MINING ENGINEERING (MNGN)

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.

MNGN203. SOFTWARE FUNDAMENTALS FOR 3D DATA ANALYSIS AND MINE PLANNING. 1.0 Semester Hr.
Software Fundamentals for 3D Data Analysis and Mine Planning. This course is designed to provide an introduction to geologic data set coming from mining exploration project, 3D visualization of sub-surface information representing geologic rock types, lithologies, alterations, and grades, and creation of solid models of geologic domains followed by statistical analysis of 3D subsurface data, interpretation of grade information into block models for economic valuation, pit limit analysis and mine planning using a commercial software package called MinePlan software from Hexagon Mining. Prerequisite: MNGN210 or instructor consent.
Course Learning Outcomes

- Master the basics of MinePlan software's menus, pulldowns, and features and options
- Master the basics of MinePlan software's 3D visualization tool "MS3D"
- Master the basics of MinePlan software's Statistical tool "Sigma"
- Master the basics of MinePlan software's 3D Modelling tool
- Master the basics of MinePlan softwares pit design and evaluation tool "MineEval"

MNGN205. MINING ENGINEERING FIELD EXPERIENCE. 1.0 Semester Hr.
The objectives of this course are to provide the student with a fundamental understanding of mine operations, exploration, mineral processing, and the importance of safety, social and community factors, and environmental stewardship through hands-on exercises and tours of mines, processing facilities, and industry-relevant sites. The curriculum within this course has been designed to expose students to a wide array of experiences and provide insights that will aid them in upper-division courses. Prerequisite: MNGN 210, MNGN 308 or instructor consent.
Course Learning Outcomes

- Basic life cycle of a mining property
- The factors that influence a successful mining operation
- The legal and regulatory responsibilities mines operate under
- The importance of exploration and resource delineation/reporting,
- Basic unit operations and mine design considerations
- Social, environmental, and workplace responsibilities
- The economics associated with the marketing and sales of mineral commoditie

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.
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.
Course Learning Outcomes

- Primary: Knowledge, Analysis, Design and Operation; Secondary: Open-ended and Teams

MNGN251. METALLURGICAL AND MATERIALS THERMODYNAMICS. 3.0 Semester Hrs.
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. Prerequisite: MATH112, CHGN122 or CHGN125, PHGN100.

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. 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.

MNGN301. MINE SURVEYING. 2.0 Semester Hrs.
Lectures and hands-on fieldwork to teach students the modern methods of mine surveying applicable to underground mining. This course will familiarize students with the tools and techniques needed to perform underground traversing including balancing of loop surveys, setting out points, establishing line and grade. (10 days) Prerequisite: MNGN210, MNGN308 or instructor consent.
Course Learning Outcomes

- Students should know and apply the basic principles of measuring and locating lines, elevations, and angles on the earth's surface.

- Students should know and apply the basic principles of modern underground and surface mine surveying using basic Brunton compass and modern total station instruments.

MNGN308. MINE SAFETY. 1.0 Semester Hr.
Causes and prevention of accidents. Mine safety regulations. Mine rescue training. Safety management and organization. 1 hour lecture; 1 semester hour. Taken as the first week of summer session. Prerequisite: MNGN210.

MNGN309. MINE SAFETY AND OPERATIONS. 2.0 Semester Hrs.
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.
Course Learning Outcomes

MNGN310. EARTH MATERIALS. 3.0 Semester Hrs.
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. 2 hours lecture; 3 hours lab; 3 semester hours. Prerequisite: GEGN101.
Course Learning Outcomes

- see attached document

MNGN311. MINING GEOLOGY. 3.0 Semester Hrs.
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.
Course Learning Outcomes

- n/a

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.
Course Learning Outcomes

MNGN314. UNDERGROUND MINE DESIGN. 3.0 Semester Hrs.
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.
Course Learning Outcomes

MNGN316. COAL MINING METHODS. 3.0 Semester Hrs.
(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.
For mining engineering majors only. Absolute and relative motions, kinetics, work-energy, impulse-momentum and angular impulse-momentum. 1 hour lecture; 1 semester hour. Prerequisite: MATH213/223, CEEN241.

MNGN318. STATICS AND DYNAMICS COMBINED FOR MN. 4.0 Semester Hrs.
This course will cover: (for statics) forces, moments, couples, equilibrium, centroids and second moments of areas, volumes and masses, hydrostatics, friction; and (for dynamics) 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). 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). Prerequisite: PHGN100, MATH213.
Course Learning Outcomes

- Identify and discuss fundamental concepts of forces, moments, pressures, mass, and gravity
- Calculate forces and moments acting on simple and complex structures, equilibrium of forces and moments
- Calculate forces and moments using centroid and center of gravity concepts
- Identify and discuss statically indeterminate equilibria
- Apply concepts of statics to mining machines and structures
- Compare and contrast translational and rotational motion, equivalence, calculations
- Apply dynamics concepts to mining machinery

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. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: CEEN311, MNGN318 or CEEN241.

MNGN322. INTRODUCTION TO MINERAL PROCESSING AND LABORATORY. 3.0 Semester Hrs.
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.
Course Learning Outcomes

- Primary: Knowledge, Analysis, and Design and Operation; Secondary: Open-ended and Teams

MNGN334. CHEMICAL PROCESSING OF MATERIALS. 3.0 Semester Hrs.
Development and application of fundamental principles related to the processing of metals and materials by thermochemical, 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. Prerequisite: MTGN272, MTGN251, CEEN267 or EDNS251. Co-requisite: MTGN334L.

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.
Course Learning Outcomes

- 1. Apply interdisciplinary analyses to examining how communities and the natural environment are intimately related.
- 2. Demonstrate their understanding of the “community concept” by applying critical thinking to the ways we conceptualize communities
- 3. Be able to articulate the ways in which natural resources are social constructions.
- 4. Describe the concept of sustainable development and its role in natural resource developments contexts.
- 5. Research, write about, and present a variety case studies on the relationship between communities and natural resource developments in different contexts.
- 6. Articulate the engineer’s role in issues and case studies related to communities and natural resource developments.

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.
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.
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.
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.
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.
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.
Course Learning Outcomes

- Not Changing

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.
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.
Experiments to accompany the lectures in MNGN422. Co-requisite: MNGN421. 3 hours lab; 1 semester hour.

MNGN424. MINE VENTILATION. 3.0 Semester Hrs.
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 MEGN261, and MNGN314. 2 hours lecture, 3 hours lab; 3 semester hours.
Course Learning Outcomes

- See right

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.
Course Learning Outcomes

- • define basic concepts and principles of thermodynamics, heat, energy and work (a)
- • know and apply, in examples, the first and second laws of thermodynamics, mass and energy balances (a)
- • perform fundamental calculations in heat transfer through conduction, convection and radiation (a, b)
- • explain the fundamentals of gas cycle processes as they apply to internal combustion engines, gas turbines, compressors and refrigeration machines (a)
- • apply mine ventilation concepts properly ventilate underground coal, metal and non-metal mines (b, e)
- • dilute and render harmless concentrations of toxic and explosive gases (e)
- • maintain respirable dust standards through adequate ventilation, use of water sprays and other engineering controls (b, e)
- • Maintain diesel particulate matter (DPM) standards through adequate ventilation and engine emission control technologies (b, e)
- • use computer simulation programs to solve mine ventilation network problems and to improve mine ventilation conditions (b, c, e, g, k)
- • communicate effectively about mine ventilation needs, methods, fire and explosion prevention measures, air conditioning and dust control. (c, e, g, k)

MNGN426. HYDRO- AND ELECTRO-METALLURGY. 3.0 Semester Hrs.
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. Prerequisite: MTGN334, MTGN352, MTGN351 or MTGN251. Co-requisite: MTGN461.

