECHNICAL ELECTIVE I			3.0
CEEN460	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT or CHGN 462			3.0
				17.0

Spring		**lec**	**lab**	**sem.hrs**
CBEN320	CELL BIOLOGY AND PHYSIOLOGY			3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) RESTRICTED ELECTIVE I	3.0		3.0
CBEN321	INTRO TO GENETICS			4.0
TECH	TECH ELECTIVE INTERDISCIPLINARY BIO TECHNICAL ELECTIVE II			3.0
				16.0

Summer		**lec**	**lab**	**sem.hrs**
BIOL FIELD SESSION*				3.0
				3.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) RESTRICTED ELECTIVE II	3.0		3.0
FREE	FREE ELECTIVE I			3.0
TECH	TECH ELECTIVE INTERDISCIPLINARY BIO TECHNICAL ELECTIVE III			3.0
TECH	TECH ELECTIVE INTERDISCIPLINARY BIO TECHNICAL ELECTIVE IV			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0

BIOLXXX	BIOLOGY ENTREPRENEURSHIP AND SEMINAR*			1.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
FREE	FREE ELECTIVE II			3.0
FREE	FREE ELECTIVE III			3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) RESTRICTED ELECTIVE III			3.0
TECH	TECH ELECTIVE INTERDISCIPLINARY BIO TECHNICAL ELECTIVE IV			3.0
TECH	TECH ELECTIVE INTERDISCIPLINARY BIO TECHNICAL ELECTIVE V			3.0
				15.0

Total Semester Hrs: 132.5

* Signifies a new course needed for major degree offering.

University Honors and Scholars Programs

University Honors & Scholars Programs

University Honors and Scholars Programs (UHSP) cultivate a signature student experience beyond the traditional boundaries of the classroom and across learning communities. UHSP's mission is to offer curricular and co-curricular honors and scholars programming for students seeking opportunities to shape a distinctive undergraduate pathway that will challenge them, help them grow, build connections, and develop adaptability beyond their technical degrees. UHSP develops the professional and interpersonal skills engineers and scientists need to succeed in their professions and to make an impact in their various communities. By emboldening interdisciplinary collaboration and experiential learning, UHSP foster critical thinking, leadership, creativity and innovation. UHSP opportunities include: interdisciplinary honors pathways, immersive scholars activities, National Collegiate Ethics Bowl participation, explorations in the creative arts, distinct hands-on curricular based research and mentorship, and STEM-Ed teaching.

UHSP is open to all students regardless of their majors; our programs are designed to cultivate a strong sense of community alongside professional and personal development. Our vision is that all Mines students can choose to have comprehensive, educational experiences where they discover, explore, and pursue their passions.

UHSP Programs:

- Thorson First-Year Honors Experience
- McBride Honors Program in Public Affairs
- Grand Challenge Scholars Program
- Undergraduate Research Scholars
- Teach@Mines

Visit the University Honors and Scholars Programs website: mines.edu/honors.

Thorson First-Year Honors Experience

The Thorson First-Year Honors Experience is a unique and collaborative approach to learning that uses real-world problems to introduce students to the roles engineers and scientists play in a fast-changing world. Working closely with some of the best teachers across the humanities, engineering, and sciences, students in the Honors community come to see how the global challenges of the future require innovative and creative thinking.

The curricular component of the Thorson First-Year Honors Experience is a 2-semester interdisciplinary course sequence called IDEAS – Innovation and Discovery in Engineering, Arts, and Sciences. In IDEAS, students explore critical and creative thinking, design, and ethical problem-solving through a multitude of lenses: they learn to think like an artist, an engineer, a designer, an activist, a poet, and a scientist.

The course sequence fulfills core curriculum requirements for all majors by replacing two required core courses (HASS 100 Nature and Human Values and EDNS 151 Design I).

We believe a world of IDEAS is also a world worth exploring, and each year we offer new and different opportunities within and beyond the course. We aspire to provide all our students with the chance to enrich their first-year at Mines in unique ways. Through community engagement opportunities, project-based learning, and teamwork Thorsonites investigate the intersection of art, design, culture, and society here in the US and abroad. Co-curricular components of the program include local field trips, community events and socials, as well as limited scholarships for some of the program's participants. Through all of these curricular and co-curricular experiences and interactions, learning extends beyond the classroom into the lasting friendships that students develop over the course of their first-year.

Courses:

HNRS105. INNOVATION AND DISCOVERY IN ENGINEERING, ARTS, AND SCIENCES I. 3.5 Semester Hrs.

(I) (WI) "Innovation and Discovery in Engineering, Arts, and Sciences" (IDEAS) applies honors pedagogies in a multidisciplinary, integrated environment that highlights the seamless boundaries between science and engineering, design, ethics, and the arts as a path toward making value-informed technical decisions. In addition to developing foundational skills in engineering design and problem-solving, students examine place, identity, citizenship, and community in various contexts as they learn what it means to be an engaged and mindful citizen and professional. IDEAS poses ethical problems and hands-on design challenges from a multitude of lenses. It incorporates experiential learning, team-based projects, and seminar discussions to encourage students to think both critically and creatively about their world. Students must pass both HNRS 105 and HNRS 115 to meet degree requirements. If students drop either of these courses, they must take both HASS 100 and EDNS 151 or their equivalents in order to graduate. 3 hours lecture; 1.5 hours lab; 3.5 semester hours.

HNRS115. INNOVATION AND DISCOVERY IN ENGINEERING, ARTS, AND SCIENCES II. 3.5 Semester Hrs.

(II) (WI) "Innovation and Discovery in Engineering, Arts, and Sciences" (IDEAS) applies honors pedagogies in a multidisciplinary, integrated environment that highlights the seamless boundaries between science and engineering, design, ethics, and the arts as a path toward making value-informed technical decisions. Students examine place, identity, citizenship, and community in various contexts as they learn what it means to be an engaged and mindful citizen and professional. IDEAS poses ethical problems and hands-on design challenges from a multitude of lenses. It incorporates experiential learning, team-based projects, and seminar discussions to encourage students to think both critically and creatively about their world. Students must pass both HNRS 105 and HNRS 115 to meet degree requirements. If students drop either of these courses, they must take both HASS 100 and EDNS 151 or their equivalents in order to graduate. Prerequisites: HNRS 105. 3 hours lecture; 1.5 hours lab; 3.5 semester hours. In order to move on to HNRS 115, HNRS 105 must be completed with a C- or better.
Visit: thorson.mines.edu

McBride Honors Program

The McBride Honors Program in Public Affairs offers an honors minor consisting of seminars, courses, and off-campus activities that has the primary goal of providing a select number of students the opportunity to cross the boundaries of their technical expertise into the ethical, cultural, socio-political, and environmental dimensions of human life. Students will develop their skills in communication, critical thinking, and leadership through seminar-style classes that explore diverse aspects of the human experience. The seminars are designed to offer coherent perspectives across the curriculum, allowing for a maximum degree of discussion and debate on complex topics. Themes, approaches, and perspectives

from the humanities and the social sciences are integrated with science and engineering perspectives to develop in students habits of thought necessary for a comprehensive understanding of societal and cultural issues that enhance critical thinking, social responsibility, and enlightened leadership.

Please see the McBride Honors Program in Interdisciplinary Minors for more details about this program.

Visit: mcbride.mines.edu

Grand Challenge Scholars Program

The Grand Challenges Scholars Program (GCSP) prepares students to be world-changers and impact-makers. The GCSP offers a way to combine coursework, extracurricular activities, and experiences that prepare you to address complex socio-technical issues, such as the National Academy of Engineering (NAE) Grand Challenges and the United Nations Sustainable Development Goals, while receiving certification from the NAE and a designation on your transcript. As a Scholar, you will have the chance to choose your own pathways to gain skills in interdisciplinary thinking, working across diverse cultures, applying engineering and science in the service of others, entrepreneurship, and addressing problems through design, research, and creativity.

Visit the Grand Challenge Scholars Program website.

Undergraduate Research Scholars

The office of Undergraduate Research Scholars works hard to provide students a wide array of opportunities to conduct cutting-edge research led by Mines faculty mentors. Research opportunities include fellowships, research assistantships, and even obtaining credits for research. Programs such as the First-Year Innovation & Research Scholar Training (FIRST) and Mines Undergraduate Research Fellowship (MURF) can help incoming students get a head start in their field of interest.

Visit the Undergraduate Research Scholars website.

Teach@Mines

Teach@Mines offers courses, a Teaching Minor, advising, and information on certification pathways to help you explore and learn more about the teaching profession.

Teach@Mines is tailored specifically to the needs of Mines students and alumni, which means we have non-traditional pathways towards licensure.

We offer courses and a Teaching Minor for students to both try out teaching and to prepare to teach (K-12 or college). A person can start on this path at any point in their Mines career as an undergraduate, graduate student, or as a Mine’s alumni. The earlier you begin, the more flexibility you have.

Please see the Teach@MInes Interdisciplinary Minor for more details about this program.

Visit the Teach@Mines website.

HNRS105. INNOVATION AND DISCOVERY IN ENGINEERING, ARTS, AND SCIENCES I. 3.5 Semester Hrs.
(I) (WI) "Innovation and Discovery in Engineering, Arts, and Sciences" (IDEAS) applies honors pedagogies in a multidisciplinary, integrated environment that highlights the seamless boundaries between science and engineering, design, ethics, and the arts as a path toward making value-informed technical decisions. In addition to developing foundational skills in engineering design and problem-solving, students examine place, identity, citizenship, and community in various contexts as they learn what it means to be an engaged and mindful citizen and professional. IDEAS poses ethical problems and hands-on design challenges from a multitude of lenses. It incorporates experiential learning, team-based projects, and seminar discussions to encourage students to think both critically and creatively about their world. Students must pass both HNRS105 and HNRS 115 to meet degree requirements. If students drop either of these courses, they must take both LAIS100 and EPIC151 or their equivalents in order to graduate. 3 hours lecture; 1.5 hours lab; 3.5 semester hours.

HNRS115. INNOVATION AND DISCOVERY IN ENGINEERING, ARTS, AND SCIENCES II. 3.5 Semester Hrs.
(II) (WI) "Innovation and Discovery in Engineering, Arts, and Sciences" (IDEAS) applies honors pedagogies in a multidisciplinary, integrated environment that highlights the seamless boundaries between science and engineering, design, ethics, and the arts as a path toward making value-informed technical decisions. Students examine place, identity, citizenship, and community in various contexts as they learn what it means to be an engaged and mindful citizen and professional. IDEAS poses ethical problems and hands-on design challenges from a multitude of lenses. It incorporates experiential learning, team-based projects, and seminar discussions to encourage students to think both critically and creatively about their world. Students must pass both HNRS105 and HNRS115 to meet degree requirements. If students drop either of these courses, they must take both LAIS100 and EPIC151 or their equivalents in order to graduate. 3 hours lecture; 1.5 hours lab; 3.5 semester hours. Prerequisite: C- or better in HNRS105.

HNRS198. SPECIAL TOPICS. 6.0 Semester Hrs.
A Special Topics course will be a pilot course in the UHSP curriculum or will be offered as an enhancement to regularly-scheduled UHSP seminars. Special Topics courses in the UHSP curriculum will not be offered more than twice. Variable credit: 1 - 6 semester hours. Repeatable for credit under different titles.

HNRS199. INDEPENDENT STUDY. 1-6 Semester Hr.
Under special circumstances, a UHSP student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled UHSP curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

HNRS298. SPECIAL TOPICS. 1-6 Semester Hr.
A Special Topics course will be a pilot course in the UHSP curriculum or will be offered as an enhancement to regularly-scheduled UHSP seminars. Special Topics courses in the UHSP curriculum will not be offered more than twice. Variable credit: 1 - 6 semester hours. Repeatable for credit under different titles.

HNRS299. INDEPENDENT STUDY. 1-6 Semester Hr.
Under special circumstances, a UHSP student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled UHSP curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

HNRS398. SPECIAL TOPICS IN THE UNIVERSITY HONORS AND SCHOLARS PROGRAM. 1-6 Semester Hr.
A Special Topics course will be a pilot course in the University Honors & Scholars Programs curriculum or will be offered as an enhancement to regularly-scheduled UHSP seminars. Special Topics courses in the UHSP curriculum will not be offered more than twice.

