Course Descriptions

Courses above the 400 level are normally reserved for graduate studies; however, with approval, undergraduate students may take graduate level courses. Graduate students may also, with approval, take undergraduate courses.

Students must receive a passing grade of "D" or better for any prerequisite course unless specifically stated.

The course titles are "show/hide" links to the complete course descriptions. Click on the course title once to "show" the complete course description. Click on the course title again to "hide" the complete course description.

Anthropology

ANTH 210 Cultural Anthropology

Credits: (3-0) 3

Introduces the nature of human culture as an adaptive ecological and evolutionary system, emphasizing basic anthropological concepts, principles and problems. Draws data from both traditional and industrial cultures to cover such concepts as values and beliefs, social organization, economic and political order, science, technology, and aesthetic expression.

Art

ARTH 211 History of World Art I

Credits: (3-0) 3

Art and architecture in the historical and contextual development of the role of visual arts including crafts, drawing, painting, sculptures and architecture, in the historical and cultural development of world civilizations from prehistory through the 14th century.

ARTH 321 Modern and Contemporary Art

Credits: (3-0) 3

An exploration of technological and cultural influences on materials and content of art from the late 1800s to the present.

ARTH 491 Independent Study

Credits: 1 to 9

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

ARTH 492 Topics

Credits: 1 to 6

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of special topics will be allowed for degree credit.

Atmospheric and Environmental Sciences

AES 110 Orientation to the Atmospheric Sciences

Credits: (1-0) 1

This course represents an introduction to the field of Atmospheric Sciences for first year undergraduate students. Basic skills and concepts to prepare students for future coursework will be presented. Guest lectures and field trips to various local sites will be used to introduce students to a variety of potential careers in the atmospheric sciences. Classroom exercises will be used to help develop critical thinking and analytical skills and to introduce the scientific method for problem solving.

AES 201 Introduction to Atmospheric Sciences

Credits: (3-0) 3

Basic physical principles are applied to the study of atmospheric phenomena. Topics covered include the structure of the atmosphere, radiative processes, atmospheric motions and other meteorological processes, air masses and fronts, weather map analysis, weather forecasting, storm phenomena including tropical and mid-latitude storms, thunderstorms, lightning, hail, tornadoes, and regional and global climate.

AES 391 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 6 credit hours.

AES 392 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours.

AES 401/501 Atmospheric Physics

Credits: (3-0) 3

An introduction to physical processes that govern the behavior of the atmosphere. Topics will include atmospheric thermodynamics; absorption, scattering and radiative transfer; convective motion, troposheric chemistry, cloud and precipitation development; and atmospheric electricity.

Prerequisites:

For AES 401, PHYS 213/213-A, MATH 321, and AES 404/504 are required. For AES 501, graduate standing is required.
Notes: Students enrolled in AES 501 will be held to a higher standard than those enrolled in AES 401.

AES 403/503 Biogeochemistry

Credits: (3-0) 3

The earth system is tightly connected through biogeochemical interactions. This course will present a multi-disciplinary array of intermediate and advanced topics in terrestrial, aquatic, and atmospheric biogeochemistry. Instantaneous to decadal time-scale interactions of carbon, water, and multiple nutrient cycles will be discussed, and a critical survey of the state-of-the-art field, modeling, and remote sensing

methods for studying biogeochemical cycles will be presented.

Prerequisites: For AES 403, CHEM 106 or CHEM 112 ; BIOL 151 ; PHYS 111 or PHYS 211/211-A . For AES 503, graduate standing.
Notes: Students enrolled in AES 503 will be held to a higher standard than those enrolled in AES 403.

AES 404/504 Atmospheric Thermodynamics

Credits: 2 or 3

This course will cover topics related to the thermodynamics of the atmosphere, particularly as they apply to a parcel of air. It will include the ideal gas law, the first and second laws of thermodynamics, adiabatic transformations, entropy, thermodynamic properties of water in its three phases, and effects of water vapor on thermodynamics of atmospheric processes. The final third of the course will introduce vertical stability and atmospheric thermodynamic diagrams.

Prerequisites: PHYS 211/211-A and MATH 225 MEM students may substitute MATH 205 for MATH 225 or permission of instructor. For AES 504, graduate standing is required.
Notes: Students enrolled in AES 504 will be held to a higher standard than those enrolled in AES 404. The 3 credit section satisfies the general requirements for IS-ATM B.S. program. The 2 credit section satisfies the requirements for the MEM B.S. program.

AES 405/505 Air Quality

Credits: (3-0) 3

Topics covered will include up-to-date science, politics and trends in urban air quality, global effects of environmental pollution, effects of meteorological process on pollutant transport and dispersion, effects of air pollutants on meteorological processes, and the chemistry and physics of pollutant production and control.

Prerequisites: For AES 405, MATH 125, and CHEM 106 or CHEM 112. For AES 505, graduate standing is required.
Notes: Students enrolled in AES 505 will be held to a higher standard than those enrolled in AES 405.

AES 406/506 Global Environmental Change

Credits: (3-0) 3

Major global environmental changes will be addressed using an interdisciplinary approach. Topics will include basic processes and principles of ecosystems, biogeochemical cycles, major climate controls, atmospheric chemistry and feedbacks between climate and various earth system processes.

Prerequisites:

For AES 406, CHEM 112, PHYS 111 or PHYS 113 or PHYS 211/211-A or PHYS 213/213-A and BIOL 311 or permission of instructor. For AES 506, graduate standing is required.
Notes: Students enrolled in AES 506 will be held to a higher standard than those enrolled in AES 406. This course is cross listed with BIOL 406/506.

AES 419/519 Computing Methods in Atmospheric Sciences

Credits: (3-0) 3

Introduction to the Linux/Unix operating system from the user's perspective. Fundamentals of the Fortran 95 programming languages. Introduction to scientific data formats commonly used in the meteorology community (net CDF, GRIB, Climate and Forecast Metadata Conventions). Introduction to NCAR Command Language (NCL).

Prerequisites: For AES 419, CSC 150/150L. For AES 519, there are no prerequisites.
Notes: Students enrolled in AES 519 will be held to a higher standard than those enrolled in AES 419.

AES 430/530 Radar Meteorology

Credits: (3-0) 3

Fundamentals of radar, scattering of electromagnetic waves by water drops and other hydrometeors, radar equations and the quantitative study of precipitation echoes, hydrometeor size distributions, Doppler weather radars, and applicants of radar in meteorology.

Prerequisites: For AES 430, MATH 125 and PHYS 213/213-A. For AES 530, graduate standing is required.
Notes: Students enrolled in AES 530 will be held to a higher standard than those enrolled in AES 430.

AES 450 Synoptic Meteorology I

Credits: (3-0) 3

Class topics will include but are not limited to analysis of surface synoptic weather, upper air, and vertical temperature-moisture soundings; the structure of extratropical storms, synoptic-scale processes responsible for development of precipitation and severe weather phenomena. Laboratory sections will introduce basic LINUX functions and include use of GEMPAK and/or NCL.

Prerequisites: AES 201 and AES 404/504

AES 455/555 Synoptic Meteorology II

Credits: (3-0) 3

Study and application of modern techniques for forecasting the development and movement of weather systems and for forecasting various weather phenomena. Includes discussion of numerical weather prediction and suite of forecasting models run daily by the National Centers for Environmental Prediction; use of current software packages such as NCL and GEMPAK for analyzing observed data and model output: interpreting weather phenomena in terms of dynamical theories; forecasting of convective weather phenomena; understanding the use of Model Output Statistics (MOS).

Prerequisites:

For AES 455, AES 450 or permission of instructor. For AES 555, graduate standing.
Notes: Students enrolled in AES 555 will be held to a higher standard than those enrolled in AES 455/455L.

AES 460/560 Atmospheric Dynamics

Credits: (3-0) 3

Equations of motion, kinematics of fluid flow, continuity equation, vertical motion, theorems of circulation and vorticity, quasi-geostrophic systems, and wave motions in the atmosphere.

Prerequisites: For AES 460, MATH 321 and PHYS 211/211-A. For AES 560, graduate standing is required.
Notes: Students enrolled in AES 560 will be held to a higher standard than those enrolled in AES 460.

AES 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 3 credit hours.

AES 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 5 credit hours.

AES 520 Remote Sensing for Research

Credits: (3-0) 3

Radiative transfer with respect to satellite remote sensing. Basic IDL programming. Image processing. Image enhancement. Image classification and interpretation. Satellite operations. Overview of operational and research satellite platforms and select applications. The remote sensing of surface and atmospheric features. Labs and student projects. Includes a laboratory component.

AES 540 Atmospheric Electricity

Credits: (3-0) 3

This course will cover topics in fair weather electricity including ions, conductivity, currents and fields making up the global circuit. In addition, topics in thunderstorm electricity including charge separation theories and the microphysical and dynamic interactions responsible for charging, current balances, and the lightning discharge will be introduced.

Prerequisites: PHYS 213/213-A or equivalent, or graduate standing.

AES 570 Wildfire Meteorology

Credits: (3-0) 3

In this course students will learn about basic physical processes related to fire behavior and fire weather. Topics include combustion and heat, forest fuels, fire danger, fire behavior and spread, fire spread models, smoke management, prescribed fire, and case studies of significant large wildfires in recent history. Some outdoor field instruction is included.

Prerequisites: AES 201 or graduate standing.

AES 591 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

AES 592 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

AES 603 Biosphere-Atmosphere Interactions

Credits: (3-0) 3

The biosphere and the atmosphere are intimately connected. In this course, the biogeochemical sources and sinks of a wide range of gases affecting atmospheric chemistry, climate, and ecosystem health are examined in detail. Microbial, plant, and animal processes relating to nitrogen, sulfur, and carbon trace gas production and consumption will be covered in detail. Relevant biophysical phenomena occurring in vegetation canopies, soils, wetlands, and oceans will be discussed. The role of humans in altering these natural processes will be revisited throughout the course, and overviews of trace gas measurement techniques will be presented.

Prerequisites: Graduate standing.

AES 612 Atmospheric Chemistry

Credits: (3-0) 3

Topics include radiative, chemical, meteorological and biological processes associated with formation of the major and minor components of the atmosphere. These will be viewed from the perspectives of classical chemistry, classical nucleation theory, instrumentation use in atmospheric chemical studies, and atmospheric chemical modeling.

Prerequisites: Graduate standing

AES 615 Earth and Systems Modeling

Credits: (3-0) 3

This course provides the background for environmental modeling using a "Systems Thinking" approach. The course will cover: radiation balance, climate feedback mechanisms, biological, ecological and hydrologic systems as well as systems-based modeling examples applied to select non-environmental problem domains. Course will include familiarization of systems modeling using the STELLA modeling package. Students will also collaborate to develop components of a larger modeling project.

Notes: This course is cross-listed with CEE 615.

AES 625 Scaling in Geosciences

Credits: (3-0) 3

Issues regarding the scaling of geophysical processes across various problem domains in the geosciences will be presented and explored through lectures, labs and course projects. Topics include Fourier Analysis, Taylor/Moment Expansion Fractals, Power Laws, and Upscaling/Downscaling Techniques. Applications include Climate, Turbulence, Weather and Climate Prediction, Remote Sensing and GIS, Ecosystem Studies, Geology and Hydrology. Includes a computer laboratory component.

Prerequisites: MATH 125, CSC 150/150L or equivalent

AES 643 Precipitation Physics and Cloud Modification

Credits: (3-0) 3

Topics will include aerosol, water droplet and ice particle microphysical processes and the interactions between these species, including precipitation development, both in natural and artificially modified clouds.

Prerequisites: Graduate standing

AES 651 Measurement and Instrumentation

Credits: (3-0) 3

An overview of the principles of measurement will be covered, in combination with detailed investigations into selected instruments designed to measure some of the following phenomena: radiation, temperature, humidity, wind, precipitation, photosynthesis, surface reflectance, and concentrations and fluxes of trace gases. Multiple scale measurement techniques will be addressed. In the laboratory part of the course, students will learn to collect, log, and format field data for quality control and analysis using both manual and automatic methods. The topics covered in this course will

vary depending on the research interests of students enrolled and the contributing professors.

Prerequisites: Graduate standing

AES 660 Atmospheric Dynamics II

Credits: (3-0) 3

Derivation, solution, and physical interpretation of the fundamental hydrothermodynamic equations as applied to atmospheric waves, mesoscale motions, atmospheric energetics, general circulation, tropical and stratospheric flows. Introduction to numerical prediction.

Prerequisites: Graduate standing

AES 690 Seminar

Credits: (1-0) 1

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division or graduate levels. May be repeated for additional credit.

Notes: Enrollment required of all graduate students in residence each spring semester.

AES 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

AES 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a

specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

AES 744 Numerical Dynamics and Prediction

Credits: (3-0) 3

Basic governing equations; wave motions; baroclinic instability; numerical methods; numerical prediction models; boundary layer; moisture and radiation parameterization, and data assimilation. Includes a computer laboratory component.

Prerequisites: Graduate standing

AES 770 Boundary Layer Processes

Credits: (3-0) 3

Atmospheric structure and processes near the ground. Turbulence and the closure problems, buoyancy and stress-driven mixed layers, mixed layer growth, heat, moisture, and momentum transfer, surface balance of radiation, heat and moisture, parameterization, and modeling of the boundary layer.

Prerequisites: Graduate standing

AES 773 Mesometeorology

Credits: (3-0) 3

Observations and analysis of basic meteorological fields on the mesocale. Dynamics, phenomenology, and forecasting of mesoscale weather phenomena; Internally generated circulations, meoscale convective systems, external forced circulations. Mesoscale modeling and nowcasting.

Prerequisites: Graduate Standing

AES 775 Applied Freshwater Science

Credits: (3-0) 3

This course will be an advanced course in applied freshwater science. We will be focusing on lake and stream/river ecosystems and cover topics that include abiotic and biotic properties. In addition, we will read and discuss articles from the scientific literature.

AES 788 Master's Research Projects

Credits: 1 to 3

Independent research problems/projects that lead to a research paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. Oral defense of the report and research findings are required at conclusion of AES 788 study project for credit to be awarded.

AES 790 Seminar

Credits: (1-0) 1

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division or graduate levels.

Notes: Not to exceed 1 credit toward fulfillment of Ph.D. degree requirements. AES 790 is cross-listed with CEE 790, GEOL 790, GEOE 790, and MES 790/890.

AES 791 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

AES 792 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

AES 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

AES 808 Fundamental Problems in Engineering and Science

Credits: (3-0) 3

The course, available only for doctoral candidates, involves description, analysis, and proposed methods of attack of long-standing, fundamental problems in science and engineering. Independent work is emphasized with goals of understanding these basic questions and proposing practical designs and experiments for their solution.

Notes: This course is cross listed with CEE 808 and GEOL 808.

AES 898 Dissertation

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee. Oral defense of dissertation and research findings is required.

Notes: Credit to be arranged. Open only to doctoral candidates.

Biology

BIOL 111 Introduction to Chemistry and Applied Biological Sciences

Credits: (1-0) 1

An introduction to the fields of chemistry and applied biological sciences, and opportunities therein, intended for first year students. Methods and concepts utilized in the fields will be presented, as will discussions of academic and scientific resources utilized in education in chemistry and applied biological sciences. Students will also engage in academic planning to meet their individual career goals. Research opportunities in the fields will also be presented.

Notes: BIOL 111 is cross-listed with CHEM 111.

BIOL 121 Basic Anatomy

Credits: (3-0) 3

Anatomy of the human body to include basic biological principles and medical nomenclature. This course is specifically designed for students in the pre-nursing curriculum.

BIOL 121L Basic Anatomy Lab

Credits: (0-1) 1

Laboratory experience that accompanies BIOL 121. Exercises to complement material in BIOL 121 with special emphasis on the anatomy of the cat.

Pre or Corequisites: BIOL 121

BIOL 123 Basic Physiology

Credits: (3-0) 3

The physiology of the human body. This course is specifically designed for students in a pre-nursing curriculum.

BIOL 123L Basic Physiology Lab

Credits: (0-1) 1

Laboratory exercises to accompany BIOL 123 including non-invasive experimentation and computer demonstration materials.

Pre or Corequisites: BIOL 123

BIOL 151 General Biology I

Credits: (3-0) 3

The introductory course for those majoring in biology and microbiology. Presents the concepts of cell biology, evolution, heredity, molecular genetics, and ecology.

BIOL 151L General Biology I Lab

Credits: (0-1) 1

Laboratory experience that accompanies BIOL 151. Laboratory exercises designed to reinforce subject material covered in BIOL 151 lectures.

Pre or Corequisites: BIOL 151

BIOL 153 General Biology II

Credits: (3-0) 3

A continuation of BIOL 151, the introductory course for those majoring in biology and microbiology. Presents the concepts of animal and plant structure and function, energetics, and reproduction.

Prerequisites: BIOL 151

BIOL 153L General Biology II Lab

Credits: (0-1) 1

Laboratory experience that accompanies BIOL 153. Laboratory exercises designed to reinforce subject material covered in BIOL 153 lectures.

Pre or Corequisites: BIOL 153

BIOL 221 Human Anatomy

Credits: (3-0) 3

Structures of various systems in the human body are presented as a structural basis for physiology.

BIOL 221L Human Anatomy Lab

Credits: (0-1) 1

Laboratory experience that accompanies BIOL 221.

Pre or Corequisites: BIOL 221

BIOL 298 Undergraduate Research

Credits: 1 to 3

Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses that are theoretical.

Prerequisites: Permission of instructor.

BIOL 311 Principles of Ecology

Credits: (3-0) 3

Basic principles of ecology including the sub disciplines of physiological ecology, population ecology, community ecology, evolutionary ecology, and ecosystems ecology from both a theoretical and applied aspect.

BIOL 311L Principles of Ecology Laboratory

Credits: (0-1) 1

Laboratory experience that accompanies BIOL 311.

Prerequisites: BIOL 153 or BIOL 311
Pre or Corequisites: BIOL 311 or permission of instructor.

BIOL 326 Biomedical Physiology

Credits: (3-0) 3

Human physiology integral to the fields of biomedical sciences, bioengineering, and health professions. Topics include the scientific principles of cell transport, cell signaling, and major organ systems including nerve, muscle, cardiovascular, respiratory, renal, digestive endocrine, metabolic, and reproductive systems. An emphasis is placed on the integrative nature of physiology and the ability to think critically as students apply physiology to real-world situations and processes.

Prerequisites: Four hours of CHEM, BIOL 153 or BIOL 221

BIOL 326L Biomedical Physiology Lab

Credits: (0-1) 1

Lab to accompany BIOL 326 Biomedical Physiology. Lab designed to provide students with hands-on experience that reinforces information presented in lecture. Lab will familiarize students with various lab techniques and equipment used in physiological experimentation and clinical settings.

Prerequisites: Four hours of CHEM, BIOL 153 or BIOL 221
Pre or Corequisites: BIOL 326

BIOL 331 Microbiology

Credits: (3-0) 3

This course will be a study of the morphology and physiology of representatives of various groups of microorganisms, with emphasis on bacteria.

Prerequisites: BIOL 151 and CHEM 106 or CHEM 112

BIOL 331L Microbiology Lab

Credits: (0-1) 1

Laboratory experience that accompanies BIOL 331.

Pre or Corequisites: BIOL 331

BIOL 333/333L Aquatic Ecology & Watershed Management

Credits: (4-0) 4

This course will provide a detailed introduction to aquatic ecology and the field of watershed management. Selected topics include watershed ecology, ecosystem services, nonpoint source pollution, aquatic invasive species, and watershed planning, monitoring, and protection.

Corequisites: BIOL 333L

BIOL 341 Microbial Processes in Engineering and Natural Sciences

Credits: (3-0) 3

This course introduces and develops important fundamental topics including: microbial structure and

chemistry; cellular metabolism; and intercellular processes and extracellular conditions that control microbial behavior, leading to applications such as biocatalysis, biofuels production, environmental bioremediation, food processing, microbial ecology, pharmaceuticals production, environmental microbiology, and wastewater renovation.

Prerequisites: CHEM 112

BIOL 341L Microbial Processes Laboratory

Credits: (0-1) 1

Most of the sustainable and environmental friendly processes used for food processing, site remediation, and biofuel synthesis using nonfood organic wastes rely on biological systems. In this context, this laboratory courses provides hands-on experience in microbial culture techniques used in various industrial sectors e.g., fermentation, metabolic engineering, techniques, functional type growth media preparation; enrichment and isolation of indigenous microorganisms; microbial production of biofuels and value-added products including industrial potential enzymes, bioethanol, biogas, and exopolysaccharides; and bioremediation.

Prerequisites: CHEM 106L or CHEM 112L
Pre or Corequisites: BIOL 341 or BIOL 331 or permission of instructor.

BIOL 371 Genetics

Credits: (3-0) 3

Principles governing the nature, transmission, and function of hereditary material with application to plants, animals, humans, and microorganisms.

Prerequisites: BIOL 151

BIOL 371L Genetics Lab

Credits: (0-1) 1

Laboratory experience that accompanies BIOL 371.

Corequisites: BIOL 371

BIOL 372L Molecular Genetics Laboratory

Credits: (0-1) 1

Molecular genetics has brought powerful gene/DNA technologies which are currently being used for human benefits. Therefore, this molecular genetics laboratory course provides hands-on experience in the basic principles of molecular biology techniques. Laboratory exercises may include gene cloning and sequencing, gene amplification, restriction endonuclease mapping, gene detection, gene transfer, and bioinformatics.

Prerequisites: CHEM 106L or CHEM 112L
Pre or Corequisites: BIOL 371 or permission of instructor.

BIOL 375 Current Bioethical Issues

Credits: (3-0) 3

Designed to introduce students to the range of ethical issues related to the research, development and application of modern biotechnology and biomedical sciences. The combination of lectures, readings, case discussions and seminars will help students to develop an understanding of the topic and to think critically about the future of the technology and the ethical issues that it presents.

BIOL 383 Bioethics

Credits: (3-0) 3

Ethical, social, and policy dilemmas in medicine and biology.

BIOL 406/506 Global Environmental Change

Credits: (3-0) 3

Major global environmental changes will be addressed using an interdisciplinary approach. Topics will include basic processes and principles of ecosystems, biogeochemical cycles, major climate controls, atmospheric chemistry, and feedbacks between climate and various earth system processes.

Prerequisites:

For BIOL 406, CHEM 112, PHYS 111 or PHYS 113 or PHYS 211/211-A or PHYS 213/213-A and BIOL 311, or permission of instructor. For BIOL 506, graduate standing is required.
Notes: Students enrolled in BIOL 506 will be held to a higher standard than those enrolled in BIOL 406. This course is cross listed with AES 406/506.

BIOL 423 Pathogenesis

Credits: (3-0) 3

Lecture/discussion course on principles of medical microbiology including the molecular basis of pathogenesis, host-parasite relationship, and pathology of animal and human diseases. Emphasis on current literature in pathogenesis.

Prerequisites: BIOL 331

BIOL 423L Pathogenesis Lab

Credits: (0-1) 1

Basic laboratory skills necessary for pathogenic microbiology. Emphasis is on bacteriological, biochemical, and serological tests of medically important pathogens.

Prerequisites: BIOL 331 and BIOL 331L or equivalent.
Pre or Corequisites: BIOL 423

BIOL 438/538 Industrial Microbiology

Credits: (3-0) 3

The roles of microbes in nature, industry, and public health are considered. Application of microbiology to engineering is emphasized.

Prerequisites: BIOL 331 or BIOL 341
Notes: Concurrent registration in BIOL 438L/538L recommended but not required.

Students enrolled in BIOL 538 and/or BIOL 538L are held to a higher standard than those enrolled in BIOL 438 and/or BIOL 438L

BIOL 438L/538L Industrial Microbiology Lab

Credits: (0-1) 1

Basic laboratory skills necessary for applied environmental microbiology. Emphasis is on sampling of environmental microorganisms, bacterial growth curve, analysis of water quality, isolation of coliphages, and Ames test for chemical mutagens.

Prerequisites: BIOL 331 or BIOL 341
Pre or Corequisites: BIOL 438/538
Notes: Students enrolled in BIOL 538 and/or BIOL 538L are held to a higher standard than those enrolled in BIOL 438 and/or BIOL 438L.

BIOL 446/546 Molecular Cell Biology

Credits: (3-0) 3

Development of modern molecular biology and applications to understanding mechanisms underlying cellular structure and physiology. Emphasis on molecular control of processes such as the cell cycle, replication, cellular movement, and regulation of gene expression, specifically with respect to eukaryotic cells.

Prerequisites: BIOL 151 and BIOL 371, or permission of instructor
Notes: Students enrolled in BIOL 546 will be held to a higher standard than those enrolled in BIOL 446.

BIOL 455/555 DNA Structure and Function

Credits: (3-0) 3

Detailed examination of the basics of DNA structures, including alternative conformations of DNA, such as left-handed DNA, triplex DNA, quadruplex DNA, unwound DNA, slipped strand structures, and others. DNA supercoiling and the dynamics of alternative structure formation are also covered. The biology associated with alternative DNA conformations is also explored.

Prerequisites: BIOL 151 and CHEM 326
Notes: Students enrolled in BIOL 555 will be held to a higher standard than those enrolled in BIOL 455.

BIOL 470/570 Cancer Biology

Credits: (3-0) 3

This course will address the current research directed at understanding the molecular and cellular basis of cancer and explore potential therapeutic targets. Topics covered will emphasize cell cycle regulation and apoptosis, cellular control of proliferation and differentiation, genetic alterations, growth factors and signal transduction, invasion and metastasis, and angiogenesis.

Prerequisites: BIOL 371 ; BIOL 446/546
Notes: Students enrolled in BIOL 570 will be held to a higher standard than those enrolled in BIOL 470.

BIOL 478/578 Microbial Genetics

Credits: (3-0) 3

Study of the genetics of prokaryotic microorganisms, with a focus on historical discoveries and their applications to new molecular genetic and bioengineering technologies.

Prerequisites: BIOL 331 and BIOL 371
Notes: Students enrolled in BIOL 578 will be held to a higher standard than those enrolled in BIOL 478.

BIOL 480/580 Bioinformatics

Credits: (3-0) 3

Bioinformatics is a rapidly growing field that comprises computational methods for collecting, organizing, and analyzing large amounts of biological data. This course introduces computational tools for study of biological sequence data. For example, several modules including sequence-based similarity, sequence pairwise and multiple alignments, cellular localization, alternative open reading frame, structure-based evidence, enzymatic function, duplication and degradation, horizontal gene transfer (constructing phylogenetic trees), genomics, and proteomics will be introduced.

Prerequisites: BIOL 331, BIOL 341, or BIOL 371, or permission of instructor.
Notes: Students enrolled in BIOL 580 will be held to a higher standard than those enrolled in BIOL 480.

BIOL 490 Seminar

Credits: 1 to 3

A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division or graduate levels. Enrollment is generally limited to fewer than 20 students.

BIOL 491 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

BIOL 492 Topics

Credits: 1 to 5

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

BIOL 497 Cooperative Education

Credits: 1 to 12

Applied, monitored, and supervised, field-based learning experience for which the student may or may not be paid. Students gain practical experience; they follow a negotiated and/or directed plan of study established between the student, instructor, and field experience supervisor. Due to the presence of a field experience supervisor, a lower level of supervision is provided by the instructor in these courses than is the case in an internship or practicum course.

BIOL 498 Undergraduate Research/Scholarship

Credits: 1 to 12

Includes Senior Project, and Capstone Experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor

BIOL 570 Cancer Biology

Credits: (3-0) 3

This course will address the current research directed at understanding the molecular and cellular basis of cancer and explore potential therapeutic targets. Topics covered will emphasize cell cycle regulation and apoptosis, cellular control of proliferation and differentiation, genetic alterations, growth factors and signal transduction, invasion and metastasis, and angiogenesis.

BIOL 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

BIOL 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Biomedical Engineering

BME 408/508 Biomedical Engineering

Credits: (3-0) 3

This course provides basic concepts in biomedical engineering. Topics covered include materials for biomedical engineering, cellular and molecular processes for biomedical engineering, biological sensing, and experimental design.

Notes: Students enrolled in BME 508 will be held to a higher standard than those enrolled in BME 408.

BME 528/528L Applied Finite Element Analysis/Lab

Credits: (2-1) 3

Basic mathematical concepts of finite element analysis will be covered. The students will learn finite element modeling using state of the art software, including solid modeling. Modeling techniques for beams, frames, two and three- dimensional solids, and then walled structures will be covered in the course.

Corequisites: BME 528L
Notes: This course is cross listed with ME 428/428L/528/528L.

BME 586 Immuno-Engineering

Credits: 2 or 3

This course is taught in 3 parts. Part I is required and provides adequate and relevant background in components and functions of the immune system. Part II covers current topics in the field of immuno-engineering including nanotechnology, vaccine development and cancer therapy. Part III focuses on understanding of fluid transport in cells, tissues and organs, and advanced modeling applications associated with transport of agents *via* blood and lymph to immune system. Cross-listed with BME. As potential options for 2 credits, students may take either Parts I and II or Parts I and III.

Prerequisites: Pre-requisites for Part I and Part II, 2 cr hr enrollment: Biol 151

Pre-requisites for Part III, 1 cr hr enrollment: Biol 151, CBE 218, CBE 318 or POI

BME 602 Anatomy and Physiology for Engineers

Credits: (3-0) 3

This course introduces biomedical engineering students to fundamentals of human anatomy and physiology. Topics include engineering anthropometry, the skeletal system, skeletal muscle, the neuromuscular control system, the respiratory system, the circulatory system, the metabolic system, the thermoregulatory system, body rhythms, and an introduction to reengineering the human body.

BME 603 Molecular Biology for Engineers

Credits: (3-0) 3

This course is designed to provide a basic knowledge on molecular biology and bioinformatics that is directly applicable to engineering and related science fields. Up-to-date techniques in genetic engineering, biotechnology, and bioinformatics will be introduced for the understanding of biological problems using engineering concepts or engineering/mechanical problems through biological tools.

Notes: This course is cross listed with CBE 603.

BME 604 Sensing and Signal Processing

Credits: (3-0) 3

Presentation of principles, characteristics, and applications of instrumentation systems including sensors, filters, instrumentation amplifiers, analog-to-digital and digital-to- analog conversions, and noise. This course will be useful to graduate students beginning their laboratory thesis research. It is available to students from other departments with permission of instructor.

BME 606 Occupational Biomechanics

Credits: (3-0) 3

Anatomical and physiological concepts are introduced to understand and predict human motor capabilities, with particular emphasis on the evaluation and design of manual activities in various occupations. Quantitative models are developed to explain muscle strength performance; cumulative and acute musculoskeletal injury; physical fatigue; and human motion control.

BME 607 Biomechanics

Credits: (3-0) 3

This course presents an introduction to biomechanics from a continuum mechanics perspective. It covers fundamental concepts of solid and fluid mechanics with applications to living systems. Topics in biosolid mechanics include stress, strain, constitutive relations, equilibrium, response to basic loading modes (extension, bending, and torsion), and buckling. Topics in biofluid mechanics include motion of a continuum, constitutive relations, fundamental balance relations, control volume and semi- empirical methods.

BME 612 Biotech-Biomedical Engineering

Credits: (3-0) 3

This course will be a survey of principles and techniques that biomedical engineers working in biotechnology and biomedical engineering will encounter in research or industry. It will serve to introduce the important advances in the state of the art in molecular and cell biology. Topics include fermentation, cell culture, recovery and purification, and technology responsible for the success of biotechnological applications, i.e., recombinant DNA technology or genetic engineering.

BME 673 Applied Engineering Analysis I

Credits: (3-0) 3

Advanced topics in engineering analysis. Special mathematical concepts will be applied to mechanical engineering problems. Topics will be selected from the following: Fourier series and boundary value problems applied to heat conduction and convection, Laplace transforms and complex variable analysis applied to vibrations and dynamic system analysis, series solutions of differential equations, partial differential equations, general matrix applications to a variety of large systems of equations in engineering, calculus of variation, and Ritz method for various engineering problems.

Notes: This course is cross listed with ME 673.

BME 675 Non-Thesis Practical Experience and Technical Communication

Credits: 1 to 3

Students in the non-thesis track will learn aspects of technical communication and data presentation necessary for careers in biomedical engineering through lectures, interpretation of the primary literature, various writing assignments, and topical presentations.

BME 690 Seminar

Credits: (1-0) 1

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media, such as internet, and are at the upper division or graduate levels. Enrollment is generally limited to 20 or fewer students.

NOTES: A total of 3 credits of BME 690 and/or BME 790 may count toward MS degree. A total of 6 credits of BME 690 and/or BME 790 may count toward PhD.

BME 710 Experimental Design and Data Analysis in Biological Engineering

Credits: (3-0) 3

This course is intended to introduce students to basic concepts and tools of experimental design and statistical analysis in biomedical research. We will discuss how to design and execute an experiment and how to use various statistical tools to estimate data parameters and test hypotheses. It is expected that students will be able to formulate a rational hypothesis from biological theory, design an experiment to test the hypothesis, and use an appropriate statistical analysis to examine the hypothesis and interpret the results upon completion of this course. The primary objective of this course is to help students understand the methodological and practical principles needed to undertake biological research and evaluate others' research as published in the biomedical literature.

BME 719 Nanomaterials for Biosensors

Credits: (3-0) 3

Topics covered will include the fundamental principles of signal recognitions in protein, DNA, and enzyme biosensors, basic properties of nanomaterials related to sensors, electrochemical biosensors, optical and fluorescence sensors, chemiresistors, sensors based on semiconductor electronic devices, and the recent development of innovative nanomaterials for next-generation biosensors.

Prerequisites: Enrollment in one of the Biomedical Engineering, or Nanoscience & Nanoengineering, or Materials Engineering and Science programs, or Permission of Instructor.
Notes: BME 719 is cross-listed with NANO 719 and MES 719.

BME 724 Biopolymers

Credits: (3-0) 3

This course is to survey the structure, function, properties and use of biopolymers. The course has three fifty minute lectures per week on Monday, Wednesday and Friday. Supporting reading materials will be assigned from the textbook and supplementary reading materials. Please note that the textbook is meant

to supplement the lectures, not to substitute for them; you will ONLY be responsible for the materials presented in the lectures.

BME 725 Biocomposites

Credits: (3-0) 3

This course focuses on composite materials applied to bioengineering. First part of the course introduces biocomposites for medical applications and biocompatibility. Second part focuses on mechanical design and manufacturing aspects of various fibrous polymer matrix composites in terms of: i) material selection, fabrication, and characterization, ii) mechanics of composite materials, iii) design with composite materials. Third part deals with ceramic or nano composites and their applications in biomedical engineering. Final part introduces various case studies such as dental, orthopedics, prosthetic socket, and external fixator applications.

BME 726 Biocomposites Bio/Mems and Nano Systems

Credits: (3-0) 3

Application of microelectromechanical systems (MEMS) and nano-systems to biological systems, interaction of living cells and tissues with MEMS substrates and nano-engineered materials, microfluidics, engineering of inputs and outputs.

BME 730 Vascular Mechanics and Pathology

Credits: (3-0) 3

The course focuses on the artery and arterial diseases, including the genesis of heart disease. Since the artery serves as both conduit of blood flow and container of blood pressure, the course covers both the general principles and the occurrence of stress concentration in the pressure vessel. The topics included are atherosclerosis, structure and mechanics of the artery, pressure vessel principles, stress concentration in the artery, endothelial cells and low density lipoproteins, smooth muscle cells and stretch, stress reduction and atherosclerosis reduction, vein graft, intracranial aneurysms, and aortic aneurysms.

BME 731 Advanced Biomechanics

Credits: (3-0) 3

The course presents the fundamentals of continuum mechanics and nonlinear theory of elasticity with applications to the mechanical behavior of soft biological tissues.

BME 732 Medical Imaging

Credits: (3-0) 3

This course covers the physics of the major modalities commonly used in medical imaging. Also covered are the various principles and methods of constructing an image from the physical interactions of energy with living tissues, and the influence of image quality of the different modalities. Medical imaging systems to be analyzed include conventional X-ray, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine (PET and SPECT), and ultrasound. Each of these modalities will be introduced from basic physical principles to the process of image formation. The primary focus is on the physical principles, instrumentation methods, and imaging algorithms; however, the medical interpretation of images, and clinical, research and ethical issues are also included where possible to give students a deeper understanding of the medical imaging field.

BME 733 Cardiovascular Fluid Dynamics

Credits: (3-0) 3

Mechanics of blood circulation, fluid mechanics of the heart, blood flow in arteries, unsteady flow in veins, current concepts in circulatory assist devices, biofluidics, and other selected topics. Review of cardiovascular physiology; introduction to fluid mechanics; Models of blood flow and arterial wall dynamics; Fluid mechanics and arterial disease; heart valve fluid dynamics; Ventricular assist devices.

BME 734 Transport Phenomena in Biomedical Engineering

Credits: (3-0) 3

The study of transport phenomena in biomedical systems including analysis of engineering and physiological systems and incorporation of these principles into the design of such systems. The objective of this course is for students to learn to think about, understand and model the dynamic behavior of complex biological systems. The scope of the systems to be studied is restricted to an analysis of biotransport phenomena in the human body.

BME 735 CAD/CAM in Medicine and Surgery

Credits: (3-0) 3

Introduction to computer aided design and modeling of prosthetic devices, and their subsequent manufacture using computer aided manufacturing techniques. Applications in orthopedic implant design and fabrication, dental implant design and fabrication, as well as other types of prosthetics. An advanced level review of current computer modeling and manufacturing technology for medical applications.

BME 736 Advanced Finite Element Methods

Credits: (3-0) 3

Variational and weighted residual approach to finite element equations. Emphasis on two- and three-dimensional problems in solid mechanics. Isoparametric element formulation, higher order elements, numerical integration, imposition of constraints, convergence, and other more advanced topics. Introduction to geometric and material nonlinearities. Introduction to the solution of dynamic problems and time integration. Use of finite element computer programs.

Notes: This course is cross listed with ME 736

BME 737 Advanced Signal Processing and Imaging

Credits: (3-0) 3

This course develops the theory essential to understanding the algorithms that are increasingly found in modern signal processing applications, such as speech, image processing, digital radio and audio, statistical and adaptive systems. Topics include: analysis of non-stationary signals, transform techniques, Wiener filters, Kalman filters, multirate systems and filter banks, hardware implementation and simulation of filters, and applications of multirate signal processing. Matlab will be used extensively.

BME 738 Information Technology in Medicine

Credits: (3-0) 3

Software techniques used in medical treatment and diagnosis, including transform techniques. Medical reference software engineering. Data mining. Hardware and connectivity issues. Bioinformatics.

BME 740 Biomaterials Surface Science and Engineering

Credits: (3-0) 3

This course focuses on the surface properties of biomaterials and their influence on biological and clinical outcomes. Specifically, the general surface properties of biomaterials such as surface chemistry, surface morphology, surface roughness, and surface charges will be explained. The course will cover the different instrumentation that is currently available to characterize biomaterial surfaces. Also, a variety of surface modification technologies available to engineer biomaterial surfaces will be covered as well. Example cases will be provided regularly to emphasize the biological and clinical significance of biomaterial surfaces.

BME 742 Applied Electrochemistry

Credits: (3-0) 3

This course will work from a knowledge of thermochemistry, physical chemistry, and analytical chemistry to understand the fundamental aspects of electrochemical processes in materials processing. This will include the thermodynamics and kinetics of aqueous electrochemical reactions and electrochemical measurement techniques. The course will focus on the application of electrometallurgical principles to a wide variety of industrial processes and will enable students to calculate relevant processing parameters and develop a sound understanding of electrochemical processes in materials processing.

Pre or Corequisites: Graduate standing.
Notes: This course is cross-listed with MES 742 and CBE 742.

BME 745 Molecular Machines

Credits: (3-0) 3

This course studies forces that determine molecular structure, transport, and diffusion, macromolecular assemblies, protein synthesis, structural biology, molecular genetics, enzymology.

BME 746 Biomimetics

Credits: (3-0) 3

This course will survey recent research at the intersection of biology and mechanical/structural engineering, in particular, applications where nature's design philosophies are applied in human-engineered structures. Multi-functional materials, hierarchical design, adaptive materials within closed loop systems, self- healing of natural structures, with a view to self-healing human engineered structures. Applications in aerospace and rehabilitation engineering.

BME 751 Drug Delivery

Credits: (3-0) 3

This course focuses on the engineering and biomolecular principles of drug therapy. Students will be introduced to the fundamentals of drug delivery, materials used for drug delivery, and controlled/targeted drug delivery strategies.

BME 761 Bioadhesives

Credits: (3-0) 3

This course will provide a survey of natural and synthetic biological adhesives that are of importance in biomedicine. Main topics include fundamentals of bioadhesion, methods of evaluating bioadhesive interactions, and concepts and strategies in designing bioadhesive systems for biomedical applications.

BME 773 Applied Engineering Analysis II

Credits: (3-0) 3

Applications of numerical methods to mechanical engineering problems. Topics will include data processing techniques, curve fitting and interpolation of experimental information, solutions to systems of ordinary differential equations, solutions to partial differential equations, and numerical integration both of known functions and functions described only by experimental data.

Notes: This course is cross listed with ME 773.

BME 788 Master's Research Problems/Project

Credits: 1 to 12

Independent research problems/projects that lead to research or design paper, but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

BME 790 Seminar

Credits: (1-0) 1

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division or graduate levels.

BME 792 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

BME 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on- one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged. Open only to students pursuing the M.S. thesis option.

BME 888 Doctorial Research in Problems and Projects

Credits: 1 to 12

Independent research problems/projects that lead to research or design paper, but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

BME 896 Field Experience

Credits: (0-1) 1

Students will spend a minimum of three hours per week in a hospital or another program-approved health care facility. They will observe and/or work with the technical and clinical staff in order to develop insights into the health care profession and the role of engineering in medicine as it applies to their focus area of study and research.

Notes: Required of doctoral students only.

BME 898 Dissertation

Credits: Credit to be arranged

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on- one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; Open only to doctoral candidates.

Chemical and Biological Engineering

CBE 111/111L Introduction to Chemical Process Modeling/Lab

Credits: (1-1) 2

The primary objectives of this course are: introduction to mathematical modeling of physical and chemical systems; verification of mathematical models by experiment; introduction to engineering software like Excel; development and interpretation of engineering drawings, process flow diagrams (PFD's), and piping and instrumentation diagrams (P&ID's); use of a drawing program, such as Visiotec; and introduction to the process simulator AspenPlus; oral and written communication of technical content to technical and non-technical audiences; and a focus on professional and academic paths in chemical engineering and related fields.

Pre or Corequisites: CHEM 112

CBE 117L Programming for Chemical and Biological Engineering

Credits: (0-1) 1

An introduction to chemical engineering through the development of computational and laboratory skills. The extended use of spreadsheets, programming, and computational software packages will be covered. Elementary numerical methods will be utilized in process modeling and laboratory experiments. Students will participate in hands-on programming exercises in a computer laboratory, or in a lab, using a tablet-pc.

Pre or Corequisites: MATH 123

CBE 200 Undergraduate Research

Credits: 1 to 3

Directed research or study of a selected problem culminating in an acceptable written report.

Prerequisites: Permission of instructor and freshman or sophomore standing.

CBE 217 Chemical Engineering Material Balances

Credits: (3-0) 3

The first course on the theory and practice of chemical engineering with emphasis on material and energy balances.

Pre or Corequisites: CHEM 114 and MATH 123 or permission of instructor.

CBE 218 Chemical Engineering Fluid Mechanics

Credits: (3-0) 3

The second course on the theory and practice of chemical engineering with emphasis on momentum transfer.

Prerequisites: MATH 125 and PHYS 211/211-A, or permission of instructor.

CBE 222 Chemical Engineering Process Thermodynamics

Credits: (3-0) 3

A study of the principles and applications of thermodynamics with emphasis on the first law, the energy balance.

Prerequisites: CHEM 114 and MATH 125, or permission of instructor.

CBE 250 Computer Applications in Chemical Engineering

Credits: (2-0) 2

The application of digital computer techniques to the solution of chemical engineering problems.

Pre or Corequisites: MATH 321, CBE 117L or equivalent.

CBE 317 Chemical Engineering Heat Transfer

Credits: (3-0) 3

The third course on the theory and practice of chemical engineering with emphasis on heat transfer. Heat transfer by conduction, convection, and radiation is studied.

Prerequisites: CBE 217 ; CBE 218, EM 331 or ME 331 ; CBE 250 or CEE 284 and MATH 321 or permission of instructor.

CBE 318 Chemical Engineering Mass Transfer

Credits: (3-0) 3

The fourth course on the theory and practice of chemical engineering with emphasis on molecular diffusion, membranes, convective mass transfer, drying, humidification, and continuous gas-liquid separation processes.

Prerequisites: CBE 218 or permission of instructor.

CBE 321 Chemical Engineering Equilibrium Thermodynamics

Credits: (3-0) 3

A continuation of CBE 222 with emphasis on the second and third laws of thermodynamics. Emphasis on thermodynamic properties of fluids, flow processes, phase and chemical equilibria.

Prerequisites: CBE 217, CBE 222, and MATH 225, or permission of instructor

CBE 333 Process Measurements and Control

Credits: (1-0) 1

A study of the equipment and techniques used in monitoring process measurements and the design of feedback control systems.

Prerequisites: CBE 217 or CBE 218 or CBE 222 or permission of instructor.

CBE 333L Chemical Engineering Process Control Lab

Credits: (0-1) 1

Laboratory experiments in process measurements, feedback control loops, and industrial data acquisition and control.

Pre or Corequisites: CBE 333

CBE 343 Chemical Kinetics and Reactor Design

Credits: (3-0) 3

A study of chemical kinetics and reactor design, including techniques for analyzing kinetic data, choosing reactor operating parameters, economic optimization of homogeneous reactions, and reactor modeling.

Pre or Corequisites: CBE 317 and CBE 321, or permission of instructor

CBE 361L Chemical Engineering Fluid Laboratory

Credits: (0-1) 1

Laboratory experiments in fluid flow, fluid flow measurements, and design of fluid handling systems.

Pre or Corequisites: CBE 218

CBE 362L Chemical Engineering Heat Transfer Laboratory

Credits: (0-1) 1

Laboratory experiments on heat transfer.

Prerequisites: CBE 317

CBE 364 Chemical Process Design, Economics, and Safety

Credits: (2-0) 2

Chemical process design and economics topics may include time value of money, DCFROR/VPV analysis of projects and investment alternatives, after tax analysis, estimation of process operating costs, use of heuristics for equipment sizing, and estimation of process capital and equipment costs. Safety topics may include toxicology and industrial hygiene, source models, properties and prevention of fires and explosions, relief design and sizing, and hazards identification.

