
LILLIBRIDGE
ENGINEERING
LABORATORY

College of Engineering

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Assistant Professors: Chiu, Perez, Tappan, Savage
Adjunct Faculty: Ambrose, Lucas, Maio

Doctor of Philosophy in Engineering and Applied Science

Program Goals:

- Prepare graduates to conduct and disseminate independent scholarly research.
- Prepare graduates for careers in academia or industry.

Program Objectives:

- Increase the knowledge of graduates in their specialized field: Engineering, Physics, Nuclear Science and Engineering, or Subsurface Science.
- Enhance the ability of graduates to contribute to their chosen field.
- Enhance effective written and oral communication skills of graduates.

The Ph.D. program in Engineering and Applied Science is an interdisciplinary program administered by the College of Engineering and offered jointly with the Department of Physics. The program allows for a broad range of research topics in both engineering and physics, but also has two special emphasis areas: (1) Nuclear Science and Engineering; and (2) Subsurface Science, each of which draws on a long-established expertise at Idaho State University in both teaching and research in these areas. Because of the unique interdisciplinary nature of the Ph.D. program in the emphasis area of Subsurface Science, the graduate faculty in the Departments of Geosciences and Mathematics may serve as committee members and/or major advisors for students in this emphasis area.

Research areas are Engineering (Civil Engineering, Electrical Engineering, Environmental Engineering, Measurement and Control Engineering, Mechanical Engineering, and Nuclear Engineering), Physics (Radiation Science, Accelerator Applications, Applied Nuclear Physics, and Health Physics), Geosciences, (Geology, Geophysics, Geochemistry, Environmental Geosciences), and Mathematics (Applied Mathematics and Computational Mathematics).

To attain a degree in this program, a student must demonstrate scholarly achievement and an ability for independent investigation. The program will normally require three years of full-time study beyond the master's degree, including research and preparation of the dissertation.

Admission

All applicants must meet Idaho State University Graduate School admission requirements for doctoral programs. Additionally, applicants must have attained a master's degree in engineering, physics, geosciences, mathematics, or a closely related field. Applicants must submit a one-page (only) statement of research interests, a one-page (only) statement of career interests, a resume, and at least 3 letters of reference along with their applications. In some special cases, a student with exceptional undergraduate academic record and aptitude for research but without an M.S. degree may be directly admitted to the Ph.D. program with the approval of the Ph.D. program committee.

Requirements

The Ph.D. degree requires completion of at least 84 credits consisting of 30 credits for the M.S. degree, 18 credits of additional course work, 4 credits of graduate seminar and 32 credits of dissertation research. Six credits of core courses are required for each emphasis area. The 30 credits for the M.S. degree are the maximum allowed. At least 9 of the 18 credits of course work must be in collateral areas as designated by the student's advisory committee. Additional dissertation research credits may be required by the student's dissertation committee.

Program of Study

An advisory committee consisting of Idaho State University graduate faculty from the four academic units will be established for each student upon entry into the program. The committee will guide the student in establishing his or her program of course work and laboratory study based upon the student's background and research interest. The advisory committee has the responsibility of ensuring that the student has adequate knowledge to support research in his or her chosen area of interest.

At the end of the first year, the student will take a written, comprehensive qualifying examination covering the relevant information within the scope of the research area. A student taking the comprehensive qualifying exam needs to be prepared to take an oral examination conducted by the student's Advisory Committee. The oral exam needs to focus primarily on material in the written exam that was not adequately answered. However, the Advisory Committee, at its discretion, may excuse a student from taking the oral examination if the student excels in the written examination. The student will be allowed two attempts to pass the oral examination, and the second attempt must be within one-half year after the first attempt. The student will be admitted to candidacy upon passing the comprehensive qualifying examination.

A dissertation committee, chaired by the candidate's major professor, will be appointed. Within six months of passing the comprehensive qualifying examination, the candidate, with guidance from the major professor, will satisfactorily complete an oral presentation and defense of a proposal for dissertation research to the committee.

The research and dissertation preparation must be conducted under the close supervision of the committee and must include at least one full year of work performed under Idaho State University graduate faculty. The candidate can submit the final dissertation anytime after six months from the date of acceptance of the research proposal.

Dissertation approval requires a public presentation of the dissertation and a satisfactory oral defense to the Dissertation Committee. Doctoral oral examinations are open to all regular members of the faculty as observers. Further, oral presentations are open to the

public until questioning by the Dissertation Committee begins.

Graduate Programs in Engineering

Program Goals:

- Prepare graduates to have an advanced understanding and the ability to apply problem-solving skills in their chosen field of study.
- Prepare graduates to undertake doctoral study and/or to take challenging careers in teaching, research, and industry, for continued personal growth and contribution to the global competitiveness of the United States.

The graduate program in the College of Engineering offers the student a choice of five majors for specialization at the master's level together with a breadth of courses to fit individual educational goals. The majors are:

1. Civil Engineering
2. Environmental Engineering
3. Measurement and Control Engineering
4. Mechanical Engineering
5. Nuclear Science and Engineering

There are 32 credit hours required for each major. Approximately half of the credits are engineering and technical electives, subject to the approval of the student's advisory committee. The thesis project, required in each major, should consist of study and research that complements the course work selected. Each student must also complete two semesters of seminar, an important component in developing research and communication skills.

The student must apply to, and meet all criteria for, admission to the Graduate School. With the assistance of the graduate faculty of the College of Engineering, the student shall select an initial advisor during the first semester of residence to help in planning a program of studies and research. The student must also complete a Plan of Study and form a complete advisory committee by the time six credits of course work have been completed.

Master of Science in Civil Engineering

Program Objectives:

- Enhance the knowledge of graduates in the advanced concepts in Civil Engineering fields such as structures, mechanics, finite element methods, geotechnics, and water resources.
- Increase the ability of graduates to synthesize and apply these advanced concepts to develop realistic designs in fields related to civil engineering and to solve identified problems, and design strategies for implementing them safely, ethically, and effectively.
- Enhance the ability of graduates to communicate these concepts effectively both in oral and written formats.

The M.S. program in Civil Engineering is designed to provide advanced study, both theoretically and experimentally, in structures, mechanics, finite element methods, water resources, and geotechnics. This program prepares the student for advanced placement in the civil engineering field in industry, research, or development areas. Additionally, this program provides a suitable base for entrance into a Ph.D. program in a field related to Civil Engineering. The program is offered both at the Pocatello and the Idaho Falls campuses, primarily through the use of telecommunications/distance learning, which includes partial in-class instruction.