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.
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. Prerequisite: MNGN210, MNGN203, MNGN308, MNGN312, MNGN314, MNGN309, MNGN321, GEOL310, GEOL311. Co-requisite: MNGN438.

Course Learning Outcomes

- Same

MNGN429. MINING ENGINEERING EVALUATION AND DESIGN REPORT II. 2.0 Semester Hrs.
(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, GEOL311, MNGN438, MNGN414. Co-requisites: MNGN322, MNGN427, and MNGN433. 2 hours lecture; 2 semester hours.
Course Learning Outcomes

- Same

MNGN430. PHYSICAL CHEMISTRY OF IRON AND STEELMAKING. 3.0 Semester Hrs.
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. Prerequisite: MTGN334, MTGN251 or MTGN351.

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.

MNGN432. PYROMETALLURGY. 3.0 Semester Hrs.
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.

MNGN433. MINE SYSTEMS ANALYSIS I. 3.0 Semester Hrs.
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.
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.
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.
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.
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.
Course Learning Outcomes

- Primary: Knowledge, Analysis, and Design and Operation; Secondary: Open-ended and Teams

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.
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. 3 hours lecture; 3 semester hours. Offered in spring.

MNGN461. TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS. 3.0 Semester Hrs.
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, MTGN352.

MNGN462. SOLID WASTE MINIMIZATION AND RECYCLING. 3.0 Semester Hrs.
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. Prerequisite: CEEN301, CEEN302,CHGN403.

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,
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: 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. 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.

MNGN501. REGULATORY MINING LAWS AND CONTRACTS. 3.0 Semester Hrs.
(I) Basic fundamentals of engineering law, regulations of federal and state laws pertaining to the mineral industry and environment control. Basic concepts of mining contracts. Offered in even numbered years. Prerequisite: Senior or graduate status. 3 hours lecture; 3 semester hours. Offered in even years.

MNGN502. GEOSPATIAL BIG DATA ANALYTICS. 3.0 Semester Hrs.
Spatial data models (vector and raster data) and structures (R tree and octree data structures), characteristics of geospatial big data (e.g. satellite images, Lidar point clouds, sensor measurements, environmental monitoring data, socio-economic data), geospatial big data sources (IoT, sensors, images, Lidar, crowd-sources), geospatial big data life cycle, visualizations for geospatial big data sets, isual design principles (Bertin`s visual variables, preattentive attributes, Gestalt principles and Tufte`s design principles), the first order and second order exploration methods for various geospatial data (spatially discrete point data, spatially continuous point data and area data), machine learning algorithms (k-means clustering, self-organizing maps, support vector machines), statistical learning methods (point pattern analyses, kriging, non-spatial, spatial regression and geographically weighted regression).
Course Learning Outcomes

- Recognize main features of spatial data models (vector and raster data) and structures (R tree and octree data structures), recall the characteristics of geospatial big data and evaluate and compare various data sets (e.g. satellite images, Lidar point clouds, sensor measurements, environmental monitoring data, socio-economic data) in terms of the 5V`s (Volume, Velocity, Veracity, Variety and Value) of big data.
- Distinguish types of geospatial big data and its sources (IoT, sensors, images, Lidar, crowd-sources, etc.) in geosciences
- Apply incremental steps of geospatial big data life cycle to a given business case (e.g., monitoring land use and land cover change, decision making processes in geosciences, monitoring human behavior, etc.)
- Design at least three data visualizations for geospatial big data sets considering visual design principles (Bertin`s visual variables, preattentive attributes, Gestalt principles and Tufte`s design principles).
- Implement the first order and second order exploration methods for various geospatial data (spatially discrete point data, spatially continuous point data and area data)
- Apply machine learning algorithms (k-means clustering, self-organizing maps, support vector machines) to geospatial data sets.
- Implement statistical learning methods (point pattern analyses, kriging, non-spatial, spatial regression and geographically weighted regression) to geospatial data sets and identify the structure of big data frameworks used in management of the geospatial big data in geosciences

MNGN503. MINING TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT. 3.0 Semester Hrs.
(I, II) The primary focus of this course is to provide students an understanding of the fundamental principles of sustainability and how they influence the technical components of a mine's life cycle, beginning during project feasibility and extending through operations to closure and site reclamation. Course discussions will address a wide range of traditional engineering topics that have specific relevance and impact to local and regional communities, such as mining methods and systems, mine plant design and layout, mine operations and supervision, resource utilization and cutoff grades, and labor. The course will emphasize the importance of integrating social, political, and economic considerations into technical decision-making and problem solving. 3 hours lecture; 3 semester hours.

MNGN504. UNDERGROUND CONSTRUCTION ENGINEERING IN HARD ROCK. 3.0 Semester Hrs.
(II) This course is developed to introduce students to the integrated science, engineering, design and management concepts of engineered underground construction. The course will cover advanced rock engineering in application to underground construction, geological interpretation and subsurface investigations, tunneling method and equipment options and system selection for projects with realistic constraints, underground excavation initial support and final lining design, and approaches to uncertainty evaluation and risk assessment for underground construction projects. Team design projects and presentations will be required. Prerequisites: CEEN312 or MTGN321. Corequisites: GEGN462 or GEGN562.
Course Learning Outcomes

- Know the typical application of the underground space, Be aware of subsurface constraints and controlling parameters, be able select project alignments, and understand the pros and cons of different subsurface conditions.
- develop the ability to design a preliminary geotech site investigation plan, including the boring, as well as field and lab testing, along with the estimated costs
- Be able to select tunneling method based on results of geotech investigation, have the practical knowledge of various tunneling methods in rock and variety of equipment, and operational settings in the tunneling projects
- Understand the ground stresses, ground/support reaction curves, and be able to select and develop a preliminary design for ground support in rock.
- Be able to select the shaft and raise development methods in rock for different subsurface conditions.
- Be able to select the right application for conventional tunneling methods, develop blast round design for tunnel
- know the options, pros and cons, and approaches to Sequential Excavation Method (SEM or NATM)
- Ability to select the right tunnel boring machine (TBM) for the given project and be able to estimate the penetration and daily advance rate
- Be able to make an assessment of the potential for ground squeezing and rock burst in deep tunnels
- Be able to offer a preliminary estimate of construction cost for tunnel, and develop a risk registry for rock tunnels

MNGN505. 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.

MNGN506. 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 insitu 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.

MNGN507. ADVANCED DRILLING AND BLASTING. 3.0 Semester Hrs.
(I) An advanced study of the theories of rock penetration including percussion, rotary, and rotary percussion drilling. Rock fragmentation including explosives and the theories of blasting rock. Application of theory to drilling and blasting practice at mines, pits, and quarries. Prerequisite: MNGN407. 3 hours lecture; 3 semester hours. Offered in odd years.

MNGN508. ADVANCED ROCK MECHANICS. 3.0 Semester Hrs.
Equivalent with MNGN418,
(I, II, S) Analytical and numerical modeling analysis of stresses and displacements induced around engineering excavations in rock. Insitu 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. One additional design project will be assigned to graduate students. Prerequisites: MNGN321. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- Not Changing

MNGN509. CONSTRUCTION ENGINEERING AND MANAGEMENT. 3.0 Semester Hrs.
Equivalent with GOGN506,
(II) The course will provide content, methods and experience in construction planning and cost estimating, scheduling and equipment performance, contractual delivery systems and relationships, key contract clauses, risk registration and management, and project controls. Special attention will be paid to geotechnical uncertainty and risk, emerging technologies and industry trends, and to ethics and sustainability as applied to construction engineering and management practices. Co-requisites: GEGN562. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- 1. Identify all phases of a construction project from cradle to grave
- 2. Understand the numerous roles and responsibilities of the key project players through all stages of a project, including regulatory framework

- 3. Analyze the advantages and disadvantages of project delivery methods and select the appropriate one for a specific construction project, including environmental and social impacts
- 4. Complete a cost estimate for a tunnel project
- 5. Compete in a construction bid scenario
- 6. Schedule a series of construction tasks using the critical path method
- 7. Establish a project cash flow projection
- 8. Identify and apply key construction contract clauses
- 9. Identify and analyze project risks, with an accent on geotechnical risk
- 10. Identify and assess safety and its management on underground construction projects
- 11. Assess and manage social and ethical issues for underground construction projects

MNGN510. FUNDAMENTALS OF MINING AND MINERAL RESOURCE DEVELOPMENT. 3.0 Semester Hrs.
Specifically designed for non-majors, the primary focus of this course is to provide students with a fundamental understanding of how mineral resources are found, developed, mined, and ultimately reclaimed. The course will present a wide range of traditional engineering and economic topics related to: exploration and resource characterization, project feasibility, mining methods and systems, mine plant design and layout, mine operations and scheduling, labor, and environmental and safety considerations. The course will emphasize the importance of integrating social (human), political, and environmental issues into technical decision-making and design. Prerequisites: MATH111, MATH112.

