School of Materials, Energy, and Earth Resources

- 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

The Ceramic Engineering program is offered under the department of Materials Science and Engineering.

Ceramic engineers produce materials vital to many advanced and traditional technologies: electronic and optical assemblies, aerospace parts, biomedical components, nuclear components, high temperature, corrosion resistant assemblies, fuel cells, electronic packaging and so on. Ceramic engineers generally work with inorganic, nonmetallic materials processed at high temperatures. In the classroom, ceramic engineering students learn the relationships between engineering properties and the chemistry and structure of ceramic materials and go on to apply these scientific principles to the design of new formulations and manufacturing processes. If you are interested in the "why" of things, ceramic engineering will definitely interest you.

Ceramic engineering usually appeals to those who have a strong interest in finding practical applications of the basic sciences, especially chemistry and physics, and can be described as one of the disciplines where 'science and engineering intersect'. Design occurs at the atomic or microstructural level of solid materials. The UMR department of ceramic engineering specializes in glass and optical materials, electronic materials, and high temperature materials, but the same scientific and engineering principles that are learned can be applied to the design of new materials for other applications, including biomaterials, high strength materials, materials for energy generation, etc.

Most ceramic engineering classes and laboratories are held in McNutt Hall, but other research laboratories on campus are available to our students. Equipment exists for X-ray investigation of materials, for detection of thermally induced changes in chemistry and structure, for high temperature processing, and for measuring a wide variety of electronic, optical, magnetic, mechanical and thermal properties. The Graduate Center for Materials Research makes additional research equipment available to ceramic engineers, including electron microscopes, optical, infrared, and X-ray spectrometers, thermal analyzers, and high temperature/controlled atmosphere furnaces, etc. Students may broaden their experience by assisting faculty in research projects, either for academic credit or for pay.

Undergraduate student organizations are very active and participation in local and national activities is encouraged. Cooperative education and internships are available with companies and research agencies around the country. Additional information about the department is available at http://www.umr.edu/~ceramics/.

Mission Statement

The department will train the future industrial and academic leaders in ceramic engineering by providing a comprehensive, forward-looking and broad-based curriculum, which emphasizes fundamental principles, practical applications, oral and written communication skills, and professional practice and ethics. The department is distinguished by a nationally recognized graduate program that emphasizes research of significance to the State of Missouri and the nation while providing a stimulating educational environment.

The specific objectives of the ceramic engineering program are to:

- Provide a comprehensive, modern ceramic engineering curriculum that emphasizes the application of fundamental knowledge and design principles to solve practical problems;
- Maintain modern facilities for safe, hands-on laboratory exercises;
- Develop oral, written, and electronic communication skills in all students;
- Coordinate leadership and team-building exercises that are needed for success in industrial, research, or academic careers;
- Supplement formal academic training with co-op, summer intern, and department research experience to enhance student preparation for graduate school or careers in industry, research, or academics.
- Promote a dynamic and interactive learning environment in the classrooms and laboratories and enhance student-faculty communications through extra-curricular activities.

Faculty

Professors:

Harlan Anderson (Curators' Professor Emeritus), Ph.D., University of California-Berkeley

Richard Brow, Ph.D., (Department Chair of Materials Science and Engineering), Pennsylvania State University

Delbert Day[1], (Curators' Professor Emeritus), Ph.D., Pennsylvania State University

Fatih Dogan, Ph.D., Technical University of Berlin, Germany

Wayne Huebner, Ph.D., University of Missouri-Rolla

P. Darrell Ownby[1], (Emeritus), Ph.D., Ohio State

Mohamed N. Rahaman, Ph.D., Sheffield, England

Robert Schwartz, Ph.D., University of Illinois-Urbana Champaign

Associate Professors:

Gregory Hilmas, Ph.D., University of Michigan

Jeffrey D. Smith, Ph.D., University of Missouri-Rolla

Assistant Professors:

William Fahrenholtz, Ph.D., University of New Mexico

[1]Registered Professional Engineer

Bachelor of Science
Ceramic Engineering

FRESHMAN YEAR

First Semester	Credit
BE10-Study & Careers in Engr.	1
Chem 1-General Chemistry	4

Chem 2-General Chemistry Lab 1
Chem 4-Intro. Lab Safety 1
Math 14-Calculus For Engineers I 4
Engl 20-Exposition & Argumentation 3
H/SS Elective[1] 3
17

Second Semester
Chem 3-General Chemistry 3
Math 15-Calculus For Engineers II 4
Phys 23-Engineering Physics I 4
H/SS Elective[1] 3
BE 20-Eng Design & Computer Appls. 3
17

SOPHOMORE YEAR

First Semester — Credit
Cr Eng 102-Atomic Structure Cryst 3
Cr Eng 104-Cer in the Modern World 2
Cr Eng 111-Cer Mat Lab I, Char 2
Math 22-Calc w/Analy Geo III 4
Physics 24-Eng Physics II 4
15

Second Semester
Cr Eng 103-Intro to Glass Sci & Tech 3
Cr Eng 122-Cer Mat Lab II-Glass & Trad Cr 2
Math 204-Diff Equa or Stat 320 or Stat 353 3
H/SS Elective[1] 6
Chem 241-Physical Chemistry 3
17

JUNIOR YEAR

First Semester — Credit
Cr Eng 231-Cer Proc Lab I 2
Cr Eng 251-Phase Equilibria 3
Bas En 50-Engr. Mechanics Statics 3
Cr Eng 203-Thermal Proc in Cer 3
Cr Eng 291-Characterization of Inorganic Solids 3
Cr Eng 292-Characterization of Ing Solids Lab . . . 1
15

Second Semester
Cr Eng 242-Cer Proc Lab II 2
Cr Eng 259-Thermo Solid-State Materials 3
Physics 107-Intro to Modern Physics 3
H/SS Elective[1] 3
BE 110-Mechanics of Materials 3
Statistics Elective[3] 3
17

SENIOR YEAR

First Semester — Credit
Cr Eng 261-Cer Senior Design Lab 2
Cr Eng 284-Elect Prop of Ceramics w/lab 4
Cr Eng 338-Thermal Properties of Ceramics 3
H/SS Elective[1] 3
Technical Elective[2] 3
15

Second Semester
Cr Eng 262-Cer Senior Design Lab 2
Cr Eng 306-Mech. Prop. of Ceramics 4
Cer Eng 331-Ceramic Processing 3
Technical Electives[2] 6
15

Note 1: Students may replace Chem 1, 2, and 3 with Chem 5, but will need to also take an additional technical elective (with advisor's approval) to reach the 128 hour requirement.

Note 2: Students may substitute Math 8 and 21 for Math 14 and 15, respectively.

1) Eighteen hours of H/SS electives to be taken in accordance with the School of Materials, Energy, and Earth Resources policy.
2) Technical electives must be selected from 200 and 300 level engineering and science courses with the advisor's approval.
3) Select from any Statistics course 200 level or higher or Emgt. 385.
4) 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 128.
2) The assumption is made that a student admitted in the department has completed 34 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

90 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 Introduction To Glass Science And Technology (Lect 3.0) A study of the atomic-level structure of oxide glasses and the relationships between composition, properties and structure of glass-forming systems. Simple rate processes will be introduced to explain temperature-dependent properties. Prerequisite: Cr Eng 102.

104 Ceramics In The Modern World (Lect 2.0) 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 2.0) Laboratory expe-

rience in collection, beneficiation, and characterization of ceramic raw materials; granulation, compaction, and sintering of particulate materials; and characterization at an introductory level. Standard laboratory practice including safety, report writing, and error analysis are also emphasized. Prerequisite: Sophomore standing.

122 Ceramic Materials Laboratory IIGlass And Ceramic Processing (Lab 2.0) Laboratory experience in design, processing, and characterization of glasses and ceramics. Glasses are formulated, melted and characterized to correlate composition and properties. Clay-based ceramics are formulated to meet performance specifications, prepared by slip casting/extrusion, and fired. 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, modelling, materials selection, engineering economics, safety, environmental issues and ethics. Prerequisite: Junior standing.

231 Ceramic Processing Lab I (Lab 2.0) 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 2.0) 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 Thermodynamics Of Solid-State Materials (Lect 3.0) Basic thermodynamic concepts are applied to the solid state. Calculations involving enthalpy, entropy, and Gibbs' free energy are studied. Inter-relationships among properties are emphasized. Fundamental concepts of phase equilibria are presented.

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, students working in small groups will fabricate and evaluate their designs. Design process elements such as safety aspects, environmental issues and ethics will be introduced. Groups will provide oral presentations and written reports of their results. Prerequisite: Cr Eng 261.