Prerequisites: CBE 218 and CBE 222 or permission of instructor.

CBE 417 Chemical Engineering Equilibrium Separations

Credits: (2-0) 2

The fifth course on the theory and practice of chemical engineering with emphasis on equilibrium staged separations.

Prerequisites: CBE 321

CBE 424/524 Molecular Modeling and Simulation

Credits: (3-0) 3

Course covers topics related to computational quantum chemistry, statistical mechanics, and molecular simulation. Emphasis is placed on the use of existing methods and programs to determine

thermodynamic and transport properties as well as reaction kinetic constants and mechanisms. Applications in biological systems, materials, phase equilibrium, and combustion will be discussed. Discussion of the benefits and limitations of computer simulations will accompany each course topic.

Prerequisites: CBE 321 and CHEM 114 or permission of instructor.
Notes: Students enrolled in CBE 524 will be held to a higher standard than those enrolled in CBE 424.

CBE 433 Process Control

Credits: (3-0) 3

Analysis and design of process control systems for industrial processes, including controller tuning and design of multivariable control schemes.

Prerequisites: MATH 321 and senior standing.
Notes: This course is cross listed with MET 433.

CBE 434/534 Design of Separation Processes

Credits: (1-0) 1

Separation technology and processes are studied with application to current industrial design problems. Topics and design case studies may include: adsorption, biological separations, crystallization, distillation, environmental separations, ion exchange, membrane separations, molecular distillation, pervaporation, solid separations, supercritical extraction, thermal strippings, and others.

Prerequisites: CBE 318
Notes: Students enrolled in CBE 534 will be held to a higher standard than those enrolled in CBE 434.

CBE 434L/534L Design of Separation Processes Laboratory

Credits: (0-1) 1

Laboratory experiments in the design of separation processes, including reverse osmosis, crystallization, ultrafiltration, microfiltration, gas permeation, ion exchange, adsorption, and others.

Pre or Corequisites: CBE 434/534
Notes: Students enrolled in CBE 534L will be held to a higher standard than those enrolled in CBE 434L.

CBE 444/544 Reactor Design

Credits: (3-0) 3

Applications of chemical engineering principles to reactor design. Emphasis includes: non-isothermal reactor modeling, homogeneous and heterogeneous reactors, economics and performance optimization, catalysis, and computer simulation.

Prerequisites: CBE 343 and CBE 250
Notes: Students enrolled in CBE 544 will be held to a higher standard than those enrolled in CBE 444.

CBE 445/545 Oxidation and Corrosion of Metals

Credits: (3-0) 3

Initially, the thermodynamics of electrochemical processes are covered; use of the Nernst equation and Pourbaix diagram is presented in this material. Fundamentals of electrode kinetics are then discussed with special emphasis on the derivation of the Butler-Volmer equation and application of the Evan's diagram. Following presentation of these fundamental concepts, phenomena observed in corrosion and oxidation such as uniform attack, pitting, stress corrosion cracking, and corrosion fatigue are discussed. Finally, selection of materials for site specific applications is covered.

Prerequisites: MET 320 or CBE 222 or ME 211 or permission of instructor.
Notes: Students enrolled in CBE 545 will be held to a higher standard than those enrolled in CBE 445. This course is cross listed with MET 445/545.

CBE 450/550 Systems Analysis Applied to Chemical Engineering

Credits: 2 to 3

The development of mathematical models for dynamic and steady state chemical engineering systems; simulation of these complex systems using computers and software, such as AspenPlus; estimation of physical and equilibrium properties; and analysis of results.

Pre or Corequisites: CBE 417 and CBE 433; or permission of instructor.
Notes: Students enrolled in CBE 550 will be held to a higher standard than those enrolled in CBE 450.

CBE 455/555 Pollution Phenomena and Process Design

Credits: (3-0) 3

The study of the industrial sources of and treatment of air, water and land pollutants. The chemical and physical phenomena operating in pollution control equipment and the design of pollution control equipment will be examined. Waste minimization and pollution prevention strategies will be considered.

Prerequisites: CBE 218, CBE 317 and CBE 318 or equivalent; or permission of instructor.
Notes: Students enrolled in CBE 555 will be held to a higher standard than those enrolled in CBE 455. This course is cross listed with CEE 555.

CBE 461L Chemical Engineering Mass Transfer and Reaction Engineering Laboratory

Credits: (0-1) 1

Laboratory experiments on mass transfer.

Prerequisites: CBE 318, CBE 343 and CBE 417

CBE 463 Process Design for Chemical Engineering

Credits: (1-1) 2

Topics may include conceptualization of chemical processes and evaluation and selection of process alternatives, inherently safer process design, synthesis of BFDs and PFDs, use of process simulators for synthesis and optimization. Students will work in groups on a common process design project, culminating in a Phase II process design (PFD level design) including process description, evaluation of alternatives, economics, and safety.

Prerequisites: CBE 318, CBE 343, and CBE 364 or permission of instructor
Pre or Corequisites: CBE 417 or permission of instructor.

CBE 465 Advanced Process and Equipment Design

Credits: (2-0) 2

Course topics featuring design of processes and equipment unit operations, such as: filtration, cyclones/hydrocyclones, sedimentation, centrifuges, vacuum system sizing and leakages, particle sizing analysis via sieves, PSA, SEM, TEM, mixers (HT, MT, etc.), dispersion of 2nd phase and droplet sizes, S, L, V dispersions, compressors, removal of liquid, size reduction/enlargement, process piping/equipment, and crushers. Coverage may also include the principles of heat exchange networks, heat integration, and process optimization.

Prerequisites: CBE 317 or permission of instructor.

CBE 466 Capstone Design for Chemical Engineering

Credits: (0-2) 2

Students will work in design teams to complete a semester-long capstone project. The course format is

predominantly design project based, featuring weekly meetings with faculty mentors. Projects will be open-ended and may vary from group to group. Projects may involve trouble shooting/optimization/redesign of an existing process. The final design package should include a comprehensive final report with PFDs, P&IDs, equipment specification sheets, and safety/economic analyses.

Prerequisites: CBE 318, CBE 343, CBE 364, CBE 417, and CBE 463 or permission of instructor.

CBE 474/574 Polymer Technology

Credits: 2 to 3

A study of the engineering aspects of polymer synthesis and reactor design, polymer testing, polymer characterization, rheology, macro- properties, and fabrication. Students may enroll for 2 or 3credits, depending upon the particular level of course matter that matches their interest. Students taking 2 credits will take two-thirds of the course material. The instructor, in conjunction with the department head, will monitor student credit hours. Course is not repeatable for credit.

Prerequisites: Senior standing or permission of instructor.
Notes: Students enrolled in CBE 574 will be held to a higher standard than those enrolled in CBE 474.

CBE 474L/574L Experimental Polymer Technology

Credits: (0-1) 1

Laboratory experiments in polymer synthesis, chemical and mechanical property testing, extrusion, and modeling.

Pre or Corequisites: CBE 474/574
Notes: Students enrolled in CBE 574L will be held to a higher standard than those enrolled in CBE 474L.

CBE 475/575 Advances in Processing and Nanoengineering of Polymers

Credits: (2-0) 2

The course will begin with an overview of the basic principles of polymer rheology and structure formation. It will then review recent examples from the scientific literature in which concepts and theories of rheological behavior and structure formation at multiple length scales have been further developed and/or applied to the processing of polymers and composites with advanced functional and multifunctional properties. Special attention will be paid to research related to processing challenges in the formation of polymer nanocomposites, nanofibers and hierarchical composite structures. As part of this course, students will be expected to develop skills in reviewing and critically assessing the scientific literature, and in developing research strategies based on current state of knowledge.

Prerequisites: CHEM 114 and CHEM 114L or MES 604 or permission of instructor.
Notes: Students enrolled in CBE 575 will be held to a higher standard than those enrolled in CBE 475. This course is cross listed with MES 475/575 and NANO 475/575.

CBE 476/576 Organosilicon Polymer Chemistry and Technology

Credits: (1-0) 1

An introduction to the engineering and science aspects of silicone-organic polymer chemistry from an industrial viewpoint. The course covers basic silicone nomenclature, monomer and polymerization reactions, curing, reinforcement, general applications, and hands-on laboratory exercises, which include making things like elastomeric (bouncy) putty and high-bouncing balls. The course is held during a one-week period.

Prerequisites: Senior standing or permission of instructor.
Notes: Students enrolled in CBE 576 will be held to a higher standard than those enrolled in CBE 476.

CBE 482/582 Upstream Oil and Gas Processing

Credits: 1 or 3

This course provides an overview of upstream petroleum processing technologies with relevant aspects of computer simulations to develop an understanding of complex fluid transport and fluid-phase interactions. It also covers process engineering aspects of gas and petroleum processing prior to refining. The first third of the course (1 credit) gives an overview of upstream processing and is appropriate for all students meeting the non-CBE prerequisite. The remaining 2 credit hours of the course provide a more detailed coverage of upstream petroleum process.

Prerequisites: Prerequisite for 1 credit hour part of the course: ME 331, or CBE 218, or equivalent, or permission of instructor. Prerequisite for full 3 credit hour course: CBE 321, CBE 318, and Pre/Co-requisite: CBE 417, or permission of instructor.
Notes: Students enrolled in CBE 582 will be held to a higher standard than those enrolled in CBE 482.

CBE 483/583 Petroleum Refining

Credits: 2 or 3

Overview of unit operations of Petroleum Refining. Use of heuristics to estimate performance of economics of refinery units. Application of chemical engineering principles to petroleum refining. Relevant aspects of computer-aided process simulation for complex mixtures. The 2 lecture credit hours are for refinery overview and heuristic design-economics. The 3 lecture credit hours include Aspen modeling of ChE refinery applications.

Prerequisites: 2 credit hour prerequisites: CBE 364 or IENG 301 or IENG 302 (Engineering Economics), CBE 222 or ME 211 (Introduction to Thermodynamics), or equivalent.

3 credit hour prerequisites: CBE 343, CBE 364 and CBE 417, or permission of instructor.
Notes: Students enrolled in CBE 583 will be held to a higher standard than those enrolled in CBE 483.

CBE 484/584 Fundamentals of Biochemical Engineering

Credits: (3-0) 3

An introduction to the characterization of microorganisms, fermentation pathways, unit processes in fermentation, biochemical kinetics, and batch and continuous fermentation. The basic engineering concepts of fermentation, separation, control, and operations will be discussed.

Prerequisites: CBE 343
Corequisites: BIOL 331 or BIOL 341
Notes: Students enrolled in CBE 584 will be held to a higher standard than those enrolled in CBE 484.

CBE 484L/584L Biochemical Engineering Laboratory

Credits: (0-1) 1

Laboratory experiments in biochemical engineering. May include fermentation, dissolved oxygen mass transfer measurements, bioseparations, and other experiments to correlate with selected lecture topics.

Pre or Corequisites: CBE 484/584
Notes: Students enrolled in CBE 584L will be held to a higher standard than those enrolled in CBE 484L.

CBE 485/585 Renewable and Sustainable Energy

Credits: (3-0) 3

This course provides assessment and evaluation of current and potential energy systems; covers resources, conversion, and end-use, and emphasizes sustainable approaches meeting global energy needs in the 21st century. Different renewable and conventional energy technologies will be covered including solar, wind, geothermal, nuclear, biofuels, fossil fuels, hydrogen, fuel cells, and discussed within frameworks that aid in evaluation and analysis of energy systems engineering in the context of economics and environmental goals.

Prerequisites: Junior standing or permission of instructor.
Notes: Students enrolled in CBE 585 will be held to a higher standard than those enrolled in CBE 485.

CBE 485L/585L Renewable and Sustainable Energy Lab

Credits: (0-1) 1

This laboratory course provides hands-on experience with current and future energy systems, energy conversion calculations and efficiency measurements. Specific labs may include photovoltaics, photocatalysis, electrocatalysis, thermochemical water-splitting, biofuel production, fuel cells, and hybrid energy systems.

Pre or Corequisites: CBE 485/585 or permission of instructor.
Notes: Students enrolled in CBE 585L will be held to a higher standard than those enrolled in CBE 485L.

CBE 486/586 Immuno-Engineering

Credits: 2 or 3

This course is taught in 3 parts. Part I is required and provides adequate and relevant background in components and functions of the immune system. Part II covers current topics in the field of immuno-engineering including nanotechnology, vaccine development and cancer therapy. Part III focuses on understanding of fluid transport in cells, tissues and organs, and advanced modeling applications associated with transport of agents *via* blood and lymph to immune system. Cross-listed with BME. As potential options for 2 credits, students may take either Parts I and II or Parts I and III.

Pre-requisites for Part I and Part II, 2 cr hr enrollment: Biol 151
Pre-requisites for Part III, 1 cr hr enrollment: Biol 151, CBE 218, CBE 318 or POI

Prerequisites: BIOL 151 BIOL 151 , CBE 218 , CBE 318 or POI

CBE 487 Global and Contemporary Issues in Chemical Engineering

Credits: 1-0) 1

A study of contemporary global and societal issues in the field of chemical engineering.

Pre or Corequisites: CBE 364 or permission of instructor

CBE 488/588 Applied Design of Experiments for the Chemical Industry

Credits: (2-0) 2

An introduction to the engineering concepts of statistics and design of experiments as applied to chemical and biological engineering problems. Includes setup and experiments for product development or for process trials. Includes critical analysis of results of an experimental design project. The course is held during a time period that will accommodate class members and industrial speakers.

Prerequisites: Senior standing or permission of instructor.
Notes: Students enrolled in CBE 588 will be held to a higher standard than those enrolled in CBE 488.

CBE 489/589 Composites Manufacturing

Credits: (1-0) 1

A background in the concepts of polymers and polymerization as well as an overview of composites concepts, constituent materials, and manufacturing processes provide the groundwork in the first half of the course. A more detailed study of the Vacuum Assisted Resin Transfer molding (VARTM) processing builds upon this groundwork, including topics such as process materials and parameters, mold design and manufacture, and product design considerations. The course concludes with post-processing topics. In conjunction with the concepts lecture, students spend time in the lab constructing and using a simple mold which will illustrate some of the challenges of molding and finishing a composite product.

Notes: This course is cross listed with MET 489/589. Students enrolled in CBE 589 will be held to a higher standard than those enrolled in CBE 489.

CBE 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

CBE 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of special topics will be allowed for degree credit.

CBE 498 Undergraduate Research/Scholarship

Credits: Credit to be arranged.

Includes senior project and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor.
Notes: A maximum of 6 credits of undergraduate research will be allowed for degree credit.

CBE 603 Molecular Biology for Engineers

Credits: (3-0) 3

This course is designed to provide a basic knowledge on molecular biology and bioinformatics that is directly applicable to engineering and related science fields. Up-to-date techniques in genetic engineering, biotechnology, and bioinformatics will be introduced for the understanding of biological problems using engineering concepts or engineering/mechanical problems through biological tools.

Notes: This course is cross listed with BME 603.

CBE 612 Transport Phenomena: Momentum

Credits: (3-0) 3

Introduction to momentum transport. Equations of continuity and motion. Velocity distributions. Boundary layer theory. Turbulent transport compressible flow.

Notes: This course is cross listed with ME 612.

CBE 613 Transport Phenomena: Heat

Credits: (3-0) 3

An in-depth study of the fundamental laws of heat transfer. Major areas considered are: heat conduction, free and forced convention, and radiative heat transfer. Emphasis is placed on the formulation and solution of engineering problems by analytical and numerical methods.

Notes: This course is cross listed with ME 613.

CBE 616 Computations in Transport Phenomena

Credits: (3-0) 3

Various computerized techniques, including finite difference and finite element, will be used to solve transient and steady state heat transfer problems involving conduction and convection.

Notes: This course is cross listed with ME 616.

CBE 621 Advanced Chemical Engineering Thermodynamics I

Credits: (3-0) 3

A mathematical development of fundamental laws of thermodynamics and their application to chemical engineering operations and processes. Equilibrium and thermal effects in homogeneous and heterogeneous systems.

Prerequisites: CBE 321 or permission of instructor.

CBE 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

CBE 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of special topics will be allowed for degree credit.

CBE 714 Transport Phenomena: Mass

Credits: (3-0) 3

An in-depth study of the fundamental laws of mass transfer. Emphasis is placed on the formulation and solution of chemical and biological engineering processes and problems by analytical and numerical methods.

Prerequisites: Permission of instructor.

CBE 728 Heterogeneous Kinetics

Credits: (3-0) 3

Principles of Absolute Rate Theory are combined with thermodynamics to study the mechanisms of homogeneous and heterogeneous reactions in metallurgical systems.

Notes: This course is cross listed with MES 728.

CBE 735 Bioseparations

Credits: (3-0) 3

This course introduces students to the principles and techniques used to recover and purify biologically-produced molecules, especially proteins, nucleic acids, and organic acids, from bacterial, mammalian, and agricultural production systems. The course will focus on centrifugation and filtration, membrane processing, two-phase extraction, precipitation and crystallization, adsorption and chromatography, and electrophoresis. Analysis will include micro and macro scale process modeling and simulation.

Prerequisites: CBE 318 or permission of instructor.

CBE 741 Microbial and Enzymatic Processing

Credits: (3-0) 3

Most of the processes used for energy generation including bioconversion of biomass, food processing, pollution control, rely not only on physico-chemical but also on biological reactions. This course introduces various renewable energy resources, processes, and products, emphasizing critical aspects and challenges of biomass conversion into biofuels and value-added bioproducts especially using extremophiles and their enzymes. Students are expected to learn both fundamental and applied aspects of microbial and enzymatic processing through scientific literature and case studies focusing on the current trends in the field.

Prerequisites: BIOL 341, BIOL 331 or permission of instructor.

CBE 742 Applied Electrochemistry

Credits: (3-0) 3

This course will work from a knowledge of thermochemistry, physical chemistry, and analytical chemistry to understand the fundamental aspects of electrochemical processes in materials processing. This will include the thermodynamics and kinetics of aqueous electrochemical reactions and electrochemical measurement techniques. The course will focus on the application of electrometallurgical principles to a wide variety of industrial processes and will enable students to calculate relevant processing parameters and develop a sound understanding of electrochemical processes in materials processing.

Pre or Corequisites: Graduate standing.
Notes: This course is cross-listed with MES 742 and BME 742.

CBE 788 Master's Research Problems/Project

Credits: Credit to be arranged.

Independent research problems/projects that lead to research or design paper, but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. Oral defense of the report and research findings are required.

Notes: Credit to be arranged; not to exceed 9 credits towards fulfillment of M.S. degree requirements. Open only to students pursing the M.S. non-thesis option.

CBE 790 Seminar

Credits: (1-0) 1

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media, such as internet, and are at the upper division or graduate levels.

Notes: This course may be repeated for credit and is designed to support the Ph.D. in Chemical and Biological Engineering. This course is cross listed with CBE 890.

CBE 791 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings

depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

CBE 792 Topics

Credits: 1 to 4

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

CBE 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Prerequisites: Approval of advisor.
Notes: Credit to be arranged: not to exceed 9 credits toward fulfillment of M.S. degree requirements. An original investigation of a chemical engineering project normally presented as a thesis for the master of science degree in chemical engineering.

CBE 890 Seminar

Credits: (1-0) 1

A highly focused and topical courses. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division of graduate levels.

Notes: This course may be repeated for credit and is designed to support Ph.D. in Chemical and Biological Engineering. This course is cross listed with CBE 790.

CBE 894 Internship

Credits: 1 to 6

A single semester work experience in conjunction with an industrial, state, governmental, or national laboratory employer. Each student will be asked to prepare a written report of their work experience.

Prerequisites: Approval of advisor.

CBE 898D Dissertation

Credits: 1 to 12

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on- one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Prerequisites: Approval of advisor.
Notes: An original investigation of a chemical/biological engineering subject, which culminates in the oral and written presentation of a dissertation for the Ph.D. degree in Chemical and Biological Engineering.

Civil and Environmental Engineering

CEE 117/117L Introduction to CADD/Lab

Credits: (1-1) 2

Students will learn to construct drawing documents using AutoCAD, the use of engineering and architectural scales, lettering practices, geometric construction (manually and AutoCAD), and the ability to visualize in three dimensions.

Corequisites: CEE 117L

CEE 130/130L Introduction to Civil and Environmental Engineering/Lab

Credits: (1-1) 2

This course serves as an introduction to the civil engineering profession. Students will learn how to solve engineering analysis and design problems, develop computational skills, and sharpen communication and teamwork skills.

Prerequisites: MATH 102
Corequisites: CEE 130L

CEE 206/206L Engineering Surveys I/Lab

Credits: (2-1) 3

Mensuration with the application of surveying techniques; basic surveying computations and field practice; theory of error propagation and its analysis; fundamental concepts of horizontal, angular, and vertical measurements; control systems related to engineering-construction surveys. Horizontal and vertical curves. Traverse computations.

Prerequisites: CEE 117 and either an acceptable score on the trigonometry placement examination, or trigonometry (MATH 120) completed with a minimum grade of "C."
Corequisites: CEE 206L

CEE 284 Applied Numerical Methods

Credits: (3-0) 3

An introduction to numerical methods and statistical analysis of data and their applications in civil engineering problems using contemporary software.

Prerequisites: MATH 123

CEE 316/316L Engineering and Construction Materials/Lab

Credits: (2-1) 3

Principles that govern physical and mechanical properties of ferrous and nonferrous metals, plastics, bituminous materials, portland cement, aggregates, concrete, and timber. Laboratory exercises to demonstrate basic principles and standard laboratory tests (ASTM Standards) of structural materials. Computer-aided graphics and word processing are required for lab reports.

Prerequisites: EM 321 with a "C" or better; and CEE 284
Corequisites: CEE 316L

CEE 325 Introduction to Sustainable Design

Credits: (3-0) 3

Theories and principles employed in sustainable design are introduced and employed in various contexts. Analyses of engineered systems will be performed both analytically and quantitatively. Principles will be employed in problem solving as well as fundamental design efforts.

Prerequisites: Junior standing.

CEE 326 Environmental Engineering I

Credits: (3-0) 3

As the first course in the theory and practice of environmental engineering, emphases are on the acquisition of introductory knowledge pertaining to natural and engineered environmental engineering systems, identification and mitigation of societal impacts upon the earth, and application of environmental engineering principles in the design and analysis of systems for water and wastewater treatment and solid/hazardous waste management.

Prerequisites: CHEM 114

CEE 327/327L Environmental Engineering II/Lab

Credits: (2-1) 3

As the second course in the theory and practice of environmental engineering, emphasis is on application of material balance concepts in environmental analysis and design with consideration of water chemistry, environmental process kinetics, ideal and non-ideal reactors, biological process fundamentals, and inter-phase mass transfer phenomena. These fundamental principles are applied in selected natural and engineered environmental contexts spanning air, water and land systems and the effects of society on environmental systems.

Prerequisites: CEE 326 with a "C" or better
Corequisites: CEE 327L

CEE 336/336L Hydraulic Systems Design/Lab

Credits: (2-1) 3

Analysis of flow in pipe systems, open channels, measuring devices, and model studies. Design of hydraulic systems associated with water supply, food control, water storage and distribution, sewer systems, and other water resources.

Prerequisites: EM 331 with a "C" or better; and CEE 284
Corequisites: CEE 336L

CEE 337 Engineering Hydrology

Credits: (3-0) 3

A quantification study of the components of the hydrologic cycle with emphasis on engineering applicants involving the design of water supplies, reservoirs, spillways, floodways, and urban drainage with computer applications.

Prerequisites: EM 331 or EM 328 either with a "C" or better

CEE 346/346L Geotechnical Engineering/Lab

Credits: (2-1) 3

Composition, structure, index, and engineering properties of soils, soil classification systems, introduction to soil engineering problems involving stability, settlement, seepage, consolidation, and compaction; and laboratory work on the determination of index and engineering properties of soils. Computer-aided graphics and word processing are required for lab reports.

Prerequisites: EM 321 with a "C" or better
Corequisites: CEE 346L

CEE 347 Geotechnical Engineering II

Credits: (3-0) 3

Composition of soils, origin, and deposition, exploration, frost problems, swelling of soils, erosion protection, soil improvement, groundwater flow and dewatering, slope stability of retaining structures, and rigid and flexible pavement design. The application of these topics to highway engineering will be stressed.

Prerequisites: CEE 346/346L with a "C" or better

CEE 353 Structural Theory

Credits: (3-0) 3

Basic concepts in structural analysis of beams, trusses, and frames. Determination of governing load conditions for moving loads by use of influence lines. Development of basic virtual work concept to obtain deflections for beams, trusses, and frames. Introduction to approximate analysis.

Prerequisites: EM 321 and CEE 284

CEE 421/521 Aqueous Geochemistry

Credits: (3-0) 3

Geochemical principles and applications for aqueous systems, including water quality and mass transport. Topics will include thermodynamics, carbonate equilibria, silica solubility, redox reactions, pE-pH relationships, and partial pressure diagrams. Geochemical modeling software will be used in

projects.

Prerequisites: CHEM 114
Notes: Students enrolled in CEE 521 will be held to a higher standard than those enrolled in CEE 421. This course is cross listed with GEOE 421/521.

CEE 425/525 Sustainable Engineering

Credits: (3-0) 3

This course will serve as an introduction to the emerging field of sustainable engineering, with focus on understanding interactions between industrial processes and the environment. Identification and implementation of strategies to reduce the environmental impacts of products and processes associated with industrial systems will be explored and evaluated using tools such as life cycle analyses and materials balances. The course will also explore appropriate sustainable technologies employed within both developing and first world countries.

Prerequisites: Junior standing.
Notes: Students enrolled in CEE 525 will be held to a higher standard than those enrolled in CEE 425.

CEE 426/526 Environmental Engineering Unit Operations and Processes

Credits: (3-0) 3

Theory and practice of environmental engineering with emphases on the design and analysis of physical/chemical environmental engineering unit operations and processes.

Notes: Students enrolled in CEE 526 will be held to a higher standard than those enrolled in CEE 426.

CEE 427/527 Environmental Engineering Biological Process Design

Credits: (3-0) 3

Theory and practice of environmental engineering with emphases on the design and analysis of biological environmental engineering unit operations and processes.

Notes: Students enrolled in CEE 527 will be held to a higher standard than those enrolled in CEE 427.

CEE 428/528 Oil and Gas Development and the Environment

Credits: (3-0) 3

This course explores environmental issues related to oil and gas development, including potential

groundwater contamination, drilling solid waste and wastewater treatment and disposal, atmospheric pollution, and unintentional releases.

Notes: Students enrolled in CEE 528 will be held to a higher standard than those enrolled in CEE 428.

CEE 433/533 Open Channel Flow

Credits: (3-0) 3

Application of continuity, momentum, and energy principles to steady flow in open channels; flow in open channels; flow in the laminar and transition ranges; specific energy and critical depth; energy losses; channel controls; gradually and rapidly varied flow; and high velocity flow.

Prerequisites: CEE 336/336L
Notes: Students enrolled in CEE 533 will be held to a higher standard than those enrolled in CEE 433.

CEE 437/437L/537/537L Watershed and Floodplain Modeling/Lab

Credits: (2-1) 3

This course will consist of the application of the HEC-HMS Flood Hydrograph Package and HEC-RAS Water Surface Profiles computer programs. Each model is applied to an actual watershed and conveyance channel. The student is responsible for two project reports, one for each model application. Data compilation and model development and execution will be conducted in the lab portion of the class. Development of the model inputs will include review of hydrologic and hydraulic processes relating to model options.

Prerequisites: CEE 337
Corequisites: CEE 437L or CEE 537L
Notes: Students enrolled in CEE 537/537L will be held to a higher standard than those enrolled in CEE 437/437L.

CEE 447/547 Foundation Engineering

Credits: (3-0) 3

Application of the fundamental concepts of soil behavior to evaluation, selection, and design of shallow and deep foundation systems. Related topics such as temporary support systems for excavations and pile driving are also included.

Prerequisites: CEE 346/346L
Notes: Students enrolled in CEE 547 will be held to a higher standard than those enrolled in CEE 447.

CEE 448/548 Applied Geotechnical Engineering

Credits: (3-0) 3

Content will include the application of principles taught in CEE 346/346L and CEE 347 to practical geotechnical engineering problems in the civil engineering profession, such as exploration, pavement design, slope stability, geosynthetics, geotechnical problems unique to the region, and dam design.

Prerequisites: CEE 346/346L
Notes: Students enrolled in CEE 548 will be held to a higher standard than those enrolled in CEE 448.

CEE 451/451L/551/551L Design of Wood Structures/Lab

Credits: (2-1) 3

This course will cover the behavior and properties of timber, lumber, and pre-engineered structural wood products. Students will learn to design members and systems using current methods and appropriate codes and specifications. An additional research requirement will be included for those taking the class for graduate credit. The course includes a lecture component complemented by a computational laboratory.

Prerequisites: CEE 353
Corequisites: CEE 451L or CEE 551L
Notes: Students enrolled in CEE 551 will be held to a higher standard than those enrolled in CEE 451.

CEE 453/553 Design of Steel Structures

Credits: (3-0) 3

Correlation of analysis and design using the current building code requirements for steel structures. Design techniques are formulated for axial, transverse and combined loading conditions, for individual members and for connections between components of a structure. Comparisons between design requirements of materials to illustrate relative benefits in structural systems.

Prerequisites: CEE 353 with a "C" or better
Notes: Students enrolled in CEE 553 will be held to a higher standard than those enrolled in CEE 453.

CEE 456 Concrete Theory & Design

Credits: (3-0) 3

Properties and behavior of concrete and reinforcing steel. Analysis and design of structural slabs, beams, girders, columns, and footings with use of strength methods. Deflection of flextural members. Development of reinforcement.

Prerequisites: CEE 353 with “C” or better

CEE 457/557 Indeterminate Structures

Credits: (3-0) 3

Analysis of indeterminate structures by classical and matrix methods. The classical methods are the force method, the slope-deflection equations and the moment-distribution method. The classical methods also are used to determine influence lines for indeterminate structures. Stiffness matrices for truss and beam elements are derived and used to analyze trusses, beams and frames.

Prerequisites: CEE 353
Notes: Students enrolled in CEE 557 will be held to a higher standard than those enrolled in CEE 457.

CEE 463 Concepts of Professional Practice

Credits: (2-0) 2

Lecture and discussion with emphasis on current civil engineering topics with emphasis on professional, personal, and ethical development.

Prerequisites: Senior in civil engineering.

CEE 468/568 Highway Engineering

Credits: (3-0) 3

The course addresses transportation systems; traffic flow theory; planning and traffic operations; design, construction, and maintenance of highways and pavements.

Prerequisites: CEE 316/316L
Notes: Students enrolled in CEE 568 will be held to a higher standard than those enrolled in CEE 468 and complete additional design work or projects.

CEE 474/574 Construction Engineering and Management

Credits: (3-0) 3

A study of construction engineering and construction project management topics in the context of earthmoving, heavy construction, and building construction.

Prerequisites: CEE 316/316L

Notes: Students enrolled in CEE 574 will be held to a higher standard than those enrolled in CEE 474. This course is cross listed with CEM 574.

CEE 489 Capstone Design Project

Credits: (0-3) 3

A significant engineering design experience culminating in final documents and presentation addressing problem clarification, concept generation, impact analysis, concept selection, engineering analysis/design, final results and recommendations. Course should be taken during final semester of study.

Prerequisites: CEE 326 , CEE 336/336L, and CEE 346/346L, all with a minimum grade of "C"

CEE 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

CEE 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

CEE 498 Undergraduate Research/Scholarship

Credits: 1 to 6

Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor.

CEE 555 Pollution Phenomena and Process Design

Credits: (3-0) 3

The study of the industrial sources of and treatment of air, water, and land pollutants. The chemical and physical phenomena operating in pollution control equipment and the design of pollution control equipment will be examined. Waste minimization and pollution prevention strategies will be considered.

Prerequisites: CBE 218 , CBE 317 , and CBE 417 , or equivalent, or permission of instructor.
Notes: This course is cross listed with CBE 455/555.

CEE 600 Research Methods

Credits: (1-0) 1

Students will gain the research skills needed to plan and implement an independent research project. Students will learn about the processes of research and writing, connections between writing and thinking/learning, and the essential components of scientific/engineering research documents, such as thesis, dissertations, research reports, and research or thesis proposals.

CEE 608 Construction Contracts

Credits: (3-0) 3

This course addresses the roles and responsibilities of the project team, project delivery methods, the preparation of accurate and enforceable specifications, and the effective administration of construction contracts. Contract documents, including project plans and specifications, will be analyzed from the perspective of coordination, interpretation, and enforcement. Guidelines and documents from various organizations will be examined to develop an understanding of the design process, product selection, and improved communication among the project participants involved in all aspects of managing a project from initial planning to completion.

Notes: Permission of Instructor will only be granted to students enrolled in an Accelerated Master's Program or have a Notice of Intent to Qualify for Construction Engineering and Management Certificate on file with the Registrar.

Cross-listed with CEM 608

CEE 615 Earth and Systems Modeling

Credits: (3-0) 3

This course provides the background for environmental modeling using a "Systems Thinking" approach. The course will cover: radiation balance, climate feedback mechanisms, biological, ecological and

hydrologic systems as well as systems-based modeling examples applied to select non-environmental problem domains. Course will include familiarization of systems modeling using the STELLA modeling package. Students will also collaborate to develop components of a larger modeling project.

Notes: This course is cross-listed with AES 615.

CEE 616 Codes and Standards

Credits: (3-0) 3

Students will study the basic design and construction related codes and standards, learning their source of authority and learning to effectively read and apply content to manage the development of projects. Documents may include IBC, NFPA, and other various State and Federal source documents.

CEE 621 Environmental Contaminant Fate and Transport

Credits: (3-0) 3

Mathematical analysis of the processes governing the fate and movement of anthropogenic contaminants in natural systems. Topics include: liquid-solid, vapor-solid, and vapor-liquid partitioning; liquid and vapor phase convection and diffusion; biotic and abiotic transformations; and mathematical modeling of coupled processes.

Prerequisites: CEE 421/521 or permission of instructor

CEE 634 Surface Water Hydrology

Credits: (3-0) 3

Review and advanced study of hydrologic cycle including precipitation, infiltration, evapotranspiration, and runoff. Applications to analysis and design of water supplies, reservoirs, spillways, floodways, urban runoff, and protection systems.

Prerequisites: CEE 337 or permission of instructor.

CEE 641 Earthquake Engineering

Credits: (3-0) 3

The course will provide entry level engineers and geologists with a fundamental understanding of earthquake strong ground motions, structural vibration and damping, ground motion prediction, seismic hazards analyses, wave propagation, dynamic soil and rock properties, ground response analysis, building code response spectra, building code compatible ground motions, simplified Newmark

techniques and liquefaction.

Prerequisites: CEE 346 or equivalent

CEE 651 Advanced Steel Design

Credits: (3-0) 3

Analysis and design of structural elements, connections and systems in structural steel.

Prerequisites: CEE 357

CEE 652 Prestressed Concrete

Credits: (3-0) 3

Principles of linear and circular prestressing. Behavior of steel and concrete under sustained load. Analysis and design of pretensioned and post-tensioned reinforced concrete members and the combination of such members into an integral structure.

Prerequisites: CEE 456 or permission of instructor.

CEE 653 Reinforced Concrete Design

Credits: (3-0) 3

Design for torsion, simple space structural elements such as corner beams, curved beams, and free-standing staircases. Yield line theory and design of two-way reinforced slabs and floor systems. Design of a multi-story frame building system.

Prerequisites: CEE 456

CEE 655/655L Applied Composites/Lab

Credits: (2-1) 3

Basic properties and principles of advanced composite materials such as fiberglass and graphite, and aramic design and testing of primary structural members including prestressing elements. Application of composite materials to engineering.

Prerequisites: CEE 353 or permission of instructor.
Corequisites: CEE-655L

CEE 657 Advanced Structural Analysis

Credits: (3-0) 3

Analysis of statically indeterminate structural systems. Flexibility and stiffness methods of analysis for two- and three-dimensional orthogonal and non-orthogonal structures with reference to digital computer procedures. Special solution procedures including use of substructures. Energy methods of structural analysis and introduction to finite element method.

Prerequisites: CEE 457/557 or permission of instructor.

CEE 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Senior or graduate standing or permission of instructor.

CEE 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Prerequisites: Senior or graduate standing.

CEE 715 Construction Operations

Credits: (3-0) 3

Course addresses the materials and methods of earthmoving, heavy, and building construction operations.

Prerequisites: Graduate standing.
Notes: This course is cross-listed with CEM 715.

CEE 730 Statistics Methods in Water Resources

Credits: (3-0) 3

Stochastic process, probability and statistics applied to hydrologic problems. Data synthesis, frequency analysis, correlation, time series, and spectral analysis.

CEE 731 Contaminant Fate and Transport

Credits: (3-0) 3

The study of fate and transport processes of contaminants in water and air environments. Modeling principles of how pollutants move and react in environmental systems (air and water) with analytical analysis and computer modeling.

Prerequisites: CEE graduate student or permission of instructor

CEE 739 Techniques of Surface Water Resource and Water Quality Investigations I

Credits: (3-0) 3

A study of the theory, design and techniques used in hydrologic and water quality investigations by environmental engineers, hydrologists, and hydraulic engineers. Topics to be covered include, but are not limited to: surface water steamflow measurements and records compilation, water quality monitoring, stormwater runoff sampling and permit process, bioassessment of water quality, sediment sampling, lake water quality assessment, and non parametric statistics.

Prerequisites: CEE 337 or permission of instructor.

CEE 743 Advanced Soil Mechanics

Credits: (3-0) 3

Methods of geotechnical analysis; seepage analysis by methods of fragments; geotechnical material failure criteria; constitutive laws for geotechnical materials; flexible and rigid surface foundations on elastic foundations; matrix method of analysis for surface foundations; stress development in soil mass; composite finite element method of analysis; movement dependent lateral earth pressure development; analysis and design of earth reinforcement.

Prerequisites: CEE 346/346L or permission of instructor.

CEE 745 Advanced Foundations

Credits: (3-0) 3

Application of the principles of soil mechanics to foundation engineering; subsurface exploration; lateral earth pressures and retaining structures; bearing capacity and settlement of shallow and deep foundations; field instrumentation and performance observation; and case studies.

Prerequisites: CEE 346/346L or permission of instructor.

CEE 746 Stability of Soil and Rock Slopes

Credits: (3-0) 3

Geologic aspects of slope stability; shear strength of geologic materials; soil and rock mechanics approaches to slope stability and analysis; two-dimensional limiting equilibrium methods of slope stability and analysis including sliding block methods, Fellenius' and Bishop's methods of slices, and the Morgenstern-Price method of slices; introduction to three -dimensional methods of stability analysis; field instrumentation and performance observations; and case studies.

Prerequisites: CEE 346/346L or permission of instructor.

CEE 747 Earth and Earth Retaining Structures

Credits: (3-0) 3

Engineering properties of compacted soils; use of the triaxial test in soil stability problems; methods of slope stability analysis with emphasis on Bishop's simplified method of slices; design considerations for earth embankments; field instrumentation and performance observations; and case studies. Application of principles of geotechnical engineering to the design of retaining structures. Areas covered are lateral earth pressure theories, rigid and flexible retaining walls, anchored bulkheads, earthquake induced earth pressures, and braced excavations. Stabilization of slopes and reinforced earth applications are also treated, along with instrumentation observations.

Prerequisites: CEE 346/346L or permission of instructor.

CEE 753 Stability of Metal Structures

Credits: (3-0) 3

The course introduces fundamental concepts of structural stability, with an emphasis on stability of steel members and systems using equilibrium and energy solutions. Topics will include: fundamental stability formulations; elastic and inelastic column buckling; lateral stability of beams; column, beam, and frame bracing; and stability design of steel frames.

Prerequisites: CEE 457/557 or permission of instructor.

CEE 757 Advanced Concrete Materials

Credits: (3-0) 3

Topics covered will include cement chemistry, oil and gas well cementing, hydration, microstructure, mechanical behavior, dimensional stability, durability concerns related to cement-based materials, novel concrete materials such as geopolymers, and strategies to prevent and mitigate concrete durability issues.

CEE 788 Master's Research Problems/Projects

Credits: Credit to be arranged.

Independent research problems/projects that lead to research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. Oral defense of the report and research findings are required.

Notes: Credit to be arranged; not to exceed 3 credits toward fulfillment of M.S. degree requirements Open only to students pursuing the M.S. non-thesis option.

CEE 790 Seminar

Credits: (1-0)

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division or graduate levels.

Notes: May not be repeated for degree credit. CEE 790 is cross-listed with GEOL 790, GEOE 790, MES 790/890, AES 790.

CEE 791 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Enrollments are usually 10 or fewer students. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: Not to exceed 3 credits toward fulfillment of M.S. degree requirements.

CEE 792 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

CEE 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 6 credits towards fulfillment of M.S. degree requirements. Open only to students pursing the M.S. thesis option.

CEE 808 Fundamental Problems in Engineering and Science

Credits: (3-0) 3

The course, available only for doctoral candidates, involves description, analysis, and proposed methods of attack of long-standing, fundamental problems in science and engineering. Independent work is emphasized with goals of understanding these basic questions and proposing practical designs and experiments for their solution.

Notes: This course is cross listed with AES 808 and GEOL 808.

CEE 898D Dissertation

Credits: 1 to 12

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the

candidate and professor with more limited interaction between and among the candidate and other members of the committee.

CEM 770 Case Studies in Construction

Credits: (3-0) 3

This is a case-oriented course that examines the role of the construction engineer as a manager, strategic planner, policy maker, and problem solver. Cases are presented for research, discussion, analysis, and report.

Computer Engineering

CENG 244/244L Introduction to Digital Systems/Lab

Credits: (3-1) 4

This course is designed to provide computer engineering, electrical engineering, and computer science students with an understanding of the basic concepts of digital systems and their hardware implementation. Topics covered include combinational logic circuits, sequential logic circuits, and CPU control.

Prerequisites: MATH 102
Corequisites: CENG-244L

CENG 264L Electromechanical Systems Product Development and Design Lab

Credits: (0-2) 2

This course focuses on the design process including project management and teamwork; formal conceptual design methods; acquiring and processing information; design management tools; design for manufacturability, reliability, maintainability, sustainability; design communication: reports and presentations; ethics in design; prototyping designs; case studies. The cornerstone is a semester-long project in which small teams of students conceive, plan, and design a simple physical product.

Prerequisites: Sophomore standing.
Notes: This course is cross listed with EE 264L and ME 264L.

CENG 291 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: A maximum of 6 credits of independent studies is allowed for degree credits.

CENG 292 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of topics is allowed for degree credits.

CENG 342/342L Digital Systems/Lab

Credits: (3-1) 4

Presents the basic concepts and mathematical tools that are applicable to the analysis and design of digital systems, particularly state machines and digital processing systems. The VHDL hardware description language is also introduced as a design tool.

Prerequisites: CENG 244/244L and CSC 150/150L
Corequisites: CENG 342L

CENG 351/351L Mechatronics and Measurement Systems

Credits: (3-1) 4

This course will encompass general measurement techniques found in mechanical and electrical engineering. These include measurement of force, strain, frequency, pressure flow rates, and temperatures. Elements of signal conditioning and data acquisition will be introduced. In addition to this material, the course will have a mechatronics approach reflected in the combined applications of electronic mechanical and control systems.

Prerequisites: CSC 150/150L and EE 220/220L or EE 301/301L

Corequisites: CENG 351L
Notes: This course is cross listed with EE 351/351L and ME 351/351L.

CENG 391 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: A maximum of 6 credits of independent studies is allowed for degree credits.

CENG 392 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of topics is allowed for degree credits.

CENG 414/514 Introduction to Computer Vision

Credits: (3-0) 3

Introductory course in computer vision. This course covers principles of image formation, local feature analysis, multi-view geometry, image warping and stitching, structure from motion, and visual recognition. We also touch upon related topics in signal and image processing including convolution, image pyramids, frequency domain analysis, and gradient-based analysis techniques.

Prerequisites: EE 313 or CSC 300
Notes: Students enrolled in CENG 514 will be held to a higher standard than those enrolled in CENG 414. This course is cross-listed with CSC 414/514.

CENG 415/415L/515/515L Introduction to Robotics/Lab

Credits: (3-1) 4

An introduction to mechatronic systems and embedded systems for robotics. This course will cover the

basics required for autonomous mobile robotics. The course will begin with a survey of existing systems and some background mathematics. Core course topics will include electromechanical components, electronics for motor control, sensors and instrumentation, mobile robotic kinematics and movement, microcontrollers, real time computing, and embedded system design and development. Course projects will include student teams building task oriented mobile robots with emphasis on the hardware development.

Prerequisites: CSC 300 with a grade of "C"
Corequisites: CENG 415L or CENG 515L
Notes: Students enrolled in CENG 515/515L will be held to a higher standard than those enrolled in CENG 415/415L. This course is cross listed with CSC 415/415L/515/515L.

CENG 420/420L Design of Digital Signal Processing Systems

Credits: (3-1) 4

An introduction to the design of digital signal processing systems. Topics include discrete-time signals and systems, the Z transform, infinite impulse-response digital filters, finite impulse- response digital filters, discrete Fourier transforms, fast Fourier transforms. (Design content-two credits.)

Prerequisites: EE 313
Corequisites: CENG 420L

CENG 421/421L/521/521L Communication Systems/Lab

Credits: (3-1) 4

Fundamentals of analog- and digital-signal transmission. Performance characteristics such as channel loss, distortion, bandwidth requirements, signal-to-noise ratios, and error probability.

Prerequisites: EE 313
Corequisites: CENG 421L/521L
Notes: This course is cross listed with EE 421/421L/521/521L. Students enrolled in CENG/EE 521/521L will be held to a higher standard than those enrolled in CENG/EE 421/421L.

CENG 440/440L VLSI Design/Lab

Credits: (3-1) 4

Provides an introduction to the technology and design of VLSI integrated circuits. Topics include MOS transistors, switch and gate logic, scalable design rules, speed and power considerations, floor planning, layout techniques, and design tools. (Design content - two credits.)

Prerequisites: EE 320/320L
Corequisites: CENG 440L

CENG 442/442L/542/542L Microprocessor-Based System Design

Credits: (3-1) 4

Presents the concepts required for the design of microprocessor-based systems. Emphasis is given to the problems of system specification, choice of architecture, design trade-offs and the use of development tools in the design process. Design projects will be implemented in the laboratory.

