MINING ENGINEERING (MIN ENG)

MIN ENG 1912 Principles Of Mining Engineering (LEC 2.0)
Principles and definitions related to mining engineering including one or more field trips to familiarize the student with current mining practices.

MIN ENG 1913 Computing In Mining Engineering (LAB 1.0)
Basic software needed by mining engineers for computer applications in various phases of mine planning, development, and operations will be covered. The overarching goal is developing early familiarity with relevant software so it can be integrated across mining engineering courses.

MIN ENG 2126 Introduction To Mining Safety (LAB 1.0)
Safety aspects of mining in accordance with the MSHA Training Program required for all new miners. Subjects include self-rescue and respiratory protection, ground control, hazard recognition, mine gases, and legal aspects associated with mining.

MIN ENG 2412 Principles Of Mineral Processing (LAB 1.0 and LEC 2.0)
Introduction to the principles of mineral processing including mineral resources; particle comminution, classification, separation and dewatering; flowsheet and equipment design.

MIN ENG 2914 Surface Mine Design (LAB 2.0 and LEC 1.0)

MIN ENG 2924 Underground Mine Design (LAB 2.0 and LEC 1.0)

MIN ENG 2925 Surveying For Mineral Engineers (LAB 2.0)
Principles of surface and underground survey practice utilizing total station, engineer's level and GPS. Traversing and details, note taking and computations, balancing surveys and error analysis, staking-out new points, and map construction with AutoCAD. Prerequisite: Preceded or accompanied by Min Eng 1912.

MIN ENG 3000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MIN ENG 3001 Special Topics (IND 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MIN ENG 3002 Mine Rescue (LAB 1.0 and LEC 2.0)
Utilization of the principles of mine safety concerning mine gases, ventilation, explosives, fires, and first aid in the organization of mine rescue personnel and techniques. Training in the use of current mine rescue equipment, recognition and control of common recovery hazards, handling of survivors. Prerequisite: Min Eng 2126.

MIN ENG 3512 Mining Industry Economics (LEC 3.0)
Importance of the mineral industry to national economy, uses, distribution, and trade of economic minerals, time value of money, mineral taxation, economic evaluation utilizing depreciation, depletion, and discounted cashflow concepts, social and economical significance of mineral resources. Prerequisite: Econ 1100 or 1200. (Co-listed with Econ 3512).

MIN ENG 3812 Statics And Mechanics Of Rock Materials (LEC 2.0 and LAB 1.0)
Application of the principles of mechanics to engineering problems of equilibrium, strength, and stiffness concerning rock materials and mine support structures. This course extends the study of statics to rock materials in mines and covers rock-related and support structure-related mechanics of materials. The course is complemented by rock mechanics laboratory. Prerequisites: MECH ENG 2340; or IDE 50 and 150.

MIN ENG 3912 Materials Handling In Mines (LAB 1.0 and LEC 2.0)
Mining applications of material transport and handling. Truck haulage and haulroads. Conveyors: belt, armored, and others; feeders; bins and bunker; material stockpiling and homogenization; rail transport; water transport; slurry transport; mine hoists and hoisting. Prerequisite: Min Eng 1912.

MIN ENG 3913 Mineral Identification And Exploration (LEC 3.0)

MIN ENG 4000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MIN ENG 4001 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MIN ENG 4096 Computer Aided Mine Design (LAB 3.0)
Mine planning and design using commercial software. Orebody description. Surface mining: geometric design, pit limits, and production planning. Underground mining: development planning, opening and support design, ventilation and production planning. Group projects with real-world mining data. Preparation for capstone design project. Prerequisites: Min Eng 4522, Min Eng 4932, and Min Eng 4933.

MIN ENG 4097 Capstone Design Project (LEC 1.0 and LAB 3.0)
Capstone project with written and oral presentations. Includes mine design and optimization, production plan, equipment and flowsheet design based on geology, resources/reserves, geotechnics, hydrology and hydro-geology. Project also incorporates markets, environmental and permitting, mine-mill organization, support facilities, economic and risk analyses. Prerequisite: Min Eng 4096.

MIN ENG 4099 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

MIN ENG 4113 Mine Atmosphere Control (LEC 2.0 and LAB 1.0)
Fundamentals of mine ventilation, including the principles of airflow, control of gases, dust, and temperature, methane drainage, mine fans, network theory, computer network simulation, and economics of airflow, with emphasis on analysis, systems design and practical application. Prerequisites: Chem 3410 and Civ Eng 3330.