Required Courses

C E	531	Advanced Mechanics of Solids	3 cr
C E	664	Dynamics of Structures	3 cr
C E	665	Finite Element Methods	3 cr
C E	667	Structures & Mechanics Lab	3 cr
Approved Engineering Electives			6 cr
Approved Technical Electives			6 cr
ENGR	650	Thesis	6 cr
ENGR	651	Seminar	2 cr

Master of Science in Environmental Engineering

Program Objectives:

- Enhance the knowledge of graduates in the advanced concepts of environmental control and remediation, involving a significant fraction of the following: chemistry, water & waste water quality, air quality, radioactive material handling and disposal, environmental laws and regulations, global environmental issues, and cost benefit analyses.
- Increase the ability of graduates to synthesize and apply these advanced concepts to develop realistic environmental engineering designs and to solve identified problems, designing strategies for implementing them safely, ethically, and effectively.
- Enhance the ability of graduates to communicate these concepts effectively both in oral and written formats.

This program is designed to provide the student with advanced technical training in environmental engineering, with an emphasis on hazardous waste treatment and control. The program fills a need in industry and government for professionals with a broad understanding of the technical aspects of environmental issues. Students enrolled in the program are generally expected to have a sufficient background in mathematics and chemistry (a minimum of one year of general chemistry). Students with an insufficient background in engineering and math are required to make up the deficiencies according to the advice of their advisory committee (usually includes ENGR 307, CE 332, ME 341).

Required Courses

ENVE 508	Water & Waste Water Quality	3 cr
ENVE 509	Water & Waste Water Lab	1 cr
ENVE 510	Intro to Environmental Engineering	3 cr
ENVE 611	Treatment Systems for Environmental Remediation	3 cr

Approved Environmental Engineering Electives (9 credits required)

Students are to select a core of at least nine credits from graduate level engineering-intensive courses from the following list. Note: a particular student may select one or more intensive engineering courses not on this list, with the express approval of her/his committee, for the purpose of focusing him/her in a particular direction not covered by this abbreviated list.

ENVE 504	Engineering Risk Assessment	3 cr
ENVE 612	Treatment of Hazardous Chemical Waste	3 cr
ENVE 614	Hazardous Waste Site Remediation	3 cr
ENVE 615	Water Quality Modeling & Control	3 cr
ENVE 616	Biological Treatment of Wastewater	3 cr

ENVE 617	Environmental Systems Engineering & Design	3 cr
ENVE 629	Physical & Chemical Treatment of Water and Waste Water	3 cr
ENVE 630	Air Pollution & Control	3 cr
ENGR 521	Advanced Engineering Analysis (Math)	3 cr
ENGR 578	Probabilistic Design	3 cr
ME 519	Alternative Energy Systems Design	3 cr
ME 576	Heat Transfer	3 cr
N E 544	Nuclear Fuel Cycles	3 cr
N E 618	Treatment of Low Level Radioactive Waste	3 cr
NSEN 619	Treatment of High Level Radioactive Waste	3 cr

Seminar (2 credits required)

The seminar course must be completed two times in order to satisfy the requirement.

ENGR 651	Seminar	1 cr (x2)

Approved Environmental Engineering Technical Electives (6 credits required)

Any graduate level course from Biological Science, Chemistry, Geology, Math, or Pharmacy as well as engineering electives may be taken as a technical elective with approval of the student's advisory committee. The following courses are recommended for consideration.

ENGR 606	Environmental Law & Regulation	3 cr
ENGR 607	Hazardous Waste Management	3 cr
ENVE 610	Introduction to Radioactive Waste Management	3 cr
BIOL 687	Environmental Science & Pollutants	3 cr
BIOL 623	Soil & Groundwater Bioremediation	3 cr
GEOL 520	Principles of Geochemistry	3 cr
PHYS 605	Radiological Environmental Monitoring & Surveillance	3 cr
PSCI 621	Biological Action of Chemicals	3 cr
PSCI 622	Principles of Toxicology	3 cr

Master of Science in Measurement and Control Engineering

Program Objectives:

- Enhance the knowledge of graduates in advanced concepts of measurement, control, signal processing, engineering mathematics, computation and other related areas.
- Increase the ability of graduates to synthesize and apply these advanced concepts to develop realistic measurement and control engineering designs and to solve identified problems, designing strategies for implementing them safely, ethically, and effectively.
- Enhance the ability of graduates to communicate these concepts effectively both in oral and written formats.

The M.S. program in Measurement and Control Engineering is designed to provide advanced study (analytically, computationally, and experimentally) in measurements, modeling, simulation, adaptive, intelligent, nonlinear, optimal, robotics, and robust control. This program prepares the student for advanced placement in the measurement and control engineering field in industry, research, or development areas. Additionally, this program provides a suitable base for entrance into a Ph.D. program in a field related to Electrical or Mechanical Engineering. The program is offered both at the Pocatello and the Idaho Falls campuses, primarily through the use of telecommunications/distance learning, which includes partial in-class instruction.

Required Courses

The following courses are required of every student receiving the M.S. Degree in Measurement and Control Engineering covered by the abbreviated list.

ENGR 521		Advanced Engineering Mathematics I	3 cr
MCE	642	Advanced Control Systems	3 cr
MCE	643	Advanced Measurement Methods	3 cr
MCE	644	Measurements and Controls Laboratory	3 cr
Approved Engineering Electives			6 cr
Approved Technical Electives			6 cr
ENGR 650		Thesis	6 cr
ENGR 651		Seminar	2 cr

Master of Science in Mechanical Engineering

Program Objectives:

- Enhance the knowledge of graduates in advanced concepts of thermodynamics, fluids, heat transfer, energy systems, vibrations, engineering mechanics, measurements, and engineering mathematics.
- Increase the ability of graduates to synthesize and apply these advanced concepts to develop realistic mechanical engineering designs implementing them safely, ethically, and effectively.
- Enhance the ability of graduates to communicate these concepts effectively both in oral and written forms.

The master's degree program in Mechanical Engineering is designed to provide advanced study, (analytically, computationally, and experimentally) in thermodynamics, fluids, heat transfer, energy systems, vibrations, engineering mechanics, and their associated measurement systems. This program prepares the student for advanced placement in the mechanical engineering field in industry, research, or development areas. Additionally, this program provides a suitable base for entrance into a Ph.D. program in a field related to Mechanical Engineering. The program is offered both at the Pocatello and Idaho Falls campuses, primarily through the use of telecommunications/distance learning, which includes partial in-class instruction.

Required Courses

ENGR 521		Advanced Engineering Mathematics I	3 cr
M E	607	Advanced Thermodynamics	3 cr
M E	640	Advanced Vibrations	3 cr
M E	643	Thermal Fluids and Vibrations Lab	3 cr
Approved Engineering Electives			6 cr
Approved Technical Electives			6 cr
ENGR 650		Thesis	6 cr
ENGR 651		Seminar	2 cr

Master of Science in Nuclear Science and Engineering

Program Objectives:

- Enhance the knowledge of graduates in the advanced concepts of neutron reactor physics, power reactor thermal hydraulics, nuclear radiation interactions and transport, radiation shielding and detection, medical and industrial applications of radiation, and the economics and safety of these applications.
- Increase the ability of graduates to synthesize and apply these advanced concepts to develop realistic nuclear engineering designs and to solve identified problems, designing strategies for implementing them safely, ethically, and effectively.
- Enhance the ability of graduates to communicate these concepts effectively both in oral and written formats.