Prerequisites: CENG 351/351L/EE 351/351L/ME 351/351L
Corequisites: CENG 442L
Notes: Students enrolled in CENG 542/542L will be held to a higher standard than those enrolled in CENG 442/442L.

CENG 444/444L/544/544L Computer Networks/Lab

Credits: (3-1) 4

This course presents the basic principles of computer networks design and analysis. Topics covered include the layers of the OSI reference model. Current and proposed implementations of local, metropolitan and wide area networks are presented; inter-networking is discussed. The different implementations are compared and their performance evaluated.

Prerequisites: CENG 244/244L and MATH 381 or MATH 442
Corequisites: CENG 444L or CENG 544L
Notes: Students enrolled in CENG 544/544L will be held to a higher standard than those enrolled in CENG 444/444L. Graduation credit will not be allowed for both this course and CSC 463/563.

CENG 446/446L Advanced Computer Architectures/Lab

Credits: (3-1) 4

This course covers the basic principles of pipelining, parallelism and memory management. Topics covered include cache and virtual memory, pipelining techniques and vector processors, multiprocessors and distributed computing systems.

Prerequisites: CENG 342/342L
Corequisites: CENG 446L
Notes: Graduation credit will not be allowed for both this course and CSC 440/440L.

CENG 447/447L/547/547L Embedded Systems

Credits: (3-1) 4

This course provides an introduction to programming embedded and real-time computer systems. It includes design of embedded interrupt driven systems and real-time interfacing. An introduction to

mixed-signal interfacing is introduced to include filter design, controller design, and embedded robotic systems.

Prerequisites: CENG 351/351L /EE 351/351L/ME 351/351L and CSC 150/150L
Corequisites: CENG 447L or CENG 547L
Notes: Students enrolled in CENG 547/547L will be held to a higher standard than those enrolled in CENG 447/447L.

CENG 448/448L/548/548L Real-Time Operating Systems

Credits: (3-1) 4

Introduction to commercial (for example: QNX) or open-source (for example: RT Linux) RTOS operating systems. Students will gain an understanding of the scheduling process in real-time OS, mutual exclusion and semaphores, and data management and message queues. Implementation of real-time tasks for real-time applications will be developed through laboratory experimentation.

Prerequisites: CSC 150/150L and CENG 351/351L/EE 351/351L / ME 351/351L
Corequisites: CENG 448L/CENG 548L
Notes: Students enrolled in CENG 548/548L will be held to a higher standard than those enrolled in CENG 448/448L.

CENG 452/452L Robotic Control Systems/Lab

Credits: (2.5-0.5) 3

Applications of discrete control systems for robotics and autonomous systems; analysis and design of automatic control systems, including both linear and nonlinear systems with continuous and discrete signals.

Prerequisites: CSC 150/150L; EE 314/314L ; or permission of instructor.
Corequisites: CENG 452L
Notes: This course is cross listed with EE 452/452L/552/552L.

CENG 464 Senior Design Project I

Credits: (0-2) 2

This course will focus on the design process and culminate with the faculty approval of design projects (including schematics and parts list) for CENG 465. Typical topics included are the development of product mission statement, identification of the customer and customer needs, development of target specifications, consideration of alternate designs using a decision matrix, project management techniques, legal and ethical issues, FCC verification and certification, use of probability and statistics for reliable design, interpretation of data sheets, and component selection.

Prerequisites: CENG 342/342L and EE 320/320L
Pre or Corequisites: EE 313; EE 314/314L; CENG 447/447L/547/547L; and ENGL 289.

CENG 465 Senior Design Project II

Credits: (0-2) 2

The course requires students to conduct their own design projects in a simulated industrial environment. Requirements include detailed laboratory notebook, periodic written and oral progress reports, and a written and oral presentation of a final project report.

Prerequisites: CENG 464

CENG 491 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: A maximum of 6 credits of independent studies is allowed for degree credit.

CENG 492 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of topics is allowed for degree credit.

CENG 498 Undergraduate Research/Scholarship

Credits: Credit to be arranged.

Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor.
Notes: Credit to be arranged; not to exceed 4 credits toward fulfillment of B.S. degree requirements

CENG 591 Independent Study

Credits: 1 to 4

Includes Directed Study, Problems, Readings, Directed Readings, Special Problems, and Special Projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor

CENG 592 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Chemistry

CHEM 106 Chemistry Survey

Credits: (3-0) 3

A one-semester survey of chemistry. Not intended for those needing an extensive chemistry background. Introduction to the properties of matter, atomic structure, bonding, stoichiometry, kinetics, equilibrium, states of matter, solutions, and acid-base concepts.

Prerequisites: MATH 101
Notes: May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associates of Arts).

CHEM 106L Chemistry Survey Lab

Credits: (0-1) 1

Laboratory designed to accompany CHEM 106.

Pre or Corequisites: CHEM 106
Notes: May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associates of Arts).

CHEM 111 Introduction to Chemistry and Applied Biological Sciences

Credits: (1-0) 1

An introduction to the fields of chemistry and applied biological sciences, and opportunities therein, intended for first year students. Methods and concepts utilized in the fields will be presented, as will discussions of academic and scientific resources utilized in education in chemistry and applied biological sciences. Students will also engage in academic planning to meet their individual career goals. Research opportunities in the fields will also be presented.

Notes: CHEM 111 is cross-listed with BIOL 111.

CHEM 112 General Chemistry I

Credits: (3-0) 3

An introduction to the basic principles of chemistry for students needing an extensive background in chemistry (including chemistry majors, science majors, and pre-professional students). Completion of a high school course in chemistry is recommended.

Prerequisites: MATH 102

CHEM 112L General Chemistry I Lab

Credits: (0-1) 1

Laboratory designed to accompany CHEM 112.

Pre or Corequisites: CHEM 112

CHEM 114 General Chemistry II

Credits: (3-0) 3

A continuation of CHEM 112. An introduction to the basic principles of chemistry for students needing an extensive background in chemistry.

Prerequisites: CHEM 112 and MATH 102

CHEM 114L General Chemistry II Lab

Credits: (0-1) 1

Laboratory designed to accompany CHEM 114.

Prerequisites: CHEM 112L
Pre or Corequisites: CHEM 114

CHEM 200 Introduction to Research

Credits: 1 to 3

Directed research in chemistry including library and laboratory work supplemented with conferences with the instructor.

Prerequisites: Permission of instructor.
Notes: At SDSM&T a formal report in the American Chemical Society (ACS) format is required to meet the requirements of the course.

CHEM 290 Seminar

Credits: (0.5-0) 0.5

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division or graduate levels.

Notes: This course is cross listed with CHEM 490.

CHEM 316 Fundamentals of Organic Chemistry

Credits: (3-0) 3

A one-semester introductory course in organic chemistry. Functional classes of organic compounds are discussed in terms of characteristic functional group, properties, structure, nomenclature, synthesis and reactivity.

Prerequisites: CHEM 114

CHEM 326 Organic Chemistry I

Credits: (3-0) 3

A systematic treatment of the chemistry of carbon compounds, including nomenclature, structure-reactivity relationships, reaction mechanisms, synthesis, and spectroscopy.

Prerequisites: CHEM 114

CHEM 326L Organic Chemistry I Lab

Credits: (0-2) 2

A laboratory designed to accompany CHEM 326. Introduction to organic functional groups and methods for the separation and purification of organic compounds.

Prerequisites: CHEM 114L
Pre or Corequisites: CHEM 326

CHEM 328 Organic Chemistry II

Credits: (3-0) 3

A continuation of CHEM 326. A systematic treatment of the chemistry of carbon compounds, including nomenclature, structure-reactivity relationships, reaction mechanisms, synthesis, and spectroscopy.

Prerequisites: CHEM 326

CHEM 328L Organic Chemistry II Lab

Credits: (0-2) 2

A laboratory designed to accompany CHEM 328. Syntheses of organic compounds.
Structural characterization is performed by instrumental methods of analysis including infrared and nuclear magnetic resonance spectrometry.

Prerequisites: CHEM 326L
Pre or Corequisites: CHEM 328

CHEM 332 Analytical Chemistry

Credits: 2 or 3

Fundamental concepts and principles of quantitative chemical analysis including quantitative chemical equilibrium calculations and error analysis applied to the evaluation of experimental measurements and data.

Prerequisites: CHEM 114
Notes: Taking this course for 2 credits will not count towards a Chemistry minor or major.

CHEM 332L Analytical Chemistry Lab

Credits: (0-1) 1

A laboratory to accompany CHEM 332 and CHEM 230. Experimental methods and techniques of gravimetry, titrimetry, pH, and UV-Vis and AA spectrometry.

Pre or Corequisites: CHEM 114L and CHEM 332 or CHEM 230

CHEM 342 Physical Chemistry I

Credits: 2 to 3

A study of the fundamental principles governing the behavior of chemical systems. Topics covered in the two-semester sequence include thermodynamics, chemical kinetics, quantum mechanics, and statistical mechanics. Properties of gases; first and second laws of thermodynamics; physical transformations of pure substances; simple mixtures and phase diagrams; chemical equilibrium and equilibrium electrochemistry.

Prerequisites: CHEM 114 and PHYS 213/213-A ; and MATH 225 or MATH 321
Notes: Students taking the course for 2 credits will not cover the first and second laws of thermodynamics and will require CBE 222 as a prerequisite. Taking this course for 2 credits will not count towards a Chemistry minor or major.

CHEM 342L Physical Chemistry I Lab

Credits: (0-1) 1

A laboratory designed to accompany CHEM 342.

Pre or Corequisites: CHEM 342 and CHEM 332

CHEM 344 Physical Chemistry II

Credits: 2 to 3

A continuation of Physical Chemistry I. A study of the fundamental principles governing the behavior of chemical systems. Kinetic theory of gases; statistical thermodynamics and properties of solids; chemical kinetics and kinetics at interfaces; quantum mechanics and spectroscopy.

Prerequisites: CHEM 342 and PHYS 213/213-A
Notes: Students taking the course for 2 credits will not cover quantum mechanics. Taking this course for 2 credits will not count towards a Chemistry minor or major.

CHEM 344L Physical Chemistry II Lab

Credits: 1 to 2

A laboratory designed to accompany CHEM 344. Topics covered can include, thermodynamics, equilibrium, electrochemistry, quantum mechanics, kinetic theory, and reaction kinetics.

Prerequisites: CHEM 114L
Pre or Corequisites: CHEM 344

CHEM 352 Systematic Inorganic Chemistry

Credits: (3-0) 3

A systematic survey of the chemistry of the elements. Periodic properties of the elements; fundamental chemical bonding and structure; acid-base and redox reactions; solid state chemistry, nonaqueous solvents; introduction to materials science.

Prerequisites: CHEM 114

CHEM 370 Chemical Literature

Credits: (1-0) 1

The use of the chemical library. Character of the various chemical journals, dictionaries, reference books, computer literature searching, and other sources of information. Written reports on chemical literature.

Prerequisites: CHEM 230 or CHEM 332 and CHEM 352
Pre or Corequisites: CHEM 328

CHEM 420/520 Organic Chemistry III

Credits: (3-0) 3

Advanced considerations of organic chemistry. Case studies in the synthesis of complex organic molecules and drawn from historical and recent organic chemical literature, which exemplify particular conformational, synthetic, and technical challenges to the organic student.

Prerequisites: CHEM 328
Notes: Students enrolled in CHEM 520 will be held to a higher standard than those enrolled in CHEM 420.

CHEM 421/521 Spectroscopic Analysis

Credits: (3-0) 3

Determination of the structure of organic compounds using the spectroscopic methods. Problems involving library and laboratory work.

Prerequisites: CHEM 328
Notes: Students enrolled in CHEM 521 will be held to a higher standard than those enrolled in CHEM 421.

CHEM 426/526 Polymer Chemistry

Credits: (3-0) 3

An introduction to the fundamental chemistry, characterization, and fabrication of polymeric substances.

Prerequisites: CHEM 328 and CHEM 342
Notes: Students enrolled in CHEM 526 will be held to a higher standard than those enrolled in CHEM 426.

CHEM 434 Instrumental Analysis

Credits: (3-0) 3

Theory and application of modern instrumental methods to chemical analysis.

CHEM 434L Instrumental Analysis Lab

Credits: (0-2) 2

A laboratory designed to accompany CHEM 434. The laboratory includes an introduction to laboratory methods and techniques of potentiometry, conductimetry, electrogravimetry, voltametry, TLC, GC, and HPLC.

Pre or Corequisites: CHEM 434

CHEM 452/552 Inorganic Chemistry

Credits: (3-0) 3

Theoretical and periodic aspects of inorganic chemistry. Discussion of the important models and concepts of modern inorganic chemistry.

Prerequisites: CHEM 352, CHEM 328 and CHEM 342
Notes: Students enrolled in CHEM 552 will be held to a higher standard than those enrolled in CHEM 452.

CHEM 452L/552L Inorganic Chemistry Lab

Credits: (0-1) 1

Synthesis and characterization of inorganic compounds. Laboratory techniques in inorganic chemistry including: synthesis of air-sensitive compounds, transition metal complexes and silicon polymers, chemical characterization of inorganic compounds using spectroscopic, magnetic, and analytical approaches.

Prerequisites: CHEM 328L
Pre or Corequisites: CHEM 452/552
Notes: Students enrolled in CHEM 552L will be held to a higher standard than those enrolled in CHEM 452L.

CHEM 464/564 Biochemistry I

Credits: (3-0) 3

A study of the fundamental principles governing the behavior of biochemical systems. Topics covered in the two semester sequence include the study of proteins, lipids and carbohydrates, metabolic processes, biological oxidation and reduction processes, molecular aspects of DNA replication and repair pathways, transcription and RNA processing, and protein translation.

Notes: Students enrolled in CHEM 564 will be held to a higher standard than those enrolled in CHEM 464.

CHEM 464L Biochemistry I Lab

Credits: (0-1) 1

Laboratory designated to accompany CHEM 464.

Prerequisites: CHEM 328L

CHEM 465/565 Biochemistry II

Credits: (3-0) 3

A continuation of CHEM 464.

Prerequisites: CHEM 464/564
Notes: Students enrolled in CHEM 565 will be held to a higher standard than those enrolled in CHEM 465.

CHEM 465L Biochemistry Laboratory II

Credits: (0-1) 1

This course will focus on the Biophysical and Thermodynamic nature of nucleic acids and proteins. Specific emphasis will be placed on the design, synthesis, and thermodynamic analysis of an RNA model system. The aim of the course will be to provide the student with a solid basis in the thermodynamics of folding of biologically important macromolecules.

Prerequisites: CHEM 464L

CHEM 482/582 Environmental Chemistry

Credits: (3-0) 3

Examination of the chemistry and chemical processes of the environment, including the role of chemistry in current environmental issues.

Prerequisites: CHEM 316 or CHEM 328
Notes: Students enrolled in CHEM 582 will be held to a higher standard than those enrolled in CHEM 482.

CHEM 490 Seminar

Credits: (0.5-0) 0.5

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division or graduate levels.

Prerequisites: Junior Standing
Notes: Repeatable for a maximum of 2 credits. This course is cross listed with CHEM 290.

CHEM 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: A maximum of 6 credits of topics and independent study credits will be allowed for degree credit.

CHEM 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of special topics and independent study credits will be allowed for degree credit.

CHEM 498 Undergraduate Research/Scholarship

Credits: 1 to 12

Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor.
Notes: A maximum of 6 credits of undergraduate research will be allowed for degree credit. At the

School of Mines, a formal report in the American Chemical Society (ACS) format is required to meet the requirements of this course.

CHEM 712 Interfacial Phenomena

Credits: 3

A course in the surface properties of solids and liquids. Areas covered include the thermodynamics of surfaces, material transfer across interfaces, nucleation, surface energies of solids, three-phase contact, wetting phenomena, and absorption.

Notes: This course is cross listed with MES 712.

CHEM 720 Nano-Struct Mats: Syn & Char

Credits: (3-0) 3

A survey and analysis of synthetic materials and characterization techniques for nano-structured materials will be presented. The classes of materials that will be studied include: inorganic nanocrystals (metals, semi-conductors metal oxides), nano-wires, porous materials, carbon nanostructures, and higher order materials, such as supported catalysts. Solution-phase synthetic routes will be emphasized, including sol-gel synthesis, non-hydrolytic molecular decomposition, and micelle-templated synthesis, with lesser emphasis on solid state and gas-phase reactions. Methods of characterization will be discussed, including: transmission electron microscopy (TEM), scanning electron microscopy (SEM), powder X-ray diffraction (XRD), UV-visible absorption/fluorescence, X-ray absorption spectroscopy, gas sorption analysis, atomic force microscopy (AFM), scanning tunneling microscopy (STM), and photoelectron spectroscopy.

Notes: This course is cross listed with MES 720.

CHEM 723 Luminescence Spectroscopy of Materials

Credits: (3-0) 3

Fundamentals of luminescent behavior and photodynamics of solid state materials and spectroscopic methods for characterization will be discussed. Applications of novel solid state materials as phosphors, sensors, and in optoelectronics devices will be considered.

Notes: This course is cross listed with MES 723.

Construction Management

CEM 574 Construction Engineering and Management

Credits: (3-0) 3

A study of construction engineering and construction project management topics in the context of earthmoving, heavy construction, and building construction.

Prerequisites: CEE 316/316L
Notes: This course is cross listed with CEE 474/574.

CEM 608 Construction Contracts

Credits: (3-0) 3

This course addresses the roles and responsibilities of the project team, project delivery methods, the preparation of accurate and enforceable specifications, and the effective administration of construction contracts. Contract documents, including project plans and specifications, will be analyzed from the perspective of coordination, interpretation, and enforcement. Guidelines and documents from various organizations will be examined to develop an understanding of the design process, product selection, and improved communication among the project participants involved in all aspects of managing a project from initial planning to completion.

Prerequisites: Graduate standing or permission of instructor
Notes: Permission of Instructor will only be granted to students enrolled in an Accelerated Master's Program or have a Notice of Intent to Qualify for Construction Engineering and Management Certificate on file with the Registrar.

Cross-listed with CEE 608

CEM 610 Construction Project Management

Credits: (3-0) 3

Course addresses advanced study and application of estimating, scheduling, and project control principles utilized within the construction industry. Course will make extensive use of computer modeling in the analysis and development of realistic construction estimates and schedules. Conceptual, assembly, and detailed estimating topics are addressed. Network, linear, matrix, and bar chart schedules are analyzed. Project control topics including cost, resource, and schedule control are addressed and applied to cash flow analysis, project duration optimization, and resource balancing problems.

Prerequisites: Graduate standing.

CEM 612 Construction Estimating

Credits: (3-0) 3

The study of basic and advanced concepts involved with construction cost estimating at the three major phases of the project. Analysis of the estimates will include material, labor equipment productivity, financial, and project delivery impacts. Prior training or experience with construction documents is recommended.

Prerequisite: Graduate standing or permission of instructor

Prerequisites: Graduate standing or permission of instructor

CEM 614 Construction Project Scheduling

Credits: (3-0) 3

Students will study purposes and impacts of project scheduling from project planning, to design, through construction and commissioning. An analysis of the impacts of advanced construction methods and topics on scheduling will be undertaken including CMAR, Lean Construction, BIM, and assignment of risk. NOTES: Basic understanding of schedules and scheduling software is expected.

CEM 615 Engineering and Construction Ethics

Credits: (3-0) 3

Students will study ethical topics as they relate to managing a construction project from the perspectives of all three major players. These will include societal and trade expectations, conflicting standards, and roles of governing agencies in ethics.

CEM 616 Codes and Standards

Credits: (3-0) 3

Students will study the basic design and construction related codes and standards, learning their source of authority and learning to effectively read and apply content to manage the development of projects. Documents may include IBC, NFPA, and other various State and Federal source documents.

CEM 619 Construction Company Management

Credits: (3-0) 3

Students will study topics as they relate to managing a construction company. These include financial

management, strategic planning, business development, human resources management, information management, quality management, and risk management.

CEM 620 Leading and Managing Design Organizations

Credits: (3-0) 3

Students will study topics as they relate to managing and leading consulting engineering and other design companies, and their relation with other organizations, agencies, and the public. These include financial management, strategic planning, business development, human resources management, information management, and risk management.

CEM 665 Construction Equipment Management

Credits: (3-0) 3

Course addresses equipment and methods used in building, heavy-highway and utility construction; equipment and crew productivity; ownership and operating costs; production rates and operating characteristics of major construction equipment and operations. Critical thinking, leadership and management skills, written and verbal communication, and listening skills vital to the role and responsibilities of a professional constructor are developed and enhanced.

Prerequisites: Graduate standing.

CEM 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

CEM 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

CEM 706 Managing Sustainable Projects

Credits: (3-0) 3

This course addresses the management of sustainable construction and the Project Manager's role in creating a sustainable environment through planning, design, and construction practices. The impact of the various sustainable building systems and standards on project management and performance will be evaluated from the Project Manager's perspective.

Prerequisites: Graduate standing or permission of instructor.

CEM 710 Advanced Construction Management

Credits: (3-0) 3

This course addresses the advanced study and application of lean project delivery in the modern construction environment. Topics may include: productivity improvement strategies; the use of information technology and Building Information Modeling (BIM) for estimating, scheduling and project control; and the human element in relation to motivation, safety, and environmental stresses.

CEM 715 Construction Operations

Credits: (3-0) 3

Course addresses the materials and methods of earthmoving, heavy, and building construction operations.

Prerequisites: Graduate standing.
Notes: This course is cross-listed with CEE 715.

CEM 750 Environmental Permitting

Credits: (3-0) 3

Course reviews the scope and the requirements of predominate environmental laws, describes the various permits and approvals required under those laws, and examines the applicability of those laws to construction projects. Identifies ways to effectively incorporate environmental planning and permitting into the project planning and design process to minimize impacts to project schedules and budgets.

CEM 788 Master's Research Problems and Projects

Credits: Credit to be arranged.

Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Notes: Credit to be arranged; not to exceed 3 credits toward fulfillment of M.S. degree requirements.

CEM 790 Seminar

Credits: (1-0) 1

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media, such as internet, and are at the upper division or graduate levels.

Notes: May not be repeated for degree credit.

CEM 791 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

CEM 792 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

CEM 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 6 credits toward fulfillment of the M.S. degree requirements.

Career Planning

CP 297/397/497 Cooperative Education

Credits: 1 to 3

Applied, monitored and supervised field-based learning experience for which the student may or may not be paid. Students gain practical experience; they follow a negotiated and or directed plan of study established between the student, instructor and field experience supervisor. Due to the presence of a field experience supervisor, a lower level of supervision is provided by the instructor in these courses than is the case in an internship or practicum course. Students must satisfy departmental co-op requirements, which include a written report of the co-op work experience and an employer's evaluation, to earn credit for the course. Minimum GPA and other co-op eligibility requirements vary among employers. Because the work performed by a student while on co-op is equivalent to the workload on a full-time student, a student on co-op assignment who is registered for CP credit shall be considered to have full-time status.

CP 697 Cooperative Education

Credits: 1 to 3

A single semester work experience at the employer's location. Students will be asked to utilize specialized skills learned in the classroom and will be permitted to develop human relations skills and maturity in a degree-relevant work environment. Each student must satisfy departmental requirements in order to earn credit for the course. Requirements will include but not be limited to a written report of the work experience and an employer's evaluation of work performance.

Prerequisites: Permission of instructor
Notes: Students must have the approval of their graduate committee and permission of instructor in order to enroll.

Computer Science

CSC 105 Introduction to Computers

Credits: (3-0) 3

Overview of computer applications with emphasis on word processing, spreadsheets, database, presentation tools and internet-based applications.

Notes: May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associates of Arts).

CSC 110 Survey of Computer Science and Mathematics

Credits: (1-0) 1

This is an introductory course for incoming freshman in Computer Science or Mathematics that provides a survey of the major areas in the computing profession along with ethical standards that are used. When applicable, guest lectures will be arranged to illuminate different areas of study.

Notes: This course is cross-listed with MATH 110.

CSC 111/111L Introduction to Computer Programming/Lab

Credits: (2-0) 2

This is an introduction to computer programming for students with little or no programming experience. Students will learn essential techniques on using a computer to solve problems and the fundamental constructs that are used in computer programs.

Corequisites: CSC 111L
Pre or Corequisites: MATH 102

CSC 150/150L Computer Science I/Lab

Credits: (2-1) 3

An introduction to computer programming. Focus on problem solving, algorithm development, design, and programming concepts. Topics include sequence, selection, repetition, functions, and arrays.

Corequisites: CSC 150L
Pre or Corequisites: MATH 123

CSC 170/170L Programming for Engineers and Scientists

Credits: (3-0) 3

This course teaches engineering and science students how to write software to solve problems in their disciplines. The emphasis on mathematics, numerical methods, and development for embedded systems will prepare students to incorporate computer solutions into courses in their majors. Topics will include an overview of the software development process, development environments, algorithm development, control structures, internal and external storage, testing, and debugging. Additional topics may include

programming robots and processing sensor data.

Corequisites: CSC 170L
Pre or Corequisites: MATH 123

CSC 210 Web Authoring

Credits: (3-0) 3

This course focuses on techniques and methods for writing specifically for the internet. Topics will include designing and creating documents for the World Wide Web, design considerations, and publishing and maintaining websites. Students will use HTML web authoring software, and other software for web development.

Prerequisites: CSC 105 or permission of instructor.

CSC 215 Programming Techniques

Credits: (4-0) 4

This is a course that builds on the concepts and techniques introduced in Computer Science 1. Topics include binary files, bit manipulation, memory management, recursion, linked lists, stacks, queues and object oriented programming. Problem solving, algorithm design, standards of program style, debugging and testing are emphasized in this course.

Prerequisites: Math 123 and CSC 150, both with a C or better, or permission of instructor.

CSC 250 Computer Science II

Credits: (4-0) 4

Problem solving, algorithm design, standards of program style, debugging and testing. Extension of the control structures and data structures of the high-level language introduced in CSC 150/150L. Elementary data structures and basic algorithms that include sorting and searching. Topics include more advanced treatment of functions, data types such as arrays and structures, and files.

Prerequisites: CSC 150/150L completed with a minimum grade of "C".

CSC 251 Finite Structures

Credits: 2 or 4

Selected topics from Boolean algebra, set theory, congruencies, equivalence relations, complexity, graph

theory, combinatorics, induction, difference equations, and logic.

Prerequisites: MATH 123 and CSC 150/150L or CSC 170/170L; or permission of instructor.

CSC 291 Independent Study

Credits: 1 to 5

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 5 credit hours.

CSC 292 Topics

Credits: 1 to 5

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours.

CSC 300 Data Structures

Credits: (4-0) 4

A systematic study of data structures and the accompanying algorithms used in computing problems; structure and use of storage; methods of representing data; techniques for implementing data structures; linear lists; stacks; queues; trees and tree traversal; linked lists; and other structures.

Prerequisites: CSC 250 completed with a minimum grade of "C" and CSC 251.

CSC 314/314L Assembly Language/Lab

Credits: (2-1) 3

A thorough introduction to assembly language programming and processor architecture. A study of low-level programming techniques, and the layout of a typical computer. The student will gain insight into the memory layout, registers, run-time stack, and global data segment of a running program.

Prerequisites: CSC 250 with grade of "C" or better.
Corequisites: CSC 314L

CSC 315 Data Structures & Algorithms

Credits: (4-0) 4

A systematic study of data structures and accompanying algorithms with an emphasis on implementation and algorithmic complexity. Program development is done on Linux systems using standard software engineering tools. Topics may include: principles of object-oriented programming, such as inheritance, abstraction, polymorphism, encapsulation, and late binding; binary and m-ary trees, heaps, maps, sets, disjoint sets, and graphs; sorting techniques, hashing, shortest path and minimal spanning tree algorithms, string matching algorithms and an introduction to dynamic programming.

Prerequisites: CSC 251 and CSC 215 both with a C or better.

CSC 317 Computer Organization and Architecture

Credits: (3-0) 3

A course in computer organization with emphasis on the hierarchical structure of computer systems. Covers such topics as: components of computer systems and their configuration, design of basic digital circuits, the microprogram level, the conventional machine level, the operating system level, assembly language, addressing modes, interpreters/translators, computer arithmetic.

Prerequisites: CSC 314/314L with grade of "C" or better; and CSC 251.

CSC 340 Software Engineering and Design

Credits: (3-0) 3

An introduction to the software engineering process including a survey of development methodologies (waterfall, iterative, incremental, agile). The class includes modules on fundamental software engineering tools and skills in the areas of testing, test plan development, performance analysis and tuning, and requirements analysis. Teams and teaming are a central theme supported by extensive use of project management systems for communication, source code/revision control, and project estimation.

Prerequisites: CSC 215 with a C or better.

CSC 372 Analysis of Algorithms

Credits: (3-0) 3

Design and analysis of algorithms for numeric and nonnumeric problems, general problem-solving approaches, theory of computation. Topics will be selected from searching, sorting, graph algorithms, numerical algorithms, geometric algorithms, cryptography, and parallel algorithms.

Prerequisites: MATH 125 and a minimum grade of "C" in CSC 300.

CSC 391 Independent Study

Credits: 1 to 5

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans.
Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 5 credit hours.

CSC 392 Topics

Credits: 1 to 5

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours.

CSC 410/510 Parallel Computing

Credits: (3-0) 3

The fundamental ideas and issues involved in programming and using parallel computers. A survey of modern architectures and operating systems. Parallel programming applications in business, economic modeling, and science. The School of Mines emphasizes scientific applications.

Prerequisites: CSC 300 with grade of "C" or better.
Notes: Students enrolled in CSC 510 will be held to a higher standard than those enrolled in CSC 410.

CSC 412/512 Cryptography

Credits: (3-0) 3

This course provides an introduction to cryptography and the mathematics behind current encryption algorithms. It covers classical cryptosystems, private-key cryptosystems (such as DES and AES), and public-key cryptosystems (such as RSA).

Prerequisites: MATH 413 and CSC 250 or permission of instructor.
Notes: Students enrolled in CSC 512 will be held to a higher standard than those enrolled in CSC 412.

CSC 414/514 Introduction to Computer Vision

Credits: (3-0) 3

Introductory course in computer vision. This course covers principles of image formation, local feature analysis, multi-view geometry, image warping and stitching, structure from motion, and visual recognition. We also touch upon related topics in signal and image processing including convolution, image pyramids, frequency domain analysis, and gradient-based analysis techniques.

Prerequisites: EE 313 or CSC 300
Notes: Students enrolled in CSC 514 will be held to a higher standard than those enrolled in CSC 414. This course is cross-listed with CENG 414/514.

CSC 415/415L/515/515L Introduction to Robotics/Lab

Credits: (3-1) 4

An introduction to mechatronic systems and embedded systems for robotics. This course will cover the basics required for autonomous mobile robotics. The course will begin with a survey of existing systems and some background mathematics. Core course topics will include electromechanical components, electronics for motor control, sensors and instrumentation, mobile robotic kinematics and movement, microcontrollers, real time computing, and embedded system design and development. Course projects will include student teams building task oriented mobile robots with emphasis on the hardware development.

Prerequisites: CSC 300 with a grade of "C" or better
Corequisites: CSC 415L or CSC 515L
Notes: Students enrolled in CSC 515/515L will be held to a higher standard than those enrolled in CSC 415/415L. This course is cross listed with CENG 415/415L/515/515L.

CSC 416/516 Advanced Algorithms for Robotics

Credits: (3-0) 3

Theory and application of advanced methods for intelligent robots. Topics may include but are not limited to: cooperative mobile robotics, mathematical and probabilistic models for complex tasks, planning, machine learning, humanoid robotics, human-robot interfaces, robot hardware and middleware.

Prerequisites: C or better in CSC 300 or permission of instructor.
Notes: Students enrolled in CSC 516 will be held to a higher standard than those enrolled in CSC 416.

CSC 426/526 Cybersecurity

Credits: (3-0) 3

The course provides an introduction to the theory and concepts of computer security in cyberspace. The course will discuss security issues and policies with regard to cyber infrastructure including software development, data storage, operating systems, networks, multimedia processing as well as the use of encryption. Vulnerability assessment and implementation of secure computing systems will be explored in group projects.

Prerequisites: CSC 300 with a grade of "C" or better.
Notes: Students enrolled in CSC 526 will be held to a higher standard than those enrolled in CSC 426.

CSC 433/533 Computer Graphics

Credits: (3-0) 3

Graphical programming concepts. Display media and device characteristics. Point, line and circle plotting. Coordinate systems and transformations. Polygon clipping and filling. Spline methods, hidden surface elimination, and shading.

Prerequisites: CSC 300 with grade of "C" or better; and MATH 225
Notes: Students enrolled in CSC 533 will be held to a higher standard than those enrolled in CSC 433.

CSC 440/440L Advanced Digital Systems/Lab

Credits: (3-1) 4

Memory and disk systems, bus and I/O systems, parallel processing. Applications of digital systems in real-time processing.

Prerequisites: CSC 317 or permission of instructor.

Corequisites: CSC-440L
Notes: Graduation credit will not be allowed for both this course and CENG 446/446L.

CSC 441/541 Networking and Data Communications

Credits: (3-0) 3

This course is the study of the principles and design of computer networks, their protocols, and application programs. The course has equal emphasis on practical experience as well as theoretical foundations. The course focuses on understanding the fundamental concepts in design and implementation of computer communication networks, particularly on analysis and development of the software architecture of the protocol stack, and network programming. The topics include layered network architectures, network programming interfaces (e.g., sockets), TCP/IP networking, packet switching, network routing, rate and congestion control, Quality-of-Service, wireless communications, and fundamentals of network security.

Prerequisites: CSC 300
Notes: Students enrolled in CSC 541 will be held to a higher standard than those enrolled in CSC 441.

CSC 442/542 Digital Image Processing

Credits: (3-0) 3

Introduction to digital image processing and computer vision, including image digitization and display, image enhancement and restoration, frequency domain techniques using the Fourier transform, image encoding, segmentation, and feature detection.

Prerequisites: CSC 300 with a grade of "C" or better; and MATH 125
Notes: Students enrolled in CSC 542 will be held to a higher standard than those enrolled in CSC 442.

CSC 445/545 Introduction to Theory of Computation

Credits: (3-0) 3

Introduction to a series of models for computation and their relationship to formal languages that are useful in the definition of programming languages along with a look at the theoretical limits of computers. Topics include finite and pushdown automata, Turing machines, grammars, decidability and computational complexity.

Prerequisites: CSC 251
Notes: Students enrolled in CSC 545 will be held to a higher standard than those enrolled in CSC 445.

CSC 447/547 Artificial Intelligence

Credits: (3-0) 3

Concepts in artificial intelligence: programming in languages such as Prolog or LISP; knowledge representation; search algorithms.

Prerequisites: CSC 300 with grade of "C" or better.
Notes: Students enrolled in CSC 547 will be held to a higher standard than those enrolled in CSC 447.

CSC 448/548 Machine Learning

Credits: (3-0) 3

A systematic study of the theory and algorithms that constitute machine learning. It covers learning based on examples including genetic algorithms, case-based reasoning, decision trees, and Bayesian methods.

Prerequisites: CSC 300 with a grade of "C" or better.
Notes: Students enrolled in CSC 548 will be held to a higher standard than those enrolled in CSC 448.

CSC 449/549 Advanced Topics in Artificial Intelligence

Credits: (3-0) 3

This course will cover advanced topics in artificial intelligence, such as: pattern recognition, neural networks, computational neuroscience, evolutionary computing, immunocomputing, swarm intelligence, machine learning, Markov decision processes, reinforcement learning, probabilistic reasoning, fuzzy logic, expert systems, and intelligent agents.

Prerequisites: CSC 300 with a grade of "C" or better and MATH 225
Notes: Students enrolled in CSC 549 will be held to a higher standard than those enrolled in CSC 449.

CSC 454/554 Data Mining Theory

Credits: (3-0) 3

A study of the fundamental ideas and issues involved in predicting and describing data. A survey of modern techniques used for converting raw data into useful information. The techniques and theory covered will involve: classification, clustering, association analysis and anomaly detection. The course will emphasize scientific applications, with the goal of extracting information from a data set and transforming it to useful information through the steps of: Preprocessing, Data Mining and Postprocessing

Prerequisites: CSC 250 with a C or better

Pre or Corequisites: MATH 381
Notes: Students enrolled in CSC 554 will be held to a higher standard than those enrolled in CSC 454.

CSC 456/456L Operating Systems/Lab

Credits: (3-1) 4

A study of the functions and structures associated with operating systems with respect to process management, memory management, auxiliary storage management, and processor management. Topics include concurrent and distributed computing, deadlock, real and virtual memory, job and processor scheduling, security and protection.

Prerequisites: CSC 317 and a "C" or better in CSC 300.
Corequisites: CSC 456L
Notes: Graduation credit will not be allowed for both this course and CENG 456.

CSC 461 Programming Languages

Credits: (4-0) 4

This course consists of two parts. The first part introduces how programming languages are designed, including an introduction to the concepts of parsing and compiling. Issues related to implementation such as type checking, binding, and memory management are discussed. Secondly, the course will survey the spectrum of programming languages paradigms, including traditional imperative, object oriented, functional, and logic languages.

Prerequisites: CSC 300 with a minimum grade of "C".

CSC 463/563 Data Communications

Credits: (4-0) 4

A study of the principles of data communications, computer networks, and open systems, following the outline provided by the ISO/OSI model.

Prerequisites: CSC 250
Notes: Students enrolled in CSC 563 will be held to a higher standard than those enrolled in CSC 463.

CSC 464 Senior Design I

Credits: (2-0) 2

This is a team-based project-design course. This course will focus on the design process and culminate

with the faculty approval of design projects. Typical topics included are the development of a design document; identification of customer needs; development of specifications; consideration of alternate designs using a decision matrix; project management techniques; and legal, global, and ethical issues.

Prerequisites: CSC 470 and CSC 484.

CSC 465 Senior Design II

Credits: (2-0) 2

This course is a continuation of CSC 464. The student will complete the project approved in CSC 464. It will require that the students implement the design projects in a simulated industrial environment. Specific requirements may include detailed laboratory notebook, periodic written and oral progress reports, and a written and oral presentation of a final project report.

Prerequisites: CSC 464 or permission of instructor.

CSC 468/568 Graphical User Interface Programming

Credits: (3-0) 3

Introduction to the theory and practice of programming graphical user interfaces. Topics will include GUI design and the fundamentals of GUI programming for desktop, Web, and mobile device applications.

Prerequisites: CSC 461
Notes: Students enrolled in CSC 568 will be held to a higher standard than those enrolled in CSC 468.

CSC 470 Software Engineering

Credits: (3-0) 3

An introduction to the software engineering process, including lifecycle phases, problem analysis, specification, project estimation and resource estimation, design, implementation, testing/maintenance, and project management. In particular, software validation and verification as well as scheduling and schedule assessment techniques will be discussed.

Pre or Corequisites: CSC 484

CSC 476/476L/576/576L Mobile Computing Development

Credits: (2-1) 3

This course introduces students to the major components of mobile application development. Topics will include an overview of the market, mobile development environments, designing the user interface/user experience, lifecycle considerations, MVC patterns, power, storage, and performance considerations, persistent data, location, and web services. Students will design and create applications on at least one of the dominant mobile platforms.

Prerequisites: CSC 468/568
Corequisites: CSC 476L/576L
Notes: Students enrolled in CSC 576/576L will be held to a higher standard than those enrolled in CSC 476/476L.

CSC 484 Database Management Systems

Credits: (3-0) 3

The study of formalized database design. This course will focus on relational model design and the use of SQL. Students will use a modern relational database to implement designs and learn the basics of data management.

Prerequisites: CSC 300 with a minimum grade of "C".

CSC 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated for a total of 5 credit hours.

CSC 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours.

CSC 498 Undergraduate Research/Scholarship

Credits: Credit to be arranged.

Includes senior project and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor.
Notes: Credit to be arranged; not to exceed 6 credits toward fulfillment of B.S. degree requirements. May be repeated for a total of 6 credit hours.

CSC 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 5 credit hours. Students should have obtained permission of an instructor in the Department of Mathematics and Computer Science prior to registering for this course.

CSC 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours. Students should have obtained permission of instructor in the Department of Mathematics and Computer Science prior to registering for this course.

CSC 752 Computer Vision

Credits: (3-0) 3

Low-level processing for extraction of intrinsic image features (edges, range, surface orientation, motion and optical flow, texture), relaxation methods, image segmentation, pattern recognition, geometric and relational structures, knowledge representation, and neural network approaches.

Prerequisites: Permission of instructor.

CSC 761 Advanced Artificial Intelligence

Credits: (3-0) 3

The objective of this course is to provide students with a background in advanced artificial intelligence problem solving methods. Topics covered include: Expert systems, fuzzy logic and fuzzy expert systems, genetic algorithms, case-based reasoning, and current research work on new areas of problem solving.

Prerequisites: Permission of instructor.

CSC 762 Neural Networks

Credits: (3-0) 3

This course presents a survey of the architecture and algorithms of neural networks. Topics covered include perceptrons, competitive learning, multi-layer networks, back propagation, and selected topics from pattern recognition.

Prerequisites: CSC 300 or permission of instructor.

CSC 772 Advanced Operating Systems

Credits: (3-0) 3

Advanced topics in operating systems design for multiprocessing and distributed systems. Topics will include areas such as methods of interprocess communication, reliability, maintainability, security, and large-scale design considerations.

Prerequisites: CSC 456/456L or permission of instructor.

CSC 784 Database Design

Credits: (3-0) 3

This course will include an overview of the relational and entity relationship (E-R) models. It will cover database design, advanced data models, emerging trends in the database field, including data warehouse, data mining, and distributed and parallel databases. Oracle database design tools and programming will be taught.

Prerequisites: CSC 300 with a grade of "C" or better; or permission of instructor.

CSC 788 Master's Research Problems/Projects

Credits: Credit to be arranged.

Independent research problems/projects that lead to research or design paper, but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. Oral defense of the report and findings are required.

Notes: Credit to be arranged; not to exceed 3 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. non-thesis option.

CSC 790 Seminar

Credits: (1-0) 1

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division graduate levels.

Notes: May not be repeated for degree credit.

CSC 791 Independent Study

Credits: 1 to 5

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 5 credit hours. Students should have obtained the permission of the instructor in the Department of Mathematics and Computer Science prior to registering for this course.

CSC 792 Topics

Credits: 1 to 5

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 6 credit hours. Students should have obtained permission of an instructor in the Department of Mathematics and Computer Science prior to registering for this course.

CSC 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursing the M.S. thesis option.

Electrical Engineering

EE 220/220L Circuits I/Lab

Credits: (3-1) 4

This course is designed to provide the electrical engineering students with an understanding of the basic concepts of the profession. Topics covered include resistive circuits, transient circuits, and sinusoidal analysis. Students also investigate essential principles by conducting laboratory experiments related to the topics studied in the classroom. P-spice is used to analyze electrical circuits using personal computers.

Prerequisites: MATH 125 completed with a minimum grade of C
Corequisites: EE 220L
Pre or Corequisites: MATH 321

EE 221/221L Circuits II/Lab

Credits: (3-1) 4

This course is designed to provide the electrical engineering student with an understanding of the basic concepts of the profession. Topics covered include resistive circuits, transient circuits, and sinusoidal analysis. Students also investigate essential principles by conducting laboratory experiments related to the topics studied in the classroom. P-spice is used to analyze electrical circuits using personal computers.

Prerequisites: EE 220/220L completed with a minimum grade of "C" and MATH 321.
Corequisites: EE 221L

EE 264L Electromechanical Systems Product Development and Design Lab

Credits: (0-2) 2

This course focuses on the design process including project management and teamwork; formal conceptual design methods; acquiring and processing information; design management tools; design for manufacturability, reliability, maintainability, sustainability; design communication: reports and presentations; ethics in design; prototyping designs; case studies. The cornerstone is a semester-long project in which small teams of students conceive, plan, and design a simple physical product.

Prerequisites: Sophomore standing.
Notes: This course is cross listed with ME 264L and CENG 264L.

EE 291 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

EE 292 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

EE 301/301L Introduction to Circuits, Machines, and Systems/Lab

Credits: (3-1) 4

Introduces the essential concepts of electrical engineering concerning circuits, machines, electronics, and systems.

Prerequisites: MATH 125 completed with a minimum grade of "C" and MATH 321 completed or concurrent.
Corequisites: EE 301L
Notes: Not for majors in Electrical or Computer Engineering.

EE 303/303L Basic Circuits/Lab

Credits: (2-1) 3

Introduces basic concepts in electrical DC and AC circuits including analysis techniques and applications. Concepts will be reinforced through lab work.

Prerequisites: MATH 125
Corequisites: EE 303L
Notes: Not for majors in Electrical or Computer Engineering.

EE 313 Signals and Systems

Credits: (3-0) 3

Characterization of continuous and discrete time signals and systems (linear and time-invariant). Analysis methods, techniques, and topics will include both transform- or frequency-based (e.g., Fourier, discrete Fourier, and z-) and time-based (e.g., differential and difference equations) approaches.

Prerequisites: EE 221/221L completed with a minimum grade of "C".

EE 314/314L Control Systems/Lab

Credits: (3-1) 4

Analysis and design of continuous and discrete time control systems for linear systems using both frequency domain and time domain techniques. Also, mathematical, topological, and circuit models of electromagnetic, electromechanical, electro thermal, etc. systems are introduced.

Prerequisites: EE 221/221L completed with a minimum grade of "C".
Corequisites: EE 314L
Pre or Corequisites: EM 216

EE 320/320L Electronics I/Lab

Credits: (3-1) 4

Presents concepts of electronic devices and circuits including modeling of semiconductor devices, analysis and design of transistor biasing circuits, and analysis and design of linear amplifiers. Use of computer simulation tools and breadboarding as part of the circuit design process is emphasized. Students are introduced to methods for designing circuits that still meet specifications even when there are statistical variations in the component values.

Pre or Corequisites: EE 221/221L

EE 322/322L Electronics II/Lab

Credits: (3-1) 4

A continuation of EE 320/320L with emphasis on design applications of linear and nonlinear integrated circuits.

Prerequisites: EE 221/221L and EE 320/320L
Corequisites: EE 322L

EE 330/330L Energy Systems/Lab

Credits: (3-1) 4

Production, transmission, and utilization of energy in systems with major electrical subsystems, with particular emphasis on electromagnetic and electromechanical systems and devices.

