Bachelor of Science in Mining Engineering

Program Description

Mining Engineering is a broad profession, which embraces all required activities to facilitate the recovery of valuable metals and minerals from the earth's crust for the benefit of humanity. It is one of the oldest engineering professions, which continues to grow in importance. Everything in our "built world" requires metals and minerals, or tools and machinery required for construction and manufacturing. An adequate supply of mineral products at competitive prices is the lifeblood of the continuing growth of industrialized nations and the foundation of progress for the developing countries.

The function of the mining engineer is to apply knowledge of pertinent scientific theory, engineering fundamentals, and improved technology to recover natural resources. Mining is a world-wide activity involving the extraction of nonmetallic and metallic ores of all kinds, as well as solid fuel and energy sources such as coal and nuclear materials. In addition to mineral extraction, the skills of mining engineers are also needed in a variety of fields where the earth's crust is utilized, such as the underground construction industry. The construction industry, with its requirements of developing earth (rock) systems, tunnels and underground chambers, and the hazardous waste disposal industry are examples of such applications. These are expanding needs, with a shortage of competent people; the mining engineer is well qualified to meet these needs.

The importance of environmental and societal impacts is recognized and given significant attention in all aspects of the mining engineering curriculum.

Mines Mining Engineering students study the principles and techniques of mineral exploration, and underground and surface mining operations, as well as, mineral processing technologies. Studies include rock mechanics, rock fragmentation, plant and mine design, mine ventilation, surveying, valuation, industrial hygiene, mineral law, mine safety, computing, mineral processing, solution mining and operations research. Throughout the mining engineering curriculum, a constant effort is made to maintain a balance between theoretical principles and their engineering applications. The mining engineering graduate is qualified for positions in engineering, supervision, and research.

The department recognizes the high expectations that industry has for our graduates as well as the responsibility we have to prepare our students for successful professional careers. To be successful, it is imperative that mining graduates possess an ever-growing set of technical skills, knowledge, and expertise. Beyond the technical aspects of basic sciences, engineering fundamentals, and problem-solving, mining engineering graduates must also acquire a host of other skills which are essential in today's global economy.

These include:

- The ability to work in interdisciplinary teams and communicate effectively to different types of audiences.
- An appreciation of the social, political, and economic realities of different cultures, countries, and indigenous peoples.
- An understanding of the global role mineral extraction and resource development have on local, regional, and international levels.
- The desire for continuing and lifelong education, intellectual and professional development, analysis, and creativity.
- The need to maintain high professional and ethical standards.
- The importance of self-confidence, conviction, and compassion.
- The skills critical to leadership and supervision.

Put simply, our vision for the Mining Engineering Department is to be internationally recognized as the world's premiere center for education and applied research in the diverse fields of mining and underground construction and tunneling. This vision spans across numerous interdisciplinary areas of study. Through collaborations with other Mines departments, academic institutions, government agencies, and industry, we are committed to expanding the international reputation of the Department for excellence in education, research, industry service, and community outreach.

The Mining Engineering Department's program objectives are:

1. Have knowledge of and skills in engineering fundamentals to solve complex and open-ended mining and earth systems-related problems.
2. Demonstrate teamwork and leadership skills relevant to their chosen profession.
3. Several years after leaving Mines, our graduates will achieve professional growth.

Program Educational Objectives (Bachelor of Science in Mining Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate profile and the ABET accreditation criteria, the educational objectives which the Mining Engineering Department aspires to accomplish can be seen in the attributes of our graduates. The graduate will:

- Obtain professional positions in minerals or related industries, government, or pursue graduate education;
- Demonstrate advancement in their chosen careers through strong technical skills , work on interdisciplinary teams and diverse environments, effective communication, knowledge of current issues, and high standard of ethical conduct;
- Engage in appropriate professional societies and continuing education activities to achieve professional growth

Student Learning Outcomes

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

ABET Accreditation Status

The Bachelor of Science in Mining Engineering is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, under the commission's General Criteria and Program Criteria for Mining and Similarly Named Engineering Programs.