The master's degree program in Nuclear Science and Engineering prepares the stu-

dent for advanced placement in the nuclear industry in commercial, research, or development areas. It provides in-depth studies and advanced design concepts in several areas of modern nuclear science and engineering. It is also an excellent program of study for entering the Ph.D. program in Nuclear Science and Engineering.

Required Courses

ENGR 521	Advanced Engineering Mathematics I	3 cr
NSEN 601	Nuclear Engineering Experiments	3 cr
NSEN 608	Advanced Radiation Transport and Shielding	3 cr
NSEN 609	Advanced Radiation Detection, Measurements and Applications	3 cr
Approved Engineering Electives		6 cr
Approved Technical Electives		6 cr
ENGR 650	Thesis	6 cr
ENGR 651	Seminar	2 cr

Master of Science in Environmental Science and Management (ESM)

This program is designed to provide the student with a broad understanding of hazardous waste problems and how they can be remediated. The courses may be completed as an option in the Master of Science in Nuclear Science and Engineering degree, the Master of Science in Measurement and Control Engineering degree, or in an interdisciplinary master's degree program. In the interdisciplinary degree, students must select another area of emphasis such as business, biology, chemistry, geology, or physics. Regulations governing the interdisciplinary master's degree program are included in the general regulations of the Graduate School elsewhere in this catalog. Further, the courses may be taken as a source of information by any qualified student. Other courses pertinent to this field are offered by the Department of Biological Sciences, the Department of Chemistry, and the Department of Geosciences. This program is jointly sponsored by the University of Idaho and many of the courses are cross listed.

To qualify for the statement, "Hazardous Waste Management Option" on the transcript, at least nine credits must be completed from the following list of courses and the student must enroll, and participate, in the seminar, ENGR 655 at least twice.

Environmental Science and Management Courses

At least nine credits required for option

BIOL 687	Environmental Science & Pollutants	3 cr
ENGR 570	Survey of Hazardous Waste Management Problems	3 cr
ENGR 606	Environmental Law & Regulations	3 cr
ENGR 607	Hazardous Waste Management	3 cr
ENVE 612	Treatment of Hazardous Chemical Waste	3 cr
ENVE 614	Hazardous Waste Site Remediation	3 cr
ENGR 655	Hazardous Waste Management Seminar	1 cr

Certificate Program in Applied Nuclear Energy

This program provides BS/BA graduates who do not have recent experience or education in the nuclear energy field with historical insights, information on basic concepts, regulatory requirements, and economic and environmental considerations. This program is not intended to lead to M.S. and Ph.D. programs in the areas of Nuclear Science and Engineering. The Certificate is granted upon completion of fourteen (14) credit hours of class work, consisting of nine credit hours of required courses, a three-credit elective course and participation in two semesters of a one-credit graduate seminar. Up to six credits of appropriate graduate course work taken at another university may be applied toward the Certificate program subject to approval by the student's Certificate Committee. With appropriate pre-planning, some of these credits could be applied to a master's degree.

Admission

The student must apply to, and meet all criteria for, admission to the Graduate School. An earned grade point average of at least 3.0 or higher is required for all upper division credits taken at the undergraduate level, regardless of the institution at which the credits were earned and GRE scores are not required.

Required courses (8 credits):

NSEN 615	Introduction to Practical Nuclear Engineering	3 cr
NSEN 617	Applications in Nuclear Energy	3 cr
ENGR 651	Seminar	2 cr
One of the following four courses (3 credits):		
ENGR 606	Environmental Law and Regulation	3 cr
PHYS 610	Radiation Regulations	3 cr
NSEN 618	Treatment of Low Level Radioactive Waste	3 cr
NSEN 619	Treatment of High Level Radioactive Waste	3 cr
Approved NE, NSEN, ENGR, ENVE, or PHYS 5xx/6xx elective course		3 cr

Thesis Option in Engineering Master's Programs

All students entering with less than two years of industrial experience as determined by the College are required to complete six credits of thesis in their related field. Students who are planning to continue their education beyond the master level are strongly recommended to choose this option. After the completion of the course work and the thesis, an oral defense of the thesis will be required.

ENGR 650	Thesis	6 cr

Non-Thesis Option in Engineering Master's Programs

All students entering with a minimum of two years industrial experience in the related area as determined by the College are eligible to choose this option. In the non-thesis program students will be required to take an additional 3-credit course and to complete a 3-credit Special Project (ENGR 660) in the related field and a written report. After completion of the course work and the Special Project, students are required to take a two-hour oral exam on their Special Project and other courses of the MS program.

ENGR 660	Special Project	3 cr

Engineering Graduate Courses

ENGR g515 Model Theory 3 credits. Theory of design and testing of scaled system models. Dimensional analysis with application to physical models. True and distorted models, linear and non-linear models, and analogies. Laboratory work required. PREREQ: CE 341 OR ME 341, AND ENGR 350.

ENGR g516 Applied Engineering Methods 3 credits. Applied discrete and continuous probability, random variables, probability distributions, sampling, data description, parameter estimation, hypothesis testing, inference, correlation, and linear and multiple regression. PREREQ: MATH 170.

ENGR g521 Advanced Engineering Mathematics I 3 credits. Analysis of complex linear and nonlinear engineering systems using advanced techniques including Laplace transforms, Fourier series and classical partial differential equations. Cross-listed as MATH g521. PREREQ: MATH 360.

ENGR g522 Advanced Engineering Mathematics II 3 credits. Cross-listed as MATH

g522. Analysis of complex linear and nonlinear engineering systems using advanced techniques, including probability and statistics, advanced numerical methods and variational calculus. PREREQ: ENGR g521 OR MATH g52l.

ENGR g560 Engineering Cost Estimating 3 credits. Introduction to design/construction processes, planning, contracts, procurement, plans/specifications, productivity analyses, safety, cost estimating, scheduling and environmental considerations. Use of data from actual construction projects. PREREQ: ENGR 360 OR PERMISSION OF INSTRUCTOR.

ENGR g578 Probabilistic Risk Assessment 3 credits. Probabilistic methods applied to analysis and design. Setting probabilistic design objectives and calculating probabilistic performance emphasized. Cross-listed as NE g578. PREREQ: ENGR 364, MATH 360 AND SENIOR STANDING IN ENGINEERING.

ENGR g583 Engineering Law and Ethics 3 credits. Contracts, liability, registration laws, codes of ethics and professionalism applied to engineering. Includes seminar with guest speakers and student presentations. PREREQ: SENIOR STANDING IN ENGINEERING.

ENGR g591 Seminar in Engineering 1 credit. A series of lectures on current topics in the literature by participants or guest lecturers chosen from industry. PREREQ: PERMISSION OF INSTRUCTOR.

ENGR g593 Human Factors in Engineering 3 credits. Overview of the discipline of human factors engineering, including design of information displays, controls, workspace, and human performance. Relationship of engineering to corporate issues such as R&D, maintenance, training, operations, safety.