MNGN511. MINING INVESTIGATIONS. 2-4 Semester Hr.
(I, II) Investigational problems associated with any important aspect of mining. Choice of problem is arranged between student and instructor. Prerequisite: none. Lecture, consultation, lab, and assigned reading; 2 to 4 semester hours.

MNGN512. 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 estimates, unit operations, equipment selection, final pit determinations, short- and long-range planning, road layouts, dump planning, and cost estimation. Prerequisite: MNGN210. 3 hours lecture; 3 semester hours.

MNGN514. MINING ROBOTICS. 3.0 Semester Hrs.
(I) Fundamentals of robotics as applied to the mining industry. The focus is on mobile robotic vehicles. Topics covered are mining applications, introduction and history of mobile robotics, sensors, including vision, problems of sensing variations in rock properties, problems of representing human knowledge in control systems, machine condition diagnostics, kinematics, and path finding. Prerequisite: CSCI404. 3 hours lecture; 3 semester hours. Offered in odd years.

MNGN515. MINE MECHANIZATION AND AUTOMATION. 3.0 Semester Hrs.
This course will provide an in-depth study of the current state of the art and future trends in mine mechanization and mine automation systems for both surface and underground mining, review the infrastructure required to support mine automation, and analyze the potential economic and health and safety benefits. Prerequisite: MNGN312, MNGN314, MNGN316. 2 hours lecture, 3 hours lab; 3 semester hours. Fall of odd years.

MNGN516. UNDERGROUND MINE DESIGN. 3.0 Semester Hrs.
Selection, design, and development of most suitable underground mining methods based upon the physical and the geological properties of mineral deposits (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. Prerequisite: MNGN210. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN517. ADVANCED UNDERGROUND MINING. 3.0 Semester Hrs.
(II) Review and evaluation of new developments in advanced underground mining systems to achieve improved productivity and reduced costs. The major topics covered include: mechanical excavation techniques for mine development and production, new haulage and vertical conveyance systems, advanced ground support and roof control methods, mine automation and monitoring, new mining systems and future trends in automated, high productivity mining schemes. Prerequisite: Underground Mine Design (e.g., MNGN314). 3 hours lecture; 3 semester hours.

MNGN518. ADVANCED BULK UNDERGROUND MINING TECHNIQUES. 3.0 Semester Hrs.
This course will provide advanced knowledge and understanding of the current state-of-the-art in design, development, and production in underground hard rock mining using bulk-mining methods. Design and layout of sublevel caving, block caving, open stoping and blasthole stoping systems. Equipment selection, production scheduling, ventilation design, and mining costs. Prerequisites: MNGN314, MNGN516. 2 hours lecture, 3 hours lab; 3 semester hours. Spring of odd years.

MNGN519. ADVANCED SURFACE COAL MINE DESIGN. 3.0 Semester Hrs.
(II) Review of current manual and computer methods of reserve estimation, mine design, equipment selection, and mine planning and scheduling. Course includes design of a surface coal mine for a given case study and comparison of manual and computer results. Prerequisite: MNGN312, 316, 427. 2 hours lecture, 3 hours lab; 3 semester hours. Offered in odd years.

MNGN520. ROCK MECHANICS IN UNDERGROUND COAL MINING. 3.0 Semester Hrs.
(I) Rock mechanics consideration in the design of room-and-pillar, longwall, and shortwall coal mining systems. Evaluation of bump and outburst conditions and remedial measures. Methane drainage systems. Surface subsidence evaluation. Prerequisite: MNGN321. 3 hours lecture; 3 semester hours. Offered in odd years.

MNGN521. EXTRACTIVE METALLURGY OF COPPER, GOLD AND SILVER. 3.0 Semester Hrs.
The same as MTGN-528 Practical applications of fundamentals of chemical-processing-of-materials to the extraction of gold, silver and copper. Topics covered include: History; Ore deposits and mineralogy; Process Selection; Hydrometallurgy and leaching; Oxidation pretreatment; Purification and recovery; Refinement; Waste treatment; and Industrial examples. Prerequisite: Graduate student or senior in good standing.
Course Learning Outcomes

- The same as MTGN-528

MNGN522. FLOTATION. 3.0 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.

MNGN523. SELECTED TOPICS. 2-4 Semester Hr.
(I, II) Special topics in mining engineering, incorporating lectures, laboratory work or independent study, depending on needs. This course may be repeated for additional credit only if subject material is different. Prerequisite: none. 2 to 4 semester hours. Repeatable for credit under different titles.

MNGN524. ADVANCED MINE VENTILATION. 3.0 Semester Hrs.
(I) Advanced topics of mine ventilation including specific ventilation designs for various mining methods, ventilation numerical modeling, mine atmosphere management, mine air cooling, prevention and ventilation response to mine fires and explosions, mine dust control. Prerequisites: MNGN424 Mine Ventilation. Lecture and Lab Contact Hours: 3 hours lecture; 3 semester credit hours.

MNGN525. INTRODUCTION TO NUMERICAL TECHNIQUES IN ROCK MECHANICS. 3.0 Semester Hrs.
(I) Principles of stress and infinitesimal strain analysis are summarized, linear constitutive laws and energy methods are reviewed. Continuous and laminated models of stratified rock masses are introduced.
The general concepts of the boundary element and finite element methods are discussed. Emphasis is placed on the boundary element approach with displacement discontinui ties, because of its relevance to the modeling of the extraction of tabular mineral bodies and to the mobilization of faults, joints, etc. Several practical problems, selected from rock mechanics and subsidence engineering practices, are treated to demonstrate applications of the techniques. Prerequi site: MNGN321, EGGN320, or equivalent courses, MATH455. 3 hours lecture; 3 semester hours. Offered in even years.

MNGN526. MODELING AND MEASURING IN GEOMECHANICS. 3.0 Semester Hrs.
(II) Introduction to instruments and instrumen tation systems used for making field measurements (stress, convergence, deformation, load, etc.) in geomechanics. Techniques for determining rock mass strength and deformability. Design of field measurement programs. Interpretation of field data. Development of predictive models using field data. Intro duction to various numerical techniques (boundary element, finite element, FLAC, etc.) for modeling the behavior of rock structures. Demonstration of concepts using various case studies. Prerequisite: Graduate standing. 2 hours lecture, 3 hours lab; 3 semester hours. Offered in odd years.

MNGN527. SOLID WASTE MINIMIZATION AND RECYCLING. 3.0 Semester Hrs.
(II) Industrial case-studies, on the application of engineering principles to minimize waste formation and to meet solid waste recycling challenges. Proven and emerging solutions to solid waste environmental problems, especially those associated with metals. Prerequisites: ESGN500 and ESGN504.