Primary Contact

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Mining Engineering Department Head
https://mining.mines.edu/

Curriculum

The Mining Engineering curriculum is devised to facilitate the widest employability of CSM graduates. The curriculum is based on scientific engineering and geologic fundamentals and the application of these fundamentals to design and operate mines and to create structures in rock and prepare mine products for the market. To achieve this goal, the curriculum is designed to ensure that the graduates:

- become broad based mining engineers who can tackle the problems of both hard and soft rock mining, regardless of whether the mineral deposit requires surface or underground methods of extraction,
- have an opportunity, through elective courses, to specialize in one or more aspects of the mining engineering profession,
- are interested in an academic or research career, or wish to pursue employment in related fields, have a sufficiently sound scientific and engineering foundation to do so effectively.

This purpose permeates both the lower and upper-division courses. Another important aspect of the curriculum is the development of the students' capabilities to be team members, with the added objective of preparing them for leadership in their professional life. The curriculum focuses on the application of engineering principles to solving problems, in short, engineering design in an earth systems approach.

Degree Requirements (Mining Engineering)

First Year

		lec	lab	sem.hrs
HASS100	NATURE AND HUMAN VALUES			3.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			1.0
S&W	SUCCESS AND WELLNESS			1.0
EDNS151	CORNERSTONE - DESIGN I			3.0
PHGN100	PHYSICS I - MECHANICS			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
CSM202	INTRODUCTION TO STUDENT WELL-BEING AT MINES			1.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS			4.0
				33.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
CSCI128	COMPUTER SCIENCE FOR STEM			3.0
HASS215	FUTURES			3.0
CEEN241	STATICS			3.0
MNGN210	INTRODUCTORY MINING			3.0
				16.0

Spring		**lec**	**lab**	**sem.hrs**
MATH225	DIFFERENTIAL EQUATIONS			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
MNGN2XX	New Special Topics			3.0
MNGN317	DYNAMICS FOR MINING ENGINEERS			1.0
MNGN209	DATA ANALYTICS FOR MINING ENGINEERS			2.0
CAS	Mid Level ELECTIVE			3.0
				15.0

Summer		**lec**	**lab**	**sem.hrs**
MNGN308	MINE SAFETY			1.0
MNGN203	SOFTWARE FUNDAMENTALS FOR 3D DATA ANALYSIS AND MINE PLANNING			1.0
MNGN205	MINING ENGINEERING FIELD EXPERIENCE(optional)			
				2.0

Junior

Fall		**lec**	**lab**	**sem.hrs**
MNGN310	EARTH MATERIALS			3.0
MNGN309	MINE SAFETY AND OPERATIONS			2.0
MNGN312	SURFACE MINE DESIGN			3.0
CAS	ELECTIVE			3.0
MNGN322	INTRODUCTION TO MINERAL PROCESSING AND LABORATORY			3.0
EBGN321	ENGINEERING ECONOMICS			3.0
				17.0

Spring		**lec**	**lab**	**sem.hrs**
MNGN311	MINING GEOLOGY			3.0
MNGN314	UNDERGROUND MINE DESIGN			3.0
MEGN351/ PEGN251	FLUID MECHANICS or PEGN 251			3.0
FREE	FREE ELECTIVE			3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS			3.0

MNGN427	MINE VALUATION			2.0
				17.0
Summer		**lec**	**lab**	**sem.hrs**
MNGN301	MINE SURVEYING			2.0
				2.0
Senior				
Fall		**lec**	**lab**	**sem.hrs**
MNGN414	MINE PLANT DESIGN			3.0
MNGN428	MINING ENGINEERING EVALUATION AND DESIGN REPORT I			1.0
MNGN438	GEOSTATISTICS			2.0
CAS ELECTIVE	400-Level			3.0
FREE	FREE ELECTIVE			3.0
MNGN412	MINE WATER, WASTE AND CLOSURE			3.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
MNGN429	MINING ENGINEERING EVALUATION AND DESIGN REPORT II			2.0
MNGN433	MINE SYSTEMS ANALYSIS			2.0
MNGN425	MINE VENTILATION AND THERMODYNAMICS			4.0
FREE	FREE ELECTIVE			3.0
MNGN482	RISK AND PROJECT MANAGEMENT			3.0
				14.0

Total Semester Hrs: 131.0

Major GPA

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

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

- MNGN100 through MNGN599 inclusive

COURSES

MNGN198. SPECIAL TOPICS MINING ENGR. 1-6 Semester Hr.

