School of Mines & Metallurgy

- Ceramic Engineering
- Geological Engineering
- Geology & Geophysics
- Metallurgical Engineering
- Mining Engineering
- Nuclear Engineering
- Petroleum Engineering

Ceramic Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy
Doctor of Engineering

Today's ceramic engineer produces materials which are critical to many advanced technologies: aerospace parts, automotive and environmental components, biomedical devices, glass, electrical, electronic and optical assemblies, components, refractories, structural materials, cements and other construction materials.

As a ceramic engineer, you will work with inorganic nonmetallic materials which are normally processed at elevated temperatures. You will apply scientific principles to the design of new formulations and to the design of processes for their manufacture. You will conduct research on the relationships between engineering properties and the chemistry and structure of various ceramic materials. If you like to know why materials act and react as they do, then ceramic engineering will interest you.

Ceramic engineering usually appeals to those who have a strong interest in finding practical applications of the basic sciences. The design concept is at the atomic or microstructural level of solid materials. The UMR department of ceramic engineering specializes in the product fields of glass, electronic materials, and refractories, and emphasizes materials processing principles applicable to all products.

Ceramic engineering classes and laboratories are held in McNutt Hall, although a number of research laboratories in other campus facilities are available to our students. Equipment exists for X-ray investigation of chemistry and crystal structure, for detection of thermally induced changes in chemistry and structure, for control of environment, and for measuring a wide variety of optical, electronic, mechanical and thermal properties.

The Graduate Center for Materials Research makes additional equipment available for ceramic engineering. There will be opportunities for you to work with faculty members and graduate students on a variety of design and research projects involving materials for many applications.

Mission Statement

The mission of the department is to provide a quality comprehensive undergraduate and graduate education (B.S., M.S. and Ph.D.) in the modern and traditional areas of ceramic engineering. This is supported and enhanced by research activities in lab classes and with internationally recognized faculty members to provide an excellent learning environment, to train graduate students, and to contribute to the state and nation's technological research effort in modern applications of ceramic materials. A major goal is to provide industry and academia with leaders in Ceramic Engineering who are capable of solving the needs and problems of the modern and traditional ceramics industries. The department provides a comprehensive, forward-looking and broad-based curriculum, which emphasizes fundamentals and practical applications, oral and written communication skills, and professional practice and ethics. Specifically, students who graduate from our program have a demonstrated ability to:

- Apply knowledge of mathematics, science, and engineering;
- Design and conduct experiments, as well as to analyze and interpret data;
- Design a system, component, or process to meet desired needs;
- Function on multi-disciplinary teams;
- Identify, formulate, and solve engineering problems;
- Understand professional and ethical responsibility;
- Communicate effectively;
- Understand the impact of engineering solutions in a global/societal context;
- Recognize the need for and an ability to engage in life-long learning;
- Understand the importance of contemporary issues on the engineering profession; and,
- Use the techniques, skills, and modern engineering tools necessary for engineering practice.

These objectives are fundamental to those of the campus who strive to educate leaders in the fields of engineering and science.

Faculty

Professors:

Harlan Anderson (Curators' Professor Emeritus), Ph.D., University of California-Berkeley
Richard Brow, Ph.D., (Department Chair), Pennsylvania State University
Delbert Day[1] (Curators' Professor Emeritus), Ph.D., Pennsylvania State University (Director, MRC)
Wayne Huebner, Ph.D., UMR, (Department Chair)
G. Edwin Lorey (Emeritus), Ph.D., Rutgers
Douglas Mattox (Emeritus), Ph.D., Rutgers
Robert E. Moore (Emeritus), (Curators') Ph.D., University of Missouri-Columbia
P. Darrell Ownby[1], (Emeritus), Ph.D., Ohio State
Mohamed N. Rahaman, Ph.D., Sheffield, England

Assistant Professors:

William G. Fahrenholtz, Ph.D., University of New Mexico
Gregory Hilmas, Ph.D., University of Michigan

[1]Registered Professional Engineer

Bachelor of Science Ceramic Engineering

FRESHMAN YEAR
(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Cr Eng 102-Atomic Structure Cryst	3
Math 22-Calc w/Analy Geo III	4
Physics 24-Eng Physics II	4
Cr Eng 111-Cer Mat Lab I, Char	1.5
Cr Eng 104-Cer in the Modern World	3
Econ 121-Miocroecon or122- Macroecon	3
	18.5

Second Semester	
Cr Eng 103-Atomic Structure-Glass	3
Cr Eng 122-Cer Mat Lab II-Rheo & Plastic	1.5
Electives-Hum or Soc Sci[1]	3
Math 204-Diff Equa or Stat 320 or Stat 353	3
Hist 112, Hist 175, or Hist 176, or Pol Sc 90	3
Bas En 50 or Bas En 51	3
	16.5

JUNIOR YEAR

First Semester	Credit
Cr Eng 231-Cer Proc Lab I	1.5
Cr Eng 251-Phase Equilibria	3
Chem 241-Physical Chemistry	3
Cr Eng 203-Thermal Proc in Cer	3
Cr Eng 205-Eng Design Process	2
Chem 251-Inter Quant Analysis	4
	16.5

Second Semester	
Cr Eng 242-Cer Proc Lab II	1.5
Cr Eng 259-Cer Thermo	3
Chem 243-Physical Chem	3
Physics 107-Intro to Modern Physics	3
Elective-Hum or Soc Sc	3
Bas En 110-Mech of Mat	3
	16.5

SENIOR YEAR

First Semester	Credit
Cr Eng 261-Cer Eng Design Lab	2
Cr Eng 284-Elect Prop of Cer	3
Cr Eng 306-Thermo Prop & Design	3
Mt Eng 204-Transport Phenomena	3
Elective[2]	3
Cr Eng 362-Thermal/Mc/El/Op Lab	1
	15

Second Semester	
Cr Eng 262-Cer Eng Design Lab	2
Cr Eng 315-Organic Add in Cr Proc	2
English 060, 160 or Speech 85	3
Electives[2]	6
Stat 213 or Stat 215 or Eng Mg 385	3
	16

Total hours: 135 hours

Note: Students who took Chem 5 must elect an additional 3 hour chemistry course (200 level or above) or a technical elective with approval from your advisor.

1 See list of requirements for engineering in humanities and social sciences.
2 Technical electives must be selected from 200 and 300 level courses with the advisor's approval.
3 All Ceramic Engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree, however, it is the first step toward becoming a registered professional engineer. This requirement is part of the UMR assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Specific Degree Requirements

1. Total number of hours required for a degree in Ceramic Engineering is 134.
2. The assumption is made that a student admitted in the department has completed 35 hours credit towards graduation. The academic program of students transferring from colleges outside UMR will be decided on a case-by-case basis.
3. The department requires a total of 18 credit hours of humanities and social science.

CERAMIC ENGINEERING COURSES

090 The Ceramic Experience [Lab 1.0] Hands-on experience with the fun of discovery through experimentation in the fabrication, properties and applications of ceramics in the modern world. Prerequisite: Freshman standing.

102 Atomic Structure of Crystalline Ceramics [Lect 3.0] The crystal-chemical principles used to design and manufacture materials with specified properties are developed and applied to oxides, clays, silicates and other nonmetallic compounds.

103 Atomic Structure of the Glassy State [Lect 3.0] A study of the short range order of structure in glass, its relationship to physical-chemical properties of glassy systems, and the application of rate processes to the physical and electrical behavior. Prerequisite: Cr Eng 102.

104 Ceramics in the Modern World [Lect 3.0] An introduction to traditional and modern applications of ceramics providing a broad overview of all aspects of current ceramic technology.

111 Ceramic Materials Laboratory I-Characterization of Materials [Lab 1.5] Laboratory experience and controlled demonstrations are provided in reducing ceramic raw materials to the particulate state and in characterizing the powders with respect to surface area, particle size, particle shape, and particle packing. Prerequisite: Sophomore standing.

122 Ceramic Materials Laboratory II-Rheology and Plastic Behavior [Lab 1.5] Theory of interactions and measurement of properties of ceramic raw materials and water, including viscosity of Newtonian and non-Newtonian liquids, plastic limits, and binder chemistry, as related to slip-casting, extrusion, and pressing operations. Prerequisite: Cr Eng 111.

202 Cooperative Training [Variable] On-the-job experience gained through cooperative education with industry, with credit arranged through departmental cooperative advisor. Grade received depends on quality of reports submitted at work supervisor's evaluation.

203 Thermal Processes in Ceramics [Lect 3.0] Considerations in rate controlled processes in the fabrication of ceramics, packing of powders, comminution and calcination, drying and firing of ceramic ware, polymorphic transformations, sintering, grain growth and hot pressing, relationships of fabrication techniques to physical properties.

205 The Engineering Design Process [Lect 2.0] Introduction to elements of design process including strategic, planning, project, management, modeling, materials selection, engineering economics, safety, environmental issues and ethics. Prerequisite: Junior standing.

231 Ceramic Processing Lab I [Lab 1.5] The first half of a two-semester sequence that gives students practical knowledge of the methods and techniques used in the fabrication of ceramics. Prerequisite: Cr Eng 122.

242 Ceramic Processing Lab II [Lab 1.5] The second half of a two-semester sequence that gives students practical knowledge of the methods and techniques used in the fabrication of ceramics. Prerequisite: Cr Eng 231.

251 Phase Equilibria [Lect 3.0] The study of unary, binary and ternary inorganic, phase equilibrium systems with examples for solving practical engineering problems. Prerequisite: Chem 3.

259 Ceramic Thermodynamics [Lect 3.0] Basic thermodynamic concepts are applied to the solid state. Calculations and estimations of thermodynamic variables and the relations to the physical properties, crystal structure and phase equilibria diagrams are studied. Solid solution and partial molal quantity concepts are presented and modeled. Prerequisite: Chem 241.

261 Ceramic Engineering Design Laboratory [Lab 2.0] Students working in groups of 3 or 4 will be assigned a design task related to a specific technology e.g. ceramic turbine blades, fuel cell electrodes, glass fibers, thermal insulation etc. The first two stages will focus on product and process design, respectively. Prerequisite: Cr Eng 242.

262 Ceramic Engineering Design Lab [Lab 2.0] A continuation of Ceramic 261 with two final tasks having to do with evaluation of the design, casting and safety aspects. Students will give individual oral reports and will submit a design project paper. Prerequisite: Cr Eng 261.

284 Electrical Properties of Ceramics [Lect 3.0] The application of ceramic chemistry and physics to the development and evaluation of the electronic, dielectric, magnetic, and optical properties of materials. Emphasis is placed on the design/application relationships which are used to develop materials. Prerequisite: Physics 107.

300 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

301 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

306 Thermomechanical Properties and Their Use in Design [Lect 3.0] This course will treat the theory and testing practice related to design for a range of thermal and mechanical properties of ceramic materials. Prerequisite: Bas En 110.

308 Electrical Ceramics [Lect 2.0 and Lab 1.0] The application and design of ceramics for the electrical industry is discussed. Particular emphasis is placed on how ceramic materials are altered to meet the needs of a specific application. The laboratory acquaints the student with measurements which are used for electrical property evaluation. Prerequisite: Cr Eng 284.

315 Organic Additives in Ceramic Processing [Lect 2.0] Basic chemistry, structure and properties or organic additives used in the ceramics industry; solvents, binders, plasticizers, dispersants. Use of organic additives in ceramic processing. Prerequisites: Cr Eng 203 and 231.

331 Ceramic Processing [Lect 3.0] Powder, colloidal and sol-gel processing, forming methods, drying, sintering and grain growth. Relation of processing steps to densification and microstructure development. Prerequisite: Senior standing.

333 Microelectronic Ceramic Processing [Lect 3.0] Materials, processing and design of microelectronic ceramics are covered. Introduction to devices, triaxial ceramics, high aluminas, tape fabrication, metallizations, thick film processing and glass-to-metal seals. Prerequisites: Cr Eng 203 & 242.

362 Thermomechanical/Electrical/Optical Properties Lab [Lab 1.0] Laboratory consisting of three separate modules of experiments for the characterization of the thermomechanical, electrical and optical properties of ceramics. The student will choose one of the three modules. Prerequisite: Bas En 110 or Cr Eng 284.

364 Refractories [Lect 3.0] The manufacture, properties, uses, performance, and testing of basic, neutral and acid refractories.

369 Glass Science and Engineering [Lect 3.0] The development, manufacturing methods, applications, and properties of flat, fiber, container, chemical, and special purpose glasses. Composition/property relationships for glasses and nucleation-crystallization processes for glass-ceramics are also covered. Prerequisite: Cr Eng 102.

371 Dielectric and Electrical Properties of Oxides [Lect 3.0] The processes occurring in inorganic materials under the influence of an electric field are considered from basic principles. Emphasis is placed on application to real systems. Prerequisite: Cr Eng 284.

377 Principles of Engineering Materials [Lect 3.0] Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Ae Eng 377, Ch Eng 377, Physics 377, Mt Eng 377)

390 Undergraduate Research [Variable] Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

391 X-ray Diffraction and Fluorescence [Lect 3.0] Symmetry and space groups; x-ray diffraction; reciprocal lattice; calculated diffracted beam intensity; indexing methods; precise lattice parameters.

392 X-ray Diffraction and Fluorescence Laboratory [Lab 1.0] Qualitative and quantitative analysis by diffraction and fluorescence; high temperature studies of expansion and kinetics of phase formation or transformation. Prerequisite: Preceded or accompanied by Cr Eng 391.

Geological Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy
Doctor of Engineering

Emphasis areas at the Bachelor of Science level in environmental protection and hazardous waste management, groundwater hydrology and contaminant transport, engineering geology and geotechnics, petroleum, energy and natural resources, and quarry engineering. Emphasis area at the Master of Science level in hazardous waste engineering and science.

Geological Engineering is the application of the principles of geology to the solution of problems in engineering practice. For example, geological engineers are responsible for the exploration and design of foundations, excavations, tunnels, dams, reservoirs and waste disposal sites. They also are involved in the exploration for ground water supplies and for metallic ores, industrial minerals and petroleum resources. In addition, geological engineers have extensive responsibilities in environmental protection. They are responsible for the investigations required for the clean-up of existing contaminated sites and for conducting the studies necessary to locate and design facilities to prevent future environmental contamination.

As a geological engineer, you probably will divide your time between field, laboratory, and office work. In the field, you might examine and map the extent and structural features of rocks and soils. You may collect samples for testing of their physical and chemical properties, or you may conduct programs for on-site testing. In the laboratory, you might perform direct testing of strength or permeability or organize research programs. Office work will include the evaluation of data computer modeling of geological conditions, writing of scientific reports, and participation in the planning, designing, and construction of engineering projects.

Since geological engineering requires a background in both science and engineering, the curriculum includes a well balanced program of geological science, basic engineering and applied geological engineering courses. In addition, the

program provides flexibility in the senior year so that you may modify the general program of study to select a sequence of technical elective courses specifically related to the environmental protection, construction, mining, or petroleum industries. In this capacity you have the opportunity to develop the program of study that is most appropriately oriented toward the field of specialization that you have chosen for your professional career.

Mission Statement

It is the mission of the Geological Engineering program to teach integrated concepts of geology and engineering in such a manner that graduates will graduate as competent, ethical, professional geological engineers. The program is designed to provide background in geological and engineering sciences courses in the lower division which support the applied analysis and design concepts courses taught in the upper division. It is expected that the students will have gained the ability to identify and, through analysis and design, solve problems resulting from the interaction of man's activities with the geologic environment. The curriculum is intended to blend theoretical concepts with practical application, so as to offer the student a well-rounded education, and to include sufficient discussion and project oriented work with real-world issues to provide the student with a thorough awareness of the graduate's responsibility to society. Since geological engineering students are oriented toward careers in environmental protection, social awareness and the engineer's responsibility to both client and society is strongly emphasized throughout the curriculum, particularly in the senior seminar and design courses.

Faculty

Professors:
David Barr[1] (Emeritus), Ph.D., Purdue
Jeffrey Cawlfield[1] (Program Head),
(Associate Director of Freshman Engineering)
Ph.D., University of California-Berkeley
C. Dale Elifrits[2] (Emeritus), Ph.D., UMR
John Rockaway[2] (Emeritus), Ph.D., Purdue
Don Warner (Emeritus and Dean Emeritus), Ph.D.,
California-Berkeley

Associate Professor:
T.M. (Mike) Whitworth, Ph.D., Purdue
J. David Rogers[2], (Karl Hasselmann Chair), Ph.D.,
California-Berkeley

Assistant Professors:
Norbert Maerz[1], Ph.D., University of Waterloo
Paul Santi[2], Ph.D., Colorado School of Mines

[1] Registered Professional Engineer
[2] Registered Geologist

Minor in Ge Eng, contact department.

