

NPRE - NUCLEAR, PLASMA, RADIOLOGICAL ENGINEERING

NPRE Class Schedule (<https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/NPRE/>)

Courses

NPRE 100 Orientation to NPRE credit: 1 Hour. (<https://courses.illinois.edu/schedule/terms/NPRE/100/>)
Introduction to nuclear, plasma, and radiological engineering. Demonstrations and discussion of nuclear phenomena (reactor operation, plasma behavior, and others). Experiments on radioactive decay and radiation shielding with formal laboratory report and a student project.

NPRE 101 Introduction to Energy Sources credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/101/>)
Explanation of energy technologies using an elementary approach presupposing no prior scientific or technical background. Coverage of all energy sources including fossil fueled, solar, hydro, and nuclear power. Integral demonstrations and a tour of the University's power plant. Discussion of energy related incidents with emphasis on environmental, economic, and social impact. Same as ENV5 101.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

NPRE 199 Undergraduate Open Seminar credit: 1 to 5 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/199/>)
May be repeated in separate terms to a maximum of 2 times.

NPRE 200 Mathematics for Nuclear, Plasma, and Radiological Engineering credit: 2 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/200/>)
Introduction to mathematics and computational aspects of nuclear, plasma, and radiological engineering; eigenvalue/eigenvector problem for nuclear reactor criticality; analytic and numerical solution of radioactive decay chain; analytic and numerical solution for particle diffusion; probability and statistics for radioactive decay and system reliability. Prerequisite: MATH 231.

NPRE 201 Energy Systems credit: 2 or 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/201/>)
Patterns of energy production and utilization and technical aspects of renewable energy resources, advanced fossil fuel systems, and advanced nuclear systems. Same as GBLB 201. Prerequisite: MATH 220 or MATH 221; one of PHYS 101, PHYS 211, CHEM 104, CHEM 204, ME 200.

NPRE 247 Modeling Nuclear Energy System credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/247/>)
Applications of elementary nuclear physics in nuclear engineering. Nuclear reactor materials and components. Steady-state and transient operation of nuclear reactors. Nuclear energy removal and conversion. Radiation shielding. Prerequisite: Credit for PHYS 211; credit or concurrent registration in CS 101 or 124 or 125; credit or concurrent registration in MATH 285.

NPRE 321 Introduction to Plasmas and Applications credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/321/>)
Provides an introduction to plasma concepts. Basics covered will include what is a plasma and how a plasma is generated to the different types of plasmas and related underlying concepts such as the sheath, frequencies, drift velocities diagnostics and an introduction to nuclear fusion. There is a practicum component where students receive hands-on experience with plasmas in a laboratory setting with live demonstrations. Prerequisite: MATH 241 and PHYS 212.

NPRE 330 Materials in Nuclear Engineering credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/330/>)
Development of a materials engineering background in the context of nuclear systems and radiation applications; relation of structure of materials to their physical and mechanical properties; development of phase formation and reaction kinetics from basic thermodynamics principles; charged particle interactions with surfaces; transport concepts of neutral and charged particles in matter; materials performance in nuclear and radiation applications, including radiation damage and effects.

NPRE 349 Introduction to NPRE Heat Transfer credit: 2 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/349/>)
Engineering principles in heat and mass transfer with emphasis on applications in NPRE will be covered. Specifically, the focus in this course will be on heat conduction, convection, radiation, and boiling. Prerequisite: MATH 285; credit or concurrent registration in TAM 335 or ME 310.

NPRE 397 Independent Study credit: 1 to 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/397/>)
Individual investigations or studies of any phase of nuclear engineering selected by the student and approved by the department. May be repeated. Prerequisite: Consent of instructor.