MIN ENG 4122 Advanced Mine Health and Safety (LEC 3.0)
A detailed study of health and safety principles, practices, analyses, regulations, issues and technology in the mining industry. Prerequisite: Min Eng 2126.
**MIN ENG 4212 Advanced Aggregate and Quarrying** (LEC 3.0)
Advanced coverage of topics on the stone and aggregate industry, including surface and underground operations, plant equipment, economics, marketing, transportation, and environmental topics. The course will include at least one field trip and a design project. Prerequisite: Min Eng 3912, co-requisite: Civ Eng 3116.

**MIN ENG 4322 Coal Mine Development And Production** (LEC 3.0)
An in-depth study of all aspects of coal mining, including an overview of coal industry, reserves and geology, planning and development of coal mines, surface and underground mechanized methods of face preparation, equipment, coal extraction, handling and preparation as practiced in the United States. Prerequisite: Accompanied or preceded by Min Eng 4912.

**MIN ENG 4412 Aggregate Materials Sizing and Characterization** (LAB 1.0 and LEC 2.0)
Geological formation of aggregates; aggregate properties and their measurements; aggregates for specific end-user applications; specifications and standards; processing (crushing, screening, classification, and washing); plant design and flow sheet analysis; quality control and assurance. Prerequisite: Min Eng 3412.

**MIN ENG 4413 Material Processing By High-Pressure Water Jet** (LEC 3.0)
Methods of generating high pressure water jets; standard equipment, existing techniques and basic calculations. Applications of water jets to materials cutting and mineral processing. Safety rules. The course will be supported by laboratory demonstrations. (Co-listed with Mech Eng 5606).

**MIN ENG 4414 Mine Plant Management** (LEC 2.0)
Optimization of mine plant and equipment performance. Availability, utilization, and reliability of equipment; matching equipment and plant to minesite specific conditions; maintenance planning, scheduling and control; parts and materials supply systems; mine information and management systems. Basics of mine automation and robotics. Prerequisite: Senior standing or consent of instructor.

**MIN ENG 4422 Coal Preparation** (LEC 2.0 and LAB 1.0)
Coal properties, sampling, testing, breaking, sizing, cleaning and dewatering. Disposal of refuse. Prerequisites: Min Eng 3412 and senior standing.

**MIN ENG 4423 Mineral Processing I (Flotation and Hydrometallurgy)** (LAB 1.0 and LEC 2.0)
Forth flotation including mineral surfaces, double layer theory, zeta potential, hydrophobicity, adsorption, collectors, frothers, modulation, kinetics, and sulphide and acid flotation systems. Hydrometallurgy including leaching, ion exchange and liquid/liquid extraction. Prerequisite: Min Eng 3412.

**MIN ENG 4424 Mineral Processing II (Mechanics and Design)** (LEC 2.0 and LAB 1.0)
Mineral particle mechanics of comminution, sizing, classification, concentration, filtering and thickening. Mill and equipment selection and design including flowsheet, development and plant assessment. Prerequisite: Min Eng 3412. (Co-listed with Met Eng 5270).

**MIN ENG 4512 Mine Management** (LEC 3.0)
Theory and practice of mine management, including basic managerial functions, management theories, communication skills, motivation, leadership, organization, maintenance management, managerial decision making, cost control, labor relations, government relations, ethics and risks management with emphasis in presentation skills. Prerequisite: Completion of 50 credits toward Mining Engineering degree. (Co-listed ECON 4512).

**MIN ENG 4522 Ore Reserve Analysis And Geostatistics** (LAB 1.0 and LEC 2.0)
An introduction to principles of geostatistics, theory of spatially correlated random variables, variance and co-variances and their application on the evaluation of mineral resources, ore reserve estimation, strategic exploration, and production planning. Real case studies from mining industry will be presented. Prerequisite: Stat 3113 or Stat 3115.

**MIN ENG 4523 Environmental And Natural Resource Economics** (LEC 3.0)
Optimum use of replenishable and non-replenishable resources, public goods and common resources, externalities, private vs. public costs, and quality of the environment; emphasis on public policy related to environmental and natural resource economics. Prerequisite: Econ 2100. (Co-listed with Econ 4440).

**MIN ENG 4524 Energy Economics** (LEC 3.0)
Market structure. World resource development. Supply and demand analysis on energy production and consumption within domestic and global settings. Prerequisite: Econ 2100. (Co-listed with Econ 4540).