HNRS399. INDEPENDENT STUDY. 1-6 Semester Hr.
Under special circumstances, a UHSP student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled UHSP curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

Director

Toni Lefton, Executive Director, University Honors & Scholars Programs

Teaching Associate Professors

Melanie Brandt, Director, McBride Honors Program

Justin Latici, McBride Practicum Advisor

CJ McClelland, Director, Grand Challenge Scholars Program

Teaching Assistant Professor

Lauren Shumaker, Director, Thorson First-Year Honors Experience

Research Associate Professor

Wendy Adams, Director, Teach@MInes

Administrative Faculty

Lakshmi Krishna, Director, Undergraduate Research Scholars

Administrative Support

Karin Murray, UHSP Program Coordinator

Katie Vuletich, Undergraduate Research, Administrative Assistant

Allie Costley, Teach@Mines Program Coordinator

Interdisciplinary Minors

Advanced Manufacturing

Program Offered

- Minor in Advanced Manufacturing

Minor and ASI in Advanced Manufacturing

The interdisciplinary Advanced Manufacturing program will prepare undergraduates to meet the challenges of careers in advanced manufacturing. Undergraduate students have the following degree options:

- Area of Special Interest (12 credit hours)
  - Requirements: AMFG401 and 9 credit hours of electives (see Table 1)
- Minor (18 credit hours)
  - Requirements: AMFG401 and one other core course to be determined and 12 credit hours of electives (see Table 1)

Table 1: Undergraduate elective courses, listed by specialty area (AMFG531, AMFG 511 and FEGN 526 require approval by appropriate program directors)

Additive Manufacturing of Structural Materials		
MEGN381	MANUFACTURING PROCESSES	3.0
MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
AMFG421	DESIGN FOR ADDITIVE MANUFACTURING	3.0
AMFG531	MATERIALS FOR ADDITIVE MANUFACTURING	3.0
AMFG498	SPECIAL TOPICS IN ADVANCED MANUFACTURING	1-6
AMFG511	DATA DRIVEN ADVANCED MANUFACTURING	3.0
FEGN525	ADVANCED FEA THEORY & PRACTICE	3.0
FEGN526	STATIC AND DYNAMIC APPLICATIONS IN FEA	3.0

Courses

AMFG401. ADDITIVE MANUFACTURING. 3.0 Semester Hrs.
(II) Additive Manufacturing (AM), also known as 3D Printing in the popular press, is an emerging manufacturing technology that will see widespread adoption across a wide range of industries during your career. Subtractive Manufacturing (SM) technologies (CNCs, drill presses, lathes, etc.) have been an industry mainstay for over 100 years. The transition from SM to AM technologies, the blending of SM and AM technologies, and other developments in the manufacturing world has direct impact on how we design and manufacture products. This course will prepare students for the new design and manufacturing environment that AM is unlocking. Prerequisites: MEGN200 and MEGN201 or equivalent project classes. 3 hours lecture; 3 semester hours.

AMFG421. DESIGN FOR ADDITIVE MANUFACTURING. 3.0 Semester Hrs.
(II) Design for Additive Manufacturing (DAM) introduces common considerations that must be addressed to successfully design or re-design parts for additive manufacturing methods. Industry-leading hardware and FEA software will be used to explore all phases of the DAM workflow, including topology optimization, additive process simulation, distortion compensation, and in-service performance. 3 hours lecture; 3 semester hours.

AMFG422. LEAN MANUFACTURING. 3.0 Semester Hrs.
Throughout the course, students will learn to apply skillsets to real world problems, focusing on lean and six-sigma principles and methodologies. The course is taught with a focus on the DMAIC structure of implementation (Define, Measure, Analyze, Improve and Control) for improving and implementing process efficiencies in industry. The course is split into three general subject areas; 1) Lean manufacturing principles, 2) six-sigma and statistical process control (SPC) methodologies and 3) Implementation techniques focusing on graphical and numerical representation of processes using R. Students will receive an in-depth overview of Lean manufacturing principles and will perform case studies at local industries to implement learned skill-sets. Next, students will step-through several hands-on activities using real products to investigate six-sigma and perform SPC analysis, identifying shifts in process data and learning how to shift processes into capable processes. Lastly, students will learn about various implementation techniques for industry and will perform an in-depth analysis of the course topics based on the industry tours performed. Prerequisite: MEGN381.

AMFG423. DESIGN AND ANALYSIS OF EXPERIMENTS. 3.0 Semester Hrs.
This course introduces effective experimental design and analysis methodologies relevant to all engineering and scientific disciplines to maximize the information learned from every experiment (test case) while minimizing the total number of tests. We will be using state-of-art methods steeped in statistics to effectively set up your experiments, understand what the results are telling you, and clearly communicate the results to peers and leadership. We apply a disciplined systems engineering approach across the four major experimental phases: plan, design, execute, and analyze. This hands-on class will focus on understanding concepts and practical applications while relying less on the statistical theoretical development. Prerequisite: MATH 201 is recommended, not required.

AMFG498. SPECIAL TOPICS IN ADVANCED MANUFACTURING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

Biology Minor

Program Offered

- Minor in Biology

Program Description

The biology minor is designed for students in any department across Mines who would like to learn about biology, the study of life. This course will enable students from any department to choose a minor in biology, and thus enable them to apply their specific expertise to any area of biology, which is also the foundation for medicine and health. This minor is also of particular benefit to pre-medical and pre-veterinary students. The course will lay a solid foundation to future technology developers for health and wellbeing of people and planet.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Minor in Biology

The minor requires 18 credit hours, which includes 9 credits of required courses, 9 credits of elective courses and 3 credits practicum or 499-Independent Study research credits.

Required courses:

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
BIOL 4XX	400 Level Capstone Course or Journal Club *	1.0
BIOL ELECT	Biology Elective Courses	9.0
Total Semester Hrs		**18.0**

* Any capstone course, recitation or journal relating to biology will be allowed. This will include 400 level courses in Mechanical engineering, computer science, chemistry, physics, environmental set up as a current research recitation for a minimum of 1.0 credit. If the capstone involves more than 1.0 credit hours, additional hours may be counted towards electives. The content of this course requires course director approval to ensure the relevance to biology. There will also be prerequisites from the list of elective courses.

ELECTIVE COURSES

CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN305	ANATOMY AND PHYSIOLOGY LAB	1.0
CBEN306	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN	3.0
CBEN309	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN LABORATORY	1.0
CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	INTRO TO GENETICS	4.0
CBEN322	BIOLOGICAL PSYCHOLOGY	3.0
CBEN324	INTRODUCTION TO BREWING SCIENCE	3.0
CBEN411	NEUROSCIENCE, MEMORY, AND LEARNING	3.0
CBEN412	INTRODUCTION TO PHARMACOLOGY	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0
CEEN461	FUNDAMENTALS OF ECOLOGY	3.0
CHGN428	BIOCHEMISTRY	3.0
CHGN429	BIOCHEMISTRY II	3.0
CHGN462	MICROBIOLOGY	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
MATH331	MATHEMATICAL BIOLOGY	3.0
PHGN433	BIOPHYSICS	3.0
MTGN472	BIOMATERIALS I	3.0
BIOL 499	Research Project or Internship	3.0

Energy

Programs Offered

- Minor in Energy
- Area of Special Interest in Energy

The discovery, production, and use of energy in modern societies have profound and far-reaching economic, political, and environmental effects. As energy is one of Mines core statutory missions, several Mines departments have come together to offer Minor and Area of Special Interest (ASI) programs related to Energy. The 18-credit Energy Minor adds value to any Mines undergraduate degree program by not only addressing the scientific and technical aspects of energy production and use but its broader social impacts as well. The Energy Minor program is intended to provide engineering students with a deeper understanding of the complex role energy technology plays in modern societies by meeting the following learning objectives:

1. Students will gain a broad understanding of the scientific, engineering, environmental, economic and social aspects of the production, delivery, and utilization of energy as it relates to the support of current and future civilization both regional and worldwide.
2. Students will develop depth or breadth in their scientific and engineering understanding of energy technology.
3. Students will be able to apply their knowledge of energy science and technology to societal problems requiring economic, scientific, and technical analysis and innovation while working in a multidisciplinary environment and be able to communicate effectively the outcomes of their analyses in written and oral form

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Program Requirements

Minor in Energy

Minimum 18 hours required:

Required Courses (6 credit hours)

ENGY200	INTRODUCTION TO ENERGY	3.0
EBGN330	ENERGY ECONOMICS	3.0

Policy Course: Select at least one of the following (minimum 3 credit hours)

HASS490	ENERGY AND SOCIETY	3.0
HASS491	ENERGY POLITICS	3.0
HASS492	ENERGY AND SECURITY POLICY	3.0

Select the remaining electives from the following:

Social Sciences and Law

EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0
EBGN340	ENERGY AND ENVIRONMENTAL POLICY	3.0
HASS419	ENVIRONMENTAL COMMUNICATION	3.0
HASS464	HISTORY OF ENERGY AND THE ENVIRONMENT	3.0
PEGN430	ENVIRONMENTAL LAW AND SUSTAINABILITY	3.0

All Energy Sources

CBEN469	FUEL CELL SCIENCE AND TECHNOLOGY	3.0
or MTGN469	FUEL CELL SCIENCE AND TECHNOLOGY	
or MEGN469	FUEL CELL SCIENCE AND TECHNOLOGY	
or MTGN469	FUEL CELL SCIENCE AND TECHNOLOGY	
CBEN472	INTRODUCTION TO ENERGY TECHNOLOGIES	3.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0
EENG481	ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS	3.0

EENG489	COMPUTATIONAL METHODS IN ENERGY SYSTEMS AND POWER ELECTRONICS	3.0
ENGY497	SUMMER PROGRAMS	1-6
ENGY498	SPECIAL TOPICS	1-6
GEOL315	SEDIMENTOLOGY AND STRATIGRAPHY	3.0
Nuclear Energy		
ENGY340	NUCLEAR ENERGY	3.0
NUGN506	NUCLEAR FUEL CYCLE	3.0
NUGN510	INTRODUCTION TO NUCLEAR REACTOR PHYSICS	3.0
Sustainable Energy		
ENGY320	INTRO TO RENEWABLE ENERGY	3.0
ENGY350	GEOTHERMAL ENERGY	3.0
CEEN477	SUSTAINABLE ENGINEERING DESIGN	3.0
CHGN311	INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY	3.0
EENG390	ENERGY, ELECTRICITY, RENEWABLE ENERGY, AND ELECTRIC POWER GRID	3.0
EENG475	INTERCONNECTION OF RENEWABLE ENERGY, INTEGRATED POWER ELECTRONICS, POWER SYSTEMS, AND POWER QUALITY	3.0
EENG589	DESIGN AND CONTROL OF WIND ENERGY SYSTEMS	3.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0
Fossil Fuels		
PEGN102	INTRODUCTION TO PETROLEUM INDUSTRY	3.0
ENGY310	INTRO TO FOSSIL ENERGY	3.0
CBEN480	NATURAL GAS HYDRATES	3.0
MNGN438	GEOSTATISTICS	3.0
PEGN251	FLUID MECHANICS	3.0
PEGN305	COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING	2.0
PEGN308	RESERVOIR ROCK PROPERTIES	3.0
PEGN450	ENERGY ENGINEERING	3.0
ENGYXXX	Additional courses with energy content may be approved by the director or co-director of the energy minor.	

Area of Special Interest in Energy

Minimum of 12 credit hours of acceptable course work:

ENGY200	INTRODUCTION TO ENERGY	3.0
EBGN330	ENERGY ECONOMICS	3.0
Two additional energy-related courses		6.0
Total Semester Hrs		**12.0**

Courses

ENGY200. INTRODUCTION TO ENERGY. 3.0 Semester Hrs.
Introduction to Energy. Survey of human-produced energy technologies including steam, hydro, fossil (petroleum, coal, and unconventionals), geothermal, wind, solar, biofuels, nuclear, and fuel cells. Current and possible future energy transmission and efficiency. Evaluation of different energy sources in terms of a feasibility matrix of technical, economic, environmental, and political aspects. 3 hours lecture; 3 semester hours.