Prerequisites: EE 221/221L with a minimum grade of "C"
Corequisites: EE 330L

EE 351/351L Mechatronics and Measurement Sys/Lab

Credits: (3-1) 4

This course will encompass general measurement techniques found in mechanical and electrical engineering. These include measurement of force, strain, frequency, pressure flow rates, and temperatures. Elements of signal conditioning and data acquisition will be introduced. In addition to this material, the course will have a mechatronics approach reflected in the combined applications of electronic mechanical and control systems.

Prerequisites: CSC 150/150L and EE 220/220L or EE 301/301L
Corequisites: EE 351L
Notes: This courses is cross listed with ME 351/351L and CENG 351/351L.

EE 362 Electric and Magnetic Properties of Materials

Credits: (3-0) 3

This course studies the behavior of materials of interest to electrical engineers and covers fundamental issues such as energy band theory, density of states, Fermi-Dirac statistics, equilibrium statistics in semiconductors, and Fermi energy. This foundation is then used to study topics such as conduction and semiconductor devices. Other topics include Peltier devices, optoelectronics, and piezoelectric devices.

Prerequisites: MATH 225, MATH 321 and PHYS 213/213-A

EE 381 Electric and Magnetic Fields

Credits: (3-0) 3

Fundamentals of field theory (i.e., Maxwell's equations) as applied to static electric and magnetic phenomena. Also, theory and applications of lossless transmission lines are covered.

Prerequisites: EE 221/221L with a minimum grade of "C", MATH 225, and PHYS 213/213-A

EE 382 Applied Electromagnetics

Credits: (3-0) 3

Maxwell's equations for time-varying electromagnetic phenomena are developed and applications including transmission lines, plane waves, and antennas are studied.

Prerequisites: EE 381

EE 391 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.

EE 392 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

EE 404/504 Nanophotonics

Credits: (3-0) 3

The course deals with optical phenomena in materials and structures with subwave-length dimensions. Topics will include the quantum theory of light, laser theory, beam propagation, and the unique properties of nanophotonic structures.

Prerequisites: Introductory quantum mechanics and electricity and magnetism; ability to solve ordinary differential equations and linear systems.
Notes: This course is cross-listed with PHYS 404/504 and NANO 504. Students enrolled in EE 504 will be held to a higher standard than those enrolled in EE 404.

EE 421/421L/521/521L Communication Systems/Lab

Credits: (3-1) 4

Fundamentals of analog- and digital-signal transmission. Performance characteristics such as channel loss, distortion, bandwidth requirements, signal-to-noise ratios, and error probability.

Prerequisites: EE 313
Corequisites: EE 421L or EE 521L
Notes: This course is cross listed with CENG 421/421L/521/521L. Students enrolled in EE 521/521L will be held to a higher standard than those enrolled in EE 421/421L.

EE 431/431L/531/531L Power Systems/Lab

Credits: (3-1) 4

The principles of energy conversion and transmission in modern power systems. Specialized problems of design, control, and protection are included.

Prerequisites: EE 314/314L and EE 330/330L
Corequisites: EE 431L
Notes: Students enrolled in EE 531/531L will be held to a higher standard than those enrolled in EE 431/431L.

EE 432/432L/532/532L Power Electronics/Lab

Credits: (3-1) 4

The conversion, regulation, and control of electric power by means of electronic switching devices; inverter and chopper circuits; pulse width modulation; motor drives.

Prerequisites: EE 330/330L
Corequisites: EE 432L
Pre or Corequisites: Students enrolled in EE 532/532L will be held to a higher standard than those enrolled in EE 432/432L.

EE 435/535 Power Transmission and Distribution

Credits: (3-0) 3

The characteristics of high voltage AC and DC transmission lines, including the use of power electronic devices to control transmission line compensation. Substation design including gas insulated switchgear. Three phase transformer characteristics and connections. Grid tie and DC link systems. Simulation of transmission and distribution systems using PowerWorld.

Prerequisites: EE 431/431L/531/531L
Notes: Students enrolled in EE 535 will be held to a higher standard than students enrolled in EE 435.

EE 437 Electronic Motor Drives

Credits: (3-0) 3

The design of controllers for AC and DC motors up to two horsepower using power electronic devices. Use of commercial off-the-shelf three-phase variable frequency drives (VFDs). Simulation of motor drive circuitry and motor dynamics using PSpice and Matlab.

Prerequisites: EE 432/432L/532/532L

EE 439/539 Grid-Connected Power Electronics Devices

Credits: (3-0) 3

The use of power electronic devices to implement transmission line compensation techniques such as Flexible AC Transmission (FACTS) for the control of power flow and power quality improvement such as Active Power Filter (APF) in modern power systems.

Prerequisites: EE 330/330L
Notes: Students enrolled in EE 539 will be held to a higher standard than those enrolled in EE 439.

EE 447/547 Advanced Power Systems

Credits: (3-0) 3

Advanced topics in analysis of unbalanced/faulted three-phase systems using symmetrical components. Dispatch and coordination of interconnected systems. System protection, generation control, transmission line transient operation, and specialized problems in transient stability. Grid tie and DC link systems. The national regulatory environment. System simulation using Matlab, Simulink and PowerWorld.

Prerequisites: EE 431/431L/531/531L or EE 434/434L (SDSU)
Notes: Students enrolled in EE 547 will be held to a higher standard than those enrolled in EE 447.

EE 448/548 Power Generation

Credits: (3-0) 3

Power generation unit characteristics, economic dispatch and commitment of generation systems, control of thermal generation units, electrical generation frequency and voltage control. Steam generation, steam turbines and electrical generation using coal and biomass fuels. Electronic sensors used in steam generation systems. Simulation of generation systems using Matlab and Simulink.

Prerequisites: EE 431/431L/531/531L
Notes: Students enrolled in EE 548 will be held to a higher standard than those enrolled in EE 448.

EE 449 Power Conversion

Credits: (3-0) 3

The design of power converters and inverters using power electronic devices in switch mode. Three phase converters, resonant pulse and multilevel inverters, switch mode regulators. Inductor design. Wind energy and grid tie systems. Survey of linear voltage regulator applications. Simulation of circuitry using PSpice and Matlab.

Prerequisites: EE 431/431L/531/531L and EE 432/432L/532/532L

EE 452/452L/552/552L Robotic Control Systems/Lab

Credits: (2.5-0.5) 3

Applications of discrete control systems for robotics and autonomous systems: analysis and design of automatic control systems, including both linear and nonlinear systems with continuous and discrete signals.

Prerequisites: CSC 150/150L; EE 314/314L; or permission of instructor.

Corequisites: EE 552L
Notes: This course is cross listed with CENG 452/452L. Students enrolled in EE 552/552L will be held to a higher standard than those enrolled in EE 452/452L.

EE 453/453L/553/553L Feedback Control Systems/Lab

Credits: (3-1) 4

Analysis and design of automatic control and process systems by techniques encountered in modern engineering practice, including both linear and nonlinear systems with either continuous or discrete signals.

Prerequisites: EE 314/314L or ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, and ME 352 **or** permission of instructor
Corequisites: EE-453L
Notes: This course is cross listed with ME 453/453L/553/553L. Students enrolled in EE 553/553L will be held to a higher standard than those enrolled in EE 453/453L.

EE 456/456L/556/556L Digital Control Systems/Lab

Credits: (3-1) 4

Digital analysis and design of automatic control and process systems using modern engineering practices, including both linear and nonlinear systems within the discrete domain.

Prerequisites: EE 314/314L
Notes: Students enrolled in EE 556/556L will be held to a higher standard than those enrolled in EE 456/456L.

EE 464 Senior Design Project I

Credits: (0-2) 2

This course will focus on the design process and culminate with the EE faculty approval of design projects (including schematics and parts lists) for EE 465 . Typical topics included are the development of a product mission statement, identification of the customer and customer needs, development of target specifications, consideration of alternate designs using a decision matrix, project management techniques, legal and ethical issues, FCC verification and certification, used of probability and statistics for reliable design, interpretation go data sheets, and component selection.

Prerequisites: Senior standing.
Pre or Corequisites: EE 313, EE 314/314L, EE 322/322L and ENGL 289

EE 465 Senior Design Project II

Credits: (0-2) 2

Sequel to EE 464 Senior Design I. Seniors build and test design project in simulated environment incorporating engineering standards and realistic constraints. Requirements include laboratory notebook, progress reports, final oral presentation and written report.

Prerequisites: EE 464

EE 481/481L/581/581L Microwave Engineering/Lab

Credits: (3-1) 4

Presentation of basic principles, characteristics, and applications of microwave devices and systems. Development of techniques for analysis and design of microwave circuits.

Prerequisites: EE 382
Corequisites: EE 481L
Notes: Students enrolled in EE 581/581L will be held to a higher standard than those enrolled in EE 481/481L.

EE 483/483L/583/583L Antennas for Wireless Communications/Lab

Credits: (3-1) 4

Introduction to antenna design, measurement, and theory for wireless communications including fundamental antenna concepts and parameters (directivity, gain, patterns, etc.), matching techniques, and signal propagation. Theory and design of linear, loop, and patch antennas, antenna arrays, and other commonly used antennas. Students will design, model, build, and test antenna(s).

Prerequisites: EE 382
Corequisites: EE 483L or EE 583L
Notes: Students enrolled in EE 583/583L will be held to a higher standard than those enrolled in EE 483/483L.

EE 491 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.

EE 492 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

EE 498 Undergraduate Research/Scholarship

Credits: Credit to be arranged.

Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor.
Notes: Credit to be arranged; not to exceed 4 credits toward fulfillment of B.S. degree requirements.

EE 500 Research Methods

Credits: (1-0) 1

This course covers techniques of performing research in experimental and theoretical settings. Literature search, rules about plagiarism, writing process are covered.

Prerequisites: Graduate standing or senior undergraduate with permission of instructor.

EE 505/505L Survey of Circuits and Systems/Lab

Credits: (2-1) 3

This course provides the necessary foundation in circuits, circuit analysis, transient circuits, sinusoidal analysis, electromechanical systems, electromagnetic systems, topological and mathematical models for the study of robotic and autonomous systems.

Prerequisites: CSC 150/150L, MATH 321 or permission of instructor.
Corequisites: EE 505L
Notes: May not be used for credit by computer engineering, electrical engineering, and mechanical engineering majors.

EE 591 Independent Study

Credits: 1 to 4

Includes Directed Study, Problems, Readings, Directed Readings, Special Problems, and Special Projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor

EE 592 Topics

Credits: 1 to 4

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

EE 592L Special Topics: Lab Experience

Credits: 0.5 to 1

This course provides opportunities for students to engage in hands-on experience in subject material that does not already have a laboratory component.

EE 612/612L High-Speed Digital Design/Lab

Credits: (2.5-0.5) 3

This course is an introduction to signal integrity and the design of high-speed circuits and interconnects. Topics include signal integrity issues such as ringing, ground bounce, clock skew, jitter, crosstalk, and unwanted radiation, time-domain analysis and spice simulation of lumped and distributed high speed circuits, micro- strip and strip-line design, ground and power plane design, proper capacitor decoupling, line termination, and multi-layer routing strategies. The student is also introduced to high-speed measurement techniques and equipment.

Prerequisites: EE 220/220L and EE 320/320L or equivalent courses in introductory circuits and introductory electronics.
Corequisites: EE 612L

EE 618/618L Sensors and Signal Processing/Lab

Credits: (2-1) 3

Presentation of principles, characteristics, and applications of instrumentation systems including sensors, filters, instrumentation amplifiers, analog-to-digital and digital-to-analog conversions, and noise. This course will be useful to graduate students beginning their laboratory thesis research. It is available to students from other departments with permission of instructor.

Corequisites: EE 618L

EE 621 Information and Coding Theory

Credits: (3-0) 3

Principles and techniques of information theory and coding theory and their applications to the design of information handling systems. Topics include: Entropy, Shannon theory, channel capacity, coding for data translation, compaction, transmission and compression, block codes, and Markov processes.

EE 622 Statistical Communication Systems

Credits: (3-0) 3

Concepts of probability and random processes; linear systems and random processes; performance of amplitude angle and pulse modulation systems in noisy environments; digital data transmission; and basic concepts of information theory.

EE 623 Random Signals and Noise

Credits: (3-0) 3

Selected topics in the theory of probability and statistics; spectral analysis; shot noise and Gaussian processes; noise figures; signal-to-noise ratios; random signals in linear systems; optimum linear systems.

Prerequisites: Permission of instructor.
Notes: Taught as required.

EE 624/624L Advanced Digital Signal Processing/Lab

Credits: (2.5-0.5) 3

This course develops the theory essential to understanding the algorithms that are increasingly found in

modern signal processing applications, such as speech, image processing, digital radio and audio, statistical and adaptive systems. Topics include; analysis of non-stationary signals, transform techniques, Wiener filters, Kalman filters, multirate rate systems and filter banks, hardware implementation and simulation of filters, and applications of multriate signal processing. Matlab will be used extensively.

Prerequisites: CENG 420/420L or equivalent.
Corequisites: EE 624L

EE 626 Wireless Communications

Credits: (3-0) 3

This course presents the basic principles of wireless communication technology. Topics covered include: transmission fundamentals, noise and interference in wireless communication networks; Diversity techniques in wireless systems; multiple access schemes, etc. The goal of this course is to provide students with the working knowledge of the broad range of wireless communication such as waveform propagation models, antenna types, path-loss models, hand-off in cellular system, time diversity, frequency diversity, space diversity, multiple-in and multiple-out (MIMO), etc.

EE 633 Power Systems Analysis I

Credits: (3-0) 3

Synchronous machine theory and modeling; short- circuit, load flow, and stability studies in large scale systems.

Prerequisites: EE 431/431L/531/531L or equivalent.
Notes: Taught as required.

EE 634 Power System Analysis II

Credits: (3-0) 3

Advanced topics in power system analysis; excitation and speed-control systems; protective relaying and relay applications.

Prerequisites: EE 633

EE 637 Advanced Power Electronics Motor Drives

Credits: (3-0) 3

Gain an understanding of drive concepts and technology used for AC and DC motors. Study the design,

control and simulation of various motor drives used in power engineering.

Prerequisites: Permission of Instructor

EE 641 Digital Systems Design

Credits: (3-0) 3

Design of digital systems (including computer systems) and implementation by fixed logic and programmed logic (microprocessors and microprogramming).

Prerequisites: Permission of instructor.

EE 643 Advanced Digital Systems

Credits: (3-0) 3

Study of current advanced topics in digital systems; multiprocessors; computer networks; digital communication; pattern recognition systems.

EE 644 Fault Tolerant Computing

Credits: (3-0) 3

The objective of this course is to provide students with a background in the various techniques used in fault tolerant approaches. After an introduction to fault tolerance, deterministic testing and probabilistic testing will be presented. Important topics in the area of fault tolerant computing will be covered, such as random testing, error detection and correction, reliability analysis, fault-tolerant design techniques, and design faults including software reliability methods.

Prerequisites: CENG 342/342L or equivalent or permission of instructor.

EE 647/647L HDL Design/Lab

Credits: (2.5-0.5) 3

This course explores modern design techniques utilizing hardware description languages (HDLs) such as VHDL, VHDL-A, and Verilog. Fundamentals language syntax will be covered in addition to advanced language constructs. Various hierarchical design styles such as dataflow, structural, and behavioral descriptions will be presented. Emphasis will be placed on both design simulation and synthesis. Synthesis platforms (e.g., FPGAs and ASICs) will also be examined. Other current issues will also be discussed such as reconfigurability, system-on-a-chip solutions, testbenches, soft processors, etc.

Prerequisites: CENG 342/342L or permission of instructor.
Corequisites: EE 647L

EE 648/648L Advanced VLSI Design/Lab

Credits: (2.5-0.5) 3

This course presents more advanced material related to the technology and design of modern VLSI integrated circuits including topics such as mixed logic design, BiCMOS logic design, memory design, low power design, silicon-on-insulator chips, deep sub-micron design issues, crosstalk, parasitic parameter extraction and optimization, gallium arsenide logic devices, design-for test, fault-tolerant VLSI architectures, etc.

Prerequisites: CENG 440/440L
Corequisites: EE 648L

EE 655 Linear System Theory

Credits: (3-0) 3

This course acts as an introduction to advanced linear system theory associated with advanced control system development. The mathematical underlying theories for the following topics are developed: metric spaces, state variables, Jordan forms, SVD, controllability, observability, stabilization, response shaping, and linear observers for multivariate systems.

EE 680 Engineering Electromagnetics

Credits: (3-0) 3

The course will cover topics often encountered in engineering electromagnetic practice, e.g., uniform plane waves and their normal and oblique scattering from planarly-layered media; physical optics and scattering by strips; metallic waveguides and resonant cavities; and dielectric waveguides.

Prerequisites: Undergraduate course in electromagnetic, or the equivalent, and knowledge of a mathematics package; or permission of instructor.

EE 691 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings

depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

EE 692 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

EE 722 Advanced Statistical Communications

Credits: (3-0) 3

Advanced concepts of probability and random processes; linear systems and random processes; performance of amplitude angle and pulse modulation systems in noisy environments; digital data transmission; and basic concepts of information theory.

Prerequisites: CENG 421/421L/521/521L/EE 421/421L/521/521L or permission of instructor

EE 724 Advanced Random Signals and Noise

Credits: (3-0) 3

Selected advanced topics in the theory of probability and statistics; spectral analysis; shot noise and Gaussian processes; noise figures; signal-to-noise ratios; random signals in linear systems; optimum linear systems.

Prerequisites: Permission of instructor

EE 725 Probability and Stochastic Processes with Applications

Credits: (3-0) 3

In this course, advanced topics of probability and stochastic processes and their applications in communication systems, communication networks, and other fields in electrical and computer engineering are covered. After an overview of probability concepts and various functions of random variables, the course embarks on introducing stochastics process, stationary, ergodic, and non-stationary processes, functions of auto- and cross-correlation, power spectral densities, and, in the context of linear systems, these functions are developed. Applications are covered throughout the course.

Prerequisites: MATH 381 or equivalent, or permission of instructor.

EE 726 Advanced Wireless Communications

Credits: (3-0) 3

This course presents the advanced topics in wireless communication and networking. Topics covered include: Diversity techniques in wireless systems; multiple access schemes, etc.; cutting-edge technology in cognitive radio networks, wireless relay networks, etc. The goal of this course is to provide students with the working knowledge of the broad range of wireless communication and prepare them for the in-depth research in wireless communications and networking.

EE 737 Organic Photovoltaics

Credits: (3-0) 3

Organic photovoltaic provides a variety of interesting and new properties which facilitate solar energy utilization. The objections of this course are to introduce material properties of polymers, small molecules, dyes, and nanomaterials for photovoltaics; describe device mechanisms and behavior of organic photovoltaics; understand the photophysical processes in organic photovoltaics; and introduce different processing techniques for device fabrication.

Notes: This course is cross listed with MES 737.

EE 739 Advanced Grid-Connected Power Electronics Devices

Credits: (3-0) 3

Advanced use of power electronic devices to improve power quality of power grid with Flexible AC Transmission Systems (FACTS) and Active Power Filters (APF) and to integrate renewable energy resources (wind power and photovoltaic power) into modern power systems.

Prerequisites: Permission of instructor

EE 751 Advanced Digital Control Systems

Credits: (3-0) 3

Study of topics in digital control systems, digital compensation techniques; real-time digital control of dynamic systems; optimization of digital systems; digital control of robotic systems, digital to continuous system interfacing.

Prerequisites: EE 453/453L/553/553L or equivalent.
Notes: Taught as required.

EE 753 Optimal Control Theory

Credits: (3-0) 3

The study of optimal control systems applied to linear and nonlinear systems via a variety of methods: e.g. linear and nonlinear programming techniques, parameter optimization, system optimization, calculus of variations applied to control systems, stochastic optimization processes and other related optimization techniques as time permits.

EE 754 Nonlinear Control Theory

Credits: (3-0) 3

The study of nonlinear systems using the phase plane method, describing functions, Lyapunov's theory, nonlinear control systems design.

EE 755 Linear State Space Control

Credits: (3-0) 3

This course acts as an introduction to the design and implementation of multivariate control system design for continuous time systems. Moreover, this course focuses on the design and application of linear state space techniques. Topics covered include: state variables, controllability, observability, stabilization, response shaping, and linear observers for multivariate systems.

EE 756 Advanced Linear System Theory

Credits: (3-0) 3

This course presents advanced linear system theory associated with advanced control system development. The mathematical underlying theories for the following topics are developed: metric spaces, state variables, Jordan forms, SVD, controllability, observability, stabilization, response shaping, and linear observers for multivariate systems.

Notes: Students may not earn credit in both EE 656 and EE 756.

EE 757 Intelligent Control Systems

Credits: (3-0) 3

This course acts as an introduction to the topic of intelligent control theory. This is a fast growing field that covers a wide range of topics. This class will introduce the following topics as time permits: Fuzzy Set Theory, Neural Networks, Regression and Optimization, Neuro-Fuzzy Modeling, Neuro-Fuzzy Control, Data Clustering, and Stochastic Based Control, e.g. GAs, as time permits.

EE 780 Advanced Engineering Electromagnetics

Credits: (3-0) 3

The course will cover advanced topics often encountered in engineering electromagnetic practice, e.g., uniform plane waves and their normal and oblique scattering from planar layered media; antennas; physical optics and scattering by strips; metallic waveguides and resonant cavities; and dielectric waveguides.

Notes: Students may not earn credit in both EE 680 and EE 780.

EE 788 Master's Research Problems/Projects

Credits: Credit to be arranged.

Independent research problems/projects that lead to research or design paper, but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Notes: Credit to be arranged; not to exceed 3 credit hours.

EE 791 Independent Study

Credits: 1 to 9

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

EE 792 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

EE 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements.

Engineering Mechanics

EM 214 Statics

Credits: (3-0) 3

The study of the effects of external forces acting on stationary rigid bodies in equilibrium. Vector algebra is used to study two and three dimensional systems of forces. Trusses, frames and machines, shear and moment in beams, friction, centroids, moments of inertia, and mass moments of inertia are discussed.

Prerequisites: MATH 123 with a minimum grade of "C".

EM 215 Dynamics

Credits: (3-0) 3

Newton's laws of motion are applied to particles and rigid bodies. Absolute and relative motion; force, mass and acceleration; work and energy; an impulse and momentum.

Prerequisites: EM 214

EM 216 Statics and Dynamics

Credits: (4-0) 4

Statics: The study of effects of external forces acting on stationary rigid bodies in equilibrium. Frames and machines, friction, centroids and moments of inertia on areas and mass are discussed. Dynamics: Newton's laws of motion are applied to particles and rigid bodies. Topics considered are absolute and relative motion; force, mass, and acceleration (or particles and rigid bodies); work and energy; and impulse and momentum (of particles).

Prerequisites: MATH 123 with a "C" or better

EM 321 Mechanics of Materials

Credits: (3-0) 3

Basic concepts of stress and strain that result from axial, transverse, and torsional loads on bodies loaded within the elastic range. Shear and moment equations and diagrams; combined stresses; Mohr's circle; beam deflections; and column action and equations.

Prerequisites: EM 214 with a minimum grade of "C".

EM 328 Applied Fluid Mechanics

Credits: (3-0) 3

Topics will include an introduction to the static and dynamic properties of real and ideal fluids; application of continuity, energy, and momentum principles to laminar, turbulent, compressible, and incompressible flows; laminar and turbulent flow of fluids in closed conduits and open channels; flow through orifices, weirs, and venturi meters. Flow in pipe networks and pumping systems will be investigated using a projectized team approach.

Prerequisites: EM 214 or concurrent enrollment in EM 216.

EM 331 Fluid Mechanics

Credits: (3-0) 3

An introduction to the static and dynamic properties of real and ideal fluids; application of continuity, energy, and momentum principles to laminar, turbulent, compressible, and incompressible flows; and laminar and turbulent flow of fluids in closed conduits and around immersed bodies.

Prerequisites: EM 214 or EM 216 either with "C" or better

EM 680 Advanced Strength of Materials

Credits: (3-0) 3

Study of advanced concepts in strength of materials. Topics will be selected from the following: theories of stress and strain, failure criteria, energy methods, torsion, nonsymmetrical beams on elastic foundation, plates, shells, stress concentrations, contact stresses, finite element methods, and plastic behavior of solids.

Notes: This course is cross listed with ME 680.

English

ENGL 003 English as a Second Language: Grammar Review and Intermediate Composition

Credits: (3-0) 3

Conversation, listening and reading comprehension, vocabulary and idioms, grammar review and intermediate composition.

Notes: Does not count toward graduation.

ENGL 013 English as a Second Language: More Complex Structural Patterns and Advanced Composition

Credits: (3-0) 3

Conservation, listening and reading comprehension, vocabulary and idioms, more complex structural patterns, and advanced composition.

Prerequisites: ENGL 003 or placement.
Notes: Does not count toward graduation.

ENGL 023 English as a Second Language: Listening and Reading, Grammar, Comprehension

Credits: 3 to 5

Written and oral responses to written and oral sources. Reading and listening comprehension, vocabulary building, pronunciation, grammar and sentence structure, and formal and informal written and spoken English.

Prerequisites: Placement or permission of instructor.
Notes: Does not count toward graduation.

ENGL 033 Basic Writing

Credits: 1 to 3

Intensive work in grammar and usage, punctuation, and paragraph development.

Prerequisites: Appropriate student placement based on entry level assessment.
Notes: Does not count toward graduation.

ENGL 101 Composition I

Credits: (3-0) 3

Practice in the skills, research, and documentation needed for effective academic writing. Analysis of a variety of academic and non-academic texts, rhetorical structures, critical thinking, and audience will be included.

Prerequisites: Appropriate student placement based on entry level assessment or completion of ENGL 033.

ENGL 201 Composition II

Credits: (3-0) 3

Study of and practice in writing persuasive prose, with the aim to improve writing skills in all disciplines. Includes literary analysis and requires a research report.

Prerequisites: ENGL 101 or permission of instructor.

ENGL 210 Introduction to Literature

Credits: (3-0) 3

Readings in fiction, drama, and poetry to acquaint students with literature and aesthetic form.

ENGL 212 World Literature II

Credits: (3-0) 3

Selected works of world literature in translation since the Renaissance.

ENGL 221 British Literature I

Credits: (3-0) 3

A chronological survey of British literature from Old English through the 18th century.

Notes: ENGL 221 and ENGL 222 need not be taken in sequence.

ENGL 222 British Literature II

Credits: (3-0) 3

A chronological survey of British literature from the 19th century to the present.

Notes: ENGL 221 and ENGL 222 need not be taken in sequence.

ENGL 241 American Literature I

Credits: (3-0) 3

Background to and survey of major works from the beginnings to the Civil War.

Notes: ENGL 241 and ENGL 242 need not be taken in sequence.

ENGL 242 American Literature II

Credits: (3-0) 3

Background to and survey of major works from the Civil War to the present.

Notes: ENGL 241 and ENGL 242 need not be taken in sequence.

ENGL 250 Science Fiction

Credits: (3-0) 3

A survey of short stories and novels from the 19th century to the present.

ENGL 279 Technical Communications I

Credits: (3-0) 3

Introductory written and oral technical communications with emphasis on research and explanations of scientific and engineering topics.

Prerequisites: ENGL 101 or equivalent and sophomore standing.

ENGL 289 Technical Communications II

Credits: (3-0) 3

Advanced written and oral technical communications with emphasis on the research, preparation, and delivery of complex technical documents.

Prerequisites: ENGL 279 or equivalent and sophomore standing.

ENGL 300 The Literary Experience of Nature

Credits: (3-0) 3

An interdisciplinary survey of writing about nature, examining the relationship between literary, cultural, and scientific perspectives.

Prerequisites: Junior or senior standing.

ENGL 330 Shakespeare

Credits: (3-0) 3

Representative comedies, tragedies, and histories of Shakespeare.

Prerequisites: ENGL 101 or permission of instructor.

ENGL 343 Selected Authors

Credits: (1-0) 1

A study of the work of one or several major literary figures. Authors may vary each time the course is offered.

Prerequisites: ENGL 101 or permission of instructor.
Notes: May be taken up to three (3) times with different authors.

ENGL 350 Humor in American Culture

Credits: (3-0) 3

The interdisciplinary study of American literary humor and its relationship to significant historical and regional issues.

Prerequisites: Junior or senior standing.

ENGL 360 Studies in European Literature

Credits: (3-0) 3

The interdisciplinary study of a facet of European literature through focus on literature of a particular century, a specific country or individual authors such as 19th century nationalism, literature of France, or James Joyce.

Prerequisites: Junior or senior standing.
Notes: May be repeated to a maximum of 6 credit hours on different topics.

ENGL 374 Studies in American Literature

Credits: 1 to 3

The interdisciplinary study of American literature through focus on a particular facet of the American experience, such as a national issue or concern, a unique historical period or literary genre, or a distinct segment of U.S. society.

Prerequisites: Junior or senior standing.
Notes: May be repeated to a maximum of 6 credit hours on different topics.

ENGL 391 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

ENGL 392 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of special topics will be allowed for degree credit.

Engineering Management

ENGM 615 Nonparametric Statistics

Credits: (3-0) 3

Theory and application of commonly used distribution-free test statistics, including sign and Wilcoxon tests, and corresponding nonparametric point and interval estimators. Additionally, basic tests of three or more samples, and other selected topics.

ENGM 620 Quality Management

Credits: (3-0) 3

This course is intended as an introduction to the philosophies, concepts, and tools of Total Quality Management. Topics include: An introduction to the philosophies of Juran, Deming, and Taguchi; total quality and quality improvement; quality and technology; and managing a quality environment. Elements of statistical process control, including pareto diagrams, box plots, histograms, and control charts will also be investigated using a commercial software package. Special projects and current readings in quality management will be assigned.

ENGM 625 Innovation and Commercialization

Credits: (3-0) 3

This course covers the practical aspects of developing an innovative idea or new technology from conceptualization through commercialization. Course topics include product innovation, product development, technology forecasting, technology transfer, small business development resources, and commercialization.

ENGM 631 Optimization Techniques

Credits: (3-0) 3

The course develops basic judgment and competence in using quantitative methods in engineering or management decisions. Students will study various types of linear programming techniques, including simplex, transportation and assignment methods and post-optimal sensitivity analysis. In addition, network-type problems, critical-path methods, dynamic and decision tree techniques will be covered. Some basic mathematical theory is taught and the computer is used to solve both assigned problems and problems developed by the student in a particular field of interest.

ENGM 640 Business Strategy

Credits: (3-0) 3

This course provides a financial management approach within a systems context approach. Financial concepts are analyzed from perspective of three basic types of decisions for any ongoing business: investment, operations, and financing. Course materials are structured around the viewpoints of major parties interested in the performance of business: managers, owners, and creditors. Financial concepts are reinforced by simulating the impact various business strategies have on the financial health of the virtual enterprise.

ENGM 650 Safety Management

Credits: (3-0) 3

Management aspects of occupational safety and health. Topics include: development and implementation of safety programs and ergonomics programs, risk management, economic impact, legislation (including OSHA, Workers' Compensation, and ADA), legal issues, wellness programs, system safety, certification, ethics, and professionalism.

ENGM 655 Ergonomics for Managers

Credits: (3-0) 3

Management aspects of ergonomics and human factors engineering. Topics include: introduction to ergonomics and human factors principles, the business case for ergonomics, understanding cumulative trauma and neurovascular disorders, development and implementation of ergonomics programs, economic and regulatory aspects, work organization, job satisfaction, quality and productivity aspects, strategic issues and trends, and certification.

ENGM 661 Engineering Economics for Managers

Credits: 1 to 4

Students are expected to have prerequisite skills in the time value of money and basic probability. Students not having these skills require the permission of instructor. The course is divided into 4 one-credit modules, which include: economic valuation for decision making, problems with uncertainty and risk, budgeting and cost management, and financial statements and enterprise management. (Manufacturing elective)

Prerequisites: MATH 281 or MATH 381 or permission of instructor

ENGM 663 Operations Planning

Credits: (3-0) 3

Organization, functions, and responsibilities of the production control department and some related functions in industry. It includes: planning, authorizing, routing, scheduling, dispatching, and controlling the flow of production. The course also introduces the student to the fundamentals of inventory control, statistical quality control, pert-cpm, and operations research. (Manufacturing elective)

Prerequisites: MATH 281 or MATH 381 or permission of instructor

ENGM 675 Legal and Ethical Issues in Engineering Management

Credits: (3-0) 3

This course will introduce students to many of the legal and ethical issues from a manager’s perspective. Topics include: employment contracts, consulting, harassment, ADA compliance, Whistle Blower Act, research ethics, and helping employees with professional development.

ENGM 720 Statistical Process Control

Credits: (3-0) 3

This course covers the application of statistical methods to problems in quality and process control. Statistical topics include: basics of processes and variability, statistically controlled processes, variable and attribute control charts, moving averages, and process capability.

Prerequisites: MATH 281 or MATH 381 or permission of instructor

ENGM 732 Stochastic Models in Operations Research

Credits: (3-0) 3

Probabilistic quantitative methods are developed. These include project control (PERT), decision trees, risk analysis, queuing, Markov chains, mathematical modeling and Monte Carlo simulation. Computer programs are used to solve practical problems after the techniques are developed and understood.

Prerequisites: MATH 281 or MATH 381 or permission of instructor

ENGM 742 Engineering Management and Labor Relations

Credits: (3-0) 3

Principles of management, supervision, administrative policies, human-factors engineering, and labor-management relationships.

ENGM 745 Forecasting for Business and Technology

Credits: (3-0) 3

This course provides an introduction to the quantitative and qualitative tools that may be used to identify and assess emerging technological advances. Topics include multiple regression, ARIMA forecast models and estimation, econometric models, and delphi techniques. Special projects and current readings in technology may be assigned.

Prerequisites: MATH 281 or MATH 381 or permission of instructor

ENGM 788 Master's Research Problems/Project

Credits: Credit to be arranged.

Independent research problems/projects that lead to a research or design paper but not to a thesis. The

plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor
Notes: Credit to be arranged; not to exceed 3 credits toward fulfillment of M.S. degree requirements Open only to students pursuing the M.S. non-thesis option.

ENGM 791 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: Student may enroll in this course only twice and for no more than a total of 6 credits.

ENGM 792 Topics

Credits: 1 to 3

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: Student may enroll in this course only twice and for no more than a total of 6 credits.

ENGM 798 Thesis

Credits: Credit to be arranged

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Prerequisites: Permission of instructor
Notes: Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. in Engineering Management thesis option.

Student Exchange – International

EXCH 289 Student Exchange - International

Credits: 0 to 18

This course allows students to register as full-time students while taking part in an exchange program. Students will register on their home campus for the number of credit hours they intend to take while enrolled at another campus.

EXCH 389 Student Exchange - International

Credits: 0 to 16

This course allows students to register as full-time students while taking part in an exchange program. Students will register on the School of Mines campus for the number of credit hours they intend to take while enrolled at another campus.

EXCH 487 Study Abroad

Credits: (0-0) 0

Designed to keep a student active at the School of Mines if out for one to two semester(s) for study abroad program and not enrolling in credit at the School of Mines. Does not guarantee eligibility for financial aid.

Notes: Repeatable, but for no more than three consecutive terms at any one point.

EXCH 489 Student Exchange - International

Credits: 0 to 18

This course allows students to register as full-time time School of Mines students while taking part in an exchange program. Students will register on the School of Mines campus for the number of credit hours they intend to take while enrolled at another campus.

EXPL 285/385/485/585/685 Study Abroad Experiences

Credits: 1 to 3

This course is designed to provide engineering and science students with study abroad experiences, including exposure to different cultures as well as learning and sharing engineering and

science/technology globally.

Prerequisites: Permission of instructor.

General Engineering

GE 130/130L Introduction to Engineering/Lab

Credits: (1-1) 2

This course serves as an introduction to the engineering profession and to its various disciplines. This course is designed to give students the opportunity to learn how to solve engineering analysis and design problems. Students will develop various computational skills, sharpen communication skills, and be exposed to professional development in the form of team building, technology tools, and project management. In addition, students will have the opportunity to learn from professional engineers and scientists through interaction with industry.

Prerequisites: MATH 102
Corequisites: GE 130L

GE 283L Community Design Projects I

Credits: 1

GE/IS 283L Community Design Projects I Lab is a service-learning design course in which teams of students from multiple disciplines work together on long-term projects that benefit the community.

Project work centers on the engineering, technology, science, and computing needs of a community partner. Interdisciplinary team interaction is an integral element for project success and a central aspect of the course experience.

The first, introductory-level course (i.e., GE/IS 283L Community Design Projects I Lab) orients freshmen- and sophomore-level students to the service learning and design program at SD Mines, introduces students to levels and types of involvement, and includes instructional modules on principles of human-centered design and ethics. The curriculum of GE/IS 283L Community Design Projects I Lab focuses on developing teaming skills and understanding human-centered design through participation in a community design project.

Student involvement in the service learning and design program at SD Mines over multiple semesters is encouraged. For students entering the program at the freshman or sophomore level, GE/IS 283L Community Design Projects I is the introductory course. To continue involvement, freshmen and sophomore students enroll in GE/IS 284L. GE/IS 284L may be taken once, but students may enroll in GE/IS Community Design Projects II Lab. Juniors and seniors enroll in the GE/IS 483L and/or GE/IS 484L class.

All design project teams are composed of students of all class levels (i.e., freshmen through seniors). Projects last at least one year, although partnerships with community organizations are ongoing and extend past the life of any individual project.

GE 284L Community Design Projects II

Credits: 1-2

GE/IS 284L Community Design Projects II Lab is a service-learning design course in which teams of students from multiple disciplines work together on long-term projects that benefit the community.

Project work centers on the engineering, technology, science, and computing needs of a community partner. Interdisciplinary team interaction is an integral element for project success and a central aspect of the course experience.

GE/IS 284L is a continuation of GE/IS 283L for freshman and sophomore students. The curriculum of GE/IS 284L Community Design Projects II Lab focuses on developing teaming skills and understanding human-centered design through continued participation in a community design project.

Student involvement in the service learning and design program at SD Mines over multiple semesters is encouraged. A student may enroll in GE/IS 484L multiple times to sustain his or her involvement through the junior and senior year after completion of GE/IS 283L and GE/IS 284L or GE/IS 483L.

All design project teams are composed of students of all class levels (i.e., freshmen through seniors). Projects last at least one year, although partnerships with community organizations are ongoing and extend past the life of any individual project.

GE 483L Community Design Projects I

Credits: (0-1) 1

GE/IS 483 Community Design Projects I Lab is a service-learning design course in which teams of students from multiple disciplines work together on long-term projects that benefit the community.

Project work centers on the engineering, technology, science, and computing needs of a community partner. Interdisciplinary team interaction is an integral element for project success and a central aspect of the course experience.

The first, introductory-level course (i.e., GE/IS483 Community Design Projects I Lab) orients junior and senior-level students to the service learning and design program at SD Mines, introduces students to levels and types of involvement, and includes instructional modules on principles of human-centered design and ethics. The curriculum of GE/IS483 Community Design Projects I Lab focuses on developing teaming skills and understanding human-centered design through participation in a community design project.

Student involvement in the service learning and design program at SD Mines over multiple semesters is encouraged. For students entering the program at the junior or senior level, GE/IS483 Community

Design Projects I is the introductory course. To continue involvement, junior and senior students enroll in GE/IS 484L Community Design Projects II Lab. A student may enroll in GE/IS 494 multiple times to sustain his or her involvement through their academic enrollment year. Students may take GE/IS 283L or 483L for credit, but not both.

All design project teams are composed of students of all class levels (i.e., freshmen through seniors). Projects last at least one year, although partnerships with community organizations are ongoing and extend past the life of any individual project.

GE 484L Community Design Projects II

Credits: 1 to 2

GE/IS 484L Community Design Projects II Lab is a service-learning design course in which teams of students from multiple disciplines work together on long-term projects that benefit the community.

Project work centers on the engineering, technology, science, and computing needs of a community partner. Interdisciplinary team interaction is an integral element for project success and a central aspect of the course experience.

GE/IS 484L is a continuation of GE/IS 283L or GE/IS 4893L for junior and senior students. The curriculum of GE/IS 484L Community Design Projects II Lab focuses on developing teaming skills and understanding human-centered design through continued participation in a community design project.

Student involvement in the service learning and design program at SD Mines over multiple semesters is encouraged. A student may enroll in GE/IS 484L multiple times to sustain his or her involvement through the junior and senior year after completion of GE/IS 283L, GE/IS 284L or GE/IS 483L.

All design project teams are composed of students of all class levels (i.e., freshmen through seniors). Projects last at least one year, although partnerships with community organizations are ongoing and extend past the life of any individual project.

GE 498 Interdisciplinary Capstone Senior Design

Credits: (0-3) 3

Content will include major interdisciplinary engineering design experience integrating fundamental concepts of mathematics, basic science, engineering design, communications skills, humanities, and social science.

Prerequisites: Senior standing or permission of instructor.

GES 186 Job Shadow

Credits: (0-1) 1

This course provides an opportunity to learn more about the profession. This experience will provide students with first hand observations in their chosen profession and a better, more realistic understanding of job duties and responsibilities. Course will also involve the student writing a report on the experience and possibly giving a presentation.

Prerequisites: Freshman or sophomore standing

IS 283L Community Design Projects I

Credits: 1

GE/IS 283L Community Design Projects I Lab is a service-learning design course in which teams of students from multiple disciplines work together on long-term projects that benefit the community.

Project work centers on the engineering, technology, science, and computing needs of a community partner. Interdisciplinary team interaction is an integral element for project success and a central aspect of the course experience.

The first, introductory-level course (i.e., GE/IS 283L Community Design Projects I Lab) orients freshmen- and sophomore-level students to the service learning and design program at SD Mines, introduces students to levels and types of involvement, and includes instructional modules on principles of human-centered design and ethics. The curriculum of GE/IS 283L Community Design Projects I Lab focuses on developing teaming skills and understanding human-centered design through participation in a community design project.

Student involvement in the service learning and design program at SD Mines over multiple semesters is encouraged. For students entering the program at the freshman or sophomore level, GE/IS 283L Community Design Projects I is the introductory course. To continue involvement, freshmen and sophomore students enroll in GE/IS 284L. GE/IS 284L may be taken once, but students may enroll in GE/IS Community Design Projects II Lab. Juniors and seniors enroll in the GE/IS 483L and/or GE/IS 484L class.

All design project teams are composed of students of all class levels (i.e., freshmen through seniors). Projects last at least one year, although partnerships with community organizations are ongoing and extend past the life of any individual project.

IS 284L Community Design Projects II

Credits: 1-2

GE/IS 284L Community Design Projects II Lab is a service-learning design course in which teams of students from multiple disciplines work together on long-term projects that benefit the community.

Project work centers on the engineering, technology, science, and computing needs of a community partner. Interdisciplinary team interaction is an integral element for project success and a central aspect of the course experience.

GE/IS 284L is a continuation of GE/IS 283L for freshman and sophomore students. The curriculum of GE/IS 284L Community Design Projects II Lab focuses on developing teaming skills and understanding human-centered design through continued participation in a community design project.

Student involvement in the service learning and design program at SD Mines over multiple semesters is encouraged. A student may enroll in GE/IS 484L multiple times to sustain his or her involvement through the junior and senior year after completion of GE/IS 283L and GE/IS 284L or GE/IS 483L.

All design project teams are composed of students of all class levels (i.e., freshmen through seniors). Projects last at least one year, although partnerships with community organizations are ongoing and extend past the life of any individual project.

IS 483L Community Design Projects I

Credits: (0-1) 1

GE/IS 483 Community Design Projects I Lab is a service-learning design course in which teams of students from multiple disciplines work together on long-term projects that benefit the community.

Project work centers on the engineering, technology, science, and computing needs of a community partner. Interdisciplinary team interaction is an integral element for project success and a central aspect of the course experience.

The first, introductory-level course (i.e., GE/IS 483 Community Design Projects I Lab) orients junior and senior-level students to the service learning and design program at SD Mines, introduces students to levels and types of involvement, and includes instructional modules on principles of human-centered design and ethics. The curriculum of GE/IS 483 Community Design Projects I Lab focuses on developing teaming skills and understanding human-centered design through participation in a community design project.

Student involvement in the service learning and design program at SD Mines over multiple semesters is encouraged. For students entering the program at the junior or senior level, GE/IS 483 Community Design Projects I is the introductory course. To continue involvement, junior and senior students enroll in GE/IS 484L Community Design Projects II Lab. A student may enroll in GE/IS 484 multiple times to sustain his or her involvement through their academic enrollment year. Students may take GE/IS 283L or 483L for credit, but not both.

All design project teams are composed of students of all class levels (i.e., freshmen through seniors). Projects last at least one year, although partnerships with community organizations are ongoing and extend past the life of any individual project.

IS 484L Community Design Projects II

Credits: 1 to 2

GE/IS 484L Community Design Projects II Lab is a service-learning design course in which teams of students from multiple disciplines work together on long-term projects that benefit the community.

Project work centers on the engineering, technology, science, and computing needs of a community partner. Interdisciplinary team interaction is an integral element for project success and a central aspect of the course experience.

GE/IS 484L is a continuation of GE/IS 283L or GE/IS 483L for junior and senior students. The curriculum of GE/IS 484L Community Design Projects II Lab focuses on developing teaming skills and understanding human-centered design through continued participation in a community design project.

Student involvement in the service learning and design program at SD Mines over multiple semesters is encouraged. A student may enroll in GE/IS 484L multiple times to sustain his or her involvement through the junior and senior year after completion of GE/IS 283L, GE/IS 284L or GE/IS 483L.

All design project teams are composed of students of all class levels (i.e., freshmen through seniors). Projects last at least one year, although partnerships with community organizations are ongoing and extend past the life of any individual project.

Geological Engineering

GEOE 110L Introduction to Geological and Mining Engineering/Lab

Credits: (0-1) 1

An introductory course for incoming freshman in geological and mining engineering covering fundamental engineering practices in both disciplines. The course will include short field exercises, hands-on practical exercises, group projects, problem solving (using spreadsheets and other current methods), and engineering ethics. When applicable, industry experts will be invited as guest lecturers to discuss current trends and practices in the industry.

Notes: This course is cross listed with MEM 110L.

GEOE 221/221L Geology for Engineers/Lab

Credits: (2-1) 3

Basic concepts in the study of the earth, with emphasis on geological processes acting on the earth's surface. Topics include rock forming processes and identification, mass wasting, ground water, streams, glaciers, coastal erosion, and earthquakes. Emphasis is given to engineering significance of processes and their resulting deposits.