MNGN528. MINING GEOLOGY. 3.0 Semester Hrs.
(I) Role of geology and the geologist in the development and production stages of a mining operation. Topics addressed: mining operation sequence, mine mapping, drilling, sampling, reserve estimation, economic evaluation, permitting, support functions. Field trips, mine mapping, data evaluation, exercises and term project. Prerequisite: GEGN401 or GEGN405. 2 hours lecture/seminar, 3 hours laboratory: 3 semester hours. Offered in even years.

MNGN529. URANIUM MINING. 2.0 Semester Hrs.
(I) Overview and introduction to the principles of uranium resource extraction and production. All aspects of the uranium fuel cycle are covered, including the geology of uranium, exploration for uranium deposits, mining, processing, environmental issues, and health and safety aspects. A lesser emphasis will be placed on nuclear fuel fabrication, nuclear power and waste disposal.

MNGN530. INTRODUCTION TO MICRO COMPUTERS IN MINING. 3.0 Semester Hrs.
(I) General overview of the use of PC based micro computers and software applications in the mining industry. Topics include the use of: database, CAD, spreadsheets, computer graphics, data acquisition, and remote communications as applied in the mining industry. Prerequisite: Any course in computer programming. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN531. THERMODYNAMICS OF METALLURGICAL AND MATERIALS PROCESSING. 3.0 Semester Hrs.
Application of thermodynamics to the processing of metals and materials, with emphasis on the use of thermodynamics in the development and optimization of processing systems. Focus areas will include entropy and enthalpy, reaction equilibrium, solution thermodynamics, methods for analysis and correlation of thermodynamics data, thermodynamic analysis of phase diagrams, thermodynamics of surfaces, thermodynamics of defect structures, and irreversible thermodynamics. Attention will be given to experimental methods for the measurement of thermodynamic quantities. Prerequisite: MTGN351.

MNGN532. PARTICULATE MATERIAL PROCESSING I - COMMINUTION AND PHYSICAL SEPARATIONS. 3.0 Semester Hrs.
An introduction to the fundamental principles and design criteria for the selection and use of standard mineral processing unit operations in comminution and physical separation. Topics covered include: crushing (jaw, cone, gyratory), grinding (ball, pebble, rod, SAG, HPGR), screening, thickening, sedimentation, filtration and hydrocyclones. Two standard mineral processing plant-design simulation software (MinOCad and JK SimMet) are used in the course. Prerequisite: Graduate or Senior in good- standing.

MNGN533. PARTICULATE MATERIAL PROCESSING II - APPLIED SEPARATIONS. 3.0 Semester Hrs.
An introduction to the fundamental principles and design criteria for the selection and use of standard mineral processing unit operations in applied separations. Topics covered include: photometric ore sorting, magnetic separation, dense media separation, gravity separation, electrostatic separation and flotation (surface chemistry, reagents selection, laboratory testing procedures, design and simulation). Two standard mineral processing plant-design simulation software (MinOCad and JK SimMet) are used in the course. Graduate or Senior in good-standing.

MNGN534. ADVANCED IRON AND STEELMAKING. 3.0 Semester Hrs.
Physicochemical principles of gas-slag-metal reactions applied to the reduction of iron ore concentrates and to the refining of liquid iron to steel. The role of these reactions in reactor design, blast furnace and direct iron smelting furnace, pneumatic steelmaking furnace, refining slags, deoxidation and degassing, ladle metallurgy, alloying, and continuous casting of steel. Prerequisites: DCGN209 or MTGN351.

MNGN535. PYROMETALLURGICAL PROCESSES. 3.0 Semester Hrs.
Detailed study of a selected few processes, illustrating the application of the principles of physical chemistry (both thermodynamics and kinetics) and chemical engineering (heat and mass transfer, fluid flow, plant design, fuel technology, etc.) to process development.

MNGN536. OPERATIONS RESEARCH TECHNIQUES IN THE MINERAL INDUSTRY. 3.0 Semester Hrs.
Analysis of exploration, mining, and metallurgy systems using statistical analysis. Monte Carlo methods, simulation, linear programming, and computer methods. Prerequisite: MNGN433. 2 hours lecture, 3 hours lab; 3 semester hours. Offered in even years.

MNGN537. EXTRACTIVE METALLURGY OF COPPER, GOLD AND SILVER. 3.0 Semester Hrs.
Practical applications of fundamentals of chemical-processing-of-materials to the extraction of gold, silver and copper. Topics covered include: History; Ore deposits and mineralogy; Process Selection; Hydrometallurgy and leaching; Oxidation pretreatment; Purification and recovery; Refinement; Waste treatment; and Industrial examples. Prerequisite: Graduate or Senior in good-standing.

MNGN538. GEOSTATISTICAL ORE RESERVE ESTIMATION. 3.0 Semester Hrs.
(I) Introduction to the application and theory of geostatistics in the mining industry. Review of elementary statistics and traditional ore reserve calculation techniques. Presentation of fundamental geostatistical concepts, including: variogram, estimation variance, block variance, kriging, geostatistical simulation. Emphasis on the practical aspects of geostatistical modeling in mining. Prerequisite: MATH323 or equivalent course in statistics; graduate or senior status. 3 hours lecture; 3 semester hours.

MNGN539. ADVANCED MINING GEOSTATISTICS. 3.0 Semester Hrs.
(II) Advanced study of the theory and application of geostatistics in mining engineering. Presentation of state-of-the-art geostatistical concepts, including: robust estimation, nonlinear geostatistics, disjunctive kriging, geostatistical simulation, computational aspects. This course includes presentations by many guest lecturers from the mining industry. Emphasis on the development and application of advanced geostatistical techniques to difficult problems in the mining industry today. 3 hours lecture; 3 semester hours. Offered in odd years.

MNGN540. CLEAN COAL TECHNOLOGY. 3.0 Semester Hrs.
(I, II) Clean Energy - Gasification of Carbonaceous Materials - including coal, oil, gas, plastics, rubber, municipal waste and other substances. This course also covers the process of feedstock preparation, gasification, cleaning systems, and the output energy blocks along with an educational segment on CO products. These output energy blocks include feedstock to electrical power, feedstock to petroleum liquids, feedstock to pipeline quality gas. The course covers co- product development including urea, fertilizers, CO2 extraction/sequestration and chemical manufacturing.

MNGN541. ELECTROMETALLURGY. 3.0 Semester Hrs.
Electrochemical nature of metallurgical processes. Kinetics of electrode reactions. Electrochemical oxidation and reduction. Complex electrode reactions. Mixed potential systems. Cell design and optimization of electrometallurgical processes. Batteries and fuel cells. Some aspects of corrosion.

MNGN542. HYDROMETALLURGY. 3.0 Semester Hrs.
Kinetics of liquid-solid reactions. Theory of uniformly accessible surfaces. Hydrometallurgy of sulfide and oxides. Cementation and hydrogen reduction. Ion exchange and solvent extraction. Physicochemical phenomena at high pressures. Microbiological metallurgy.

MNGN543. PRINCIPLES OF MATERIALS PROCESSING REACTOR DESIGN. 3.0 Semester Hrs.
Review of reactor types and idealized design equations for isothermal conditions. Residence time functions for nonreacting and reacting species and its relevance to process control. Selection of reactor type for a given application. Reversible and irreversible reactions in CSTR's under nonisothermal conditions. Heat and mass transfer considerations and kinetics of gas-solid reactions applied to fluo-solids type reactors. Reactions in packed beds. Scale up and design of experiments. Brief introduction into drying, crystallization, and bacterial processes. Examples will be taken from current metallurgical practice.

MNGN545. 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.

