Hydrologic Science and Engineering

Degrees Offered
- Master of Science (Hydrology), Thesis
- Master of Science (Hydrology), Non-thesis
- Doctor of Philosophy (Hydrology)

Program Description
Hydrologic Science and Engineering (HSE) is comprised of faculty from several different Mines departments and offers interdisciplinary graduate degrees in hydrology.

The program offers programs of study in fundamental hydrologic science and applied hydrology with engineering applications. Our program encompasses groundwater hydrology, surface-water hydrology, vadose-zone hydrology, watershed hydrology, contaminant transport and fate, contaminant remediation, hydrogeophysics, and water policy/law.

HSE requires a core study of formal graduate courses for all degrees. Programs of study are interdisciplin ary in nature, and coursework is obtained from multiple departments at Mines and is approved for each student by the student's advisor and thesis committee.

To achieve the Master of Science (MS) degree, students may elect the Non-Thesis option, based exclusively upon coursework and an independent study project or a designated design course, or the Thesis option. The thesis option is comprised of coursework in combination with individual laboratory, modeling and/or field research performed under the guidance of a faculty advisor and presented in a written thesis approved by the student's committee.

To achieve the Doctor of Philosophy (PhD) degree, students are expected to complete a combination of coursework and novel, original research, under the guidance of a faculty advisor and Doctoral committee, which culminates in a significant scholarly contribution to a specialized field in hydrologic sciences or engineering. Full-time enrollment is expected and leads to the greatest success, although part-time enrollment may be allowed under special circumstances. All doctoral students must complete the full-time, on-campus residency requirements (catalog.mines.edu/graduate/registrationandtuitionclassification/).

Currently, students will apply to the Hydrology program through the Graduate School and be assigned to the HSE participating department of the student's HSE advisor. Participating units include: Chemistry and Geochemistry, Civil & Environmental Engineering (CEE), Geology and Geological Engineering (GE), Geophysical Engineering, Humanities, Arts, and Social Sciences (HASS), Mechanical Engineering (ME), Mining Engineering (MN), and Petroleum Engineering (PE). HSE is part of the Western Regional Graduate Program (WICHE), a recognition that designates the programs as unique within the Western United States. An important benefit of this designation is that students from several western states are given the tuition status of Colorado residents. These states include Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.

For more information on program curriculum please refer to the HSE website at hydrology.mines.edu (http://hydrology.mines.edu).

Program Requirements

MS Non-Thesis: 30 credit hours total, including a design course or independent study. (See a list of design courses below)

MS Thesis: 30 credit hours total, consisting of 24 credit hours of coursework and 6 credit hours of thesis credit. Students must also write and orally defend a research thesis.

PhD: 72 total credit hours, consisting of coursework (at least 36 h), and research (at least 24 h). Students must also successfully complete qualifying examinations, write and defend a dissertation proposal, write and defend a doctoral dissertation, and are expected to submit the dissertation work for publication in scholarly journals.

Thesis & Dissertation Committee Requirements
Students must meet the general requirements listed in the graduate bulletin section Graduate Degrees and Requirements. In addition, the student's advisor or co-advisor must be an HSE faculty member. For MS thesis students, at least two committee members must be members of the HSE faculty. For doctoral students, at least two faculty on the committee must be a member of the HSE faculty. For PhD committee the required at-large member must be from a Mines department outside the student's home department, and where applicable, outside the students minor department.

Prerequisites
- baccalaureate degree in a science or engineering discipline
- college calculus: two semesters required
- differential equations: one semester required
- college physics: one semester required
- college chemistry: two semesters required
- college statistics: one semester required
- fluid mechanics

Note that some prerequisites may be completed in the first few semesters of the graduate program if approved by the HSE Director/Program Manager. Contact Cassie Glenn for questions - caungst@mines.edu

Mines' Combined Undergraduate / Graduate Degree Program
Students enrolled in Mines' combined undergraduate/graduate program (meaning uninterrupted registration from the time the student earns a Mines undergraduate degree to the time the student begins a Mines graduate degree) 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 400+ level courses that count towards the undergraduate degree requirements as "Elective Coursework" or any 500+ level course, may be used for the purposes of double-counting at the discretion of the graduate advisor. These courses must have been passed with a "B-" or better, not be substitutes for required coursework, and meet all other University, Department, Division, and Program requirements for graduate credit.

Required Curriculum
Students will work with their academic advisors and graduate thesis committees to establish plans of study that best fit their individual interests and goals. Each student will develop and submit a plan of study to their advisor during the first semester of enrollment. Doctoral students...
may transfer in credits from an earned MS graduate program according to requirements listed in the Graduate Degrees and Requirements (catalog.mines.edu/graduate/programs/) section of the graduate bulletin, and after approval by the student’s thesis committee.

Core Curriculum
Curriculum areas of emphasis consist of core courses, and electives. Core courses cover four areas of knowledge: Groundwater, Surface Water, Chemistry, and Contaminant Fate and Transport. Students can elect to take 9 or 12 credit hours of core curriculum depending on selected option. Courses that meet core requirements include the following:

**Option #1 (9 credit hrs.)**
- GEGN466   GROUNDWATER ENGINEERING  3.0
- GEGN582   INTEGRATED SURFACE WATER HYDROLOGY  3.0
- CEEN/GEGN587  HYDROGEOCHEMICAL PROCESSES  3.0

**Option #2 (12 credit hrs.)**
- GEGN466   GROUNDWATER ENGINEERING  3.0
- GEGN582   INTEGRATED SURFACE WATER HYDROLOGY  3.0
- CEEN550   PRINCIPLES OF ENVIRONMENTAL CHEMISTRY  3.0

AND Choose one of the following:
- CEEN584   SUBSURFACE CONTAMINANT TRANSPORT  3.0
- CEEN580   CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT  3.0

Students who have completed coursework for a previous degree that satisfies one of these requirements can get core curriculum requirements waived with the appropriate Waiver Form and approval of advisor.