ENGR 501 Methods of Engineering 3 credits. Introduction to fundamental concepts of engineering related to hazardous waste management. Not counted toward graduation. PREREQ: PHYS 111.

ENGR 510 Introduction to Environmental Engineering 3 credits. Introduction to physical, chemical, and biological principles of solid and hazardous waste management, water and wastewater treatment, air pollutant control, and national environmental regulation. PREREQ: CHEM 112 AND ENGR 309, OR PERMISSION OF INSTRUCTOR.

ENGR 570 Survey of Hazardous Waste Management Problems 3 credits. Environmental, technical, political and economic aspects of hazardous waste management. Credit not given if UI ChE 570 or ISU ENVE 607 taken. PREREQ: ENGR 501 OR EQUIVALENT.

ENGR 572 Waste Treatment Technologies 3 credits. Procedures for characterization of hazardous waste sites, identification and application of physical, chemical, biological and thermal treatment. PREREQ: PERMISSION OF INSTRUCTOR.

ENGR 589 Principles of Hazardous Waste Site Remediation 3 credits. Restoration technologies for waste sites. Site characterization and clean-up methods for chemical, radioactive, mixed wastes in soils and water. Practical methodologies. Credit not granted if ENVE 614 taken. PREREQ: ENGR 570 OR ENVE 607.

ENGR 606 Environmental Law and Regulations 3 credits. Federal, state, local environmental regulations addressing environmental impact assessment; water and air pollution control, hazardous waste, resource recovery, reuses, toxic substances, occupational safety and health, radiation, siting, auditing, liability. Cross-listed with POLS 606. PREREQ: PERMISSION OF INSTRUCTOR.

ENGR 607 Hazardous Waste Management 3 credits. Management of hazardous and solid wastes, emphasis on CERCLA (Superfund) process for cleaning of uncontrolled hazardous waste sites and RECRA process for industrial treatment, storage, disposal facilities. PREREQ: MATH 508.

ENGR 609 Advanced Transport Phenomena 3 credits. Advanced theory and applications of heat, mass, and momentum transport; gases for correlation in engineering design of a variety of process equipment. PREREQ: ME/NE g576, CE/ME/NE 341, MATH g521.

ENGR 650 Thesis 1-6 credits. Thesis research must be approved by the student's advisory committee. Six credits may be used to satisfy the research requirements for the degree. Graded S/U.

ENGR 651 Seminar 1 credit. Current topics in engineering. Invited speakers will be used when possible. Students presentations required. May be taken a maximum of four times. PREREQ: PERMISSION OF INSTRUCTOR. Graded S/U.

ENGR 652 Special Problems 1-3 credits. Special experimental, computational, or theoretical investigation leading to development of proficiency in some area of engineering. Formal report required. PREREQ: PRIOR PROJECT APPROVAL REQUIRED BY AN ENGINEERING FACULTY. May be graded S/U.

ENGR 655 Environmental Topics Seminar 1 credit. Environmental engineering and science topics related to hazardous waste characterization, cleanup, regulations. Includes case histories and presentations by graduate students and visiting speakers. PREREQ: PERMISSION OF INSTRUCTOR. Graded S/U.

ENGR 660 Special Project 3 credits. A significant project, involving engineering applications, toward the completion of M.S. program with non-thesis option. Includes a report and oral examination. Graded S/U.

Civil Engineering Graduate Courses

CE g531 Advanced Mechanics of Solids 3 credits. An introduction to elasticity, plasticity, and energy foundations, stability, plates. PREREQ: ENGR 350 AND MATH 360.

CE g534 Geotechnical Design 3 credits. Application of soil mechanics to design of foundations, retaining wall, stable slopes, buried conduits and pavement structures. Computer methods utilized. PREREQ: ENGR 350, AND CE 332.

CE g535 Hydraulic Design 3 credits. Hydraulic design of water control and transport structures, pipelines, and distribution systems. Computer methods utilized. PREREQ: CE/ME 341.

CE g536 Roadway Design 3 credits. Fundamentals of earthwork, route location, drainage, and pavement materials with application to geometric and pavement design of highways, streets and rural roads. PREREQ: ENGR 223; CE 301 OR 302. COREQ: CE 332.

CE g537 Geotechnical Engineering Laboratory 1 credits. Field and laboratory work on site investigation, soil sampling classification and testing. Evaluation of soil properties. Design of experiment. PREREQ: CE 332.

CE g540 Vibration Analysis 3 credits. Free vibration and forced response of single and multiple degree of freedom systems, normal modes, random vibrations. Cross-listed as ME g540. PREREQ: MATH 360, ENGR 220, AND ENGR 350.

CE g554 Basic Engineering Geology 3 credits. Geology applied to civil engineering projects; rock engineering classification systems and geotechnical parameters such as joint set orientation; ground behavior and underground construction. Preparation of baseline geotechnical reports. Cross-listed as GEOL g554. COREQ: GEOL 314 OR CE 332.

CE g555 Geologic Data Methods 3 credits. Geotechnical investigations for civil works projects. Geologic mapping for civil engineering purposes. Development of engineering geologic profiles. Core logging. Preparation of Geotechnical Data Reports for civil works projects. Cross-listed as GEOL g555. PREREQ: CE g554.

CE g561 Advanced Structural Analysis 3 credits. Analysis of statically indeterminate structures. Continuation of the use of classical methods. Introduction to computer methods in structural analysis including the use of commercially available software, and lateral load effects. PREREQ: CE 362.

CE g562 Design of Steel Structures 3 credits. Design of steel members and connections with emphasis on the AISC specifications. PREREQ: CE 362.

CE g564 Design of Concrete Structures 3 credits. Design of reinforced concrete beams, columns, and slabs. Introduction to pre-stressing. PREREQ: CE 362.

CE g565 Prestressed Concrete Structures 3 credits. Basic concepts in prestressed concrete design, full versus partial prestressing, flexural design, ultimate load design, beams with constant and variable tendon eccentricity, design of reinforcement for shear and torsion. PREREQ: CE g564.

CE g566 Design of Wood Structures 3 credits. Design of solid and laminated wood members

and connections. Includes the design of wooden diaphragms for resisting lateral loads. PREREQ: CE 362.

CE g567 Structural Engineering Laboratory 1 credit. Measurement of stresses and load distribution through concrete, steel and wood components and structures. Design of experiment. PREREQ: CE 362.

CE g568 Behavior of Composite Materials 3 credits. Macro and micromechanical behavior of laminae and laminates; bending, buckling and vibration of laminated beams and plates. Cross-listed as ME g568. PREREQ: ENGR 350 AND MATH 230.

CE g575 Essentials of Geomechanics 3 credits. Essentials of rock fracture relevant to geological engineering including stress and strain, properties and classification of rock masses, rock fracture mechanisms. Cross-listed as GEOL g575. PREREQ: GEOL 421 OR ENGR 350.