**MIN ENG 4742 Environmental Aspects Of Mining** (LEC 3.0)
Permitting: the legal environment of reclamation and environmental impact assessment; post-mining land-use selection and mine planning for optimum reclamation of all mines: metal, nonmetal, and coal; unit operations of reclamation: drainage, backfill, soil replacement, revegetation, maintenance, etc. Prerequisites: Co-requisites: MIN ENG 4933 or GEO ENG 5441 or ENV ENG 5619. (Co-listed with GEO ENG 4276).

**MIN ENG 4823 Rock Mechanics** (LAB 1.0 and LEC 2.0)
Applications of the fundamental principles of mechanics to engineering problems of equilibrium, strength and stiffness of rock materials. Review of in-situ stresses, laboratory and field instrumentation, rock and rockmass properties, pillar design, roof span design, rock reinforcement, surface subsidence, slope stability, and violent failures. Field trip required. Prerequisites: Physics 2135; Civ Eng 2210; Geology 3310.

**MIN ENG 4824 Soils and Overburden Materials for Mining Engineering** (LEC 2.0)
Physical and mechanical properties of soils and overburden materials. Soils and overburden characterization for reclamation and mine closure and overburden blasting. Soil failure modes and slope stability for surface mine layouts, waste dumps, tailings and earth dams, and foundations for heavy mining machinery. Prerequisites: Civ Eng 2210.

**MIN ENG 4912 Mine Power And Drainage** (LEC 2.0 and LAB 1.0)

**MIN ENG 4922 Tunneling & Underground Construction Techniques** (LAB 1.0 and LEC 2.0)
Cover both mechanical excavation and conventional excavation techniques to underground tunneling and construction. The emphasis will be on equipment selection and prediction of performance expected of the equipment. Ground control systems will be covered as technology emerges. Excavation methods and support of large caverns, often found in civil structures, will also be discussed. A limited focus will be on underground construction specifications and underground advance rate and cost estimation techniques. Prerequisites: Min Eng 4823, Min Eng 4932 or Civ Eng 3715, Civ Eng 3116 or Geo Eng 5471.
MIN ENG 4932 Underground Mining Methods And Equipment (LEC 3.0)

MIN ENG 4933 Surface Mining Methods And Equipment (LEC 3.0)
Principles of planning, constructing, and operating economically viable surface mines. Cost effective mining methods: placer mining, strip mining, open pit mining, quarrying. Selection of equipment for surface mining operations. Optimization of mine performance. Field trip required. Prerequisites: Min Eng 3912; Min Eng 3512; preceded or accompanied by Min Eng 4823.

MIN ENG 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of the instructor required.

MIN ENG 5001 Special Topics (IND 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MIN ENG 5113 Advanced Mine Atmosphere Control (LEC 2.0 and LAB 1.0)
Advanced mine ventilation network based on airflow requirements, control of gases, dust, and temperature, methane drainage, mine fans, network theory based on the Code of Federal Regulations. Computer simulation of ventilation systems, mine fire simulation, and economics of airflow based on underground mine layouts. Research paper or design project required. Prerequisite: Mi Eng 4113 or Consent of Instructor.

MIN ENG 5122 Advanced Topics in Mine Health and Safety (LEC 3.0)
Advanced topics in mine health and safety including practices and regulations; risks and hazards recognition, mitigation and control; disaster prevention and control. Students will complete a research paper or project report. Pre-requisite: Mi Eng 4212 or Consent of Instructor.

MIN ENG 5212 Advanced Aggregates and Quarrying (LEC 3.0)
Advanced topics in aggregates mining, mine design and planning, and project valuation. In-pit crushing and conveying, and advances in comminution technology for the aggregates industry. Design project or research paper required. Prerequisite: Mi Eng 4212 or Consent of Instructor.

MIN ENG 5322 Advanced Coal Mining Methods (LEC 3.0)
Advanced topics in coal mining methods, planning and development of surface and underground mining systems; planning of logistics, resources, infrastructure for large-scale surface coal mines; face preparation, equipment interface, haulage systems, sequencing and scheduling and extraction from underground coal mines. Students will complete a research paper or project report. Prerequisites: Min Eng 4322 or Consent of Instructor.