MNGN198. SPECIAL TOPICS IN MINING ENGINEERING. 0-6 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.

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

MNGN209. DATA ANALYTICS FOR MINING ENGINEERS. 2.0 Semester Hrs.
MNGN 209 is an innovative course designed specifically for sophomore-year mining engineering students, focusing on the essential skills and knowledge of data collection and analysis in the mining industry. The course provides an in-depth exploration of data sources, acquisition methods, data analytics, geospatial data analysis, and applying statistical principles and programming to mining operations. The course establishes the foundation of integrating theoretical understanding with practical application. Hence, students will learn to harness cutting-edge technologies and data analysis techniques to optimize mining operations and solve complex engineering problems. Prerequisites: CSCI128.
Course Learning Outcomes

- Expose students to different sources of data in mining
- Exploratory Data Analysis using Phthon
- Data Equisiton Methods in Mining
- Geospatial Data Analysis
- Evaluation of Quality and Reliability of Data

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.

MNGN298. SPECIAL TOPICS IN MINING ENGINEERING. 0-6 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.

MNGN298. SPECIAL TOPICS. 1-6 Semester Hr.

MNGN298. SPECIAL TOPICS. 0-6 Semester Hr.

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, MNGN203.

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, MNGN203.
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

MNGN320. MINING AND SUSTAINABILITY. 3.0 Semester Hrs.
This course offers a comprehensive examination of the relationship between mining and sustainability. Through readings, lectures, case studies, guest speakers, and discussions, undergraduate students will explore environmental, social, economic, and political dimensions of mineral supply chains and examine how mineral developments intersect with local communities, governments, and other stakeholders. Students will gain a deep understanding of how the concept of sustainability in mining is conceptualized, implemented, and critiqued and develop critical thinking skills to address contemporary issues and dilemmas facing the mining industry.
Course Learning Outcomes

- Analyze the concept of sustainability and explain how it is used and mobilized by mining companies, communities, governments, and other stakeholders.
- Critically assess the environmental, social, and economic impacts and benefits of mining activities and propose strategies to mitigate the negative impacts of mining.
- Evaluate the diverse perspectives of stakeholders involved in mining, such as local communities, governments, environmental organizations, and mining companies, and integrate these viewpoints into sustainable decision-making processes.
- Develop and justify actionable recommendations for improving the sustainability of mining projects, considering technological innovations, regulatory frameworks, and community engagement.
- Demonstrate the ability to communicate complex issues related to mining and sustainability through a variety of formal and informal writing exercises, independent research, oral presentations, and group discussions.

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. 2 hours lecture; 3 hours lab; 3 semester hours. Prerequisite: MATH213/223, MNGN210, MNGN308.

MNGN323. INTRODUCTION TO EXTRACTIVE METALLURGY. 3.0 Semester Hrs.
Introduce fundamentals and applications of Thermodynamics, Reaction Mechanism, and Kinetics to understand the processes of Chemical Metallurgy as applied to extracting metals and minerals from various resources including recycling end-of-life consumer goods. Prerequisite: MNGN210, MNGN322 or consent of instructor.
Course Learning Outcomes

- Know and apply the basic principles of thermodynamics and chemistry.
- Know and apply the basic principles of chemical kinetics and thermodynamics to solve the problems related to extractive metallurgy.

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

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. 0-3 Semester Hr.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous
six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 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.

MNGN398. SPECIAL TOPICS. 0-6 Semester Hr.

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.

MNGN399. INDEPENDENT STUDY. 1-6 Semester Hr.

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. 3 hours lecture; 3 semester hours. Prerequisite: MNGN321 or CEEN312.

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. 3 hours lecture; 3 semester hours. Offered in odd years. Prerequisite: MNGN321.

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.