CE g576 Engineering Geology Project 1 credits. Team projects studying actual problems in engineering geology. Cross-listed as GEOL g576. PREREQ: GEOL g554 OR CE g554.

CE g580 Earthquake Engineering 3 credits. Topics include: mechanism and characterization of earthquakes; seismic risk analysis; site and structural response; applications from points of view of engineer and geologist. PREREQ: GEOL 313 or CE 332, OR PERMISSION OF INSTRUCTOR.

CE 652 Advanced Topics in Civil Engineering 3 credits. Discussion of current research topics conducted by engineering faculty from ISU and elsewhere. Topics can be arranged with instructor and advisor. PREREQ: PERMISSION OF INSTRUCTOR.

CE 664 Dynamics of Structures 3 credits. Evaluation of response of structures subjected to dynamic forces including earthquake-induced forces and deformations. Applications include single- and multi-degree of freedom systems, and continuous systems. PREREQ: CE/ME g540 OR PERMISSION OF INSTRUCTOR.

CE 665 Finite Element Methods 3 credits. Introduction to finite element methods applied to linear one- and two-dimensional problems. Application of the concept to specific problems in various fields of engineering and applied sciences. Cross-listed as ME 665. PREREQ: ENGR 264, ENGR 350, AND MATH 360.

CE 667 Structures and Mechanics Laboratory 3 credits. Strain gauge installation and circuitry. Strain measurements and analysis of variety of structural and mechanical systems. Dynamic measurements of various structures. PREREQ: CE 531 OR PERMISSION OF INSTRUCTOR.

Computer Science Graduate Courses

C S g520 Computer Security and Cryptography 3 credits. Public key and private key cryptography, key distribution, cryptographic protocols, requisite mathematics and selected topics in the development of security and cryptography. PREREQ: CS 385.

C S g542 GUI Development 3 credits. Planning and construction of Graphical User Interfaces and essential software engineering concepts. Includes the use of a modern toolkit language. COREQ: CS 385.

C S g544 Image and Audio Processing 3 credits. Image/audio acquisition, quantization, spatial and spectral filters, sharpening, smoothing, restoration, compression, segmentation, Fourier and Wavelet transforms. PREREQ: CS 287, MATH 352, MATH 360.

C S g545 Data Compression 3 credits. A survey of modern techniques of data compression, both lossy and loss-less, and encryption. COREQ: CS 386.

C S g551 Theory and Implementation 3 credits. Data models, relational algebra, SQL, data storage, index structures, query compilation and execution, concurrency control. PREREQ: CS 263, CS 385. COREQ: CS 386.

CS g560 Comparative Programming Languages 3 credits. Design of historical and contemporary programming languages, concentrating on promoting understanding of structural organization, data structures and typing, name structures, and control structures. PREREQ: CS 385. COREQ: CS g576.

CS g570 Parallel Processing 3 credits. Topics in high performance computing: parallel architectures, SIMD, MIMD, SMP, NUMA models, message passing, cache coherency issues, MPI, PVM, parallel programming languages, the Beowulf cluster approach, applications. COREQ: CS 386.

CS g576 Microprocessors 3 credits. Introduction to microprocessor architecture. Programming principles using machine and assembly languages, addressing modes, memory mapping, number representation and processing. Cross-listed as EE g526. PREREQ: CS 374.

CS g577 Operating Systems 3 credits. Processes description and control, threads, concurrency, memory management scheduling, I/O and files, distributed systems, security, networking. PREREQ: CS 263. COREQ: CS g576.

CS g580 Theory of Computation 3 credits. Finite representations of languages, deterministic and nondeterministic finite automata, context free languages, regular languages, parsing, Turing Machines, Church's Thesis, uncomputability, computational complexity classes. COREQ: CS 386.

CS g581 Compilers and Lexical Analysis 3 credits. Covers lexical analysis, syntax analysis, top-down, bottom-up, and LR parsing, syntax directed translation, type checking, code generation and optimization, and writing a compiler. COREQ: CS 386.

CS g587 Topics in Computer Science 3 credits. Selected topics in Computer Science will be chosen depending on the instructor's interests. PREREQ: CS 386.

CS g591 Ethical and Societal Issues in Computer Science 3 credits. Investigates various ethical issues arising in the profession, ranging from research to commercial settings. The societal impacts of computing and its prevalence in all aspects of the modern world are investigated. Seminar format: students will read papers, make oral presentations, conduct class discussion, and submit written reports.

Electrical Engineering Graduate Courses

EE g513 Techniques of Computer-Aided Circuit Analysis and Design 3 credits. Automatic formulation of equations and fundamental programming techniques pertinent to computer-aided circuit analysis, design, modeling. May include sensitivity calculations, system analogies, optimization. PREREQ: CS 370, ENGR 340, 342.

EE g517 Probabilistic Signals and Systems 3 credits. Introductory probability theory. Density functions, moments, random variables. Normal, exponential distributions, Estimation of mean and variance. Correlation, spectral density. Random processes, response of linear systems to random inputs. PREREQ: EE 345.

EE g518 Communication Systems 3 credits. Basic principles of analysis and design of modern analog and digital communication systems, including transmission and reception. PREREQ: EE 329 AND EE 345.

EE g525 Mechatronics 3 credits. Basic kinematics, sensors, actuators, measurements, electronics, microprocessors, programmable logic controllers, feedback control, robotics and intelligent manufacturing. Cross-listed as ME g525. PREREQ: ENGR 340, ENGR 342, MATH 360.

EE g527 Embedded Systems Engineering 2 credits. Integration of algorithms, software and hardware to design real-time and embedded systems for signal processing and control. PREREQ: CS g575. COREQ: EE g527L.

EE g527L Embedded Systems Engineering Laboratory 1 credit. Lab activities include the complete process of design and implementation of embedded signal processing and control systems through the integration of algorithms, software, and hardware. COREQ: EE g527.

EE g529 Advanced Electronics 2 credits. Introduction to operational amplifiers and their applications, current mirrors, active loads, differential amplifiers, feedback and stability, filters, oscillators, Schmitt triggers, power amplifiers and voltage regulators. PREREQ: EE 329, 345. COREQ: EE g529L.

EE g529L Advanced Electronics Laboratory 1 credit. Laboratory course emphasizing transistor biasing, amplifiers and other basic analog circuit designs. COREQ: EE g529.

EE g532 Introduction to VLSI Design 3 credits. Photolithography, CMOS fabrication, MOSFET

operation, CMOS passive elements, design rules and layout, CAD tools for IC design, invertors, static logic and transmission gates, dynamic logic. PREREQ: EE 329.

EE g533 Mixed Signal Design 3 credits. Analog IC design. Passive components, parasitic elements, component matching, IC layout techniques, amplifiers, current sources, comparators, op amps, noise, switched capacitor circuits. Includes lab work using design tools. PREREQ: EE g532.