284 Electrical Properties Of Ceramics (Lect 3.0 and Lab 1.0) The application of ceramic chemistry and physics to the development and evaluation of electronic, dielectric, magnetic, and optical properties. Emphasis is placed on the relationships between properties and crystal structure, defects, grain boundary nature, and microstructure. Prerequisite: Physics 107.

291 Characterization Of Inorganic Solids (Lect 3.0) X-ray diffraction analysis is emphasized including lattice parameter determination, qualitative and quantitative analysis methods, and sources of error. In addition, the basic principles of other common characterization techniques including electron microscopy, thermal analysis, and energy dispersive spectroscopy are discussed. Prerequisite: Cr Eng 102 or Mt Eng 121 or a similar introductory course on structure of solids.

292 Characterization Of Inorganic Solids Laboratory (Lab 1.0) Practical aspects of x-ray diffraction analysis will be emphasized; students will gain hands-on experience in qualitative and quantitative analysis techniques, use of electronic databases, and operation of modern powder diffractometers. Prerequisite: Preceded or accompanied by Cr Eng 291.

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 Mechanical Properties Of Ceramics (Lect 3.0 and Lab 1.0) This course will treat the theory and testing practice related to design based on the mechanical properties of ceramics. The course also includes a laboratory consisting of experiments for the characterization of the mechanical properties of ceramics. 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, disper-

sants. 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.

338 Thermal Properties Of Ceramics (Lect 3.0) This course will teach the crystal physics underlying heat capacity, internal energy, phonon and photon conduction, and thermal expansion. These properties will be used to rationalize the behavior of a wide variety of ceramic materials in severe thermal environments. Prerequisite: Senior Standing.

340 Biomaterials I (Lect 3.0) This course will introduce senior undergraduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. Prerequisite: Senior undergraduate standing.

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 103.

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 347, 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.

392 X-Ray Diffraction Laboratory (Lab 1.0) Practical aspects of sample preparation, instrument set-up, data collection, and analysis are covered. Students cannot receive credit for Cr Eng 292 and Cr Eng 392. Prerequisite: Preceded or accompanied by Cr Eng 291, or Cr Eng 477, or an advanced crystallography course.

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.

The Geological Engineering program is offered under the department of Geological Sciences and Engineering.

Geological Engineering is the application of geological principles in order to solve problems in the related areas of the **geoenvironment** and **geotechnics**. One might think of geological engineers as engineers focusing on problems related to the Earth's natural resources, the Earth's geological environment, and the Earth's energy and mineral wealth. Geological engineers will carry out site investigations of the soil, rock and fluids at and under the surface of the Earth; they will analyze data they obtain in the field or through laboratory testing; they will evaluate the Earth's environmental and geological concerns at their particular field site; they will formulate alternative solutions to the environmental or geological problems they face; and they will select and develop the most effective engineering design to alleviate the problem within the framework of the economic, environmental, societal and political situation in which they operate.

Geological engineers deal with geoenvironmental problems such as groundwater contamination, remediation of pollution in the subsurface, and design and monitoring of waste storage facilities such as landfills and waste repositories. Geological engineers also work

to protect the public from geologic hazards such as landslides, earthquake damage, flooding, and volcanic eruptions. As the human population expands and requires more and more of the Earth's resources the geological engineering community will play an increasingly critical role: in protection of the water, mineral and agricultural resources, in the wise use of the same, and in designing engineering systems to minimize the impact of human activity and minimize the potential hazards from environmental and geological processes.

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 through a variety of electives so that you may modify the general program of study to select a sequence of 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], Ph.D., University of California-Berkeley
C. Dale Elifrits[2], (Emeritus), Ph.D., UMR
Jay Gregg[2] (Department Chair of Geological Sciences and Engineering), Ph.D., Michigan State
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
A. Curt Elmore[1], Ph.D., University of Arizona
Leslie Gertsch, Ph.D., Colorado School of Mines

[1] Registered Professional Engineer
[2] Registered Geologist

Bachelor of Science Geological Engineering

FRESHMAN YEAR

First Semester	Credit
Math 14-Calculus for Engineers I	4
Chem 1-General Chemistry	4
Chem 4-Intro Lab Safety	1
Chem 2-General Chemistry Lab	1
English 20-Exposition & Argumentation	3
BE 10-Study & Careers in Eng	1
H/SS Elective [(a)]	3
	17

Second Semester	
Math 15-Calculus for Engineers II	4
Chemistry/Geochemistry Elective [(b)]	3
BE 20-Engineering Design w/Comp	3
Physics 23-Engineering Physics I	4
H/SS Elective [(a)]	3
	17

SOPHOMORE YEAR

First Semester	Credit
Math 22-Calc w/Analytic Geometry III	4
Physics 24-Engineering Physics II	4
Computer Programming elective[(c)]	3
Ge Eng 50-Geology for Engineers	3
Economics Elective (Econ 121 or 122)	3
	17

Second Semester	
Math 204-Elementary Differential Equations	3
Bas Eg 50-Statics	3
Ge Eng 110-Principles of Ge Eng	1
Geo 125-Physical Mineralogy & Petrology	3
Ge Eng 275-Geomorphology & Terrain Analysis	3
Humanities/Soc Sci Elective[(a)]	3
	16

JUNIOR YEAR

First Semester . . . . . .Credit
Bas En 150-Dynamics 2
Bas En 110-Mechanics of Materials 3
Ge Eng 248-Fund of Geographic Info Systems 3
Hum/Soc Sc Elective[a] 3
Earth Energy Elective[d] 3
14

Second Semester
Cv Eng 230-Fluid Mechanics 3
Geo 220-Structural Geology 4
Geophysics Elective 3
Technical Communications Elective[e] 3
Humanities/Soc. Sci elective[a] 3
16

SENIOR YEAR

First Semester Credit
Ge Eng 343-Subsurface Exploration or
Geo 340-Petroleum Geology 3
Ge Eng 310- Senior Seminar 0.5
Ge Eng 331-Subsurface Hydrology 3
Ge Eng 341-Eng Geology & Geotechnics 3
Ge Eng 350-Geol Eng Senior Design. 3
Cv Eng 215-Elementary Soil Mechanics or
Mi Eng 231-Rock Mechanics I 3
15.5

Second Semester
Ge Eng 374-Eng Geologic Field Methods 3
Ge Eng 310- Senior Seminar 0.5
Earth Mechanics Elective[f] 3
Eng Econ Elective[g] 3
Technical Electives[h] 6
15.5

a) 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. A total of 18 hours of humanities and social science credit is required.

b) The Chemistry/Geochemistry elective must be selected from chemistry, geochemistry or biology courses as approved by your advisor.

c) The Computer Programming elective must be a 3-hr course focused on computer programming such as FORTRAN, C++, Visual Basic, or other programming platform as approved by your advisor.

d) The Earth Energy Elective must be a 3-hr course focused on the petroleum, mining, or other earth energy systems. Typical courses might be PE 131, PE 141, PE 232, PE 241, Geol 223, Geol 340, and Geol 332.

e) The Technical Communications elective should be a 3-hr course such as Engl 160 - Technical Writing, or Speech and Media Studies 85. Other courses focused on technical or scientific communication may be acceptable for this elective.

f) To be selected from GE 371, GE 381, Mining 231, PE 141, PE 241, CE 215, CE 229, or CE 315.

g) To be selected from CE 241, Eng Mgt 208, Eng Mgt 209, or PE 257.

h) To be selected from advanced courses in geological, mining, petroleum or civil engineering, geology or other courses in the School of Materials, Energy, and Earth Resources and School of Engineering with approval of your advisor. Must contain design content and must be approved by your advisor.

i) All GE students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade is not required; however, it is the first step toward becoming a registered professional engineer. This requirement is part of the UMR assessment process. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

j) 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 128. The assumption is made that a student admitted to the Department has completed 34 hours toward graduation to fulfill the requirements of the Freshman Engineering program.

Minor in Geological Engineering

Geological Engineering offers employment opportunities for a broad spectrum of disciplines including Civil, Mining, Nuclear, and Petroleum Engineering as well as for geologists and geophysists. A minor in Geological Engineering or Engineering Geology, therefore, enhances the academic credentials of a student and broadens employment choices. A minor in Geological Engineering requires 15 hours of UMR credit to include the following:

Ge Eng 50[1]-Geo for Eng or Phy Geo . . . . . .3 hrs
Ge Eng 275-Geomorphology . . . . . .3 hrs
Ge Eng 331-Groundwater Hydrology . . . . . .3 hrs.
Ge Eng 341-Eng Geo & Geotechnics . . . . . .3 hrs.
Ge Eng Elective[2] . . . . . .3 hrs.
15 hrs.