Corequisites: GEOE 221L

GEOE 324/324L Engineering Geophysics I/Lab

Credits: (2-1) 3

Application of the more commonly used methods of geophysical prospecting in mineral exploration, petroleum exploration, and engineering construction. Includes field design and interpretation of surveys using the engineering seismograph, gravity meter, electrical resistivity equipment, scintillometers, and magnetometers. Extensive use of computers is made in the laboratory work.

Prerequisites: MATH 125 and PHYS 213/213-A
Corequisites: GEOE 324L
Notes: A minimum grade of "C" is required for graduation with a Geological Engineering B.S.

GEOE 410 Engineering Field Geology

Credits: 6

Instruction and practice for both team and independent work involving field techniques for geological engineering. Field work is conducted for five weeks at numerous sites throughout the Black Hills. The field mapping section teaches construction of engineering stratigraphic columns, geologic maps, and structural cross-sections. Field techniques are taught for rock strength assessment, hydrologic analysis of surface and groundwater, and performing engineering site characterizations. Slope stability computer models are used to analyze field data and design engineered slopes in rock and soil. Excel is used extensively for analysis of collected field data and hydrologic data. Written engineering reports accompany all columns, maps, sections, and generated models. Topics and field sites change frequently. One week is devoted to engineering stratigraphy and geologic mapping. Remaining weeks are devoted to engineering problems including surface and ground-water hydrology, geotechnical evaluations and modeling of rock and soil slopes, site characterizations, and field use of laser scanning and photogrammetry. Most projects require construction of a geologic map. Arrangements for transportation and room and board are made through the Black Hills Natural Sciences field station.

Prerequisites: CEE 346/346L, GEOL 331/331L , and GEOL 322/322L
Notes: A minimum grade of "C" is required for graduation with a Geological Engineering B.S.

GEOE 412/512 Science and Engineering Field Applications

Credits: 3 to 6

Field course offered by Black Hills Natural Sciences Field Station to accommodate field education needs of scientists and engineers in multiple disciplines such as geology, geological engineering, petroleum engineering, environmental engineering, etc. Course offerings will take place in the summer months, and content of each camp will be defined by staff from the SDSM&T Geology and Geological

Engineering Department and industry partners.

Prerequisites: Permission of instructor.
Notes: Students enrolled in GEOE 512 will be held to a higher standard than those enrolled in GEOE 412. This course is cross listed with GEOL 412/512.

GEOE 421/521 Aqueous Geochemistry

Credits: (3-0) 3

Geochemical principles and applications for aqueous systems, including water quality and mass transport. Topics will include thermodynamics, carbonate equilibria, silica solubility, redox reactions, pE-pH relationships, and partial pressure diagrams. Geochemical modeling software will be used in projects.

Prerequisites: CHEM 114
Notes: Students enrolled in GEOE 521 will be held to a higher standard than those enrolled in GEOE 421. This course is cross listed with CEE 421/521.

GEOE 425/425L/525/525L Engineering Geophysics II/Lab

Credits: (2-1) 3

The course concentrates on geophysical techniques applicable to petroleum exploration and production, including the acquisition of seismic data, its preparation, interpretation, and use in engineering design. Use of computer packages and individual program design is emphasized.

Prerequisites: MATH 125, GEOE 324/324L and GEOE 211/211L
Corequisites: GEOE 425L or GEOE 525L
Notes: Students enrolled in GEOE 525/525L will be held to a higher standard than those enrolled in GEOE 425/425L.

GEOE 461/561 Petroleum Drilling and Production Engineering

Credits: (3-0) 3

Introduction to engineering principles of modern oil and gas well drilling and production engineering. Drilling topics include design of oil or gas well drilling operations (including horizontal and casing drilling), interpretation of well bore and formation properties, casing design and cementing, and well completion design. Production topics include well in-flow performance, wellbore damage characterization, acidizing and hydraulic fracturing (simulation) are discussed. Reservoir engineering topics include computer-aided design for downhole pressure, single and multi-phase flow measurements, physical modeling of oil production, and permeability testing. Global oil production and societal implications will be emphasized.

Notes: A minimum grade of "C" is required for graduation with a Geological Engineering B.S. Students enrolled in GEOE 561 will be held to a higher standard than those students enrolled in GEOE 461.

GEOE 464 Geological Engineering Design Project I

Credits: (3-0) 3

Independent engineering design work by students on a comprehensive geological engineering project that integrates 1) groundwater and 2) fuels or minerals. Economic and legal constraints, environmental concerns, safety, and aesthetic considerations will be included. Engineering reports (oral and written) with analysis, specifications, and results are required.

Prerequisites: EM 331 , GEOL 331/331L, and GEOL 322/322L
Pre or Corequisites: GEOE 475/475L
Notes: A minimum grade of "C" is required for graduation with a Geological Engineering B.S.

GEOE 465 Geological Engineering Design Project II

Credits: (3-0) 3

Independent engineering design work by students on a comprehensive geological engineering project that integrates 1) environmental site planning and natural hazards and 2) geomechanics and geotechnics. Economic and legal constraints, environmental concerns, safety, and aesthetic considerations will be included. Engineering reports (oral and written) with analysis, specifications, and results are required.

Prerequisites: GEOL 331/331L and CEE 346/346L
Pre or Corequisites: GEOL 322/322L and GEOE 324/324L
Notes: A minimum grade of "C" is required for graduation with a Geological Engineering B.S.

GEOE 466/466L/566/566L Engineering and Environmental Geology/Lab

Credits: (2-1) 3

The application of geology to engineering, including topics such as landslides, earthquakes, fluvial processes, land subsidence, and their global context. Field trips and laboratory exercises illustrate the influence of geology on the environment. Computer applications are required for problem assignments and a final comprehensive report (oral and written) involving the design of engineering works in complex geological terrain.

Prerequisites: Junior or senior standing.
Corequisites: GEOE 466L or GEOE 566L
Notes: Students enrolled in GEOE 566/566L will be held to a higher standard than those enrolled in GEOE 466/466L. A minimum grade of "C" is required for graduation with a Geological Engineering B.S.

GEOE 467/567 Introduction to Geomechanics

Credits: (3-0) 3

An introduction to topics relevant to rock fracture as it pertains to geological engineering. This includes discussion of stress and strain, properties and classification of continuous and discontinuous rock masses, and discussion of rock fracture mechanisms.

Notes: Students enrolled in GEOE 567 will be held to a higher standard than those enrolled in GEOE 467.

GEOE 468/468L/568/568L Geohazards/Lab

Credits: (2-1) 3

A comprehensive analysis of the mechanisms behind geologic processes that affect the human environment in catastrophic ways. Topics include earthquake and volcanic hazards, mass movements, and land subsidence. Assignments, labs, and final projects will focus on rigorous analyses using common industry-utilized software packages to monitor and mitigate these hazards. Field experiences will allow students to apply the principles discussed to real-world situations.

Prerequisites: CEE 346/346L or permission of instructor.
Corequisites: GEOE 468L or GEOE 568L
Notes: Students enrolled in GEOE 568/568L will be held to a higher standard than those enrolled in GEOE 468/468L.

GEOE 475/475L Groundwater/Lab

Credits: (2-1) 3

Geohydrologic principles, applications, and design considerations concerning groundwater occurrence, flow, and quality. Groundwater and surface-water relations; theory of aquifer tests; flow nets; head distribution by graphical, analytical, and digital models; groundwater contamination. Laboratories include water budgets, chemistry of groundwater, design of exploration programs and aquifer tests, computer solutions, and field trips to areas of geohydrologic interest. A design project with written and oral presentations is required.

Prerequisites: GEOL 201 or GEOE 221/221L, and MATH 125
Corequisites: GEOE 475L
Notes: This course is cross listed with CEE 475/475L. A minimum grade of "C" is required for graduation with a Geological Engineering B.S.

GEOE 482/482L/582/582L Applied Geomorphology/Lab

Credits: (3-0) 3

A systematic analysis of landform evolution with emphasis on process and terrain analysis. Topics include process-response in geomorphic systems and quantitative techniques used in engineering design applications. Laboratory consists of aerial photos, topographic map interpretation and the application of geomorphology as an engineering tool. Field trips taken to regional areas of interest. Computer solutions in engineering analysis and a design project are required.

Prerequisites: GEOL 201 or GEOE 221/221L
Corequisites: GEOE 482L, GEOE 582L
Pre or Corequisites: GEOL 322/322L
Notes: Students enrolled in GEOE 582/582L will be held to a higher standard than those enrolled in GEOE 482/482L.

GEOE 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 3 credit hours. Research findings are required.

GEOE 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A description of the work to be performed must be filed in the Department of Geology and Geological Engineering.

GEOE 615 Advanced Field Methods in Groundwater

Credits: (0-3) 3

Advanced instruction and independent work involving field techniques such as aquifer mapping, water quality sampling and interpretation, piezometer tests, and the design, conduct, and analysis of aquifer

tests.

Prerequisites: GEOE 475/475L or equivalent.

GEOE 641 Geochemistry

Credits: (3-0) 3

Geochemical principles, applications, and design considerations, including thermodynamics, kinetics, and transport phenomena. Applications in low-temperature aqueous systems, carbonate equilibria, geothermal and hydrothermal systems, petroleum generation, metamorphism, and igneous processes. Computer solutions to geochemical problems will be used. An engineering design project is required.

GEOE 663/663L Groundwater Geochemistry/Lab

Credits: (2-1) 3

A study of the natural chemistry of groundwater and the effects of man's activities on groundwater quality. Laboratories include dispersion experiments and several field trips to areas of interest relating to groundwater geochemistry.

Prerequisites: GEOE 475/475L or equivalent.
Corequisites: GEOE 663L

GEOE 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: A description of the work to be performed must be filed in the Department of Geology and Geological Engineering.

GEOE 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a

specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A description of the work to be performed must be filed in the Department of Geology and Geological Engineering.

GEOE 700 Developing and Planning Research

Credits: (1-0) 1

An overview of research proposal writing and presentation as well as responsible research conduct in the geosciences and engineering. Students will produce a preliminary thesis/dissertation proposal, peer review the proposals of fellow students, and prepare a proposal presentation on a selected research question.

Notes: This course is cross-listed with GEOL 700 and MEM 700.

GEOE 711 Synthetic Aperture Radar Interferometry

Credits: (3-0) 3

Application of Interferometric Synthetic Aperture Radar (InSAR) as a tool used to measure ground surface displacements resulting from both natural and anthropogenic sources. The course will cover the history of radar imagery acquisition, InSAR theory and limitations, InSAR processing methodology, and post-processing techniques.

GEOE 762 Analytical Methods in Groundwater

Credits: (3-0) 3

Quantitative methods used to evaluate groundwater resources, including pumping tests as well as physical and computer methods.

Prerequisites: GEOE 475/475L or equivalent.

GEOE 764/764L Advanced Groundwater/Lab

Credits: (2-1) 3

Basic hydrologic principles with emphasis on hydrologic and geologic interrelationships. Design problems of location, development, and conservation of groundwater. Use of quantitative techniques for aquifer evaluations. Studies of groundwater contamination. Laboratories, field trips, and problem

assignments require use of analytical methods.

Prerequisites: GEOL 201 or GEOE 221/221L or equivalent.
Corequisites: GEOE 664L

GEOE 766/766L Applied Groundwater Flow and Transport Modeling/Lab

Credits: (2-1) 3

Practical applications of digital models as tools in the study of groundwater flow systems. Methods of simulating aquifer systems and solute transport will be used. Specific emphasis will be placed on the development, application, and limitations of finite-difference and finite-element computer models.

Prerequisites: GEOE 475/475L or CEE 634, or equivalent.
Corequisites: GEOE 766L

GEOE 768 Engineering Geology of Surficial Deposits

Credits: (3-0) 3

Review of weathering, soils, and Quaternary deposits. Emphasis on engineering design problems such as those found in highway construction, landfills, water supply, waste disposal, landslides, and land subsidence. Engineering geology of surficial deposits including alluvium, loess, clay, and glacial and periglacial deposits. Two field trips are required.

GEOE 782/782L Fluvial Processes/Lab

Credits: (2-1) 3

A systematic study of watershed evolution and the development and function of the attendant stream composition. Emphasis is placed on morphometry, quasi-equilibrium, classification, fluvial mechanics, fluvial landforms, and stream restoration technology. Study and discussion of current literature will focus on process and results. Students will partake in lecture presentation of specified topics.

Corequisites: GEOE 782L

GEOE 790 Seminar

Credits: (1-0) 1

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over

electronic media such as internet and are at the upper division graduate levels.

Notes: May be repeated once for degree credit. GEOE 790 is cross-listed with CEE 790, GEOL 790, MES 790/890, AES 790.

GEOE 798 Thesis

Credits: 1 to 9

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. thesis option.

GEOE 898 Dissertation

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee. Oral defense of dissertation and research findings are required.

Notes: Credit to be arranged; not to exceed 36 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates.

GEOL 451/451L Economic Geology/Lab

Credits: (2-1) 3

Study of the economics and distribution of mineral resources, geologic characteristics and origins of metallic ore deposits, and the application of genetic models, geochemical techniques, and geophysical methods to the design of mineral exploration programs. Laboratory work includes ore mineralogy and textures, sample suites from ore deposits, calculation of ore reserves (manual and computer), and design and implementation of exploration programs (computer exercises). A term paper is required on the design of exploration programs. Field trips are arranged to nearby ore deposits.

Prerequisites: Junior or senior standing.
Pre or Corequisites: GEOL 322/322L

Geography

GEOG 101 Introduction to Geography

Credits: (3-0) 3

The course presents a broad, introductory overview of geographic concepts, themes, and elements designed to help students better understand and analyze the world from a geographic perspective. It provides a background to earth's physical and human elements and systems. It also emphasizes the unique quality of world regions, and the spatial interaction of people, elements, and regions, as well as major global and regional problems and prospects.

GEOG 200 Introduction to Human Geography

Credits: (3-0) 3

Systematic study of world culture from the perspective of five integrating themes: culture region, cultural diffusion, cultural ecology, cultural integration, and cultural landscape. Topics include population, agriculture, political and economic systems, religion and language, folk and popular culture, and ethnicity.

GEOG 210 World Regional Geography

Credits: (3-0) 3

A survey of the earth from a broad global framework through the differentiation of the world in terms of both natural and human environmental features and characteristics on a regional basis.

GEOG 212 Geography of North America

Credits: (3-0) 3

A regional and topical analysis of the geographic patterns of the United States and Canada. Focus is upon the interaction of groups of people with the natural environment to produce regional differentiation. Geographic aspects of the physical geography, population, culture groups, economy, settlement systems, land division, and use of natural resources.

GEOG 400 Cultural Geography

Credits: (3-0) 3

A detailed analysis of the concept of culture in a geographical context, including such applications as

culture and nature, cultural growth and change, cultural universals, culture and economy, cultural relativity, cultural landscape, culture region, and cultural conflict.

GEOG 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum.

Notes: A maximum of 6 credits will be for degree credit.

Geology

GEOL 110 Explorations in Geology

Credits: (2-0) 2

In this course, students will study the relationships between science and society as exemplified by the sub-disciplines of geology, practice hypothesis testing and computational analyses in the geosciences, and receive an introduction to the Geology B.S. program.

GEOL 201 Physical Geology

Credits: (3-0) 3

Basic concepts in the study of the earth and its history. Brief introduction of the earth's place in the universe and solar system and the evolution, composition and structure of the earth. Introduction to minerals, and igneous, sedimentary and metamorphic rocks. Survey of geological processes acting at the surface of earth such as wind, rivers, glaciers, ground water, and the sea; introduction to internal processes regarding plate tectonics theory and growth of mountains. Societal implications of geological processes are emphasized throughout the course.

Notes: Students taking GEOL 201L should take it concurrently with GEOL 201.

GEOL 201L Physical Geology Laboratory

Credits: (0-1) 1

Classification and identification of the important rocks and minerals. Interpretation of topographic and geologic maps. Field trips to view representative rock types of the Black Hills area.

Pre or Corequisites: GEOL 201

GEOL 212/212L Mineralogy and Crystallography/Lab

Credits: (2-1) 3

A study of morphological and geometrical crystallography followed by determinative mineralogy. The 32 crystal classes and about 120 minerals are studied in detail. Course includes a brief introduction to optical microscopy. Emphasis in the laboratory is directed toward descriptive and determinative mineralogy.

Corequisites: GEOL 212L
Pre or Corequisites: CHEM 112; and GEOL 201/GEOL 201L or GEOE 221/221L
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 322/322L Structural Geology/Lab

Credits: (2-1) 3

A study of the character and genesis of large-scale and small-scale deformation structures and their patterns in the earth's crust. Laboratory work includes various trigonometric, geometric, and stereographic methods applicable to structural analysis and presents open-ended problems in geologic, structure contour, and isopach map interpretation.

Prerequisites: GEOL 331/331L and GEOL 341/341L;or MEM 314/314L
Corequisites: GEOE 322L
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 323 Search for Our Past

Credits: (3-0) 3

Study of the geologic history of North America. The formation and early history of the earth, the tectonic evolution of the continents, and the history of evolution of life are studied. Current scientific issues regarding tectonics and the biosphere are also discussed, such as evolutionary theory, the Gaia hypothesis, and biocomplexity.

Prerequisites: GEOL 201 or GEOE 221/221L
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 331/331L Stratigraphy and Sedimentation/Lab

Credits: (2-1) 3

The principles of correlation and sediment analysis are discussed. A background in sedimentary source materials, depositional environments, nomenclature and classification of stratigraphic units, and the interpretation of stratigraphic units will be presented. Emphasis is placed on modern depositional systems and their ancient counterparts. Laboratory exercises stress field trips to local sections, facies descriptions, rock analysis, and interpretation of an exploration prospect.

Prerequisites: GEOL 201 /GEOL 201L or GEOE 221/221L or permission of instructor.
Corequisites: GEOL 331L
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 341/341L Igneous and Metamorphic Petrology/Lab

Credits: (2-1) 3

Identification and classification of igneous and metamorphic rocks in hand sample and thin section. Emphasis is on environments of formation as deduced from textures and structures. Lecture, laboratory, and field trips.

Prerequisites: GEOL 212/212L
Corequisites: GEOL 341L
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 351 Earth Resources and the Environment

Credits: (3-0) 3

This course will examine the distribution, origin, use, and future of earth's energy, metallic, and non-metallic resources. Economic, political, sociological, and environmental implications of the resource industries will be emphasized. Resource issues of topical interest will be discussed.

Prerequisites: GEOL 201 or GEOE 221/221L or permission of instructor.

GEOL 361 Oceanography I

Credits: (3-0) 3

An introductory course in oceanography that focuses on ocean basins of the world, their composition and processes by which they formed. Other subjects to be examined include the "hot springs" of the deep oceans, patterns of sediment distribution, life in the oceans, the role of the oceans as an integral part of global climatic cycles including the "greenhouse effect."

GEOL 372 Dinosaurs

Credits: (3-0) 3

An in-depth introduction to dinosaur paleontology. This course will utilize geologic and biologic principles to foster a comprehension of dinosaur systematics, phylogeny, biology, and evolution. Dinosaurs will also be used as a focus to examine the scientific method, critical thinking, and the public perception of science.

GEOL 403/503 Regional Field Geology

Credits: (0-1) 1

A one-week guided field trip to an area of outstanding geologic interest in a global context.

Prerequisites: GEOL 201 or GEOE 221/221L
Notes: Students enrolled in GEOL 503 will be held to a higher standard than those enrolled in GEOL 403.

GEOL 410 Field Geology

Credits: (0-6) 6

This five-week course focuses on the instruction and practice in the use of surveying instruments and aerial photographs for the purpose of completing small and intermediate-scale geologic maps, structure sections, and structure contour maps of Precambrian matasediments, Phanerozoic sedimentary rocks, and Tertiary intrusions within designated areas of the Black Hills region. A written geologic report will accompany the maps and sections conducted for five weeks during the summer in the northern Black Hills. Field equipment will be furnished by the department. Arrangements for transportation, room and board are made through the Black Hills Natural Sciences Field Station.

Prerequisites: GEOL 322/322L or permission of instructor
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 412/512 Science and Engineering Field Applications

Credits: 3 to 6

Field course offered by Black Hills Natural Sciences Field Station to accommodate field education needs of scientists and engineers in multiple disciplines such as geology, geological engineering, petroleum engineering, environmental engineering, etc. Course offerings will take place in the summer months, and content of each camp will be defined by staff from the School of Mines Department of Geology and Geological Engineering.

Prerequisites: Permission of instructor.

Notes: Students enrolled in GEOL 512 will be held to a higher standard than those enrolled in GEOL 412. This course is cross listed with GEOE 412/512.

GEOL 416/416L/516/516L Introduction to GIS/Lab

Credits: (2-1) 3

Introduction to principles and applications of geographic information systems (GIS) including data management and analysis. Laboratory work will include introduction to PC-based GIS software and data sets. Students are expected to have basic computer system, word processing, and spreadsheet skills prior to taking this class.

Corequisites: GEOL 416L or GEOL 516L
Notes: Students enrolled in GEOL 516 will be held to a higher standard than those enrolled in GEOL 416. A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 417/517 Geospatial Databases

Credits: (3-0) 3

Building on basic principles of Geographic Information Systems, this course launches students into developing geospatial databases for research projects in science and engineering. Students learn to compile and manage spatial data using industry standard models. Assignments include hands-on practice downloading, processing, editing, scanning, and digitizing data. The class includes an extensive introduction to the software documentation to build independent learning and problem-solving ability. Students are expected to complete a semester project that relates to their own interests.

Prerequisites: GEOL 416/416L/516/516L or permission of instructor.
Notes: Students enrolled in GEOL 517 will be held to a higher standard than those enrolled in GEOL 417.

GEOL 419/519 Advanced Geospatial Analysis

Credits: (3-0) 3

This course will introduce those already familiar with GIS and basic statistical principles to advanced spatial analysis techniques including interpolation, sampling, spatial distributions, surface analysis, and geospatial modeling. Emphasis is placed on developing the knowledge to effectively and soundly employ geospatial analysis techniques in a variety of applications.

Prerequisites: GEOL 416/416L/516/516L or permission of instructor.
Notes: Students enrolled in GEOL 519 will be held to a higher standard than those enrolled in GEOL 419.

GEOL 420/520 Introduction to Remote Sensing

Credits: (3-0) 3

An introduction to the theory and applications of remote sensing. Students will study the electromagnetic spectrum as it applies to remote sensing as well as the physical principles of imaging system technologies. Imaging and applications of visible, near-infrared, thermal infrared, and microwave band remote sensing are discussed. Environmental remote sensing applications to be covered include terrestrial and ocean ecology, resource exploration, land use and land cover change, natural hazards, and atmospheric constituents. Image processing techniques will be introduced.

Prerequisites: Junior standing.
Notes: Students enrolled in GEOL 520 will be held to a higher standard than those enrolled in GEOL 420.

GEOL 422/422L/522/522L Tectonics and Sedimentary Basin Analysis/Lab

Credits: (2-1) 3

Investigation of different types of sedimentary basins within their tectonic settings. Basin analysis studies involve multidisciplinary research using techniques and fundamentals of sedimentology, structural geology, petrography and petrology, and geomorphology. This course provides perspective on the main tectonic factors controlling overall basin evolution. The content and in-class discussions help students learn applications of basin analysis in industry and academic research.

Prerequisites: GEOL 322/322L and GEOL 331/331L, or permission of instructor
Corequisites: GEOL 422L/522L
Notes: Students enrolled in GEOL 522/522L will be held to a higher standard than those enrolled in GEOL 422/422L.

GEOL 442/442L/542/542L Optical Petrology/Lab

Credits: (2-1) 3

The study of igneous, sedimentary, and metamorphic rocks and ore samples in thin and polished section, with emphasis on their identification, classification, and genesis.

Prerequisites: GEOL 341/341L or MEM 314/314L
Corequisites: GEOL 442L or GEOL 542L
Notes: Students enrolled in GEOL 542 will be held to a higher standard than those enrolled in GEOL 442.

GEOL 450 Fluid and Thermal Diffusion

Credits: (3-0) 3

Quantitative techniques to describe the occurrence, flow, and implications of fluids and heat in the crust. Topics include: characterization of fluid and thermal systems; derivation of governing equations; boundary value problems; poroelastic theory; earthquake coupling and induced seismicity; heat transfer, hydrothermal systems; and numerical methods including finite difference, finite element, and matrix methods.

Prerequisites: GEOL 201 or GEOE 221/221L ; MATH 125 or equivalent; PHYS 213/213-A or equivalent; CSC 111/111L or CSC 170/170L or equivalent; or permission of instructor

GEOL 461/461L Invertebrate Paleontology/Lab

Credits: (2-1) 3

A systematic study of the structure and classification of selected invertebrate taxa. The course will provide a useful tool for field and laboratory work involving fossil-bearing rocks and will form a background for advanced work in paleontology or paleontological stratigraphy.

Corequisites: GEOL 461L
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 464 Senior Research I

Credits: (0-1) 1

A study of scientific research methodology with emphasis on identifying research problems and formulating a methodology to address a specific research question. Students will identify a topic of study chosen with the advice and approval of an instructor, and develop a proposal for their senior research project.

Prerequisites: GEOL 322/322L
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 465 Senior Research II

Credits: (0-3) 3

The student undertakes a field and/or laboratory study of a topic chosen with the advice and approval of an instructor. This work is basis for a thesis written in a standard format.

Prerequisites: GEOL 464 with a minimum grade of "B," and permission of instructor.
Notes: A grade of "C" or better is required for graduation with a Geology B.S.

GEOL 471/571 Field Paleontology

Credits: (0-2) 2

A field-oriented course, conducted at various fossil localities, stressing collection and detailed documentation of fossils for exhibition and research. Course may be repeated as needed for additional graduate credit requirements, but repeat registration must be taken at a different field site than previous registrations.

Notes: Students enrolled in GEOL 571 will be held to a higher standard than those enrolled in GEOL 471.

GEOL 472/472L/572/572L Museum Collections Management/Lab

Credits: (2-1) 3

This course focuses on the ethics, theories, and methodologies of museum collections management, including specimen/object preparation, curation and conservation. The laboratory provides practical, hands-on training in preparing and documenting museum collections. Students will be required to design and complete a collections management project.

Corequisites: GEOL 472L or GEOL 572L
Notes: Students enrolled in GEOL 572 will be held to a higher standard than those enrolled in GEOL 472.

GEOL 473/473L/573/573L Museum Exhibit Design/Lab

Credits: (2-1) 3

This course focuses on museum exhibit research, design, documentation, presentation and implementation, with an emphasis on exhibit planning and evaluation. Students will be required to bring a real-time museum exhibit project to completion.

Corequisites: GEOL 473L or GEOL 573L
Notes: Students enrolled in GEOL 573 will be held to a higher standard than those enrolled in GEOL 473.

GEOL 474/574 Paleontological Resource Management

Credits: (3-0) 3

This course is designed to provide intensive background and professional training for resource management work in the paleontological and geological sciences, with a focus on Federal and state land management agency issues. Topics include analysis of applicable laws and regulations, understanding standards and compliance requirements, managing permits and reports, managing repositories for

Federal and state earth science collections and archives, and learning formal monitoring and mitigation procedures for managing paleontological resources affected by highway, pipeline, and other construction efforts.

Notes: Students enrolled in GEOL 574 will be held to a higher standard than those enrolled in GEOL 474.

GEOL 475/475L/575/575L Vertebrate Fossil Preparation and Conservation

Credits: (2-1) 3

In this course, students will learn the basic techniques, tools, and equipment maintenance needed for preparation of vertebrate fossil material and develop a thorough understanding of the importance of fossil conservation. The laboratory portion of the course will enable students to have hands-on experience applying various conservation methods and techniques to fossil specimens.

GEOL 476/576 Petroleum Geology

Credits: (3-0) 3

Petroleum source rocks, hydrocarbon generations and migration, reservoir properties, traps and seals, and subsurface fluids and conditions are covered. Petroleum exploration methods, major oil-producing sedimentary basins, and unconventional hydrocarbon resources also are addressed. Data from well drilling and testing, evaluation of well logs and other subsurface data, and computer software are incorporated into course assignments.

Prerequisites: GEOL 331/331L or permission of instructor.
Pre or Corequisites: GEOL 322/322L or permission of instructor.
Notes: Students enrolled in GEOL 576 will be held to a higher standard than those enrolled in GEOL 476.

GEOL 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 3 credit hours.

GEOL 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

GEOL 604 Advanced Field Geology

Credits: (0-3) 3

Field techniques and related laboratory methods of investigation in moderately complicated geologic environments. Includes data collection, presentation, and interpretation. Laboratory work involving aerial photographs, drilling projects, and miscellaneous work may be introduced during inclement weather in December.

Prerequisites: GEOL 410

GEOL 621/621L Advanced Structural Geology/Lab

Credits: (2-1) 3

Examination of selected geologic terrains such as fold-thrust belts, Laramide foreland uplifts and basins, wrench and rift systems, etc., concentration on geometric styles, sequential and mechanical development and regional models. Includes selected readings and laboratory examinations of maps regarding the various types of terrains.

Prerequisites: GEOL 322/322L or permission of instructor.
Corequisites: GEOL-621L

GEOL 622 Geotectonics

Credits: (3-0) 3

The course examines development of regional and world-wide structures of the earth in regard to plate tectonic processes and current thought regarding concepts of sea-floor spreading, continental drift, paleomagnetism, origin of continents, ocean basins, and mountain building.

GEOL 632 Rocky Mountain Stratigraphy

Credits: (3-0) 3

Stratigraphic sequences in the Rocky Mountain area are studied with emphasis on the paleoenvironmental and tectonic conditions under which the strata were deposited. First semester considers Paleozoic strata; the second semester considers Mesozoic and Cenozoic rocks.

Prerequisites: Senior or graduate standing in geology or geological engineering.

GEOL 633/633L Sedimentation/Lab

Credits: (2-1) 3

Sedimentary process-response models are studied. The procedures for classification and description of sedimentary rocks are reviewed. Numerous field trips to localities illustrating a variety of sedimentary facies are conducted. Laboratory determinations are made of such parameters of sedimentary particles as size, shape and degree of roundness, mineralogy and chemical composition. An analysis is made of field and laboratory data by graphical and statistical methods and a geological interpretation is made of the results. Natural resources associated with various facies are emphasized.

Corequisites: GEOL 633L

GEOL 644/644L Petrology of the Igneous and Metamorphic Rocks/Lab

Credits: (2-1) 3

This course will emphasize phase diagrams, phase equilibria, and geochemistry of igneous and metamorphic rocks from the standpoint of constraining evolutionary models. Problems will involve quantitative modeling of natural samples using field observations, petrographic observations, mineral chemistry, and whole rock chemistry. Field trips are planned.

Prerequisites: GEOL 542/542L or permission of instructor.
Corequisites: GEO 644L

GEOL 650 Seminar in Ore Deposits

Credits: 1 to 3

Studies by a group of advanced students, under the guidance of one or more selected instructors, of topics of special and current interest to the group. Involves a combination of lectures, papers, readings, oral and/or written presentations, and discussions. Course focuses on different themes in ore deposits, and varies each time offered. Themes that will be offered include such topics as the geology of gold deposits, uranium deposits, porphyry copper deposits, volcanogenic massive sulfides, and sediment-hosted metal deposits. Emphasis is placed on gaining an in-depth knowledge on the controls of

localization of a specific class of mineral deposits.

Prerequisites: GEOL 451/451L or permission of instructor.

GEOL 652 Problems in Ore Deposits

Credits: (3-0) 3

Emphasis is placed on the principles of hydrothermal ore deposits, and techniques used to study hydrothermal ore deposits. Modern theories on metallic ore deposition will be applied to the critical study of major classes of metallic ore deposits.

Prerequisites: GEOL 451/451L or permission of instructor.

GEOL 656L Scanning Electron Microscopy

Credits: (0-1) 1

A practical introduction to the use of the scanning electron microscope for geologists, paleontologists, and materials scientists and engineers.

GEOL 672/672L Micropaleontology/Lab

Credits: (2-1) 3

A study of the morphology, ecology, and stratigraphic significance of selected groups of protozoans and invertebrate and plant microfossils with special emphasis on Foraminifera and conodonts.

Corequisites: GEO 672L
Notes: This course is cross listed with PALE 672/672L.

GEOL 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: A description of the work to be performed must be filed in the Department of Geology and Geological Engineering.

GEOL 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A description of the work to be performed must be filed in the Department of Geology and Geological Engineering.

GEOL 700 Developing and Planning Research

Credits: (1-0) 1

An overview of research proposal writing and presentation as well as responsible research conduct in the geosciences and engineering. Students will produce a preliminary thesis/dissertation proposal, peer review the proposals of fellow students, and prepare a proposal presentation on a selected research question.

Notes: This course is cross-listed with GEOE 700 and MEM 700.

GEOL 725 Geodynamics

Credits: (3-0) 3

Quantitative expressions for quasi-static geophysical processes, in the context of the Plate Tectonics paradigm. Topics include: boundary value problems, elastic and viscoelastic mechanics; heat conduction and thermoelastic mechanics; and fluid migration and poroelastic mechanics.

Prerequisites: MATH 125 or equivalent and PHYS 213/213-A or equivalent, or permission of instructor.

GEOL 728 Linear Inverse Methods in Geology

Credits: (3-0) 3

Theory and applications of linear inverse methods to quantitatively interpret geologic data. Topics include: model design; matrix assembly, operations, and inverse methods; parameter estimation, uncertainty, and resolution.

Prerequisites: MATH 125 or equivalent and CSC 111/111L or equivalent, or permission of instructor.

GEOL 771/771L Paleobiology/Lab

Credits: (3-1) 4

A detailed examination of the study of fossil organisms, including the use of biological and geological information to interpret the patterns and processes of past life. Emphasis will be placed on the diversity and evolution of fossil organisms and the methods by which paleontologists study them. Lab sessions will be devoted to study of the taxonomy and anatomy of pertinent groups of fossil organisms and their living relatives.

Corequisites: GEOL 771L

GEOL 772 Terrestrial Paleoecology

Credits: (2-0) 2

A study of the relationships between organisms and environment and biotic interactions as interpreted from the fossil record with particular emphasis on Mesozoic and Cenozoic terrestrial systems. Course will include the background and philosophy of paleoecological study, contemporary methods for ecological interpretation of fossil organisms and communities. Course format will consist of lecture, directed readings, and discussion.

GEOL 773 Quantitative Methods in Paleontology

Credits: (3-0) 3

The course will cover quantitative methods commonly used in paleoecological, morphometric, evolutionary, and paleoenvironmental studies. Students will learn to evaluate statistical methods for their appropriateness and conduct statistical analyses. Directed readings from the scientific literature will provide examples of these methods as they are used by the geoscience community.

GEOL 774 Paleoenvironments

Credits: (2-0) 2

Course will cover geochemical (stable isotope, trace element, REE) and biological (faunal, biomarker) proxies in used in paleoenvironmental and paleoclimatological studies in marine and terrestrial sedimentary environments. Students will learn the chemical/biological basis of each proxy, how to appropriately interpret the proxies, and what each proxy can reveal about past climates and environments. Format will be a mix of directed readings with discussion and short lectures.

GEOL 775/775L Phylogenetic Systematics/Lab

Credits: (3-1) 4

An overview of current methods and best practices for evaluating the systematic relationships of taxa and for testing hypotheses within a phylogenetic framework. Course also includes an overview of recent phylogenetic hypotheses of relationships within and among major clades. Laboratory will consist of directed examination of the morphological characters and phylogenetic hypotheses of specific clades.

Corequisites: GEOL 775L

GEOL 790 Seminar

Credits: (1-0) 1

A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division graduate levels.

Notes: May be repeated once for degree credit. GEOL 790 is cross-listed with CEE 790, GEOE 790, MES 790/890, AES 790.

GEOL 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursing the M.S. thesis option.

GEOL 808 Fundamental Problems in Engineering and Science

Credits: (3-0) 3

This course, available only for doctoral candidates, involves description, analysis, and proposed methods of attack of long-standing, fundamental problems in science and engineering. Independent work is emphasized with goals of understanding these basic questions and proposing practical designs and experiments for their solution.

Notes: This course is cross listed with AES 808 and CEE 808.

GEOL 898 Dissertation

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee. Oral defense of dissertation and research findings are required.

Notes: Credit to be arranged; not to exceed 30 credits towards fulfillment of Ph.D. degree requirements. Open only to doctoral candidates.

German

GER 101 Introductory German I

Credits: (4-0) 4

Becoming sensitized to authentic listening, speaking, reading, writing and culture skills at the elementary level. Introduction to basic functional grammar and sentence structure.

GER 102 Introductory German II

Credits: (4-0) 4

Continued emphasis on authentic listening, speaking, reading, writing, and culture skills at the elementary level.

Prerequisites: GER 101 or permission of instructor.

General Engineering and Science

GES 100 First Year Seminar

Credits: 1 to 3

Designed to engage students in their college experience, both academically and personally. The course aids students as they acquire and develop the skills necessary to reach their educational objectives. Through readings, discussions, reflective writing, and class activities, all of which illuminate a specific topic, students will practice skills that will enable them to succeed in their college courses. In addition, the class will help students acclimate to the university culture.

GES 115M University Mentoring

Credits: (0-0) 0

This course is designed to provide new college students the opportunity to learn how to succeed at the South Dakota School of Mines and Technology. Students will be introduced and matched to a professional mentor who will provide academic and career advice that will help ensure professional development. In addition, students will have the opportunity to learn from peer advisors who are successful upper-classmen in selected majors.

General Studies

GS 900 Visiting Scholars

Credits: (0-0) 0

A zero-credit tracking course used to identify participants in the Visiting Scholars Program.

History

HIST 121 Western Civilization I

Credits: (3-0) 3

Surveys the evolution of western civilization from its beginnings into the Reformation and religious wars.

HIST 122 Western Civilization II

Credits: (3-0) 3

Surveys the development of western civilization from the Reformation era to the present.

HIST 151 United States History I

Credits: (3-0) 3

Surveys the background and development of the United States from its colonial origins to the Civil War and Reconstruction.

HIST 152 United States History II

Credits: (3-0) 3

Surveys development of the United States since the Civil War and Reconstruction.

HIST 465 Westward Expansion of US

Credits: (3-0) 3

Examines the role of the West in American history from exploration and colonization to the closing of the frontier about 1900, emphasizing territorial expansion of the U.S. and various frontier developments, e.g. transportation, transformation of the wilderness into statehood, influence of the frontier in shaping the American character and the role of the West in shaping national policies.

HIST 492 Topics

Credits: 1 to 4

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated once for credit when the topic is different and with the permission of department head.

Humanities

HUM 100 Introduction to Humanities

Credits: (3-0) 3

This interdisciplinary course introduces students to humanistic knowledge, inquiry, and values by focusing on connections among humanities disciplines (such as art, languages, literature, music, philosophy, and religion).

HUM 200 Connections: Humanities & Technology

Credits: (3-0) 3

A thematic approach to human values stressing the relationship between technology and the humanities; traces the development and social impact of our major technologies.

HUM 291 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.

HUM 350 American Social History

Credits: (3-0) 3

A study of lives, customs, and beliefs of ordinary Americans, using fiction and nonfiction from various periods.

Prerequisites: Junior or senior standing.

HUM 375 Computers in Society

Credits: (3-0) 3

Examines the social impact of computers with emphasis on the development of computer establishment, the cultural blueprint being shaped for the future, and the question of values and social responsibility in personal, business, and governmental sectors.

Prerequisites: Junior or senior standing.

HUM 491 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.

HUM 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of special topics will be allowed for degree credit.

Industrial Engineering

IENG 215 Cost Estimating for Engineers I

Credits: (1-0) 1

This course covers the fundamentals of financial statements and analysis. Topics include the structure of accounts, the balance sheet, the income statement, changes in owner equity, statement of cash flows, and analysis of financial statements to determine the financial health of the business entity.

IENG 216 Cost Estimating for Engineers II

Credits: (1-0) 1

This course covers the fundamentals of building the operational budgets needed for modern industrial practice. Topics include sales forecasting, sales budget, production budget, material budget, direct labor budget, factory overhead, cost-of-goods sold, and budget variances.

Corequisites: MATH 123

IENG 217 Cost Estimating for Engineers III

Credits: (1-0) 1

This course covers the fundamentals of cost accounting and cost estimating. Topics include estimation of factory overhead, operation estimating, product estimating, job order costing, process costing, and activity based costing.

Prerequisites: MATH 123

IENG 241L Introduction to Quality Methods and Teaming

Credits: (0-2) 2

Quality improvement methods, team processes, and related ways of thinking are introduced. Students will be exposed to the data collection and analysis tools often used for quality improvement across multiple disciplines. Laboratory activities involve teams and team processes, data collection and analysis, and an introduction to statistical analysis.

IENG 248/248L Engineering Graphics and Computer Modeling

Credits: (1-1) 2

Introduction to graphical communication theory, including freehand sketching techniques, geometric construction, multi-view, pictorial, sectional and auxiliary view representation and dimensioning techniques. Practical application of theoretical concepts using solid modeling software to capture design intent, generate engineering drawings, and explore computer analyses of solid models for manufacturing purposes.

IENG 301 Basic Engineering Economics

Credits: (2-0) 2

Introduces the concepts of economic evaluation regarding capital investments, including the time value of money and income tax effects.

Prerequisites: Junior or higher standing preferred.
Notes: Graduation credit cannot be given for both IENG 301 and IENG 302.

IENG 302 Engineering Economics

Credits: (3-0) 3

Studies economic decision making regarding capital investment alternatives. Covers compound interest and depreciation models, replacement and procurement models. Analysis is made variously assuming certainty, risk and uncertainty.

Prerequisites: Junior or higher standing preferred.
Notes: Graduation credit cannot be given for both IENG 301 and IENG 302.

IENG 311/311L Work Methods and Measurements/Lab

Credits: (2-1) 3

This course presents the underlying theory and basic methodology for work methods and measurement techniques. Emphasis is placed on knowledge of the basis for selection of a technique appropriate for individual as related to the task to be performed.

Corequisites: IENG 311L
Pre or Corequisites: IENG 381 or MATH 381

IENG 321/321L Ergonomics/Human Factors Engineering/Lab

Credits: (2-1) 3

Topics covered include: engineering anthropometry, workplace design, biomechanical modeling, work kinesiology and musculoskeletal disorders, cognitive engineering, and office ergonomics.

Prerequisites: PSYC 101 or permission of instructor.
Corequisites: IENG 321L
Pre or Corequisites: MATH 281 or IENG 381/MATH 381 or permission of instructor.

IENG 331 Safety Engineering

Credits: (3-0) 3

Overview to the field of Safety Engineering emphasizing quantitative problem solving. Will draw on fundamental knowledge from the fields of chemistry, physics, mechanics, mathematics, and statistics. Contents: fundamental concepts and terminology, injury and accident statistics, ethics, certification, regulations, standards, hazards and their control, and management aspects.

Prerequisites: Junior or senior standing.

IENG 352 Creativity and Innovation

Credits: (1-0) 1

This course focuses on the Herrmann Whole Brain model and creative thinking to strengthen team processes and the tools necessary for product and process innovations. Students will receive an exposure to the whole brain model and to a variety of problems that will require more creative and innovative thought processes to solve the problem.

IENG 353 Commercialization of New Technology

Credits: (1-0) 1

This course provides the students with an understanding of the intellectual property considerations for new innovations as well as how to adapt new technologies for commercialization in the market place. Topics include patents, trademarks, copyrights, trade secrets, technology transfer, SBIR, and STTR. This course is required for the Technology Innovation certificate program.

IENG 354 Marketing Technology Innovations

Credits: (1-0) 1

This course introduces the student to the tools and strategies needed to understand the voice of the customer and provides the rudiments of a marketing plan for commercialization of new or innovative technologies. Topics include environmental analysis, diffusion of technology and innovations, early adopters, and market research strategies.

IENG 355 Financing Technology Innovations

Credits: (1-0) 1

Beginning with technology business forecasts, this course develops the sales budget, production budget, material budget, overhead expenses, and cash flow budgets in sequence. Proforma income and balance sheets are then derived from these budgets. Sources of capital during different stages of the technology life cycle are also covered. This course is required for the Technology Innovation certificate.

Prerequisites: IENG 215 and IENG 216 or ACCT 210 or ACCT 406 or ENGM 661

IENG 356 Technology Start Ups

Credits: (1-0) 1

This course presents timing and innovation to be considered during the early stages of the technology life cycle and provides the basis for the development of a business plan. Topics include technology and innovation strategies, dimensions of technological innovations, new technology ventures, corporate new ventures, organizational structures, and elements of a business plan.

IENG 362 Stochastic Models

Credits: (3-0) 3

This course covers stochastic models in operations research and is a complementary course to MATH

353. Topics include queuing theory, Markov chains, Pert/CPM, decision theory, dynamic programming and inventory control models.

Prerequisites: IENG 381 /MATH 381 or permission of instructor.

IENG 366 Engineering Management

Credits: (3-0) 3

A course designed to acquaint the student with engineering management discipline through the formation and operation of business and industrial enterprises. In addition to engineering management decision tools, students will be exposed to emergent trends in learning organizations, systems thinking, change management, and processes utilizing all four quadrants of Herrmann Whole Brain model for advanced problem solving.

IENG 381 Introduction to Probability and Statistics

Credits: (3-0) 3

Introduction to probability theory, discrete and continuous distributions, sampling distributions and the central limit theorem with general principles for statistical inference.

Prerequisites: MATH 125 with a "C" or better
Notes: This course is cross listed with MATH 381. Individuals may apply at most 4 credits toward a degree from the following lists of courses: MATH 281, IENG 381/MATH 381, MATH 442.

IENG 382 Probability Theory and Statistics II

Credits: (3-0) 3

Review of general principles for statistical inference, linear regression and correlation, multiple linear regression, ANOVA, and statistical design of experiments.

Prerequisites: IENG 381/MATH 381
Notes: This course is cross listed with MATH 382.

IENG 415/515 Decision Analysis

Credits: (3-0) 3

Introductory Decision Analysis techniques which include decision trees, SMART analysis (similar to decision matrices), utility functions, methods for eliciting probabilities, Bayes theorem, and resource negotiation problems.

Notes: Students enrolled in IENG 515 will be held to a higher standard than those enrolled in IENG 415.

IENG 425 Production and Operation Management

Credits: (3-0) 3

Management of the production environment. Topics such as bills of materials, inventory control, production control, production scheduling and MRP will be discussed. The impact of production management on the design process and how products can be designed for better manufacture.