ENGY310. INTRO TO FOSSIL ENERGY. 3.0 Semester Hrs.
(II) Students will learn about conventional coal, oil, and gas energy sources across the full course of exploitation, from their geologic origin, through discovery, extraction, processing, processing, marketing, and finally to their end-use in society. Students will be introduced to the key technical concepts of flow through rock, the geothermal temperature and pressure gradients, hydrostatics, and structural statics as needed to understand the key technical challenges of mining, drilling, and production. Students will then be introduced to unconventional (emerging) fossil-based resources, noting the key drivers and hurdles associated with their development. Students will learn to quantify the societal cost and benefits of each fossil resource across the full course of exploitation and in a final project will propose or evaluate a national or global fossil energy strategy, supporting their arguments with quantitative technical analysis. 3 hours lecture; 3 semester hours.

ENGY320. INTRO TO RENEWABLE ENERGY. 3.0 Semester Hrs.
(I) Survey of renewable sources of energy. The basic science behind renewable forms of energy production, technologies for renewable energy storage, distribution, and utilization, production of alternative fuels, intermittency, natural resource utilization, efficiency and cost analysis and environmental impact. 3 hours lecture; 3 semester hours.

ENGY340. NUCLEAR ENERGY. 3.0 Semester Hrs.
(I) Survey of nuclear energy and the nuclear fuel cycle including the basic principles of nuclear fission and an introduction to basic nuclear reactor design and operation. Nuclear fuel, uranium resources, distribution, and fuel fabrication, conversion and breeding. Nuclear safety, nuclear waste, nuclear weapons and proliferation as well economic, environmental and political impacts of nuclear energy. 3 hours lecture; 3 semester hours.

ENGY350. GEOTHERMAL ENERGY. 3.0 Semester Hrs.
(I) Geothermal energy resources and their utilization, based on geoscience and engineering perspectives. Geoscience topics include world wide occurrences of resources and their classification, heat and mass transfer, geothermal reservoirs, hydrothermal geochemistry, exploration methods, and resource assessment. Engineering topics include thermodynamics of water, power cycles, electricity generation, drilling and well measurements, reservoir-surface engineering, and direct utilization. Economic and environmental considerations and case studies are also presented. 3 hours lecture; 3 semester hours.

ENGY399. INDEPENDENT STUDY. 0.5-6 Semester Hr.
Students can do individual research or special problem projects supervised by a faculty member. The student and instructor will agree on the subject matter, content, and credit hours.

ENGY499. INDEPENDENT STUDY. 0.5-6 Semester Hr.
Students can do individual research or special problem projects supervised by a faculty member. The student and instructor will agree on the subject matter, content, and credit hours.

ENGY501. ENERGY RESOURCES AND ELECTRIC POWER SYSTEMS. 3.0 Semester Hrs.
(I) This course will provide successful students a quantitative understanding of how fossil, renewable and nuclear energy resources are harnessed to electric power. A foundational underpinning will be the thermodynamics of energy conversion, using fundamental principles and language bridging physics, chemistry and engineering. Examples will be taken from both established and emerging technologies spanning solar, nuclear, wind fossil fuel and bioenergy conversion. Students will also learn how to analyze electricity generation, transmission, and grid-scale storage systems with a focus on the U.S. as a framework for analyzing other developing markets. 3 hours lecture; 3 semester hours.

ENGY502. ENERGY FOR TRANSPORTATION. 3.0 Semester Hrs.
(I) This course focuses on multiple aspects of current and proposed transportation technologies to analyze the challenges and opportunities of moving toward more sustainable transportation infrastructure. This course is designed to train students to develop analytical skills and to use computational tools for evaluating performance and environmental impacts of various vehicle and fueling technologies. Successful students will develop a basis for assessing energy resource requirements and environmental concerns within the context of technical performance, policy frameworks, and social perspectives. The course will include the following topics: travel demand and travel modes; transportation technologies; fossil-fuel and electric power plants and associated fuels; emissions (CO2 and pollutants) formation and impacts on air quality, climate, and human health; national/international transportation policy; and transportation planning. 3 hours lecture; 3 semester hours.

ENGY503. ENERGY SYSTEMS INTEGRATION AND EFFICIENCY. 3.0 Semester Hrs.
(II) This course will provide students with basic skills to analyze the operation and evolution of the electric grid and electricity utilization with a particular emphasis on trends toward increased renewable energy penetration. The course will develop students' analytical skills to evaluate how electricity generation, transmission, distribution and storage are managed and controlled. Successful students will gain a basic understanding of electromechanical machines for power conversion and AC power distribution as well as renewable energy sources and battery systems with DC storage. The course will introduce students to how efficient energy utilization and demand response management impact the electric grid performance and electricity markets. An emphasis on managing energy loads in buildings, the commercial sector, and energy-intensive manufacturing will expose students to system-level modeling tools that can assess how to manage power demands with transient power generation and market forces. The course will also address the integrated nature of energy systems with an emphases on connections to water demands and on risks arising due to cybersecurity and resiliency threats facing the electric grid. 3 hours lecture; 3 semester hours.

ENGY599. INDEPENDENT STUDY. 0.5-6 Semester Hr.
Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree.

ENGY691. NREL ROTATION: ANALYSIS OF INTEGRATED ENERGY SYSTEMS. 3.0 Semester Hrs.
(I) This course introduces graduate students enrolled in the Advanced Energy Systems Program to research opportunities, culture, and expectations in energy science and technology with a particular emphasis on systems and/or policy analysis. Students will work within directorates at NREL with an emphasis on systems modeling, analysis, and/or integration. This class will engage students in a semester-long research project in energy system analysis and prepare students for best practices with respect to research project and data management, literature reading, report writing, and presentation. 1 hour lecture; 6 hours lab; 3 semester hours.

ENGY692. NREL ROTATION: ENERGY SCIENCE & TECHNOLOGIES. 3.0 Semester Hrs.
(I) This course prepares graduate students enrolled in the Advanced Energy Systems Program in research practices, culture, and expectations in energy science and technology with a particular emphasis on science and engineering related to energy materials, processes, and/or systems. Students will work within directorates at NREL with an emphasis on science and/or technology. This class will engage students in a semester-long research project in energy science and/or technology. Students will also learn and practice journal publication and research poster best practices, research career path planning, and proposal funding strategies. 1 hour lecture; 6 hours lab; 3 semester hours.

Professors

Reuben T. Collins, Physics Department Emertius

Elizabeth Van Wie Davis, Humanities, Arts, and Social Sciences

Roderick G. Eggert, Division of Economics and Business

Linda Figueroa, Division of Environmental Science and Engineering

Greg S. Jackson, Mechanical Engineering

Mark P. Jensen, University Chair in Nuclear Science and Engineering

Manika Prasad, Petroleum Engineering

Angus A. Rockett, Professor of Metallurgical and Materials Engineering and Head of Department

Sridhar Seetharaman, Metallurgical and Materials Engineering

P.K. Sen, Electrical Engineering

Roel Snieder, Department of Geophysics, Keck Foundation Professor of Basic Exploration Science

Associate Professors

Kathleen Hancock, co-director, Division of Humanities, Arts, and Social Sciences

John Heilbrunn, Division of Humanities, Arts, and Social Sciences

Andrew M. Herring, Department of Chemical Engineering

Kathryn Johnson, Department of Mechanical Engineering

Masami Nakagawa, Department of Mining Engineering

Timothy R. Ohno, co-director

Marcelo Simoes, Division of Engineering

Neal Sullivan, Associate Professor

Eric Toberer

Assistant Professors

Eric Toberer , Department of Physics

Jeffrey C. King, Department of Metallurgical and Materials Engineering

Jeramy Zimmerman

Teaching Professors

Linda Battalora, Department of Petroleum Engineering

Charles Stone, Department of Physics

Teaching Associate Professors

Joseph Horan, Division of Humanities, Arts, and Social Sciences

John M. Persichetti, Department of Chemical Engineering

Guy T. McBride, Jr. Honors Program in Public Affairs

Program Educational Objectives

The McBride Honors Program in Public Affairs offers an honors minor consisting of seminars courses with the primary goal of providing a select number of students the opportunity to cross the boundaries of their technical expertise into the ethical, cultural, socio-political, and environmental dimensions of human life. Students will develop their skills in communication, critical and creative thinking, and leadership through seminar style classes that explore diverse aspects of the human experience. The seminars are designed to offer coherent perspectives across the curriculum, allowing for a maximum degree of discussion and debate on complex topics. Themes, approaches, and perspectives from the humanities and the social sciences are integrated with science and engineering perspectives to develop in students habits of thought necessary for a comprehensive understanding of societal and cultural issues that enhance critical thinking, creativity, social responsibility, and enlightened leadership.

Program Description

The McBride Honors Program minor is a 21 credit hour curriculum.

The Program is delivered primarily in an interdisciplinary seminar format that maximizes discussion, debate, and innovative activities. Seminars are taught by dedicated faculty members from the humanities, social sciences, life sciences and physical sciences, and engineering. The curriculum of the McBride Honors Program includes the following features and educational experiences:

- Student-centered seminars guided by faculty collaborators from various disciplines.
- An interdisciplinary approach that integrates domestic and global perspectives into the curriculum.
- One-to-one long-lasting intellectual relationships and camaraderie among students and between faculty and students.
- The development and practice of oral/written communication, argumentation, and listening skills.
- The opportunity to develop an individualized learning experience which may involve study abroad, service learning, research, entrepreneurial projects, and/or professional internships.

An important experience in the Program is engaging in a Practicum (e.g. an internship, overseas study, public service, or undergraduate research experience). Because engineers and scientists will continue to assume significant responsibilities as leaders in public and private sectors, it is essential that CSM students be prepared for more than their traditional "first jobs". Leadership and management demand an understanding of the accelerating pace of change that marks the social, political, economic, and environmental currents of society and a commitment to social and environmental responsibility. Regardless of their career goals, however, this same understanding is demanded of an educated person in the contemporary world. While the seminars in the Program are designed to nourish such an understanding, these Practicum experiences allow students to see firsthand the kinds of challenges that they will face in their professional and personal lives and to engage with the world as their classroom.

Foreign study is also possible either through CSM-sponsored trips or through individual plans arranged in consultation with the Director and the Office of International Programs. The program offers some competitive funding opportunities to selected students to facilitate study abroad or other exceptional educational experiences. Please contact the Director or see the Program website for more information.

Student Profile

The McBride Honors Program in Public Affairs seeks to enroll students who can benefit most from the learning experiences upon which the Program is based while significantly contributing to the broader learning objectives of the McBride community. Most honors programs admit students exclusively on the basis of academic record. Although the McBride Honors Program uses SAT and ACT test scores, and grade point average as important indicators of success in the McBride Program, they form only part of the criteria used in the admission process. The McBride Program also examines extracurricular activities, interest in human affairs, evidence of a mindset of curiosity and exploration, and the willingness to engage actively in discussion and debate. Applicants must demonstrate their commitment to public service, their leadership potential, their intrinsic motivation to learn, willingness to understand and respect perspectives other than their own, and writing, listening, and speaking abilities.

Once admitted into the Program, a McBride student commits to:

- completing the McBride curriculum as stated in the Catalog;
- participating in the McBride seminars as an active and responsible member of the learning community, always completing reading and writing assignments on time in order to be ready to learn;
- engaging in the highest level of intellectual discourse in a civil and respectful manner with all members of the CSM community, particularly with those who hold different beliefs, values, and views;
- understanding that the McBride faculty are committed to provide the best education to help students become thoughtful and responsible persons, citizens, and professionals; and
- upholding the highest standards of ethical conduct and the CSM Honor Code, particularly those related to academic honesty and respect for peers, instructors, and Program administrators.

Although the educational experiences in the McBride Honors Program are rigorous and demand a high degree of dedication from the students, McBride graduates have gained positions of their choice in industry, business, government, and within non-governmental organizations, or in other professions more easily than others, and have been successful in winning admission to high-quality graduate, law, medicine and other professional schools.