MIN ENG 5412 Advanced Aggregates Sizing and Characterization (LEC 2.0 and LAB 1.0)
Advanced methods for evaluating aggregate occurrences, extraction, material flow sheet analysis; Advances in processing and classification; advanced statistical methods for quality control and assurance, and standards. Students will complete and present a research paper on the subject. Field trip to a nearby quarry required. Prerequisite: Mi Eng 4412 or Consent of Instructor.

MIN ENG 5413 Adv Mtl Proc Hghpres Wtr Jet (LEC 3.0)
Advanced methods for continuously generating high pressure, power calculations, applications of waterjets in the mining and manufacturing industries, and safety considerations. Research paper or design project required. Prerequisite: Mi Eng 4413 or Consent of Instructor.

MIN ENG 5422 Advanced Coal Preparation (LEC 2.0 and LAB 1.0)
Advanced methods for designing coal processing circuitry and practices, flowsheet design, sampling, advanced ash and moisture analyzers; coarse, intermediate, and fine coal cleaning; dewatering; dry coal cleaning research. Research paper or design project required. Prerequisite: Mi Eng 4422 or Consent of Instructor.

MIN ENG 5423 Advanced Flotation and Hydrometallurgy (LEC 2.0 and LAB 1.0)
Theoretical basis of froth flotation, electrical characteristics at interfaces, interfacial forces, adsorption kinetics and thermodynamics, flotation reagents, flotation process flowsheets. Physicochemical principles of hydrometallurgical processes, leaching methods and reagents. Hydrometallurgical processes flowsheets. Research paper or design project required. Prerequisites: Mi Eng 4423 or Consent of Instructor.

MIN ENG 5424 Advanced Mechanics And Design (LAB 1.0 and LEC 2.0)
Strategy of beneficiation as a combination of unit operations: Mineral sampling and particle size distribution, mineral particle mechanics of comminution and energy requirement, mineral crushing and grinding circuits, classification, solid-liquid separation and instrumentation, Mineral processing plant flow sheet design. Research paper or design project required. Prerequisites: Mi Eng 4424 or Consent of Instructor.

MIN ENG 5522 Advanced Ore Reserve Analysis And Geostatistics (LEC 2.0 and LAB 1.0)
Advanced discussions on principles of geostatistics, theory of spatially correlated random variables, variance and co-variances and their application on the evaluation of mineral resources, ore reserve estimation, strategic exploration, and production planning. Real case studies from mining industry will be presented. Course project. Prerequisites: Math 3304 & Stat 3113 or instructor consent.

MIN ENG 5532 Advanced Mining Economics (LEC 3.0)

MIN ENG 5612 Principles of Explosives Engineering (LEC 2.0 and LAB 1.0)
Theory and application of explosives in the mining industry; explosives, initiating systems, characteristics of explosive reactions and rock breakage, fundamentals of blast design, drilling and blasting, regulatory and safety considerations. Prerequisites: Min Eng 2126; successful background check. (Co-listed with Exp Eng 5612).

MIN ENG 5622 Blasting Design And Technology (LEC 2.0 and LAB 1.0)
Advanced theory and application of explosives in excavation; detailed underground blast design; specialized blasting including blast casting, construction and pre-splitting. Introduction to blasting research. Examination of field applications. Prerequisites: Min Eng 5612. Student must be at least 21 years of age. Successful background check. (Co-listed with Exp Eng 5622).
MIN ENG 5742 Advanced Environmental Aspects of Mining (LEC 3.0)
Applied and fundamental research issues pertaining to: permitting – the legal environment of reclamation and environmental impact assessment; post-mining land-use selection and mine planning for optimum reclamation of all mines: metal, nonmetal, and coal; unit operations of reclamation: drainage, backfill, soil replacement, revegetation, maintenance, etc. Course project. Prerequisites: Min Eng 5932 and 5933 or instructor consent. (Co-listed with GE XXXX).

MIN ENG 5822 Strata Control (LEC 3.0)
A detailed review of artificial ground support, both above and below ground, including slope stabilization techniques and shaft and tunnel liner design. The use of shotcrete, roofbolts, and solid liners and the principles of underground longwall and room and pillar mine support. Longwall and hydraulic mining practice is covered. Prerequisite: Min Eng 4823.

MIN ENG 5823 Rock Mechanics III (LAB 1.0 and LEC 2.0)
Advanced methods for designing rock excavation to resolve geotechnical and ground control problems. Topics including stress analysis, rock properties, instrumentation, pillar design, roof span design, rock reinforcement, surface subsidence, rock burst, and slope stability. Research paper or design project required. Prerequisites: Mi Eng 4823 or Consent of Instructor.