Bachelor of Science Geological Engineering

FRESHMAN YEAR
(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Math 22-Calculs w/Analytic Geometry III	4
Physics 24-Engineering Physics Ii	4
Cmp Sc 73-Basic Scientific Programming[a]	2
Cmp Sc 77-Computer Programming Lab[a]	1
Ge Eng 50-Geology for Engineers	3
Economics Elective	3
	17

Second Semester	
Math 204-Elementary Differential Equations	3
Bas Eg 50 or Bas En 51-Eng Mech-Statics	3
Ge Eng 110-Principles of Ge Eng	1
Geo 125-Physical Mineralogy & Petrology[b]	3
Ge Eng 275-Geomorphology & Terrain Analysis	3
Ge Eng 249-Fund of Cmp Appl in Ge Eng	3
	16

JUNIOR YEAR

First Semester	Credit
Cv Eng 230-Elementary Fluid Mechanics	3
Bas En 110-Mechanics of Materials	3
Hum/Soc Sc Elective[c]	3
Pe Eng 131-Drilling Practices & Well Completions	3
Ge Eng 248-Fund of Geographic Info Systems	3
	15

Second Semester	
Advanced Hum/Soc Sc Elective[c]	3
Bas En 150-Engineering Mechanics-Dynamics	2
Geo 220-Structural Geology	4
Geo 223-Stratigraphy & Sedimentation or	
Geo 332-Depositional Systems	3
Geophysics Elective	3
English 160-Technical Writing	3
	18

SUMMER	Credit
Ge Eng 373-Geologic Field Methods	3
Ge Eng 374-Engineering Geologic Field Methods	3
	6

SENIOR YEAR

First Semester	Credit
Ge Eng 343-Subsurface Exploration or	
Geo 340-Petroleum Geology	3
Ge Eng 310-Seminar	0.5
Ge Eng 331-Subsurface Hydrology	3
Engineering Economics Elective[d]	3
Ge Eng 341-Eng Geology & Geotechnics	3
Cv Eng 215-Elementary Soil Mechanics or	
Mi Eng 231-Rock Mechanics I	3
	15.5

Second Semester

Advanced Hum/Soc Sci Elective[c]	3
Ge Eng 310-Seminar	0.5
Earth Mechanics Elective[e]	3
Technical Electives[f]	6
Ge Eng 350-Geological Engineering Design	3
	15.5

[a] Or Bas En 20, if Cmp Sc courses elected in freshman year.

[b] Or Geo 113 and 130.

[c] The sequence of course selection must provide both breadth and depth of content and must be selected from the list of approved Humanities/Social Science Electives available from your advisor. The department requires a total of 18 hours of humanities and social science courses.

[d] To be selected from Cv Eng 241, Eng Mg 208 or Pe Eng 257.

[e] Must be selected from Ge Eng 340, Ge Eng 371, Ge Eng 381, Mi Eng 231, Pe Eng 141, or Cv Eng 215, Cv Eng 229, Cv Eng 315.

[f] To be selected from advanced courses in geological, mining, petroleum or civil engineering, geology or other courses in the School of Mines and Metallurgy and School of Engineering with approval of your advisor. Must contain design content and must be selected from the list of approved Technical Electives available from your advisor.

[g] All Geological Engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree, however, it is the first step toward becoming a registered professional engineer. This requirement is part of the UMR assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

[h] Geological engineering students must earn the grade of "C" or better in all geological engineering courses to receive credit toward graduation. The total number of credit hours required for a degree in Geological Engineering is 138. The assumption is made that a student admitted to the Department has completed 35 hours toward graduation to fulfill the requirements of the Freshman Engineering Program.

Geological Engineering Emphasis Areas

Electives are selected by the student with advisor approval. Some appropriate electives are listed for each emphasis area.

Environmental Protection and Hazardous Waste Management

Ge Eng 335-Environmental Geological Engineering
Ge Eng 337-Geological Aspects of Hazardous Waste Management
Ge Eng 381-Intermediate Subsurface Hydrology and Transport Mechanics
Ge Eng 372-Soil Science in Engineering Practice
Ge Eng 315-Statistical Methods in Environmental Geology and Engineering
Ge Eng 376-Mined Land Reclamation
Ge Eng 333-Risk Assessment in Environmental Studies
Ge Eng 339-Groundwater Remediation

Groundwater Hydrology and Contaminant Transport

Ge Eng 381-Intermediate Subsurface Hydrology and Transport Mechanics
Ge Eng 333-Risk Assessment in Environmental Studies
Ge Eng 339-Groundwater Remediation
Ge Eng 372-Soil Science in Engineering Practice
Ge Eng 315-Statistical Methods in Environmental Geology and Engineering
Pe Eng 341-Well Test Analysis
Cv Eng 215-Elementary Soil Mechanics
Pe Eng 232-Well Logging

Engineering Geology and Geotechnics

Ge Eng 371-Rock Engineering
Cv Eng 215-Elementary Soil Mechanics
Mi Eng 231-Rock Mechanics
Cv Eng 229-Foundation Engineering
Mi Eng 308-Drilling and Blasting
Ge Eng 346-Applications of Geographic Info Systems
Ge Eng 353-Regional Geological Engineering Problems in North America
Ge Eng 315-Statistical Methods in Environmental Geology and Engineering

Petroleum, Energy and Natural Resources

Pe Eng 241-Petroleum Reservoir Engineering
Mi Eng 231-Rock Mechanics
Ge Eng 346-Applications of Geographic Info Systems
Ge Eng 381-Intermediate Subsurface Hydrology and Transport Mechanics
Geo 341-Applied Petroleum Geology
Pe Eng 232-Well Logging I
Pe Eng 257-Petroleum Economic Valuation
Pe Eng 341-Well Test Analysis

Quarry Engineering

Mi Eng 231-Rock Mechanics
Cv Eng 215-Soil Mechanics
Cv Eng 216-Construction Materials-Properties and Testing
Ge Eng 371-Rock Engineering
Ge Eng 376-Mined-Land Reclamation
Mi Eng 221-Mining Exploration
Mi Eng 307-Principles of Explosives Engineering
Mi Eng 308-Drilling and Blasting
Mi Eng 345-Strata Control

GEOLOGICAL ENGINEERING COURSES

050 Geology for Engineers. [Lect 2.0 and Lab 1.0] A study of earth materials, surface features, surface and internal structures and their relationship to engineering works. Analysis of the agents of weathering, erosion, diastrophism and their effects on engineering construction.

110 Principles of Geological Engineering [Lect 1.0] Introduction to the concepts defining the application of geologic science to the solution of problems in engineering practice, including field trips to illustrate current examples of professional responsibility.

123 OSHA 40 HR Hazwopper Course [Lab 1.0] This course covers environmental health and safety considerations required by federal regulation to work with hazardous substances. The course meets training and performance standards for working at sites of uncontrolled hazardous waste and at sites requiring emergency response operations following the release of hazardous substances.

200 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

201 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

235 Environmental Geoscience [Lect 2.0 and Lab 1.0] A basic course which integrates principles of basic geology and geologic processes with the activities of man. Essential elements of physical geology and surfacial processes are covered in lectures and laboratories, along with present-day environmental issues (waste disposal, air and water quality). Prerequisite: Junior status.

236 Basic Weather [Lect 2.0 and Lab 1.0] A course to study basic concepts of atmospheric science such as air masses, frontal weather patterns and weather forecasting. The course also will include topics on climate and severe weather. Prerequisites: Physics 23, Ge Eng 50. (Co-listed with Physics 236)

248 Fundamentals of Geographic Information Systems [Lect 2.0 and Lab 1.0] Introduction to the fundamental, concepts and components Techniques for acquiring, manipulating and analyzing digital terrain data for geological and geotechnical applications. Prerequisite: Ge Eng 275.

249 Fundamentals of Computer Applications in Geological Engineering [Lect 2.0 and Lab 1.0] Applications of existing and available software packages utilizing a variety of hardware systems for geological engineering purposes. Emphasis on practical utilization of personal computers and network operations for graphical analysis of geologic data, mapping of surface and subsurface configurations and modeling of geologic processes. Prerequisites: Ge Eng 50, Cmp Sc 73, 77.

275 Geomorphology and Terrain Analysis [Lect 2.0 and Lab 1.0] Study of geomorphic processes, landform development and surfical materials. Course content stresses the evaluation of the engineering properties of terrain factors for site selection and design of engineered structures. Prerequisite: Ge Eng 50.

300 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

301 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

310 Seminar [Lect 0.5] Discussion of current topics. Prerequisite: Senior standing.

315 Statistical Methods in Environmental Geology and Engineering [Lect 3.0] Study of statistical methods applicable to geologic investigations in environmental protection studies. Topics include design of test programs to meet regulatory guidelines, statistical procedures for analysis of test data and applicable statistical techniques for comparing test conclusions with regulatory criteria.

331 Subsurface Hydrology [Lect 2.0 and Lab 1.0] Introduction to the theory and engineering concepts of the movement of subsurface fluids. Properties of water and other subsurface fluids. Hydraulic characteristics of earth materials. Engineering problems related to subsurface fluids. Prerequisite: Ge Eng 50.

333 Risk Assessment in Environmental Studies [Lect 3.0] This course will present the concepts required to assess the human health and environmental risks resulting from contaminants in soil and groundwater. Course topics include evaluation of data sets, exposure calculation, chemical fate and transport, and development of conceptual site models.

335 Environmental Geological Engineering [Lect 3.0] Introduction to engineering geologic mapping for site selection for solid waste disposal facilities; landfill site selection, design, permitting, construction, operation, and closeout/reclamation. Prerequisites: Ge Eng 275, accompanied or preceded by Cv Eng 215.

337 Geological Aspects of Hazardous Waste Management [Lect 3.0] Nature and classification of hazardous wastes; federal and state regulation for treatment and disposal; geological characterization of facility sites; design of impoundments, storage and containment facilities; ground water monitoring and protection; site permitting and licensing planning. Prerequisite: Ge Eng 275.

339 Groundwater Remediation [Lect 3.0] A survey of conventional and innovative techniques for remediation of contaminated groundwater. Topics include groundwater cleanup standards, physico-chemical properties of groundwater and contaminants, fate and transport of contaminants in the subsurface, hydrogeologic site characterization, and selection process of a remedial technology. Various computer programs developed to assist in preliminary selection and design of remediation technologies will be used. Prerequisite: Ge Eng 331.

340 Field Operations in Ground Water Hydrology [Lect 3.0] A survey of ground water field operations. Topics include ground water exploration, well drilling methods, drilling fluids, well screens, water and monitoring well design, well development and testing, and pumps. A design project will be completed. Prerequisite: Ge Eng 331.

341 Engineering Geology and Geotechnics [Lect 3.0] Study of procedures and techniques used to evaluate geologic factors for site selection and the design of engineered structures. Prerequisite: Ge Eng 275.

343 Subsurface Exploration [Lect 2.0 and Lab 1.0] Lectures and field and laboratory exercises in the use of geologic and geophysical techniques for evaluation of subsurface geology and resources. Prerequisites: Pe Eng 131, Geo 220.

344 Remote Sensing Technology [Lect 2.0 and Lab 1.0] Principles of digital image processing including image enhancement and multispectral classification. Emphasis upon design and implementation of remote sensing systems and analysis of remotely sensed data for geotechnical and environmental investigations. Prerequisite: Ge Eng 248.

346 Applications of Geographic Information Systems [Lect 2.0 and Lab 1.0] Applications of geographic information systems and remote sensing to environmental monitoring, mineral resource exploration and geotechnical site evaluation. Prerequisite: Ge Eng 275 or consent of instructor.

349 Computer Applications in Geological Engineering [Lect 3.0] Advanced topics in computer applications including: statistical analysis, geostatistical modeling, groundwater and contaminant transport simulation, computer contouring algorithms, and digital image processing. Emphasis is on understanding the mathematical algorithms and computer implementation as well as the practical application to site investigation, decision making, and modeling projects. Prerequisite: Ge Eng 249.

350 Geological Engineering Design [Lect 2.0 and Lab 1.0] Geological engineering design is an open-ended project course requiring the collection of data, analysis and synthesis of that data and design of a socially acceptable, economical solution to the selected problem. Oral and written reports are required. Prerequisite: To be taken in the semester before graduation.

351 Geological Engineering Case Histories [Lect 3.0] This course presents significant concepts in geological engineering practices by using examples from practical experience to illustrate the objectives. The examples will be drawn from classic case histories as well as the professional experience of the instructor.

353 Regional Geological Engineering Problems in North America [Lect 3.0] A physiographic approach to engineering materials and problems. Course emphasizes the distribution and engineering characteristics of soil and rock to construction and site problems and includes aggregates, foundations, excavations, surface and ground water, slope stability and arctic conditions.

371 Rock Engineering [Lect 3.0] Data requirements for design; engineering properties of rock; characterization of fractures and rock masses; stereonet analysis of discontinuities; graphic analysis of failure; ground stress distribution; tunnel construction methods; ground support principles; selection of tunneling equipment; and specifications for underground construction. Prerequisite: Ge Eng 275.

372 Soil Science in Engineering Practice [Lect 3.0] A study of the ways in which soils and geologic conditions influence engineered projects. Soil formation, soil chemistry and properties to include composition, organic component, ion exchange and water relationships as well as erosion control and revegetation will be covered. Prerequisite: Ge Eng 275.

373 Geologic Field Methods [Lab 3.0] Field practice in geologic mapping and interpretaton in the Western United States using topographic

base maps and aerial photos. Emphasizes the description and interpretation of stratigraphic sections, sedimentary and tectonic structures. Prerequisite: Two courses in either Geology or Geological Engineering.

374 Engineering Geologic Field Methods [Lab 3.0] Instruction in methods of field investigation required for engineering geological studies. Course will include procedures for interpretative mapping of surficial geologic conditions, site characterization, and evaluation of geologic hazards. Written reports are required. Prerequisite: Geo 373.

376 Mined-Land Reclamation [Lect 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: Ge Eng 50 and prerequisite or co-requisite; one of Ge Eng 246, Cv Eng 215, or Mi Eng 226. (Co-listed with Mi Eng 376)

381 Intermediate Subsurface Hydrology and Contaminant Transport Mechs [Lect 3.0] A study of the physical/chemical properties of rocks and sediments in the subsurface environment. Emphasis is put on waterrock properties such as permeability, capillarity, and mechanical dispersion. Both microscopic and macroscopic approaches are used. Prerequisites: Cv Eng 230 & Ge Eng 331.

390 Undergraduate Research [Variable] Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

Geology & Geophysics

Bachelor of Science
Master of Science
Doctor of Philosophy

Emphasis areas at the Bachelor of Science level in geochemistry, geology, geophysics, groundwater and environmental geology, and petroleum geology.

As a student in the department of geology and geophysics you may become involved in studies on: plate tectonics (how movement of the Earth's crustal plates have formed mountain ranges and oceans), adsorption of pollutants by soils, plant fossils in ancient rivers and deltas, identification of ore minerals with microscopes and the significance of this to industrial problems, exploration of oil and gas using seismic reflection, detecting subsurface structures using shallow seismic refraction and ground penetrating radar, pollution problems associated with capped oil wells, examining the products of ancient volcanic explosions, how hot groundwater deposited metal ores in ancient rocks. You may even find yourself snorkeling over a coral reef in the Caribbean Sea.

Geology is the study of the history, composition, and structure of Earth and other planetary bodies. Geophysics is the integration of geology with physics, mathematics, and computer science to the study of Earth and other planets. Geochemistry is the application of chemistry to the study of the composition of Earth and other planets. Traditionally geologists, geophysicists, and geochemists have been involved in the exploration for and production of resources such as metals and petroleum. In recent years, however, these scientists have become increasingly involved in the identification and solution of environmental problems such as groundwater pollution, and geological hazards such as the risk of earthquakes in regions of seismic activity.