EE g572 Electrical Machines and Power 3 credits. Theory and application of electrical machinery and transformers. Power and energy relationships in power systems, transmission lines, network solutions and symmetrical components. Includes 1-credit laboratory component. PREREQ: ENGR 340, ENGR 342, MATH 360.

EE g572L Electrical Machines and Power Laboratory 1 credit. Laboratory course emphasizing an experimental study of the fundamental physical phenomena and characteristics of transformers, induction motors, synchronous and direct current machines. COREQ: EE g572.

EE g573 Automatic Control Systems 3 credits. Study of continuous-time and control systems using both frequency-domain and state-space techniques; topics include design methodology, performance specifications, analysis and design techniques. PREREQ: EE 345 OR ME g505.

EE g574 Advanced Circuit Theory 3 credits. Methods of analog electrical circuit analysis and synthesis. Topics include signal flow graphs, multi-port networks, simulation techniques, and topological methods for formulation of network equations. PREREQ: ENGR 340, ENGR 342 AND EE 345.

EE g575 Digital Signal Processing 3 credits. Design of recursive and non-recursive digital filters; frequency-domain analysis, fast Fourier transform techniques, spectral analysis; applications. Includes 1-credit laboratory component. PREREQ: EE 345.

EE g576 Semiconductor Processing and Fabrication 3 credits. Silicon semiconductor processing and basic integrated circuit fabrication. Physics, chemistry and technology in basic processing steps in production of integrated circuits. PREREQ:. PHYS 211-212 AND MATH 170 OR EQUIVALENT.

EE g578 Semiconductor Devices 3 credits. Operating principles of basic building blocks of modern silicon-based semiconductor devices to include p-n junctions, field effect transistors and bipolar junction transistors. PREREQ: PHYS 212 OR EQUIVALENT.

EE g579 Advanced Semiconductor Devices 3 credits. Review of semiconductor band theory. Opto-electronics, quantum mechanics, heterojunctions, power and microwave semiconductor devices. PREREQ: EE g578 OR EQUIVALENT.

EE g582 Principles of Power Electronics 3 credits. Introduction to steady state converter modeling and analysis. Principles of converter dynamics and control including controller design. PREREQ: EE 329. COREQ: EE g573.

EE g584 Signal Processing Laboratory 1 credit. Design finite and infinite response digital filters in digital signal processing system applications. COREQ: EE g575.

EE g592 Digital Control Systems 3 credits. Design of advanced control algorithms; topics include: observers and state estimation, linear quadratic regulator, frequency-domain techniques for robust control, and an introduction to multivariable and nonlinear control. PREREQ: ENGR g573.

Environmental Engineering Graduate Courses

ENVE g504 Environmental Risk Assessment 3 credits. Quantitative and qualitative approaches to characterizing and controlling contaminant pathways. Risk assessment requirements and implications in superfund projects for engineers working on remediation. PREREQ: BIOL 521 AND ENGR 501 IF REQUIRED BY HWM.

ENVE g508 Water and Waste Water Quality 3 credits. Principles of chemistry in applications to water and waste water treatment systems for water quality control and reuse. PREREQ: CHEM 111 OR EQUIVALENT.

ENVE g509 Water and Waste Water Lab 1 credit. Fundamental analytical procedures for measurement of water and wastewater quality. Introduction to materials and protocols associated with general environmental analytical techniques. COREQ: ENGR g508.

ENVE g510 Introduction to Environmental Engineering 3 credits. Introduction to physical, chemical, and biological principles of solid and hazardous waste management, water and waste water treatment, air pollution control, and national environmental regulation. PREREQ: ENVE g508 OR EQUIVALENT.

ENVE g530 Air Pollution and Solid Waste 3 credits. Sources, characteristics, regulations, and effects of air pollution and solid waste on environmental quality; analysis and design of control systems, including the recovery of resources from solid waste. PREREQ: PERMISSION OF INSTRUCTOR.

ENVE 610 Introduction to Radioactive Waste Management 3 credits. Principles and practices of radioactive waste storage, transportation and disposal. Evolution of government regulations and current solutions developed in response to the regulations. PREREQ: ENGR 501.

ENVE 611 Treatment Systems for Environmental Engineering 3 credits. Fundamental principles and processes for physical, chemical, and biological treatment of wastes including mixing, flocculation, sedimentation, stripping, aeration, sorption and leaching. Some experiments required. PREREQ: ENVE 510.

ENVE 612 Treatment of Hazardous Chemical Waste 3 credits. Alternative processes and operations for the treatment of hazardous chemicals. PREREQ: MATH 360, ENVE 607, AND COURSE IN UNIT OPERATIONS.

ENVE 614 Hazardous Waste Site Remediation 3 credits. Characterizing waste sites, application of physical, chemical, biological corrective actions, site restoration. Case studies illustrate corrective action and site restoration. PREREQ: ENGR 341, ENVE 607 AND COURSE IN FLUID FLOW THROUGH POROUS MEDIA.

ENVE 615 Water Quality Modeling and Control 3 credits. Fundamental principles for mathematical modeling and analysis of environmental contaminant's fate and transport in lakes, rivers, estuaries, and groundwater. PREREQ: ENVE 510.

ENVE 616 Biological Treatment of Wastewater 3 credits. Fundamental principles, design, and operation of aerobic and anaerobic biological waste treatment processes. PREREQ: ENVE 510.

ENVE 617 Environmental Systems Engineering and Design 3 credits. Application of physical, chemical, and biological operations and processes to the design of water, waste water, and industrial waste treatment systems. PREREQ: ENVE 510 OR PREVIOUS DESIGN EXPERIENCE.

ENVE 629 Physical and Chemical Treatment of Water and Waste Water 3 credits. Fundamental principles, design and operations of physical and chemical water and waste water treatment processes. Removal of hazardous materials emphasized. PREREQ: ENVE 510 and CHEM 535.

ENVE 630 Air Pollution and Control 3 credits. An introductory air pollution course. Regulations, atmospheric dispersion models, control of emissions and sources and human health effects are emphasized. PREREQ: ENVE 510.

Measurement and Control Engineering Graduate Courses

MCE 640 System Modeling, Identification and Simulation 3 credits. Model development, off-line and on-line identification methods for engineering systems, diagnostic tests and model validation and analog and digital simulation methods. PREREQ: EE g573.

MCE 642 Advanced Control Systems 3 credits. State space analysis and design to include stability, controllability, observability, realizations, state feedback and estimation. PREREQ: EE/ME g573 OR EQUIVALENT.

MCE 643 Advanced Measurement Methods 3 credits. Instrumentation systems used in detection and signal conditioning of thermal-hydraulic process variables, radiation including lasers, and electrical and mechanical properties of materials. PREREQ: ME g505 OR EQUIVALENT.

MCE 644 Measurements and Controls Laboratory 3 credits. Work with measuring systems for a variety of process variables. Investigation of characteristics of various process control components and systems. Transient and stationary conditions will be included. PREREQ: MCE 642 AND MCE 643 OR EQUIVALENT.