[1]Geo 051 may be substituted for geology and geophysics majors.
[2]To be selected with geological engineering advisor approval

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-Environmental Aspects of Mining
- 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-Environmental Aspects of Mining
- 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

50 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.

51 Physical and Environmental Geology (Lect 3.0 and Lab 1.0) Materials, structures and other features of the Earth and planetary bodies are studied in the context of Earth resource hazards and environmental challenges. The laboratory focuses on the study of common rocks and minerals, air photographs, maps, and case studies of geological problems. One field trip is required. (Co-listed with Geology 51)

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

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 of Geographic Information Systems. 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, physicochemical 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.

342 Military Geology (Lect 3.0) This course will familiarize geologists, geophysicists, civil and geological engineers with the fundamental principles of physical geology, geohydrology and geomorphology as applied to military problems, such as development of fortitications, core infrastructure, water resources and combat engineering requirements. Prerequisite: Ge Eng 275 or graduate standing.

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. Prerequisite: Cv Eng 215 or Pe Eng 131.

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.

375 Aggregates And Quarrying (Lect 3.0) Properties and uses of aggregates. Finding aggregate deposits and methods of extraction. Aggregate processing. Aggregate testing. Economics and politics of aggregates. Special topics in aggregates and quarrying. Prerequisites: Ge Eng 50, Ge Eng 275.

376 Environmental Aspects Of Mining (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; Mi Eng 324 and 326 or prereq./coreq. Cv Eng 215. (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 and 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 geochemistry, and petroleum geology.

The Geology and Geophysics program is offered under the department of Geological Sciences and Engineering.

Geology, geochemistry and geophysics study the history, composition, and structure of Earth and other planetary bodies. The expertise and activities in the Department of Geology and Geophysics make The University of Missouri-Rolla one of the leading U.S. research universities. Faculty and students are investigating areas such as the study of nuclear waste disposal, ground water pollution, palynostratigraphy (micro fossils), geophysical characterization of geological hazards (e.g., earthquakes, collapsed caverns) and geotechnical problems (e.g., bridge and roadway degradation), 3D seismic applications to petroleum exploration, evolution of petroleum reservoirs, genesis of ore deposits, the role of magmatism and tectonics, and industrial processing of minerals. The Department provides the only program in Missouri in geophysics and geochemistry with an emphasis upon exploration and environmental applications.

Students are drawn to geology and geophysics by a desire to explore a topic that is for many a personal pas-

sion. As a student in the Department of Geology and Geophysics, you may become involved in a wide range of studies. We have students investigating their world and beyond in areas as diverse as planetary geology, fossils and evolution, volcanology, development of cave systems, exploration for oil and gas, adsorption of pollutants by soils, imaging near-surface structures using ground penetrating radar, ore mineralization, creation of mountain systems, the beauty of minerals, to name but a few. Many courses involve work outdoors within the state of Missouri as well as in national parks such as the Grand Canyon. You may even find yourself snorkeling over a coral reef in the Caribbean Sea.

In the first two years of study, students develop a strong foundation in geology through the core curriculum. This foundation is strengthened by course work in chemistry, physics, mathematics and computer science, and the humanities and social sciences. Students begin to take more specialized courses pertaining to their particular area of interest in their junior and senior years. The numerous elective courses offered by the Geology and Geophysics Department, as well as courses outside the department, provide our majors with the flexibility to custom design an emphasis area of their choice, focusing in on aspects of Earth Science that are of most interest to them. In this way, our majors develop a broad understanding of the fundamentals of our diverse discipline while preserving this important opportunity to develop their own passion within geology and geophysics.

The Earth Sciences have been an integral part of UMR since its founding in 1870. Our 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 numerous opportunities for social and scientific interaction among students, professionals, and faculty.

The Department of Geology and Geophysics is located in McNutt Hall and it is especially well endowed with modern, state-of-the-art equipment for teaching and research in most areas of the Earth Sciences. The availability of such equipment provides our students with an excellent laboratory and field educational experience. In addition, cooperative studies with the Missouri Geological Survey and the U.S. Geological Survey provide students with opportunities for part time employment and on-the-job experience while they pursue their degree.

Geological Scientists enjoy their work. As a professional geologist or geophysicist you may explore for oil, gas, and coal to provide for our nation's energy needs. You may search for minerals critical to industry. You may become involved in minimizing environmental hazards. In all cases, you will have the opportunity to work out-of-doors, in the lab, and with cutting edge technology.

Mission Statement

1) Provide the highest quality education to students from the state of Missouri, the nation, and abroad leading to the B.S., M.S., and Ph.D. degrees in geology and geophysics. Prepare students for professional careers in five emphasis areas: geology, geochemistry, geophysics, groundwater and environmental geochemistry, and petroleum geology. Provide service courses for students in related departments (including geological engineering, mining engineering, petroleum engineering, metallurgical engineering, ceramic engineering, civil engineering, physics, biology and chemistry) as well as many of the departments in the humanities and liberal arts.

2) The Department has both the opportunity and the mission to engage in basic and applied research that contributes to the solution of problems related to Mankind and the environment. To meet this goal, the Department collaborates on projects that transcend the traditional boundaries between scientific and engineering disciplines. Faculty and students commonly conduct research with geologists in the Rolla offices of the United States Geological Survey and the Missouri Geological Survey, with scientists and engineers from various disciplines at UMR and other campuses of the University of Missouri system, as well as with other Earth Scientists in universities within the United States and abroad (e.g., Ireland, Republic of South Africa).

3) Provide graduates to the mining, petroleum, groundwater, and environmental industries; to the Missouri Geological Survey, the U.S. Geological Survey and other government research institutions.

4) Provide professional service in the fields of geology, geophysics, geochemistry, groundwater and environmental geology. Such service includes the identification of minerals, rocks, and fossils that are sent to the department, the assessment of geologic hazards, 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 fundamental 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. Our graduates have continued their education in prestigious programs, including Arizona State, California-Berkeley, Colorado, Colorado School of Mines, Delaware, MIT, Michigan, Michigan State, Oklahoma, Stanford, Texas, Virginia Tech, Washington, University of Missouri-Columbia and the University of Missouri-Rolla.

Faculty

Professors:

Neil L. Anderson[2], Ph.D., Calgary

Jay Gregg[2] (Department Chair of Geological Sciences and Engineering), Ph.D., Michigan State

Robert Laudon,[1,2] Ph.D., University of Texas at Austin

Associate Professors:
Estella A. Atekwana, Ph.D., Dalhousie University
John P. Hogan, Ph.D., Virginia Poly Tech.
Francisca Oboh-Ikuenobe[2], Ph.D., Cambridge
David J. Wronkiewicz, Ph.D., New Mexico Institute of Mining and Technology
Assistant Professors:
Eliot A. Atekwana, Ph.D., Western Michigan University
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
Lecturers:
William W. Little, Ph.D., University of Colorado
Patrick S. Mulvany, Ph.D., University of Missouri-Rolla
Cheryl Seeger, Lecturer, Ph.D., University of Missouri-Rolla
Emeritus Professors
Sheldon Grant (Emeritus), Ph.D., Utah
Richard Hagni[1,2] (Curators' Professor Emeritus), Ph.D., University of Missouri-Columbia
Geza Kisvarsanyi (Emeritus), Ph.D., University of Missouri-Rolla
Richard Rechtien (Emeritus), Ph.D., Washington University
Gerald Rupert (Emeritus), Ph.D., University of Missouri-Rolla
Alfred Spreng[1,2] (Emeritus), Ph.D., Wisconsin
[1] Certified Professional Geologist
[2] Registered Geologist

Bachelor of Science Geology and Geophysics

FRESHMAN YEAR

First Semester	Credit
Math 4-College Algebra or Sci & Eng Elective	3
Math 6-Trig (or 2 hours free electives)	2
English 20-Exposition and Argumentation	3
Chem 4-Intro to Lab Safety	1
Geo 51-Physical Geology	4
Free elective(1)	1
	14

Second Semester	
Math 8-Calculus w/Analytic Geometry I	5
Chem 1-General Chemistry	4
Chem 2-General Chemistry Lab	1
Geo 52-Evolution of the Earth(5)	4
	14

SOPHOMORE YEAR

First Semester	Credit
Math 21-Calculus w/Analytic Geometry II	5
History (112,175 or 176) or Pol Sc 90	3
Geo 113-Mineralogy & Crystallography	5
Geo 338 or Cmp Sc 53, 71 or 73 & 77	3
	16