NPRE 398 Special Topics credit: 1 to 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/398/>)
Subject offerings of new and developing areas of knowledge in nuclear, plasma, and radiological engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

NPRE 402 Nuclear Power Engineering credit: 3 or 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/402/>)
Principles of utilization of fission energy in nuclear power engineering; includes such topics as fission processes and controlled chain reactions; nuclear reactor types, design principles, and operational characteristics; power reactor design criteria; radiation hazards and radioactive waste treatment; economics; other applications such as propulsion and research reactors. 3 undergraduate hours. 4 graduate hours. Credit is not given for both NPRE 402 and NPRE 247.

NPRE 412 Nuclear Power Econ & Fuel Mgmt credit: 3 or 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/412/>)
Quantitative analysis of the impact of the nuclear power industry; nuclear fuel cycle and capital costs for thermal and fast reactors; optimization of the use of nuclear fuels to provide the lowest energy costs and highest system performance; comparison between fossil fuel systems, fission systems, and controlled thermonuclear fusion systems. 3 undergraduate hours. 4 graduate hours. Prerequisite: NPRE 402 or NPRE 247. Junior standing is required.

NPRE 413 Nuclear Separations and Fuel Reprocessing credit: 2 or 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/413/>) Radionuclide separations are the basis for recycling of nuclear fuel. This class will cover the chemistry and engineering of nuclear separations as used in reprocessing. Students will learn the basics of f-element and fission product chemistry, mathematical algorithms of reprocessing schemes, past, current, and future reprocessing schemes, and the unit operations of reprocessing. After completing this class, the student will understand the chemical and engineering bases behind reprocessing schemes past and present. 2 or 3 undergraduate hours. 2 or 3 graduate hours. Prerequisite: Junior, Senior, or Graduate Standing.

NPRE 421 Plasma and Fusion Science credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/421/>)

Physics of plasmas, including particle and fluid descriptions, waves, collisions, stability, and confinement, with applications to controlled thermonuclear fusion reactors, problems in fusion engineering, and astrophysics. 3 undergraduate hours. 3 graduate hours. Prerequisite: NPRE 321.

NPRE 423 Plasma Laboratory credit: 2 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/423/>)

Experiments relating to plasma engineering and fusion energy. Topics in ultra-high vacuum technology rf and dc electric plasma probes, measurements of dc and pulsed magnetic fields, dynamics of a theta pinch, and laser interferometry to measure plasma density. 2 undergraduate hours. 2 graduate hours. Prerequisite: NPRE 421 and NPRE 451.

NPRE 429 Plasma Engineering credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/429/>)

Basic principles and examples for adapting and applying the plasma state to solve a number of modern engineering problems. Plasma processing of materials for microelectronics and other uses, lighting, plasma displays, and other technologies. 3 undergraduate hours. 3 graduate hours. Prerequisite: ECE 329 or PHYS 435.

NPRE 430 Advanced Materials in Nuclear Engineering credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/430/>)

Development of advanced materials concepts in light water reactor nuclear engineering systems. This includes foundational concepts such as radiation damage, corrosion, and the materials systems found in light water reactors. Advanced concepts include kinetic rate theory, evolution of irradiated microstructures, water chemistry control, stress corrosion cracking, radiation induced segregation, and other phenomenon associated with radiation damage are introduced. Advanced microanalytical analysis techniques will be presented, as will computational approaches applicable to the study of radiation damage in metals. Materials for use in advanced reactor concepts will be presented. 3 undergraduate hours. 3 graduate hours. Prerequisite: NPRE 330.

NPRE 432 Nuclear Engrg Materials Lab credit: 2 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/432/>)

Experiments relating to materials applications in nuclear engineering and energy systems. Examination of topics in room and elevated temperature mechanical properties of structural materials, corrosion, physical properties, radiation damage and effects, and materials selection in design. 2 undergraduate hours. 2 graduate hours. Prerequisite: Credit or concurrent registration in NPRE 330.

