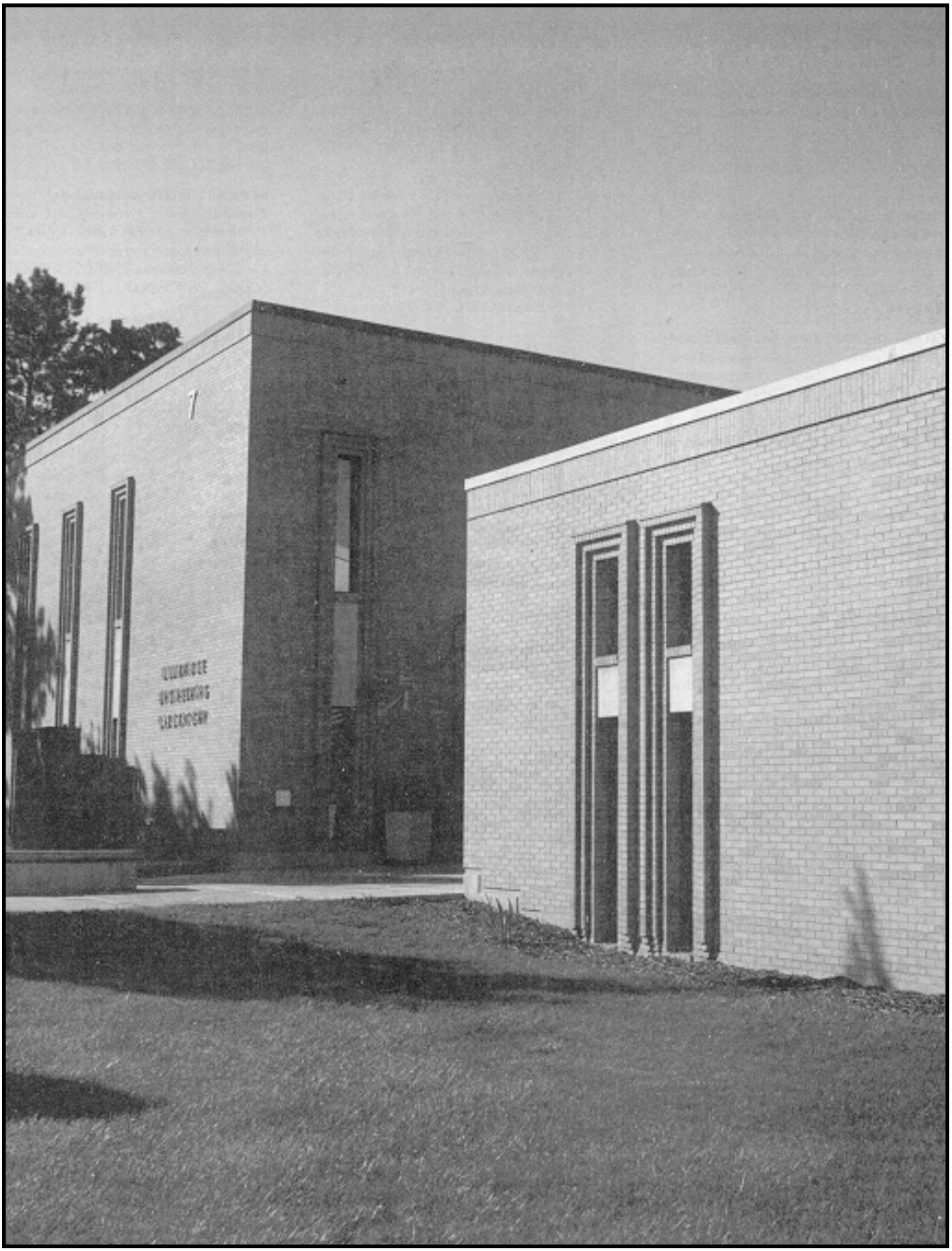


College of Engineering

Jay F. Kunze, Dean
Professors Campo, Naidu, Neill, Robinson, Smedley, Stephens, Stuffle
Associate Professors Leung, Moore, Rao, Sadid, Sato, Wabrek
Assistant Professors Bennion, Blotter, Mc Whirter
Adjunct Faculty Blacker, Beitel, Imel, Larson, Lineberry, O'Brien, Smart
Affiliate Faculty: Caffrey, Sisson, Zaltzman

Doctor of Philosophy in Engineering and Applied Science

The doctoral program is administered by the College of Engineering and offered jointly with the Department of Physics. Research areas emphasized are Measurement and Control, Environmental Engineering, Nuclear Engineering, Radiation Science, Accelerator Applications, Applied Nuclear Physics, and Health Physics. 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.