Second Semester	
English 60 (writing course)	3
Econ 121-Prin of Micro or 122-Prin of Macro	3
Geo 130-Igneous and Metamorphic Petrology(5)	5
Geo-275-Intro to Geochemistry	3
	14

JUNIOR YEAR

First Semester	Credit
Physics 23-Engineering Physics I(2)	4
Stat 213,215,217 or Ge Eng 315-Stat	3
Geo 220-Structural Geology(5)	4
Hum/Soc Sci Elective	3
Elective (Geo & Geop)(4)	3
	17

Second Semester	
Physics 24-Engineering Physics II(2)	4
Geo 223/224-Stratigraphy & Sedimentation Lab	4
Elective (Geo & Geop)(4)	3
Free Elective(1)	3
	14

SUMMER OF JUNIOR YEAR

	Credit
Geo 373-Field Geology	3
Geo 374-Advanced Field Geology	3
	6

SENIOR YEAR

First Semester	Credit
Elective (Science & Eng)(3)	6
Elective (Geo & Geop)(4)	6
Hum/Soc Sci Elective	6
	18

Second Semester	
Electives (Science & Eng)(3)	6
Electives (Geo & Geop)(4)	6
Geo 210-Seminar	1
Geop 381-Global Tectonics(5)	3
	16

1) Free 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) Students may substitute Physics 21 and 22 for Physics 23; Physics 25 and 26 for Physics 24.
3) All Geology/Geophysics students must complete at least 15 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. 12 hours of this course work must be numbered 100 or above.
4) All Geology/Geophysics students including those taking emphasis areas, must complete at least 18 hours of course work numbered 200 or above in the Geology and Geophysics department, in addition to the required core curriculum. Of these 18 hours, at least one course should be selected from each of three (out of five) emphasis area groups listed in the program.
5) Communications emphasized (CE) courses

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	5
Geo 130-Igneous & Metamorphic Petrology	5

Geo 210-Seminar 1
Geo 220-Structural Geology 4
Geo 223-Stratigraphy & Sedimentation 3
Geo 224-Stratigraphy Lab 1
Geo 275-Intro to Geochemistry 3
Geo 373-Field Geology 3
Geo 374-Advanced Field Geology 3
Geop 381-Global Tectonics 3
Total 39

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
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 Geochemistry 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(5)	Geo 324(3)
Geo 220(4)	Geo 373(3)
Geo 223(3)	Geop 380(3)
Geo 254(2)	Geop 382(3)

Geology Courses

51 Physical And Environmental Geology (Lect 3.0 and Lab 1.0) Materials, structures and other features of the Earth and planetary bodies are studied in the context of Earth resource hazards and environmental challenges. The laboratory focuses on the study of common rocks and minerals, air photographs, maps, and case studies of geological problems. One field trip is required. (Co-listed with Geo Eng 51)

52 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 4.0 and Lab 1.0) An introduction to the study of minerals, including their systematic classification, crystallography, morphology, chemistry, societal use, geologic occurrence, environmental application and impact, and 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 Igneous And Metamorphic Petrology (Lect 4.0 and Lab 1.0) A comprehensive study of megascopic and microscopic characteristics of igneous and metamorphic rocks. Fundamental theories for their origin are presented. The class includes an intensive four day trip examining these rock types in the field. 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: Geo 130 or Geo 125.

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.

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) Application of basic chemical principals towards investigations of element distributions in geologic systems. Emphasis on origin of elements in our Solar System, element distribution during planetary formation, phase equilibria, rock-water interactions, thermodynamic principles, environmental and isotope geochemistry. Prerequisite: Chem 1.

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.

330 Granites And Rhyolites (Lect 3.0 and Lab 1.0) Processes governing the generation and crystallization of felsic magma will be covered, with specific reference to: 1) crust vs mantle sources, 2) melt migration and emplacement, 3) magma chamber dynamics, 4) the volcanic-plutonic connection, and 5) the relationship to tectonic setting. A field trip at the student's expense is required. Prerequisite: Geo 130.

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.

334 Advanced Igneous and Metamorphic Petrology (Lect 3.0 and Lab 1.0) Processes governing the formation of igneous and metamorphic rocks as constrained by geochemical, isotopic, and thermodynamic data, with particular reference to the relationship between rock suites and tectonic setting. The laboratory will emphasize the description of rock suites in hand sample and thin section. A field trip at the student's expense is required. Prerequisite: Geology 130.

338 Computer Mapping In Geology (Lect 2.0 and Lab 1.0) This course introduces the basics of both surface and subsurface geologic mapping. It introduces procedures and problems associated with digitizing, gridding, contouring, volumetrics and generation of three dimensional diagrams on the PC. Integration of field gathered data with USGS and GSI databases for the purpose of making surface geologic maps is also included. Prerequisite: 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 decisionmaking 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)

372 Geological Field Studies (Variable) Intensive field study of selected regions of geological interest. This course is built around a week to ten-day long field trip to be held over spring break or after final exams at the end of a semester. Students are expected to bear the expense of the field trip. Prerequisites: Geo 51 or Ge Eng 50.

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 of geochemistry and techniques of geochemical analysis in a student research project investigating geochemical processes (mineral deposits, environmental geochemistry, trace element migration, or water-rock interaction). Field trip fee required. Prerequisites: Geo 113 and Geo 275.

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.

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: Math 22 and Cmp Sc 53, 73 & 77, or 74 & 78.

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 285.

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. Prerequisite: 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 2.0 and Lab 1.0) 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 flu-

ids, 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 285 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

The department has sufficient bredth for students to focus on chemical metallurgy, manufacturing metallurgy, and physical metallurgy.

The Metallurgical Engineering program is offered under the department of Materials Science and Engineering.

The development of mankind has frequently been linked to the ability to use metals recovered from the earth's crust. Metallic materials are found in all areas of the world, and are in use in virtually every industry. 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 production from minerals, waste and recycled materials, the manufacture of components from metals and alloys, and the design of metallic materials to achieve appropriate mechanical, physical and chemical properties.

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 production of metals from mineral ores and recycled material, utilizing physical and chemical processes. Typical processes include mineral beneficiation, pyrometallurgy, hydrometallurgy and elecrometallurgy. Modern challenges include the recovery of metallic values from ores of decreasing grade, expanded recycling of materials, and a variety of materials - related environmental issues. Combatting corrosion is another major area.

The manufacturing metallurgist is concerned with the manufacture of metal products with the desired geometry, precision and performance properties at a desired production rate and level of quality. Deformation processes, welding and joining, powder metallurgy, metal casting, heat treatment, platings and coatings, and inspection for quality assurance are all potential aspects of a manufacturing system.

The properties of all metallic components are related to the chemical composition of the material, and the resultant structure, beginning with atoms and crystals and progressing through crystalline assemblies. The study of the microstructure of metals and alloys and the control of the associated properties is the responsibility of the physical metallurgist. The development of corrosion-resistant stainless steels, ultra-lightweight alloys for aircraft, high-temperature 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 assurance of component quality 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. There are ample technical electives to provide complete emphasis areas in chemical, manufacturing, and physical metallurgy.

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

The department is housed in McNutt Hall and has outstanding facilities for both classroom and laboratory learning. There are four electron microscopes, a well equipped metals casting and joining laboratory, and comprehensive metals deformation and testing facilities. The undergraduate curriculum emphasizes laboratory activities to ensure that graduates receive a hands-on education, and the extensive research activities and facilities provide numerous opportunities for undergraduate students. 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
Richard Brow, Ph.D., (Department Chair of Materials Science and Engineering), Pennsylvania State University
Fred Kisslinger[1] (Emeritus), Ph.D., Cincinnati
Ronald A. Kohser, 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
Mark E. Schlesinger[1], Ph.D., University of Arizona
David C. Van Aken[1], Ph.D., Illinois

Associate Professors:

Rajiv S. Mishra, Ph.D., Sheffield
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, (Associate Director of Freshman Engineering), Ph.D., Colorado School of Mines
Von L. Richards, Ph.D., Michigan

Assistant Professor:

F. Scott Miller, Ph.D., UMR

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

Bachelor of Science Metallurgical Engineering

FRESHMAN YEAR

First Semester	Credit
BE 10-Study and Careers in Eng	1
Chem 1-General Chemistry	4
Chem 2-General Chemistry Lab	1
Math 14-Calculus for Engineers I[1]	4
Engl 20-Exposition and Argumentation	3
BE 20-Eng. Design and Computer Appls	3
	16