MNGN412. MINE WATER, WASTE AND CLOSURE. 3.0 Semester Hrs.
This course is an interdisciplinary engineering course, designed to provide undergraduate mining engineering students with a fundamental understanding of water, tailings and mine waste, and mine closure and their influence throughout the life cycle of a mining project. This course seeks to engage students to explore fundamental problems encountered in mining engineering practice using their understanding of surface and underground mining, material transport, and mineral processing systems. Students will participate in group discussions and apply critical thinking to evaluate engineering design concepts for the management of water, tailings, and mine waste, and to integrate closure concepts in early project planning stages. Prerequisites: MNGN312, MNGN314.
Course Learning Outcomes

- Surface and Ground Water Fundamentals
- Water Regulations and Management for Mining
- Emerging Water Management Technologies
- Water as Sustainable Resource
- Mine Water and Waste Management Infrastructure
- Design and Operations of Mine Tailings and Waste Dumps
- Integrated Approach to Mine Water, Tailings and Mine Waste Management
- Risk Mitigation In Mine Water, Tailings and Mine Waste During Closure
- Managing Mine Water, Tailings and Mine Waste Mine for Mine Closure
- Methods for Estimating Mine Closure Costs

MNGN414. MINE PLANT DESIGN. 3.0 Semester Hrs.
Systems and subsystems in surface and underground mine plants, their individual components, and system hierarchy; digital technologies, including sensors and IoT; the cyber-physical infrastructure used in mine plant systems, equipment maintenance; maintenance strategies; data-

driven technologies in maintenance, mine plant design principles; and equipment selection for mine dewatering, mine power, and ore and waste haulage. system safety and its implementation in mine plant systems; project planning and execution to mine plant design. 2 hours lecture, 3 hours lab; 3 semester hour. Prerequisite: MNGN312 and MNGN314.
Course Learning Outcomes

- Describe systems and subsystems in surface and underground mine plants, their individual components, and system hierarchy.
- Identify digital technologies, including sensors and IoT, the cyber-physical infrastructure used in mine plant systems, and their role in mine plant systems.
- Understand fundamental concepts of equipment maintenance, maintenance strategies, organization, and the use of data-driven technologies in maintenance.
- Apply surface and underground mine plant design principles and equipment selection for mine dewatering, mine power, and ore and waste haulage.
- Comprehend principles of system safety and its implementation in mine plant systems.
- Understand and apply fundamental design processes and the elements of project planning and execution to mine plant design.

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.

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, MEGN351 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: MNGN322, MNGN323. 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. 2 hours lecture; 2 semester hours. Prerequisite: MNGN203, MNGN210.

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. 2 hours lecture; 2 semester hours. Prerequisite: MNGN428.
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: MNGN322, MNGN323.

MNGN433. MINE SYSTEMS ANALYSIS. 2.0 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. The course covers three different topical areas of operations research techniques that are used in the mining industry: linear and mixed integer programing (MILP); stochastic simulations and the network flow techniques. Various examples coming from the mining industry representing open pit ultimate pit limit problem, multi period production scheduling, cutoff grade optimization and truck dispatching problems are formulated and solved as a mixed integer program (MILP). The K. Lane's cutoff grade optimization problem is formulated and solved as non-linear optimization problem to maximize NPV of annual extraction subject to mining, milling, and refining annual tonnage constraints. The development of digital twin model of mining systems through deterministic and stochastic computer simulation techniques are covered. The concept of graphs and networks are introduced. The Learchs and Grossmann, max flow and pseudo flow techniques are given for solving optimum pit limit problem. Prerequisite: MNGN312, MNGN314, and Senior or graduate status. 1 hours lecture, 3 hours lab; 2 semester hours.
Course Learning Outcomes

- Operations Research Linear and Integer Programing O(MILP) ptimization
- Linear Programing (LP) Formulations for Mine Planning Problems
- Linear Programing (LP) Formulations for Truck Dispatching
- K. Lanes Cutoff Grade Optimization
- Deterministic and Stochastic Simulations
- Fundamentals of Stochastic Simulation
- @Risk Software
- Network Flow Techniques
- Application of Network Flow Techniques to Open Pit Optimization