Admission

Students typically begin the Program in the fall of their sophomore year, although in some cases transfer students and juniors may join the program. Students should apply to the McBride Program by the deadline set by the Program, by filling out an application, submitting the

required materials, and securing a letter of recommendation (see website for details: http://mcbride.mines.edu/), and participating in an interview.

Note: Students must complete HASS100 Nature and Human Values or HNRS105 & HNRS115, Innovation and Discovery in Engineering, Arts and Sciences, prior to, or concurrently with, enrolling in the first course, HNRS305 Explorations in Modern America or HNRS315 Explorations in the Modern World.

Humanities & Social Science (H&SS) Core Curriculum Requirements

Students completing the McBride Honors Program are required to complete HASS100"Nature and Human Values," or HNRS105 & HNRS115, "Innovation and Discovery in Engineering, Arts and Sciences " and EBGN201, "Principles of Economics." McBride students who have completed HRNS315 are exempt from completing HASS200, "Human Systems."

Transfer and Graduation Policies

The McBride Program accepts applications from transfer students as follows:

Transfer students must complete and submit an application and participate in the interview process like other applicants under the time frame set by the Program. Transfer students should expect to complete the entire McBride curriculum, but under some circumstances, transfer students may petition the Director for course substitutions.

Academic Standards

Students must perform to the highest levels of writing, reading, and discussion in preparation for and during McBride seminars. Participation in class projects and discussions is essential. Students who do not maintain an appropriate level of participation and engagement may be asked to leave the Program.

Academic integrity and honesty are expected of all Mines students. Any infractions in these areas will be handled under the rules of CSM and the McBride Program and may result in dismissal from the Program. The Program demands a high level of achievement not only in Honors courses, but in all academic work attempted at CSM. To that end, a student must meet the following minimum requirements:

- A minimum cumulative GPA 2.9 is required for admission. Failure to meet the GPA requirement will result in voiding the invitation to join the McBride Program or being placed on probation for one semester. If the required minimum GPA has not been met at the end of the probationary semester the student will be withdrawn from the Program.
- A minimum cumulative GPA of 3.0 in Honors coursework is required to remain in good academic standing in the Program. Students who drop below the minimum in their McBride coursework will be placed on probation for one semester. If the required minimum GPA has not been met at the end of the probationary semester, or in any subsequent semester, the student may be withdrawn from the Program.
- A minimum *cumulative* GPA of 2.9 is required in all course work at CSM. Students who drop below a cumulative GPA of 2.9 will be placed on probation for one semester. If the required minimum GPA has not been met at the end of the probationary semester, or in any subsequent semester, the student will be withdrawn from the Program.
- The minimum *cumulative GPA* and the minimum *Honors GPA* at the time of graduation are required in order to receive the "Minor in the McBride Honors Program in Public Affairs." Graduating seniors who fall below these minima will receive a "Minor in Public Affairs" without the Honors designation if they choose to complete the Public Affairs minor instead of transferring their credits to the Division of Humanities, Arts, and Social Sciences. Exemptions may be granted at the discretion of the program director.
- If students wish to appeal their withdrawal from the McBride Honors Program, they must write a letter of appeal to the Director, who will review the student's case in consultation with McBride faculty.

Curriculum

The Curriculum Effective for Students Beginning Fall 2013

Each elective will follow a specific theme that provides an in-depth look at a particular problem or case study relating to the overarching topic of the course. These specific themes will change frequently. Prior to registration each semester, the course theme and description will be announced to all McBride students via email and posted on the McBride website. Students may take a given course twice if and only if the course theme is different.

Honors Core Courses (6 credits):		
HNRS305	EXPLORATIONS IN MODERN AMERICA	3.0
HNRS315	EXPLORATIONS IN THE MODERN WORLD	3.0
Honors Practicum Requirement (3 credits):		
HNRS405	MCBRIDE PRACTICUM	1-3
Honors Electives (12 credits):		
HNRS425	EXPLORATIONS IN POLITICS, POLICY, AND LEADERSHIP	3.0
HNRS430	EXPLORATIONS IN IDEAS, ETHICS, AND RELIGION	3.0
HNRS435	EXPLORATIONS IN CULTURE, SOCIETY, AND CREATIVE ARTS	3.0
HNRS440	EXPLORATIONS IN INTERNATIONAL STUDIES & GLOBAL AFFAIRS	3.0
HNRS445	EXPLORATIONS IN SCIENCE, TECHNOLOGY, AND SOCIETY	3.0
HNRS450	EXPLORATIONS IN EARTH, ENERGY, AND ENVIRONMENT	3.0
Special Topics		
HNRS398	SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS	1-6
HNRS498	SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS	1-6
HNRS499	INDEPENDENT STUDY	1-6

HNRS305. EXPLORATIONS IN MODERN AMERICA. 3.0 Semester Hrs.
(I, II) (WI) Honors core course that develops student skills in reading, writing, critical thinking, and oral communication. skills through the exploration of selected topics related to the social, cultural, and political ideas and events that have shaped the development of the modern United States and its role in the world. Prerequisite: Admission to the Program and HASS100. 3 lecture hours, 3 credit hours.

HNRS315. EXPLORATIONS IN THE MODERN WORLD. 3.0 Semester Hrs.
(I, II) (WI) Honors core course that develops student writing skills and critical thinking abilities through the exploration of selected topics related to the social, cultural, and political ideas and developments that have shaped the modern world. Prerequisite: Admission to the Program and HASS100. 3 lecture hours, 3 credit hours.

HNRS405. MCBRIDE PRACTICUM. 1-3 Semester Hr.
(I, II) (WI) With approval of the Program, a McBride student may enroll in an individualized study project which substitutes for or enhances the regularly-scheduled McBride curriculum seminars. This option may be used to pursue an approved foreign study program, service learning program, international internship, undergraduate research project, or other authorized experiential learning program of study. Students must also prepare a faculty-guided major research paper that integrates the experience with the goals, objectives, and focus of the Honors Program in Public Affairs. 1-3 semester hours. Repeatable up to 6 hours.

HNRS425. EXPLORATIONS IN POLITICS, POLICY, AND LEADERSHIP. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to policy, politics, and/or leadership through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in The Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS430. EXPLORATIONS IN IDEAS, ETHICS, AND RELIGION. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to ideas, ethics, and/or religion through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS435. EXPLORATIONS IN CULTURE, SOCIETY, AND CREATIVE ARTS. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to culture, society, and/or the creative arts through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS440. EXPLORATIONS IN INTERNATIONAL STUDIES & GLOBAL AFFAIRS. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to international studies and/or global affairs through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS445. EXPLORATIONS IN SCIENCE, TECHNOLOGY, AND SOCIETY. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to the relationships between science, technology, and society through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS450. EXPLORATIONS IN EARTH, ENERGY, AND ENVIRONMENT. 3.0 Semester Hrs.
(I, II) (WI) Study of selected topics related to earth, energy, and/or the environment through case studies, readings, research, and writing. This course may focus on the human dimensions or broader impacts of science, technology, engineering, or mathematics. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

HNRS476. COMMUNITY ENGAGEMENT THROUGH SERVICE LEARNING. 3.0 Semester Hrs.
(II) Community Engagement through Service Learning combines a traditional classroom environment with an off campus learning experience with a local non-profit or community organization. Students spend 3-4 hours per week serving the organization they choose and meet in class once per week to discuss reading assignments, present research findings, and share experiences and insights about the course material. Instructors may choose to focus on a particular topic or social issue, such as poverty and privilege, or may engage with community issues more broadly. The course focuses on several aspects of a student?s learning, including intra- and interpersonal learning, discovering community, and developing communication skills and critical and interdisciplinary approaches. Course work will focus on critical reading, group discussion and deliberation, oral presentations of research, and writing assignments. Prerequisites: none. 2 hours lecture; 3-4 hours lab; 3.0 semester hours.

HNRS498. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS. 1-6 Semester Hr.
A Special Topics course will be a pilot course in the McBride curriculum or will be offered as an enhancement to regularly-scheduled McBride seminars. Special Topics courses in the McBride curriculum will not be offered more than twice. Variable credit: 1 - 6 semester hours. Repeatable for credit under different titles.

HNRS499. INDEPENDENT STUDY. 1-6 Semester Hr.
Under special circumstances, a McBride student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled McBride curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

Teaching Professor

Professor Toni Lefton, Executive Director, University Honors & Scholars Programs

Teaching Associate Professors

Professor Melanie Brandt, McBride Honors Program Director

Professor Justin Latici, McBride Practicum Advisor

Operations Research

Minor Program in Operations Research (OR)

The Operations Research minor consists of a minimum of 18 credit hours of a logical sequence of courses. Only three of these hours may be taken in the student's degree-granting department. Three of these hours must consist of a deterministic modeling course, three must consist of a stochastic modeling course, and no more than three must draw from a survey course (combining both stochastic and deterministic modeling).

The objectives of the minor are to supplement an engineering or applied science background with a formal approach to mathematical modeling that includes assessing and/or improving the performance of a system.

Such a system could be naturally occurring or man-made. Examples of such systems are manufacturing lines, mines, wind farms, mechanical systems such as turbines and generators (or a collection of such objects), waste water treatment facilities, and chemical processes. The formal approach includes optimization, (e.g., linear programming, nonlinear programming, integer programming), decision analysis, stochastic modeling, and simulation.

Deterministic Modeling (minimum of one)

CSCI262	DATA STRUCTURES	3.0
CSCI404	ARTIFICIAL INTELLIGENCE	3.0
CSCI406	ALGORITHMS	3.0
MATH332	LINEAR ALGEBRA	3.0
EBGN455	LINEAR PROGRAMMING	3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG417	MODERN CONTROL DESIGN	3.0
MEGN502	ADVANCED ENGINEERING ANALYSIS	3.0
MEGN588	INTEGER OPTIMIZATION	3.0

Stochastic Modeling (minimum of one)

EBGN459	SUPPLY CHAIN MANAGEMENT	3.0
EBGN461	STOCHASTIC MODELS IN MANAGEMENT SCIENCE	3.0
EBGN528	INDUSTRIAL SYSTEMS SIMULATION	3.0
EBGN560	DECISION ANALYTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
MATH438	STOCHASTIC MODELS	3.0
MNGN438	GEOSTATISTICS	3.0
PEGN438	PETROLEUM DATA ANALYTICS	3.0
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0

Survey Course (Maximum of one)

MNGN433	MINE SYSTEMS ANALYSIS I	3.0

Quantum Engineering

Minor Program in Quantum Engineering

Quantum Engineering is an interdisciplinary program that seeks to equip students for careers in emerging technologies in quantum information sciences. It encompasses a wide range of disciplines that include chemistry, computer science, electrical engineering, mathematics, materials science, and physics, and is necessarily a collaborative effort among many Mines departments.

Quantum Engineering Minor

Quantum Engineering is an interdisciplinary program that seeks to equip students for careers in emerging technologies in quantum information sciences. It encompasses a wide range of disciplines that include chemistry, computer science, electrical engineering, mathematics, materials science, and physics, and is necessarily a collaborative effort among many Mines departments.

The interdisciplinary minor in Quantum Engineering requires 18 credit hours.

QE minor students will be required to take Honors Linear Algebra (MATH342) or Linear Algebra (MATH332) and three of the following courses: Quantum Programming (CSCI481/CSCI581), Low Temperature Microwave Measurement (EENG432/EENG532), Quantum Many-Body Physics (PHGN441), Microelectronics Processing (PHGN435), and Fundamentals of Quantum Information (PHYS519).