Second Semester	
Met 125-Chemistry of Materials[3]	3
Math 15-Calculus for Engineers II[2]	4
Phys 23-Engineering Physics I	4
Hum/Soc Sci Elective[8]	3
History Elective (Government)[4]	3
	17

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
BE 50 Statics	3
Econ 121/122-Principles of Micro or Macro Econ	3
	17

Second Semester	
Math 204-Elementary Differential Equations	3
BE 110-Mechanics of Materials	3
Mt Eng 215-Fundamentals of Metal Behavior	3
Mt Eng 216-Metals Behavior Lab	1
Mt Eng 221-Principles of Metals Processing	3
Mt Eng 222-Metals Processing Lab	1
Hum/Soc Sci Elective[8]	3
	17

JUNIOR YEAR

First Semester	Credit
Mt Eng 204-Transport Phenomena in Metallurgy	3
Mt Eng 281-Metallurgical Thermodynamics I	3
Mt Eng 217-Metals Microstructural Development	3
Mt Eng 218-Metals Structures & Properties Lab	1
Technical Elective[6]	3
Communication Elective[5]	3
	16

Second Semester	
Mt Eng 202-Extractive Met Lab	1
Mt Eng 203-Intro to Extractive Metallurgy	3
EE 281-Electrical Circuits	3
Hum/Soc Sci Elective[8]	3
Technical Elective[6]	3
Statistics Elective[7]	3
	16

SENIOR YEAR

First Semester	Credit
Mt Eng 315-Metallurgy Process Design Principles	2
Mt Eng 354-Process Metallurgy-Lab	2
Mt Eng 355-Process Metallurgy Applications	2
Cer Eng 291-Characterization of Inorganic Solids	3
Technical Elective[6]	3
Free Elective[9]	3
	15

Second Semester	
Mt Eng 316-Mt Design Project	2
Hum/Soc Sci Electives[8]	3
Technical Elective[6]	6
Free Elective[9]	3
	14

NOTES:

1) Math 8 can be substituted for Math 14
2) Math 21 can be substituted for Math 15
3) Chem 3 can be substituted for Met 125
4) History Elective (3 hours)-HIST 112, 175, 176, or PolSci 90
5) Communication Elective (3hours)-ENGL 60, ENGL 160, or SpM 85
6) Technical Electives (15 hours) (Met. Eng. or Approved listing)

[7] Statistics Elective-Eng Mg 385, STAT 213, or STAT 215

[8] HSS Electives-to be taken in accordance with the School of Materials, Energy, and Earth Resources policy on H/SS

[9] Free Electives (6 hours)-algebra, trigonometry, basic ROTC, and courses considered remedial excluded

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.

Suggested course electives are provided below:

Chemical/Process Metallurgy:

- Met Eng 307,308-Metals Casting
- Met Eng 358-Steelmaking
- Mt Eng 359-Environmental Aspects of Metals Manufacturing
- Mt Eng 363-Metal Coating Processes
- Mt Eng 365-Microfabrication Materials and Processes
- Mt Eng 381-Corrosion and Its Prevention
- Cr Eng 364-Refractories
- Min Eng 241-Principles of Mineral Processing
- Min Eng 242-Mineral Processing Lab

Physical Metallurgy:

- Mt Eng 313-Electron Microscopy
- Mt Eng 331, 332-Steels and Their Treatments
- Mt Eng 333-Nonferrous Alloys
- Mt Eng 341-Nuclear Materials I
- Mt Eng 375-Metallurgical Failure Analysis
- Mt Eng 385-Mechanical Metallurgy
- Cr Eng 251-Phase Equilibria
- Cr Eng 284-Electrical Properties of Ceramics
- Cr Eng 291-Characterization of Inorganic Solids
- ME 336-Fracture Mechanics
- ME 338-Fatigue Analysis

Manufacturing Metallurgy:

- 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 359-Environmental Aspects of Metals Manufacturing
- Mt Eng 363-Metal Coating Processes
- Mt Eng 365-Microfabrication Materials and Processes
- Mt Eng 367-Intro to Powder Metallurgy
- Mt Eng 385-Mechanical Metallurgy
- ME 253-Manufacturing

Materials Minor Curriculum

A Materials Minor is available to any UMR student. The minor requires a total of 15 hours of materials related course work and must include Mt Eng 121 or Mt Eng 377 and Mt Eng 221 or ME 153. An additional 3 hours must come from either Metallurgical or Ceramic Engineering courses. The remaining 6 hours may be from any combination of materials related courses approved by Metallurgical Engineering.

Approved Materials related courses

Approved courses in Metallurgical Engineering
Additional hours may come from any 100, 200 or 300 level courses.

Approved courses in Ceramic Engineering
Additional hours may come from any 100, 200 or 300 level courses.

Approved courses in Chemistry
Chem 381 Chemistry and Inherent Properties of Polymers

Approved courses in Aerospace Engineering
AE 311 Introduction to Composite Materials and Structures
AE 329 Smart Materials and Sensors
AE 336 Fracture Mechanics
AE 344 Fatigue Analysis

Approved courses in Chemical Engineering
Ch Eng 349 Structure and properties of Polymers
Ch Eng 381 Corrosion and its Prevention

Approved courses in Electrical Engineering
EE 329 Smart Materials and Sensors

Approved courses in Mechanical Engineering
ME 329 Smart Materials and Sensors
ME 336 Fracture Mechanics
ME 338 Fatigue Analysis

Metallurgical Engineering Courses

1 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, includ-

ing alloying, deformation and heat treating. Prerequisite: Chem 1.

125 Chemistry Of Materials (Lect 3.0) Basic Inorganic Chemistry of Materials. Topics will include chemical properties, structure and bonding of solids, energy, enthalpy, entropy, thermochemistry, kinetics and rate processes. Application of chemistry principles to materials engineering through flowsheeting, reactor design, materials/metals processing and the environment. Prerequisite: Chem 1.

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.

212 Cooperative Training (Variable) On-the-job experience gained through cooperative education in the field of metallurgical engineering with credit arranged through department cooperative advisor. A pass/fail grade will be given based on the quality of reports submitted and work supervisor's evaluation.

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.

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.

307 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.

340 Biomaterials I (Lect 3.0) This course will introduce senior undergraduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. Prerequisite: Senior undergraduate standing.

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: Bas Eng 110; Nuc Eng 205; Nuc Eng 223; Met Eng 121.(Co-listed with Nuc 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 Process Metallurgy Applications (Lect 2.0) Application of thermodynamics to process metallurgy. Equilibrium calculations with stoichiometry and heat balance restrictions, phase transformations, and solution thermodynamics. Use of thermodynamic software to solve complex equilibria in metallurgical applications. Prerequisite: Mt Eng 281.

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.

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.

365 Microfabrication Materials And Processes (Lect 3.0) An overview course on the materials and processes used to fabricate integrated circuits, microelectromechanical systems (MEMS), interconnect substrates and other microelectronic components from starting material to final product. The emphasis will be on the influence of structure and processing on the electrical, mechanical, thermal, and optical properties. Prerequisites: Chem 1 or equivalent; Senior or Graduate Standing.

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.

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 347, Physics 377, Cr Eng 377)

381 Corrosion And Its Prevention (Lect 3.0) A study of the theories of corrosion and its application to corrosion and its prevention. Prerequisite: Chem 243 or Mt Eng 281. (Co-listed with Ch Eng 381)

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
Master of Engineering

Emphasis areas at the bachelor level in explosives engineering, mining health and safety, quarry engineering, coal, mining and the environment, and sustainable development.

The Mining Engineering program is offered under the department of Mining and Nuclear Engineering.

The overall objectives of the Mining Engineering program 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.

Program Educational Objectives for ABET:

Interactions among industry, alumni, students and the faculty led to the following specific program educational objectives:

1. To provide graduates with a firm foundation in mathematics, the basic sciences, and general engineering. This objective addresses outcomes related to ABET Criterion 3a.

2. To provide graduates with a strong foundation in the core mining engineering fundamentals. This objective addresses outcomes related to program criteria.

3. To provide graduates with the knowledge of relevant technologies as well as techniques, skills, and tools needed for modern mining engineering practice. This objective addresses outcomes related to ABET Criterion 3k.

4. To develop problem solving and design capabilities in graduates. This objective addresses outcomes related to ABET Criteria 3b, 3c, and 3e.

5. To instill in graduates a sense of creativity and enthusiasm for life-long learning. This objective addresses outcomes related to ABET Criterion 3i.

6. To instill in graduates a sense of effective professional attributes. This objective addresses outcomes related to ABET Criteria 3d, 3f, and 3g.

7. To provide graduates with a breath of knowledge. This objective addresses outcomes related to ABET Criteria 3h and 3j.