MNGN546. MINE HEALTH AND SAFETY. 2.0 Semester Hrs.
This course focuses behaviors into a culture of safety and health consciousness is a significant management challenge, particularly in the developing world. The topics include: 1) organizational culture and behavior management, 2) strategic safety planning, 3) hazard recognition, 4) root cause analysis, 5) incident management and emergency preparedness, and 6) training programs. Learning emphasis will be balanced among fundamentals, future trends and risk depending on the specific discussion topic. The frequency of training and refresher programs throughout the project life cycle will be addressed. The importance of a health and safety culture transcending the workplace through mine employees into their families, neighbors and communities will also be discussed. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters Mining Engineering and Management Program.
Course Learning Outcomes

- 1. Understand the importance of establishing an organization-wide culture of health and safety and will
- 2. Understand the processes and techniques for effecting changes in human behavior
- 3. Understand the elements of strategic safety planning
- 4. Understand the elements and processes for accident recognition, investigation, analysis and prevention
- 5. Understand the processes and techniques for responding to crisis and emergency situations
- 6. Understand how to design, set up and manage health and safety training programs that are tailored to specific project needs.

MNGN547. GEOLOGY AND MINING. 3.0 Semester Hrs.
This course focuses on how the ore deposit geology, structure, resource assessment and geochemistry are inextricably linked to major project decisions and cost control regarding mining methods and water management. The course emphasizes fundamentals of exploration, geosystem characterization, and the risks associated with failure to integrate these aspects into decision making. Major topics include: 1) ore genesis, 2) exploration methods, 3) geostatistics and resource development, 4) geologic hazards, 5) geochemistry and geo environmental considerations, 6) groundwater (further addressed in Water, Waste and Closure course), and 7) geologic factors for consideration in mine design. The importance and cost efficiency of

collecting and managing data concurrent with its generation will be emphasized. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters Mining Engineering and Management Program.

Course Learning Outcomes

- 1. Students will describe various principal ore genesis events and relationships with local and regional geology.
- 2. Students will assess the relationship between ore deposits and mine planning activities.
- 3. Students will formulate exploration programs.
- 4. Students will formulate sampling and data validation (EDA) requirements, and identify geostatistical assessment requirements required by JORC and NI 43-101 documents.
- 5. Students will identify the parameters required to minimize risks associated with geological structures, resource evaluation and mine planning.

MNGN548. INFORMATION TECHNOLOGIES FOR MINING SYSTEMS. 3.0 Semester Hrs.

This course will focus on the role of information systems (IS) for specific mining systems in the mine life cycle. We will look at various data sources and acquisition methods like internet-of-things, crowdsourcing, and blockchain. Management of data is the principal function of an IS, so we will look at the main features and functions of a database management system (DBMS). Due to the exponential growth of unstructured data, the integration of structured data sets managed in a DBMS with big data infrastructures, which are mainly unstructured, and will be another focus of the course. Geographic Information Systems (GIS) will be introduced for managing spatial and tabular data. Advancements in sensor technologies allow the various remote sensing (RS) products to be integrated with GIS in various mining systems. The fundamental principles of design visualizations will also be explored. The IS in various full/semi-autonomous mining systems will be covered, and we will analyze the methods of interoperability and related infrastructures. We will identify cybersecurity issues related to autonomous mining systems and future trends. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters - Mining Engineering and Management Program.

Course Learning Outcomes

- 1. Students will design and evaluate mining support facilities, and utilities.
- 2. Students will design top-level communication, control and monitoring systems.
- 3. Students will construct mine operations databases, perform queries, and evaluate outcomes.
- 4. Students will evaluate mine plant systems for cost, environmental compliance, risk, and life-of-project sustainability.
- 5. Students will formulate, evaluate, and present design alternatives for a mine plant project.

MNGN549. MARINE MINING SYSTEMS. 3.0 Semester Hrs.

(I) Define interdisciplinary marine mining systems and operational requirements for the exploration survey, sea floor mining, hoisting, and transport. Describe and design components of deep-ocean, manganese-nodule mining systems and other marine mineral extraction methods. Analyze dynamics and remote control of the marine mining systems interactions and system components. Describe the current state-of-the-art technology, operational practice, trade-offs of the system design and risk. Prerequisite: EGGN351, EGGN320, GEOC408. 3 hours lecture; 3 semester hours. Offered alternate even years.

MNGN550. NEW TECHNIQUES IN MINING. 3.0 Semester Hrs.

(II) Review of various experimental mining procedures, including a critical evaluation of their potential applications. Mining methods covered include deep sea nodule mining, in situ gassification of coal, in situ retorting of oil shale, solution mining of soluble minerals, in situ leaching of metals, geothermal power generation, oil mining, nuclear fragmentation, slope caving, electro-thermal rock penetration and fragmentation. Prerequisite: Graduate standing. 3 hours lecture; 3 semester hours. Offered in even years.

MNGN551. MINE ACCOUNTING. 2.0 Semester Hrs.

Accounting is the process of recording business transactions. Financial analysis uses accounting information to gain insights into the financial position, performance, and prospects of a company. This course aims at building the accounting and financial knowledge and skills to allow students to participate in decision-making, financial, and corporate management processes. The objective is to make better managers and leaders by developing practical knowledge and abilities to interpret financial statements, evaluate a competitive position from the financial perspective, and determine the financial implications of business decisions. This is exclusively an online course that is cohort-based with limited enrollment. It is offered specifically for the Professional Masters Program in Mining Engineering and Management.

Course Learning Outcomes

- 1. Students will be knowledgeable of principles of accounting as applicable to engineers and managers in the mining industry.
- 2. Students will understand and be able to evaluate financial statements and balance sheets.
- 3. Students will understand the application of cost accounting methods for mine projects and operations including the proper application of accruals.
- 4. Students will understand accounting standards in the U.S. and internationally from a managerial perspective.
- 5. Students will be aware of mandatory financial reporting requirements for corporate entities in the U.S.

MNGN552. 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. 3 hours lecture, 3 semester hours. Offered in spring.

MNGN553. MINE DESIGN AND OPERATION PLANNING. 3.0 Semester Hrs.

This course provides an overview of mine design and operations fundamentals with a focus on the future trends which considers where the industry will be in the next decade(s). Topics give an over-arching significance to social, environmental, health and safety considerations in traditional design and operations decision-making. Principal topics will include 1) mining methods and planning, 2) production scheduling and optimization, 3) robotics and automation, 4) equipment capabilities and selection processes, 5) mine ventilation, 6) rock mechanics and ground control, and 7) waste disposal (high level, further addressed in Water, Waste and Closure course). Project life cycle and sustainability principles will be applied throughout the course content. This is exclusively an online course that is cohort based with limited enrollment. It is offered

specifically for the Professional Masters Mining Engineering and Management Program.

Course Learning Outcomes

- 1. Students will specify underground and surface mining methods that can optimally exploit a mineral resource based on its chemical and physical characteristics.
- 2. Students will prepare mine production schedules that can provide desired cash flows based on ore production and waste disposal.
- 3. Students will evaluate emerging technologies to improve health and safety, and improve productivity.
- 4. Students will design mine ventilation plans to effectively provide the desired working atmosphere.
- 5. Students will characterize local geological conditions to design a ground control plan.
- 6. Students will develop a sustainable waste disposal plan to comply with government regulations and social concerns.
- 7. Students will assess risks and develop plans to mitigate and manage risks.

MNGN554. MINE FINANCE. 2.0 Semester Hrs.

This course describes the finance principles applicable to the mining industry. It addresses the practical application of these principles to a level of detail appropriate for a manager or corporate executive to understand what it takes to raise money in the international marketplace to finance a corporate entity or a specific mining project. This is exclusively an online course that is cohort-based with limited enrollment. It is offered specifically for the Professional Masters Program in Mining Engineering and Management.

Course Learning Outcomes

- 1. Students will be knowledgeable of principles of finance as applicable to engineers and managers in the mining industry.
- 2. Students will be aware and understand various financing methods for establishing corporate equity and for funding specific mine projects.
- 3. Students will understand the fundamentals of asset and cash management in a mining venture.
- 4. Students will be aware of approaches and challenges of mergers and acquisitions.
- 5. Students will be aware of the financial challenges and potential remedies throughout the mine life cycle from exploration to closure.
- 6. Students will know how to apply financial ratios in analyzing a mining company’s financial health.
- 7. Students will be aware of the purposes and protocols for audits.