MIN ENG 5912 Advanced Mine Power And Drainage (LEC 2.0 and LAB 1.0)
Advanced methods for evaluating electric power requirements and distribution mining geometries; Design and evaluation of mine drainage systems based on power requirements, layouts, efficiency, hydraulic gradients, water-bearing formations; Risk evaluation of emergency power failures and mine flooding. Research paper or project required. Prerequisite: Mi Eng 4912 or Consent of Instructor.

MIN ENG 5913 Advanced Computer Aided Mine Design (LEC 2.0 and LAB 1.0)
Project-based mine planning and design course. Engineering design process applied to computer-aided mine planning and design. Mine layouts, production planning, and materials scheduling optimization. Prerequisite: Graduate standing.

MIN ENG 5922 Advanced Tunneling & Underground Construction Techniques (LEC 2.0 and LAB 1.0)
Advanced topics in mechanical and conventional excavation techniques in underground tunneling and construction. Topics include tunneling layouts design, equipment and performance modeling, ground control systems including support, drainage, and structural integrity. Construction specifications, advance rate and contractual cost estimation. Prerequisite: Consent of instructor. (Co-listed with Exp Eng 5922).

MIN ENG 5932 Advanced Underground Mining Methods (LEC 3.0)
Advanced methods for designing, planning, developing and operating economic and efficient underground mining systems. Systems include mass mining methods, room and pillar, longwall, cut and fill with equipment, ventilation and drainage control interface. Research paper or design project required. Prerequisite: Mi Eng 4932 or Consent of Instructor.

MIN ENG 5933 Advanced Surface Mining Methods (LEC 3.0)
Advanced topics in surface mine planning, methods and equipment acquisition, and deployment in surface mining operations. Strategic and tactical mine planning with focus on efficiency, safety, environmental standards and economics. It will also focus on fleet management with emphasis on repair, rebuild and replacement for higher availabilities, utilization and production output. Students will complete a research paper or project report. Prerequisites: Min Eng 4933 or Consent of Instructor.

MIN ENG 6000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MIN ENG 6001 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MIN ENG 6010 Seminar (RSD 1.0)
Discussion of current topics.

MIN ENG 6040 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

MIN ENG 6050 Continuous Registration (IND 0.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

MIN ENG 6080 Graduate Project (IND 3.0)
Advanced engineering design, experimentation, evaluation and assessment leading to the preparation of a project report. For practicing professionals, this project could be based on an actual industry problem. Prerequisites: Graduate Standing.

MIN ENG 6085 Internship (IND 0.0-15)
Students working toward a doctor of engineering degree will select, with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

MIN ENG 6099 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

MIN ENG 6132 Advanced Mine Health And Safety Design (LEC 3.0)
Principles of design of mining operations with emphasis on the health and safety of the worker. Prerequisite: Graduate standing.

MIN ENG 6133 Mine Atmospheric Control II (LEC 3.0)
Climatic measurements and temperature precalculations, emergency plans for fan failures and mine fires, mine air contaminants, mine noises, mine dust, refrigeration and cooling plant layout, radiation control. Prerequisite: Min Eng 4113.
**MIN ENG 6432 Advanced Mineral Engineering Design II** (LEC 1.0 and LAB 2.0)
Incorporation of principles developed in Min Eng 6132 in advanced design projects for mineral plants and systems, with emphasis on environmental protection, health, and safety. Prerequisite: Min Eng 6132.

**MIN ENG 6522 Mining Property Feasibility Studies And Evaluation Procedure** (LEC 2.0 and LAB 1.0)
A systematic phased approach is presented, designed to increase the level of confidence and accuracy of estimates, moving from exploration through to a "bankable" study. Liability, ethics, resource/reserves, political/social/investment risk, economic parameters, and due diligence are discussed. Prerequisite: Min Eng 3512 or Geology 3511 or Min Eng 4742 or Geophys 3251.

**MIN ENG 6532 Mine Management II** (LEC 3.0)
The course covers advanced concepts in managing mine operations. Topics to be covered include TQM, statistical process control, benchmarking, KPI, standards and standardization, ISO 9000: Quality Control, ISO 14000: Environmental systems, OHSAS 18000. Management systems, SA8000, Social Accountability and others. Prerequisite: Consent of instructor.