Courses are the same for all undergraduate students in geology and geophysics during their first two years. This course work emphasizes a strong background in chemistry, physics, mathematics and computer science, as well as course work in the humanities and social sciences. Students begin to take more specialized courses pertaining to their area of emphasis in their junior and continuing into their senior year. All geology and geophysics students are required to complete a five week summer field course which is taught in Utah and Arizona. This course is usually taken between the student's junior and senior year.

As a professional geologist or geophysicists you may explore for oil, gas, and coal to help provide for our nation's energy needs. You may search for minerals to supply various metals critical to keep the wheels of industry turning. You may become involved in identifying sources of water pollution or determining the best ways to dispose of nuclear waste. In all cases, you will have the opportunity to work out-of-doors as well as in the laboratory. Very few geological scientists ever regret the kind of work that they do.

Suggested programs of study are presented for the following emphasis areas in Geology and Geophysics (General Geology, Geophysics, Ground-water and Environmental Geology, Geochemistry, and Petroleum Geology). Students are commonly drawn to Geology and Geophysics by a desire to explore a topic, that is for many, a personal passion. We have students investigating their world and beyond in areas as diverse as planetary geology,

evolution of life, volcanology, development of caves, deposition of ore minerals, creation of mountain systems, the beauty of minerals, to name but a few. The numerous elective courses offered by the Geology and Geophysics department, as well as courses outside the department, provide our majors, with the guidance of their advisor, the flexibility to custom design emphasis areas of their choice, focusing in on aspects of the Earth Sciences that are of most interest to them. In this way we ensure our majors develop a broad strong understanding in the fundamentals of our diverse discipline while preserving this important opportunity to develop their own passion for Geology and Geophysics.

The earth sciences have been an integral part of UMR since its founding more than a century ago. Our very active student organizations in geology and geophysics are among the oldest in the nation and include the Dake Society, American Association of Petroleum Geologists, Society of Exploration Geophysicists, and the Sigma Gamma Epsilon (Eta Chapter) honor society. These organizations provide the opportunity for social and scientific interaction between students, professional in industry, and faculty.

The department of geology and geophysics is located in the new V. H. McNutt Hall and it is especially well endowed with modern, state-of-the-art equipment for teaching and research in most areas of the geological sciences. The availability of such equipment provides our students with an excellent laboratory and field educational experience. In addition to the department's facilities, other earth science related facilities located in Rolla include the Missouri Geological Survey and the U.S. Geological Survey mid-continent mapping division. Cooperative programs with these agencies provide students with opportunities for part time employment and on-the-job experience.

MISSION STATEMENT

1. Provide a high-quality education to students from the state of Missouri, the nation, and abroad. The department provides education leading to the B.S., M.S., and Ph.D. degrees in Geology and Geophysics. The department provides an education for students who wish to enter the professional fields in five emphasis areas: 1)geology, 2)geophysics 3)geochemistry, 4)groundwater and environmental geology, and 5)petroleum geology 6)service courses for students in related departments (including geological engineering, mining engineering, petroleum engineering, metallurgical engineering, ceramic engineering, civil engineering, physics, and chemistry) as well as many of the departments in the humanities and liberal arts.
2. Engage in research that contributes to the solution of problems of fundamental, applied, and "importance to mankind" nature in the areas of geology, geophysics, geochemistry, groundwater and environmental geology, and petroleum geology, economic geology, magmatism and crustal evolution. The department has both the opportunity and the mission, because of the strong emphasis on engineering and research in the School of Mines and Metallurgy, to collaborate in projects that transcend the traditional boundaries between the Department of Geology and Geophysics and other departments. The department also has the opportunity and the mission, because of its location in Rolla, to collaborate in research with geologists in the Rolla offices of the United States Geological Survey and the Missouri Geological Survey. Similarly, collaboration with the geology faculty at UMC and UMKC has been a very active and desirable aspect of our mission. Collaboration with universities outside Missouri has included Maine, Virginia Tech, and Oklahoma.
3. Provide graduates to the mining, petroleum, groundwater, and environmental industries; to the Missouri Geological Survey, Rolla offices of the National Mapping and Water Resources Division of the U.S. Geological Survey, and to many companies, for example, Doe Run Company in Viburnum, Missouri, Harbison-Walker (RHI) in Fulton, Missouri, Environmental Protection Agency in Kansas City, Burns & McDonnell, Kansas City, McLaren Hart, St. Louis, and many others.
4. Provide professional service in the fields of geology, geophysics, geochemistry, and groundwater and environmental geology. Such service includes the identification of minerals, rocks, and fossils that are sent to the department, the provision of professional expertise in the areas of geology, geophysics, geochemistry, and groundwater and environmental geology to the public, contributing to the development and operation of professional organizations, and, when called upon, assisting local and state agencies with the evaluation of geological problems.
5. Provide a strong foundation in fundamentals principles of geology and geophysics for undergraduate students who desire to pursue opportunities for advanced research in the top graduate schools across the United States. About 70% of our graduates have continued their education in graduate programs, including Arizona State, Auburn, California-Berkeley, Colorado, Colorado School of Mines, Delaware, Georgetown, Kansas, MIT, Mississippi, Michigan, Michigan State, Oklahoma, Stanford, VPI, and Washington.

The department's expertise and activities makes UMR one of the leading research universities in the United States in the study of the geochemistry and

mineralogy of nuclear waste disposal, high-resolution geophysical characterization for environmental and highway-related problems, 3D seismic applications to petroleum exploration, genesis of Mississippi Valley-type ore deposits, applications of cathodo-luminescence petrography to studies of ore genesis, evolution of petroleum reservoirs, the role of magmatism in the thermal and compositional evolution of the lithosphere, the chemical and microstructural composition of ceramic and metallurgical materials, ore microscopic studies of mineral deposits, and process mineralogy studies of industrial problems. It provides the only programs in Missouri in geophysics with an emphasis upon exploration and environmental applications and in palynostratigraphy. The department has provided strong programs in economic geology and applied geophysics for many years.

Faculty

Professors:
Neil L. Anderson[3], Ph.D., Calgary
Sheldon Grant (Emeritus), Ph.D., Utah
Jay Gregg[3] (Department Chair), Ph.D., Michigan State
Richard Hagni[2,3,] (Curators' Professor Emeritus), Ph.D., University of Missouri-Columbia
Geza Kisvarsanyi (Emeritus), Ph.D., University of Missouri-Rolla
Robert Laudon[2,3] Ph.D., University of Texas @ Austin
Gerald Rupert (Emeritus), Ph.D., University of Missouri-Rolla
Alfred Spreng[2,3] (Emeritus), Ph.D., Wisconsin

Associate Professors:
Estella A. Atekwana, Ph.D., Dalhousie University
Francisca Oboh-Ikuenobe[3], Ph.D., Cambridge
Richard Rechtien (Emeritus), Ph.D., Washington University

Assistant Professors:
Steven J. Cardimona, Ph.D., University of Texas @ Austin
John P. Hogan, Ph.D., Virginia Poly Tech.
David J. Wronkiewicz, Ph.D., New Mexico Institute of Mining and Technology

Adjunct Professors:
John Burst, Ph.D., University of Missouri-Rolla
Waldemar M. Dressel, B.S., Mining Engineering, University of Missouri-Rolla w/Geology emphasis
Charles Robertson, M.A., University of Missouri-Columbia
James E. Vandike, M.S., South Dakota School of Mines
James H. Williams, Ph.D., University of Missouri-Rolla

[1] Registered Professional Engineer
[2] Certified Professional Geologist
[3] Registered Geologist

Bachelor of Science Geology and Geophysics

FRESHMAN YEAR

First Semester	Credit
Math 8-Calculus w/Analytic Geometry I	5
English 20-Exposition and Argumentation	3
History 112,175,176 or Pol Sc 90	3
Geo 51-Physical Geology	4
Chem 4-Intro to Lab Safety	1
	16

Second Semester	
Math 21-Calculus w/Analytic Geometry II	5
Chem 1-General Chemistry	4
Chem 2-General Chemistry Lab	1
Geo 52-Evolution of the Earth	4
Elective[1] (Phys Ed,Music,etc.)	1
	15

SOPHOMORE YEAR

First Semester	Credit
Math 22-Calculus w/Analytic Geometry III	4
Chem 3-General Chemistry	3
Geo 113-Mineralogy & Crystallography	4
Econ 121-Prin of Micro or 122-Prin of Macro	3
English Literature Elective	3
	17

Second Semester	
Stat 215-Engineering Statistics[2]	3
Geo 130-Petrology	4
Geop 381-Global Tectonics	3
Hum/Soc Sci Elective	3
Cmp Sc 53,71 or 73 & 77 (program language)	3
	16

JUNIOR YEAR

First Semester	Credit
Physics 23-Engineering Physics I[3]	4
Geo 223-Stratigraphy & Sedimentation	3
Geo 224-Stratigraphy lab	1
Elective (Science & Eng)[4]	3
Hum/Soc Sci Elective	3
Elective (Geo & Geop)[5]	3
	17

Second Semester	
Physics 24-Engineering Physics II[3]	4
Geo 220-Structural Geology	4
Elective (Geo & Geop)[5]	3
Hum/Soc Sci Elective	3
	14

SUMMER OF JUNIOR YEAR	Credit
Geo 373-Field Geology	3
Geo 374-Advanced Field Geology	3
	6

SENIOR YEAR

First Semester	Credit
English 160-Technical Writing	3
Elective (Science & Engineering)[4]	6
Elective (Geo & Geop)[5]	3
Elective[1]	3
	15

Second Semester	
Electives (Science & Engineering)[4]	9
Electives (Geo & Geop)[5]	6
Geo 210-Seminar	1
	16

1 Elective hours may be taken in any combination of credit hours (1,2,3 etc.) and can include any course offerings at the University.
2 Stat 213, or Ge Eng 315 may be taken instead of Stat 215.
3 Students may substitute Physics 21 and 22 for Physics 23 and Physics 25 and 26 for Physics 24.
4 All Geology/Geophysics students, including those taking emphasis areas, must complete at least 18 hours of course work in science (which may include additional Geology/Geophysics courses), mathematics, and/or engineering in addition to Geology/Geophysics, mathematics, and science courses required for the basic program. 15 hours of this course work must be numbered 100 or above.
5 All Geology/Geophysics students, including those taking emphasis areas, must complete at least 15 hours of course work numbered 200 or above in the Geology/Geophysics department, in addition to the required Geology/Geophysics courses. Of these courses two must be from Geophysics 285,286,380,382,389; or one or the other of Geology 375 or 376.

Core Curriculum

(Taken by all students in Geology & Geophysics.)

	Credit
Geo 51-Physical Geology	4
Geo 52-Evolution of the Earth	4
Geo 113-Mineralogy & Crystallography	4
Geo 130-Petrology	4
Geo 210-Seminar	1
Geo 220-Structural Geology	4
Geo 223-Stratigraphy & Sedimentation	3
Geo 224-Stratigraphy Lab	1
Geop 381-Global Tectonics	3
Geo 373-Field Geology	3
Geo 374-Advanced Field Geology	3
	Total 34

Geochemistry Emphasis Area

The following courses are required:	Credit
Geo 234-Petrology & Petrography	3
Geo 275-Intro to Geochemistry	3
Geo 294-Metallic & Industrial Mineral Deposits	3
Geo 376-Aqueous Geochemistry	3
	Total 12

In addition, to complete degree requirements with an emphasis area in Groundwater and Environmental Geology students must complete 4 courses (12 hours minimum) to be selected from an approval list and with guidance from student's advisor.

General Geology Emphasis Area

The following courses are required:	Credit
Geo 227 Systematic Paleontology	3
Geo 275 Introduction to Geochemistry	3
Geo 234 Petrology and Petrography	3
Geo 294 Metallic and Industrial Mineral Deposits	3
Geo 340 Petroleum Geology	3
16	Total 15

In addition to complete degree requirements with an emphasis area in General Geology students must complete 4 courses (12 hrs. minimum) to be selected from an approved list and with guidance from student's advisor.

Geophysics Emphasis Area

The following courses are required:	Credit
Math/Stat 204-Elementary Differential Equations	3
Math/Stat 325-Partial Differential Equations	3
Cmp Sc 228-Intro to Numerical Methods	3
Geop 286-Intro to Geophysical Data Analysis	3
Geop 382-Environmental and Eng Geophysics	3
Geop 336-Geophysical Field Methods	3
Geop 385-Exploration and Dev Seismology	3
	Total 21

In addition, to complete degree requirements with an emphasis area in Geophysics students must complete 2 courses (6 hrs. minimum) to be selected from an approved list and with guidance from student's advisor.

Groundwater and Environmental Geology Emphasis Area

The following courses are required:	Credit
Geo 275 Intro to Geochemistry	3
Geo 375 Applied Geochemistry	3
Geo 376 Aqueous Geochemistry	3
Ge Eng 335 Environmental Geological Eng or	
Ge Eng 331 Subsurface Hydrology	3
Ge Eng 337 Geol Aspects of Haz Waste Mgt	3
	Total 15

In addition, to complete degree requirements with an emphasis area in Groundwater and Environmental Geology students must complete 4 courses (12 hrs. minimum) to be selected from an approval list and with guidance from student's advisor.

Petroleum Geology Emphasis Area

The following courses are required:	Credit
Geo 227-Systematic Paleontology	3
Geo 275-Intro to Geochemistry	3

Geo 324-Adv Stratigraphy & Basin Evolution 3
Geo 338-Computer Mapping.....2
Geo 340-Petroleum Geology.....3
Geo 385-Exploration & Dev Seismology 3
Pe Eng 232-Well Logging I 3
Total 20

In addition, to complete degree requirements with an emphasis area in Petroleum Geology students must complete two courses (6 hours minimum) to be selected from an approval list and with guidance from student's advisor.

Minor Curriculum in Geology

The minor will consist of 12 hours of geology in addition to those taken to satisfy the student's major curriculum. Choice of courses for the minor must be approved by both the student's major and minor departments. Suggested courses:

Geo 51 (3)	Geo 275(3)
Geo 52 (4)	Geo 294(3)
Geo 113(4)	Geo 324(3)
Geo 220(4)	Geo 373(3)
Geo 223(3)	Geop 380(3)
Geo 254(2)	Geop 382(3)

GEOLOGY COURSES

051 Physical Geology [Lect 3.0 and Lab 1.0] Materials of the earth's crust, structures, and geologic features of the surface. Laboratory study of common minerals and rocks, and topographic and geologic maps. One field trip at student expense is required.

052 Evolution of the Earth [Lect 3.0 and Lab 1.0] A survey of the physical and biological history of the earth from the coalescence of the solar system to the present. A one day field trip at student expense is required. Prerequisites: Recommend Ge Eng 50 or Geo 51 or Bio 110 but not required.

101 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

113 Mineralogy and Crystallography [Lect 3.0 and Lab 1.0] An introduction to the study of minerals, including their classification, crystallography, morphology, chemistry, use, occurrence, and systematic identification by means of their physical and chemical properties. Prerequisites: Chem 1 and Chem 2.

125 Physical Mineralogy and Petrology [Lect 2.0 and Lab 1.0] An introduction to the study of physical mineralogy and petrology, overviewing systematic determination of minerals and rocks by means of their physical properties. Includes the recognition of crystal forms and field relationships of rocks. Course designed for non-geology majors, credit will not count towards a geology-geophysics degree. Prerequisites: Chem 1 and Chem 2 or Chem 5; Ge Eng 50 or Geo 51

130 Petrology [Lect 3.0 and Lab 1.0] A study of the megascopic characteristics and field relationships of rocks and their use in rock hand specimens is emphasized. Prerequisite: Geo 113.

200 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

201 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

210 Seminar [Variable] Discussion of current topics. Required for two semesters during senior year.

211 Optical Mineralogy [Lab 2.0] The optical properties of minerals and their use in mineral identification. The identification of minerals using the petrographic microscope is taught with emphasis on the oil immersion method. Prerequisite: Geo 113.

220 Structural Geology [Lect 3.0 and Lab 1.0] A study of the architecture of the earth. Geologic structures, criteria for recognition, solution of structural problems, and properties and behavior of rocks under different geologic conditions are emphasized. Field trip fee required. Prerequisite: Geo 51 or Ge Eng 50.

223 Stratigraphy and Sedimentation [Lect 3.0] Principles of physical stratigraphy, bio-stratigraphy and introductory sedimentation. Introduction to depositional systems, facies, unconformaties, stratigraphic nomenclature and correlation. One field trip at student expense is required. Prerequisite: Accompanied or preceded by Geo 130.