Prerequisites: MATH 123; IENG 381/MATH 381 or BADM 221

IENG 431/531 Industrial Hygiene

Credits: (3-0) 3

Principles of industrial hygiene, including the identification and evaluation of chemical, physical, and biological agents which affect the health and safety of employees; the application of control measures for the various agents; and study of threshold limit values and occupational health toxicology.

Prerequisites: Senior or graduate standing or permission of instructor.
Notes: Students enrolled in IENG 531 will be held to a higher standard than those enrolled in IENG 431.

IENG 441 Simulation

Credits: (3-0) 3

Development of computer simulation models of real or conceptual systems. Interpretation of results of computer simulation experiments.

Prerequisites: IENG 381/MATH 381 or MATH 442

IENG 451/451L Operational Strategies/Lab

Credits: (2-1) 3

Review of philosophies, systems, and practices utilized by world-class organizations to meet current operational challenges. Focuses include “lean production” in the manufacturing industries, including material flow, plant-floor quality assurance, job design, work and management practices as well as the most effective practices in the service industries. Students complete lab projects and tour organizations

to analyze the extent and potential of the philosophies.

Prerequisites: Junior standing or permission of instructor.
Corequisites: IENG 451L

IENG 452 Introduction to Six Sigma

Credits: (1-0) 1

This course introduces students to the philosophy of Six Sigma. Topics include the history of Six Sigma and the Six Sigma problem solving methodology.

IENG 461 Six Sigma Greenbelt Exam

Credits: (1-0) 1

This self-paced, pass/fail course culminates in a written exam. Passing this exam is necessary component of the Six Sigma Greenbelt Certification.

IENG 462 Industrial and Engineering Management Profession

Credits: (1-0) 1

This course covers professional aspects of the industrial engineering and engineering management professions including personal, professional, and ethical development as well as professional practice.

Prerequisites: Senior standing or permission of instructor.

IENG 463 Six Sigma Greenbelt Project

Credits: (1-0) 1

Taken in conjunction with another course requiring a project, students in this course will use the Six Sigma problem solving philosophy in the completion of the project. Students will then document how they used the Six Sigma process and the results of the project in a written report.

IENG 464 Senior Design Project I

Credits: (0-2) 2

Small groups of students work on original design projects. Topics are solicited from local companies,

hospitals, banks, mines, government agencies, thus providing students the opportunity to apply their knowledge and techniques to real problems in business and industry.

Prerequisites: Senior standing or graduation within three semesters.

IENG 465 Senior Design Project II

Credits: (0-3) 3

Small groups of students work on original design projects. Topics are solicited from local companies, hospitals, banks, mines, government agencies, thus providing students the opportunity to apply their knowledge and techniques to real problems in business and industry. As applicable, these are continuation projects started in IENG 464.

Notes: Continuation of IENG 464.

IENG 466/566 Project Planning and Control

Credits: (3-0) 3

Project planning, execution and control of less repetitive types of work. This includes quantitative aspects such as costs, time and performance specifications; and qualitative aspects such as organization structures, psychological and sociological relationships.

Prerequisites: PSYC 101 preferred.
Notes: Students enrolled in IENG 566 will be held to a higher standard than those enrolled in IENG 466.

IENG 471 Facilities Planning

Credits: (3-0) 3

Topics covered include: material handling, computerized layout planning, storage facilities, flexible manufacturing systems, and "Factory of the Future."

Prerequisites: Senior standing or graduation within three semesters.

IENG 475/475L Computer-Controlled Manufacturing Systems and Robotics

Credits: (2-1) 3

Fundamental concepts of using computers in the design of a computer integrated, discrete-item, manufacturing facility are covered. Basic ideas of Computer Aided Design (CAD), Group Technology

(GT), process planning, integrated production control and computer numerical control are covered. The manufacturability issues and concepts of selecting and using robots in the workplace are explored.

Prerequisites: Senior standing or permission of instructor.
Corequisites: IENG 475L

IENG 479/579 Research Ethics

Credits: (1-0) 1

This course introduces students to the ethical and professional issues involved in performing research. Topics include: human and animal subjects, research review boards, fiscal responsibilities and audits, and dealing with research teams.

Notes: Students enrolled in IENG 579 will be held to a higher standard than those enrolled in IENG 479.

IENG 486 Statistical Quality and Process Control

Credits: (3-0) 3

This course covers the development of statistical methods for application to problems in quality and process control. Statistical topics include: basics of processes and variability, statistically controlled processes, variable and attribute control charts, moving averages, individual trend and others, process capability, sampling plans for attributes and variables.

Prerequisites: IENG 281/MATH 281 or MATH 442 or permission of instructor.
Notes: This course is cross listed with MATH 486.

IENG 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

IENG 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is no wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Interdisciplinary Sciences

IS 201 Introduction to Science, Technology, and Society

Credits: (3-0) 3

Includes study of current issues within the IS specializations. Introduces students to how science and technology affect individual, societal, and global change (e.g., how science and technology influence ethical choices, the political and economic systems, and the relationship between humans and the natural world.)

Prerequisites: ENGL 101 and sophomore standing.
Notes: Required for all students seeking a B.S. in Interdisciplinary Sciences. This course cannot be counted as social science/humanities credit.

IS 380 Internship in Interdisciplinary Studies

Credits: 1 to 4

The opportunity for a student to complete a plan for an internship and thereby acquire practical job-related experience.

Prerequisites: Permission of instructor.
Notes: A maximum of 6 credits will be allowed for degree credit. This course cannot be counted for social science/humanities credit.

IS 391 Independent Study

Credits: 1 to 3

Includes directed problems, readings directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: This course cannot be counted for social science/humanities credit.

IS 392 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is no wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits will be allowed for degree credit. This course cannot be counted for social science/humanities credit.

IS 396 Field Experience

Credits: (1-0) 1

Applied, monitored, and supervised field-based learning experience for which the student may or may not be paid. Students gain practical experience; they follow a negotiated and/or directed plan of study established by the student, instructor, and field-based supervisor. Due to the presence of a field experience supervisor, a lower level of supervision is provided by the instructor in these courses than is the case with an internship or practicum course.

Notes: This course cannot be counted for social science/humanities credit.

IS 401 Writing and Research in the Interdisciplinary Sciences

Credits: (3-0) 3

Advanced writing in the interdisciplinary sciences with emphasis on research and explanation of science topics in the IS specializations. This course provides students with a basic understanding of the various styles of science writing, including writing for popular and professional audiences, and the use of the library and/or laboratory research in formal research papers. This course is required for all students pursuing the B.S. degree in Interdisciplinary Sciences.

Prerequisites: IS 201, ENGL 289 and senior standing.
Notes: This course is required for all students pursuing the B.S. degree in Interdisciplinary Sciences. A minimum grade of "C" is required for enrollment in IS 498. This course cannot be counted as social science/humanities credit.

IS 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: This course cannot be counted for social science/humanities credit.

IS 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is no wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits will be allowed for degree credit. This course cannot be counted for social science/humanities credit.

IS 498 Undergraduate Research/Scholarship

Credits: (0-3) 3

Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Senior standing, permission of instructor, an approved Letter of Intent on file in the Interdisciplinary Sciences Office and successfully completion of IS 401 with a minimum grade of "C".
Notes: This course is required for all students pursuing the B.S. degree in Interdisciplinary Sciences. This course cannot count as social science/humanities credit.

Mathematics

MATH 021 Basic Algebra

Credits: (3-0) 3

This course prepares students for college level mathematics. Topics generally include: basic properties of real numbers, exponents & radicals, rectangular coordinate geometry, solutions to linear and

quadratic equations, inequalities, polynomials, and factoring. Students may also be introduced to functions and systems of equations.

Prerequisites: Appropriate mathematics placement.
Notes: This is a remedial level course and no credit for MATH 021 will be granted for graduation.

MATH 100 Math Recitation

Credits: 0

This course is a recitation for Math 120, Math 123 and Math 125 where students will spend additional time in small groups covering techniques and concepts related to Trigonometry, Calculus I and Calculus II.

Corequisites: Math 120, Math 123 or Math 125

MATH 101 Intermediate Algebra

Credits: (3-0) 3

Basic properties of real numbers, linear equations and inequalities, quadratic equations, systems of equations, polynomials and factoring, rational expressions and equations, and radical expressions and equations, and an introduction to functions such as polynomial, exponential and logarithmic functions.

Prerequisites: MATH 021 or appropriate mathematics placement.
Notes: May not be used for credit toward a baccalaureate degree, but may be used toward the associate degree.

MATH 102 College Algebra

Credits: (3-0) 3

Equations and inequalities; polynomial functions and graphs, exponents, radicals, binomial theorem, zeros of polynomials; systems of equations; exponential, logarithmic, and inverse functions, applications and graphs. Other topics selected from sequences, series, and complex numbers.

Prerequisites: MATH 101 with a minimum grade of "C" or appropriate mathematics placement.
Corequisites: MATH 102L
Notes: May not be used for credit toward an engineering or science degree (except for Interdisciplinary Sciences-Pre-Professional Health Science Specialization; Interdisciplinary Sciences-Science, Technology, and Society Specialization; chemistry; and associates of arts).

MATH 102L College Algebra Lab

Credits: (0-1) 1

Laboratory to accompany MATH 102.

Corequisites: MATH 102

MATH 110 Survey of Computer Science and Mathematics

Credits: (1-0) 1

This is an introductory course for incoming freshmen in Computer Science or Mathematics that provides a survey of the major areas in the profession along with ethical standards that are used. When applicable, guest lectures will be arranged to illuminate different areas of study.

Notes: This course is cross-listed with CSC 110.

MATH 115 Precalculus

Credits: (5-0) 5

A preparatory course for the calculus sequence. Topics include: polynomial, rational, exponential, logarithmic and trigonometric functions and their graphs; systems of equations, inequalities and complex numbers.

Prerequisites: MATH 101 with a minimum grade of "C" or appropriate mathematics placement.
Notes: May not be used for credit toward an engineering or science degree (except for Interdisciplinary Sciences-Pre-Professional Health Science Specialization; Interdisciplinary Sciences-Science, Technology, and Society Specialization; Chemistry; Associates of Arts).

MATH 120 Trigonometry

Credits: (3-0) 3

Topics include: trigonometric functions, equations, and identities; inverse trigonometric functions; exponential and logarithmic functions, and applications of these functions.

Prerequisites: MATH 102 with a minimum grade of "C" or appropriate mathematics placement.
Notes: May not be used for credit toward an engineering or science degree (except for Applied Biological Sciences, Interdisciplinary Sciences-Pre-Professional Health Science Specialization; Interdisciplinary Sciences-Science, Technology, and Society Specialization; Chemistry; and Associate of Arts).

MATH 123 Calculus I

Credits: (4-0) 4

The study of limits, continuity, derivatives, applications of the derivative, antiderivatives, the definite and indefinite integral, and the fundamental theorem of calculus.

Prerequisites: MATH 115 with a grade of "C" or appropriate mathematics placement or permission of instructor.
Notes: Students who are initially placed into MATH 102 or below must complete MATH 102 and MATH 120 with a minimum grade of "C" before enrolling in MATH 123. Students who are placed in MATH 120 should consult their advisor to determine whether their placement score was sufficiently high to allow concurrent registration in MATH 123.

MATH 125 Calculus II

Credits: (4-0) 4

A continuation of the study of calculus, including the study of sequences, series, polar coordinates, parametric equations, techniques of integration, applications of integration, indeterminate forms, and improper integrals.

Prerequisites: MATH 115 or MATH 120 with a minimum grade of "C" or appropriate score on departmental Trigonometry Placement Examination and MATH 123 with a minimum grade of "C".

MATH 205 Mining and Management Mathematics I

Credits: (2-0) 2

A survey of calculus in higher dimensions that includes an introduction to vectors, vector valued functions, and partial derivatives.

Prerequisites: MATH 125 with a minimum grade of "C" or permission of instructor.
Notes: This course may not be used for credit toward an engineering or science degree (except for Mining Engineering).

MATH 221 Introduction to Discrete Mathematics

Credits: (2-0) 2

The main purpose of this course is to provide background and experience on the structure of proofs. Topics may include: elementary logic; basic set theory; and sequences of summations, functions, matrices, and proof techniques.

Prerequisites: MATH 123 with a minimum grade of "C" or permission of instructor.

MATH 225 Calculus III

Credits: (4-0) 4

A continuation of the study of calculus, including an introduction to vectors, vector calculus, partial derivatives, and multiple integrals.

Prerequisites: MATH 125 with a minimum grade of "C".

MATH 281 Introduction to Statistics

Credits: (3-0) 3

A study of descriptive statistics including graphs, measures of central tendency and variability and an introduction to probability theory, sampling and techniques of statistical inference with an emphasis on statistical applications.

Prerequisites: MATH 102 or MATH 115
Notes: Individuals may apply for at most 4 credits toward a degree from the following list of courses: MATH 281, IENG 381/MATH 381, MATH 442.

MATH 291 Independent Study

Credits: 1 to 5

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 5 credit hours.

MATH 292 Topics

Credits: 1 to 5

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours.

MATH 315 Linear Algebra

Credits: (3-0) 3

Course topics include: the theory and applications of systems of linear equations, matrices, determinants, vector spaces, linear transformations and applications.

Prerequisites: MATH 225 or permission of instructor.

MATH 321 Differential Equations

Credits: (3-0) 3

Selected topics from ordinary differential equations including development and applications of first order, higher order linear and systems of linear equations, general solutions and solutions to initial-value problems using matrices. Additional topics may include Laplace transforms and power series solutions. In addition to analytical methods this course will also provide an introduction to numerical solution techniques.

Prerequisites: MATH 125 with a minimum grade of "C".
Notes: MATH 225 and MATH 321 may be taken concurrently or in either order.

MATH 353 Linear Optimization

Credits: (3-0) 3

Convex sets and functions, linear inequalities and combinatorial problems; topics in linear programming from fundamental theorems of simplex method through sensitivity analysis, duality, transportation and assignment problems.

Prerequisites: MATH 225 or permission of instructor.

MATH 373 Introduction to Numerical Analysis

Credits: (3-0) 3

This course is an introduction to numerical methods. Topics include elementary discussion of errors, polynomial interpolation, quadrature, non-linear equations, and systems of linear equations. The algorithmic approach and efficient use of the computer will be emphasized. Additional topics may include: calculation of eigenvalues and eigenvectors, numerical differentiation and integration, numerical solution of differential equations.

Prerequisites: MATH 321; and CSC 150/150L or CSC 170/170L or permission of instructor.

MATH 381 Introduction to Probability and Statistics

Credits: (3-0) 3

Introduction to probability theory, discrete and continuous distributions, sampling distributions and the central limit theorem with general principles for statistical inference and applications of random sampling to hypothesis testing, confidence limits, correlation, and regression.

Prerequisites: MATH 125 with a "C" or better
Notes: This course is cross listed with IENG 381. Individuals may apply at most 4 credits toward a degree from the following list of courses: MATH 281 , IENG 381 /MATH 381, MATH 442.

MATH 382 Probability Theory and Statistics II

Credits: (3-0) 3

Review of general principles of statistical inference, linear regression and correlation, multiple linear regression, ANOVA, and statistical design of experiments.

Prerequisites: MATH 381/IENG 381
Notes: This course is cross listed with IENG 382.

MATH 391 Independent Study

Credits: 1 to 5

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 5 credit hours.

MATH 392 Topics

Credits: 1 to 5

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours.

MATH 402 Communicating Mathematics

Credits: (1-0) 1

The student will produce a word-processed technical report of research conducted in MATH 498 and given a department colloquium talk summarizing her or his work. Department faculty member(s) will provide guidance in the production of the technical report and in the preparation for the colloquium talk.

Prerequisites: MATH 498

MATH 413 Abstract Algebra I

Credits: (3-0) 3

Introduction to the theory and applications of algebraic structures including groups, rings, and fields.

Prerequisites: MATH 225 and CSC 251 or MATH 225 and MATH 221

MATH 421 Complex Analysis

Credits: (3-0) 3

The algebra of complex numbers; complex functions; contour integration and Cauchy integral theorems; Taylor and Laurent series and the residue theorem; the evaluation of real definite integrals; elementary mapping problems.

Prerequisites: MATH 225

MATH 423 Advanced Calculus I

Credits: (4-0) 4

A theoretical treatment of calculus that covers: limits; continuity and differentiability of functions of a single variable.

Prerequisites: MATH 225 and CSC 251 or MATH 225 and MATH 221 or permission of instructor.

MATH 424 Advanced Calculus II

Credits: (4-0) 4

A continuation of MATH 423 that covers calculus of several variables; convergence of sequences and series; integration; and applications.

Prerequisites: MATH 423

MATH 432 Partial Differential Equations

Credits: (3-0) 3

Fourier series, partial differential equations, Frobenius series, Bessel functions, and transform methods.

Prerequisites: MATH 225 and MATH 321, both with a minimum grade of "C"

MATH 443/543 Data Analysis

Credits: (3-0) 3

Accessing, validating, processing, extracting, visualizing and presenting data. Exposure to managing data in a relational database management system. Looking for underlying structure in data using data reduction techniques (e.g., multidimensional scaling, principal components analysis) and, more generally, unsupervised learning techniques (e.g., clustering). Prediction using supervised learning techniques such as discriminant analysis, logistic regression and decision trees. Software may include R and some version of SQL.

Prerequisites: MATH 225 or permission of instructor.
Notes: Students enrolled in MATH 543 will be held to a higher standard than those enrolled in MATH 443.

MATH 447/547 Design of Experiments

Credits: (3-0) 3

Single and multifactor experiments, analysis of variance, factorial designs, the use of multiple regression, and response surface methodology. Topics may include nonparametric and permutation/randomization alternatives to the traditional parametric tests.

Prerequisites: MATH 381/IENG 381 with C or better
Notes: Students enrolled in MATH 547 will be held to a higher standard than those enrolled in MATH 447.

MATH 451/551 Math Modeling

Credits: (3-0) 3

The primary goal of this course is to present the mathematical formulation and analysis utilized in

scientific modeling. Applications from both science and engineering will be covered. The types of models will include deterministic and stochastic models. Topics may include: epidemiology, biomass, elasticity, heat flow, electrical circuits, mechanical vibrations and optimization.

Prerequisites: MATH 321 or permission of instructor.
Notes: Students enrolled in MATH 551 will be held to a higher standard than those enrolled in MATH 451.

MATH 452/552 Advanced Studies in Mathematics

Credits: (3-0) 3

This course is a capstone experience where students will enhance their mathematics background on selected topics. One of the goals of this course is to foster the ability to learn advanced mathematics and also learn to apply the use of technology in the study of mathematics.

Prerequisites: MATH 225 and MATH 321, or permission of instructor.
Notes: Students enrolled in MATH 552 will be held to a higher standard than those enrolled in MATH 452.

MATH 471 Numerical Analysis I

Credits: (3-0) 3

Analysis of rounding errors, numerical solutions of nonlinear equations, numerical differentiation, numerical integration, interpolation and approximation, numerical methods for solving linear systems.

Prerequisites: MATH 373 or CSC 372

MATH 486 Statistical Quality and Process Control

Credits: (3-0) 3

This course covers the development of statistical methods for application to problems in quality and process control. Statistical topics include: basics of processes and variability, statistically controlled processes, variable and attribute control charts, moving averages, individual trend and others, process capability, sampling plans for attributes and variables.

Prerequisites: IENG 381 /MATH 381 or MATH 442 or permission of instructor.
Notes: This course is cross listed with IENG 486.

MATH 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 3 credit hours.

MATH 492 Topics

Credits: 1 to 6

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours.

MATH 498 Undergraduate Research/Scholarship

Credits: (1-0) 1

Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: Permission of instructor.

MATH 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: May be repeated to a total of 6 credit hours. Students should have obtained permission of an instructor in the Department of Mathematics and Computer Science prior to registering for this course.

MATH 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated to a total of 6 credit hours.

Mechanical Engineering

ME 110/110L Introduction to Mechanical Engineering/Lab

Credits: (2-0) 2

A course for first-year mechanical engineering students that will provide an introduction to the mechanical engineering profession. Topics to be covered include: Problem solving, mechanical engineering fundamentals, engineering design, solid modeling, CAD, professional development, technical communication, and academic success skills.

Prerequisites: MATH 120 completed or concurrent
Corequisites: ME 110L

ME 125 Product Design and Development, Design for Manufacturing

Credits: (1-0) 1

Design for Manufacturability will teach design skills (solid modeling CAD and CAM) to improve the interface with manufacturing as well as the manufacturing skills required for departmental project builds. There is a strong emphasis on the connection between the design process and manufacturing with an end goal of concurrent engineering. Additionally there is exposure to corporate policy with an emphasis on safety.

Corequisites: ME 126L or ME 127L

ME 126L Product Design and Development, Design for Manufacturing Lab

Credits: (0-1) 1

The “hands on” companion to ME125 Design for Manufacturing. Initial 4 lab series includes woods, conventional machine shop, manual mill and manual lathe. Student will complete an individual design project and a group design project.

ME 127L Product Design and Development, Virtual Design for Manufacturing Lab

Credits: (0-1) 1

The "hands off" companion to ME125 Design for Manufacturing. Initial 4 lab series includes 3D printing, CNC machining, 2D graphic design and 3D graphic design. Student will complete an individual design project and a group design project.

ME 210 Statics of Mechanisms

Credits: (3-0) 3

This class will cover the following areas: fundamental treatment of forces and force systems; internal and external forces; support reactions; definition of a free-body diagram (FBD); emphasis on development of FBD-drawing skills; moment of a force; force system resultants; vector methods in two and three dimensions; equilibrium analysis of particles and rigid bodies; truss analysis by methods of joints and sections; analysis of simple machines; analysis of friction; centroids of composite areas and volumes; resultants of distributed loads.

Prerequisites: ME 110/110L.
Pre or Corequisites: PHYS 211/211-A.

ME 211 Introduction to Thermodynamics

Credits: (3-0) 3

An introduction to the basic concepts of energy conversion, including the first and second laws of thermodynamics, energy and entropy, work and heat, thermodynamic systems analysis, and the concepts of properties and state. Application of these fundamentals to energy conversion systems will be presented.

Prerequisites: MATH 125 and PHYS 211/211-A
Notes: A minimum grade of "C" is required for graduation.

ME 216 Introduction to Solid Mechanics

Credits: (3-0) 3

This course covers the fundamental concepts of solid mechanics including the definition of stress, transformations and states of stress; plane stress, plane strain, octahedral stresses, three dimensional stresses, and principal stresses in two and three dimensions. Additional topics include strain analysis, strain measurements and rosette analysis, generalized Hooks law, and orthotropic materials. Specific applications are an introduction to composite materials, analysis of thin and thick cylinders, statically indeterminate members, torsional loading of shafts, power transmission and the shaft analysis, torsional loads in non-circular components and thin tubes, stress concentrations, and combined loads.

Prerequisites: MATH 125, ME 210 with a minimum grade of "C", or permission of instructor

ME 221 Dynamics of Mechanisms

Credits: (3-0) 3

Brief review of dynamics of a particle. Kinetics and kinematics of two and three-dimensional mechanisms. Emphasis will include free body diagrams, vector methods, and various coordinate systems. Newton's law and energy methods will both be used.

Prerequisites: MATH 125; ME 210 or EM 214 either with minimum grade of "C", or permission of instructor
Notes: A minimum grade of "C" is required for graduation.

ME 264 Electromechanical Systems Product Development and Design

Credits: (2-0) 2

The course presents in a detailed fashion useful tools and structured methodologies that support the product development practice. Also, it attempts to develop in the students the necessary skills and attitudes required for successful product development in today's competitive marketplace. Each student brings his/her own background to the team effort and must learn to synthesize his/her perspective with those of the students on the team to develop a marketable product. An introduction to manufacturing aspects that must be taken into consideration during product development is provided in context of the project.

Prerequisites: ME 110/110L and sophomore standing.
Corequisites: ME 264L

ME 264L Electromechanical Systems Product Development and Design Lab

Credits: (0-2) 2

This course focuses on the design process including project management and teamwork; formal conceptual design methods; acquiring and processing information; design management tools; design for manufacturability, reliability, maintainability, sustainability; design communication: reports and presentations; ethics in design; prototyping designs; case studies. The cornerstone is a semester-long project in which small teams of students conceive, plan, and design a simple physical product.

Prerequisites: Sophomore standing.
Notes: This course is cross listed with EE 264L and CENG 264L.

ME 265/265L Product Design and Development- Introduction to Systems Engineering/Lab

Credits: (2-2) 4

The course presents useful tools and structured methodologies that support the product development practice and provides a brief introduction to selected systems engineering topics. In addition, it attempts to develop in the students the necessary skills and attitudes required for successful product development in today's competitive marketplace. The cornerstone is a semester-long project in which small teams of students plan, conceive, design, and prototype a simple physical product. Each student brings his/her own background to the team effort, and must learn to synthesize his/her perspective with those of the other students in the group.

Prerequisites: Mechanical Engineering undergraduate students only. ME 110/110L, ME 125, CSC 170/170L; and sophomore standing or permission of instructor
Corequisites: ME 265L

ME 269/269L Energy Systems Product Development and Design/Lab

Credits: (2-2) 4

This is a sophomore-level course on sustainable conversion and use of energy; long term utilization of energy sources and the environment; fossil, nuclear, and selected renewable sources; conversion techniques and efficiency; sustainable energy for vehicles. The course will include laboratory exercises and a semester project combining design, construction, and testing.

Prerequisites: ME 110/110L
Corequisites: ME 269L

ME 291 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings frequency depend on the requirements of the topic.

Prerequisites: Permission of instructor

ME 292 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a

specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

ME 312 Thermodynamics II

Credits: (3-0) 3

Thermodynamic power cycles using vapors and gases. One-dimensional compressible flow. Energy analysis. Refrigeration cycles. Moistures and psychrometry. Maxwell's relations. Combustion and thermochemistry.

Prerequisites: ME 211 and ME 221, both with a minimum grade of "C" or permission of instructor.
Notes: A minimum grade of "C" is required for graduation.

ME 313 Heat Transfer

Credits: (3-0) 3

A study of the transfer of heat by conduction, convection and radiation. Application to thermal systems.

Pre or Corequisites: MATH 373, ME 331 or permission of instructor.
Notes: A minimum grade of "C" is required for graduation.

ME 316 Solid Mechanics

Credits: (3-0) 3

Covers stress analysis and failure theories of both brittle and ductile materials and energy methods. Also includes such topics as elastic impact, stability, axis-symmetric loaded members in flexure and torsion, and an introduction to plastic behavior of solids.

Prerequisites: ME 216 and ME 221, both with a minimum grade of "C" or permission of instructor
Notes: A minimum grade of "C" is required for graduation.

ME 322 Machine Design I

Credits: (3-0) 3

Applications of the fundamentals of strength of materials, basic elastic theory, material science and how they apply to the design and selection of machine elements. Elements include shafts, gears, fasteners, and drive components such as gears and chains.

Prerequisites: ME 316, ME 264/ME 264L or ME 269/269L with minimum grade of "C", or permission

of instructor
Notes: A minimum grade of "C" is required for graduation.

ME 331 Thermo Fluid Dynamics

Credits: (3-0) 3

A study of the nature of fluids, constitutive relations, fluid statics/buoyancy, and the equations governing the motion of ideal (inviscid) and viscous, incompressible fluids, as well as inviscid, compressible fluids (1-dimensional gas dynamics). Internal and external flows, including viscous pipe flow, the Moody diagram, lift, drag and separation. Laminar and turbulent boundary layer theory, and dimensional analysis, modeling, and similitude.

Prerequisites: MATH 321, ME 211 and ME 221 with a minimum grade of "C", or permission of instructor
Notes: A minimum grade of "C" is required for graduation.

ME 351/351L Mechatronics and Measurement Systems/Lab

Credits: (3-1) 4

This course will encompass general measurement techniques found in Mechanical and Electrical Engineering. These include measurement of force, strain, frequency, pressure flow rates and temperatures. Elements of signal conditioning and data acquisition will be introduced. In addition to this material, the course will have a Mechatronics approach reflected in the combined applications of electronic mechanical and control systems.

Prerequisites: CSC 150/150L and EE 220/220L or EE 301/301L
Corequisites: ME 351L
Notes: This course is cross listed with EE 351/351L and CENG 351/351L A minimum grade of "C" is required for graduation.

ME 352 Introduction to Dynamic Systems

Credits: (3-0) 3

This is an introductory course in the control of dynamic systems. The course presents the methodology for modeling and linearizing of electrical, mechanical, thermal, hydraulic and pneumatic systems. The course also covers control system analysis and synthesis in the time and the frequency domains.

Prerequisites: MATH 321, ME 221 with minimum grade of "C", or permission of instructor
Notes: A minimum grade of "C" is required for graduation.

ME 391 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depend on the requirements of the topic.

Prerequisites: Permission of instructor.

ME 392 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

ME 400/500 Research Problems/Projects

Credits: 1 to 3

Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor
Notes: Students enrolled in ME 500 will be held to a higher standard than those enrolled in ME 400.

ME 402/502 Gas Dynamics

Credits: (3-0) 3

This course will review fundamental concepts from thermodynamics including isentropic flow and normal shock functions. The equations of motion will be derived in differential form and wave theory will be introduced. Multidimensional flows and oblique shock theory will be discussed. Integral methods for inviscid, compressible flow will be developed and numerical methods (including the method of characteristics for hyperbolic equations) will be employed in the second half of the course.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.
Notes: Students enrolled in ME 502 will be held to a higher standard than those enrolled in ME 402.

ME 404 Heating, Ventilating, and Air Conditioning

Credits: (3-0) 3

A study of space heating and cooling systems and equipment, building heating and cooling load calculations, solar radiation concepts, and moist air properties/conditioning processes. Indoor air quality/comfort and health issues will be discussed. Basic heat and mass transfer processes will be introduced; pump and fan performance issues along with duct and piping system design. Heat exchangers and mass transfer devices will also be studied.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.

ME 419 Thermal-Fluid Systems Design

Credits: (3-0) 3

Investigation and design of thermal and fluid systems and components, emphasizing the major thermal/fluid design issues that arise in internal combustion engine power conversion; analysis and synthesis involving modeling and optimization of thermo-fluid systems, components, and processes. Development and application of fundamental numerical tools and algorithms for thermal and fluid problems. A central design problem for a thermal/fluid system or component will be selected to meet an existing or future project need and will be decomposed into the relevant thermal and fluid aspects which will be studied throughout the course. Review of the basics of the design process and physical processes important to thermal-fluid problems (basic thermodynamics, heat transfer and fluid mechanics), the fundamentals of building and solving mathematical models, and design issues and concepts unique to internal combustion engines will be discussed. Students will be required to implement one or more previously developed Fluent learning modules to study the use of CFD in thermal/fluid system design. The final project will incorporate skills developed in the learning modules into the required design of the system or component. The laboratory will include experiments to complement the lecture material and provide a means for hands on validations of concepts.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.

ME 419L Thermal-Fluid Systems Design Lab

Credits: (0-1) 1

Investigation and design of thermal and fluid systems and components, emphasizing the major thermal/fluid design issues that arise in internal combustion engine power conversion; analysis and synthesis involving modeling and optimization of thermo-fluid systems, components, and processes. Development and application of fundamental numerical tools and algorithms for thermal and fluid problems. A central design problem for a thermal/fluid system or component will be selected to meet an existing or future project need and will be decomposed into the relevant thermal and fluid aspects which will be studied throughout the course. Review of the basics of the design process and physical processes important to thermal-fluid problems (basic thermodynamics, heat transfer and fluid mechanics), the

fundamentals of building and solving mathematical models, and design issues and concepts unique to internal combustion engines will be discussed. Students will be required to implement one or more previously developed Fluent learning modules to study the use of CFD in thermal/fluid system design. The final project will incorporate skills developed in the learning modules into the required design of the system or component. The laboratory will include experiments to complement the lecture material and provide a means for hands on validations of concepts.

ME 422 Machine Design II

Credits: (3-0) 3

This course will explore advanced structural design concepts within an integrated framework of theory, simulation, experiment, and materials. Of particular importance will be the study of modern topics, such as plastic materials and their response to service loads. Structural mechanics and materials response will be brought together in support of machine component design.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.

ME 423 Mechanical Vibrations

Credits: (3-0) 3

Study of the oscillatory nature and vibration design of mechanical systems. One, two, multi, and infinite degree of freedom systems are analyzed for their response in both free and forced vibration regimes. Particular emphasis is given to designing for vibration control. Brief introductions are made to vibration testing and measurement, and human response to vibrations.

Prerequisites: ME 312, ME 351/351L, ME 352 or permission of instructor.

ME 425 Probabilistic Mechanical Design

Credits: (3-0) 3

Basic concepts of probability and statistics are introduced including Gaussian, Exponential, and Weibul distributions. Primary emphasis is placed on treating stresses, strains, deformations, and strength limitations as random variables and computing probability of failure under required loads. Considerable time is devoted to converting data into meaningful engineering parameters for making engineering decisions. Statistical methods applied to topics in mechanical design. (design elective)

Prerequisites: ME 322

ME 426 Mechanical Systems Analysis Laboratory

Credits: (0-1) 1

Use of experimental methods and modern instrumentation techniques to understand the free and forced oscillations of machines and machine components, as well as the control of these vibrations. Laboratory exercises are designed to reinforce material learned in the companion lecture class ME 423, extend knowledge into new areas, and help to make the connection between theory and practice.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.

ME 427/427L Computer-Aided Design and Manufacture/Lab

Credits: (2-1) 3

Discussion of methods and topics in computer-aided design and manufacture. How to bridge the gap between the design/analysis phase and the actual manufacture phase. Database requirements of CNC machine tools and how they can be constructed.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.
Corequisites: ME 427L

ME 428/428L/528/528L Applied Finite Element Analysis/Lab

Credits: (2-1) 3

Basic mathematical concepts of finite element analysis will be covered. The students will learn finite element modeling using state of the art software, including solid modeling. Modeling techniques for beams, frames, two and three- dimensional solids, and then walled structures will be covered in the course.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.
Corequisites: ME 428L/528L
Notes: Students enrolled in ME 528/528L will be held to a higher standard than those enrolled in ME 428/428L. This course is cross listed with BME 528/528L.

ME 430 Introduction to Wind Energy Engineering

Credits: (3-0) 3

This course is an introduction to the theory of and the basic concepts of modern wind energy converters. Various types of wind power generators are discussed and in particular horizontal and vertical axis

turbine rotors. Other core subjects are: wind energy conversion, the effect of lift and drag, Betz's Momentum Theory, and an introduction to rotor aerodynamics. Concepts of wind, wind prediction, boundary layers, wind loads, and turbulences will be covered. Rotor blades, material selection, airfoils, loads, stresses, failure modes, control systems, and wind energy distribution are also introduced.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.

ME 432/432L/532/532L Experimental Stress Analysis/Lab

Credits: (3-1) 4

An introduction to experimental methods for determining stresses inside mechanical components from measuring their deformations and related topics. Topics include: review of stress/strain analysis, analysis of experimental data, data acquisition, strain gages, introductory photoelasticity, and digital image correlation.

Prerequisites: ME 322 or permission of instructor.
Corequisites: ME 432L or ME 532L
Notes: Students enrolled in ME 532/532L will be held to a higher standard than those enrolled in ME 432/432L.

ME 443 Composite Materials

Credits: (3-0) 3

This course will cover heterogeneous material systems; basic design concepts and preparation; types of composite materials; advances in filaments, fibers and matrices; physical and mechanical properties; failure modes; thermal and dynamic effects; and application to construction, transportation and communication.

Prerequisites: ME 316 or concurrent enrollment in MET 440.
Notes: This course is cross listed with MET 433.

ME 453/453L/553/553L Feedback Control Systems/Lab

Credits: (3-1) 4

Analysis and design of automatic control and process systems by techniques encountered in modern engineering practice, including both linear and nonlinear systems with either continuous or discrete signals.

Prerequisites: EE 314/314L **or** ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, and ME 352 **or** permission of instructor
Corequisites: ME 453L

Notes: This course is cross listed with EE 453/453L/553/553L. Students enrolled in ME 553/553L will be held to a higher standard than those enrolled in ME 453/453L.

ME 455/455L Vehicle Dynamics/Lab

Credits: (2-1) 3

Fundamental principles and practices of modern automotive chassis and suspension design, operation and testing are presented in this course. The dynamics of acceleration, braking, ride and handling are covered. Steady state cornering using the standard bicycle model is covered in detail. Laboratory work involves shock absorber and spring testing and the setup and evaluation of Formula SAE and Mini Baja chassis. Students must complete a chasses design project.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.
Corequisites: ME 455L

ME 457/557 Intermediate Dynamics

Credits: (3-0) 3

This course presents a continuation of the study of the dynamics of particles and rigid bodies from ME 221 . Topics include two-dimensional and three-dimensional kinematics and kinetics of rigid bodies, equations of motion and their solution via Matlab / Simulink, and an introduction to analytical dynamics via Lagrange's equations.

Prerequisites: ME 352 and MATH 373
Notes: Students enrolled in ME 557 will be held to a higher standard than those enrolled in ME 457.

ME 460 Fuels and Combustion

Credits: (3-0) 3

This course provides an introductory treatment of fuels and combustion science. The objectives of the course are to develop an understanding of hydrocarbon fuels, combustion reactions and kinetics, flame dynamics, flame stability, and pollutant formation. Coverage includes laminar and turbulent flames, premixed and diffusion flames, and detonations. Fundamental aspects of combustion are applied to analysis of the combustion process and pollutant formation in internal combustion engines and other combustors.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.

ME 477 Mechanical Engineering Design I

Credits: (0-2) 2

The first semester of a two course sequence in senior design practice. Integrates concepts from all areas in mechanical engineering into a practical design project. Fundamentals of the design process, specifications, decision making, and preliminary design will be the focus, with the major part of the course being the project.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 all with a minimum grade of "C" or permission of instructor.

ME 479 Mechanical Systems Design II

Credits: (0-2) 2

The second semester continuation of Mechanical Systems Design. Integrates concepts from all areas in mechanical engineering into a practical design project. Detailed design and analysis, manufacturing, and assembly will be the focus.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 all with a minimum grade of "C" and ME 477 or permission of instructor.

ME 481L Advanced Production Development Lab I

Credits: (0-1) 1

Advanced laboratory experience in product development. Students will perform activities in support of preliminary product design and trade studies, including virtual prototyping, computational investigations and proof-of-concept experiments.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor.
Corequisites: ME 477

ME 482L Advanced Product Development Lab II

Credits: (0-1) 1

Advanced laboratory experience in product development. Students will perform activities in support of detailed product design, including virtual prototyping, computational investigations, and testing of components and systems.

Prerequisites: ME 312, ME 313, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of

instructor.
Corequisites: ME 479

ME 491 Independent Study

Credits: 1 to 5

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

ME 492 Topics

Credits: 1 to 5

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

ME 555/555L Advanced Applications in Computational Mechanics/Lab

Credits: (1-2) 3

Introduction to solid modeling techniques using advanced solid modeling software. Use of Computational Fluid Mechanics codes for the solution of complex fluid mechanics and heat transfer problems. Use of finite element codes for the solution of non-linear and transient problems in solid mechanics.

Prerequisites: Senior or higher standing.
Corequisites: ME 555L

ME 591 Independent Study

Credits: 1 to 4

Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Enrollments are usually 10 or fewer students. Meetings depend upon the requirements of the topic.

ME 612 Transport Phenomena: Momentum

Credits: (3-0) 3

Introduction to momentum transport. Equations of continuity and motion. Velocity distributions. Boundary layer theory. Turbulent transport compressible flow.

Notes: This course is cross listed with CBE 612.

ME 613 Transport Phenomena: Heat

Credits: (3-0) 3

An in-depth study of the fundamental laws of heat transfer. Major areas considered are: heat conduction, free and forced convection, and radiative heat transfer. Emphasis is placed on the formulation and solution of engineering problems by analytical and numerical methods.

Notes: This course is cross listed with CBE 613.

ME 616 Computations in Transport Phenomena

Credits: (3-0) 3

Various computerized techniques, including finite difference and finite element, will be used to solve transient and steady state heat transfer problems involving conduction and convection.

Notes: This course is cross listed with CBE 616.

ME 618 Conduction Heat Transfer

Credits: (3-0) 3

The study of conduction heat transfer from fundamental physical considerations and methods for analyzing conduction heat transfer including Bessel's equation and related functions, separation of variables, superposition, complex combination, Laplace Transforms, normalization, and numerical method applications.

ME 619 Convection Heat Transfer

Credits: (3-0) 3

The study of convection heat transfer from fundamental conservation principles including fluid stresses

and flux laws, integral and differential equations of the boundary layer, and momentum and heat transfer for both external and internal flow under both laminar and turbulent conditions. Topics studied include the influence of temperature dependent properties, convection at high velocities, and free-convection boundary layers.

ME 620 Radiation Heat Transfer

Credits: (3-0) 3

The study of thermal radiation heat transfer including fundamental concepts, radiation heat transfer in enclosures with no attenuating medium, and radiation heat transfer in the presence of an attenuating medium.

ME 623 Advanced Mechanical Vibrations

Credits: (3-0) 3

Study of the vibration of systems of articles both forced and free. Included is the study of transient vibrations and system natural frequencies. Classical studies of the vibration of continuous systems, free and forced, damped and undamped using computer solutions are emphasized. Introduction to Theoretical and Experiment Modal Analysis. (Design Elective)

Prerequisites: ME 423 or equivalent.

ME 625 Smart Structures

Credits: (3-0) 3

Topics will include dynamics of flexible structures, distributed sensing and actuation, linear and nonlinear control of flexible structures, electrostatic actuation, piezoelectric sensing and actuation, noise absorption, self-healing structures, introduction to adaptive optics, elastic control, vibration control, and other application areas as necessary.

ME 673 Applied Engineering Analysis I

Credits: (3-0) 3

Advanced topics in engineering analysis. Special mathematical concepts will be applied to mechanical engineering problems. Topics will be selected from the following: Fourier series and boundary value problems applied to heat conduction and convection, Laplace transforms and complex variable analysis applied to vibrations and dynamic system analysis, series solutions of differential equations, partial differential equations, general matrix applications to a variety of large systems of equations in engineering, calculus of variation, and Ritz method for various engineering problems.

Notes: This course is cross listed with BME 673.

ME 680 Advanced Strength of Materials

Credits: (3-0) 3

Study of advanced concepts in strength of materials. Topics will be selected from the following: theories of stress and strain, failure criteria, energy methods, torsion, nonsymmetrical beams on elastic foundation, plates, shells, stress concentrations, contact stresses, finite element methods, and plastic behavior of solids.

Notes: This course is cross listed with EM 680.

ME 683 Advanced Mechanical System Control

Credits: (3-0) 3

Derivation of state equations for continuous and discrete control systems. A study of optimal and adaptive control of mechanical systems. (Manufacturing Elective)

ME 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

ME 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

ME 713 Advanced Solid Mechanics I

Credits: (3-0) 3

Presented and discussed. Emphasis is placed on the mathematical description of phenomenological behavior, deformation and flow. Practical solutions from the classical theories of solid mechanics are discussed.

Notes: This course is cross listed with MES 713.

ME 715 Advanced Composite Materials

Credits: (3-0) 3

Includes classification and mechanical behavior of composite materials, macro-mechanical behavior of lamina and laminates. Course emphasizes study of advanced composite laminates including failure theories, experimental methods, stresses, strains, and deformations.

ME 736 Advanced Finite Element Methods

Credits: (3-0) 3

Variational and weighted residual approach to finite element equations. Emphasis on two- and three-dimensional problems in solid mechanics. Isoparametric element formulation, higher order elements, numerical integration, imposition of constraints, convergence, and other more advanced topics. Introduction to geometric and material nonlinearities. Introduction to the solution of dynamic problems and time integration. Use of finite element computer programs.

Notes: This course is cross listed with BME 736.

ME 770 Continuum Mechanics

Credits: (3-0) 3

Introduction to tensor algebra and calculus. Derivation of kinematic, stress, strain, and thermodynamic field equations governing continuous media. Development of constitutive relations for real materials. Applications to problems in fluid and solid mechanics.

Notes: This course is cross listed with MES 770.

ME 773 Applied Engineering Analysis II

Credits: (3-0) 3

Applications of numerical methods to mechanical engineering problems. Topics will include data processing techniques, curve fitting and interpolation of experimental information, solutions to systems of ordinary differential equations, solutions to partial differential equations, and numerical integration both of known functions and functions described only by experimental data.

Notes: This course is cross listed with BME 773.

ME 781 Robotics

Credits: (3-0) 3

The course covers the following topics as related to modern industrial robots, sensors and actuators, motion trajectories, synthesis, control, computers and languages, available robots, and applications. (Manufacturing Elective)

ME 788 Master's Research Problems/Projects

Credits: Credit to be arranged.

Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive or intensive. Does not include research courses which are theoretical.

ME 790 Seminar

Credits: (1-0) 1

A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division graduate levels.

Notes: May not be repeated for credit.

ME 791 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher

involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

ME 792 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

ME 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

ME 896 Field Experience

Credits: (0-3) 3

Applied, monitored, and supervised field-based learning experience for which the student may or may not be paid. Students gain practical experience; they follow a negotiated and/or directed plan of study established by the student, instructor, and field-based supervisor. Due to the presence of a field experience supervisor, a lower level of supervision is provided by the instructor in these courses than is the case with an internship or practicum course.

ME 898D Dissertation

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credits to be arranged; not to exceed 30.

Mining Engineering and Management

MEM 110L Introduction to Geological and Mining Engineering

Credits: (0-1) 1

An introductory course for incoming freshman in geological and mining engineering covering fundamental engineering practices in both disciplines. The course will include short field exercises, hands-on practical exercises, group projects, problem solving (using spreadsheets and other current methods), and engineering ethics. When applicable, industry experts will be invited as guest lecturers to discuss current trends and practices in the industry.

Notes: This course is cross listed with GEOE 110L.

MEM 120 Introduction to Mining, Sustainable Development and Introductory Management

Credits: (2-0) 2

This course presents an introductory overview of current surface and underground mining practices, new and emerging mining technology, mining terminology, and mining economics. Mining engineering faculty members are introduced and career paths available to the mining engineering graduate are discussed. The concept of sustainable development as it relates to a minerals venture is introduced, and the interrelationships between mining, the environment, societal needs, and governance is discussed. Also included is an introduction to management concepts, presentation skills, meeting skills, negotiation skills, and basic project management tools.