**MIN ENG 6622 Environmental Controls For Blasting** (LAB 1.0 and LEC 2.0)
Advanced blast mechanics; overbreak control including comprehensive coverage of perimeter and smoothwall specialist blasting techniques and geotechnical factors affecting blast vibration, limits analysis monitoring and control; air blast control including limits, monitoring and atmospheric and topographic effects. Prerequisites: Min Eng 5612, Successful background check. (Co-listed with Exp Eng 6412).

**MIN ENG 6632 Theory Of High Explosives** (LEC 3.0)
Study of the application of chemical thermodynamics and the hydrodynamic theory to determine the properties of high explosives; application of detonation theory to steady-state detonations in real explosives; application of the above to the blasting action of explosives. Prerequisite: Graduate Standing. (Co-listed with Exp Eng 6212).

**MIN ENG 6712 Managing Social and Environmental Risks In Mining (Intro to Responsible Mining)** (LEC 3.0)
This course is an introduction to responsible mining. It focuses on industry and NGO programs around sustainability and reporting in mining, financial community response, community of interest engagement and participation, and safety and crisis response and management. Prerequisites: Min Eng 4742 or Min Eng 5742.

**MIN ENG 6735 Sustainability In Mining** (LEC 3.0)
Sustainability defined: social, economic and environmental impacts. Mining as sustainable development interventions. Mine planning for sustainability, sustainability assessment and reporting, sustainable mine closure and post-mining land use. Case studies. Prerequisite: Min Eng 4742.

**MIN ENG 6842 Advanced Rock Mechanics** (LEC 3.0)
Advanced topics in static and dynamic rock mechanics; elasticity theory, failure theories and fracture mechanics applied to rock; stress wave propagation and dynamic elastic constants; rock mass classification methods for support design; pillar design in coal and metal mines; introduction to numerical models. Prerequisite: Min Eng 4823 or Civ Eng 3715.

**MIN ENG 6843 Rock Mechanics IV** (LEC 3.0)
Advanced topics in dynamic rock mechanics. Stress wave propagation in the earth, dynamic elastic constants in isotropic and anisotropic rock, Hopkinson bar impact analysis, spallation and radial fracturing caused by stress pulses, shock wave generation in rock by explosives, shock wave propagation and effects. Prerequisite: Min Eng 4823 or Civ Eng 3715.

**MIN ENG 6912 Simulation of Mining Systems** (LEC 3.0)
Overview of stochastic simulation. Model formulation using general purpose process simulation software. Model verification and validation. Simulation experimentation. Prerequisites: Graduate standing or Stat 5643.

**MIN ENG 6922 Optimization Applications In Mining I** (LEC 3.0)
Mining applications of deterministic optimization techniques are covered, including linear, integer, mixed-integer, dynamic, unconstrained and constrained nonlinear, and heuristic programming. Prerequisite: Graduate standing or consent.

**MIN ENG 6923 Geostatistics** (LEC 3.0)
Definition of geostatistical data; theory of random fields; autocorrelation and measures of spatial variability including semivariograms, variograms and covariance functions; and spatial prediction and validation. Case studies in mineral resource estimation and environmental pollutant prediction will be presented. Prerequisites: Graduate standing or consent of instructor.

**MIN ENG 6932 Advanced Mining Systems** (LEC 3.0)
Principles of design for the development and production of hard rock mineral deposits that require integrated surface and underground mining methods. Cost considerations leading to optimization. Terminal feasibility report required. Prerequisites: Min Eng 4932 and Min Eng 4933.

**MIN ENG 6935 Underground Mine Design** (LEC 3.0)
This course will focus on the determinants of underground mine design, geomechanical mine design for underground mining; mine optimization; mine environmental systems; and underground mine design and optimization. Prerequisite: Min Eng 4932 or equivalent.

**MIN ENG 6936 Surface Mine Design** (LEC 3.0)
This course will focus on the determinants of surface mine design, geomechanical and geometrical mine design for open pit and strip mining; mine layouts optimization; mine environmental systems; and research directions in surface mine design and optimization. Prerequisite: Min Eng 4933 or equivalent.

**MIN ENG 6992 Research Methods** (LEC 3.0)
Foundations, dimensions, and methods for designing and investigating research problems. Focus on fundamentals and applied research, research methods, literature review, experimental design and experimentation, dissertation composition, concepts of originality and intellectual property. Prerequisites: PhD students only. (Co-listed with Exp Eng 6292).