224 Stratigraphy Lab [Lab 1.0] This course re-enforces the principles of stratigraphy and sedimentation through the use of "hands-on" laboratory procedures such as seive and pipette analyses, correlation problems, fence diagrams and stratigraphic maps. One field trip at student expense is required. Prerequisite: Concurrent with Geo 223.

227 Systematic Paleontology [Lect 2.0 and Lab 1.0] Introduction to the study of fossil invertebrates. Emphasis of the course is on fossil morphology, classification, and environmental relationships. Prerequisite: Geo 52.

234 Petrology and Petrography [Lect 2.0 and Lab 1.0] The chemical composition, mineralogy, texture, mode of occurrence, and origin of rocks. The laboratory deals with the study of rock types using the petrographic

microscope. Two field trips at student expense are required. Prerequisite: Geo 211.

254 Map and Airphoto Interpretation [Lect 1.0 and Lab 1.0] Geologic interpretation from topographic maps and aerial photographs, in order to develop geologic maps, geologic cross-sections, structure contour maps, and other means of depicting geology. Prerequisites: Geo 52 and 220.

260 Methods of Karst Hydrogeology [Lect 3.0] This course is designed to familiarize geologists and geological engineers with karst hydrogeology. It will include the formation of karst, aquatic geochemistry in karst areas, identifying karst features and understanding their hydrologic significance. The techniques for investigating groundwater in karst areas will be emphasized, and will include groundwater tracing using fluorescent dyes. Several field trips at student expense will be required. Prerequisites: Geo 51 or Ge Eng 50 and Geo 223.

275 Introduction to Geochemistry [Lect 3.0] Basic principles of geochemistry and trace element analysis. Distribution and mobility of elements in igneous, sedimentary, and metamorphic rocks. Prerequisites: Chem 1 and 3 or Chem 8.

286 Introduction to Geophysical Data Analysis [Lect 3.0] The principles of time series and space series data analysis, digitization and aliasing, frequency-wavenumber spectra, digital filtering, linear system theory, complex number spaces, vector spaces, and matrix methods. Prerequisites: Cmp Sc 63 & 73, Physics 25, & Math 204 (or concurrent registration).

294 Metallic and Industrial Mineral Deposits [Lect 3.0] Basic processes involved in the formation of metallic and industrial mineral deposits illustrated by typical examples of deposits from throughout the world. Exploration and economic factors in mineral exploration and development are reviewed. Two all day field trips at student expense required. Prerequisites: Geo 51 and 113.

300 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

301 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

305 Hydrogeology [Lect 3.0] This course discusses geologic aspects of major surface and subsurface hydrologic systems of North America. Chemical and physical relationships between groundwater and fractures, faults, karst, subsurface pressures, mineral deposits plus both contaminant and hydrocarbon migration are discussed. Prerequisites: Ge Eng 50 or Geo 51, Geo 223 recommended.

312 Ore Microscopy [Lect 1.0 and Lab 2.0] A study of polished sections of minerals and ores under reflected light. Includes the preparation of polished sections, the identification of ore minerals, and the study of the textures, associations, and alterations of ore minerals. Prerequisite: Geo 113.

324 Advanced Stratigraphy and Basin Evolution [Lect 3.0] Advanced topics in sedimentary geology including: tectonic controls on sedimentary basin development, global sequence stratigraphy, regional facies and diagenetic patterns, basin hydrogeology, thermal evolution of basins and distribution of economic resources. Prerequisites: Geo 223, 220, preceded or accompanied by Geo 275 recommended.

325 Advanced Physical Geology [Lect 3.0] History and materials of the Earth's crust, structures and geological features of the surface. Study of common minerals and rocks, topographic and geologic maps, depositional systems, sedimentary classification systems. Prerequisite: Consent of instructor.

329 Micropaleontology [Lect 2.0 and Lab 1.0] Introduction to the preparation and study of microscopic fossils. Prerequisite: Geo 227.

332 Depositional Systems [Lect 3.0] Depositional systems and their interpretation using seismic stratigraphy. Emphasis on deltaic formations, submarine fans, carbonate depositional environments and their recognition using reflection seismic techniques. Field trip fee required. Prerequisite: Geo 223.

338 Computer Mapping in Geology [Lect 1.0 and Lab 1.0] This course teaches the basics of computer gridding, contouring, digitization, volumetrics and generation of three dimensional diagrams both on the personal computer and on the UMR mainframe. Strengths and weaknesses of various software packages, including gridding algorithms and editing packages, are compared. Prerequisites: Cmp Sc 73, Geo 51.

340 Petroleum Geology [Lect 2.0 and Lab 1.0] Principles of origin, migration, and accumulation of oil and gas. The laboratory introduces the procedures used for exploration, and development of hydrocarbon resources. Prerequisite: Geo 220.

341 Applied Petroleum Geology [Lect 1.0 and Lab 2.0] The principles of petroleum geology are applied in solving hydrocarbon exploration and developmental problems. Geological and economical techniques for evaluating hydrocarbonbearing reservoirs are presented, with methods for decision making under conditions of extreme uncertainty. Prerequisite: Geo 340.

345 Radioactive Waste Management and Remediation [Lect 3.0] Sources and classes of radioactive waste, long-term decay, spent fuel storage, transport, disposal options, regulatory control, materials issues, site selection and geologic characterization, containment, design and monitoring requirements, domestic and foreign waste disposal programs, economic and environmental issues; history of disposal actions, and conduct of remedial actions and cleanup. Prerequisite: Math 204. (Co-listed with Nu Eng 345)

373 Field Geology [Lab 3.0] Field practice in geologic mapping and interpretation in the Western United States using topographic base maps and aerial photos. Emphasizes the description and interpretation of stratigraphic sections, sedimentary and tectonic structures. Prerequisite: Two Geology courses.

374 Advanced Field Geology [Lab 3.0] Detailed field work in areas related to the projects of Geology 373. Courses to be taken the same summer. A written report on the full summer's projects is required. Prerequisite: Geo 373.

375 Applied Geochemistry [Lect 2.0 and Lab 1.0] Application of the principles and techniques of geochemistry to mineral exploration. Prerequisites: Geo 275 and Geo 113.

376 Aqueous Geochemistry [Lect 3.0] Studies of the interaction of water with minerals and organic materials at low temperatures; including processes affecting the migration of elements (alteration, precipitation, and adsorption), the influence of geochemical processes on water composition, weathering, soil formation, and pollution. Prerequisite: Geo 275.

383 Electrical Methods in Geophysics [Lect 3.0] The theory and instrumentation for measurements of the electrical properties of the earth. Includes passive and active techniques, the advantages and disadvantages of the various techniques, and geologic interpretations of electrical soundings. Several weekends are spent making a variety of electrical surveys of local features. Prerequisites: Math 325 and Geop 321.

384 Gravity and Magnetic Methods [Lect 3.0] The theory of gravity and magnetic surveying for geologic bodies of economic interest. Includes methods for the calculation of size and depth of bodies with different degrees of magnetization and density. Prerequisites: Math 325 and Geop 321.

385 Exploration and Development Seismology [Lect 2.0 and Lab 1.0] Principles of reflection seismology as applied to the delineation of geologic structures and the determination of stratigraphy and lithology. Emphasis on both the capabilities and limitations of the seismic method. The laboratory utilizes both modeled and actual seismic data. Prerequisites: Geo 220, Geo 223 or permission of instructor.

386 Wave Propagation [Lect 3.0] A study of Hamilton's principle and energy theorems, fundamentals of plane wave theory, waves in stratified fluids, elastic waves in solids, electromagnetic and hydromagnetic radiation, and Allens's functions and point sources. Prerequisites: Geop 286 and 321.

387 Acquisition of Seismic Data [Lect 2.0 and Lab 1.0] Theory and application of the acquisition of seismic data. Determination of recording and energy source array responses, evaluation of energy sources, and the design of a complete acquisition system. Prerequisite: Geop 286 and 380 or permission of instructor.

390 Undergraduate Research [Variable] Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

394 Coal Petrology [Lect 3.0] Formation, composition, and properties of coals. Discussion of the geology of selected coal deposits, the analysis of coal, and the optical identification of coal minerals. Prerequisite: Permission of instructor.

GEOPHYSICS COURSES

201 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course.

285 Geophysical Imaging [Lect 2.0 and Lab 1.0] A study of the major geophysical methods applicable to shallow engineering and environmental geoscience. Topics include the background theory and practical application of gravity, magnetics, radiometrics, resistivity, induced polarization, spontaneous potential, reflection and refraction seismics, ground penetrating radar, electromagentics, and borehole logging methods. Prerequisites: Physics 24; Ge Eng 50 or Geo 51.

286 Introduction to Geophysical Data Analysis [Lect 3.0] The application of time series and spatial series analysis techniques to geophysical data. Topics covered include digitization and aliasing of geophysical signals, frequency and wavenumber spectra, digital filtering and linear systems theory. Prerequisites: Cmp Sc 73 and 77, Physics 25 and Math 22.

300 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

301 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

321 Potential Field Theory [Lect 3.0] The mathematics and physics of gravitational, magnetic, and electrical fields of the earth as derived from potential functions, with applications to practical problems. The theorems of Laplace, Poisson, Gauss, and Green and their applications to geophysics are presented. Prerequisite: Accompanied or preceded by Math 325.

336 Geophysical Field Methods [Lect 2.0 and Lab 1.0] Imaging of selected subsurface and engineering features by various geophysical methods. Special emphasis on ground penetrating radar and magnetic methods; and the acquisition and reduction of associated data. One field trip at student expense required. Prerequisite: Geop 384 or permission of instructor.

380 Seismic Stratigraphy [Lect 2.0 and Lab 1.0] A study of the seismic expression of depositional models. Reflection patterns and reflection amplitudes are interpreted to determine bed thicknesses, fluid content, depositional environment, and lithology. Special data acquisition and processing techniques are examined. Prerequisites: Geop 385, Geo 220, 223.

381 Global Tectonics [Lect 3.0] An integrated view of the Earth's structure and dynamics with an emphasis on information gained through geophysical methods. Topics include seismology, heat flow, gravity, rheological and compositional structure, plate motions and intermotions, and mantle driving mechanisms for plate tectonics. Prerequisites: Physics 23 and 24, Geo 220.

382 Environmental and Engineering Geophysics [Lect 2.0 and Lab 1.0] An introduction to the theory and application of the gravity, magnetic, resistivity, self-potential, induced polarization and electromagnetic methods as applied to the solution of engineering and environmental problems. Prerequisite: Math 22.

383 Electrical Methods in Geophysics [Lect 1.0 and Lab 2.0] The theory and instrumentation for measurements of the electrical properties of the earth. Includes passive and active techniques, the advantages and disadvantages of the various techniques, and geologic interpretations of electrical soundings. Several weekends are spent making a variety of electrical surveys of local features. Prerequisites: Math 325 and Geop 285 or Geop 382.

385 Exploration and Development Seismology [Lect 2.0 and Lab 1.0] Principles of reflection seismology as applied to the delineation of geologic structures and the determination of stratigraphy and lithology. Emphasis on both the capabilities and limitations of the seismic method. The laboratory utilizes both modeled and actual seismic data. Prerequisite: Math 22.

386 Wave Propagation [Lect 3.0] A study of Hamilton's principle and energy theorems, fundamentals of plane wave theory, waves in stratified fluids, elastic waves in solids, electromagnetic and hydromagnetic radiation, and Allen's functions and point sources. Prerequisites: Geop 281, 321.

387 Acquisition of Seismic Data [Lect 2.0 and Lab 1.0] Theory and application of the acquisition of seismic data. Determination of recording and energy source array responses, evaluation of energy sources, and the design of a complete acquisition system. Prerequisites: Geop 286, 380.

388 Geophysical Instrumentation [Lab 1.0] Field and laboratory practice in the use of geophysical instrumentation. Techniques of geophysical data reduction and interpretation are also covered. May be taken more than once for credit with Geop 383 and Geop 384. Prerequisite: Concurrent registration in Geop 382, 283 or 384.

389 Seismic Data Processing [Lect 2.0 and Lab 1.0] Introduction to seismic data processing. Topics to be covered include statics corrections, filtering, velocity analysis, deconvolution, stacking and migration. Prerequisites: Math 22 and Geop 286 or Geop 385.

390 Undergraduate Research [Variable] 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.

Metallurgical Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy

Emphasis areas at the bachelor of science level in chemical metallurgy, manufacturing metallurgy, and physical metallurgy.

The development of mankind has frequently been linked to the ability to use metals from the earth's crust. Metallic materials are found in all areas of the world, and are in use in virtually every industry. Thus their production is vital to the economy and to the continued development of the human race. Metallurgical Engineering is a broad discipline that studies metals extraction from minerals and waste and recycled materials, the production of components from metals and alloys, and the design of metallic materials to enable appropriate physical and chemical properties to be achieved.

UMR has one of the few metallurgical engineering departments in the United States with the capability of covering the whole spectrum of metallurgical activities. It is the only such department in Missouri and in any of the contiguous states.

A graduate of metallurgical engineering may work in a variety of areas. The chemical metallurgist is involved in the recovery of metals from mineral ores and recycled material, utilizing physical and chemical processes. Typical processes include mineral beneficiation (magnetic separation of iron ores), pyrometallurgy (smelting of copper ores), hydrometallurgy (leaching of gold ores), and elecrometallurgy (electrolysis of aluminum ores). The modern challenge which faces the chemical metallurgist is to recover the metallic values from ores of decreasing grade; and to do this with a minimum of energy while safeguarding the environment.

The manufacturing metallurgist is concerned with the shaping and joining of metallic materials into appropriate forms for use in machines, tools, buildings, and implements. Typical shaping processes include casting, rolling, extrusion, forging, and drawing. The pressing of car bodies, casting of engine blocks, drawing of wire, rolling of I-beams, extrusion of tube, and forging of crank shafts are examples of manufacturing metallurgy. Powder metallurgy is a relatively new manufacturing technique that is finding increased application. The control of production rate and quality are especially important factors in this emphasis area of metallurgy.

The properties of all metallic components are related to the elemental composition of the material, and the manner in which the various elements are combined as microscopic structures. The study of the microstructure of metals and alloys and the control of their properties are the responsibility of the physical metallurgist. The development of corrosion-resistant stainless steels, ultra-lightweight alloys for aircraft, wear-resistant alloys for engines, and shape-memory alloys for space structures are examples of the work of the physical metallurgist. The heat treatment of alloys is an area of importance for both physical and manufacturing metallurgy. In addition, the investigation of material failures and the monitoring of service life are tasks that are performed by physical and manufacturing metallurgists.

At UMR, students do not have to select an emphasis area and may simply select technical electives appropriate to their interests. However, there are prescribed combinations of technical electives which fit the emphasis areas of chemical, manufacturing, and physical metallurgy. The department has also introduced a materials minor program in conjunction with Ceramic Engineering.

Students are encouraged to undertake summer and cooperative training employment with approved companies to obtain appropriate industrial experience while supplementing their academic studies and incomes.

The department is housed in McNutt Hall and has outstanding facilities for classroom and laboratory learning. The department has recently acquired technologically advanced equipment for student laboratories and for research. Examples of the new equipment include a resistance melting furnace, a spark spectrographic analyzer, a sputtering unit, and a thermal spray unit. The department has three electronmicroscopes, a well equipped metals casting and joining laboratory, comprehensive metals deformation and testing facilities, and excellent computer laboratory with the addition of new software and computers, and improved network access. The undergraduate curriculum emphasizes laboratory activities to ensure that graduates receive a hands-on education. Additional information is available at http://www.umr.edu/~meteng.

MISSION STATEMENT

The mission of the department is to provide a quality, comprehensive undergraduate and graduate education in the traditional areas of metallurgical engineering. The major program goal is to produce a Bachelor of Science graduate with a sound fundamental knowledge and extensive hands-on-technical, communication, and leadership skills, capable of contributing in any technical area associated with metallurgy. The department is also committed to a strong graduate program, which ensures significant research activity, an active and

involved faculty, and a robust, healthy environment for education. The provision of service course work for students in other engineering disciplines is also in important goal, as is interaction with professional societies and industry to promote continuing education, research, and technical information transfer. The utilization of the departmental resources to assist the state agencies and industry of Missouri and the mid-west is an integral part of the departmental mission.