MEM 201L Surveying for Mineral Engineers

Credits: (0-2) 2

Principles of surface and underground surveying, including measurements, data collection, calculations, error analysis, topographic mapping, and applications of the Global Positioning System.

Prerequisites: Sophomore standing.

MEM 202 Materials Handling and Transportation

Credits: (2-0) 2

The theory of operation of mining equipment, and its selection and application to materials handling in surface and underground mines. Emphasis is on economics, productivity, reliability, maintenance and safety.

Prerequisites: MEM 120 and PHYS 211/211-A

MEM 203 Introduction to Mine Health and Safety

Credits: (1-0) 1

Instruction in the safety aspects of mining in accordance with MSHA rules. A study of mine regulations and the recognition of mine hazards along with their prevention and control.

Prerequisites: Sophomore standing.

MEM 204 Surface Mining Methods and Unit Operations

Credits: (2-0) 2

A study of surface mining techniques and unit operations applicable to metal mining, coal mining, quarrying and other surface mining operations. Topics include mine design and planning, surface drilling and blasting, the applicability and performance characteristics of earthmoving equipment, and an introduction to mine drainage.

Prerequisites: MEM 120 or permission of instructor.

MEM 301/301L Computer Applications in Mining/Lab

Credits: (1-1) 2

Computer hardware and software. Applications in exploration and resource modeling, equipment selection and simulations, mine planning and design, rock stability analysis, and economics and cost estimates. Emphasis on three-dimensional modeling and visualization. Vulcan software and other software applications.

Prerequisites: GEOE 110L or permission of instructor.
Corequisites: MEM 301L

MEM 302 Mineral Economics and Finance

Credits: (3-0) 3

An introduction to the concepts of the time value of money and the application of time value of money decision criteria to mineral project evaluation situations. Both before-tax and after-tax investment situations are discussed. A discussion of the financing options available to a company for expansion, new project development or acquisitions.

Prerequisites: Junior standing.

MEM 303 Underground Mining Methods and Equipment

Credits: (2-0) 2

A study of underground mining techniques, unit operations, and equipment applicable to coal mining, metal mining, quarrying and tunneling operations. Topics include mining method selection, mine design and planning, drilling and blasting, and novel underground mining methods.

Prerequisites: Sophomore or junior standing.

MEM 304/304L Theoretical and Applied Rock Mechanics/Lab

Credits: (2-1) 3

Principles of rock mechanics and mechanics of materials. Concept of stress, strain and the theory of elasticity. Applications in mining, geological engineering and tunneling. Emphasis on the design of safe structures in rocks. Laboratory experience for determining the basic physical and mechanical properties of rocks.

Prerequisites: EM 214 or EM 216 or equivalent and junior standing.
Corequisites: MEM 304L

MEM 305 Introduction to Explosives Engineering

Credits: (3-0) 3

An introduction to explosives products; the theory of rock breakage by explosives; and the design of blast patterns for different applications including surface blasting techniques, underground blasting techniques, controlled blasting and specialized techniques. The techniques and equipment used to control and/or monitor airblast, ground vibration and flyrock are studied.

Prerequisites: Junior standing.

MEM 307 Mineral Exploration and Geostatistics

Credits: (3-0) 3

The application of the theory of geostatistics to quantify the geological concepts of (1) area of influence of a sample, (2) the continuity of the regionalized variable within a deposit, and (3) the lateral changes in the regionalized variable according to the direction. Basic concepts and theory of probability and

statistics will be introduced, including probability distributions, sampling distributions, treatment of data, the mean, variance, and correlation. Computer techniques will be extensively used for geostatistical estimation of grade, volume and variance.

Prerequisites: Junior standing.

MEM 314/314L Mineralology and Petrology for Mining Engineers/Lab

Credits: (3-1) 4

A study of the identifying characteristics of the many classes of minerals and rocks with emphasis on the application to the mining engineering discipline. Discussion of the role that these characteristics play in mine design and management will be included whenever possible. The laboratory will focus on hands-on sample description and identification of common silicate and non-silicate minerals and the description and classification of igneous, sedimentary and metamorphic rocks. The course will include lecture, laboratory and field trips.

Prerequisites: GEOL 201 or GEOE 221/221L and CHEM 112
Corequisites: GEOL 314L

MEM 376 Managerial Finance for Mining Engineers

Credits: (3-0) 3

This course provides an introduction to the role that financial managers play in the mining industry and the financial market environment in which the mining industry operates. Topics will include financial statements and ratio analysis, cash flow, risk and return, time value of money, the cost of capital, capital budgeting, and liabilities management.

Prerequisites: ECON 201 or ECON 202

MEM 401/401L Theoretical and Applied Mine Ventilation/Lab

Credits: (3-1) 4

Analysis of mine atmosphere and the control of airflow in an underground mine. Basic principles of thermodynamics and air conditioning. Emphasis is on solutions of airflow networks and the design principles for mine ventilation systems. Laboratory experience for determining the basic pressure and airflow parameters, ventilation network analysis and fan characteristics.

Prerequisites: MEM 303, AES 404/504, EM 331, and senior standing.
Corequisites: MEM 401L

MEM 405 Mine Permitting and Reclamation

Credits: (3-0) 3

A study of environmental problems associated with both surface and underground mining and the reclamation practices that have been developed or are being evaluated to alleviate these problems. Federal, state and local reclamation regulations are examined for their effects on present and future mining practices and costs. Field trips to mining operations in the Black Hills region or the Powder River Basin will be taken for on-site observation of actual reclamation practices.

Prerequisites: Junior standing.

MEM 410/510 Advanced Mineral Economics for Managers

Credits: (3-0) 3

A discussion of the fundamental factors critical to valuation of mineral properties. The three major approaches to mineral property valuation - the cost approach, the market approach, and the income approach - will be discussed. Additional subjects for discussion will include: selecting discount rates, leveraged cash flow, risk assessment, real asset pricing models, and forecasting techniques.

Prerequisites: MEM 302 or equivalent or permission of instructor.
Notes: Students enrolled in MEM 510 will be held to a higher standard than those enrolled in MEM 410.

MEM 415/515 Advanced Mining Geotechnical Engineering

Credits: (3-0) 3

This course provides students with a practical understanding of the advanced application of geotechnical engineering principles in mining - from the perspective of planning, design, and operations in both soft and hard rock as well as underground and open-cut mining systems. In the course will be a further discussion of new methods of collection and analysis of geotechnical data, geotechnical risk of different mining methods, caving mechanics, dynamic events: seismicity, rock bursts, airblasts & outbursts, geotechnical instrumentation and monitoring, and geotechnical risk mitigation.

Prerequisites: MEM 304/304L or equivalent or permission of instructor.
Notes: Students enrolled in MEM 515 will be held to a higher standard than those enrolled in MEM 415.

MEM 420/520 Advanced Tunneling and Underground Excavation

Credits: (3-0) 3

The course will discuss advanced topics in tunnel excavation and design. These topics will include

laboratory and in situ rock characterization and classification. Also to be discussed are mechanical, convention, and cut and cover methods of excavation and tunnel layout in hard and soft rock. Presentations will address equipment selection and prediction of performance expected of the equipment; and initial ground support and design of permanent lining. Also discussed will be tunnel safety, instrumentation and monitoring, and tunnel risk analysis.

Prerequisites: MEM 304/304L or equivalent or permission of instructor.
Notes: Students enrolled in MEM 520 will be held to a higher standard than those enrolled in MEM 420.

MEM 425/525 Advanced Rock Mechanics

Credits: (3-0) 3

A discussion of advanced topics in static and dynamic rock mechanics: elasticity theory, failure theories, and fracture mechanics applied to rock, stress wave propagation, and dynamic elastic constants, rock mass classification methods for support design. Discussions will include advanced analytical, numerical modeling and empirical design methods and probabilistic and deterministic approaches to rock engineering designs. Presented will be excavation design examples for shafts, tunnels, large chambers and mine pillars in coal and metal mines. Also discussed will be seismic loading of structures in rock and the phenomenon of rock burst and its alleviation.

Prerequisites: MEM 304/304L or equivalent or permission of instructor.
Notes: Students enrolled in MEM 525 will be held to a higher standard than those enrolled in MEM 425.

MEM 430/530 Resource Industry Mergers and Acquisitions

Credits: (3-0) 3

A discussion of the fundamentals of acquisitions in the resource industry, including negotiations and *due diligence*. The primary types of transactions will be discussed, including direct acquisition, joint ventures, options/earnings, mergers, amalgamation, leases and off-takes. Other relevant subjects to be discussed during the class include public market financing for acquisitions and the process of *due diligence* for mergers and acquisitions.

Prerequisites: MEM 302 or equivalent or permission of instructor.
Notes: Students enrolled in MEM 530 will be held to a higher standard than those enrolled in MEM 430.

MEM 433/433L/533/533L Computer Applications in Geoscience Modeling/Lab

Credits: (3-1) 4

The use of computer techniques in modern geoscience modeling of mining, geology, and environmental

problems such as exploration, geological characterization and mining exploitation. Practical application of state-of- the-art Vulcan modeling software will be an essential part of the course.

Prerequisites: Junior standing.
Corequisites: MEM 433L or MEM 533L
Notes: Students enrolled in MEM 533/533L will be held to a higher standard than those enrolled in MEM 433/433L.

MEM 435/535 Resource Industry Finance and Accounting

Credits: (3-0) 3

Fundamental concepts the cost of capital, capital budgeting, the balance sheet and the analysis of financial statements, including rations and cash flow analysis for the resource industry. A discussion of reporting requirements for public companies will also be included.

Prerequisites: MEM 302 or equivalent or permission of instructor.
Notes: Students enrolled in MEM 535 will be held to a higher standard than those enrolled in MEM 435.

MEM 440/540 Advanced Mine Ventilation and Environmental Engineering

Credits: (3-0) 3

Advanced topics in: mine air-quality control; economics of airflow; climate simulation; rock-to-air heat transfer in underground openings; ventilation network analysis; control flow and free splitting networks; controlled recirculation; diffusion and migration of contaminants in mine environment; control of mine fires and explosion; noise in underground environment; mine air conditioning systems; mine lighting; mine rescue apparatus.

Prerequisites: MEM 401/401L or equivalent or permission of instructor.
Notes: Students enrolled in MEM 540 will be held to a higher standard than those enrolled in MEM 440.

MEM 445/545 Advanced Geostatistics and Grade Estimations

Credits: (2-1) 3

The theory of regionalized variables. Exploratory spatial data analysis, resource estimation, random function models for spatial data, estimation and modeling of variograms and covariance's, isotropy, anisotropy, ordinary and universal kriging estimators and equations, regularization of variograms, estimation of spatial averages, non-linear estimators, cross validation, includes use of geostatistical software. Two-dimensional and three-dimensional kriging. Application of hydrology, soil science, atmospheric science, ecology, geography and related fields.

Prerequisites: MEM 307 or equivalent and MEM 301/301L or equivalent or permission of instructor.
Corequisites: MEM 445L/545L
Notes: Students enrolled in MEM 545/545L will be held to a higher standard than those enrolled in MEM 445/445L.

MEM 445L/545L Advanced Geostatistics and Grade Estimations

Credits: (0-1) 1

Laboratory to accompany MEM 445/545.

Pre or Corequisites: MEM 445/545

MEM 446 Human Resource Management for Mining Engineers

Credits: (3-0) 3

This course provides a survey of human resource topics specific to the mining industry. Major areas of study include recruitment and retention, compensation and benefits, the legal environment, international human resources, labor relations and collective bargaining, organizational development, and occupational safety.

MEM 450/550 Rock Slope Engineering

Credits: (3-0) 3

Modes of slope failure. Economic consequences of instability in mining and construction. Geological factors controlling stability of rock slopes. Shear strength of highly jointed rock mass and discontinuities. Projection methods. Vectoral analysis of 3-D problems by means of the stereographic projection method. Analytical, graphical and computer analysis of planar, wedge and toppling failures. Probabilistic methods.

Prerequisites: MEM 304/304L or CEE 346/346L or equivalent.
Notes: Students enrolled in MEM 550 will be held to a higher standard than those enrolled in MEM 450.

MEM 455/555 Rock Slope Engineering II

Credits: (3-0) 3

Advanced topics in rock slope engineering including limiting equilibrium analysis of plane shear, rotational shear, and wedge-type failure; 2-D and 3-D numerical methods; analysis of rockfall; and laboratory and field methods including measurement of structural orientation, determination of strength

properties using the direct shear, and instrumentation.

Prerequisites: MEM 304/304L or CEE 346/346L or equivalent, and MEM 450/550 or CEE 646 or equivalent, or permission of instructor.
Notes: Students enrolled in MEM 555 will be held to a higher standard than those enrolled in MEM 455.

MEM 464 Mine Design and Feasibility Study

Credits: (0-4) 4

A complete mine feasibility study conducted as a senior design project. Students will have a choice of designing one of the following: a surface or underground coal mine, a quarry, a surface or underground hard rock metal mine, or a sub-surface underground space (tunneling, large excavations, industrial/environmental underground storage site, or underground science laboratory). A comprehensive study of principles and practices involved in developing an ore deposit (surface or underground) starting with drill hole data following through with a complete feasibility study (based on financial returns on investment and sensitivity analysis) covering ore reserve calculations, and selection of mining methods and equipment. Computerized approach will be an integral part of the course: SurvCADD software and Vulcan software are available to use. In addition to a computerized model of the mine, a final written report and presentation in front of the class will be required.

Pre or Corequisites: MEM 302, MEM 304/304L, MEM 401/401L and senior standing.

MEM 466 Mine Management

Credits: (2-0) 2

The study of critical management issues of fundamental importance to the mining industry: forms of management, organizational structures, project management and mine administration, risk management and modern management tools. Development of leadership skills. Management of human resources.

Prerequisites: Senior standing or permission of instructor.

MEM 476 International Business for Mining Engineers

Credits: (3-0) 3

This course provides an overview of the unique problems faced by mining companies engaged in international activities; the importance of understanding the foreign economic, political, cultural, and legal environment; the mechanics of importing and exporting; the international dimensions of management, marketing, and accounting; and competitive factors and conditions in an increasingly global and volatile mining environment.

MEM 480/580 Advanced Explosives and Blasting

Credits: (3-0) 3

A discussion of most recent advances in blasting technology. Most recent developments in new explosives and initiation systems along with new methods of face profiling and blast design concepts will be dealt with in detail. Discussions will include guest speakers and some real time case studies. Electronic initiation systems and their associated technological challenges will be studied in some detail.

Prerequisites: MEM 305, or equivalent, or permission of instructor.
Notes: Students enrolled in MEM 580 will be held to a higher standard than those enrolled in MEM 480.

MEM 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

MEM 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

MEM 610 Topics in Mineral Economics, Sustainability and Mine Regulation

Credits: (3-0) 3

This survey course covers mineral resources development from the legal, regulatory, management and environmental (sustainability, reclamation and closure) perspective. The course is ideal for graduate students who are working on mineral resources research or special topics from a variety of disciplines who wish to learn more about the scope, current issues, and future challenges.

Prerequisites: Graduate student or permission of instructor.

MEM 630 Mining Law and Environment

Credits: (3-0) 3

This course undertakes an examination of relevant legislation and practice with respect to mining laws and the mining environment, starting with the Mining Act of 1872, the 1920 Mineral Leasing Act, and the 1977 Surface Mining Control and Reclamation Act. The student will examine state, national, and international mining laws as well as mining environment issues that impact the mining industry.

MEM 691 Independent Study

Credits: To be arranged

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee. Credit to be arranged but not to exceed more than 6 credits towards fulfillment of M.S. degree requirements.

MEM 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

MEM 700 Developing and Planning Research

Credits: (1-0) 1

An overview of research proposal writing and presentation as well as responsible research conduct in the geosciences and engineering. Students will produce a preliminary thesis/dissertation proposal, peer review the proposals of fellow students, and prepare a proposal presentation on a selected research question.

Notes: This course is cross-listed with GEOE 700 and GEOL 700

MEM 788 Master's Research Problems/Projects

Credits: Credit to be arranged.

Independent research problems/projects that lead to a research or design paper but not to a thesis. The

plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive or intensive. Does not include research courses which are theoretical.

MEM 790 Seminar

Credits: (2-0) 2

A highly focused and topical course. The format include student presentations and discussions of reports based on literature, practices, problems, and research. Seminar may be conducted over an electronic media internet and or at the upper division graduate levels. Enrollment is generally limited to less than 20 students.

MEM 798 Thesis

Credits: To be arranged

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee. Credit to be arranged but not to exceed more than 6 credits towards fulfillment of M.S. degree requirements.

Materials Engineering and Science

MES 475/575 Advances in Processing and Nanoengineering of Polymers

Credits: (2-0) 2

The course will begin with an overview of the basic principles of polymer rheology and structure formation. It will then review recent examples from the scientific literature in which concepts and theories of rheological behavior and structure formation at multiple length scales have been further developed and/or applied to the processing of polymers and composites with advanced functional and multifunctional properties. Special attention will be paid to research related to processing challenges in the formation of polymer nanocomposites, nanofibers and hierarchical composite structures. As part of this course, students will be expected to develop skills in reviewing and critically assessing the scientific literature, and in developing research strategies based on current state of knowledge.

Prerequisites: CHEM 114 /CHEM 114L or MES 604 or permission of instructor.
Notes: Students enrolled in MES 575 will be held to a higher standard than those enrolled in MES 475. This course is cross listed with CBE 475/575 and NANO 475/575.

MES 601 Fundamentals of Materials Engineering

Credits: (4-0) 4

The objective of this course is to provide students with the working knowledge required to understand principles governing engineering aspects of materials synthesis and manufacturing. Students are able to analyze the effect of transport phenomena, surface chemistry, solution thermodynamics and kinetics on design, control and process optimization of various materials processes.

Prerequisites: Admission to M.S./MES or Ph.D./MES program or permission of instructor.
Notes: This course is taught when the required seven student minimum is reached.

MES 603 Condensed Matter Physics

Credits: (4-0) 4

The objective of this course is to provide students with the working knowledge required to understand the principles of condensed matter physics with application to materials science and engineering. The students will be able to analyze basic experiments related to electronic structure of atoms and chemical bonding in solids, diffraction of x-rays and electrons by crystal lattices, lattice dynamics, elastic and thermal properties of solids, electronic band structure, classification of solids, dynamics of electrons in crystals, optical properties of solids, doped semiconductors, p-n junctions and hetero- junctions, dielectric properties of insulators, piezoelectricity, electrostriction, ferroelectricity, and magnetic properties of solids (dia-, para-, and ferro-magnetism).

Prerequisites: Admission to M.S./MES or Ph.D./MES program or permission of instructor..

MES 604 Chemistry of Materials

Credits: (4-0) 4

The objective of this course is to provide students with the working knowledge required to understand the theoretical chemical basis for chemical and physical properties of crystalline, ceramic, polymeric and metallic materials. Students will be able to analyze macroscopic properties on the basis of underlying chemical concepts.

Prerequisites: Admission to M.S./MES or Ph.D./MES program or permission of instructor.

MES 636 Photovoltaics

Credits: (3-0) 3

This course will cover modern silicon photovoltaic (PV) devices, including the basic physics, ideal and nonideal models, device parameters and design, and device fabrication. The emphasis will be placed on crystalline and multicrystalline devices, but thin films will also be introduced. PV applications and

economics will also be discussed.

Notes: This course is cross listed with NANO 636.

MES 678L Micro X-Ray Computed Tomography

Credits: (0-1) 1

A practical introduction to the principles and use of micro x-ray computed tomography for materials scientists and engineers, geologists, paleontologists, and other interested graduate students.

MES 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

MES 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: This course is cross listed with MES 792.

MES 711 Materials and Advanced Energy Generation and Storage

Credits: (3-0) 3

Materials for advanced energy generation and storage devices, such as batteries, polymer/solid-state/traditional/biological/microbial fuel cells, and super- /pseudocapacitors are discussed in this course. The main topics highlight the basic properties of materials, fundamental principles of catalytic/electrochemical reactions, kinetics, reaction mechanisms, and the recent approaches in development of innovative materials for the next generation of energy generation and storage devices. Furthermore, the challenges and criteria to achieve the state-of-the art performance for each of the specified areas are discussed.

MES 712 Interfacial Phenomena

Credits: (3-0) 3

A course in the surface properties of solids and liquids. Areas covered include the thermodynamics of surfaces, material transfer across interfaces, nucleation, surface energies of solids, three- phase contact, wetting phenomena, and adsorption.

Notes: This course is cross listed with CHEM 712.

MES 713 Advanced Solid Mechanics I

Credits: (3-0) 3

Presented and discussed. Emphasis is placed on the mathematical description of phenomenological behavior, deformation and flow. Practical solutions from the classical theories of solid mechanics are discussed.

Notes: This course is cross listed with ME 713.

MES 716 Digital Fabrication: Materials and Processes

Credits: (3-0) 3

The principles of interfacial phenomenon, solution thermodynamics, and colloid chemistry will be used in illuminated process by which metallic nanoparticulates can be formed and incorporated into inks for use in manufacturing of a variety of products. Students will learn 1) the methods and science behind the manufacture of a variety of functional nanoparticles, 2) the methods of incorporating these particles into inks and the printing of these inks for digital fabrication applications, and 3) the interfacial processes involved in line spreading and curing of the printed traces.

Notes: This course is cross listed with NANO 716

MES 719 Nanomaterials for Biosensors

Credits: (3-0) 3

Topics covered will include the fundamental principles of signal recognitions in protein, DNA, and enzyme biosensors, basic properties of nanomaterials related to sensors, electrochemical biosensors, optical and fluorescence sensors, chemiresistors, sensors based on semiconductor electronic devices, and the recent development of innovative nanomaterials for next-generation biosensors.

Prerequisites: Enrollment in one of the Biomedical Engineering, or Nanoscience & Nanoengineering, or Materials Engineering and Science programs, or Permission of Instructor.
Notes: MES 719 is cross-listed with BME 719 and NANO 719.

MES 720 Nano-Struct Mats: Syn & Char

Credits: (3-0) 3

A survey and analysis of synthetic materials and characterization techniques for nano-structured materials will be presented. The classes of materials that will be studied include: inorganic nano cyrstals (metals, semi-conductors, metal oxides), nano-wires, porous materials, carbon nanostructures, and higher order materials, such as supported catalysts. Solution-phase synthetic routes will be emphasized, including sol-gel synthesis, non-hydrolytic molecular decomposition, and micelle-templated synthesis, with lesser emphasis on solid state and gas-phase reactions. Methods of characterization will be discussed, including: transmission electron microscopy (TEM), scanning electron microscopy (SEM), powder X-ray diffraction (XRD), UV-visible absorption/fluorescence, X-ray absorptionspectroscopy, gas sorption analysis, atomic force microscopy (AFM), scanning tunneling microscopy (STM), and photoelectronspectroscopy.

Notes: This course is cross listed with CHEM 720.

MES 723 Luminescence Spectroscopy of Materials

Credits: (3-0) 3

Fundamentals of luminescent behavior and photodynamics of solid state materials and spectroscopic methods of characterization will be discussed. Applications of novel solid state materials as phosphors, sensors, and in optoelectronics devices will be considered.

Notes: This course is cross listed with CHEM 723.

MES 728 Heterogeneous Kinetics

Credits: (3-0) 3

Principles of Absolute Rate Theory are combined with thermodynamics to study the mechanisms of homogeneous and heterogeneous reactions in metallurgical systems.

Notes: This course is cross listed with CBE 728.

MES 736 Advanced Photovoltaics

Credits: (3-0) 3

This course builds on the foundations established in MES/NANO 636. It will cover advanced photovoltaic concepts, including thin films, compound semiconductors, spectral conversion devices, and organic and polymeric devices. Advanced device designs will be emphasized. Evaluation will include a research paper on a current PV topic.

Notes: This course is cross listed with NANO 736.

MES 737 Organic Photovoltaics

Credits: (3-0) 3

Organic photovoltaic provides a variety of interesting and new properties which facilitate solar energy utilization. The objectives of this course are to introduce material properties of polymers, small molecules, dyes, and nanomaterials for photovoltaics; describe device mechanisms and behavior of organic photovoltaics; understand the photophysical process in organic photovoltaics; and introduce different processing techniques for device fabrication.

Notes: This course is cross listed with EE 737.

MES 742 Applied Electrochemistry

Credits: (3-0) 3

This course will work from a knowledge of thermochemistry, physical chemistry, and analytical chemistry to understand the fundamental aspects of electrochemical processes in materials processing. This will include the thermodynamics and kinetics of aqueous electrochemical reactions and electrochemical measurement techniques. The course will focus on the application of electrometallurgical principles to a wide variety of industrial processes and will enable students to calculate relevant processing parameters and develop a sound understanding of electrochemical processes in materials processing.

Pre or Corequisites: Graduate standing.
Notes: This course is cross-listed with CBE 742 and BME 742.

MES 770 Continuum Mechanics

Credits: (3-0) 3

Introduction to tensor algebra and calculus. Derivation of kinematic, stress, strain, and thermodynamic field equations governing continuous media. Development of constitutive relations for real materials. Applications to problems in fluid and solid mechanics.

Notes: This course is cross listed with ME 770.

MES 788 Master's Research Problems/Projects

Credits: Credit to be arranged.

Independent research problems/projects that lead to a research or design paper but not to a thesis. A plan of student is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses with are theoretical. Oral defense of the report and research findings are required.

Prerequisites: Approval of advisor.
Notes: Credit to be arranged: not to exceed 5 credit hours toward fulfillment of the M.S. in MES.

MES 790/890 Seminar

Credits: (1-0) 1

A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division graduate levels.

Notes: May not be repeated for degree credit. Students enrolled in MES 890 will be held to a higher standard than those enrolled in MES 790. MES 790/890 is cross-listed with CEE 790, GEOL 790, GEOE 790, and AES 790.

MES 791 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

MES 792 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: This course is cross listed with MES 692.

MES 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 6 credit hours toward fulfillment of the M.S. in MES.

MES 898 Dissertation

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee. Oral defense of dissertation and research findings are required.

Notes: Credit to be arranged; not to exceed 30 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates.

Metallurgical Engineering

MET 110 Introduction to Metallurgical Engineering

Credits: (1-0) 1

An introductory course for incoming freshmen in metallurgical engineering covering the history of, career opportunities in, and engineering practices of metallurgical engineering. This course will include group projects and presentations, problem solving, engineering ethics, technical reports and field trips.

MET 220 Mineral Processing and Resource Recovery

Credits: (3-0) 3

An introductory course in mineral processing highlighting unit operations involved including comminution, sizing, froth flotation, gravity separation, electrostatic separation, magnetic separation and flocculation. Other topics discussed include remediation of contaminant effluents and the unit operations associated with recycling of post-consumer materials using mineral processing techniques.

Prerequisites: MATH 123 and CHEM 112
Notes: A minimum grade of "C" is required for graduation with a B.S. degree in Metallurgical Engineering.

MET 220L Mineral Processing and Resource Recovery Laboratory

Credits: (0-1) 1

An introductory laboratory course in mineral processing highlighting relevant unit operations.

Pre or Corequisites: MET 220

MET 231 Structures and Properties of Materials Lab

Credits: (0-1) 1

A laboratory involving quantitative metallography, heat treating practice, mechanical property measurements and metallurgical design of the thermal mechanical treatment of metals.

Pre or Corequisites: MET 232

MET 232 Properties of Materials

Credits: (3-0) 3

A course in engineering materials and their applications. The different technological uses of metals, ceramics, plastics, and composite materials are discussed and explained in terms of their basic atomic structure, and mechanical, thermal, optical, electrical, and magnetic properties. Material selection in engineering design is emphasized.

Prerequisites: MATH 123 and CHEM 112

MET 310 Aqueous Extraction, Concentration, and Recycling

Credits: (3-0) 3

Scientific and engineering principles involved in the winning of metals from ores and scrap. Areas covered include the unit operations of comminution, sizing, solid/liquid separations, leaching, ion exchange, solvent extraction, and surface phenomena as related to flocculation, froth floatation, and electrostatic separation.

Prerequisites: MET 320 or CBE 321 or CHEM 342

MET 310L Aqueous Extraction, Concentration, and Recycling Lab

Credits: (0-1) 1

Laboratory experiments in design of processing equipment and cost estimation, zeta potential, surface tension, leaching kinetics, electrowinning, and solvent extraction.

Pre or Corequisites: MET 310

MET 320 Metallurgical Thermodynamics

Credits: (4-0) 4

The principles of chemical thermodynamics and their application to metallurgical engineering processes. Topics covered include the zero, first and second laws of thermodynamics, the fundamental equations of state for open and closed systems, criterion of equilibrium, heat capacities, reaction equilibrium constants and their dependence upon temperature and pressure, chemical potential, standard and reference states, stability diagrams, and solution thermodynamics.

Prerequisites: PHYS 211/211-A, CHEM 112, and MATH 125

MET 321/321L High Temperature Extraction, Concentration, and Recycling/Lab

Credits: (3-1) 4

Thermodynamic principles involved in the winning of metals. Areas covered include calcination, oxidation, reduction processes, smelting, high- temperature refining, electrorefining, slags, and slag-metal interactions.

Prerequisites: MET 320
Corequisites: MET 321L

MET 330 Physics of Metals

Credits: (3-0) 3

The fundamental principles of physical metallurgy with emphasis on the mathematical description of mechanisms that control the structure of materials. Topics covered are structure of metals, x-ray diffraction, elementary theory of metals, dislocations, slip phenomena, grain boundaries, vacancies, annealing, and solid solutions.

Prerequisites: MET 232 with a grade of "C" or better.

MET 330L Physics of Metals Lab

Credits: (0-1) 1

Practical laboratory exercises that involve (1) x-ray diffraction methods, (2) transmission electron microscopy as it applies to dislocations in materials, (3) recovery, recrystallization and grain growth as it applies to annealing of materials, (4) optional and scanning electron microscopy as it applies to the microstructure of materials, and (5) thermomechanical processing of metals with limited regions of solid solubility.

Prerequisites: MET 231
Pre or Corequisites: MET 330

MET 332 Thermomechanical Processing

Credits: (3-0) 3

The relationship between the structure and properties of materials. Topics covered are the iron-carbon system, hardenability of iron base alloys, stainless steels, cast irons, aluminum, copper and magnesium, rubber and copper polymers. Concepts of heat treatment, age hardening, dispersion hardening, and hot and cold working correlated with modification of the structure and physical properties of materials.

Prerequisites: MET 232 with a grade of "C" or better.
Pre or Corequisites: MET 330 and MET 320 or ME 211

MET 351 Engineering Design I

Credits: (2-0) 2

Introduction to engineering design. Compare the scientific method with the engineering design method. Define the concept of need as it pertains to the design process. Develop skills associated with the use of modern and classic sources of information. In addition, material selection processes, interaction of materials, and materials processing topics are presented. Focus on the design process, and the design method. The development of interdisciplinary teams is a high priority.

Pre or Corequisites: MET 320

MET 352 Engineering Design II

Credits: (1-0) 1

A continuation of the design sequence.

Prerequisites: MET 351

MET 422 Transport Phenomena

Credits: (4-0) 4

The principles of momentum, heat and mass transfer and their application to metallurgical engineering. Topics covered include thermal conductivity, mass diffusion, mechanisms of transport, Fourier's and Fick's Laws, shell balance, boundary conditions, equations of change, unsteady-state transport, mass and heat distributions in turbulent flow, and interphase transport.

Prerequisites: MATH 321
Pre or Corequisites: MET 320

MET 426/526 Steelmaking

Credits: (3-0) 3

Chemical reactions and heat and mass transport phenomena associated with the production of steel. Unit operations studied include the blast furnace, the basic oxygen furnace, the electric arc furnace, and selected direct reduction processes.

Prerequisites: MET 320 or graduate standing.
Notes: Students enrolled in MET 526 will be held to a higher standard than those enrolled in MET 426.

MET 430/430L Welding Engineering and Design of Welded Structures/Lab

Credits: (2-1) 3

Introduces the state-of-art in welding processes and technology. Discusses fundamentals of the fabrication welded structures by introducing basics of solidification in welds, metallurgy of welds, fatigue and fracture in welds, joint design and weld defects and inspection. Laboratory exercises will focus on advanced welding processes, characterization, and materials testing methods.

Prerequisites: MET 232
Corequisites: MET 430L

MET 432/532 Advanced Materials and Processes

Credits: (3-0) 3

The physical metallurgy, structure, advanced processing methods, and applications of various advanced metallic materials will be covered in this course. Topics will include laser processing, advanced forging, powder metallurgy and other emerging techniques for materials such as superalloys, metal matrix composites, nanocrystalline materials, advanced steels, titanium alloys, shape memory alloys, amorphous materials and mechanical alloyed materials.

Prerequisites: MET 232 or graduate standing.
Notes: Students enrolled in MET 532 will be held to a higher standard than those enrolled in MET 432.

MET 433 Process Control

Credits: (3-0) 3

Analysis and design of process control systems for industrial processes, including control tuning and design of multi-variable control scheme.

Prerequisites: MATH 321 and senior standing.
Notes: This course is cross listed with CBE 433.

MET 440/540 Mechanical Metallurgy

Credits: (3-0) 3

A course concerned with responses of metals to loads. Areas covered include elastic and plastic deformation under different force systems, dislocation theory, fracture, internal friction, fatigue, creep, residual stresses, and general fundamentals of metal working.

Prerequisites: MET 232 with a grade of "C" or better.
Pre or Corequisites: ME 216 or EM 321
Notes: Students enrolled in MET 540 will be held to a higher standard than those enrolled in MET 440.

MET 440L/540L Mechanical Metallurgy Lab

Credits: (0-1) 1

A course that provides practical experience in the mechanical behavior of metals focusing on mechanical testing, mechanical processing, and failure analysis.

Prerequisites: MET 231
Pre or Corequisites: MET 440/540
Notes: Students enrolled in MET 540L will be held to a higher standard than those enrolled in MET 440L.

MET 443 Composite Materials

Credits: (3-0) 3

The course will cover heterogeneous material systems; basic design concepts and preparation; types of composite materials; advances in filaments, fibers and matrices; physical and mechanical properties; failure modes; thermal and dynamic effects; and applications to construction, transportation and

communication.

Prerequisites: ME 316 or concurrent enrollment in MET 440.
Notes: This course is cross listed with ME 443.

MET 444/544 Security Printing Technology

Credits: (3-0) 3

The security and anti-counterfeiting technology field will be covered with an emphasis on printing of security end products. Students will understand the principles involved in the manufacture and use of security inks, the use of substrates in security printing, the manufacture, and the use of security inks design and use secure documents and authentication tools. Areas to be covered include interfacial phenomena such as dispersion of nanoparticles, substrate wetting, effect of particle concentration on solvent viscosity, how various printers function and color theory.

Notes: Students enrolled in MET 544 will be held to a higher standard than those enrolled in MET 444.

MET 445/545 Oxidation and Corrosion of Metals

Credits: (3-0) 3

Initially, the thermodynamics of electrochemical processes are covered; use of the Nernst equation and Pourbaix diagram is presented in this material. Fundamentals of electrode kinetics are then discussed with special emphasis on the derivation of the Butler-Volmer equation and application of the Evan's diagram. Following presentation of these fundamental concepts, phenomena observed in corrosion and oxidation such as uniform attack, pitting, stress corrosion cracking, and corrosion fatigue are discussed. Finally, selection of materials for site specific applications is covered.

Prerequisites: MET 320 or CBE 222 or ME 211 or graduate standing.
Notes: Students enrolled in MET 545 will be held to a higher standard than those enrolled in MET 445. This course is cross listed with CBE 445/545.

MET 450/550 Forensic Engineering

Credits: (3-0) 3

The principles of physical metallurgy, mechanical metallurgy, manufacturing processes, and service environments will be used to determine the causes(s) for failure of metallic, composite, and polymer engineering components. Analytical techniques and procedures to characterize fractographic features and microstructures, such as optical metallography, macrophotography, and scanning electron microscopy, will also be reviewed. Actual failed engineering components from a variety of industrial applications will be used as examples and be evaluated in the course. Fundamental engineering concepts, legal procedures of forensic engineering, failure mechanisms, technical report writing, and remedial recommendations will also be discussed.

Prerequisites: MET 231, MET 232, EM 321 or ME 216 or permission of instructor.
Notes: Students enrolled in MET 550 will be held to a higher standard than those enrolled in MET 450.

MET 464 Engineering Design III

Credits: (0-2) 2

A continuation of the design sequence.

Prerequisites: MET 352

MET 465 Engineering Design IV

Credits: (0-1) 1

A continuation of the design sequence, which includes a final technical design report and appropriate display material for the School of Mines Design Fair.

Prerequisites: MET 464

MET 489/589 Composites Manufacturing

Credits: (1-0) 1

A background in the concepts of polymers and polymerization as well as an overview of composites concepts, constituent materials, and manufacturing processes provide the groundwork in the first half of the course. A more detailed study of the Vacuum Assisted Resin Transfer molding (VARTM) processing builds upon this groundwork, including topics such as process materials and parameters, mold design and manufacture, and product design considerations. The course concludes with post-processing topics. In conjunction with the concepts lecture, students spend time in the lab constructing and using a simple mold which will illustrate some of the challenges of molding and finishing a composite product.

Notes: This course is cross listed with CBE 489/589. Students enrolled in MET 589 will be held to a higher standard than those enrolled in MET 489.

MET 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher

involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

MET 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

MET 601 Biomaterials

Credits: (3-0) 3

This course will provide students with an overview of the field of biomaterials with the knowledge necessary to conduct biomedical product development and/or biomaterials research. The first portion of the course will provide an introduction to the major classes of materials used in medical devices including metals, polymers, ceramics, composites, and natural materials. Topics covered will include material properties, material processing, testing, corrosion, biocompatibility, tissue responses, etc. The second portion of the course will cover specific biomaterial applications such as dental, orthopedic, cardiovascular, drug delivery, and tissue engineering. The topics of implant cleanliness and sterilization methods will also be discussed. In addition, the topic of national and international governmental regulations and requirements will be reviewed including examples of investigative devices exemptions and 510k submissions.

Notes: This course is cross listed with BME 601.

MET 614 Advanced Metallurgical Simulation Techniques

Credits: (3-0) 3

An advanced course in the simulation of metallurgical processes. Topics covered include numerical solution of partial differential equations, optimization techniques and numerical integration and interpolation. Although the course is intended primarily for metallurgy majors, the coverage is sufficiently broad that non-metallurgy majors are encouraged to enroll.

MET 624 Advanced Chemical Metallurgy

Credits: (3-0) 3

Application of metallurgical thermodynamics and transport phenomena to extractive metallurgical processes.

Prerequisites: MET 320, MET 321/321L and MET 422

MET 625 Strengthening Mechanisms in Metals

Credits: (3-0) 3

Study of the scientific fundamentals leading to the improvement of the mechanical properties of metallic materials. The treatment includes strengthening by strain hardening, grain and twin boundaries, solute atoms, precipitates, dispersed particles and fibers, martensitic transformations, texturing, point defects, and thermomechanical treatments. Enhancement of fracture, fatigue, and creep behavior is also treated.

Prerequisites: Permission of instructor.

MET 632 Theory of Dislocations

Credits: (3-0) 3

A study of defect theory in solids and their role in governing material behavior. Topics covered include the concept, properties, and mutual interaction of dislocations, point defects, stacking faults, dislocation dynamics (motion and multiplication). Application of defect theory to the phenomena of slip, plastic yielding, thermally-activated plastic flow, microstrain, internal friction, strain hardening, and mechanical twinning.

Prerequisites: MET 440 or permission of instructor.

MET 791 Independent Study

Credits: 1 to 3

Includes directed study, problems readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

MET 792 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Military Science

MSL 101 Leaderships and Personal Development

Credits: (1-0) 1

Make your first peer group at college one committed to performing well and enjoying the experience. Increase self-confidence through team study and activities in basic drill, physical fitness, rappelling, leadership reaction course, first aid, making presentations and basic marksmanship. Learn fundamental concepts of leadership in a profession in both classroom and outdoor laboratory environments.

Corequisites: MSL 101L

MSL 101L Leadership and Personal Development Lab

Credits: (0-1) 1

Designed to accompany MSL 101. Provides the students with hands-on experience to supplement and reinforce classroom instruction. Subjects addressed include drill and ceremonies, physical fitness training, marksmanship, first aid, rappelling and basic mountaineering skills. Voluntary off campus activities reinforce course work.

Corequisites: MSL 101
Notes: This course will count for 1 credit hour of physical education credit.

MSL 102 Introduction to Tactical Leadership

Credits: (1-0) 1

Learn and apply principles of effective leadership. Reinforce self-confidence through participation in physically and mentally challenging exercise with upper-division ROTC students. Develop communication skills to improve individual performance and group interaction. Relate organizational ethical values to the effectiveness of a leader.

Corequisites: MSL 102L

MSL 102L Introduction to Tactical Leadership Lab

Credits: (0-1) 1

Designed to accompany MSL 102. Provides the student with hands-on experience to supplement and reinforce classroom instruction. Subjects addressed include drill and ceremonies, physical fitness training, marksmanship, first aid, rappelling and basic mountaineering skills. Voluntary off campus activities reinforce course work.

Corequisites: MSL 102
Notes: This course will count for 1 credit hour of physical education credit.

MSL 201 Innovative Team Leadership

Credits: (1-0) 1

Learn/apply ethics-based leadership skills that develop individual abilities and contribute to the building of effective teams of people. Develop skills in oral presentations, writing concisely, planning events, coordination of group efforts, advanced first aid, land navigation, and basic military tactics. Learn fundamentals of ROTC's leadership assessment program.

Corequisites: MSL 201L

MSL 201L Innovative Team Leadership Lab

Credits: (0-1) 1

Students will develop leadership and management skills by being given the opportunity to perform duties in various leadership positions. Emphasis is placed on the development of leadership and managerial skills. Course is supplemented with instruction on the use of a lensatic compass and a topographic map, as well as various survival skills. Voluntary off campus activities reinforce course work.

Corequisites: MSL 201

MSL 202 Foundations of Tactical Leadership

Credits: (1-0) 1

Introduction to individual and team aspects of military tactics in small unit operations. Includes use of radio communications, making safety assessments, movement techniques, planning for team safety/security and methods of pre-execution checks. Practical exercises with upper-division ROTC students. Learn techniques for training others as an aspect of continued leadership development.

Corequisites: MSL 202L

MSL 202L Foundations of Tactical Leadership Lab

Credits: (0-1) 1

Students are provided the opportunity to reinforce classroom leadership and management training with practical experience. Students will also receive training in small unit tactics and use of the M-16 rifle. Voluntary off campus activities reinforce course work.

Corequisites: MSL 202

MSL 290 Basic Small Unit Leadership

Credits: (2-0) 2

Provides the student with practical experience in small unit leadership development, team building, and the technical and tactical skills needed to be a professional officer in the United States Army. Course includes instruction in and practical application of rifle marksmanship, orienteering, mountaineering, weapons proficiency, physical training, and small unit leadership skills.

Corequisites: Concurrent registration in either MSL 101 or MSL 201 is required.
Notes: May be repeated for a maximum of 4 credit hours.

MSL 291 Internship in Leadership I

Credits: (2-0) 2

This course is designed for ROTC Cadets who have completed M.S. I and II but not academically aligned to contract as M.S. IIIs. The course will expand on their applied leadership skills. Upon approval of the instructor, students will develop training plans, schedules, evaluation outlines and classroom instruction. Students may also do department approved research.

Notes: The class may be repeated up to two times, for a maximum of 4 credits, with permission of department head.

MSL 294 ROTC Summer Leadership Internship

Credits: (0-4) 4

The mission of ROTC Basic Camp is to serve as an alternative for the first two years of on-campus ROTC enrollment. Basic Camp offers students who did not take ROTC courses during their first two years of school the opportunity to enroll in ROTC at the start of their junior year. Basic Camp is a six week training period in which the student undergoes basic military training within a regular Army environment. Instruction consists of both classroom instruction and practical exercises along with considerable field training. All students are closely supervised and carefully evaluated by military officers.

MSL 301 Adaptive Team Leadership

Credits: (2-0) 2

Series of practical opportunities to lead small groups, receive personal assessments and encouragement, and lead again in situations of increasing complexity. Uses small unit tactics and opportunities to plan and conduct training for lower division students both to develop such skills and as vehicles for practicing leadership.

Corequisites: MSL 301L

MSL 301L Adaptive Team Leadership Lab

Credits: (0-2) 2

Provides the student with practical experience to supplement and reinforce classroom instruction. Subjects include drill and ceremonies, physical training instruction techniques and leadership, which will complement the student's preparation of ROTC advanced camp. Off campus.

Corequisites: MSL 301

MSL 302 Leadership in Changing Environments

Credits: (2-0) 2

Continues methodology of MSL 301. Analyze tasks; prepare written or oral guidance for team members to accomplish tasks. Delegate tasks and supervise. Plan for and adapt to the unexpected in organizations under stress. Examine and apply lessons from leadership case studies. Examine importance of ethical decision making in setting a positive climate that enhances team performance.

Prerequisites: MSL 301
Corequisites: MSL 302L

MSL 302L Leadership in Changing Environments Lab

Credits: (0-2) 2

Provides student with additional training in land navigation, drill and ceremonies, physical training, instruction techniques and leadership, which will complement the students' preparation for ROTC advanced camp. Off campus training is required.

Corequisites: MSL 302

MSL 394 Advanced Military Science Internship

Credits: (0-4) 4

Contracted ROTC Advanced Course Cadets will attend a six-week intensified military training phase at Ft. Lewis, Washington which will provide both classroom and practical experience in the military and leadership skills required by a commissioned officer.

MSL 401 Developing Adaptive Leaders

Credits: (2-0) 2

Introduces formal management skills including problem analysis, planning techniques, and the delegation and control of activities, providing an understanding of the command and staff organization used in the modern army and creating a forum for discussing professional and ethical decisions faced by commissioned officers.

Corequisites: MSL 401L

MSL 401L Developing Adaptive Leaders Lab

Credits: (0-2) 2

Provides practical experience supplementing and reinforcing classroom instruction, including drill and ceremonies, physical fitness training, instruction techniques, and operation of the cadet battalion. Off-campus training required.

Corequisites: MSL 401

MSL 402 Leadership in a Complex World

Credits: (2-0) 2

Provides information for transition to active or reserve commissioned service, developing administrative controls essential in managing a military organization, introducing the management of financial and personal affairs, and allowing time for discussion and analysis of the ethical decision-making process.