MNGN555. MINE INVESTMENT EVALUATION. 3.0 Semester Hrs.

This course discusses the elements, methods and analyses required to evaluate the viability and robustness of a mining project. Current practices for introducing the uncertain nature of most of the important variables in an investment analysis are addressed. While future trends and risks will be covered, course emphasis will be on the fundamentals of determining the feasibility of a project and the elements contained in a robust financial model to demonstrate that feasibility. Topics include: 1) laws and security exchange expectations for publicly disclosed documents, 2) feasibility study content, 3) responsibilities of the Qualified Person, 4) capital and operating cost estimation, 5) accruals and taxes, 6) financial analysis and cash flow modeling, 7) sensitivity analysis, and 8) public reporting. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters Mining Engineering and Management Program.

Course Learning Outcomes

- 1. Students acquire an advanced knowledge in mine capital investment evaluation utilizing time value of money principles.
- 2. Students are knowledgeable of implications on capital investments of tax policy, sustainability requirements, leasing, debt financing and other forms of capital structure in a project.
- 3. Students acquire knowledge for performing cost estimation for capital and operating cost budgets in feasibility studies.
- 4. Students are knowledgeable of how to prepare and the requirements for feasibility studies at the different levels of detail.
- 5. Students will be aware of world standards for public reporting requirements of mineral resources, reserves and investments.
- 6. Students are knowledgeable of methods of sensitivity and real options evaluation of capital investments.

MNGN556. MINE WATER AND ENVIRONMENT. 3.0 Semester Hrs.

Equivalent with CEEN556,

(I) This course will cover core aspects of mine water and mining geotechnics. The main topics to be covered relate to surface and groundwater flow along open pits and underground excavations, tailings and impoundments, mine spoils and waste rock, reclamation and closure. Course emphasizes leadership, teamwork, communication, and creative problem solving skills through the use of case examples, homework, and exams which emphasize typical water and geotechnical problems relevant to the mining industry. Prerequisite: CHGN121, CHGN122. 3 hours lecture, 3 semester hours.

Course Learning Outcomes

- Predict physical characteristics of a hydrogeological system
- Construct conceptual models of the hydrogeological conditions in a mine setting
- Propose effective methods for management of an abandoned mine
- Describe requirements for mine closure and reclamation

MNGN557. MINERAL ECONOMICS AND POLICY. 2.0 Semester Hrs.

This course is designed to help students learn some of the basic economic principles that will help them better understand mineral commodity market behavior and the important factors that drive mineral supply, demand, prices and other market elements. The course is designed to help you build the economic, market and policy knowledge and skills to effectively participate in company decision-making and strategic management discussions. It concentrates on the economic factors and principles that mine managers and executives need to recognize, analyze and deal with in order to position their company for long-term success in volatile commodity markets. The overall objective of this course is not to make students mineral economists, but to make them a better managers and leaders by developing a practical understanding of the commodity markets in which they will deal. It will also give them a deeper knowledge of government's perspective and role in the mineral industry. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters Mining Engineering and Management Program.

Course Learning Outcomes

- 1. Students will be knowledgeable of the underlying mineral market dynamics of supply and demand.
- 2. Students will be aware of historical and potential factors that influence the demand and supply of minerals.

- 3. Students will understand the role of public policy in defining the mining industry in a nation including the requirements for tax and royalty revenue, economic contributions and sustainable development of the local and greater communities.

MNGN558. MINERAL PROCESSING. 3.0 Semester Hrs.
This course addresses the fundamentals for developing an appropriate and cost-efficient mineral process for a given ore type and the risks that factor into deploying the selected process. Consideration will be given for the need to demonstrate a proven and robust process to potential investors (a bankable process). Topics will include 1) unit operations and material handling, 2) sampling techniques specific to process considerations, 3) material testing and data organization and management, 4) water and energy considerations, 5) mill design and development (concept through construction), and 6) process waste disposal (high level, further addressed in Water, Waste and Closure course). Timing of process design within the project life cycle will be addressed. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters Mining Engineering and Management Program.
Course Learning Outcomes

- 1. Students will identify and specify mill unit operations that are appropriate for a given ore.
- 2. Students will establish project develop plans from concept through operation.
- 3. Students will estimate the capital and operating cost of mills.
- 4. Students will develop an economic model from concentrate qualities and smelter schedules.
- 5. Students will assess risks and emerging trends in mineral processing systems.
- 6. Students devise mill performance testing programs.
- 7. Students will construct water and energy management plans.

MNGN559. MECHANICS OF PARTICULATE MEDIA. 3.0 Semester Hrs.
(1) This course allows students to establish fundamental knowledge of quasi-static and dynamic particle behavior that is beneficial to interdisciplinary material handling processes in the chemical, civil, materials, metallurgy, geophysics, physics, and mining engineering. Issues of interst are the definition of particl size and size distribution, particle shape, nature of packing, quasi-static behavior under different external loading, particle collisions, kinetic theoretical modeling of particulate flows, molecular dynamic simulations, and a brief introduction of solid-fluid two-phase flows. Prerequisite: none. 3 hours lecture; 3 semester hours. Fall semesters, every other year.

MNGN560. INDUSTRIAL MINERALS PRODUCTION. 3.0 Semester Hrs.
This course describes the engineering principles and practices associated with quarry mining operations related to the cement and aggregate industries. The course will cover resource definition, quarry planning and design, extraction, and processing of minerals for cement and aggregate production. Permitting issues and reclamation, particle sizing and environmental practices, will be studied in depth.

MNGN561. PROJECT MANAGEMENT. 3.0 Semester Hrs.
This course addresses the many aspects of business and project management. As the business environment changes, mine managers and executives face competing pressures to deliver both profits and effective social, environmental and economic results. Leadership is a fundamental tool for the effective executive. While a solid base of technical and operational skills is required, they must also engage a workforce, build and retain employees and seize opportunities for growth and development. While the course will address future trends and risks, emphasis will be on the fundamentals of effective business and project management. Topics include: 1) leadership, 2) project planning and controls, 3) quality assurance, 4) business process improvement, 5) risk assessment techniques, 6) personnel management and 7) conflict resolution. Because the leadership role is one that goes beyond the workplace, the course will explore the role of the project manager in communications and supporting sustainable investments. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters Mining Engineering and Management Program. Prerequisites: MATH225 and MTGN461 or equivalent.
Course Learning Outcomes

- 1. Students are knowledgeable of all aspects of project management from major mine construction projects to business improvement projects.
- 2. Students are capable of applying improvement tools to boost business results.
- 3. Students are adept at methods for analyzing and managing risk.
- 4. Students understand methods to improve decision-making under conditions of uncertainty.
- 5. Students are capable of applying constraints analysis and using methods to optimize mine systems and processes.
- 6. Students understand when and how to apply various approaches for conflict resolution in the business.

MNGN562. MINING ENVIRONMENTAL AND SOCIAL RESPONSIBILITY. 2.0 Semester Hrs.
This course explores the fundamentals of, and to the extent relevant, the future trends in building environmentally and socially responsible mining projects in the context of the project life cycle. Emphasis will be on 1) host country and international industry regulatory expectations and good practice; 2) communication strategies, stakeholder engagement, and building community support; 3) mining project screening and scoping, 4) characterization of environmental and social media; 5) predicting project-induced environmental and social impacts and identifying plausible mitigating actions to reduce adverse impacts to acceptable levels and enhance project benefits; and 6) developing and implementing effective social and environmental management systems. Course emphasis will be on executing these fundamentals adequately and in a culturally appropriate manner, and on the risk to project continuity and corporate reputation if these fundamentals are mishandled. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters Mining Engineering and Management Program.
Course Learning Outcomes

- 1. Understand the significance and commonalities of the administrative and regulatory framework in host country jurisdictions and the importance of industry good practices, lender and development bank expectations.
- 2. Understand the fundamentals of the environmental and social assessment process and how it fits into the overall project cycle.
- 3. Understand the business case for social and environmental assessment, including key concepts and the roles and responsibilities of assessment professionals.
- 4. Understand what goes into each procedural step of the assessment process.