Faculty

Professors:
Donald R. Askeland (Distinguished Teaching Professor Emeritus), Ph.D., Michigan
Anton Brasunas[1] (Emeritus), Sc.D., Massachusetts Institute of Technology
John Beverly Clark (Emeritus), Ph.D., Carnegie Institute of Technology
Fred Kisslinger[1] (Emeritus), Ph.D., Cincinnati
Ronald A. Kohser (Associate Dean of Mines & Metallurgy), Ph.D., Lehigh
H. Philip Leighly, Jr.[1,2] (Emeritus), Ph.D., Illinois
Arthur E. Morris (Emeritus), Ph.D., Pennsylvania State
Thomas J. O'Keefe (Curators' Emeritus), Ph.D., UMR
David G. C. Robertson[2], Ph.D., University of New South Wales
John L. Watson (Department Chair), Ph.D., Bristol
Harry W. Weart (Emeritus), Ph.D., Wisconsin

Associate Professors:
Joseph W. Newkirk, Ph.D., University of Virginia
Matthew J. O'Keefe, Ph.D., Illinois
Kent D. Peaslee[1], Ph.D., UMR
Christopher W. Ramsay, Ph.D., Colorado School of Mines
Mark E. Schlesinger[1], Ph.D., University of Arizona
David C. Van Aken[1], Ph.D., Illinois

Assistant Professor:
Rajiv S. Mishra, Ph.D., Sheffield

Teaching Associate:
F. Scott Miller, Ph.D., UMR

[1] Registered Professional Engineer
[2] Chartered Engineer, United Kingdom

Bachelor of Science Metallurgical Engineering

FRESHMAN YEAR

See *Freshman Engineering Program*, but note that (a) as 12 credit hours of Hum/Soc Sci electives are included in semesters 3-8, metallurgical engineering students need only take one Hum/Soc Sc elective, and hence only 32 credit hours of the 35 credit hours listed, in the first two semesters to satisfy the freshman program requirement and to transfer to the department in semester 3 (b) the department recommends the Chemistry 1, 2 and 3 sequence, and (c) metallurgical engineering preference students are required to take Mt Eng 001 in the *Second Semester* of their freshman year.

SOPHOMORE YEAR

First Semester	Credit
Physics 24-Engineering Physics II	4
Math 22-Calculus w/Analytic Geometry III	4
Mt Eng 121-Metallurgy for Engineers	3
Mt Eng 125-Fundamentals of Chemical Metallurgy	2
Mt Eng 126-Computer Application in Mt Eng	3
	16

Second Semester	
Hum/Soc Sci-Elective*	3
Math 204-Elementary Differential Equations	3
Mt Eng 215-Fundamentals of Metal Behavior	3
Mt Eng 216-Metals Characterization Lab	1
Mt Eng 281-Metallurgical Thermodynamics I	3
Hum/Soc Sci-Econ 121-Principles of Microeconomics Or Econ 122-Principles of Macroeconomics	3
	16

Junior Year

First Semester	Credit
Bas En 50 or Bas En 51-Mech Statics	3
Mt Eng 202-Extractive Metallurgy Lab	1
Mt Eng 203-Intro to Extractive Metallurgy	3
Mt Eng 204-Transport Phenomena in Metallurgy	3
Mt Eng 217-Metals Microstructural Development	3
Mt Eng 218-Metals Structures & Properties Lab	1
Hum/Soc Sci-English 60-Writing & Research or English 160-Tech Writing or SP&M S 85-Principles of Speech	3
	17

Second Semester	
Bas En 110-Mechanics of Materials	3
Statistics Elective*	3
Mt Eng 221-Principles of Materials Processing	3
Mt Eng 222-Metals Processing	1
Mt Eng 241-Principles of Minerals Processing	2
Mt Eng 355-Metallurgical Thermodynamics II	3
Technical Elective*	3
	18

SENIOR YEAR

First Semester	Credit
Advanced Science Elective*	3
Mt Eng 354-Mt Process Simulation & Control	2
Mt Eng 315-Mt Process Design Principles	2
Hum/Soc Sci Electives*	3
Technical Electives*	6
(must include 1 credit hour of lab)	16

Second Semester
Mt Eng 316-Mt Design Project 2
Hum/Soc Sci Electives* 6
Technical Electives* 8
16

*Electives must be chosen from approved course listings in consultation with department academic advisor.

NOTE: All Metallurgical Engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree, however, it is the first step toward becoming a registered professional engineer. This requirement, together with the department's Senior Assessment, is part of the UMR assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Appropriate course electives for the Metallurgical Engineering Emphasis Areas.

Chemical Metallurgy:
Mt Eng 242-Mineral Process Lab
Mt Eng 351-Flotation and Hydrometallurgy
Mt Eng 353-Particle Mechanics and Design
Mt Eng 363-Electrometallurgy of Corrosion and Deposition Processes
Mt Eng 303-New Developments in Chemical Metallurgy
Cmp Sc 228-Intro to Numerical Methods
Cr Eng 364-Refractories
Mt Eng 356-Principles of Extractive Metallurgy

Physical Metallurgy:
Cmp Sc 228-Intro to Numerical Methods
Mt Eng 341-Nuclear Materials I
Mt Eng 361-Alloying Principles
Mt Eng 368-Physical Metallurgy III Lab
Mt Eng 313-Electron Microscopy
Mt Eng 385-Mechanical Metallurgy
Physics 107-Intro to Modern Physics
Physics 307-Modern Physics II
Physics 381-Elem Solid State Physics
Physics 311-Thermal Physics
Cr Eng 284-Electrical Properties of Ceramics
Cr Eng 391,392- X-ray Diffraction & Fluorescence
El Eng 221-Principles of Semiconductor Devices
EMech 321-Intermediate Mechanics of Materials
EMech 336-Fracture Mechanics
Mt Eng 375-Metallurgical Failure Analysis

Manufacturing Metallurgy:
Cr Eng 315-Organic Additives in Ceramic Processing
Cr Eng 364-Refractories
Mt Eng 305,306-Nondestructive Testing
Mt Eng 307,308-Metals Casting
Mt Eng 311-Metals Joining
Mt Eng 321-Metal Deformation Processes
Mt Eng 329-Material Selection
Mt Eng 331,332-Steels and Their Treatments
Mt Eng 333-Nonferrous Alloys
Mt Eng 361-Alloying Principles
Mt Eng 368-Physical Metallurgy III Lab
Mt Eng 385-Mechanical Metallurgy
Mt Eng 333-Non-Ferrous Alloys

Materials Minor Curriculum
To enable students outside of Metallurgical Engineering to receive instruction in the field of materials, a Materials Minor is available. To qualify for the minor, a student must take the following classes:

Mt Eng 211,215,217,350,360
Cr Eng 102,203,242
Chem 381

METALLURGICAL ENGINEERING COURSES

001 Introduction to Metallurgical Engineering [Lect 1.0] Introduction to the field of metallurgical engineering with specific reference to the emphasis areas of extractive, manufacturing and physical metallurgy. The course will include lectures, videos and field trips to local industry.

101 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

121 Metallurgy for Engineers [Lect 3.0] Introduction to the structure and properties of metals and alloys and to processes used to modify the structure and properties of metallic materials, including alloying, deformation and heat treating. Prerequisite: Chem 1.

125 Fundamentals of Chemical Metallurgy [Lect 2.0] Survey of primary and secondary resources for the production of metals. Study of flowsheets for the common metals. Heat and mass balance for unit extractive processes, with emphasis on the chemical behavior of metals. Process technology and economics of production. Prerequisite: Chem 3.

126 Computer Application in Metallurgical Engineering [Lect 2.0 and Lab 1.0] Introduction to the use of microcomputers for simulation, data analysis including statistics, data acquisition from laboratory instruments, and automatic process control systems. The course will provide instruction in programming and software usage, and the laboratory will enable students to fully utilize the potential of microcomputer in later courses.

200 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

201 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

202 Extractive Metallurgy Laboratory [Lab 1.0] A series of laboratory experiments designed to illustrate the principles of pyrometallurgy, hydrometallurgy, and electrometallurgy. Prerequisites: Preceded or accompanied by Mt Eng 203; preceded or accompanied by Chem 4 or an equivalent training program approved by UMR.

203 Introduction to Extractive Metallurgy [Lect 3.0] Production and refining of metals by pyrometallurgy, hydrometallurgy, and electrometallurgy. Emphasis on heat and mass balance calculations for the unit processes of metals extraction. Introduction to the principles of combustion, heat utilization and recovery. Prerequisite: Mt Eng 281 or Cr Eng 259 or Ch Eng 143.

204 Transport Phenomena in Metallurgy [Lect 3.0] The application of the principles of fluid flow and heat transfer to the solution of practical problems in metallurgical engineering. Prerequisite: Physics 23.

211 Metallurgy Laboratory [Lab 1.0] Introduction to metallography, mechanical testing and modification of material properties through structural development; Corrosion; Solidification. Prerequisite: Senior standing in Cr Eng.

215 Fundamentals of Materials Behavior [Lect 3.0] An introduction to crystal structure, deformation, defects and thermal treatment; mechanical testing; fracture; fatigue and creep. Prerequisite: Mt Eng 121.

216 Metals Characterization Laboratory [Lab 1.0] Introduction to the characterization of metals through the use of optical microscopy, x-ray diffraction, transmission electron microscopy and mechanical testing. Prerequisites: Mt Eng 121, accompanied by Mt Eng 215.

217 Metals Microstructural Development [Lect 3.0] Fundamentals of microstructural developments as relating to solid solutions, solidification and transformations; phase diagrams; case studies. Prerequisites: Mt Eng 215, 216.

218 Metals Structures and Properties Laboratory [Lab 1.0] Investigation of the relationships between microstructures and properties for various materials. Prerequisites: Mt Eng 215, 216, accompanied by Mt Eng 217.

221 Principles of Materials Processing [Lect 3.0] An introduction to various methods of processing of metals and influences of processing on design. Includes: casting, welding, shaping, inspection and testing. Prerequisite: Mt Eng 121.

222 Metals Processing [Lab 1.0] Laboratory study of the methods of processing of metals. Prerequisite: Accompanied or preceded by Mt Eng 221.

241 Principles of Mineral Processing [Lect 2.0] Introduction to the principles of mineral processing including mineral resources; particle comminution, classification, separation and dewatering; flowsheet and equipment design. Prerequisites: Mt Eng 121, 125.

242 Mineral Processing Laboratory [Lab 1.0] An introductory laboratory to provide instruction in sampling, classification, comminution, mineral separation and dewatering. Prerequisite: Accompanied or preceded by Mt Eng 241.

281 Metallurgical Thermodynamics I [Lect 3.0] Thermodynamic laws and thermodynamic functions and their relation to problems of metallurgical interest, thermochemistry, thermophysics, and chemical or phase equilibria. Prerequisites: Mt Eng 125 or Chem 52; Mt Eng 126 or Cmp Sc 77.

300 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

301 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

303 New Developments in Chemical Metallurgy [Variable] Survey of selected modern processes for the production of metals, the treatment of wastes, and recycling of metal values. Processes are studied with respect to raw materials, chemical reactions, energy consumption, process intensity, yield and environmental impact. Prerequisite: Mt Eng 203.

305 Nondestructive Testing [Lect 2.0 and Lab 1.0] Principles and application of various means of nondestructive testing of metallic materials. Radiological inspection methods, ultrasonic testing, magnetic methods, electrical and eddy current methods, and others. In addition, laboratory exercises using industrial grade NDT equipment to inspect a variety of parts and materials. Prerequisites: Physics 24 or 25.

306 Nondestructive Testing Laboratory [Lab 1.0] Application of radiological and ultrasonic methods of nondestructive testing of metallic materials. A radiographic X-ray units and ultrasonic equipment are used in the inspection of a variety of materials and manufactured parts. Prerequisite: Accompanied or preceded by Mt Eng 305.

07 Metals Casting [Lect 2.0] An advanced course in the materials and methods used in modern metals casting processes. Application of metallurgical principles to the casting of metals. Prerequisite: Mt Eng 221 or Mc Eng 153.

308 Metals Casting Laboratory [Lab 1.0] An advanced laboratory study of mold materials, metal flow, and cast metals. Emphasis is given to design of gating, risering, and ladle treatment techniques required for economical, highquality castings. Prerequisite: Accompanied or preceded by Mt Eng 307.

310 Seminar [Variable] Discussion of current topics.

311 Metals Joining [Lect 2.0] Metals joining processes such as welding and brazing. Effects of welding on materials. Treatment and properties of welded joints. Welding defects and quality control. Prerequisite: Mt Eng 121 or 221.

313 Scanning Electron Microscopy [Lect 2.0 and Lab 1.0] A course in the theory and application of scanning electron microscopy and x-ray microanalysis. Topics considered are electron optics, image formation and analysis; x-ray generation, detection and analysis; and characterization of fracture surfaces. Prerequisites: Mt Eng 215 and 216 or course in optical microscopy - consent of instructor required.

315 Metallurgical Process Design Principles [Lect 2.0] Application of mass, component and energy balances for metallurgical design. The fundamentals of engineering economic analysis will be examined and experimental design techniques will be introduced. Students will be prepared for the selection and planning of the subsequent design project. Prerequisite: Senior standing in Mt Eng.

316 Metallurgical Design Project [Lab 2.0] Student groups will undertake selected projects, which will represent a capstone design experience utilizing skills, understanding and data from previous courses. The faculty supervised open-ended design projects will involve a variety of tasks appropriate to the metallurgical engineer. Prerequisite: Mt Eng 315.

321 Metal Deformation Processes [Lect 3.0] An introduction to metal deformation concepts followed by a study of various forming processes from both the analytical and applied viewpoints. Processes to include: forging, wire drawing, extrusion, rolling, sheet metal forming, and others. Prerequisite: Mt Eng 221.

325 Fundamentals of Materials Behavior I [Lect 3.0] Introduces students without a metallurgical background to the physical, chemical and structural basis of the equilibrium behavior of materials. Includes thermodynamic potentials, phase equilibria, phase diagrams and their relation to microstructure and chemical thermodynamics of condensed phases. Prerequisites: Graduate standing, Math 204, Physics 107. (Not for metallurgy majors) (UMR Engineering Education Center, St. Louis only).

327 Fundamentals of Materials Behavior II [Lect 3.0] A continuation of Metallurgy 325 emphasizing the kinetic processes involved in materials behavior. Concepts of the theory of absolute reaction rates, diffusion in metallic solids, elementary dislocation theory, plastic deformation, crystallization solid state phase transformations. Prerequisite: Mt Eng 325. (Not for metallurgy majors) (UMR Engineering Education Center, St. Louis only).

329 Material Selection, Fabrication, and Failure [Lect 3.0] Factors governing the selection of materials for specific needs, fabrication, heat treatment, surface treatment, and other aspects in the production of a satisfactory component. Failure analysis and remedies. Lecture plus assigned problems. Prerequisites: Mt Eng 217, 218, 221.

331 Steels and Their Treatment [Lect 3.0] Industrially important ferrous alloys are described and classified. The selection of proper heat treatments to facilitate fabrication and to yield required service properties in steels suitable for various applications is considered. Prerequisites: Mt Eng 271, 218.

332 Metals Treatment Laboratory [Lab 1.0] The students plan and perform experiments that illustrate heat treating processes and their effects on the properties and structure of commercial alloys. Prerequisite: Accompanied or preceded by Mt Eng 331.

333 Nonferrous alloys [Lect 3.0] Structure and properties of nonferrous alloys (Al, Ti, Mg, Ni and Cu) are described. The role of processing and microstructure in the development of mechanical properties is emphasized. Prerequisites: Mt Eng 217 or Mt Eng 377.

341 Nuclear Materials I [Lect 3.0] Fundamentals of materials selection for components in nuclear applications. Design and fabrication of UO2 fuel; reactor fuel element performance; mechanical properties of UO2; radiation damage and effects, including computer modeling; corrosion of materials in nuclear reactor systems. Prerequisite: Nu Eng 205. (Co-listed with Nu Eng 341)

343 Nuclear Materials II [Lect 3.0] Extractive metallurgy of uranium, thorium, and zirconium. Equation of state of UO2 and fuel chemistry. LMFBR fuel and interaction of sodium and stainless steel. Materials for fusion and other advanced nuclear applications. Reprocessing of spent fuel and disposal. Prerequisite: Mt Eng 341.