MCE 645 Advanced Control Theory and Applications 3 credits. Topics selected from advanced control theory and applications, depending upon the interest of students and faculty. May be repeated for credit when topics vary. PREREQ: MCE 642 OR PERMISSION OF INSTRUCTOR.

MCE 646 Intelligent Control Systems 4 credits. Analysis and design of systems using intelligent techniques such as neural networks, fuzzy logic, genetic algorithms, and artificial intelligence. PREREQ: PERMISSION OF INSTRUCTOR.

MCE 647 Nonlinear Control Systems 3 credits. Phase plane analysis. Lyapunov stability. Describing functions. Singular perturbation and feedback linearization. PREREQ: MCE 642 OR PERMISSION OF INSTRUCTOR.

MCE 649 Robotics and Automation 3 credits. Robotic manipulator kinematics, dynamics, trajectory planning, sensors, programming and control. The application concepts of robotics in industry will be briefly introduced. PREREQ: MCE 642.

MCE 653 Optimal Control Systems 3 credits. Performance index. Calculus of variations, Pontryagin maximum principle. Linear quadratic regulator. Time and fuel optimal control. Linear quadratic Gaussian problem. Kalman Filter. H optimal control. Industrial applications. PREREQ: MCE 642 OR PERMISSION OF INSTRUCTOR.

MCE 654 Adaptive Control Systems 3 credits. Real-time parameter estimation. Deterministic, stochastic, and predictive self-tuning regulators. Model reference adaptive systems. Auto tuning. Stochastic adaptive control. Properties of adaptive systems. PREREQ: MCE 642 OR PERMISSION OF INSTRUCTOR.

MCE 656 Robust Control Systems 3 credits. Analyze and design basic robust controllers using methods for robustness investigation such as v-analysis and H 4 control algorithms. PREREQ: MCE 642 OR PERMISSION OF INSTRUCTOR.

Mechanical Engineering Graduate Courses

ME g505 Measurement Systems Design 3 credits. Introduction to instrumentation systems analysis and design, including: statistical analysis, system modeling, actuators, transducers, sensor systems, signal transmission, data acquisition, and signal conditioning. PREREQ: ENGR 340, ENGR 342 AND MATH 360. COREQ: ME g506.

ME g506 Measurement Systems Laboratory 1 credit. Principles of measurement, measurement standards and accuracy, detectors and transducers, digital data acquisition principles, signal conditioning systems and readout devices, statistical concepts in measurement, experimental investigation of engineering systems. COREQ: ME g505.

ME g516 Thermal Power Cycles 3 credits. Application of thermodynamics to design of systems for conversion of thermal energy to power by various power cycles. PREREQ: ENGR 264 AND ME 341.

ME g519 Energy Systems and Resources 3 credits. Fundamentals of conventional (fossil, nuclear fission), and alternative (solar, wind, geothermal) energy systems. Electrical energy supply, building HVAC, resources utilized by transportation sector. PREREQ: ENGR 307, MATH 360. COREQ: ENGR 340, 342.

ME g525 Mechatronics 3 credits. Basic kinematics, sensors, actuators, measurements, electronics, microprocessors, programmable logic controllers, feedback control, robotics and intelligent manufacturing. Cross-listed as EE g525. PREREQ: ENGR 340, ENGR 342, MATH 360.

ME g540 Vibration Analysis 3 credits. Free vibration and forced response of single and multiple degree of freedom systems, normal modes, random vibrations, discrete, lumped mass, and continuous systems. Vibration control techniques. Cross-listed as CE g540. PREREQ: ENGR 220, ENGR 350, MATH 360, AND ME 323.

ME g543 Thermal Fluids Laboratory 1 credit. Measurement of thermal and fluid properties, experiments on fluid flow and heat transfer systems. Cross-listed as NE g543. PREREQ: CE/ME/NE 341 AND ME/NE g576.

ME g551 Compressible Fluid Flow 3 credits. Fundamentals of compressible flow and gas dynamics, development of basic principles, practical applications. Techniques developed for isentropic friction, heat addition, isothermal flow, shock wave analysis, propagation, expansion waves, reflection waves. PREREQ: ENGR 309 AND ENGR 341.

ME g568 Behavior of Composite Materials 3 credits. Macro and micromechanical behavior of laminae and laminates; bending, buckling and vibration of laminated beams and plates. Cross-listed as CE g568. PREREQ: ENGR 350 AND MATH 230.

ME g576 Heat Transfer 3 credits. Principles and engineering applications of heat transfer. Analysis of conduction, convection and radiation heat transfer. Design of heat exchangers. Cross-listed as NE g576. PREREQ: CE/ME/NE 341.

ME 607 Advanced Thermodynamics 3 credits. Thermodynamic property relationships, gas mixtures, thermodynamic optimization, irreversible thermodynamics, constructual theory, applications towards solar power, power generation, and refrigeration systems. PREREQ: ME 516, MATH 360.

ME 640 Advanced Vibrations 3 credits. Vibrational theory of continuous, multiple-degree-of-freedom systems, and random vibrations. Use of advanced numeric techniques. PREREQ: CE/ME g540. COREQ: ENGR/MATH g521.

ME 643 Thermal Fluids and Vibrations Lab 3 credits. Advanced thermal/fluid and vibrational system analysis measurements of mechanical systems. PREREQ: ME g506, ME g543.

ME 665 Finite Element Methods 3 credits. Introduction to finite element methods applied to linear one- and two-dimensional problems. Application of the concept to specific problems in various fields of engineering and applied sciences. Cross-listed as CE 665. PREREQ: ENGR 264, ENGR 350, AND MATH 360.

ME 676 Conduction Heat Transfer 3 credits. Single and multiple dimension steady and unsteady conduction heat transfer. Non-constant thermal conductivity. Emphasis on problem formulation, analytical solutions, and numerical techniques. PREREQ: ME g576. CO-REQ: MATH 521.

Nuclear Engineering Graduate Courses

N E g502 Introduction to Nuclear Science and Engineering 3 credits. Basic nuclear and atomic processes; radioactive decay, binding energy, radiation interactions, reaction cross sections, Neutron diffusion, radiation sources. PREREQ: PHYS 212. COREQ: ENGR 307, MATH 360.

NE g543 Thermal Fluids Laboratory 1 credit. Measurement of thermal and fluid properties, experiments on fluid flow and heat transfer systems. Cross-listed as ME g543. PREREQ: CE/ME/NE 341 AND ME/NE g576.

NE g544 Nuclear Fuel Cycles 3 credits. Exploration of the processes associated with nuclear fuel cycles including mining, fabrication, reprocessing, and disposal. Intended primarily as a descriptive course. PREREQ: NSEN g502 or NSEN 515.

NE g545 Neutron Reactions and Transport 3 credits. Physical principles underlying neutron interactions. Multi-region and multi-energy diffusion and transport. Beamport and filter concepts and design. PREREQ: NE g502. COREQ: ENGR 364 AND MATH g521.