Students may select an additional 2 courses from the list above or the following list to further increase specialization:

PHGN440	SOLID STATE PHYSICS	3.0
PHGN446	OPTICAL ENGINEERING	3.0
PHGN480	LASER PHYSICS	3.0
PHGN466	MODERN OPTICAL ENGINEERING	3.0
CSCI423	COMPUTER SIMULATION	3.0
CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	3.0
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
CSCI474	INTRODUCTION TO CRYPTOGRAPHY	3.0
MTGN211	STRUCTURE OF MATERIALS	3.0
MTGN315	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS	3.0
MTGN252	MATERIALS KINETICS	3.0
MTGN350	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0
MTGN456	ELECTRON MICROSCOPY	2.0
MTGN473	COMPUTATIONAL MATERIALS	3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING	4.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0
EENG411	DIGITAL SIGNAL PROCESSING	3.0
EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0
EENG428/430	COMPUTATIONAL ELECTROMAGNETICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH454	COMPLEX ANALYSIS	3.0
MATH458	ABSTRACT ALGEBRA	3.0

Space and Planetary Science and Engineering

Program Offered

Area of Special Interest in Space and Planetary Science and Engineering

Program Description

The Space and Planetary Science and Engineering Program offers an Area of Special Interest for students interested in the science, engineering, and exploration of space. This program brings together courses from several Mines departments and programs covering a diverse array of topics, including planetary science, astronomy, space physics, and the design of engineering systems for space exploration. The curriculum can be chosen from a list of approved courses, in consultation with an SPSE program advisor. Interested students

should contact SPSE Program Director, Dr. Angel Abbud-Madrid, at aabbudma@mines.edu. **(**aabbudma@mines.edu**)**

Since the advent of the space age in the middle of the last century, the pace of human and robotic exploration of space has been ever increasing. This exploration is made possible by feats of engineering to allow long-term operation of robotic systems and human explorers in the harsh environment of space. The product of this exploration is a large and growing body of knowledge about our neighbors in the Solar System and our place in the universe. The mission of the Space and Planetary Science and Engineering (SPSE) program is to provide students with a pathway for studying extraterrestrial applications of science, engineering, and resource utilization through an Area of Special Interest.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Program Requirements

Area of Special Interest in Space and Planetary Science and Engineering:

Enrollment in the Area of Special Interest is approved by the Director. Students will then be assigned to an SPSE ASI advisor from among the affiliated faculty, who will monitor and advise their progress. The Area of Special Interest requires a total of 12 credits, up to 3 of which may be at the 200 level or below and up to 3 of which may overlap with the requirements of the degree-granting program. Students may choose their ASI courses from the list of approved courses below or from any additional courses approved by the students' ASI advisor. Application of EDNS Cornerstone or Capstone project credits towards the ASI requires choice of a space or planetary related project and approval by the students' SPSE ASI advisor.

SPSE-approved Courses

EDNS251	DESIGN II	3.0
MEGN408	INTRODUCTION TO SPACE EXPLORATION	3.0
EDNS491	SENIOR DESIGN I	3.0
EDNS492	SENIOR DESIGN II	3.0
GEGN469	ENGINEERING GEOLOGY DESIGN	3.0
GEOL410	PLANETARY GEOLOGY	3.0
GPGN438	GEOPHYSICS PROJECT DESIGN	3.0
GPGN470	APPLICATIONS OF SATELLITE REMOTE SENSING	3.0
PHGN418	GENERAL RELATIVITY	3.0
PHGN324	INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS	3.0
PHGN423	PARTICLE PHYSICS	3.0
PHGN471 & PHGN481	SENIOR DESIGN PRINCIPLES I and SENIOR DESIGN PRACTICE	3.0
PHGN472 & PHGN482	SENIOR DESIGN PRINCIPLES II and SENIOR DESIGN PRACTICE	3.0
MEGN451	FLUID MECHANICS II - AERODYNAMICS	3.0
MEGN498	AEROSPACE STRUCTURES	3.0

Director, SPSE Area of Special Interest

Angel Abbud-Madrid, Mechanical Engineering & Space Resources

Affiliated Faculty

Christopher Dreyer, Mechanical Engineering & Space Resources

Alex Flournoy, Physics

Leslie Lamberson, Mechanical Engineering

Derrick Rodriguez, Mechanical Engineering

Frederic Sarazin, Physics

Paul Sava, Geophysics

Matthew Siegfried, Geophysics

George Sowers, Mechanical Engineering & Space Resources Program

John Spear, Civil and Environmental Engineering

Neal Sullivan, Mechanical Engineering

Lesli Wood, Geology and Geological Engineering

Underground Construction & Tunneling

Programs Offered

Minor in Underground Construction and Tunneling (18.0 credit hours) and an Area of Special Interest (ASI) (12.0 credit hours).

Program Educational Objectives

Underground Construction and Tunneling is a growing discipline involving knowledge in the disciplines of mining engineering, geological engineering and civil engineering, among others. The Departments of Mining Engineering, Geology & Geological Engineering and Civil and Environmental Engineering offer an interdisciplinary Minor or Area of Special Interest (ASI) course of study that allows students from these departments to take a suite of courses providing them with a basis for work and further study in this field.

The objectives of the minor and ASI are to supplement an engineering background with a formal approach to subsurface engineering that includes site characterization, design and construction of underground infrastructure, including water, storm water, highway or subway tunnels and subsurface facilities.

The Mines guidelines for Minor/ASI (p. 33) can be found in the Undergraduate Information (p. 13)section of the Mines Catalog (p. 2).

Curriculum

Underground Construction & Tunneling Engineering Minor and ASI

The Underground Construction & Tunneling Engineering minor consists of a minimum of 18 credit hours of coursework from the list below. An Area of Special Interest (ASI) in Underground Construction & Tunneling requires 12 credit hours of coursework from the list below. A student's advisor may authorize a student's Minor or Area of Special Interest (ASI) application. For questions about the minor and to request consideration of additional courses including independent study, students should meet with a UC&T faculty member. The petition process requires one month

to complete. See the following page (p. 33) for CSM's Minor and ASI requirements.

Program Requirements:

Required Courses (Minor)

CEEN312	SOIL MECHANICS	3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	3.0
MNGN404	TUNNELING	3.0

Electives (Minor)

CEEN314	STRUCTURAL THEORY	3.0
CEEN350	CIVIL AND CONSTRUCTION ENGINEERING MATERIALS	3.0
CEEN360	INTRODUCTION TO CONSTRUCTION ENGINEERING	3.0
CEEN499	INDEPENDENT STUDY	1-6
GEGN466	GROUNDWATER ENGINEERING	3.0
or GEGN467	GROUNDWATER ENGINEERING	
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	4.0
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3.0
GEGN499	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6
MNGN314	UNDERGROUND MINE DESIGN	3.0
MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0
MNGN424	MINE VENTILATION	3.0
MNGN499	INDEPENDENT STUDY	1-6

Required Courses (Area of Special Interest - ASI)

CEEN312	SOIL MECHANICS	3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	3.0
MNGN404	TUNNELING	3.0

Electives (Area of Special Interest - ASI)

Students may choose one course from the required Minor courses or elective courses listed above.

Department of Civil & Environmental Eningineering

Marte Gutierrez, Professor

Michael Mooney, Professor

Department of Geology & Geological Engineering

Jerry Higgins, Associate Professor

Wendy Zhou, Associate Professor

Department of Mining Engineering

Hugh Miller, Associate Professor

Ray Henn, Adjunct Professor

Priscilla Nelson, Professor

Special Programs

Skills Building Courses

The following courses are offered by various Administrative departments on campus to give students the opportunity to build valuable skills to assist with their academic and professional development.

The Freshman Seminar course, CSM101, is a required course and is part of the undergraduate degree requirements. All incoming Freshman will be registered for this course during their first semester at Mines. Incoming Transfer students may be eligible to receive transfer credit for this course to meet their degree requirements, based on previously completed coursework at the college level.

Transfer students who have successfully completed fewer than 30.0 transcripted semester hours at an institution of higher education after high school graduation will automatically be enrolled in CSM101.

CSM101	FRESHMAN SUCCESS SEMINAR	0.5
CSM250	ENGINEERING YOUR CAREER PATH	1.0
CSM275	CASA BOUNCE BACK PROGRAM	1.0

For more information about CSM101, contact New Student & Transition Services.

For more information about CSM250, contact the Career Center.

For more information about CSM275, contact the Center for Academic Services and Advising (CASA).

Study Abroad

Spending time abroad is a valuable professional and personal endeavor. Given the worldwide scope and impact of engineering, global competence and intercultural skills are an extremely valuable asset to the work place and in life. Studying abroad helps you develop and hone these skills. Colorado School of Mines encourages students to include an international study/research/volunteer experience in their undergraduate and/or graduate education.

The Education Abroad division in the Office of Global Education helps students prepare to study abroad from their first initial interest until they return to campus. The Education Abroad team will liaise with the appropriate stakeholders to support the student in applying to a host university abroad, selecting courses, and other pre-departure preparations.

Mines maintains student exchange programs with engineering universities in South America, Europe, Oceania, Africa, and Asia. Courses taken at a partner university abroad can fulfill an equivalent course at Mines if they are pre-approved and successfully passed with a grade of "C-" or better. Transfer credit is awarded; a student's GPA is not affected by courses taken abroad.

Education Abroad also assists faculty with the development of faculty-led courses abroad during the summer and school breaks.

Financial aid and selected scholarships and grants can be used to finance approved study abroad programs. International university partners may occasionally have additional scholarship funding for study

abroad or internship programs. There are a few national study abroad scholarship opportunities available. More information can be found in the Office of Global Education.

Students wishing to pursue study abroad opportunities, either coursework or research, should contact the Office of Global Education in the Green Center - Suite 219. Staff in the office are happy to meet one on one to discuss opportunities abroad. Drop in times are available each day or students can make an appointment by visiting mines.edu/global.

FIRST YEAR SEMESTER ABROAD EXPERIENCE

Colorado School of Mines now offers a First Year Semester Abroad Experience (FYSAE) for incoming students. This innovative experience brings Mines students to Antibes, France, a city along the breathtaking French Riviera. As part of a collaborative and tight-knit cohort, students take STEM-focused courses and Humanities that are equivalent to the courses taught on the Golden campus. Students start their undergraduate experience abroad and then seamlessly return to the Mines campus for their second semester.

Experience benefits:

- Participation in a signature experience in Antibes where the Mines cohort joins other students from around the world
- Take Mines approved courses that keep students on track towards their degree
- A full time Resident Director will support students throughout the experience, providing guidance, support, and tutoring
- Explore the French Riviera and surrounding area through organized excursions, volunteer days, culinary workshops and more
- Gain intercultural awareness, professional skills and a more inclusive, worldly perspective
- Participate in pre-departure and re-entry orientations to feel connected to the Mines community

Experience all of the above for costs similar to studying on the Mines campus (with the exception of flight and visa costs), while staying on track to graduate with a Mines degree

Writing Across the Curriculum (WAC)

To support the institutional goal of developing professional communication skills, required writing and communication-intensive courses are designated in both the core and in the degree-granting programs. According to guidelines approved by the Undergraduate Council, degree-granting programs are to identify four courses, often two junior and two senior-level courses, as writing-intensive. The (generally four) writing-intensive courses within the various degree-granting programs are designated with (WI) in their course descriptions. Course descriptions can be found on the Undergraduate Programs and Departments page, under the Courses tab for each department.

In addition to disciplinary writing experience, students also obtain writing experience outside their disciplines as courses in HASS are virtually all writing intensive. The Campus Writing Program, housed in the Division of Humanities, Arts, and Social Sciences (HASS), supports the WAC program.

Writing Center

The Writing Center provides free academic support to all members of the campus community, including faculty, staff, students, and alumni. Our tutors can provide assistance with any form of communication including papers, scholarship essays, and presentations at any stage of the process. Writing Center faculty are experienced technical and professional writing instructors who are experts in a wide variety of fields. The Writing Center is located in Alderson Hall 133 (phone: 303-273-3085) and offers face-to-face, online, and drop-in tutoring. Please visit https://writing.mines.edu to learn more about our services.

Policies and Procedures

Standards, Codes of Conduct

Students can access campus rules and regulations, including the student code of conduct, alcohol policy, public safety and parking policies, the distribution of literature and free speech policy, and a variety of others by visiting the School's policy website. We encourage all students to review the website and expect that students know and understand the campus policies, rules and regulations as well as their rights as a student. Questions and comments regarding the above mentioned policies can be directed to the Dean of Students located in the Student Life Office in the Ben Parker Student Center.