Admissions

All applicants must meet ISU Graduate School admission requirements for doctoral programs. Additionally, applicants must have attained a master's degree in engineering, physics or a closely related field.

Requirements

The PhD degree requires completion of a least 84 credits consisting of 30 credits for the MS degree, 18 credits of course work and 36 credits of dissertation research. The 30 credits for the MS degree is 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 College of Engineering and the Department of Physics 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 area of interest. At the end of the first year, the student will sit for a written, comprehensive examination over the didactic information within the scope of the research area. The student will be allowed only two attempts to pass this 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 examination.

A dissertation committee, chaired by the candidate's major professor, will be appointed. Within six months, 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 done 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 committee must formally approve the research proposal at least one-half year before the dissertation is submitted for approval.

Dissertation approval requires a public presentation of the dissertation and a satisfactory oral defense to the committee.

Master of Science in Engineering

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

1. Nuclear Science and Engineering
2. Measurement and Control Engineering
3. Environmental Engineering

There are 32 credit hours required for each major. Approximately half of the credits are engineering and technical electives, which should generally follow the guidelines specified in the College of Engineering Graduate Studies Handbook, 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 coursework selected. Each student must also complete two semesters of seminar, an important component in developing research and communication skills.

The student must meet all of the requirements of the Graduate School for the Master of Science degree. 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 coursework have been completed.

Nuclear Science and Engineering

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

NS&E 601	Nuclear Engineering Experiments	3 cr
NS&E 604	Dynamics of Nuclear Systems	3 cr
NS&E 605	Advanced Nuclear Engineering	3 cr
Approved Engineering Electives		9 cr
Approved Technical Electives		6 cr
ENGR 650	Thesis	6 cr
ENGR 651	Seminar	2 cr

Measurement and Control Engineering

The master's degree program in Measurement and Control Engineering fills a growing need in industry for engineers who can design and implement instrumentation and control systems for the increasingly complex manufacturing and production techniques being used today. Advances in modern, as well as classical, measurement and control systems have far outpaced the

traditional control courses. This program serves to fill the gap left in most traditional engineering curricula.

Required Courses (9 credits required)