350 Composites [Lect 3.0] An introduction to the structure, properties and fabrication of fiber and particulate composites. Prerequisites: Mt Eng 215 & 211 or Cr Eng 102 & 242.

351 Mineral Processing II (Flotation and Hydrometallurgy) [Lect 2.0 and Lab 1.0] Froth 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: Mt Eng 241.

353 Mineral Processing II (Mechanics and Design) [Lect 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: Mt Eng 241.

354 Metallurgical Process Simulation and Control [Lect 1.0 and Lab 1.0] Simulation of metallurgical processes through the use of theoretical and empirical models, numerical methods, and analog representation. Introduction to instrumentation, computer interfacing and process control theory. Prerequisites: Mt Eng 121, 125, 126.

355 Metallurgical Thermodynamics II [Lect 2.0 and Lab 1.0] Continuation of metallurgical engineering 281. Equilibrium calculations with stoichiometry and heat balance restrictions. Phase transformation, solution thermodynamics and partial molar properties. Applications of thermodynamics to the analysis and design of extractive and physical metallurgy processes. Computer calculations of complex equilibria. Prerequisite: Mt Eng 203.

356 Principles of Extractive Metallurgy [Lect 3.0] Application of thermodynamics, heat and mass balances, and kinetics to the understanding, analysis, and design of metal extraction processes. Use of stability and phase diagrams to analyze existing processes and design new ones. Prerequisite: Mt Eng 355.

358 Steelmaking [Lect 3.0] Introduction to the fundamentals and unit processes used to turn impure iron and scrap into steel. Includes desulfurization, BOF and electric furnace operations, ladle metallurgy, casting, and stainless steel manufacture.

359 Environmental Aspects of Metals Manufacturing [Lect 3.0] Introduction to environmental aspects of metal extraction, melting, casting, forming, and finishing. Subjects include history of environmental movement and regulations permitting, risk analysis, disposal and recycling of metal manufacturing residues, environmental ethics, environmental technologies and case studies. Prerequisite: Junior/Senior standing.

360 Materials Selection & Fabrication [Lect 2.0] Factors governing the selection of materials, including metals, ceramics, polymers and composites, for specific need. Fabrication of materials. Prerequisites: Mt Eng 215 & 211 or Cr Eng 102 & 242.

361 Alloying Principles [Lect 3.0] Basis for alloy design and property control. Predictions of phase stability, alloy properties and metastable phase possibilities; interfaces in solids and their role in phase transformations. Prerequisites: Mt Eng 217, 218.

363 Metal Coating Processes [Lect 3.0] Introduction to the current technologies used to enhance metal performance, particularly corrosion resistance, by overlay coatings. Deposition processes are emphasized and the fundamentals of the behavior of the films in high technology and electronic materials applications is discussed. Prerequisites: Mt Eng 202, 203.

367 Introduction to Powder Metallurgy [Lect 2.0 and Lab 1.0] A survey of the powder metallurgy field, from fabrication of powders to finishing operations. Includes all basics of powder metallurgy and many new processes currently used in industry. Also covers design, production, economics and energy concerns. Hands-on laboratory time is included. Prerequisites: Mt Eng 217, 218.

368 Physical Metallurgy III Laboratory [Lab 1.0] Experiments in physical metallurgy including internal friction, precipitation hardening, order-disorder transformations, plastic deformation and thermal expansion.

375 Metallurgical Failure Analysis [Lect 3.0] Application of the principles of manufacturing and mechanical metallurgy for the analysis of failed components. Analytical techniques such as Scanning Electron Microscopy, Optical Metallography, and High Resolution Photography are used to characterize microstructure and fractographic features. In addition, appropriate methods to gather data, assimilate it, and draw conclusions from the data such that it will stand up in a court of law will be addressed. Prerequisite: Senior or Graduate Student standing.

377 Principles of Engineering Materials [Lect 3.0] Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Ae Eng 377, Ch Eng 377, Physics 377, Cr Eng 377)

385 Mechanical Metallurgy [Lect 3.0] Elastic and plastic behavior of metallic single crystals and polycrystalline aggregates. Resulting changes in mechanical properties are considered. Included are applications to metal fabrication. Prerequisites: Mt Eng 215, 216, Bas En 110.

390 Undergraduate Research [Variable] 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.

Mining Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy
Doctor of Engineering

Emphasis areas at the bachelor level in explosives engineering and quarry engineering.

The overall objectives of the Department of Mining Engineering are to provide the students with a specialized expertise in mining engineering, a cultural foundation and a sound basis for future growth and development. These objectives are achieved at the undergraduate level by providing education in basic sciences, engineering sciences and design, and in the field of humanities and social sciences.

The mining engineering courses offered focus on providing students with the knowledge necessary to enter a variety of segments of the mining industry. Graduating mining engineers who satisfactorily complete the program criteria, and where appropriate, the quarry option or the explosives emphasis, usually obtain employment in one or more of the following areas: mine engineering, mining operations, the extraction/processing of coal, base metals, precious metals, industrial minerals, quarry industry, explosives industry, construction or demolition, mining equipment suppliers and mining/geotechnical consulting firms.

Mining engineering is the profession concerned with location, extraction, and use of mineral resources. Lunar and ocean mining constitute new frontiers.

The mining engineer is concerned with all phases of mineral recovery, including exploration, evaluation, development, extraction, mine evaluation, reclamation, processing, and marketing of minerals. In addition to engineering, science and liberal arts courses, appropriate courses are taken in explosives engineering, geology, mineral beneficiation, coal mine development and production, mining of metallic and aggregate minerals, mine systems design, mining economics and law, mine hygiene and safety, mine management, mine ventilation, rock mechanics, ground support, and reclamation.

The mining engineer relies upon geologic knowledge and highly sensitive instruments for the location and evaluation of mineral deposits. Problems involved in the development and exploitation of the ore body and the benefaction and marketing of valuable constituents must be determined in advance. Mining must be carried out efficiently, safely, and economically, with the welfare of the public as a primary consideration. Land must be restored to a useful condition after mining ceases and pollution controls must be designed to prevent harmful environmental effects.

Intensive research programs are conducted at UMR in explosives engineering, coal beneficiation, mineral economics, mine operations and design, mine atmospheric control and ventilation, minerals transportation, and various fields or rock mechanics. Appropriate research by faculty and graduate students ensures relevance of the program to industry needs.

An Experimental Mine and the Rock Mechanics and Explosives Research Center are located close to the campus and provide facilities for laboratory instruction and research. Trips to coal, metal, and industrial mineral operations supplement classroom activities. Summer employment and co-op training provide valuable practical mining and engineering expertise.

MISSION STATEMENT

The overall objectives of the Department of Mining Engineering are to provide the students with a specialized expertise in mining engineering, a cultural foundation and a sound basis for future growth and development. These objectives are achieved at the undergraduate level by providing education in basic sciences, engineering sciences and design, and in the field of humanities and social sciences.

The mining engineering courses offered focus on providing students with the knowledge necessary to enter a variety of segments of the mining industry. Graduating mining engineers who satisfactorily complete the program criteria, and where appropriate, the quarry option or the explosives emphasis, usually obtain employment in one or more of the following areas: mine engineering, mining operations, the extraction/processing of coal, base metals, precious metals, industrial minerals, quarry industry, explosives industry, construction or demolition, mining equipment suppliers and mining/geotechnical consulting firms.

Faculty

Professors:
R. Lee Aston (Adjunct) J.D., Ph.D., Aston University, UK
Richard L. Bullock[1] (Quenon Chair), D. Eng., UMR
Tad Golosinski, Ph.D., Cracow, Poland
R. Larry Grayson[1] (Department Chair), Ph.D., West Virginia University
Charles Haas[1] (Emeritus), D.Sc., Colorado School of Mines
Marian Mazurkiewicz (Emeritus), D.Sc. Wroclaw University, Poland
Lee W. Saperstein[1], D. Phil, Oxford University
David Summers (Curators'), Ph.D., Leeds
John W. Wilson (Emeritus), Ph.D., University of the Witwatersrand
Paul N. Worsey, Ph.D., University of Newcastle-Upon-Tyne

Associate Professors:
Jerry C. Tien[1], Ph.D., UMR

Assistant Professor:
Derek Apel, Ph.D., Queens University,Kingston, Canada

Adjunct Professor:
R. Karl Zipf[1], Ph.D., Penn State

[1] Registered Professional Engineer

Bachelor of Science Mining Engineering

FRESHMAN YEAR
(See Freshman Engineering Program)
[1,2]

SOPHOMORE YEAR

First Semester	Credit
Mi Eng 110-Surveying for Mineral Engineers	3
Mi Eng 151-Intro to Mining Safety	1
Math 22-Calculus & Analytic Geometry III	4
Cmp Sc 73, Cmp Sc 77 or Cmp Sc 53.	3
English 65-Tech Writer in Bus & Industry	3
Econ 121-Prin of Microecon or Econ 122-Prin of Macroecon	3
	17

Second Semester	
Geo 125-Physical Mineralogy & Petrology	3
Geo 220-Structural Geology	4
Physics 24-Engineering Physics II	4
Bas En 50-Eng Mechanics-Statics	3
Math 204-Elementary Differential Equations	3
	17

JUNIOR YEAR

First Semester	Credit
Mi Eng 221-Mining Exploration	3
Mi Eng 270-Mining Industry Economics	3
Cv Eng 230-Elementary Fluid Mechanics	3
El Eng 282-Electrical Circuits & Machines	3
Bas En 110-Mechanics of Materials	3
Mc Eng 227-Thermal Analysis	3
	18

Second Semester	
Bas En 150-Engineering Mechanics-Dynamics	2
Mi Eng 218-Mine Atmosphere Control	3
Mt Eng 242-Mineral Process Lab	1
Mi Eng 231-Rock Mechanics I	3
Mt Eng 241-Principles of Mineral Processing	2
Mi Eng 307-Principles of Explosives Engineering	3
Humanities\Social Sciences[2]	3
	17

SENIOR YEAR

First Semester	Credit
Mi Eng 217-Mine Power,Drainage & Transportation	3
Mi Eng 325-Mining Methods	4
Mi Eng 343-Coal Mine Development & Production or Mt Eng 353-Mineral Processing II[4]	3
Humanities\Social Sciences[2]	4
	14

Second Semester'	
Mi Eng 322-Mine Management	2
Mi Eng 376-Mined-Land Reclamation[4]	3
Mi Eng 393-Mine Planning and Design	4
Technical Elective[3,4]	3
Technical Elective[3,4]	3
Humanities/Social Sciences[2]	3
	18

NOTE:

1 History 175 may be substituted by Political Science 90, History 112, or 176.

2 The Department requires a total of 16 credit hours of Hum & Soc Sci courses (including Econ 121/122). These courses are to be chosen from a list of courses approved by your advisor and at least two courses (6 hours) that built on depth must be taken.

3 For students with Explosives Engineering Emphasis, Mi Eng 350 (Blasting Tech) has to be taken as a Technical Elective. Additional 3 hours to be taken in Junior year from the following: Mi Eng 301,390 (Special Topics and Mining Research, both in an explosive area), or Ge Eng 371 (Rock Engineering).

4 For students with Quarrying Emphasis, Cv Eng 216 (Construction Materials) has to be taken as a Technical Elective and Mt Eng 353 (Mineral Processing II) will replace Mi Eng 343 (Coal Mining).

5 Mining courses in italics are offered every semester.

6 All Mining Engineering students must take the Fundamentals of Engineering Examination prior

to graduation. A passing grade on this examination is not required to earn a B.S. degree, however, it is the first step toward becoming a registered professional engineer. This requirement is part of the UMR assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Requirements for a Minor in Mining Engineering

A student who receives a Bachelor of Science degree in an accredited engineering program from UMR may receive the Minor in Mining Engineering by completing 15 credit hours from the courses listed below. Non-engineering students who have a strong background in mathematics and the physical sciences may also qualify for the Minor in Mining Engineering, with the approval of the Department and based on an individually designed program of study. Students will need to consult with the Chair of the Mining Engineering Department to determine pre-requisite requirements for each course. The program granting the Bachelor of Science degree shall determine whether or not courses taken for the Mining Engineering Minor may also be used to fulfill the requirements of the B.S. degree from that program.

The following courses are required for the Minor in Mining Engineering:

Mi Eng 221-Mining Exploration
Mi Eng 324-Underground Mining Methods & Equipment
Mi Eng 326-Surface Mining Methods & Equipment

Two other Mi Eng 200- or 300- level lecture courses (3 credit hours), or relevant courses from other disciplines, as approved, must be taken to match the student's area of emphasis in Mining Engineering. The following areas of emphasis may be pursued:

Explosives Engineering; Quarrying; Mineral Economics; Mining-Environmental; Mining-Equipment; Mining-Geo-technical; Mining-Health and Safety; Mining Operations Management; Mining-Tunneling; Surface Mining; Underground Mining.

The Minor in Mining Engineering is not accredited by the Accreditation Board of Engineering and Technology (ABET).

Quarrying Engineering Emphasis

Senior year

a) Cv Eng 216 (Construction Materials) in lieu of Technical Elective.
b) Mt Eng 353 (Mineral Processing II) in lieu of Mi Eng 343 (Coal Mine Development and Production).

Explosives Engineering Emphasis

Junior and Senior Years

a) Choose one of the following courses in lieu of Mt Eng 121 (Metallurgy for Engineers) in Junior year:
   Mi Eng 390-Research in explosives area
   Mi Eng 301-Special Topics in explosives area
   Ge Eng 371-Rock Engineering
b) Mi Eng 350-(Blasting Design & Technology) in lieu of Technical Elective in Senior Year

MINING ENGINEERING COURSES

003 Principles of Mining Engineering [Lect 1.0] Principles and definitions related to mining engineering including one or more field trips to familiarize the student with current mining practices.

110 Surveying for Mineral Engineers [Lect 2.0 and Lab 1.0] 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. Prerequisites: Bas En 20, Math 6, accompanied or preceded by Mi Eng 003.

151 Introduction to Mining Safety [Lab 1.0] Instruction in the safety aspects of mining 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. Prerequisite: Accompanied or preceded by Mi Eng 3.

200 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

201 Special Topics [Variable] This course is designed to give the department an **202 Mine Rescue** [Lab 1.0] 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: Mi Eng 151.

217 Mine Power, Drainage & Transportation [Lect 2.0 and Lab 1.0] Engineering principles of utilities and material distribution throughout mines. Principles of supporting mining operations. Mining applications of materials handling and transport, conveyors, slurries, mine hoists, rail haulage, electrical power, air conditioning, air compressors, pumps and drainage, and hydraulics. Prerequisites: Cv Eng 230, El Eng 282, and as prereq./coreq. Mc Eng 227.

218 Mine Atmosphere Control [Lect 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: Cv Eng 230, El Eng 282, and as prereq./coreq. Mc Eng 227.

221 Mining Exploration [Lect 3.0] Classification of mineral deposits. Mining laws. Role of mining and processing in defining orebodies. Geology, geophysics, geochemistry, geobotany, and drilling in mineral exploration. Sampling orebodies. Ore reserve modeling. Introduction to probability, statistics, and geostatistics. Reserve estimation project. Prerequisites: Geo 220, Mi Eng 110, and as prereq. or coreq. Geo 113.

224 Underground Mining of Metallic and Industrial Minerals [Lect 3.0] Principles utilized in the development of metallic and industrial mineral deposits into productive entities by underground mining methods, including ground support, equipment selection and coordination, economics safety, and overall operational considerations. Prerequisites: Mi Eng 221, 270.

226 Surface Mining of Metallic and Industrial Minerals [Lect 3.0] Principles utilized in the development of metallic and industrial mineral deposits into productive entities by surface mining methods, including bank stability, benching, equipment selection and coordination, economics, safety and overall operational considerations. Prerequisites: Mi Eng 221, 270.

231 Rock Mechanics I [Lect 2.0 and Lab 1.0] Rock as an engineering material; elastic and non-elastic properties; Mohr's criterion for failure; slope and highwall stability; field stresses; elastic design of underground openings, pillars, and roof beams; principles of roof-bolt design; surface subsidence; and rock testing methods. Prerequisites: Bas En 110, 120 and either Mi Eng 221 or Cv Eng 215 or Geo 130 & 220.