For emphasis, the following policies are included or identified in this section:

- Student Honor Code
- Policy on Academic Integrity/Misconduct
- Policy Prohibiting Sexual Harassment, Sexual Violence, and Interpersonal Violence
- Unlawful Discrimination Policy
- Alcohol and Other Drugs Education and Prevention Policy
- Electronic Communications (E-mail) Policy
- Student Complaint Process
- Access to Student Records
- Posthumous Degree Awards
- Equal Opportunity, Equal Access, and Affirmative Action
    - Office of Institutional Equity & Title IX
    - SpeakUP@Mines

Please note: Any policy or procedure updates during the term will be reflected in the Mines Policy Library and those versions shall control.

Student Honor Code

1.0 PREAMBLE

The students of Colorado School of Mines have adopted the following Student Honor Code in order to establish a high standard of student behavior at Mines. The Code may only be amended through a student referendum supported by a majority vote of the Mines student body. Mines students shall be involved in the enforcement of the Code through their participation in the Student Conduct Appeals Board.

2.0 CODE

Mines students believe it is our responsibility to promote and maintain high ethical standards in order to ensure our safety, welfare, and enjoyment of a successful learning environment. Each of us, under this Code, shall assume responsibility for our behavior in the area of academic integrity. As a Mines student, I am expected to adhere to the highest standards of academic excellence and personal integrity regarding my schoolwork, exams, academic projects, and research endeavors. I will act honestly, responsibly, and above all, with honor and integrity in all aspects of my academic endeavors at Mines. I will not misrepresent the work of others as my own, nor will I give or receive unauthorized assistance in the performance of academic coursework. I will conduct myself in an ethical manner in my use of the library, computing center, and all other school facilities and resources. By practicing these principles, I will strive to uphold the principles of integrity and academic excellence at Mines. I will not participate in or tolerate any form of discrimination or mistreatment of another individual.

Policy on Academic Integrity/Misconduct

1.0 ACADEMIC INTEGRITY

The Colorado School of Mines (Mines) affirms the principle that all individuals associated with the Mines academic community have a responsibility for establishing, maintaining, and fostering an understanding and appreciation for academic integrity. In broad terms, this implies protecting the environment of mutual trust within which scholarly exchange occurs, supporting the ability of the faculty to fairly and effectively evaluate every student's academic achievements, and giving credence to the university's educational mission, its scholarly objectives, and the substance of the degrees it awards. The protection of academic integrity requires there to be clear and consistent standards, as well as confrontation and sanctions when individuals violate those standards. The Colorado School of Mines desires an environment free of any and all forms of academic misconduct and expects students to act with integrity at all times.

2.0 POLICY ON ACADEMIC MISCONDUCT

Student Academic Misconduct arises when a student violates the principle of academic integrity and/or when a student aids and abets in the commission of academic misconduct. Academic misconduct may also occur when a student is negligent in their reasonable responsibilities as a student to be aware of or proactively confirm or clarify appropriate conduct with coursework, assignments or exams, and subsequently proceeds in a manner befitting of misconduct. Such behavior erodes mutual trust, distorts the fair evaluation of academic achievements, violates the ethical code of behavior upon which education and scholarship rest, and undermines the credibility of the university.

Because of the serious institutional and individual ramifications, student misconduct arising from violations of academic integrity is not tolerated at Mines. If a student is found to have engaged in such misconduct sanctions such as change of a grade, loss of institutional privileges, or academic suspension or dismissal may be imposed.

The Dean of Students Office administers this faculty-approved policy. Within the Dean of Students Office, two administrators will facilitate the separate aspects of the policy, including the initial resolution and appeal process, in order to remain impartial with respect to potential appeals whilst simultaneously providing procedural guidance to faculty and students.

Forms of Misconduct. As a guide, some of the more common forms of academic misconduct are noted below. This list is not intended to be all-inclusive; rather, the list is illustrative of practices the Mines faculty have deemed inappropriate.

1. **Dishonest Conduct** - general conduct unbecoming a scholar. Examples include issuing misleading statements; withholding pertinent information; submitting previously graded work as new and/or original without acknowledgement and permission; not fulfilling,

in a timely fashion, previously agreed to projects or activities; and verifying as true, things that are known to the student not to be true or verifiable.

2. **Plagiarism** - presenting the work of another as one's own. This is usually accomplished through the failure to acknowledge the borrowing of ideas, data, or the words of others. Examples include submitting as one's own work the work of another student, a ghost writer, or a commercial writing service; quoting, either directly or paraphrased, a source without appropriate acknowledgment; and using figures, charts, graphs or facts without appropriate acknowledgment. Inadvertent or unintentional misuse or appropriation of another's work is nevertheless plagiarism.
3. **Falsification/Fabrication** - inventing or altering information. Examples include inventing or manipulating data or research procedures to report, suggest, or imply that particular results were achieved from procedures when such procedures were not actually undertaken or when such results were not actually supported by the pertinent data; false citation of source materials; reporting false information about practical, laboratory, or clinical experiences; falsifying attendance or participation; submitting false excuses for absence, tardiness, or missed deadlines; and, altering previously submitted examinations.
4. **Tampering** - interfering with, forging, altering or attempting to alter university records, grades, assignments, or other documents without authorization. Examples include using a computer or a false-written document to change a recorded grade; altering, deleting, or manufacturing any academic record; and, gaining unauthorized access to a university record by any means.
5. **Cheating** - using or attempting to use unauthorized materials or aid with the intent of demonstrating academic performance through fraudulent means. Examples include copying from another student's paper or receiving unauthorized assistance on a homework assignment, quiz, test, or examination; using books, notes or other devices such as calculators, PDAs and cell phones, unless explicitly authorized; acquiring without authorization a copy of the examination before the scheduled examination; and copying reports, laboratory work or computer files from other students. Authorized materials are those generally regarded as being appropriate in an academic setting, unless specific exceptions have been articulated by the instructor.
6. **Impeding** - negatively impacting the ability of other students to successfully complete course or degree requirements. Examples include removing pages from books and removing materials that are placed on reserve in the Library for general use; failing to provide team members necessary materials or assistance; and, knowingly disseminating false information about the nature of a test or examination.
7. **Sharing Work** - giving or attempting to give unauthorized materials or aid to another student. Examples include allowing another student to copy your work; giving unauthorized assistance on a homework assignment, quiz, test or examination; providing, without authorization, copies of examinations before the scheduled examination; posting work on a website for others to see; and sharing reports, laboratory work or computer files with other students.

Additionally, individual courses may specify appropriate and/or inappropriate scholastic conduct as long as course specific guidance is not in conflict with this senior, university misconduct policy and is well known by way of advanced written distribution to all students enrolled (e.g. published course syllabus).

Allegations of misconduct brought forward by faculty must fall within with the aforementioned seven examples of common misconduct and/or be specifically and explicitly addressed in the published course materials

3.0 PROCEDURES FOR ADDRESSING ACADEMIC MISCONDUCT

Faculty members and thesis committees have discretion to address and resolve misconduct matters in a manner that is commensurate with the infraction and consistent with the values of the Institution. This includes imposition of appropriate academic sanctions for students involved in academic misconduct. However, in order to maintain consistency when handling such issues, if a member of the Mines' community has grounds for suspecting that a student or students have engaged in academic misconduct, they have an obligation to act on this suspicion by utilizing the following procedure:

3.1 Notify the Dean of Students Office. Upon suspicion of misconduct, it is the faculty member's responsibility to email the Dean of Students Office. The Dean of Students Office will provide procedural guidance to the faculty member, including pre-written email templates which the faculty may use.

Student names may be disclosed at this time, but are not necessary. Prepared sample templates and procedural guidance will consider and include appropriate accessibility language to ensure an accessible process for students and faculty, alike.

3.2 Notify and Meet with Student(s). Following correspondence with the Dean of Students Office, the faculty member or thesis committee representative must meet with and inform the student(s) of the suspicions/allegations and potential charge of academic misconduct within ten (10) business days of suspecting misconduct.

This meeting allows the student the opportunity to give his/her/their perspective or explanation prior to any decision being made as to whether or not misconduct occurred. The student should be aware of the subject of the meeting and the alleged misconduct at the time of scheduling. The meeting also allows the faculty member to have a conversation with the student(s) in an effort to educate him/her/them on appropriate conduct.

Following this meeting (at end of meeting or afterward, and within the prescribed timeline), the faculty member should inform the student of their decision as to whether or not misconduct occurred. In the instance where the faculty member(s) believe misconduct occurred, the student should be explicitly informed of the nature of the misconduct (e.g. cheating, plagiarism, etc.).

The meeting can be done via telephone if needed, but a face-to-face meeting between the faculty member and student is preferred. It is recommended, but not required, that the faculty invite a neutral, silent colleague to the meeting as an impartial witness. If the student or faculty member is unable to meet because of pre-existing commitments or unforeseen priorities, the ten-day timeline may be temporarily suspended with mutual written agreement of faculty and student(s), and written approval by the Dean of Students Office prior to expiration of the deadline.

3.3. Actions Taken; Circumstances. The circumstances of the academic misconduct dictate the process to be followed:

3.3.1 Regular Coursework. In the case of an allegation of academic misconduct associated with **regular coursework** (including exams), if after talking with the student, the faculty

member finds the student is responsible for academic misconduct the faculty member should:

- Contact the Dean of Students and his/her Department Head/Division Director to officially report the violation in writing within five (5) business days of meeting with the student (as outlined above – see 3.1). Report of a violation should detail the nature of the misconduct (e.g. cheating, plagiarism, etc.).
- The Dean of Students Office will communicate the resolution in writing to the student, the faculty member(s), appropriate members of Academic Affairs, the Office of Graduate Studies (if applicable), the student's advisor, and any additional appropriate parties including Athletics, course coordinators, or the Registrar's Office. The Dean of Students will keep official records on all students with academic misconduct violations. Disciplinary action/ sanctioning for misconduct with regular coursework:
  - 1st Offense: Zero credit (or no points) on the assignment/exam/effort. Educational sanctioning as prescribed and facilitated by the Dean of Students Office. Notation of first offense in disciplinary record.
    - Failure to comply with educational sanctioning expectations and timeline will result in immediate acceleration of offense to sanctioning prescribed with 2nd offense (F in course and inability to withdraw). Additionally, the student's disciplinary standing will also be upgraded to 2nd offense.
    - With 1st offense, faculty may choose to provide a restorative credit assignment or make-up quiz or exam wherein students can work to recover credit penalized as part of misconduct sanctioning.
  - 2nd Offense: "F" in the course and inability to withdraw. Notation of second offense in disciplinary record.
  - 3rd or Greater Offense: "F" in the course. Suspension from school for 1-year minimum (calendar year). "Suspension as a result of Academic Misconduct" permanently noted on university transcript. Return to Mines not guaranteed, and only possible by way of Mines Readmissions Committee.

3.3.2 Activities Not Part of Regular Coursework. In the case of an allegation of academic misconduct associated with **activities not a part of regular coursework** (e.g., an allegation of cheating on a comprehensive examination or academic misconduct in connection with a graduate thesis project), if after talking with the student, faculty member(s) finds the student is responsible for misconduct the faculty should:

- Contact the Dean of Students and his/her Department Head/Division Director to officially report the violation in writing within five (5) business days of meeting with the student (as outlined above – see 3.1). The Dean of Students Office will communicate the resolution in writing to the student, the faculty member(s), appropriate members of Academic Affairs, the Office of Graduate Studies (if applicable), the student's advisor, and any additional appropriate parties including Athletics, course coordinators, or the Registrar's Office. The Dean of Students will keep official records on all students with academic misconduct violations.
- Assign an outcome to the activity that constitutes failure. If appropriate, the student's advisor may also assign a grade of "PRU" (unsatisfactory progress) for research credits in which the student is enrolled. Regular institutional procedures resulting from either of these outcomes are then followed. Faculty members may impose a lesser penalty if the circumstances warrant, however, the typical sanction is failure.