NE g546 Nuclear Fuel Cycle Systems Design 3 credits. Criticality, shielding and thermal design of fuel and waste transportation and storage facilities. Criticality and thermal analysis codes. Regulations, environmental and economic considerations. Introduction to safety criteria. PREREQ: NE g502, AND g545.

NE g547 Nuclear Systems Laboratory 1 credits. Techniques of radiation detection and measurements, flux measurements, neutron activation analysis, approach to criticality, Inhour equation, subcritical experiments. PREREQ: NE g545.

N E g548 Design, Control and Use of Radiation Systems 3 credits. Generation detection and measurement systems design for control and use of neutrons and gamma rays in industrial and medical applications. Radiation protection, regulations, environmental and economic considerations. COREQ: ENGR g545.

N E g576 Heat Transfer 3 credits. Principles and engineering applications of heat transfer. Analysis of conduction, convection and radiation heat transfer. Design of heat exchangers. Cross-listed as ME g576. PREREQ: CE/ME/NE 341.

NE g578 Probabilistic Risk Assessment 3 credits. Probabilistic methods applied to analysis

and design. Setting probabilistic design objectives and calculating probabilistic performance emphasized. Cross-listed as ENGR g578. PREREQ: ENGR 364, MATH 360 AND SENIOR STANDING IN ENGINEERING.

NE g587 Medical Applications in Engineering and Physics 3 credits. Applications of engineering and physics, principles, particularly nuclear science, to medicine. Covers radioisotopes, x-ray imaging, magnetic resonance and ultrasound imaging, radiation protection, codes and standards. PREREQ: MATH 360 AND PHYS 212.

Nuclear Science and Engineering Graduate Courses

NSEN 584-585 Survey of Nuclear Engineering 3 credits. For BS engineering graduates with no nuclear background. Lecture, laboratory each semester. Nuclear science; reactor physics, kinetics and thermal hydraulics; nuclear fuel cycle. Not counted toward graduation requirements. PREREQ: BS IN ENGINEERING.

NSEN 601 Nuclear Engineering Experiments 3 credits. Experimental verification of theoretical models will be stressed. Kinetic behavior, neuron spatial distribution, perturbation, and other characteristic equations will be investigated. PREREQ: NE g545 AND NE g576.

NSEN 603 Advanced Thermal Hydraulics 3 credits. Advanced studies of both fluid flow and heat transfer in nuclear reactor cores. Conservation equations; constitutive relations; formulation and solution approaches for complete equation set. PREREQ: CE/ME/NE 341, ME g576.

NSEN 604 Dynamic Behavior of Nuclear Systems 3 credits. Kinetic behavior of nuclear reactors including feedback effects of power transients, fuel burn up, coolant perturbations, etc. Mathematical models developed to predict both short and long term behavior. PREREQ: NE g445.

NSEN 605 Advanced Nuclear Engineering 3 credits. Detailed treatment of current, advanced nuclear power reactor designs. Emphasis on the inherent and engineered safety features and on advantages and disadvantages of each design. PREREQ: NE g545, NSEN 604 AND NSEN 571.

NSEN 608 Advanced Radiation Transport and Shielding 3 credits. Advanced treatment of radiation transport and shielding concepts; interaction and attenuation of neutrons, charged particles, and electromagnetic radiation. Use of deterministic and Monte Carlo computer codes. PREREQ: NE g545, MATH g521.

NSEN 609 Advanced Radiation Detection, Measurements, and Applications 3 credits. Advanced treatment of radiation detectors, measurement techniques, data acquisition, and signal processing. Emphasis on applications in science, industry, and medicine. PREREQ: NSEN g545, NE g548, MATH g521.

NSEN 615 Introduction to Practical Nuclear Engineering 3 credits. Basic concepts of nuclear reactor physics. Present nuclear plant descriptions. Evaluation of fossil, nuclear plant environmental impacts, cycle and overall efficiencies and economics. PREREQ: PERMISSION OF INSTRUCTOR.

NSEN 616 Special Applications of Nuclear Energy 3 credits. Isotopic power systems for remote applications, nuclear propulsion for space vehicles, process heat and space heat reactors, maritime nuclear power plants, medical and industrial applications of nuclear radiation. PREREQ: PERMISSION OF INSTRUCTOR.

NSEN 617 Applications of Nuclear Energy 3 credits. Continued study of nuclear power plant design, operation, and safety analysis of present plants, proposed future concepts. Examination of biological effects of radiation and nuclear medicine, food irradiation and waste heat applications. PREREQ: NSEN 615.

NSEN 618 Treatment of Low Level Radioactive Waste 3 credits. Design and analysis of processes and facilities for treating low-level radioactive waste. Volume reduction, handling, solidification and decontamination processes will be covered. PREREQ: NE g502 OR PERMISSION OF INSTRUCTOR.

NSEN 619 Treatment of High Level Radioactive Waste 3 credits. Design and analysis of processes and facilities for treating high-level radioactive waste. Shielding, criticality, separation and stabilization processes will be covered. PREREQ: NE g502 OR PERMISSION OF INSTRUCTOR.

NSEN 620 Radiation Health Physics and Safety 3 credits. Advanced health physics methods applied to nuclear plants. Radiation safety regulations and ALARA concept. Application of shielding codes to achieve compliance. PREREQ: NE g502 AND PHYS 532 OR EQUIVALENT.

NSEN 625 Two-Phase Flow 3 credits. Fundamentals of two-phase flow. Traditional models. Derivation and examination of conservation equations. Investigation of two-phase flow regimes. PREREQ: NSEN 603.

NSEN 628 Reliability and Risk Analysis 3 credits. Statistical and probabilistic methods of evaluating process and equipment reliability. Use of FMEA, fault tree techniques and Markov methods. Risk and efficacy assessment. PREREQ: ENGR/NE g578 OR MATH g550.

NSEN 631-632 Advanced Reactor Physics 3 credits. Study of advanced theories used in the calculation of nuclear reactor parameters including such topics as the Boltzman transport equation with energy and space dependence multi-group, multi-region diffusion for reflected systems, perturbation theory, etc. Special emphasis will be given to the application of digital computers in nuclear reactor design problems. PREREQ: NE g545.

NSEN 636 Boiling and Condensation 3 credits. Study of the thermophysics of vaporization and condensation, including heat transfer equipment applications. Includes interfacial phenomena, phase stability, homogeneous and heterogeneous nucleation, pool boiling, and external condensation. PREREQ: NSEN 625.

NSEN 646 Two-Phase Flow Measurements Laboratory 2 credits. Design, calibration, operation of two-phase density and mass flow measurement systems. Qualitative and quantitative measurements of flow regime characteristic parameters. Single- and two-component flows. Measurement of upstream disturbance effects. PREREQ: MCE 644.

Engineering and Applied Science Doctoral Graduate Courses

EAS 699 Doctoral Dissertation Variable Credit. Research toward completion of the dissertation for Ph.D. in Engineering and Applied Science. Graded S/U.