270 Mining Industry Economics [Lect 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 economic significance of mineral resources. Prerequisites: Econ 121 or 122, accompanied or preceded by Mi Eng 221.

300 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

301 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

302 Computer Applications in the Mining & Minerals Industry [Lect 2.0 and Lab 1.0] History of computer technology usage in the mining industry. Exposure to the use of computers in mine planning, design, exploration, ventilation & environment, rock mechanics, open pit stability, simulation of mining systems and equipment selection.

305 Explosives Handling and Safety [Lect 1.0] Basic handling & safety for explosives, explosive devices and ordnance related to laboratory handling, testing, manufacturing & storage, for both civil and defense applications. For "credit offering" of the UMR Explosives Handling & Safety Industrial Short Course.

306 Material Processing by High-Pressure Water Jet [Lect 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 Mc Eng 306)

307 Principles of Explosives Engineering [Lect 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: Ge Eng 50; accompanied or preceded by either Cv Eng 215 or Geo 220.

308 Drilling and Blasting [Lect 1.0 and Lab 1.0] The mechanics of rock breakage in drilling and blasting. Drill equipment systems, and the application of engineering principles in the design of blasting rounds for construction and mining excavation problems. Prerequisite: Mi Eng 307.

11 Mine Plant Management [Lect 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.

317 Mining Equipment Design and Maintenance [Lect 2.0 and Lab 1.0] This course will teach the basic understanding of mining machine design principles with special attention placed on kinematics, assembly and disassembly as well as maintenance procedures and techniques involved. Prerequisite: Mi Eng 217.

318 Mine Atmospheric Control II [Lect 2.0 and Lab 1.0] 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: Mi Eng 218.

322 Mine Management [Lect 2.0] 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, with emphasis in presentation skills. Prerequisite: Completion of 120 credits in Mining Engineering curriculum.

325 Mining Methods for Metal and Industrial Minerals [Lect 4.0] The process of developing metallic and industrial mineral deposits into productive entities. Principles of planning, constructing, and operating economically viable underground and surface mines. Cost effective mining methods and equipment selection. Principles of operation and coordination of mining projects. Stoping methods, benching methods. Prerequisites: Mi Eng 221, 270.

343 Coal Mine Development and Production [Lect 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 Mi Eng 217.

344 Coal Preparation [Lect 2.0 and Lab 1.0] Coal properties, sampling, testing, breaking, sizing, cleaning and dewatering. Disposal of refuse. Prerequisites: Mt Eng 241 and senior standing.

345 Strata Control [Lect 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: Mi Eng 231.

350 Blasting Design and Technology [Lect 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. Prerequisite: Mi Eng 307.

370 Valuation of Mineral Properties [Lect 3.0] Engineering principles utilized for establishing values of metallic, fuel, and industrial mineral deposits; reserve estimation from exploration samples, geostatistics; mine taxation; influence and sensitivity analyses; alternative valuation techniques. Prerequisite: Mi Eng 270.

376 Mined-Land Reclamation [Lect 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: Ge Eng 50 and prerequisite or co-requisite, one of Ge Eng 246, Cv Eng 215 or Mi Eng 226. (Co-listed with Ge Eng 376)

383 Tunneling & Underground Construction Techniques [Lect 2.0 and Lab 1.0] 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: Mi Eng 231, Mi Eng 325 or Cv Eng 215, Cv Eng 216 or Ge Eng 371.

390 Undergraduate Research [Variable] 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.

393 Mine Planning and Design [Lect 2.0 and Lab 2.0] Selection of a mining design project that results in the preparation of a comprehensive engineering report and oral presentation for the economic exploitation of the selected geologic deposit. The course includes instruction and student guidance that integrates and applies engineering economics, sciences, use of commercial software & principles to develop a mineable deposit. Prerequisite: Completion of 120 hours in Mining Engineering curriculum.

Nuclear Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy
Doctor of Engineering

The Nuclear Engineering Department has a primary mission to provide an outstanding and comprehensive undergraduate and graduate education to tomorrow's leaders in nuclear engineering. The department provides quality trained nuclear engineering professionals and leaders to Missouri and the nation, in the commercial nuclear industry, national laboratories, hospitals, and the nation's defense agencies. The objective of the Bachelor of Science program is to provide each student with sound fundamental knowledge of nuclear engineering and related technologies, extensive hands-on laboratory experience including reactor operations, technical communication and leadership skills, and the capability to conduct research related to the nuclear engineering field.

The department is committed to a strong engineering program administered by highly motivated and active nuclear engineering faculty; it is the only B.S. Nuclear Engineering Degree program accredited in the state of Missouri. The Nuclear Engineering department at UMR, one of the earliest accredited undergraduate programs in the nation, interacts with professional societies, and the nuclear industry to promote continuing education, research opportunities, and public dissemination of information about issues and advances in the field.

Nuclear engineers develop and promote the utilization of energy released from nuclear fission, fusion, and the decay of radioisotopes. Currently, there are more than 100 nuclear power plants operating in the United States producing about 20 percent of our nation's electricity. These plants use nuclear fission to produce energy and are cooled by ordinary (light) water, hence the name, Light Water Reactors. This technology reduces utility emissions of carbon dioxide, the primary greenhouse gas, by about 20 percent each year. In addition, nuclear reactors are used for the propulsion of submarines and aircraft carriers.

In fusion power plants, under development, strong magnetic fields contain a plasma fuel of hydrogen isotopes, such as deuterium, at temperatures hotter than the sun. The deuterium extracted from one gallon of water could produce as much energy as burning 300 gallons of gasoline.

Radioisotopes are used in industry and research, and in medicine for diagnostic and therapeutic purposes. The medical use of radioisotopes and X-rays saves hundreds of thousands of lives every year throughout the world. Radioisotopes are also used in small power generators for space flights.

If you choose nuclear engineering, you could work in the areas of nuclear reactor design, plant licensing, plant operation, fuel management and development, radioactive waste disposal, health physics, instrumentation and control, fusion research, space nuclear power, and applications of radioisotopes in industry, medicine, and research. As a nuclear engineer you might be employed by utilities, reactor vendors, architect-engineering firms, consulting firms, industrial research centers, national laboratories, government agencies or universities.

The nuclear engineering curriculum consists of three components: mathematics and basic sciences, humanities and social sciences, and engineering topics. The students apply the principles of physics, chemistry and mathematics to the study of engineering topics which include statics, mechanics of materials, electronic circuits and machines, thermodynamics, and metallurgy. The knowledge gained in these areas is applied to the understanding of nuclear engineering topics including reactor fluid mechanics and heat transfer, reactor physics, nuclear radiation measurements, radioactive waste management, reactor laboratory and operation, nuclear materials, and nuclear systems design (a Capstone design course).

Engineering design is an integral part of almost all of the required courses in the nuclear engineering program. Design topics include but are not limited to reactor cooling systems, radiation protection, structural components, waste disposal and transportation systems, nuclear reactor cores and the design of experiments for radiation detection and measurement. While obtaining experience in these areas the students are prepared for designing a complete nuclear system such as a nuclear plant for electric power generation, space propulsion and communication, desalination, district heating or radioisotope production for industrial, medical or research applications.

In the senior Nuclear Systems Design course (Nu Eng 323), students work in small groups of two or three on different components of a system. They interact and exchange ideas with the nuclear engineering faculty and other groups on a weekly basis both collectively and individually in the form of reports and oral presentations. In this course, all of

the knowledge acquired by the students including that in the humanities and social sciences, is brought to bear on the selection of the final design. In addition to the technical considerations, the issues addressed include economics, safety, reliability, aesthetics, ethics, and social impact. At the end of the semester the students write a comprehensive and cohesive final report for their final design and make an oral presentation of their work.

Laboratory facilities available to nuclear engineering students include a radiation measurements laboratory, a 200 kW swimming pool-type nuclear reactor, a materials analysis laboratory, and a computer learning center. The students have access to state-of-the-art computing facilities including personal computers, workstations, mainframes, and super computers. The department offices and laboratories are primarily housed in Fulton Hall. The nuclear reactor is housed in its own building.

MISSION STATEMENT

The Nuclear Engineering Department has a primary mission to provide an outstanding and comprehensive undergraduate and graduate education to tomorrow's leaders in nuclear engineering. The Nuclear Engineering Department provides quality trained nuclear engineering professionals and leaders to Missouri and the nation, in the commercial nuclear industry, national laboratories, hospitals, and the nation's defense departments. The goal of the Bachelor of Science program is to provide each student with sound fundamental knowledge of nuclear engineering and related technologies, extensive hands-on laboratory experience including reactor operations, technical communication and leadership skills, and the capability to conduct research related to the nuclear engineering field.

The department is committed to a strong engineering program administered by highly motivated and active nuclear engineering faculty; it is the only B.S. Nuclear Engineering Degree program accredited in the state of Missouri. The Nuclear Engineering department at UMR, one of the earliest accredited undergraduate programs in the nation, interacts with professional societies, and the nuclear industry to promote continuing education, research opportunities, and public dissemination of information about advances in the field.

Faculty

Professors:
Ray Edwards[1], Sc.D., MIT
Arvind Kumar (Department Chair), Ph.D., California-Berkeley
Nicholas Tsoulfanidis[1] (Associate Dean of Mines & Metallurgy), Ph.D., Illinois

Associate Professors:
Shahla Keyvan, Ph.D., California-Berkeley
Gary Mueller[1], Ph.D., UMR

Assistant Professor: Akira Tokuhiro, Ph.D., Purdue University

Adjunct Professor:
David A. Summers, Ph.D., The University of Leeds, England

Associate Professor Emeritus:
Albert Bolon[1], Ph.D., Iowa State

[1] Registered Professional Engineer

Bachelor of Science Nuclear Engineering

FRESHMAN YEAR
(See Freshman Engineering Program)[1,2]

SOPHOMORE YEAR

First Semester	Credit
Cmp Sc 73-Basic Scientific Programming	2
Cmp Sc 77-Computer Programming Lab	1
Bas En 50 or Bas En 51-Eng Mech-Statics	3
Math 22-Calculus w/Analytic Geometry III	4
Nu Eng 105-Intro to Nuclear Engineering	2
Physics 24-Engineering Physics II	4
	16

Second Semester	
Cmp Sc 228-Intro to Numerical Methods	3
El Eng 282-Electrical Circuits & Machines	3
Electives-Econ(3)	3
Bas En 110-Mechanics of Materials	3
Math 204-Elem Diff Equations	3
Nu Eng 203-Interactions of Radiation w/Matter or Physics 107-Intro to Modern Physics	3
	18

JUNIOR YEAR

First Semester	Credit
Mc Eng 219-Thermodynamics	3
Stat 215-Engineering Statistics	3
Mt Eng 121-Metallurgy for Engineers	3
Nu Eng 205-Fundamentals of Nuclear Engineering	3
Nu Eng 221-Reactor Fluid Mechanics	3
	15

Second Semester	
English 160-Technical Writing	3
Elective-Engineering/Science/Math(4)	3
Nu Eng 204-Nuclear Radiation Measurements	3
Nu Eng 223-Reactor Heat Transfer	3
Nu Eng 303-Reactor Physics I	3
Nu Eng 321-Nuclear Power Plant Design	3
	18

SENIOR YEAR

First Semester	Credit
Elective-Hum or Soc Sc[5]	3
Elective-Engineering/Science/Math[6]	2
Nu Eng 304-Reactor Lab I	2
Nu Eng 310-Seminar	0.5
Nu Eng 311-Reactor Physics II	3
Nu Eng 341-Nuclear Materials I	3
Nu Eng 307-Nuclear Fuel Cycle	3
	16.5

Second Semester	
Elective-Hum or Soc Sci[7]	6
Elective-Engineering\Science\Math[4]	3
Nu Eng 306-Reactor Operation	1
Nu Eng 308-Reactor Lab II	2
Nu Eng 310-Seminar	0.5
Nu Eng 323-Nuclear System Design	3
	15.5

(1) Nuclear Engineering students are expected to take Nuclear Technology Applications (Nu Eng 25) during their Freshman Year. Minimum credit hours for graduation is 135.
(2) See Freshman Engineering Program.
(3) Econ 121 or 122.
(4) To be selected from approved departmental course list. Must include one 3.0 credit hour 300 level math course.
(5) Humanities and Social Science courses from approved departmental course list.
(6) Any 300 level course from Engineering/ Science/Math, e.g. Mc Eng 240, Nu Eng 309, Nu Eng 333 or any 2 credit Special Topics 300 class.
(7) Humanities and Social Science courses for depth from approved departmental course list.

Fundamentals of Engineering Exam: All Nuclear Engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree, however, it is the first step toward becoming a registered professional engineer. This requirement is part of the UMR assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Minor Curriculum

Nuclear power plants and other nuclear installations employ not only nuclear but also civil, mechanical, electrical, and chemical engineers. A nuclear engineering minor, therefore, enhances the academic credentials of a student and broadens his/her employment choices. A minimum of 15 hours is required for a minor in nuclear engineering.

Before the courses listed below can be taken, the student should have completed Elementary Differential Equations (Math 204 or equivalent) and Atomic and Nuclear Physics (Physics 107 or Nu Eng 203 or equivalent). Required courses are:

Nu Eng 204 Nuc Radiation Measurements (3 hrs)
Nu Eng 205-Fundamentals of Nu Eng (3 hrs)
Nu Eng 223-Reactor Heat Transfer (3 hrs)

The other 6 hours should be selected from nuclear engineering 300-level courses.

NUCLEAR ENGINEERING COURSES

025 Nuclear Technology Applications [Lect 1.0] It is a project oriented course that examines various aspects of nuclear technology, such as radiation detection, radiation protection, food irradiation, medical and industrial applications. The students will work in small groups on stimulating projects. 15.5

105 Introduction to Nuclear Engineering [Lect 2.0] Atoms and nuclei; nuclear reactions; radioactivity, interactions of radiation with matter; fission and fusion reactors; nuclear fuels; radiation effects on materials and man; radioactive waste disposal; reactor safety; radiation protection. Prerequisite: Sophomore standing.

200 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

201 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

203 Interactions of Radiation with Matter [Lect 3.0] Atoms and nuclei; relativistic kinematics; quantum theory; nuclear decay; cross sections; neutron, gamma, and charged particle interactions; production of radioisotopes; electrical, thermal and magnetic properties of solids. Prerequisites: Math 22, Physics 21.

204 Nuclear Radiation Measurements [Lect 2.0 and Lab 1.0] Acquaints the student with theory and operation of the principal experimental tools, methods, radiation detectors and measuring devices used by a nuclear engineer or nuclear scientist in experiments dealing with atomic and nuclear phenomena. Prerequisites: Nu Eng 203 or Physics 107, and preceded or accompanied by each of English 160 and Stat 215.

205 Fundamentals of Nuclear Engineering [Lect 3.0] An introduction to the principles and equations used in nuclear fission reactor technology, including reactor types; neutron physics and reactor theory; reactor kinetics and control; radiation protection; reactor safety and licensing; and environmental aspects of nuclear power. Prerequisite: Preceded or accompanied by Nu Eng 203 or Physics 107.

221 Reactor Fluid Mechanics [Lect 3.0] A study of the fundamental principles of incompressible viscous and inviscid flows in ducts, nozzles, tube bundles and applications to nuclear engineering; fluid statics; dimensional analysis and similitude; boundary layer theory. Prerequisite: Mc Eng 219.

223 Reactor Heat Transfer [Lect 3.0] A study of the fundamental principles of conduction, convection and thermal radiation with volumetric source terms for nuclear engineering applications; empirical correlations; finite difference methods; analysis of nuclear reactor cores. Prerequisite: Nu Eng 221.

300 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

301 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

303 Reactor Physics I [Lect 3.0] Study of neutron interactions, fission, chain reactions, neutron diffusion and neutron slowing down; criticality of a bare thermal homogeneous reactor. Prerequisites: Math 204 and Nu Eng 203 or Physics 107.

304 Reactor Laboratory I [Lect 1.0 and Lab 1.0] Acquaints the student with neutron flux measurement, reactor operation, control rod calibration, reactor power measurement and neutron activation experiments. Experiments with the thermal column and neutron beam port are also demonstrated. Prerequisites: English 160, Nu Eng 204 and 205.

306 Reactor Operation [Lab 1.0] The operation of the training reactor. The program is similar to that required for a NRC license. Prerequisite: Nu Eng 205.