In addition, a fluid mechanics class is required for students to complete the HSE degree programs. If a student has previously taken a fluid mechanics course (for example as part of an undergraduate degree) then this requirement is met; if a student has not previously taken a fluid mechanics course this requirement can be satisfied by taking: GEGN/CEEN 585 - Fluid Mechanics for Hydrology.

Areas of Specialization
Students may choose to complete an Area of Specialization within the MS in Hydrology degrees by taking additional defined courses. These areas of specialization are: Hydrogeophysics, Hydrobiogeochemistry, and Hydrology, Policy, and Management. The Area of Specialization will appear on the transcripts of students who register for and complete the required coursework. Courses required for these Areas of Specialization are:

1. **Hydrogeophysics:**
   - GPGN 574: Groundwater Geophysics
   - GPGN 533: Geophysical Data Integration & Geostatistics
   - GPGN 570: Satellite Remote Sensing
   - or GPGN 520: Advanced Electrical and Electromagnetic Methods

2. **Hydrobiogeochemistry**
   Students choose three of the following course with at least one from each of microbiology focused and geochemistry focused courses. Students with a Hydrobiogeochemistry Area of Specialization encouraged to enroll in CEEN550 and a separate Contaminant Fate and Transport course (CEEN580 or CEEN584) to satisfy the HSE core, leaving GEGN586 and CEEN551 as the geochemistry focused courses.

   **Microbiology focus:**
   - CEEN 562 Environmental Geomicrobiology
   - CEEN 560 Molecular microbial ecology and the environment

   **Geochemistry focus:**
   - CEEN550: Principles of Environmental Chemistry
   - GEGN 586: Numerical modeling of geochemical systems
   - CEEN551: Environmental Organic Chemistry

3. **Hydrology, Policy, and Management**
   Students wanting a Hydrology, Policy, and Management track will choose 3 of the following 4 courses:
   - HASS588: Global Water Politics & Policy
   - HASS584: U.S. Water Politics & Policy
   - EBGN537: Water Economics
   - HASS525: Environmental Communication
   A grade of B- or better is required in all core classes for graduation.

Design Courses
For Non-Thesis MS students, the following is a list of Design Courses* that may be completed in lieu of an Independent Study:

- CEEN515   HILLSLOPE HYDROLOGY AND STABILITY  3.0
- CEEN581   WATERSHED SYSTEMS MODELING  3.0
- CEEN575   HAZARDOUS WASTE SITE REMEDIATION  3.0
- CEEN584   SUBSURFACE CONTAMINANT TRANSPORT  3.0
- GEGN532   GEOLOGICAL DATA ANALYSIS  3.0
- GEGN575   APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS  3.0
- GEGN583   MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS  3.0
- GEGN584   FIELD METHODS IN HYDROLOGY  3.0
- GEGN586   NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS  3.0

Elective courses may be chosen from the approved list below or as approved by your advisor or thesis committee.

- CEEN471   WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN  3.0
- CEEN511   UNSATURATED SOIL MECHANICS  3.0
- CEEN512   SOIL BEHAVIOR  3.0
- CEEN515   HILLSLOPE HYDROLOGY AND STABILITY  3.0
- CEEN560   MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT  3.0
- CEEN562   ENVIRONMENTAL GEOMICROBIOLOGY  3.0
- CEEN570   WATER AND WASTEWATER TREATMENT  3.0
- CEEN571   ADVANCED WATER TREATMENT ENGINEERING AND WATER REUSE  3.0
CEEN575  HAZARDOUS WASTE SITE REMEDIATION  3.0
CEEN581  WATERSHED SYSTEMS MODELING  3.0
CEEN582  MATHEMATICAL MODELING OF ENVIRONMENTAL SYSTEMS  3.0
CEEN611  MULTIPHASE CONTAMINANT TRANSPORT  3.0
GEGN470  GROUND-WATER ENGINEERING DESIGN  3.0
GEGN532  GEOLOGICAL DATA ANALYSIS  3.0
GEGN573  GEOLOGICAL ENGINEERING SITE INVESTIGATION  3.0
GEGN575  APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS  3.0
GEGN581  ANALYTICAL HYDROLOGY  3.0
GEGN584  FIELD METHODS IN HYDROLOGY  3.0
GEGN586  NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS  3.0
GEOL540  ISOTOPE GEOCHEMISTRY AND GEOCHRONOLOGY  3.0
GPGN470  APPLICATIONS OF SATELLITE REMOTE SENSING  3.0
MATH530  STATISTICAL METHODS I  3.0
MATH531  STATISTICAL METHODS II  3.0
MATH532  SPATIAL STATISTICS  3.0
EBGN510  NATURAL RESOURCE ECONOMICS  3.0
HASS588  GLOBAL WATER POLITICS AND POLICY  3.0
GEGN585  FLUID MECHANICS FOR HYDROLOGY  2.0

Department of Geology and Geological Engineering
David Benson, Professor
Reed Maxwell, Professor
Danica Roth, Assistant Professor
Paul Santi, Professor
Kamini Singha, Professor
Alexis Sitchler, Associate Professor
Wendy Zhou, Associate Professor and Graduate Dean

Department of Geophysics
John Bradford, Professor &Vice Provost for External Initiatives and Dean of Earth Resources and Environmental Programs
Brandon Dugan, Associate Professor and Baker Hughes Chair in Petrophysics & Borehole Geophysics and Associate Department Head GP
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