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. 2.0 Semester Hrs.
The geostatistical techniques historically proven to be the most accurate way of analyzing spatially correlated geologic information and generating mineral resource models. Geostatistical concepts provide a handful tools to analyze specially correlated geologic data to quantify special correlation between data points and how to use this correlation in determining grades at unsampled locations from surrounding sample information. The main purpose of the course is to discuss and explain all the existing geostatistical concepts and tools that are used for the mineral resource estimation, and how the geostatistics are applied to the geologic modelling and the corresponding mineral grade estimation and classification in the current mining industry. Since geostatistical resource estimation involves determining block values based on a few known points, there is significant uncertainty associated with every estimates. This course will also introduce you to characterizing uncertainty associated with grade estimation and how this uncertainty is classified into different risk categories in terms of measured, indicated, and inferred resources. 1 hours of lecture and 3 hours of lab. 2 semester hours. Prerequisites: MNGN312, MNGN314.
Course Learning Outcomes

- How do process large scale exploration drill hole data sets.
- Generate and interpret univariate summary statistics of sample assay grades, and geologic attributes within geostatistical domains.
- Understand regionalized variables and spatial characteristic of geologic data
- Understand compositing and relationship between composite grades and assay grades statistics.
- Understand how to generate and interpret directional experimental variograms. Identify anisotropy directions and model experimental variograms.
- Create 3-D block models and determine block grades using nearest neighbor (polygon) method and Inverse Distance Techniques.
- Understand how to set up search neighborhood and estimation parameters for estimation of block grades Perform geostatistical mineral resource estimation using ordinary kriging and indicator kriging.
- Understand impact of mining dilution on resource estimation; definition of Smallest Mining Unit (SMU) and geostatistical concept volume variance relationship.
- Check and review the mineral resource models globally, and against composite and assay grades data sets.
- Classify mineral resource estimates into measured, indicated, and inferred categories.
- Characterize uncertainty associated with mineral resource estimates using geostatistical simulation techniques.

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. 0-3 Semester Hr.
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. 3 hours lecture; 3 semester hours. Prerequisite: MNGN321.

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. 3 hours lecture; 3 semester hours. Offered in spring. Prerequisites: MNGN322, MNGN323.

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. METALLURGICAL TRANSPORT AND RATE PHENOMENA. 3.0 Semester Hrs.
A review of the conservation of momentum followed by an introduction to heat and mass transfer concepts along with elementary reactor design emphasizing heterogeneous kinetics. The analogous transport properties of viscosity, thermal conductivity, and mass diffusivity of materials encountered during processing operations will be reviewed. Elementary concepts of conductive, convective, and radiative heat transfer along with those of both natural and convective mass transfer will be presented. Design equations for continuous stirred tank reactors, plug flow reactors, and batch reactors will be introduced, compared, and applied. Prerequisite: MNGN322, MNGN323.

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: MNGN322, MNGN323.

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. RISK AND PROJECT MANAGEMENT. 3.0 Semester Hrs.
Project management is the application of knowledge, skills, tools, and techniques to the suite of project activities to meet project requirements and stakeholder expectations. It’s the practice of planning, organizing, and executing the tasks needed to turn requirements into scope work that can be completed and commissioned resulting in a new or improved mining asset. This course will address fundamentals and key aspects of project management as systems approach to 1) defining project scope, 2) identifying deliverables, 3) managing risks, and 4) effectively communicating across teams. 2 hours lecture and 1 hour case study presentation and discussion per week; 3 hours lecture; 3 semester hours. Prerequisite: MNGN312, MNGN 314.
Course Learning Outcomes

- Introduction to Project Management Tools
- Creating Project Tasks and Execution Plans
- Evaluating Project Risks and Controls
- Applications of Project Management Fundamentals
- Critical Thinking Skills in Managing Projects

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.

MNGN498. SPECIAL TOPICS. 1-6 Semester Hr.

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MNGN498. SPECIAL TOPICS. 1-6 Semester Hr.

MNGN498. SPECIAL TOPICS. 1-3 Semester Hr.

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.

MNGN499. INDEPENDENT STUDY. 1-6 Semester Hr.

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