8. If selected, to provide graduates with a strong foundation of working knowledge in an area of emphasis, i.e., explosives or quarrying engineering or coal mining.

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, an area of emphasis, usually obtain employment in one or more of the following areas: mine engineering, mining operations management, 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 and mineral policy. 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], (Emeritus), D. Eng., UMR
Samuel Frimpong (Quenm Chair), Ph.D., University of Alberta
Tad Golosinski (Emeritus), Ph.D., Cracow, Poland
R. Larry Grayson[1], (Department Chair of Mining and Nuclear Engineering), 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 Assistant Professor:

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

[1] Registered Professional Engineer

Bachelor of Science Mining Engineering

FRESHMAN YEAR

First Semester	Credit
Chem 001-General Chemistry I	4
Chem 002-General Chemistry I Lab	1
Chem 004-Lab Safety	1
Math 014-Calculus for Engineers I	4
Bas En 010-Study & Careers in Eng	1
English 020-Exposition & Argumentation	3
Hist 112, 175, 176 or Pol Sc 90	3
	17
Second Semester	
Math 015-Calculus for Engineers II	4
Physics 023-Engineering Physics	4
Bas En 020-Eng Design w Comp Appl	3
Mi Eng 003-Principles of Mi Eng	1
Min Eng 151-Intro to Mining Safety	1
Ge Eng 050-Geology for Engineers	3
	16

SOPHOMORE YEAR

First Semester	Credit
Mi Eng 110-Surveying for Mineral Engineers	2
Stat 213-Applied Eng Stat	3
Math 022-Calculus & Analytic Geometry III	4
Geo 220-Structural Geology	4
English 065-Tech Writer in Bus & Industry	3
Mi Eng 050-Comp in Mi Eng	1
	17
Second Semester	
Geo 125-Physical Mineralogy & Petrology	3
Mi Eng 215-Mat Handling in Mines	3
Physics 024-Engineering Physics II	4
Bas En 140-Statics & Dynamics[1]	3
Math 204-Elem Differential Equations	3
	16

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
Econ 121-Principles of Micro or Econ 122- Principles of Macro	3
Human/Soc Sc[2]	6
	18
Second Semester	
Mi Eng 324-U/G Mi Methods & Equip	3
Mi Eng 326-Surface Mining Methods & Equip	3
Mi Eng 232-Stat/Mech Rock Mat[1]	2
Mi Eng 231-Rock Mechanics I	3
Mi Eng 307-Principles of Explosives Eng	3
Mi Eng 241/242-Mineral Proc	3
	17

SENIOR YEAR

First Semester	Credit
Mi Eng 317-Mine Power and Drainage	3
Mi Eng 3I8-Mine Atmos. Control	3
Technical Elective [3,4,5,6,7,8]	3
Human/Soc Sc[2]	6
	15
Second Semester	
Mi Eng 322-Mine Management[9]	2
Mi Eng 376-Environmental Aspects of Mining	3
Mi Eng 393-Mine Planning and Design[9]	4
Technical Elective[3,4,5,6,7,8]	3
	12

Notes:

1) Students may elect to take Bas En 50, Bas En 110, and Bas En 150 instead and not take Mi Eng 232.
2) Humanities and Social Science to be taken in accordance with The School of Materials, Energy, and Earth Resources policy.
3) For students with the Mining Health and Safety Emphasis, Mi Eng 202 (Mine Rescue), Eng Mgt 311 (Human Factors), or other approved substitute courses have to be taken as Technical Electives.
4) For students with the Sustainable Development Emphasis, Pol Sci 315 (Public Policy Analysis), Econ 340 (Environmental and Natural Resource Economics), or other approved substitute courses have to be taken as Technical Electives.

[5] For students with Explosives Engineering Emphasis, Mi Eng 350 (Blasting Tech) and either Mi Eng 301, 390 (Special topics and Mining Research, both in an explosives area), Ge Eng 371 (Rock Engineering) or Mi Eng 383 (Tunneling/Construction) have to be taken as Technical Electives.

[6] For students with Quarrying Emphasis, Cv Eng 216 (Construction Materials) and Mi Eng 304 (Advanced Aggregate and Quarrying) have to be taken as Technical Electives.

[7] For students with Coal Emphasis, Mi Eng 343 (Coal Mine Development and Production), Mi Eng 311 (Mine Plant management) or an approved substitute course have to be taken as Technical Electives.

[8] For students with Mining and the Environment Emphasis, Geol Eng 235 (Environmental Geoscience), Geol Eng 333 (Risk Assessment in Environmental Studies), or approved substitute courses have to be taken as Technical Electives.

[9] Mining courses in *italics* offered every semester.

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; Sustainable Development; Surface Mining; Underground Mining.

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

Mining Health and Safety Emphasis

Junior and Senior Years

A) Mi Eng 202 (Mine Rescue) or approved substitute course in lieu of Technical Elective.

B) Eng Mgt 311 (Human Factors) or approved substitute course in lieu of Technical Elective.

Sustainable Development Emphasis

Junior and Senior Years

A) Pol Sci 315 (Public Policy Analysis) or approved substitute course in lieu of Technical Elective.

B) Econ 340 (Environmental and Natural Resource Economics) or approved substitute course in lieu of Technical Elective.

Quarrying Engineering Emphasis

Senior year

A) Cv Eng 216 (Construction Materials) in lieu of Technical Elective.

B) Mi Eng 304 (Advanced Aggregate and Quarrying) in lieu of Technical Elective.

Explosives Engineering Emphasis

Junior and Senior Years

A) Choose one of the following courses in lieu of Technical Elective 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

Coal Emphasis

Junior and Senior Years

A) Mi Eng 343 (Coal Mine Development and Production) in lieu of Technical Elective.

B) Mi Eng 311 (Mine Plant Management) or approved substitute course in lieu of Technical Elective.

Mining and the Environment Emphasis

Junior and Senior Years

A) Geol Eng 235 (Environmental Geoscience) or an approved substitute course in lieu of Technical Elective.

B) Geol Eng 333 (Risk Assessment in Environmental Studies) or an approved substitute course in lieu of Technical Elective.

Mining Engineering Courses

3 Principles Of Mining Engineering (Lect 1.0) Principles and definitions related to mining engi-

neering including one or more field trips to familiarize the student with current mining practices.

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

110 Surveying For Mineral Engineers (Lab 2.0) Principles of surface and underground survey practice utilizing total station, engineer's level and GPS. Traversing and details, note taking and computations, balancing surveys and error analysis, staking-out new points, and map construction with AutoCAD. Prerequisites: Mi Eng 50, 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 opportunity to test a new course. Variable title.

202 Mine Rescue (Lect 2.0 and 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.

215 Materials Handling In Mines (Lect 2.0 and Lab 1.0) Mining applications of material transport and handling. Truck haulage and haulroads. Conveyors: belt, armored, and others; feeders; bins and bunkers; material stockpiling and homogenization; rail transport; water transport; slurry transport; mine hoists and hoisting. Prerequisite: Mi Eng 003.

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 125, Geo 220 and Mi Eng 110.

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 and Bas En 120; or Bas En 140; and Cv Eng 215 or Geo 125, Geo 220.

232 Statics And Mechanics Of Rock Materials (Lect 2.0) Application of the principles of mechanics to engineering problems of equilibrium, strength, and stiffness concerning rock materials and mine support structures. This course extends the study of statics to rock materials in mines and covers rockrelated and support structure-related mechanics of materials. Prerequisite: Co-requisite Mi Eng 231.

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.

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 Mi Eng 241.

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. Prerequisite: 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.

304 Advanced Aggregate and Quarrying (Lect 3.0) Advanced coverage of topics on the stone and aggregate industry, including surface and underground operations, plant equipment, economics, marketing, transportation, and environmental topics. The course will include at least one field trip and a design project. Prerequisite: Min Eng 215, co-requisite: Civ Eng 216.

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.

309 Advanced Aggregate and Quarrying (Lect 3.0) Advanced coverage of topics on the stone and aggregate industry, including surface and underground operations, plant equipment, economics, marketing, transportation, and environmental topics. The course will include at least one field trip and a design project. Prerequisite: Min Eng 215, co-requisite: Cv Eng 216.

309 Commercial Pyrotechnics Operations (Lect 2.0 and Lab 1.0) Provide participants with basic pyrotechnic operator certification (with passing of PGI test) and advanced lead pyrotechnic operator training. Class work will be complemented by practical training in laboratory sessions, culminating in a full pyrotechnic show, from start to finish. Prerequisites: Chem 1. US Citizen or permanent resident (to fulfill the requirements of the SAFE EXPLOSIVES ACT 2003). Resident enrollment at UMR (e.g. not distance or internet).