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

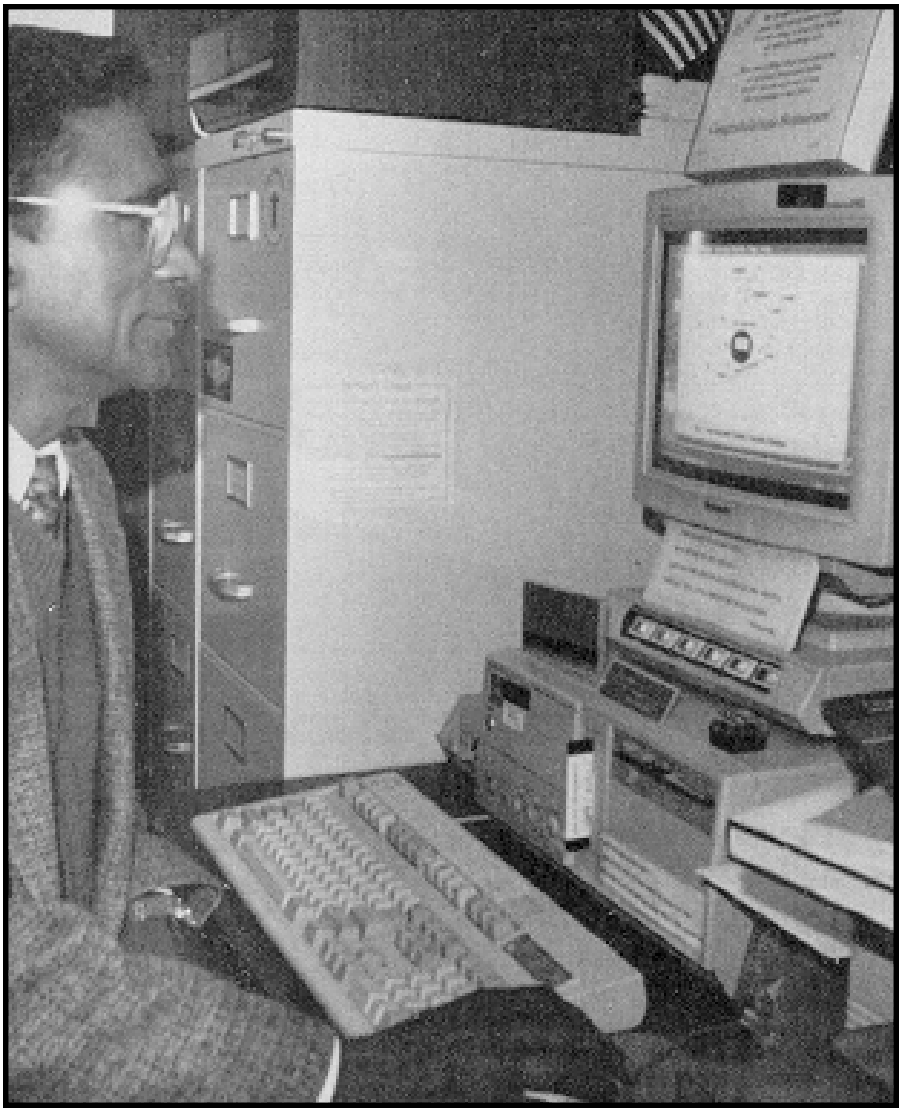
M&CE 642	Advanced Control Systems	3 cr
M&CE 643	Advanced Measurement Methods	3 cr
M&CE 644	Measurements and Controls Laboratory	3 cr
Approved Engineering Electives		9 cr
Approved Technical Electives		6 cr
ENGR 650	Thesis	6 cr
ENGR 651	Seminar	2 cr

Environmental Engineering

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 and one semester of organic chemistry). Students with an insufficient background in engineering and math are required to make up the deficiency according to the advice of their advisory committee.

Required Courses

CHEM 535	Environmental Chemistry	2 cr
CHEM 537	Environmental Chemistry Lab	1 cr
CE 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.

ME 519	Energy System and Resources	3 cr
ENGR 521	Advanced Engineering Analysis (Math)	3 cr
NS&E 544	Nuclear Fuel Cycles	3 cr
ME 576	Heat Transfer	3 cr
ENGR 578	Probabilistic Design	3 cr
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 and Control	3 cr
ENVE 616	Biological Treatment of Wastewater	3 cr
NS&E 618	Treatment of Low Level Radioactive Waste	3 cr
NS&E 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 Bioscience, 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 and Regulation	3 cr
ENGR 607	Hazardous Waste Management	3 cr
ENGR 610	Introduction to Radioactive Waste Management	3 cr
BIOS 587	Environmental Science and Pollutants	3 cr
BIOS 623	Soil and Groundwater Bioremediation	3 cr
GEOL 520	Principles of Geochemistry	3 cr
PSCI 621	Biological Action of Chemicals	3 cr
PSCI 622	Principles of Toxicology	3 cr
PHYS 605	Radiological Environmental Monitoring & Surveillance	3 cr

Thesis (6 credits required)

All student receiving the M.S. degree in Environmental Engineering are required to complete a thesis. These credits should be included in the program of study.

ENGR 650 Thesis 6 cr

Hazardous Waste Management

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 Geology. 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.

Hazardous Waste Management Courses

At least nine credits required for option

BIOS 587	Environmental Science and Pollutants	3 cr
ENGR 570	Survey of Hazardous Waste Management	3 cr
ENGR 606	Environmental Law and 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

Engineering Graduate Courses

CE g332 Basic Geotechnics 3 credits. Classification, analysis and evaluation of soils as engineering material. Water movement through soils. Soil mechanics applied to analysis of foundations, earth slopes and other structures. PREREQ: ENGR 223. COREQ: ENGR 309.

ENGR g415 Model Theory 3 credits. Theory of design and testing of scaled models of engineering systems. Principles of dimensional analysis and their applications to design of physical models. The course considers true and distorted models, linear and non-linear models, and analogies. Some laboratory work required. PREREQ: ENGR 321 AND ENGR 309.