Corequisites: MSL 402L

MSL 402L Leadership in a Complex World Lab

Credits: (0-2) 2

Provides practical experience supplementing and reinforcing classroom instruction, including drill and ceremonies, physical fitness training, instructional techniques, small unit leadership and familiarization with duties of commissioned officers. Off campus training is required.

Corequisites: MSL 402

MSL 403 Third Year Advanced Military Science

Credits: (2-0) 2

Provides a transition to entering active or reserve commissioned service, including an in-depth study of military decision making, giving experience in planning and conducting squad and platoon level military exercises and leadership.

Prerequisites: MSL 401 and MSL 402

MSL 404 Third Year Advanced Military Science

Credits: (2-0) 2

Provides an in-depth study of military decision-making, giving experience in planning and conducting military exercises at squad and platoon level, including an opportunity to develop leadership techniques.

Prerequisites: MSL 401 and MSL 402

MSL 411 Developing Subordinate Leaders I

Credits: (2-0) 2

Provides practical experience supplementing and reinforcing classroom instruction, including drill and ceremonies, physical fitness training, instruction techniques, and operation of the cadet battalion. Off campus training required.

Corequisites: MSL 401

MSL 412 Developing Subordinate Leaders II

Credits: (2-0) 2

Provides practical experience supplementing and reinforcing classroom instruction, including drill and ceremonies, physical fitness training, instructional techniques, small unit leadership and familiarization with duties of commissioned officers. Off campus training is required.

Corequisites: MSL 402

MSL 480 Advanced Small Unit Leadership

Credits: (2-0) 2

Provides practical experience in small unit leadership development, team building, and officers' technical/tactical skills, including rifle marksmanship, orienteering, mountaineering, weapons proficiency, physical training, and small unit leadership skills.

Corequisites: MSL 301 and MSL 301L or MSL 401 and MSL 401L
Notes: May be repeated for a maximum of 4 credit hours.

MSL 491 Advanced Internship in Leadership

Credits: (2-0) 2

This course is designed for ROTC Cadets who have completed M.S. IV, but have not completed graduation requirements. The course will allow students to fully develop and conduct training on advanced military subjects. Students may also do department approved research.

Notes: The class may be repeated two times, for a maximum of 4 credits, with the permission of the department head.

MSL 494 Leader Development and Assessment Course

Credits: 3 to 4

This course is designed for ROTC Cadets who have completed M.S. IV but have not completed graduation requirements. The course will allow students to fully develop and conduct training on advanced military subjects. Students may also do department approved research.

Notes: The class may be repeated two times, for a maximum of 4 credits, with the permission of the department head.

Applied Music

MUAP 102 Class Instruction-Voice

Credits: (1-0) 1

One to two semester hours credit for class instruction is given for two one hour class meetings. Adequate preparation through practice is expected of all students.

Notes: May be used to fulfill the humanities credit for graduation.

MUAP 120 Applied Music-Woodwinds

Credits: 1 to 4

One to two hours credit for private lessons is given for half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for two to four hours of credit. Adequate preparation through practice is expected of all students.

Notes: May be used to fulfill the humanities credit for graduation.

MUAP 121 Applied Music-Woodwinds

Credits: 1 to 4

One to two hours credit for private lessons is given for half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for two to four hours of credit. Adequate preparation through practice is expected of all students.

Notes: May be used to fulfill the humanities credit for graduation.

MUAP 130 Applied Music-Brass

Credits: 1 to 4

One to two hours credit for private lessons is given for half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for two to four hours of credit. Adequate preparation through practice is expected of all students.

Notes: May be used to fulfill the humanities credit for graduation.

MUAP 131 Applied Music-Brass

Credits: 1 to 4

One to two hours credit for private lessons is given for half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for two to four hours of credit. Adequate preparation through practice is expected of all students.

Notes: May be used to fulfill the humanities credit for graduation.

MUAP 200 Applied Music-Voice

Credits: 1 to 4

One to two semester hours of credit for private lessons is given for on half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for two to four hours of credit. Adequate preparation through practice is expected of all students.

Prerequisites: Permission of instructor.
Notes: May be used to fulfill the humanities credit for graduation.

MUAP 201 Applied Music-Voice

Credits: 1 to 4

Class voice instruction is open to anyone interested. Emphasis is placed on the development of the fundamental voice techniques.

Notes: May be used to fulfill the humanities credit for graduation.

Music Ensemble

MUEN 100 Concert Choir

Credits: 0 to 2

An ensemble performing accompanied and unaccompanied literature for mixed voices. Membership determined by instructor's permission and audition only.

Notes: Any combination of PE and MUEN 100/ MUEN 101, MUEN 121, MUEN 122 may be allowed toward fulfillment of the physical education credit for graduation. May not be used to fulfill the humanities credit for graduation.

MUEN 101 Choral Ensembles

Credits: 1 to 2

An ensemble performing accompanied and unaccompanied literature for mixed voices. Membership determined by instructor's permission and audition only. School of Mines does not require an audition.

Prerequisites: Permission of instructor.
Notes: Any combination of PE and MUEN 100/ MUEN 101, MUEN 121, MUEN 122 may be allowed toward fulfillment of the physical education credit for graduation. May not be used to fulfill the humanities credit for graduation

MUEN 121 Symphonic Band

Credits: (1-0) 1

Members are selected by audition to perform the finest in original and transcribed literature in concert performances on and off-campus.

Notes: Any combination of PE and MUEN 100, MUEN 101, MUEN 121, MUEN 122 may be allowed toward fulfillment of the physical education credit for graduation. May not be used to fulfill the humanities credit for graduation.

MUEN 122 Concert Band

Credits: (1-0) 1

A joint enterprise open to university students and interested area musicians. Includes rehearsals and performance of band literature culminating in a public performance.

Notes: Any combination of PE and MUEN 100, MUEN 101, MUEN 121/ MUEN 122 may be allowed toward fulfillment of the physical education credit for graduation. May not be used to fulfill the humanities credit for graduation.

MUEN 260 Non-Credit Music Ensemble

Credits: 0

Development of vocal or instrumental skills and aesthetic perception through the study and performance of music.

Notes: This course cannot be counted for social science/humanities credit.

Music

MUS 100 Music Appreciation

Credits: (3-0) 3

A non-technical discussion designed to increase the enjoyment and appreciation of music.

MUS 110 Basic Music Theory I

Credits: 2 to 4

An integrated study and application of tonality, melody, harmony, texture and form, from music notation through modulation. Includes sight singing, ear training and dictation. Introduction to composition and arranging, i.e. instrument ranges, transposition, tessitura and preliminary score analysis.

MUS 117 Music in Performance I

Credits: (1-0) 1

This course introduces the functions and techniques of the craft of music through the study of music from both western and non-western cultures. It develops essential music performance tools and perceptual knowledge in musical analysis through the study, rehearsal, and performance of music, developing cultural awareness and creativity.

Notes: Repeatable for a maximum of 3 credits. If repeated for a total of three credits, this course counts towards partial fulfillment of the General Education Goal Four requirement.

MUS 317 Music in Performance II

Credits: (1-0) 1

This course builds on concepts introduced in MUS 117 to develop advanced understandings of cultural, historical, and aesthetic perceptions through in-depth study and performance of ensemble music of both western and non-western cultures.

Prerequisites: Three previous semesters of any combination of MUEN 101 /MUEN 122 or MUS 117 and/or permission of instructor.
Notes: Repeatable for a maximum of 3 credits.

Nanoscience and Nanoengineering

NANO 401 Introduction to Nanoscience

Credits: (3-0) 3

Introduction to the concepts, motivations, and challenges of nanoscience. Topics include the emergence and background of nanoscience. Properties, applications, and characterization of nanoscale materials and systems will be examined. The course will particularly benefit students considering graduate studies that may involve nanotechnology research. Principles of basic physics, chemistry, and mathematics will be involved.

Prerequisites: PHYS 213/213-A, PHYS 213L , CHEM 114, MATH 321 or permission of instructor.

NANO 445/545 Introduction to Nanomaterials

Credits: (3-0) 3

This course will introduce the theoretical basis and synthetic processes on nanomaterials. Specifically, this course will focus on the synthesis and fabrication of nanostructures and nanomaterials, and also include content on the nanoscale property measurements. Finally, the course will cover applications of nanomaterials, particularly focusing upon inorganic nanomaterials.

Prerequisites: MET 232, EM 321
Notes: Students enrolled in NANO 545 will be held to a higher standard than those enrolled in NANO 445.

NANO 475/575 Advances in Processing and Nanoengineering of Polymers

Credits: (2-0) 2

The course will begin with an overview of the basic principles of polymer rheology and structure formation. It will then review recent examples from the scientific literature in which concepts and theories of rheological behavior and structure formation at multiple length scales have been further developed and/or applied to the processing of polymers and composites with advanced functional and multifunctional properties. Special attention will be paid to research related to processing challenges in the formation of polymer nanocomposites, nanofibers and hierarchical composite structures. As part of this course, students will be expected to develop skills in reviewing and critically assessing the scientific literature, and in developing research strategies based on current state of knowledge.

Prerequisites: CHEM 114 /CHEM 114L or MES 604 or permission of instructor.
Notes: Students enrolled in NANO 575 will be held to a higher standard than those enrolled in NANO 475. This course is cross listed with CBE 475/575 and MES 475/575.

NANO 504 Nanophotonics

Credits: (3-0) 3

The course deals with optical phenomena in materials and structures with subwave-length dimensions. Topics will include the quantum theory of light, laser theory, beam propagation, and the unique properties of nanophotonic structures.

Prerequisites: Introductory quantum mechanics and electricity and magnetism; ability to solve ordinary differential equations and linear systems.
Notes: This course is cross-listed with EE 404/504 and PHYS 404/504.

NANO 521 Electromagnetism

Credits: (4-0) 4

This is a course in the principles of electricity and magnetism, with applications to dielectric and magnetic materials. Topics include the development of Maxwell's equations, and applications.

Prerequisites: PHYS 213/213-A and MATH 321
Notes: This course is cross listed with PHYS 421/521.

NANO 551 Classical Mechanics

Credits: (4-0) 4

This is a systematic introduction to classical mechanics emphasizing motion in three dimensions. Topics include central forces, harmonic oscillations, non-inertial reference frames, rigid body motion, and Langrangian and Hamiltonian Mechanics.

Prerequisites: PHYS 113 or PHYS 213/213-A
Pre or Corequisites: MATH 321
Notes: This course is cross listed with PHYS 451/551.

NANO 571 Quantum Mechanics

Credits: (4-0) 4

This is a systematic introduction to quantum mechanics, emphasizing the Schrödinger equation. Topics include simple soluble problems, the hydrogen atom, approximation methods and other aspects of quantum theory.

Prerequisites: MATH 321 or permission of instructor.
Notes: This course is cross listed with PHYS 471/571.

NANO 604 Nanophotonic Materials

Credits: (3-0) 3

This graduate course will study the analysis and properties of nanostructured photonic materials such as photonic crystals and plasmonic materials.

NANO 636 Photovoltaics

Credits: (3-0) 3

This course will cover modern silicon photovoltaic (PV) devices, including the basic physics, ideal and nonideal models, device parameters and design, and device fabrication. The emphasis will be placed on crystalline and multicrystalline devices, but thin films will also be introduced. PV applications and economics will also be discussed.

Notes: This course is cross listed with MES 636.

NANO 701 Nano Materials

Credits: (3-0) 3

This course will focus on the formation of nanomaterials via gas and liquid phase routes. Theory of homogeneous and heterogeneous nucleation, growth mechanisms and kinetics as well as population balances will be discussed. The second part of the course will cover particle surface functionalization, colloidal properties and stability, processing of nonparticle suspensions, and chemical and physical fabrication techniques. Application of nanostructures and nanomaterials will be discussed as well.

NANO 702 Theory and Application of Nanoscale Materials

Credits: (3-0) 3

The course will survey current research in nanoscience and nanotechnology, providing the essential background and theory at a level accessible to students from varied scientific and engineering backgrounds. Special emphasis will be placed on nano-scaled materials and their practical applications.

Prerequisites: Introductory quantum mechanics, ability to solve ordinary differential equations and linear systems.

NANO 703/703L Instrumentation and Characterization of Nano-Materials/Lab

Credits: (3-1) 4

This is an introductory course on instrumentations used in characterization of nano-scaled materials. The course is aimed at entry level graduate students who want to learn characterization of nano-scale materials using state-of-the-art instruments.

Corequisites: NANO 703L

NANO 704 Crystallography and Structure of Nanomaterials

Credits: (3-0) 3

This graduate course covers crystallographic characteristics and structural properties of nanomaterials. Emphasis is placed on electron and x-ray diffraction signatures of nanoparticle size, shape, and configuration.

NANO 705 Nanoelectronics

Credits: (3-0) 3

This graduate course covers the electronic properties and applications of nanomaterials and particular emphasis on quantum semiconductor structures.

NANO 706 Diffraction Methods for Nanomaterials Research

Credits: (3-0) 3

This graduate course covers structural, optical, and electronic defects in nano-scaled materials.

NANO 707 Defects in Nanomaterials

Credits: (3-0) 3

This graduate course covers the characterization and identification of structural and electronic defects in nano-scaled materials systems.

NANO 708 Nanomaterials for Photovoltaics

Credits: (3-0) 3

This graduate course covers the engineering of materials and structures on the nanometer length scale for the photovoltaic power generation from radiant sources, especially the sun.

NANO 709 Scientific Instrumentation, Control, and Visualization

Credits: (3-0) 3

This graduate course covers the instrumentation and control of scientific experiments as well as processing and visualization of the resulting data. Emphasis is placed on the use of modern software such as LabView, Matlab and others of recent interest.

Prerequisites: Graduate standing.

NANO 712/712L Electromagnetic Properties of Heterogeneous Materials/Lab

Credits: (2-1) 3

Focuses on the macroscopic electromagnetic properties of heterogeneous materials and their applications. With nanotechnology, it is possible to manufacture materials with totally new properties that cannot be attained by conventional methods. Through the combined use of analysis (such as mixing theory) and numerical methods, the macroscopic material properties will be computed directly from the microscopic composition of the material.

Corequisites: NANO 712L

NANO 715 Polymeric Nanomaterials

Credits: (3-0) 3

This course is an introduction of fundamental concepts, synthesis, characterizations, structural and physical properties of polymeric nanomaterials. The contents include, but are not limited to, nanofibers, carbon nanotubes, nanocomposites, polymer self-assembly, biopolymers in nanoscience's, and nanoparticle coatings.

NANO 716 Digital Fabrication: Materials and Processes

Credits: (3-0) 3

The principles of interfacial phenomenon, solution thermodynamics, and colloid chemistry will be used

in illuminated process by which metallic nanoparticulates can be formed and incorporated into inks for use in manufacturing of a variety of products. Students will learn 1) the methods and science behind the manufacture of a variety of functional nanoparticles, 2) the methods of incorporating these particles into inks and the printing of these inks for digital fabrication applications, and 3) the interfacial processes involved in line spreading and curing of the printed traces.

Notes: This course is cross listed with MES 716.

NANO 717 Nanochemistry

Credits: (3-0) 3

The course introduces both the fundamentals and frontiers of the rapidly developing interdisciplinary field of nanomaterials from a chemist's point of view. The course covers synthesis and fabrication methods of nanomaterials including "top-down" nanofabrication, "bottom-up" chemical synthesis, and self-assembly. The course discusses the unique properties and the structure-property relationship of nanomaterials.

NANO 719 Nanomaterials for Biosensors

Credits: (3-0) 3

Topics covered will include the fundamental principles of signal recognitions in protein, DNA, and enzyme biosensors, basic properties of nanomaterials related to sensors, electrochemical biosensors, optical and fluorescence sensors, chemiresistors, sensors based on semiconductor electronic devices, and the recent development of innovative nanomaterials for next-generation biosensors.

Prerequisites: Enrollment in one of the Biomedical Engineering, or Nanoscience & Nanoengineering, or Materials Engineering and Science programs, or Permission of Instructor.
Notes: NANO 719 is cross-listed with BME 719 and MES 719.

NANO 721 Electrodynamics I

Credits: (3-0) 3

A continuation of PHYS 421. This course treats advanced problems with special emphasis on solutions of the wave equation, Laplace's equation, and Poisson's equation. Through introduction of the methods of special relativity, the unity of electrical and magnetic phenomena and the covariance of Maxwell's equations are demonstrated. If time permits, topics such as MHD and plasma physics are also introduced.

Notes: This course is cross listed with PHYS 721.

NANO 736 Advanced Photovoltaics

Credits: (3-0) 3

This course builds on the foundations established in MES 736 /NANO 636. It will cover advanced photovoltaic concepts, including thin films, compound semiconductors, spectral conversion devices, and organic and polymeric devices. Advanced device designs will be emphasized. Evaluation will include a research paper addressing a current PV topic.

Notes: This course is cross listed with MES 736.

NANO 743 Statistical Mechanics

Credits: (3-0) 3

Review fundamentals of thermodynamics, introduce Legendre transforms and develop the concepts of phase equilibria and stability, ensembles, partition functions, and the role of fluctuations. Statistical mechanics of non-interacting ideal systems and phase transformations, mean field theory, renormalization group theory and Monte Carlo calculations applied to the Ising Model.

Notes: This course is cross listed with PHYS 743.

NANO 751 Theoretical Mechanics

Credits: (3-0) 3

Advanced treatment of classical mechanics, including Lagrange's and Hamilton's equations, rigid-body motion, canonical transformations, calculus of variations, and relativity using vectors, matrices, and tensors.

Notes: This course is cross listed with PHYS 751.

NANO 771 Quantum Mechanics I

Credits: (3-0) 3

Physical basis of quantum mechanics, Schroedinger's equation and its solution, matrix mechanics, operator methods, approximate methods with an introduction of the relativistic wave equation.

Prerequisites: PHYS 471
Notes: This course is cross listed with PHYS 771.

NANO 791 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

NANO 792 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

NANO 890 Seminar

Credits: (1-0) 1

A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division of graduate levels.

Notes: Repeatable for a maximum of 3 credits.

NANO 898D Dissertation

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 30 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates.

Paleontology

PALE 672/672L Micropaleontology/Lab

Credits: (2-1) 3

A study of the morphology, ecology, and stratigraphic significance of selected groups of protozoans and invertebrate and plant microfossils with special emphasis on Formaninifera and conodonts.

Corequisites: PALE 672L
Notes: This course is cross listed with GEOL 672/672L.

PALE 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.
Notes: A description of the work to be performed must be filed in the Department of Geology and Geological Engineering.

PALE 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A description of the work to be performed must be filed in the Department of Geology and Geological Engineering Department. This course is cross listed with GEOL 692.

PALE 798 Thesis

Credits: Credit to be arranged.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Notes: Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursing the M.S. thesis option.

Physical Education

PE 100 Activity Courses

Credits: (1-0) 1

Activities stressing individual physical fitness and lifetime activities according to student needs and interest.

Notes: The same activity course cannot be counted toward graduation credit.

PE 103 Nutrition for Everyday Living

Credits: (1-0) 1

This course will teach nutritional components of healthy diet, impact on both composition, and overall health. Course includes lecture and activity.

Notes: This course can only be taken one time for credit.

PE 105 Wellness & Physical Fitness

Credits: (1-0) 1

For men and women. An activity course with lecture instructing students in many different aspects of personal wellness and physical fitness with practical application.

Notes: This course can only be taken one time for credit.

PE 113 Varsity Sports I

Credits: (1-0) 1

This course is an introduction/conditioning course offered fall semester. A student must be a member of a varsity sport team that is sponsored by SDSM&T to be enrolled in this course.

Notes: This course can only be taken four times for credit, however it may only be used two times to fulfill physical education graduation requirements.

PE 118 Beginning and Intermediate Swimming (Men and Women)

Credits: (1-0) 1

This course will provide instruction in basic skills and fundamental strokes of swimming. After developing basic skills, the fundamental strokes are perfected along with elementary forms of rescue.

Notes: This course can only be taken one time for credit.

PE 160 Modified Physical Education Activity

Credits: (1-0) 1

This course is designed to adapt a variety of activities to the special needs and interests of students who qualify under the Americans with Disabilities Act. The course will seek to adapt physical fitness and sports activities for the special needs students within the limitations of current staffing and facilities.

Notes: Course can be repeated once for additional credit.

PE 191 Independent Study

Credits: 1 to 3

Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans.

Prerequisites: Permission of instructor.

Philosophy

PHIL 100 Introduction to Philosophy

Credits: (3-0) 3

Introduces competing philosophical views of reality, perception, learning, and values, emphasizing their relevance to the contemporary world.

PHIL 200 Introduction to Logic

Credits: (3-0) 3

Introduces the formal study of argumentation, including forms of logic, inductive and deductive reasoning, proofs, refutations, and fallacies.

PHIL 220 Introduction to Ethics

Credits: (3-0) 3

Examines the major currents and components of ethical theory from classical times to the present, investigating problems arising from specific theories, as well as critically analyzing the validity of these theories for current ethical concerns.

PHIL 233 Philosophy and Literature

Credits: (3-0) 3

Examination of selected topics from the Western World's literary tradition and analysis of their contributions in the areas of philosophy of life, philosophy of religion, and the concepts of duty and human nature. Study and discussion of topics in relation to their significance for the individual.

Physics

PHYS 111 Introduction to Physics I

Credits: (3-0) 3

This is the first course in a two semester algebra-level sequence, covering fundamental concepts of physics. The sequence is appropriate for pre-professional majors requiring two semesters of physics. Topics include classical mechanics, thermodynamics, and waves.

Prerequisites: MATH 102 or MATH 123 or permission of instructor.
Notes: The School of Mines course covers classical mechanics only. May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

PHYS 111L Introduction to Physics I Laboratory

Credits: (0-1) 1

This laboratory accompanies PHYS 111.

Pre or Corequisites: PHYS 111
Notes: May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

PHYS 113 Introduction to Physics II

Credits: (3-0) 3

This course is the second course in a two semester algebra-level sequence, covering fundamental concepts of physics. Topics include electricity and magnetism, sound, light, optics, and some modern physics concepts.

Prerequisites: PHYS 111
Notes: The School of Mines course covers electricity and magnetism only. May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

PHYS 113L Introduction to Physics II Laboratory

Credits: (0-1) 1

This laboratory accompanies PHYS 113.

Pre or Corequisites: PHYS 113
Notes: May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

PHYS 183 Elements of Modern Astronomy

Credits: (3-0) 3

This course presents a broad view of astronomy in a straightforward and descriptive manner without complex mathematics. It introduces students to basic concepts and the historic and modern foundations of the science of astronomy. Students will gain some insight into the basic physics underlying conclusions drawn from observational and theoretical astronomy, astrophysics, and cosmology. The course provides descriptions of a wide variety of objects found in the universe, from gas and dust particles to stars, planets, and galactic clusters.

PHYS 211/211-A University Physics I/Recitation

Credits: (3-0) 3

This is the first course in a two semester calculus-level sequence, covering fundamental concepts of physics. This is the preferred sequence for students majoring in physical science or engineering. Topics include classical mechanics and thermodynamics.

Prerequisites: MATH 123
Notes: The School of Mines course covers classical mechanics only.

PHYS 213/213-A University Physics II/Recitation

Credits: (3-0) 3

This course is the second course in a two semester calculus-level sequence, covering fundamental concepts of physics. This is the preferred sequence for students majoring in physical science or engineering. Topics include electricity and magnetism, sound, light, and optics.

Prerequisites: PHYS 211/211-A
Notes: The School of Mines course covers electricity and magnetism only.

PHYS 213L University Physics II Laboratory

Credits: (0-1) 1

This laboratory accompanies PHYS 213/213-A. Introduction to physical phenomena and measurements. Recording and processing data, determining uncertainties, reporting results. The experiments supplement the work PHYS 211 and PHYS 213.

Pre or Corequisites: PHYS 213/213-A

PHYS 225 Vibrations, Waves, and Optics

Credits: (3-0) 3

Exploration of the rich behavior of vibrating systems. Simple harmonic motion, driven oscillators and resonance, normal modes, Fourier analysis, progressive waves, geometrical optics, diffraction and interference.

Prerequisites: MATH 225; or permission of instructor
Pre or Corequisites: PHYS 213/213-A

PHYS 275 Relativity

Credits: (3-0) 3

Michelson-Morley experiment, inertial reference frames, the principle of relativity, space-time coordinates of an event, Lorentz Transformations, clock paradox, momentum-energy 4-vector, equivalence of energy and rest mass, the principle of equivalence, curved space-time and qualitative features of general relativity and cosmology, relevance of relativity to space travel.

Prerequisites: PHYS 111 or PHYS 211/211-A and a working knowledge of elementary algebra and trigonometry.

PHYS 291 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

PHYS 292 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

PHYS 312 Experimental Physics Design I

Credits: (0-2) 2

This course is structured to acquaint the student with the experimental design methods. The experiments are chosen to cover as many areas as possible in keeping with the backgrounds of faculty and abilities of the students.

Prerequisites: CENG 244/244L or permission of instructor.

PHYS 314 Experimental Physics Design II

Credits: (0-2) 2

This course is structured to acquaint the student with the experimental design methods. The experiments are chosen to cover as many areas as possible in keeping with the backgrounds of faculty and abilities of the students.

Prerequisites: CENG 244/244L or permission of instructor.

PHYS 321 The Physics & Implications of Space Travel

Credits: (3-0) 3

NASA has recently begun accepting applications for the first manned mission to Mars! How long until mankind is able to travel beyond our own solar system? What are the requirements and implications of such ventures?

There is a dynamic relationship between technology, the science that makes it possible and the people that use it. Many courses attempt to treat technology, science and people as separate entities even though changes in one tend to have a direct and almost immediate impact on the others. To truly understand the implications that space travel would have on humanity, we must integrate all aspects of this dynamic relationship into one. The result is a course based on equal parts Physics and Metaphysics.

PHYS 331 Introduction to Modern Physics

Credits: (3-0) 3

This course concentrates on observations and theories of the 20th Century that carried the physicists' world-view beyond the classical.

Prerequisites: PHYS 113 or PHYS 213/213-A

PHYS 341 Thermodynamics

Credits: (2-0) 2

This course is an intermediate level thermodynamics course dealing with systems from a macroscopic perspective. Topics include the first and second laws of thermodynamics, phase diagrams, and equilibria.

Prerequisites: PHYS 213/213-A, and MATH 225 or permission of instructor.

PHYS 343 Statistical Physics

Credits: (2-0) 2

This course provides a systematic introduction to the use of statistical principles applied to the study of thermodynamic systems.

Prerequisites: PHYS 331 , PHYS 341 and MATH 321 or permission of instructor.

PHYS 361 Optics

Credits: (3-0) 3

This is an intermediate level study of geometrical and physical optics. Topics include analysis of refraction phenomena, thick lenses, wave nature of light, interference, diffraction, and polarization.

Prerequisites: PHYS 113 or PHYS 213/213-A and MATH 225 or permission of instructor.

PHYS 386/386L Observational Astronomy/Lab

Credits: (2-1) 3

This course is designed to help students expand their knowledge of astronomy through interactive seminars and observing sessions. The focus of this course will be on developing observational and data collection skills using state of the art telescopes. Background knowledge will be fostered through instructor-supervised seminars led by students. Students will use current web-based and advanced amateur/professional publications to lead the seminar sessions. Advanced observing sessions will be held off-campus at the Badlands Observatory in Quinn, SD. Observing sessions will incorporate advanced 18 and 26 inch telescopes provided by the instructors; also with CCD cameras and software for data collection and image manipulation. Observing sessions will also involve student in ongoing searches for near-earth asteroids.

Prerequisites: PHYS 183
Corequisites: PHYS 386L

PHYS 391 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends upon the requirements of the topic.

Prerequisites: Permission of instructor.

PHYS 392 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

PHYS 404/504 Nanophotonics

Credits: (3-0) 3

The course deals with optical phenomena in materials and structures with subwave-length dimensions. Topics will include the quantum theory of light, laser theory, beam propagation, and the unique properties of nanophotonic structures.

Prerequisites: Introductory quantum mechanics and electricity and magnetism; ability to solve ordinary differential equations and linear systems.
Notes: This course is cross-listed with EE 404/504 and NANO 504. Students enrolled in PHYS 504 will be held to a higher standard than those enrolled in PHYS 404.

PHYS 412 Advanced Design Projects I

Credits: (0-3) 3

The student designs and carries out original projects. The aim is to involve the student in project design and the application of knowledge to a realistic problem. Students will be significantly engaged in the research efforts of the department.

PHYS 414 Advanced Design Projects II

Credits: (0-4) 4

The student designs and carries out original projects. The aim is to involve the student in project design and the application of knowledge to a realistic problem. Students will be significantly engaged in the research efforts of the department.

PHYS 421/521 Electromagnetism

Credits: (4-0) 4

This is a course in the principles of electricity and magnetism, with applications to dielectric and magnetic materials. Topics include the development of Maxwell's equations, and applications.

Prerequisites: PHYS 213/213-A and MATH 321
Notes: Students enrolled in PHYS 521 will be held to a higher standard than those enrolled in PHYS 421. This course is cross-listed with NANO 521.

PHYS 433/533 Nuclear and Elementary Particle Physics

Credits: (3-0) 3

This course covers fundamental topics in nuclear physics and elementary particles. Topics include radioactivity, nuclear spectra and structure, nuclear models, elementary particle theories and high energy physics.

Prerequisites: PHYS 471 or permission of instructor.
Notes: Student enrolled in PHYS 533 will be held to a higher standard than those enrolled in PHYS 433.

PHYS 439/539 Solid State Physics

Credits: 4

This course looks at solid materials from a microscopic level. Topics include basic crystal structure; mechanical and thermal properties; and electronic processes with reference to electrical properties of metals, semiconductors, and insulators.

Prerequisites: MATH 225, MATH 321, PHYS 331 or permission of instructor.
Notes: Students enrolled in PHYS 539 will be held to a higher standard than those enrolled in PHYS 439.

PHYS 445/545 Statistical Mechanics

Credits: (4-0) 4

This course provides a systematic introduction to the use of statistical principles applied to the study of thermodynamic systems.

Prerequisites: PHYS 451/551 and MATH 321 or permission of instructor.
Notes: Students enrolled in PHYS 545 will be held to a higher standard than those enrolled in PHYS 445.

PHYS 451/551 Classical Mechanics

Credits: (4-0) 4

This is a systematic introduction to classical mechanics emphasizing motion in three dimensions. Topics include central forces, harmonic oscillations, non-inertial reference frames, rigid body motion, and Lagrangian and Hamiltonian Mechanics.

Prerequisites: MATH 321
Notes: Students enrolled in PHYS 551 will be held to a higher standard than those enrolled in PHYS 451. This course is cross listed with NANO 551.

PHYS 471/571 Quantum Mechanics

Credits: (4-0) 4

This is a systematic introduction to quantum mechanics, emphasizing the Schrödinger equation. Topics include simple soluble problems, the hydrogen atom, approximation methods and other aspects of quantum theory.

Prerequisites: MATH 321 or permission of instructor.
Notes: Students enrolled in PHYS 571 will be held to a higher standard than those enrolled in PHYS 471. This course is cross listed with NANO 571.

PHYS 481/581 Mathematical Physics

Credits: 4

This course looks at mathematical methods used to formulate and solve problems in various fields of physics. Topics are chosen from: series solutions, special functions, computational methods, complex variables, multi-variate methods, transform methods, and other areas of mathematical applications to physics.

Prerequisites: Permission of instructor.
Notes: PHYS 481 is 4 credits and PHYS 581 is 3 credits. Students enrolled in PHYS 581 will be held to a higher standard than those enrolled in PHYS 481.

PHYS 491 Independent Study

Credits: 1 to 4

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

PHYS 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

PHYS 683 Mathematical Physics II

Credits: (3-0) 3

A continuation of PHYS 581. The topics of emphasis are partial differential equations, boundary value problems, special functions, Green's Functions, and linear algebra. Additional topics of interest will be chosen; possible topics include differential forms and geometry, tensors in physics, group theory, distributions, statistical methods, integral equations, difference equations, numerical methods, variation techniques, etc.

Prerequisites: PHYS 581

PHYS 691 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

PHYS 692 Topics

Credits: 1 to 3

Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

PHYS 721 Electrodynamics I

Credits: (3-0) 3

This is the first course of a two-semester sequence in electrodynamics. Topics in the sequence include boundary value problems, Maxwell's equations, multi-pole expansions and gauge transformations. Additional topics will be chosen from such areas as the relativistic formulation of electro-magnetic theory, Lagrangian formulations of classical fields, plane and spherical waves, wave guides, multipole radiation, radiation from moving charges, plasma physics, magneto-hydrodynamics, relativistic (synchrotron) radiation, and radiation in collisions and other applications of interest.

Prerequisites: PHYS 421 or equivalent.
Notes: This course is cross listed with NANO 721.

PHYS 723 Electrodynamics II

Credits: (3-0) 3

This course is the second course in a two-semester sequence and covers advanced topics in electrodynamics.

Prerequisites: PHYS 721

PHYS 733 Experimental Particle Physics: Principles, Data Analysis, and Simulation

Credits: (3-0) 3

This course introduces advanced technology and analysis techniques in modern particle and astroparticle physics experiments. It consists of four parts, (1) Particle interactions with matter and particle detectors, (2) Overview of backgrounds, (3) Detector and experiment calibration, (4) Simulation and data analysis. Lectures will be given along with practice on the application of important physics principles, popular simulation and analysis tools. As their final project, each student is required to present an analysis of one typical modern particle or astroparticle physics experiment, or to participate in research work on dark matter search, neutrino and cosmic ray experiments and present the results.

Prerequisites: CSC 150/150L, PHYS 433/533, PHYS 471/571, or permission of instructor.

PHYS 739 Condensed Matter Physics I

Credits: (3-0) 3

Topics include crystal structure and the reciprocal lattice, quantum theory of electrons and phonons, x-ray diffraction, crystal binding energies, and energy band theory. Additional topics may be chosen from the properties of metals, semiconductors, and insulators.

Prerequisites: PHYS 439 or equivalent.

PHYS 743 Statistical Mechanics

Credits: (3-0) 3

This is a one-semester course in classical and quantum statistical mechanics. Topics include ensembles, partition functions, identical particles, Fermi-Dirac and Bose-Einstein statistics. Other topics will be chosen from mean field theory, phase transformations, renormalization group theory, Monte Carlo techniques, and other topics of interest.

Prerequisites: PHYS 443 (USD course) or equivalent.
Notes: This course is cross listed with NANO 743.

PHYS 749 Condensed Matter Physics II

Credits: (3-0) 3

This course is the second course in a two-semester sequence and covers advanced topics in condensed matter physics.

Prerequisites: PHYS 739

PHYS 751 Classical Mechanics

Credits: (3-0) 3

This is a one semester course in classical mechanics. Topics include Newtonian Mechanics, Hamilton's Principle, Non-Inertial Frames of Reference, Lagrangian Mechanics. Other topics will be chosen from such areas of study as Rigid Body Motion, Chaos theory, Hamilton-Jacobi theory, Perturbation theory, Quaternion applications to rotations, Lagrangian/Hamiltonian formulations for Continuous systems and fields, and other topics of interest.

Prerequisites: PHYS 451 or equivalent.
Notes: This course is cross listed with NANO 751.

PHYS 761 Nuclear and Particle Physics

Credits: (3-0) 3

This is a one semester course in nuclear and elementary particle physics. Nuclear physics topics may include nuclear structure (nuclear form factors, multipole moments, liquid and shell models); nuclear decay; nuclear reactions; and other topics of interest. Elementary particle physics topics may include the role of symmetry in particle physics, Quantum Electrodynamics and Quantum Chromodynamics; the Standard Model of Particle Physics; Strong and Weak interactions; Accelerator and Experimental Particle Physics; and other selected topics beyond the Standard Model.

Prerequisites: PHYS 771 or equivalent.

PHYS 763 Advanced Particle Physics

Credits: (3-0) 3

This one-semester course is aimed at bridging the gap between standard textbook material and research literature. The course will illustrate applications of particle physics and technology introduced in prerequisite courses to a variety of fields, which may include industry, medicine, and leading-edge physics research at accelerators and underground laboratories such as that focused on neutrino physics or dark matter. Participants will be guided through one or several applications taken from those fields in great detail. This course provides necessary training for those who intend to work in a discipline where

particle physics and technology plays an important role.

Prerequisites: PHYS 761

PHYS 765 Advanced Nuclear Physics

Credits: (3-0) 3

This one-semester course is aimed at bridging the gap between standard textbook material and research literature. Topics in nuclear structure, including microscopic models, shell models, and collective models will be addressed. Similarly, topics of nuclear reactions via strong, weak, and electromagnetic interaction mechanisms, as well as models of excitation, evolution and de-excitation of excited nuclear states will be studied. The nuclear physics and technology introduced in prerequisite courses are applied in nuclear medicine (PET and cancer therapy), industry (material analysis and ion implantation for example), archaeology (radiocarbon dating for example), and astrophysics (nucleosynthesis, stellar evolution for example). Participants will be guided through one or several applications taken from those fields in great detail. This course provides necessary training for those who intend to work in a discipline where nuclear science and technology plays an important role.

Prerequisites: PHYS 761

PHYS 771 Quantum Mechanics I

Credits: (3-0) 3

This is the first course of a two semester sequence in quantum physics. Topics include the Schrödinger equation and its solutions, matrix mechanics, operator methods, the harmonic oscillator, the hydrogen atom, spin and angular momentum.

Prerequisites: PHYS 471 or equivalent.
Notes: This course is cross listed with NANO 771.

PHYS 773 Quantum Mechanics II

Credits: (3-0) 3

This is the second course in a two semester sequence. Additional topics include perturbation methods. Applications will be chosen from such topics as scattering theory, second quantization, theory of identical particles, relativistic quantum mechanics, creation and annihilation operators and other topics of interest.

Prerequisites: PHYS 771

PHYS 775 General Relativity

Credits: (3-0) 3

This course includes study of Minkowski Space, tensor algebra and calculus, non-Euclidean Geometry, and the Einstein Field Equations. Applications will be chosen from such topics as the Schwarzchild, Kerr, and Reisner-Nordstrom solutions, gravitational waves, Post-Newtonian Formulisms, 3 + 1 formulism, and other topics of interest.

Prerequisites: PHYS 421/521 , PHYS 451/551 or equivalent.

PHYS 779 Group Theory

Credits: (3-0) 3

Topics may include symmetry transformations, continuous groups, finite groups, applications to valence theory, Lorentz group, and fundamental particles.

Prerequisites: PHYS 471 or equivalent.

PHYS 783 Quantum Field Theory

Credits: (3-0) 3

This course is the study of relativistic quantum field theory and its application to the standard model. The course covers quantization of relativistic fields; perturbation theory and Feynman diagram; S-matrix; introduction to gauge theories and the standard model; and other topics of interest.

Prerequisites: PHYS 771 or equivalent.

PHYS 784 Advanced Quantum Field Theory

Credits: (3-0) 3

This course is the second semester of the quantum field theory sequence covering the application of quantum field theory to the standard model; including electroweak interactions and spontaneous symmetry breaking. Other possible topics include grand unification and supersymmetry.

Prerequisites: PHYS 783

PHYS 785 Astrophysics and Cosmology

Credits: (3-0) 3

This course introduces the broad base of fundamental topics in astrophysics and cosmology. Topics include observational properties of stars; stellar physics; stellar atmospheres; distance scales; galactic structures; interstellar medium, normal and peculiar galaxies and high energy astrophysics, cosmological observations and Friedmann models; the early universe at different epochs; the origin of dark matter and formation of galaxies and large scale structure.

Prerequisites: PHYS 771 or equivalent.

PHYS 786 Nuclear Astrophysics and the Origin of the Elements

Credits: (3-0) 3

This one-semester course is aimed at bridging the gap between standard nuclear physics textbooks and state-of-the-art research literature. It will be illustrated how the field of nuclear astrophysics, at the intersection of nuclear physics, astrophysics, and observational astronomy, explores the chemical evolution of our universe, determines the energetics of astrophysical objects, and identifies their observational signatures. Participants will be guided through four major directions: nucleosynthesis processes in stars studied with very low energy accelerator experiments; explosive nucleosynthesis processes requiring measurements far off of stability with radioactive beams; neutron-induced nucleosynthesis in late stellar evolution pursued at reactor and neutron spallation facilities; and finally neutrino-induced nucleosynthesis, still mostly confined to theoretical prediction and observation. It provides necessary training for those who intend to work in a discipline where nuclear science plays an important role.

Prerequisites: PHYS 771 ; or permission of instructor.

PHYS 790 Seminar

Credits: 1 to 3

A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as internet and are at the upper division graduate levels.

PHYS 791 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings

depending upon the requirements of the topic.

Prerequisites: Permission of instructor.

PHYS 792 Topics

Credits: 1 to 3

Include current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

PHYS 798 Thesis

Credits: 1 to 9

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

PHYS 898-D Dissertation

Credits: 1 to 9

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Political Science

POLS 100 American Government

Credits: (3-0) 3

A study of the basic principles of the American system of government with emphasis on problems relating to governmental structure and policies.

POLS 165 Political Ideologies

Credits: (3-0) 3

Ideas defending communism, fascism, and democracy, including variations such as democratic socialism, Christian democracy, capitalism, liberalism, New Left, neo-conservatism, liberation theology. Practice of ideology. Concepts of comparative analysis.

POLS 250 Introduction to International Relations

Credits: (3-0) 3

A study of international relations including the sources of power and conflict, and the methods by which states compete and cooperate with each other. Additional international actors and contemporary issues will be addressed.

POLS 350 International Relations

Credits: (3-0) 3

How nations/states behave and why they behave as they do in their relations with each other.

Prerequisites: Junior or senior standing or permission of instructor.

POLS 407 Environmental Law & Policy

Credits: (3-0) 3

An examination of the political issues involved with environmental and ecological concerns such as land use, population, air and water pollution, energy, and public policy.

Prerequisites: Junior or senior standing or permission of instructor.

POLS 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits will be allowed for degree credit.

Psychology

PSYC 101 General Psychology

Credits: (3-0) 3

This course is an introduction survey of the field of psychology with consideration of the biological bases of behavior, sensory and perceptual processes, learning and memory, human growth and development, social behavior and normal and abnormal behavior.

PSYC 319 Teams and Teaming

Credits: (1-0) 1

The basic processes necessary for individuals to effectively work together are presented with an emphasis including values such as trust, the importance of conflict, interpersonal communication, and the dynamics of commitment.

PSYC 321 Human Development: Lifespan

Credits: (3-0) 3

In this course, theories of social, cognitive, emotional, and physical development are discussed for each era of human growth including gestation, infancy, childhood, adolescence, and young, middle, and late adulthood. This course is recommended for all students seeking a theoretical and applicable knowledge of human development.

Prerequisites: PSYC 101

PSYC 323 Human Development Through the Lifespan

Credits: (4-0) 4

Focus will be upon physiological/biological, intellectual, emotional, social and psychological development. Includes the normal sequence of development as well as developmental irregularities.

Prerequisites: PSYC 101 or permission of instructor.

PSYC 331 Industrial and Organizational Psychology

Credits: (3-0) 3

This course covers the application of psychological principles to such problems as employee selection, supervision, job satisfaction, and work efficiency.

Prerequisites: PSYC 101 and junior standing or permission of instructor.

PSYC 391 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

PSYC 392 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: May be repeated twice with different topics for a maximum of 6 credits.

PSYC 451 Psychology of Abnormal Behavior

Credits: (3-0) 3

This course is a comprehensive survey of abnormal personality and behavior. It includes an examination of the origins, symptoms and treatment of psychological disorders.

Prerequisites: PSYC 101 or permission of instructor.

PSYC 461 Theories of Personality

Credits: (3-0) 3

Students will learn about the role of philosophy and science and their contributions to the development of personality theory. Students will examine, in depth, the theoretical contributions made in the areas of psychoanalytic, behavioristic, and humanistic personality theories. The students will be able to articulate their own beliefs concerning the development of human personality.

Prerequisites: PSYC 101 or permission of instructor.

Sociology

SOC 100 Introduction to Sociology

Credits: (3-0) 3

Comprehensive study of society, with analysis of group life, and other forces shaping human behavior.

SOC 150 Social Problems

Credits: (3-0) 3

A study of present day problems in contemporary societies, such as racism, sexism, ageism, alcoholism, drug addiction, physical and mental health, war and environmental issues - their significance and current policies and action.

SOC 250 Courtship and Marriage

Credits: (3-0) 3

Courtship and marriage period given special emphasis, as are problems of mate selection, marital adjustments, reproduction, child-parent relations, divorce, and later years of marriage.

SOC 351 Criminology

Credits: (3-0) 3

Focuses on theories of crime, juvenile delinquency and justice, laws, systems of criminal behavior, victimization, and corrections.

Prerequisites: SOC 100 or SOC 150

SOC 391 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

SOC 392 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of special topics will be allowed for degree credit.

SOC 411 Licit and Illicit Drugs

Credits: (3-0) 3

A survey of the use, abuse, and addictive properties of psychoactive drugs other than alcohol; approaches to prevention, treatment, and identification of use.

Prerequisites: SOC 100, SOC 150 or PSYC 101
Notes: Will apply toward certification for chemical dependency counseling.

SOC 420 Alcohol Use and Abuse

Credits: (3-0) 3

A survey of the use, abuse, and addictive nature of beverage alcohol, some of the problems associated with excessive use of alcohol, and approaches to prevention and treatment.

Prerequisites: SOC 100, SOC 150 or PSYC 101
Notes: Will apply toward certification for chemical dependency counseling.

SOC 491 Independent Study

Credits: 1 to 3

Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

Prerequisites: Permission of instructor.

SOC 492 Topics

Credits: 1 to 3

Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

Notes: A maximum of 6 credits of special topics will be allowed for degree credit.

Spanish

SPAN 101 Introductory Spanish I

Credits: (4-0) 4

Introduces the fundamental elements of Spanish sentence structure and vocabulary. Promotes speaking, listening and writing within a cultural context. Class work may be supplemented with required aural/oral practice outside of class.

SPAN 102 Introductory Spanish II

Credits: (4-0) 4

Introduces the fundamental elements of Spanish sentence structure and vocabulary. Promotes speaking, listening, and writing within a cultural context. Class work may be supplemented with required aural/oral practice outside of class.

Prerequisites: SPAN 101 or permission of instructor.

Speech

SPCM 101 Fundamentals of Speech

Credits: (3-0) 3

Introduces the study of speech fundamentals and critical thinking through frequent public speaking practice, including setting, purpose, audience, and subject.

Notes: This course cannot count as social science/ humanities credit.