311 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 Mine Power And Drainage (Lect 2.0 and Lab 1.0) Engineering principles of mine power distribution and application and mine dewatering. Electric power: Basics of electrical circuits, AC/DC power, transformers, electric meters, power distribution, power management. Hydraulic power systems. Compressed air in mines. Mine dewatering: passive and active systems. Controlling water inflow. Dewatering wells: horizontal and vertical. Water pumping and pumping systems. Prerequisite: Cv Eng 230.

318 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. Prerequisite: Cv Eng 230.

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.

324 Underground Mining Methods And Equipment (Lect 3.0) Principles of planning, constructing, and operating economically viable underground mines. Cost effective mining methods: room-and-pillar, stopping, caving. Selection of equipment for underground mining operations. Prerequisites: Mi Eng 003, coreq. Mi Eng 221 and Mi Eng 231.

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.

326 Surface Mining Methods And Equipment (Lect 3.0) Principles of planning, constructing, and operating economically viable surface mines. Cost effective mining methods: placer mining, stripping, open pit mining, quarrying. Selection of equipment for surface mining operations. Optimization of mine performance. Prerequisites: Mi Eng 215; coreq. Mi Eng 231.

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 Environmental Aspects Of Mining (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; Mi Eng 324 and 326 or prereq./coreq. Cv Eng 215. (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 program is offered under the department of Mining and Nuclear Engineering.

The Nuclear Engineering Program has a primary mission to provide an outstanding and comprehensive undergraduate and graduate education to tomorrow's leaders in nuclear engineering. The department provides well-educated nuclear engineering professionals and leaders to Missouri and the nation, in the commercial nuclear industry, national laboratories, hospitals, graduate schools, and the nation's defense and federal agencies. The objectives of the Bachelor of Science program are to provide each student with fundamental knowledge of nuclear engineering and related technologies, analytical and problem solving ability, ability for technical communications, professional ethics, leadership and interpersonal skills, capability to conduct research, and the ability to recognize the value of and pursue life-long learning.

The program 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 program 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 the emission of greenhouse gases like carbon dioxide significantly, thus contributing to a better environment. 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 several hundred 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: general education, mathematics and basic 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 a significant number of 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 program has a primary mission to provide an outstanding and comprehensive undergraduate and graduate education to tomorrow's leaders in nuclear engineering. The program provides well-educated nuclear engineering professionals and leaders to Missouri and the nation in the commercial nuclear industry, national laboratories, hospitals, graduate schools, and the nation's defense and federal agencies.

Program Educational Objectives

The Educational Objectives of the Nuclear Engineering undergraduate program are:

- To provide graduates with sound fundamental knowledge of nuclear engineering and related technologies stemming from a solid understanding of the basic engineering, mathematical, and scientific principles that underpin them.
- To provide graduates with analytical and problem solving abilities that encompasses not only technical ability but also the logical, creative, and collaborative abilities necessary to address multifaceted, multidisciplinary endeavors.
- To provide graduates with technical communication (oral and written) ability and a commitment to and understanding of professional ethics, thereby ensuring their ability to address contemporary societal issues.
- To provide graduates with the leadership and interpersonal skills that will propel them to excellence in their profession.
- To provide graduates with the capability to conduct quality research, enabling them to contribute to meeting societal needs.
- To provide graduates with a recognition of and desire for the continuous pursuit of life-long learning that will foster the ability to not only adapt to change but be proactive in producing change.

Program Outcomes

Students graduating from this program should have:

- an ability to apply knowledge of mathematics, science, and engineering.
- an ability to design and conduct experiments, as well as to analyze and interpret data.
- an ability to design a system, component, or process to meet desired needs.
- an ability to function on multi-disciplinary teams.
- an ability to identify, formulate, and solve engineering problems.
- an understanding of professional and ethical responsibility.
- an ability to communicate effectively.
- the broad education necessary to understand the impact of engineering solutions in global and societal contexts.
- a recognition of the need for, and an ability to engage in life-long learning.
- a knowledge of contemporary issues.

- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- hands-on laboratory experience and/or reactor operations.

Faculty

Professor:

R. Larry Grayson[1], (Department Chair of Mining and Nuclear Engineering), Ph.D., West Virginia University
Arvind Kumar, Ph.D., California-Berkeley

Associate Professor:

Gary Mueller[1], Ph.D., UM-Rolla

Assistant Professor:

Seungjin Kim, Ph.D., Purdue University
Akira Tokuhiro, Ph.D., Purdue University

Adjunct Professors:

Mariesa Crow[1], Ph.D., Illinois; Professor of Electrical & Computer Engineering, UM-Rolla
Delbert Day[1], Ph.D., Pennsylvania State; Curators' Professor Emeritus, UM-Rolla
Heather Gepford, Ph.D., Georgia Tech; Health Physicist, Nuclear Regulatory Commission
Timothy Herrmann[1], B.S., UM-Rolla; General Superintendent, Major Projects, AmerenUE Callaway Nuclear Plant, Fulton, MO
Eric Loewen, Ph.D., Wisconsin; Consulting Engineer, Idaho National Engineering Environmental Laboratory
Sudarshan Loyalka, Ph.D., Stanford; Curators' Professor of Nuclear Engineering, UM-Columbia
William Miller[1], Ph.D., UM-Columbia; Professor and James C. Dowell Research Professor of Nuclear Engineering, UM-Columbia
Tod Moser[1], M.S., UM-Columbia; Principal Engineer, Dominion Engineering, Inc.
Mark Prelas[1], Ph.D., Illinois; Professor of Nuclear Engineering, UM-Columbia
David A. Summers, Ph.D., Leeds, England; Curators' Professor of Mining Engineering, UM-Rolla
Robert Tompson Jr., Ph.D., UM-Columbia; Associate Professor of Nuclear Engineering, UM- Columbia
Wynn Volkert, Ph.D., UM-Columbia; Curators' Professor of Radiological Sciences, biochemistry, Chemistry, and Nuclear Engineering, UM-Columbia.

Emeritus Professors:

Albert Bolon[1], Ph.D., Iowa State
D. Ray Edwards[1], Sc.D., MIT
Nicholas Tsoulfanidis[1], Ph.D., Illinois

[1] Registered Professional Engineer

Bachelor of Science

Nuclear Engineering

FRESHMAN YEAR

First Semester	Credit
Freshman Chemistry Requirement(1)	5
Eng 20-Exposition and Argumentation	3
Bas Eng 10-Study and Careers in Engineering	1
Math 14-Calculus for Engineers I	4
Nu Eng 25-Nuclear Technology Applications(2)	1
	14
Second Semester	
Elective-Hum or Soc Sci(3)	3
History 112, 175, 176, or Political Science 90	3
Physics 23-Engineering Physics I	4
Bas Eng 20-Eng Design w/Computer App.	3
Math 15-Calculus for Engineers II	4
	17

SOPHOMORE YEAR

First Semester	Credit
Cmp Sc 73-Basic Scientific Programming	2
Cmp Sc 77-Computer Programming Lab	1
Bas En 50-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
Econ 121 or 122-Micro/Macroeconomics	3
Nu Eng 206-Reactor Operations I	1
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
	16

JUNIOR YEAR

First Semester	Credit
Elective-Hum or Soc Sci(3)	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
Nu Eng 204-Nuclear Radiation Measurements	3
Nu Eng 223-Reactor Heat Transfer	3
Nu Eng 303-Reactor Physics I	3
Nu Eng 319-Nuclear Power Plant Systems	3
Free Electives(5)	3
	18

SENIOR YEAR

First Semester	Credit
Elective-Hum or Soc Sc(6)	3
Nu Eng 304-Reactor Lab I	2
Nu Eng 307-Nuclear Fuel Cycle	3
Elective-300 level Math	3
Nu Eng 322-Nuclear System Design I	1
Nu Eng 341-Nuclear Materials I	3
	15
Second Semester	
Elective-Hum or Soc Sci(3)	3
Elective-300 level Nuclear Engineering	3
Free Elective(4)	6
Nu Eng 308-Reactor Lab II	2
Nu Eng 323-Nuclear System Design II	3
	17

[1] Chemistry 1 and 2 or Chemistry 5 and Chemistry 4 or an equivalent training program approved by UMR.

[2] Nuclear Engineering students are expected to take Nuclear Technology Applications (Nu Eng 25) during their Freshman year. Minimum credit hours for graduation is 128.

[3] Humanities and Social Science to be taken in accordance with The School of Materials, Energy, and Earth Resources policy.