ME g416 Thermal Power Cycles 3 credits. Application of thermodynamics to design systems for conversion of thermal energy to power by various power cycles. PREREQ: ENGR 264 AND ENGR 309.

ME g419 Alternative Energy Systems Design 3 credits. Fundamentals of non-traditional energy generation, conversion and conservation techniques covered. Design and application of small, dispersed systems emphasized. PREREQ: ENGR 313, 309 AND MATH g360; COREQ: ENGR 341.

ENGR g421 Advanced Engineering Analysis I 3 credits. Cross-listed as MATH g421. Analysis of complex linear and nonlinear engineering systems using advanced techniques including Laplace transforms, Fourier series and classical partial differential equations. PREREQ: MATH g360, ENGR 264.

ENGR g422 Advanced Engineering Analysis II 3 credits. Cross-listed as MATH g422. Analysis of complex linear and nonlinear engineering systems using advanced techniques, including probability and statistics, advanced numerical methods and variational calculus. PREREQ: ENGR g421 OR MATH g42l.

ENGR g425 Mechatronics 3 credits. Basic kinematics, sensors, actuators, measurements, electronics, microprocessors, programmable logic controllers, feedback control, robotics and intelligent manufacturing. PREREQ: ENGR 313, MATH g360.

EE g426 Microprocessors 3 credits. Introduction to microprocessor architecture. Programming principles using machine and assembly languages, addressing modes, memory mapping, number representation and processing. PREREQ: ENGR 374.

EE g427 Embedded Systems Engineering 3 credits. Integration of algorithms, software and hardware to design real-time and embedded systems for signal processing and control. PREREQ: EE g426, EE g473, EE g475, OR PERMISSION OF INSTRUCTOR.

EE g429 Advanced Electronics 3 credits. Amplifier design and analysis, large-signal amplifiers and nonlinear effects, feedback, oscillators. PREREQ: ENGR 329.

ME g451 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.

EE g472 Electrical Machines and Power 3 credits. Theory and application of electrical machinery and transformers. Power and energy relationships in power systems including generation, transmission and distribution. Includes 1-credit laboratory component. PREREQ: ENGR 313, MATH g360.

EE g473 Automatic Control Systems 3 credits. Study of continuous-time and discrete-time control systems using both frequency-domain and state-space techniques; topics include design methodology, performance specifications, analysis and design techniques. PREREQ: EE 345.

EE g474 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 313 AND EE 345.

EE g475 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.

ME g476 Heat Transfer 3 credits. Continuation of transport phenomena with emphasis on heat transfer. Conduction, convection, and radiation will be covered. Numerical solutions and equipment design emphasized. PREREQ: 264; COREQ: ENGR 309.

ENGR g478 Probabilistic Design 3 credits. Probabilistic methods applied to analysis and design. Setting probabilistic design objectives and calculating probabilistic performance emphasized. PREREQ: ENGR 264, MATH g360 AND SENIOR STANDING IN ENGINEERING.

ENGR g491 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.

EE g492 Advanced Control System Design 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 g473.

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: BIOL 202, CHEM 111, MATH 43.

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. 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 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.

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.

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 Hazardous Waste Management 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.

Environmental Engineering Graduate Courses

ENVE g408 Water and Wastewater Quality 3 credits. Designs and applications of water and wastewater treatment systems for water quality control and reuse. PREREQ: ENGR 309, CHEM 112. COREQ: ENGR g409.

ENVE g409 Water and Wastewater 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 g408.

ENVE g410 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, ENGR 309.

ENVE 504 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: BIOS 521 AND ENGR 501 IF REQUIRED BY HWM.

ENVE 611 Treatment Systems for Environmental Remediation 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: ENGR 341 AND ENVE 510.

ENVE 612 Treatment of Hazardous Chemical Waste 3 credits. Alternative processes and operations for the treatment of hazardous chemicals. PREREQ: MATH g360, 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 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.

Nuclear Science and Engineering Graduate Courses

NS&E g444 Nuclear Fuel Cycles 3 credits. Exploration of the processes associated with nuclear fuel cycles including mining, fabrication, reprocessing, and disposal. PREREQ: ENGR 371, CHEM 316-318.

NS&E g445 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: ENGR 264, ENGR 371. COREQ: MATH g421.