307 Nuclear Fuel Cycle [Lect 3.0] Nuclear fuel reserves and resources; milling, conversion, and enrichment; fuel fabrication; in-and-out-of core fuel management; transportation, storage, and disposal of nuclear fuel; low level and high level waste management, economics of the nuclear fuel cycle. Prerequisite: Nu Eng 205.

308 Reactor Laboratory II [Lect 1.0 and Lab 1.0] A continuation of Nuclear Engineering 304 with experiments of a more advanced nature. Prerequisite: Nu Eng 304.

309 Licensing of Nuclear Power Plants [Lect 2.0] The pertinent sections of the Code of Federal Regulations, the Nuclear Regulatory Commission's Regulatory Guides and Staff Position Papers, and other regulatory requirements are reviewed. Safety analysis reports and environmental reports for specific plants are studied.

310 Seminar [Variable] Discussion of current topics. Prerequisite: Senior standing.

311 Reactor Physics II [Lect 3.0] Analytic and computer based methods of solving problems of reactor physics. Prerequisites: Nu Eng 303, Cmp Sc 228.

315 Space Nuclear Power and Propulsion [Lect 3.0] A study of the design, operation and application of radioisotope power generators and nuclear reactors for space power and propulsion systems used on both manned and unmanned missions. Prerequisite: Math 204.

321 Nuclear Power Plant Design [Lect 3.0] A study of current nuclear power plant concepts and the environmental economics and safety considerations affecting their design. Includes such topics as: thermal, mechanical and electrical aspects of nuclear power facilities, and the nuclear fuel cycle. Prerequisites: Nu Eng 205 and Mc Eng 219.

323 Nuclear System Design [Lect 3.0] A complete design of a nuclear system (e.g.a fission or fusion nuclear reactor plant, a space power system, a radioactive waste disposal system). Prerequisites: Nu Eng 311, 321.

333 Health Physics [Lect 2.0] Radiation sources, dose calculations, dose units, biological effects of radiation, federal and state regulations regarding radiation, proper use of radioisotopes, operation and use of health physics instruments and dosimeters. Prerequisite: Nu Eng 203 or Physics 107.

335 Radiation Protection Engineering [Lect 3.0] The stopping of charged particles, photons, and neutrons by matter. Sources of radiation (nuclear reactors, radioactive wastes, x-ray machines, and accelerators). Biological effects of radiation. Radiation protection guides. Radiation shield design. Prerequisite: Nu Eng 205.

341 Nuclear Materials I [Lect 3.0] Fundamentals of materials selection for components in nuclear applications, design and fabrication of UO2 fuel; reactor fuel element performance; mechanical properties of UO2; radiation damage and effects, including computer modeling; corrosion of materials in nuclear reactor systems. Prerequisites: Nu Eng 205, Mt Eng 121. (Co-listed with Mt Eng 341)

345 Radioactive Waste Management and Remediation [Lect 3.0] Sources and classes of radioactive waste, long-term decay, spent fuel storage, transport, disposal options, regulatory control, materials issues, site selection and geologic characterization, containment, design and monitoring requirements, domestic and foreign waste disposal programs, economic and environmental issues, history of disposal actions, and conduct of remedial actions and

clean up. Prerequisite: Math 204. (Co-listed with Geo 345)

351 Reactor Kinetics [Lect 3.0] Derivation and solutions to elementary kinetics models. Application of the point kinetics model in fast, thermal reactor dynamics, internal and external feedback mechanism. Rigorous derivation and solutions of the space dependent kinetics model fission product and fuel isotope changes during reactor operation. Prerequisite: Nu Eng 205.

361 Fusion Fundamentals [Lect 3.0] Introduction to the plasma state, single particle motion, kinetic theory, plasma waves, fusion, power generation, radiation mechanisms, inertial confinement and fusion devices, including conceptual fusion power plant designs. Prerequisite: Preceded or accompanied by Math 204.

381 Probabilistic Risk Assessment I [Lect 3.0] A study of the techniques for qualitative and quantitative assessment of reliability, safety and risk associated with complex systems such as those encountered in the nuclear power industry. Emphasis is placed on fault tree analysis. Prerequisite: Nu Eng 205.

390 Undergraduate Research [Variable] 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.

Petroleum Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy
Doctor of Engineering

Anyone interested in providing adequate and safe fossil energy for the future should consider a career in petroleum engineering.

Because of the demand for oil and gas and advances in petroleum technology, the field of petroleum engineering plays an important role in the world today. As a petroleum engineering student, you will study the technology of oil and gas drilling, production, reserves estimation, and the prediction of future production. You will also study the various techniques for evaluating the characteristics of Petroleum bearing formations and their fluid contents. Modern experimental and computational tools are utilized to study the technology of well logging, well testing, well stimulation, petroleum reservoir engineering, secondary and tertiary recovery and geology. Other areas of study will include: economic analysis of oil and gas production, reservoir simulation, and artificial lift methods.

Recent curriculum changes have been made to keep pace with rapid advances in well testing, computer simulation, environmental concerns, and advanced drilling techniques.

Mission Statement

The mission of the Petroleum Engineering program is (1) to maintain a quality undergraduate program, and (2) to promote a small, high quality graduate program. It is believed the second objective helps both faculty and students in achieving quality at the undergraduate level. The undergraduate program is designed to provide a well-rounded, technically strong curriculum to prepare students for a successful professional career, or for advanced study in Petroleum Engineering or other professional areas. The emphasis of the undergraduate program is on reservoir engineering; however, in preparing students for all aspects of the industry, courses are also offered in drilling and production engineering. With the current industry innovations, resulting in a combination of production and reservoir duties in many companies, courses in these areas have incorporated an integration of these concepts.

Faculty

Professors:

Leonard F. Koederitz[1], (Distinguished Teaching Professor), (Department Chair), Ph.D., University of Missouri-Rolla

Daopu T. Numbere, Ph.D., University of Oklahoma

Associate Professors:

Shari Dunn-Norman, Ph.D., Heriot-Watt

Anuj Gupta[1], Ph.D., University of Texas at Austin

[1] Registered Professional Engineer

Bachelor of Science
Petroleum Engineering

FRESHMAN YEAR

(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Pe Eng 141-Prop of Hydrocarbon Fluids	3
Ge Eng 50-Geology for Eng	3
Math 22-Calc w/Analytic Geom III	4
Physics 24-Eng Physics II	4
Cmp Sc 74-Intro to Prog Meth[1]	2
Cmp Sc 78-Prog Meth Lab[1]	1
	17

Second Semester
Econ 121-Microecon or 122-Macroecon 3
Math 204-Elem Diff Equa 3
Pe Eng 131-Drill Pract & Well Comp 3
Pe Eng 132-Petro Prod Lab 1
Bas En 50 or Bas En 51-Statistics 3
History 176-Amer Hist Since 1877[2] 3
16

JUNIOR YEAR
First Semester Credit
Pe Eng 241-Petr Reservoir Eng 3
Pe Eng 242-Petr Reservoir Lab 1
Pe Eng 232-Well Logging I 3
El Eng 281 or El Eng 282-El Circuits 3
Chem 221- or 241 or Geop 285 or 385 3
Cv Eng 230-Elem Fluid Mech 3
16

Second Semester
SP&MS 85-Princ of Speech 3
Pe Eng Tech Elective 3
Pe Eng 257-Petro Econ 3
Bas En 150-Eng Mech-Dyn 2
Bas En 110-Mech of Mat 3
Ge Eng/Geology Elective[3] 3
17

SENIOR YEAR
First Semester Credit
Pe Eng 316-Prod App 3
Mc Eng 227-Thermal Analysis 3
Pe Eng 310-Seminar 1
Pe Eng Tech Elective 3
Adv Hum/Soc Sci Elective 3
Adv Math/Stat or Cmp Sc Elective 3
16

Second Semester
Pe Eng 335-Second Recovery of Petro 3
Pe Eng Tech Elective 3
Geo 340-Petro Geology[4] 3
Adv Hum/Soc Sci Elective 3
English 160-Tech Writing 3
Pe Eng 347-Petro Eng Design 3
18

1 or Bas En 20, if Cmp Sc 73-77 selected in Freshman Year Program
2 or Pol Sc 90, Hist 112,175
3 to be selected from Geo 220, Ge Eng 343, Ge Eng 248 or Ge Eng 335
4 All Petroleum Engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree, however, it is the first step toward becoming a registered professional engineer. This requirement is part of the UMR assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

The total number of credit hours required for a degree in Petroleum Engineering is 135.

The assumption is made that a student admitted to a department has completed 35 hours credited towards graduation. The academic program of students transferring from colleges outside of UMR will be decided on a case by case basis.

Humanities/Social Science electives are to be selected from a list of approved courses and the sequence of course selection must provide both breadth and depth of content.

Petroleum Engineering students must earn the grade of "C" or better in all Petroleum Engineering courses to receive credit toward graduation.

Minor Curriculum in Petroleum Engineering

The Petroleum Industry employs not only Petroleum but also Civil, Electrical, Chemical, Geological, Mechanical and other engineers. A Petroleum Engineering minor, therefore, enhances the academic credentials of a student and broadens their employment choices. A minor in Petroleum Engineering requires 15 hours of UMR credit to include the following:

Required Course/Times Offered Hours
Pe Eng 131 Fall & Spring Semester ..... 3 hrs.
Pe Eng 141 Fall ..... 3 hrs.
Pe Eng 241 Fall ..... 3 hrs.
Pe Eng 316 Fall or Pe Eng 335 Spring ..... 3 hrs.
One elective course* ..... 3 hrs.
Total 15 hrs.

*The elective course is to be selected from any other 200 or 300 level Petroleum Engineering courses offered except Seminars.

PETROLEUM ENGINEERING COURSES

131 Drilling Practices and Well Completions [Lect 2.0 and Lab 1.0] Properties and occurrence of petroleum; petroleum exploration, equipment, materials, and processes employed in drilling and production practices; well completions; oil field operation. Prerequisites: Preceded or accompanied by Math 21 and Physics 23.

132 Petroleum Production Laboratory [Lab 1.0] Properties and chemical treatment of oil well drilling mud; methods of field testing; synthesis of drilling muds; properties of well cements, oil well brines, oil field emulsions;

specialized oil field equipment operation. Prerequisite: Accompanied by Pe Eng 131.

141 Properties of Hydrocarbon Fluids [Lect 3.0] Physical properties of petroleum fluids; chemical components of petroleum fluids. Elementary phase behavior; calculations of the physical properties of gases, liquids, and gas-liquid mixtures in equilibrium. Prerequisites: Chem 3, preceded or accompanied by Cmp Sc 53 or Cmp Sc 73 and Cmp Sc 77.

200 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

201 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

232 Well Logging I [Lect 2.0 and Lab 1.0] An introduction to the electrical, nuclear, and acoustic properties of rocks: theory and interpretation of conventional well logs. Prerequisite: Physics 24 or 25.

241 Petroleum Reservoir Engineering [Lect 3.0] Properties of reservoir formations and fluids; reservoir mechanics including fluid flow through reservoir rock, capillary phenomena, material balance, volumetric analyses, drive mechanisms. Prerequisites: Math 22, accompanied or preceded by Pe Eng 141 or senior standing.

242 Petroleum Reservoir Laboratory [Lab 1.0] Core analysis determination of intensive properties of crude oil and its products; equipment and methods used to obtain petroleum reservoir information. Prerequisite: Accompanied by Pe Eng 241.

257 Petroleum Valuation and Economics [Lect 3.0] Estimation of oil and gas reserves; engineering costs; depreciation; evaluation of producing properties; federal income tax considerations; chance factor and risk determination. Prerequisites: Pe Eng 241, Econ 121 or Econ 122.

271 Fundamental Digital Applications in Petroleum Engineering [Lect 3.0] Applications of Windows-based Visual Basic solutions to engineering problems including selected topics in fluid flow, PVT behavior, matrices in engineering solutions, translating curves to computer solutions, predictor-corrector material balance solutions, and graphical display of results. Prerequisite: Junior Standing.

300 Special Problems [Variable] Problems or readings on specific subjects or projects in the department. Consent of instructor required.

301 Special Topics [Variable] This course is designed to give the department an opportunity to test a new course. Variable title.

302 Offshore Petroleum Technology [Lect 3.0] An introduction to both the practical and theoretical aspects of development of offshore oil fields. Practical problems include current drilling and workover procedures, oil storage methods, and oil transportation problems. Theoretical topics which are introduced include the prediction of wind, wave, and current forces. Prerequisite: Pe Eng 131.

303 Environmental Petroleum Applications [Lect 3.0] This course is a study of environmental protection and regulatory compliance in the oil and gas industry. The impact of various environmental laws on drilling and production operations will be covered. Oilfield and related wastes and their handling are described. Federal, state and local regulatory agencies are introduced, and their role in permitting and compliance monitoring is presented. Legal and ethical responsibilities are discussed. Prerequisite: Senior standing.

308 Applied Reservoir Simulation [Lect 3.0] Simulation of actual reservoir problems using both field and individual well models to determine well spacing, secondary recovery prospects, future rate predictions and recovery, coning effects, relative permeability adjustments and other history matching techniques. Co-requisite: Pe Eng 257.

310 Seminar [Lect 1.0] Discussion of current topics. (Course cannot be used for graduate credit). Prerequisite: Senior standing in Pe Eng.

314 Advanced Drilling Technology [Lect 3.0] In-depth studies of cost control; hole problems; well planning; drilling fluids and cuttings transport; hydraulics; pressure control, directional drilling; drill bits; cementing; fishing; wellhead and tubular designs; computer modeling of drilling systems optimized design of drilling procedure. Prerequisites: Pe Eng 131, Cv Eng 230, Cmp Sc 73.

316 Production Applications [Lect 2.0 and Lab 1.0] An introduction to production engineering topics: single and multi-phase flow through pipes; inflow performance; nodal systems analysis; perforating; acidizing; hydraulic fracturing; well completion equipment and practices; production logging; well servicing. Prerequisites: Cv Eng 230, Pe Eng 131, preceded or accompanied by Pe Eng 241.

320 Fundamentals of Petroleum Reservoir Simulation [Lect 3.0] An introduction to petroleum reservoir simulation. Fundamentals of finite difference approximation of the partial differential equations of flow through porous media. Discussion of various simulation schemes, data handling, boundary conditions. Use of a dry gas and black oil simulators. Prerequisites: Cmp Sc 73, Math 204.

323 Artificial Lift [Lect 3.0] This course is a study of artificial lift methods used to produce liquids (oil/water) from wellbores. Methods covered include sucker rod (piston) pumps, electric submersible pumps, gas lift, hydraulic lift and plunger lift. Prerequisite: Pe Eng 241 or equivalent.

329 Applied Petroleum Reservoir Engineering [Lect 3.0] Quantitative study of oil production by natural forces, gas cap, water influx, solution gas, etc.; material balance equations, study of gas, non-retrograde gas condensate, and black oil reservoirs. Predictive calculations of oil recovery from different reservoir types. Prerequisites: Pe Eng 241 and 242.

333 Reservoir Characterization [Lect 3.0] The integration and extrapolation of Geologic, Geophysical, and Petroleum Engineering data for flow model construction.

335 Secondary Recovery of Petroleum [Lect 3.0] Oil recovery by water or gas injection. Various prediction methods. Design of water flooding projects. Cyclic steam stimulation of oil wells, design criteria. Oil recovery from thermally stimulated wells, prediction methods. Brief-introduction to EOR (enhanced oil recovery) methods. Prerequisites: Pe Eng 241, 242, and Mc Eng 227.

341 Well Test Analysis [Lect 2.0 and Lab 1.0] Causes of low well productivity; analysis of pressure buildup tests, drawdown tests, multi-rate tests, injection well fall off tests, and open flow potential tests; design of well testing procedures. Prerequisites: Pe Eng 241 and Math 204.

347 Petroleum Engineering Design [Lect 2.0 and Lab 1.0] The application of engineering principles in the design, selection, and installation of oil field equipment. Prerequisites: Pe Eng 241, 316, Bas En 110.

360 Natural Gas Engineering [Lect 3.0] Gas reserves estimation, deliverability, and future production performance prediction. Deliverability testing of gas wells including isochronal, flow after flow, drawdown and buildup. Gasfield development and underground storage. Gas production metering gauging and transmission. Prerequisite: Preceded or accompanied by Pe Eng 241.