- 5. Understand how to limit the scale of the assessment to address only what is needed, no more and no less, so that the resulting environmental and social assessment is cost-efficient, appropriately scaled and fit-for-purpose.
- 6. Understand the need and processes for stakeholder engagement and how it fits with the social and environmental assessment process throughout the project cycle.
- 7. Understand the business case for stakeholder engagement and the roles and responsibilities of assessment professionals.
- 8. Understand the elements of, and continuous improvement processes for, a comprehensive environmental and social management system.

MNGN563. WATER WASTE AND MINE CLOSURE. 3.0 Semester Hrs.
This course addresses three disciplines that are critically important to a successful and sustainable mining project. Beyond the ore deposit, water is essential for all mining projects. Supplies must be balanced among local and regional water users. Closure and reclamation is one phase of the mine life cycle and constitutes a significant mitigating action and cost to mining projects. The course will address fundamentals and future trends, but significant emphasis will be placed on the environmental, social, and cost control risks. Topics covered include: 1) water supply, disposal and treatment, 2) site-wide water management, 3) mine waste rock management, 4) process waste and tailings management, 5) solid, hazardous and medical waste minimization, recycling and disposal, 6) closure design (conceptual to construction-ready), 7) surety estimation and available surety instruments, and 8) post-closure elements including monitoring, maintenance, retrenchment, close-out costs and surety release. The importance of effective water and waste management practices, as well as integrating closure planning techniques into engineering designs, will be stressed throughout the project life cycle. This is exclusively an online course that is cohort based with limited enrollment. It is offered specifically for the Professional Masters Mining Engineering and Management Program.
Course Learning Outcomes

- 1. Understand the fundamentals of watershed hydrology and hydrometeorology at mine sites 2. Understand the fundamentals of hydrogeology, including aquifer properties, saturated and unsaturated flow and groundwater quality. 3. Understand mining hydrogeology, mine dewatering systems and the development of the water supply 4. Understand surface water management, sedimentation control and surface water models 5. Understand water balances and models, including facility-specific water balances (e.g., tailings, heap leach facilities) and site-wide water balances 6. Understand hydrology at closure, including pit lakes, underground reservoirs and water treatment 7. Understand the risks associated with mismanagement of mine wastes 8. Understand the applicable guidelines and regulatory framework pertaining to mine wastes. 9. Understand the elements of material characterization, including physical and geochemical characterization 10. Understand the methods and design criteria for heap leaching systems and for the permanent storage of mine waste rock and mill tailings 11. Understand the fundamentals of solid, hazardous and medical waste management 12. Understand slope stability evaluations as they relate to mine waste and closure scenarios 13. Understand the fundamentals of mine closure planning, design and implementation as well as the financial implications

MNGN565. MINE RISK MANAGEMENT. 3.0 Semester Hrs.
(II) Fundamentals of identifying, analyzing, assessing and treating risks associated with the feasibility, development and operation of mines. Methodologies for identifying, assessing and treating risks will be presented and practiced in case studies and exercises. Concepts and principles for analyzing risks will be demonstrated and practiced utilizing deterministic and stochastic models, deductive models, decision trees and other applicable principles. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- At the conclusion of the class students will… a) Be aware of the types of risks associated with the mining industry b) Be knowledgeable of the systematic risk management process – identification, analysis, assessment and treatment c) Be familiar with concepts and methods used in risk identification, analysis, assessment and treatment d) Be familiar with techniques applied in causative analysis e) Be familiar with quantitative risk analysis methods as applied to the mining industry – decision trees, stochastic modeling, deductive modeling and other applicable principles

MNGN566. INNOV8X. 3.0 Semester Hrs.
Innov8x 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.
Course Learning Outcomes

- Frame and translate complex ambiguous problems in resources sciences and engineering into actionable opportunities for innovation
- Conduct effective, objective and ongoing beneficiary discovery in efficient ways
- Combine tools and methods to quickly test assumptions and secure beneficiary acceptance
- Develop creative approaches to navigate real and perceived constraints
- Leverage mentor and stakeholder support through credible communication based on research
- Launch innovative solutions with the advocacy of beneficiaries and stakeholders
- Create value by solving complex sociotechnical problems with scientific and technical foundations

MNGN567. SUSTAINABLE DEVELOPMENT AND EARTH RESOURCES. 3.0 Semester Hrs.
(II) Earth resource industries are increasingly being called on to contribute to sustainable development in the communities and regions in which they take place. In this graduate level course, students will develop an understanding and appreciation of the ways in which resource extraction projects can contribute to sustainable development. The course will be framed around the UN Sustainable Development Goals and will include the following elements: 1) examination of sustainable development principles relevant to mining and energy projects and current best practices and continuing challenges; 2) critical assessment of necessary elements of corporate social responsibility policies and practices; 3) evaluation of stakeholder roles and specify

strategies for effective stakeholder engagement; 4) identification of criteria for engineering and management that contribute to sustainable development; and 5) evaluation of real cases that demonstrate where social license to operate was either gained/maintained or not granted/withdrawn. 2 hours lecture; 3 hours lab; 3 hours total.

Course Learning Outcomes

- Demonstrate knowledge of sustainable development principles relevant to mining and energy projects and identify current best practices and continuing challenges.
- Critically evaluate necessary elements of Corporate Social Responsibility concepts and practices (transparency, accountability, continuous improvement, etc.).
- Determine stakeholder roles in general and for particular projects, and specify strategies for effective stakeholder engagement
- Specify criteria for engineering projects that contribute to sustainable development, and evaluate the “business case” for incorporating such criteria.
- Identify mine management successes in real cases where a social license to operate was gained/maintained, or “fatal flaws” in cases where a social license was not granted/withdrawn; and suggest alternative approaches in unfavorable cases.

MNGN570. 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.

MNGN571. ENERGY, NATURAL RESOURCES, AND SOCIETY. 3.0 Semester Hrs.

(I) This is a graduate course that applies a social science lens to understanding the intersections between energy and mineral developments and communities. In this seminar-style course, we will examine these intersections through a case study approach that includes directed readings, such as ethnographies and peer-reviewed journal articles, and that incorporates student-led discussions and research projects. By exploring various development initiatives, such as oil and gas, mining, wind, solar, nuclear, and hydropower, students will gain a comprehensive understanding of the energy-mineral-society nexus and the role communities play in both furthering and limiting these developments. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- Apply critical thinking and interdisciplinary analyses to the relationship between energy and mineral developments and society.
- Research, write about, present, and discuss case studies on the relationship among energy, natural resources, and society in a variety of contexts
- Apply concepts such as, sustainability, community development, corporate social responsibility, and social license to operate to analyses of the energy-natural resources-society nexus

MNGN572A. MINING INDUSTRY MANAGEMENT CAPSTONE DESIGN. 0.5 Semester Hrs.

This is the first of a three-course series to design, develop and deliver a project that will ideally be of value to the student?s employer in his or her current role in the company. The project will be created and done independently by the student, typically in conjunction with his or her existing job. Prerequisite: None Co-requisite: None.

Course Learning Outcomes

MNGN572B. MINING INDUSTRY MANAGEMENT CAPSTONE DEVELOPMENT. 0.5 Semester Hrs.

This is the second of a three-course series to design, develop and deliver a project that will ideally be of value to the student?s employer in his or her current role in the company. The project will be created and done independently by the student, typically in conjunction with his or her existing job. Prerequisite: MNGN571A.