NS&E g446 Design of Fuel Cycle Systems 3 credits. Criticality, shielding and thermal design of fuel or waste transportation and storage facilities. Criticality and thermal analysis code use. Storage and transportation regulations, environmental and economic considerations. Introduction to safety criteria. PREREQ: ENGR g445.

NS&E g447 Nuclear Systems Laboratory 3 credits. Techniques of radiation detection and measurements, flux measurements, neutron activation analysis, approach to criticality, Inhour equation, subcritical experiments. PREREQ: ENGR g445.

NS&E g448 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 g445.

NS&E 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.

NS&E 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: ENGR 432 AND ENGR 433.

NS&E 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: ENGR 341, ME g476.

NS&E 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: ENGR 432.

NS&E 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: NS&E 604 AND NS&E 571.

NS&E 616 Special Application of Nuclear Energy 3 credits. Topics will include the use of isotopic power sources for remote systems, nuclear propulsion for earth and space vehicles, process heat sources, portable power plants, etc. Advances in related fields such as direct conversion gas turbines for high temperature application, etc. PREREQ: ME g476.

NS&E 617 Power Plant Engineering 3 credits. Detailed discussion of project engineering, safety and analysis licensing, and regulations that pertain to the procurement and operation of nuclear power systems. PREREQ: PERMISSION OF INSTRUCTOR.

NS&E 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: ENVE 610 AND ENGR 371.

NS&E 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: ENVE 610 AND ENGR 371.

NS&E 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: ENGR 371 AND PHYS 532 OR EQUIVALENT.

NS&E 621 Shielding and Radiation Protection 3 credits. Analysis of materials for radiation shielding application, design of composite shields, duct streaming, buildup factors in shield design, and other topics. Shield requirements for instruments and personal protection. PREREQ: NS&E g471 OR EQUIVALENT.

NS&E 624 Reactor Safety 3 credits. Safety criteria involved in the safe design of nuclear reactor systems. Criticality safety as well as containment, handling, and analysis of potentially hazardous situations. PREREQ: NS&E 603.

NS&E 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: NS&E 603.

NS&E 626 Siting and Regulations 3 credits. Problems encountered in the location of large nuclear plants with regard to existing federal and state regulations. Regulatory practices and the responsibility of the engineer in designing for regulatory compliance.

NS&E 627 Computers in Nuclear Analysis, 3 credits. Large scale computational methods in reactor science, including multi-group diffusion, cross-section generation, fuel depletion, economics and heat transfer. Extensive use of computer required.

NS&E 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 g478 OR MATH g450.

NS&E 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: ENGR 432 OR EQUIVALENT.

NS&E 633 Controlled Thermonuclear Energy 3 credits. Theory of thermonuclear reactions, weakly ionized gases; Boltzmann theory; elementary plasma physics; and possible thermonuclear reactors. PREREQ: PERMISSION OF INSTRUCTOR.

NS&E 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: NS&E 625.

NS&E 639 System Analysis of Reactor Dynamics 3 credits. Selected topics in nuclear system dynamics, simulation, and control; content varies. PREREQ: PERMISSION OF INSTRUCTOR.

NS&E 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: M&CE 644.

NS&E 647 Experiment Design and Data Analysis 3 credits. Statistical analysis and other techniques for data interpretation and qualification. Experiment design principles. On-line digital signal processing methods. PREREQ: ENGR g478 OR MATH g450; COREQ: ENGR g421 OR MATH g421.

NS&E 699 Doctoral Dissertation. Research toward completion of the dissertation. Variable credit. Graded S/U.

Measurement and Control Engineering Graduate Courses

M&CE 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 g473.

M&CE 642 Advanced Control Systems 3 credits. Study of advances in classical and modern control systems. Optimization, estimation and Eigenstructure control. PREREQ: EE g473 OR EQUIVALENT.

M&CE 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: ENGR 344 OR EQUIVALENT.

M&CE 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: M&CE 642 AND M&CE 643 OR EQUIVALENT.

M&CE 645 Advanced Control Theory 3 credits. Topics selected from nonlinear, adaptive, robust, stochastic, intelligent, or process control theory, depending upon the interests of students and faculty. May be repeated for credit when topics vary. PREREQ: M&CE 642.

M&CE 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: M&CE 642.

M&CE 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: M&CE 642 OR PERMISSION OF INSTRUCTOR.

Table of Contents

Continue to Next Section