3.3.3 Research Activities. In the case of an allegation of academic misconduct associated with **research activities**, investigation and resolution of the misconduct is governed by the Institution's Research Integrity Policy. The Research Integrity Policy is available as section 10.3 of the Faculty Handbook. If, after talking with the student, the faculty member feels the student is responsible for misconduct of this type, the faculty member should proceed as indicted in the Research Integrity Policy. If appropriate, the student's advisor may also assign a grade of "PRU" for research credits in which the student is enrolled. Regular institutional procedures resulting from this grade assignment are then followed.

3.4 Student Reporting. Students who suspect other students of academic misconduct should report the matter to the appropriate faculty member, the appropriate Department Head/Division/ Program Director, the Dean of Undergraduate Studies, the Dean of Graduate Studies or the Dean of Students. The information is then provided to the faculty member concerned.

4.0 STUDENT ACADEMIC MISCONDUCT APPEAL PROCESS

4.1 Purpose

A student may appeal a decision within certain timelines and under specific criteria. For all charges of academic misconduct, upon notification of a finding of academic misconduct and the associated penalties, the student may appeal the decision of the faculty member.

An appeal is not a second hearing of the case, but rather it is a review of the procedures followed and information presented to determine if the process provided was in accordance with the policy, or if the decision was unsupported by the evidence, as set forth below.

This appeal process governs all requests for appeal related to violations of the Academic Integrity/Misconduct Policy. Grade Appeals, residency appeals, student conduct appeals, and appeals related to research misconduct are handled through separate processes. Please see the Mines Policy website for more information on those processes.

4.2 Grounds for Appeal

An appeal request will be considered only if it includes the specific grounds for an appeal and the rationale that support the selected grounds. The three items listed below are the only acceptable grounds for an appeal:

- **Due Process**. To determine whether the meeting with the faculty member and the process followed was conducted fairly and in conformity with the prescribed procedures. Any procedural errors must have been so substantial as to effectively deny the student a reasonable opportunity to prepare and present information about an alleged policy violation. The student should be able to show that there would have been a different outcome if the procedural error had not occurred. Minor deviations that do not materially affect the outcome are not a basis for sustaining an appeal.
- **New Information**. To consider information or other relevant facts sufficient to alter a decision because such information was not known by the student at the time of the original conduct meeting with the faculty member.
- **Unsupported Decision**. To determine whether the decision reached by the faculty member was supported using the preponderance of evidence standard to establish that a violation of the policy occurred. This ground for appeal requires the student to show that no reasonable person could have determined that the student was responsible or could have imposed the sanctioned issued based on the available evidence.

4.3 Submitting an Appeal Request

Decisions reached by a faculty member may be appealed by the student. A student may file an appeal by completing a Student Conduct Appeal Form and submitting it to the Dean of Students' Office by the date stated on the original decision letter (typically seven business days). This form is available online at https://www.mines.edu/policy-library/student/ and in person at the Student Life Office. It is the student's obligation to complete the form in its entirety and provide any and all materials that she/he wishes to have considered at the time of the appeal submission. Incomplete form, late submissions, or revised requests will not be accepted. If the student's appeal request is not received by the designated deadline, the decision of the faculty member is final and no further appeal will be permitted.

4.3.1 Appeal Request Review. Once an appeal request is received, it is forwarded to the Dean of Students. Within five business days, the Dean of Students will review the request to determine if the acceptable grounds for an appeal have been met, if the appeal has been timely filed, and if the request is complete. After review of the request, the Dean of Students will take one of the following actions:

a. Accept the Appeal Request - See section 4.3.2 below
b. Deny the Appeal Request – The Dean of Students will notify the student that the appeal has been denied and the basis for the denial. An appeal that does not set forth sufficient grounds for appeal (as described in section 2.0 above) will be denied. In such cases, the original decision of the faculty member is considered binding upon all involved and the matter will be considered closed unless the student can provide evidence that the Dean of Students made an arbitrary decision without fully considering the information presented. If that is the case, the student requesting the appeal must notify the Associate Vice President of Student Life in writing within two business days and request that the appeal be reviewed again by the Associate Vice President of Student Life. The Associate Vice President of Student Life will review the request within two business days. The Associate Vice President of Student Life will either accept the appeal request (see section 3.2) or deny the appeal request. If the Associate Vice President of Student Life denies the appeal request, the decision is final and considered binding upon all involved.

4.3.2 Accepted Appeal. Once the appeal request has been accepted by the Dean of Students (or Associate Vice President of Student Life), the Dean of Students will proceed as follows:

a. Notify the student and the faculty member that the appeal has been accepted and the appeal will proceed.
b. Schedule a date and time for the appeal meeting to be held.
c. Provide the student and faculty member with an overview of the appeal process and allow them to submit any additional information related to the academic misconduct charge that they would like to be included in the appeal meeting.
d. Forward the appeal and all supporting documents to the participating members of the Student Conduct Appeals Board.

4.4 Student Conduct Appeals Board

The Student Conduct Appeals Board ("Board") consists of 16 members of the campus community, including 6 students, 6 faculty, and 4 staff, plus the Dean of Students as the chair. A minimum of three Board members (including 1 student and 1 faculty member) are required for all appeal meetings.

Upon acceptance of an appeal, the list of the members of the Student Conduct Appeals Board will be provided to the student and the faculty member. Both the student and the faculty member may each request the removal of one of the Board members' from participating in the appeal meeting. Upon receipt of such requests, the Dean of Students will remove the potential member from participating.

Once an appeal request is accepted and the appeal meeting scheduled, non-excluded Board members will be contacted and invited to participate at the appeal meeting. Appeals Board members have an affirmative obligation to excuse themselves if they have a conflict of interest. The Dean of Students will provide participating Board members with all pertinent information regarding the incident and appeal, including but not limited to the student's education records, the appeal request, and other information submitted by the student and the faculty member.

4.5 Appeal Meeting

The student and the faculty member will meet individually with the participating Student Conduct Appeals Board members during the appeal meeting. Both the student and the faculty member will be allowed to provide a brief statement and then answer questions from the Appeals Board members. The student and faculty member will not be permitted to question one another. All questioning will be done by the Board members. The Board members may, at their discretion, meet with any appropriate witnesses during the meeting. After all questioning has occurred, the student and faculty member will be excused.

4.5.1 Recordings. If requested by the student or faculty member, one verbatim record, such as a recording, will be made. This recording shall be the property of Mines. If such a recording is made, a student wishing to obtain a copy of the recording must submit a request to the Dean of Students. This may be done via mail, email, or in person. Once the request has been received, the Dean of Students will provide both parties with a copy of the recording.

4.5.2 Advisor. The appeal meeting is an internal University judicial matter. Students are allowed to have one individual advisor (parent, lawyer, friend etc.) in the room during the appeal meeting. The advisor is not allowed to speak on the student's behalf or address the committee during the appeal meeting. He/she is only allowed to hear the information being provided to the committee, confer with the student, and offer the student advice. This individual is not permitted to represent the student or speak on the student's behalf during the appeal meeting.

4.6 Pending Action

Throughout the entire appeal process, and while the decision of the Dean of Students or the Student Conduct Appeals Committee is pending, the student must continue to comply with all conditions of the original decision made by the faculty member. Unless otherwise specified in the original written notification of suspension, a student may continue to attend classes while the appeal is pending.

4.7 Decision

At the conclusion of the appeal meeting, the Student Conduct Appeals Board will make one of the following decisions:

A. Reverse the decision of the faculty member and withdraw the charge from the student's record.
B. Affirm the decision of the faculty member and uphold the sanction(s).
C. Forward the case to the Office of Academic Affairs for further consideration: the Student Conduct Appeals Board believes that additional matters implicated in the appeal should be reviewed and considered which could include increasing or decreasing the sanctions imposed or addressing additional issues that arose through the appeal process. Recommendations for appropriate sanctions should be made by the Student Appeals Committee to the Office of Academic Affairs. The additional review and consideration will be conducted by the Dean of Undergraduate Studies or Dean of Graduate Studies, depending on the academic standing of the student requesting the appeal. The Office of Academic Affairs staff member will make a final decision that will be communicated to the student within 10 business days.

The decision made will be communicated to the student and faculty member within 24 hours of the conclusion of the appeal meeting. The decision issued by the Student Conduct Appeals Board or the Office of Academic Affairs (in matters that are forwarded for further consideration) is final and shall be considered binding upon all involved, from which no additional appeals are permitted.

For the most up-to-date version of this procedure and appeal request forms, please see the student section of the policy website.

POLICY PROHIBITING UNLAWFUL DISCRIMINATION

1.0. BACKGROUND AND PURPOSE

The Colorado School of Mines ("Mines") is committed to inclusivity and access for all persons and strives to create learning and workplace environments that exclude all forms of unlawful discrimination, harassment, and retaliation. Mines' commitment to non-discrimination, affirmative action, equal opportunity, and equal access is reflected in the administration of its policies, procedures, programs, and activities, as well as its efforts to achieve a diverse student body and workforce.

As part of this commitment, the Board of Trustees of the Colorado School of Mines promulgates this policy pursuant to the authority conferred by §23-41-104(1), C.R.S., and in accordance with applicable federal and Colorado civil rights laws.

2.0 POLICY STATEMENT

Mines prohibits discrimination and harassment on the basis of age, ancestry, creed, marital status, race, color, ethnicity, religion, national origin, sex, gender, gender identity, gender expression, disability, sexual orientation, genetic information, veteran status, or military service. This prohibition applies to all students, employees, contractors, visitors, and volunteers.

Mines will not tolerate retaliation against Mines community members for filing complaints regarding or implicating any of these protected statuses, or otherwise participating in investigations regarding such complaints.

It is a violation of this policy to intentionally submit a false complaint or file a complaint that is not made in good faith or to provide materially false or misleading information during an investigation.

3.0 RESPONSIBILITIES

The Board of Trustees directs the President, or the President's delegates, to develop, manage, and maintain appropriate procedures and resources to implement this policy.

4.0 COMPLIANCE/ENFORCEMENT

Violators of this policy will be subject to disciplinary action, up to and including termination of employment, expulsion, and termination of contractual relationships with Mines.

5.0 EXCLUSIONS/DISCLAIMER

No one filing a complaint under this policy will be permitted to simultaneously file a grievance under the State of Colorado Personnel

Board Rules or the Colorado School of Mines Faculty Handbook against the same individual and arising out of the same event(s).

6.0 RESOURCES OR ATTACHMENTS

- Equal Pay Act of 1963
- Titles IV, VI, and VII of the Civil Rights Act of 1964
- Title IX of the Education Amendments of 1972
- Rehabilitation Act of 1973 (sections 503 and 504)
- Vietnam Era Veterans Readjustment Assistance Act
- Age Discrimination Act
- Pregnancy Discrimination Act
- Age Discrimination in Employment Act of 1976
- Americans with Disabilities Act (as amended)
- Executive Order 11246
- Jeanne Clery Disclosure of Campus Security Policy and Crime Statistics Act of 1991
- Uniform Services Employment and Reemployment Act
- Violence Against Women Act of 1994
- Violence Against Women Reauthorization Act of 2013
- Colorado Anti-Discrimination Act
- Statement of Equal Opportunity, Access and Nondiscrimination (https://www.mines.edu/equal-opportunity/)
- Title IX Office website: https://www.mines.edu/title-ix/
- Human Resources website: https://www.mines.edu/human-resources/

KEY WORDS
Discrimination, harassment, age, ancestry, creed, marital status, race, color, ethnicity, religion, national origin, sex, gender, gender identity, gender expression, disability, sexual orientation, genetic information, veteran status, military service

HISTORY & REVIEW CYCLE

For a complete policy statement *and the most up-to-date procedures, please see the* policy website*. Promulgated by the Mines Board of Trustees on March 13, 1992. Amended by the Mines Board of Trustees on June 10, 1999; June 22, 2000; June 7, 2003; August 14, 2007; August 29, 2014; February 8, 2019; and August 14, 2020.*

Alcohol and Other Drugs Education and Prevention Policy

In compliance with the federal government's Drug Free Schools & Communities Act, there are community standards and potential consequences at the Colorado School of Mines pertaining to the illegal use of alcohol or drugs. The unlawful possession, use, or distribution of illicit drugs and the unlawful or unauthorized use of alcohol by employees and students at Mines will result in disciplinary action consistent with School policies, and local, state, and federal laws.