Course Learning Outcomes

- Ability to think through, define and design a project with sufficient detail to allow for detailed project planning and development. Evaluate and communicate clearly a written response to a request for proposal (RFP) from the perspective of a contractor or consultant that encompasses contractor background, project scope and content and a detailed schedule, budget, milestone deliverables, and tasks necessary to complete the project to address client needs. Craft a response to an RFP with specific sensitivity to the target audience and their needs and objectives and also serves as an effective marketing document for contractor/consultant expertise and experience

MNGN572C. MINING INDUSTRY MANAGEMENT CAPSTONE DELIVERY - FINAL SECTION. 1.0 Semester Hr.

This is the final course of a three-course series to design, develop and deliver a project that will ideally be of value to the student?s employer in his or her current role in the company. The project will be created and done independently by the student, typically in conjunction with his or her existing job. Prerequisite: MNGN572B.

Course Learning Outcomes

MNGN575. HEAT MINING. 3.0 Semester Hrs.

(I) Heat Mining focuses on identifying available sub-surface heat sources. Heat trapped in crystalline rock deep underground is available by engineering an artificial geothermal system. Hot geothermal fluid, heat generated by underground coal fire and hot water trapped in abandoned underground mine are some of other examples. We will discuss how to find them, how to estimate them, and how to extract and convert them to a usable energy form. The concept of sustainable resource development will be taught as the foundation of heat mining. Prerequisites: None. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- The following outcomes are expected: understanding of the concept of sustainable heat mining; understanding the state-of-the-art heat recovery and utilization methods; understanding stakeholders

MNGN581. FUNDAMENTALS OF TAILINGS ENGINEERING I. 3.0 Semester Hrs.

This course provides a broad overview of tailings storage facility (TSF) operation and governance. Topics covered include mineral processing and tailings generation (volume vs. commodity produced; tailings physical, mineralogical, and geochemical) characterization; tailings continuum and rheology (including solid-liquid separation, dewatering, thickening, and filtering); introduction to tailings geotechnics; TSF Design and Operations; tailings innovations in the mining industry. Prerequisite: BSc in Mining Engineering, Geosciences, or related fields.

Course Learning Outcomes

- Describe the process in which tailings are generated from ore processing, and contrast tailings production from different mines as a function of commodity;

- Distinguish and compare different types of tailings in terms of physical and chemical/mineralogical characteristics, and develop a logical argument based on the concepts of tailings generation to explain the differences;
- Differentiate tailings based on the rheology of the “tailings continuum” and explain how the factors affecting yield strength and viscosity impact on tailings management;
- Analyze the different technologies applied for water reduction in the context of tailings dewatering, thickening, and filtering;
- Contrast current practices in mine tailings to identify challenges that are pushing innovation in the industry, including demands for tailings minimization, environmental and social impacts, and governance (ESG);
- Explain the importance of integrating the existing mine workings into planning and siting of a tailings facility;
- Apply data / information sources to design an effective site investigation.
- Apply material balance and water balance analysis to TSF initial design, and identify and assess external considerations that influence siting;
- Apply multiple accounts analysis to assess candidate locations for a future tailings facility;
- Design an effective surveillance and monitoring program considering the outcomes from geotechnical investigations;
- Discuss strength and deformation of tailings with emphasis on drained and undrained shear behavior, and describe importance of and methods used for evaluating dilative/contractive and brittle/ductile behavior;
- Describe a framework to connect stress, density, water pressures and shear behavior, and identify common loading conditions in tailings facilities, and identify critical design cross sections; and,
- Apply several methods of geotechnical analyses to evaluate the stability and performance of TSFs.

MNGN582. FUNDAMENTALS OF TAILINGS ENGINEERING II. 3.0 Semester Hrs.
This course provides a framework for engineering design and decisions regarding tailings storage facility (TSF) water systems, multi-stakeholder risk management and operations, and TSF closure. Topics covered include TSF Water Management, TSF Operations and Compliance and TSF Closure and Reclamation. Prerequisite: BSc in Mining Engineering, Civil Engineering, Geosciences or related engineering fields.
Course Learning Outcomes

- Define the role of water in the planning and operation of a TSF.
- Describe the hydrologic processes important to surface water, seepage and groundwater management at TSFs.
- Understand the current practice of addressing climate uncertainty and climate change.
- Analyze the role of the mine water management plan in TSF management and decision making.
- Explain what water balance models are, how they can be used to improve decision making, and what techniques can be implemented to improve model reliability.
- Describe the essential components, risks and generally accepted risk mitigation for the design and operation of TSF water management systems.
- Provide perspective on project management aspects of tailings construction, including managing construction contractors, resident engineering, quality assurance and quality control, and documentation
- Manage development and implementation of an OMS (Operation, Maintenance and Surveillance) systems
- Manage the process of developing EAP (Emergency Action Plans; called Emergency Preparedness and Response Plans in the Global Industry Standard
- Explain and implement applicable international standards of care, including the Global Tailings Standard, the Mining Association of Canada (MAC) guidelines, The Canadian Dam Association (CDA) guidelines and other related references
- Describe the process and components of TSF decommissioning and closure.
- Compare and contrast techniques for minimizing TSF closure challenges via closure-oriented tailings management through life-of-mine.
- Select components and design different cover types for function.
- Prepare closure cost estimates and schedules.
- Compare financial assurance instruments.
- Distinguish between net present value and whole-of-life accounting.
- Develop a TSF closure plan that fits within an integrated site-wide closure plan.

MNGN585. MINING ECONOMICS. 3.0 Semester Hrs.
(I) Advanced study in mine valuation with emphasis on revenue and cost aspects. Topics include price and contract consideration in coal, metal and other commodities; mine capital and operating cost estimation and indexing; and other topics of current interest. Prerequisite: MNGN427 or EBGN504 or equivalent. 3 hours lecture; 3 semester hours. Offered in even years.

MNGN590. MECHANICAL EXCAVATION IN MINING. 3.0 Semester Hrs.
(II) This course provides a comprehensive review of the existing and emerging mechanical excavation technologies for mine development and production in surface and underground mining. The major topics covered in the course include: history and development of mechanical excavators, theory and principles of mechanical rock fragmentation, design and performance of rock cutting tools, design and operational characteristics of mechanical excavators (e.g. continuous miners, roadheaders, tunnel boring machines, raise drills, shaft borers, impact miners, slotters), applications to mine development and production, performance prediction and geotechnical investigations, costs versus conventional methods, new mine designs for applying mechanical excavators, case histories, future trends and anticipated developments and novel rock fragmentation methods including water jets, lasers, microwaves, electron beams, penetrators, electrical discharge and sonic rock breakers. Prerequisite: Senior or graduate status. 3 hours lecture; 3 semester hours. Offered in odd years.

MNGN598. SPECIAL TOPICS IN MINING ENGINEERING. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

MNGN599. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II, S) 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.

MNGN625. GRADUATE MINING SEMINAR. 1.0 Semester Hr.
(I, II) Discussions presented by graduate students, staff, and visiting lecturers on research and development topics of general interest. Required of all graduate students in mining engineering every semester during residence.

MNGN631. TRANSPORT PHENOMENA IN METALLURGICAL AND MATERIALS SYSTEMS. 3.0 Semester Hrs.
Physical principles of mass, momentum, and energy transport. Application to the analysis of extraction metallurgy and other physicochemical processes.

MNGN698. SPECIAL TOPICS IN MINING ENGINEERING. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

MNGN699. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II, S) 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.

MNGN700. GRADUATE ENGINEERING REPORTMASTER OF ENGINEERING. 1-6 Semester Hr.
(I, II) Laboratory, field, and library work for the Master of Engineering report under supervision of the student?s advisory committee. Required of candidates for the degree of Master of Engineering. Variable 1 to 6 hours. Repeatable for credit to a maximum of 6 hours.

MNGN707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.
(I, II, S) Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.