[4] Courses which do not count towards this requirement are remedial courses such as algebra and trigonometry, physical education courses, extra credits in required courses, and basic Air Force and Army ROTC courses (courses taught in the first two years of the ROTC program).

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.

Nuclear Engineering 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

25 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.

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

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: Math 15 or Math 21.

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 24.

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 205.

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: Physics 107 or Nu Eng 203; Math 204.

206 Reactor Operations I (Lab 1.0) A first course in reactor operations training and practical approach to nuclear reactor concepts. Students will receive hands-on training and are encouraged to take the NRC Reactor Operator's Exam. Prerequisites: Math 14 or Math 8; preceded or accompanied by Nu Eng 25.

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. Prerequisites: Math 204, Bas Eng 110.

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. Prerequisite: Nu Eng 205.

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: Nu Eng 204, 205.

306 Reactor Operation II (Lab 1.0) The operation of the training reactor. The program is similar to that required for the NRC Reactor Operator's license. Students from other disciplines will also benefit from the course. Prerequisite: Nu Eng 105, 206.

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: Mc Eng 219 or Nu Eng 319.

319 Nuclear Power Plant Systems (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: thermodynamics, thermal hydraulics, and mechanical and electrical aspects of nuclear power facilities. Prerequisites: Nu Eng 205 and accompanied or preceded by Nu Eng 223.

322 Nuclear System Design I (Lect 1.0) A preliminary 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 223, 303, 319, preceded or accompanied by Nu Eng 341.

323 Nuclear System Design II (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). Prerequisite: Nu Eng 322.

333 Applied Health Physics (Lect 3.0) Radiation sources; external and internal dosimetry; biological effects of radiation; radiation protection principles; regulatory guides; radioactive and nuclear materials management. Prerequisite: Nu Eng 203 or Physics 107.

335 Radiation Protection Engineering (Lect 3.0) Radiation fields and sources including nuclear reactors, radioactive wastes, x-ray machines, and accelerators. Stopping of radiation (Charges particles, photons, and neutrons) by matter. Radiation transport methods. Radiation shielding design. Dose rate calculations. Biological effects of radiation. Regulatory guides (10CFR20). 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: Bas Eng 110; Nuc Eng 205; Nuc Eng 223; Met Eng 121. (Co-listed with Met 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 Engineering
Master of Science
Doctor of Philosophy
Doctor of Engineering

The Petroleum Engineering program is offered under the department of Geological Sciences and 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, emphasis areas in reservoir characterization, information technology, and energy industry management.

Mission Statement

The mission of the Petroleum Engineering program is (1) to maintain a quality undergraduate program, and (2) to promote a 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 in other professional areas. The emphasis of the undergraduate program is in preparing students for all aspects of the oil and gas industry. With the current industry innovations resulting in a combination of production and reservoir duties, courses in these areas have incorporated an integration of these concepts.

Faculty

Professors:

Jay Gregg[2] (Department Chair of Geological Sciences and Engineering), Ph.D., Michigan State

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

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

Associate Professors:

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

[1] Registered Professional Engineer
[2] Registered Geologist

Bachelor of Science Petroleum Engineering

FRESHMAN YEAR

(See Freshman Engineering Program) Students planning on majoring in petroleum engineering should take a three hour elective in chemistry, geochemistry, or biology in the freshman year, in addition to Chem 1, 2, and 4.

First Semester	Credit
English 20-Expo & Argumentation	3
BE 10-Study & Careers in Eng	1
Chem 1-Gen Chemistry	4
Chem 2-Gen Chem Lab	1
Chem 4-Intro to Lab Safety	1
History 112, 175, 176, or Poly Sci 90	3
Math 14-Calc for Engineers I	4
	17

Second Semester	
Elective in Chem, Geo Chem, or Bio Sc	3
Math 15-Calc for Engineers II	4
Ge Eng 50 or 51-Geo for Engrs/Physical Geo	3
Physics 23-Eng Physics I	4
BE 20-Eng Design w/Com Apps	3
	17

SOPHOMORE YEAR

First Semester	Credit
Pe Eng 131-Drill Pract & Well Completions	3
Pe Eng 132-Petrol Production Lab	1
Pe Eng 141-Prop of Petroleum Hydrocarbons	3
Basic Eng 50-Statics	3
Math 22-Calc w/Analytic Geom III	4
Physics 24-Eng Physics II	4
	18

Second Semester	
Math 204-Elem Diff Equa	3
Pe Eng 241-Petro Reservoir Engineering	3
Pe Eng 242-Petro Reservoir Lab	1
Bas En 150-Statics	2
Econ 121 or 122-Prin of Economics	3
Emphasis Elective[1]	3
	15

JUNIOR YEAR

First Semester	Credit
Pe Eng 316-Production Applications	3
Pe Eng 232-Well Logging	3
Pe Eng 257-Petroleum Economics	3
Cv Eng 230-Elem Fluid Mech	3
Hum/Soc Sci Elective[1]	3
	15

Second Semester
ME 227-Thermal Analysis 3
Pe Eng Tech Elective 3
Emphasis Elective 3
Bas En 110-Mechanics of Materials 3
Hum/Soc Sci Elective[2] 3
15

SENIOR YEAR

First Semester Credit
Pe Eng 310-Ethics and Professionalism 1
Pe Eng Tech Elective 3
Engl 60/160-Research or Tech Writing or SPM 85 . . .3
Adv Hum/Soc Sci Elective[2] 3
EE 281 or EE 282 or EE 283 3
Adv Math/Stat or Cmp Sc Elective[3] 3
16

Second Semester
Pe Eng 347-Petro Eng Design[4] 3
Pe Eng Tech Elective 3
Pe Eng 335-Secondary Recovery 3
Adv Hum/Soc Sci Elective[2] 3
Emphasis Elective 3
15

1) Emphasis electives to be selected from approved list within emphasis areas listed
2) Humanities/Social Science electives are to be selected from a list of approved courses to be taken in accordance with the School of Materials, Energy, and Earth Resources policy on Humanities/Social Science electives. Psych 50 required for Energy Management emphasis area
3) Advanced Math/Statistics elective must be selected from 200-level Math or Statistics course, or may be selected from Computer Science 73/77, Computer Science 74/78 or an upper level Computer Science course. CS 74/78 required for the IT emphasis area.
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 128.

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

Energy Industry Management Emphasis Area

(9 hours total)
Note: Select Psych 50 for one Humanities/SS elective
Select three courses from the following list:
Eng Mg 211- Mgt. Eng. & Tech
Eng Mg 308 - Economic Decision Analysis
Eng Mg 313 - Managerial Decision Making
Eng Mg 327 - Legal Environment
Eng Mg 361 - Project Management
Eng Mg 364 - Value Analysis

Information Technology Emphasis Area

(9 hours total)
Note: Select Comp Sci 74 and 78 for Advanced Math/Stat/Comp Sci elective
Select IST 51 - Visual Basic
and two other courses from the following list:
IST 151 - Java
IST 211 - Web Design
BUS 110 Mngt & Org Behavior or Eng Mg 211

Reservoir Characterization Emphasis Area

(9 hours total)
Select Geo 340 - Petroleum Geology and two other courses from the following list:
Geo 220 - Structural Geology
Geo 223 - Stratigraphy and Sedimentation
Geo 385 - Exploration and Development Seismology
Geo 332 - Depositional Systems

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

121 Petroleum Introduction and Communications (Lect 2.0) Introduction to petroleum engineering, and the oil and gas industry, through programming concepts and software tools (word processing, spreadsheets, databases, drawing and presentation software). Data manipulation and communications are emphasized through the application of industry data. Prerequisite: Entrance requirements.

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 (or 15) 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. Prerequisite: Chem 1.

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 reservior 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, Econom 121 or Econom 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 the development of oil and gas fields offshore, including offshore leasing, drilling, well completions, production facilities, pipelines, and servicing. Subsea systems, and deepwater developments are also included. This course is suitable for mechanical, electrical and civil engineering students interested in ultimately working offshore. Prerequisite: Pet Eng 131 recommended.

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: Pet Eng 131, preceded or accompanied by Civ Eng 230 and Pet 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 3.0) Senior capstone design project(s) based on industry data. Application of reservoir engineering: drilling and production engineering principles to evaluate and solve an industry problem such as a new field development, evaluation of an existing reservoir asset, or analysis of field re-development. Prerequisites: Pe Eng 241, Pe Eng 316, and senior standing.

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.

School of Materials, Energy, and Earth Resources Courses

101 Special Topics (Variable) This course is designated to give the department an opportunity to test a new course.