While Colorado's Constitution allows for specific legal use, possession, and growing of marijuana under certain circumstances, because of Mines' status as a federal contractor and grant recipient and because marijuana use is still prohibited under federal law, the use, possession, and growing of marijuana on campus is prohibited. Student use of alcohol and other drugs (including marijuana) that results in an impaired ability to perform academically, or behavior that violates the Code of Conduct constitutes a violation of this policy.

For more information, or for further policy details, please see the Alcohol and Other Drugs Education and Prevention Policy and the Colorado Drug Law Summary in the Policy Library, student section. Also see the Residence Life Policies and the Annual Campus Security and Fire Safety Report for more on programming and requirements.

Electronic Communications (E-mail) Policy

1.0 BACKGROUND AND PURPOSE

Communication to students at the Colorado School of Mines (Mines) is an important element of the official business of the university. It is vital that Mines have an efficient and workable means of getting important and timely information to students. Examples of communications that require timely distribution include information from Fiscal Services, the Registrar's Office, or other offices on campus that need to deliver official and time-sensitive information to students. (Please note that emergency communications may occur in various forms based on the specific circumstances).

Electronic communication through email and Trailhead Portal announcements provides a rapid, efficient, and effective form of communication. Reliance on electronic communication has become the accepted norm within the Mines community. Additionally, utilizing electronic communications is consistent with encouraging a more environmentally-conscious means of doing business and encouraging continued stewardship of scarce resources. Because of the wide-spread use and acceptance of electronic communication, Mines is adopting the following policy regarding electronic communications with students.

2.0 POLICY

It is the policy of the Colorado School of Mines that official university-related communications with students will be sent via Mines' internal email system or via campus or targeted Trailhead announcements. All students will be assigned a Mines email address and are expected to periodically check their Mines assigned email as well as their Trailhead portal page. It is also expected that email sent to students will be read in a timely manner. Communications sent via email to students will be considered to have been received and read by the intended recipients.

For a complete policy statement and associated procedures please see the policy website*,* information technology section. ***The policy website shall be considered the official & controlling Mines' policy.*** Nothing in the procedures should be construed as prohibiting university-related communications being sent via traditional means. Use of paper-based communication may be necessary under certain circumstances or may be more appropriate to certain circumstances. Examples of such communications could include, but not be limited to disciplinary notices, fiscal services communications, graduation information and so forth.

Questions about this policy may be directed to either of the following: Registrar's Office @ 303-273-3200 or registrar@mines.edu; or

Computing, Communications & Information Technologies (CCIT) @ 303-273-3431 or complete a request form at the Mines Help Center.

Student Complaint Process

Students are consumers of services offered as part of their academic and co-curricular experience at the Colorado School of Mines. If a student needs to make a complaint, specific or general, about their experience at Mines, he or she should contact the Office of the Dean of Students at 303-273-3288. If the issue is related to discrimination, sexual harassment, or sexual violence, there are specific procedures

that will be followed (these are noted and linked in this section or contact the Director, Title IX & Equity, 303-273-2558. Additional contacts listed in the Title IX section below.) For all other concerns, the student should begin with the Dean's Office if interested in making any complaint. All complaints, as well as the interests of all involved parties, will be considered with fairness, impartiality, and promptness while a complaint is being researched and/or investigated by the School.

Access to Student Records

Students at the Colorado School of Mines are protected by the Family Educational Rights and Privacy Act of 1974, as amended. This Act was designed to protect the privacy of education records, to establish the right of students to inspect and review their education records, and to provide guidelines for the correction of inaccurate or misleading data through informal and formal hearings. Students also have the right to file complaints with The Family Educational Rights and Privacy Act Office (FERPA) concerning alleged failures by the institution to comply with the Act. Copies of local policy can be found in the Registrar's Office. Contact information for FERPA complaints:

Family Policy Compliance Office
U.S. Department of Education
400 Maryland Avenue, SW
Washington, D. C. 20202-4605

Directory Information. The School maintains lists of information which may be considered directory information as defined by the regulations. This information includes name, current and permanent addresses and phone numbers, date of birth, major field of study, dates of attendance, part or full-time status, degrees awarded, last school attended, participation in officially recognized activities and sports, class, academic honors, university email address, and photo including student ID picture. Students who desire that this information not be printed or released must so inform the Registrar before the end of the first two weeks of the fall semester for which the student is registered. Information will be withheld for the entire academic year unless the student changes this request. The student's signature is required to make any changes for the current academic year. The request must be renewed each fall term for the upcoming year. The following student records are maintained by Colorado School of Mines at the various offices listed below:

1. General Records: Registrar and Graduate Dean
2. Transcript of Grades: Registrar
3. Computer Grade Lists: Registrar
4. Encumbrance List: Controller and Registrar
5. Academic Probation/Suspension List: Graduate Dean
6. Advisor File: Academic Advisor
7. Option/Advisor/Enrolled/ Minority/Foreign List: Registrar, Dean of Students, and Graduate Dean
8. Externally Generated SAT/GRE Score Lists: Graduate Dean
9. Financial Aid File: Financial Aid (closed records)
10. Medical History File: School Physician (closed records)

Student Access to Records. The graduate student wishing access to his or her educational records will make a written request to the Graduate Dean. This request will include the student's name, date of request and type of record to be reviewed. It will be the responsibility of the Dean to arrange a mutually satisfactory time for review. This time will be as soon as practical but is not to be later than 30 business days from receipt of the request. The record will be reviewed in the presence of the Dean or designated representative. If the record involves a list including other students, steps will be taken to preclude the viewing of the other student name and information.

Challenge of the Record. If the student wishes to challenge any part of the record, the Dean will be so notified in writing. The Dean may then

1. remove and destroy the disputed document, or
2. inform the student that it is his decision that the document represents a necessary part of the record; and, if the student wishes to appeal,
3. convene a meeting of the student and the document originator (if reasonably available) in the presence of the Executive Vice President for Academic Affairs as mediator, whose decision will be final.

Destruction of Records. Records may be destroyed at any time by the responsible official if not otherwise precluded by law except that no record may be destroyed between the dates of access request and the viewing of the record. If during the viewing of the record any item is in dispute, it may not be destroyed.

Access to Records by Other Parties. Colorado School of Mines will not permit access to student records by persons outside the School except as follows:

1. In the case of open record information as specified in the section under Directory Information.
2. To those people specifically designated by the student. Examples would include request for transcript to be sent to graduate school or prospective employer.
3. Information required by a state or federal agency for the purpose of establishing eligibility for financial aid.
4. Accreditation agencies during their on-campus review.
5. In compliance with a judicial order or lawfully issued subpoena after the student has been notified of the intended compliance.
6. Any institutional information for statistical purposes which is not identifiable with a particular student.
7. In compliance with any applicable statue now in effect or later enacted. Each individual record (general, transcript, advisor, and medical) will include a log of those persons not employed by Colorado School of Mines who have requested or obtained access to the student record and the legitimate interest that the person has in making the request.

The School discloses education records without a student's prior written consent under the FERPA exception for disclosure to school officials with legitimate educational interests. A school official is a person employed by the School in an administrative, supervisory, academic or research, or support staff position (including law enforcement unit personnel and health staff); a person or company with whom the School has contracted as its agent to provide a service instead of using School employees or officials (such as an attorney, auditor, or collection agent); a person serving on the Board of Trustees; or a student serving on an official committee, such as a disciplinary or grievance committee, or assisting another school official in performing his or her tasks.

A school official has a legitimate educational interest if the official needs to review an education record in order to fulfill his or her professional responsibilities for the School.

See also FERPA at Mines in the Registrar's pages.

Posthumous Degree Awards

The faculty may recognize the accomplishments of students who have died while pursuing their educational goals. If it is reasonable to expect that the student would have completed his or her degree requirements, the faculty may award a Baccalaureate or Graduate Degree that is in all ways identical to the degree the student was pursuing. Alternatively, the faculty may award a Posthumous BS, MS, or PhD to commemorate students who distinguished themselves while at Mines by bringing honor to the School and its traditions.

Consideration for either of these degrees begins with a petition to the Faculty Senate from an academic department or degree granting unit. The petition should identify the degree sought. In the event that the degree-granting unit is seeking a conventional degree award, the petition should include evidence of the reasonable expectations that the student would have completed his or her degree requirements. For a Baccalaureate, such evidence could consist of, but is not limited to:

- The student was a senior in the final semester of coursework,
- The student was enrolled in courses that would have completed the degree requirements at the time of death
- The student would have passed the courses with an acceptable grade, and would likely have fulfilled the requirements of the degree.

For a Graduate Degree:

- For graduate degrees not requiring a research product, the student was enrolled in courses that would have completed the degree requirements at the time of death, would have passed the courses with an acceptable grade, and would likely have fulfilled the requirements of the degree.
- For graduate degrees requiring a research product, the student had completed all course and mastery requirements pursuant to the degree and was near completion of the dissertation or thesis, and the student's committee found the work to be substantial and worthy of the degree.

The requirement that there be a reasonable expectation of degree completion should be interpreted liberally and weight should be given to the judgment of the departmental representative(s) supporting the petition.

In the event that the degree being sought is a Posthumous BS, MS, or PhD, the petition should include evidence that the student conducted himself or herself in the best tradition of a Mines' graduate and is therefore deserving of that honor.

Equal Opportunity, Equal Access, and Affirmative Action

The institution's Statement of Equal Opportunity and Equal Access to Educational Programs, and associated staff contacts, can be found in the Welcome Section of this Catalog as well as the on the policy website. Colorado School of Mines maintains an affirmative action plan, which is available at the Arthur Lakes Library, the Dean of Students' Office, and the Office of Human Resources.

Office of Institutional Equity & Title IX

Pursuant to Title IX of the Education Amendments of 1972, 20 U.S.C. § 1681, and 34 CFR Part 106, Mines does not discrimination on the basis of sex in any of its education programs or activities, including admissions and employment. All inquiries about the application of Title IX or Part 106 may be directed to Mines Title IX Coordinator or the Assistant Secretary of Education, U.S. Department of Education, or both:

Mines Title IX Coordinator is Katie Schmalzel
Office: Title IX House, 1706 Illinois Street
Email: kschmalz@mines.edu or titleix@mines.edu
Phone: 303.273.3260
Website: https://www.mines.edu/institutional-equity-title-ix/

The Policy Prohibiting Sexual Harassment, Sexual Assault, and Interpersonal Violence can be found here: https://www.mines.edu/policy-library/policy-prohibiting-sexual-harassment/.

The Procedure to Resolve Complaints of Sexual Harassment, Sexual Assault, and Interpersonal Violence can be found here: https://www.mines.edu/policy-library/procedure-to-resolve-complaints-of-sh-sa-ipv/.

Additionally, complaints of discrimination, harassment, and retaliation on the basis of a protected class [race, color, religion or creed, sex (including pregnancy, childbirth, related medical conditions, sexual orientation, gender identity, and gender expression), marital status, ethnicity, national origin, age, disability, genetic information, ancestry, and veteran status or military service], are managed through the Office of Institutional Equity & Title IX. The Policy Prohibiting Unlawful Discrimination is listed above and can also be found here: https://www.mines.edu/policy-library/prohibiting-unlawful-discrimination-policy/.

SpeakUP@Mines

Students and employees have an additional anonymous channel for reporting concerns through the Whistleblower Policy and the SpeakUP@Mines program.

Consumer Information - Your Right to Know

As a prospective or continuing student at Colorado School of Mines, you have a right to certain information that the university is required by law to provide. Much of that information is safety related or financial in nature, but other broad categories are included such as graduation rates, athletics, and the various costs associated with attending Mines.

Current federal regulations require that institutions of higher education disclose such information and make it readily available to current and prospective students. A new provision in the Higher Education Amendments of 1998 requires institutions to provide a list of the information to which students are entitled with instructions on how they may obtain it. A paper copy of all of the information can be found in the Compliance and Policy Office in Guggenheim Hall.

More information can be found on the Financial Aid website.

Directory of the School

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Coaches/Athletics Faculty

Please refer to the Mines' Athletics Web Site for all current Faculty information.

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