NPRE 435 Radiological Imaging credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/435/>)

Physical, mathematical and experimental foundations of radiological imaging techniques, such as typical sources of ionizing radiation, the interactions of radiation with matter, image formation techniques, linear systems theory applied to radiological imaging, and the techniques for tomographic image reconstruction. Includes diagnostic radiological imaging modalities, such as X-ray computed tomography (CT), single photon computed emission tomography (SPECT), positron emission tomography (PET), as well as modern X-ray imaging techniques, such as phase contrast imaging and diffraction-enhanced X-ray imaging. Provides a solid foundation for understanding of modern radiological imaging techniques, and in-depth discussions on the strengths and limitations of various modalities in application to medical, physical, security and environmental imaging. 3 undergraduate hours. 3 graduate hours. Prerequisite: NPRE 445.

NPRE 441 Radiation Protection credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/441/>)

Sources of nuclear radiation; ionization and energy deposition in matter with an emphasis on biological systems; principles of dosimetry; determination of exposure and limits for internal and external emitters; basic shielding calculations. 4 undergraduate hours. 4 graduate hours. Prerequisite: NPRE 445.

NPRE 442 Radioactive Waste Management credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/442/>)

Radiation and radiological concepts and measurement, the fuel cycle and waste classification, Part 61, state and federal regulations and regulatory agencies, radiochemistry and the environmental fate of radionuclides, uranium-related wastes, low-level wastes, high-level wastes, used fuel reprocessing, private fuel storage, waste package stability, risk assessment, geologic repositories, transporting radioactive wastes, decommissioning wastes, transmutation, an international perspective on radioactive waste management, and the global nuclear energy partnership. 3 undergraduate hours. 3 graduate hours. Prerequisite: MATH 231; PHYS 102 or PHYS 212.

NPRE 445 Interaction of Radiation with Matter credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/445/>)

The classical and quantum theories of the interaction of radiation with matter are the core components of nuclear science and engineering. In this course, we provide a quantitative introduction to introductory quantum mechanics, fundamentals of atomic and nuclear physics, and interaction of radiation (charged particles, photons, and neutrons) with matter. 4 undergraduate hours. 4 graduate hours. Prerequisite: NPRE 200, MATH 285, PHYS 212.

NPRE 448 Nuclear Syst Engrg & Design credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/448/>)

Engineering principles underlying nuclear systems designed with emphasis on nuclear power reactors. Materials for nuclear systems. Energy generation and removal in single- and two-phase flows. Reactor and component control systems and nuclear fuel reloading patterns. 4 undergraduate hours. 4 graduate hours. Prerequisite: MATH 285, ME 200, and NPRE 455.

NPRE 449 Nuclear Systems Engineering and Design credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/449/>)

Engineering principles underlying nuclear power plant components and systems will be covered. Specifically, focus in this course will be on energy generation, heat conduction, single- and two-phase flows, and on energy removal in single- and two-phase flows. Equal emphasis will be placed on component and system level treatment, as well as on both the underlying theory and its applications to practical design and maintenance problems encountered in the field of nuclear engineering. 3 undergraduate hours. 3 graduate hours. Prerequisite: NPRE 349, NPRE 455.

NPRE 451 NPRE Laboratory credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/451/>)

Radiation detection and instrumentation; radiation dosimetry and shielding; basic measurements in nuclear engineering; engineering applications; micro computer data acquisition and experimental control. 3 undergraduate hours. 3 graduate hours. Prerequisite: NPRE 445.

NPRE 452 Advanced Radiological Science Lab credit: 2 or 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/452/>)

Advanced laboratory course on current radiation detection methods that exploit modern physics concepts and are applied in radiological science research. 2 undergraduate hours. 4 graduate hours. Prerequisite: NPRE 451.

NPRE 455 Neutron Diffusion & Transport credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/455/>)

Neutron migration, neutron slowing down and thermalization; neutron continuity equation, multigroup diffusion theory, homogeneous and heterogeneous medium, thermal and fast assemblies; numerical methods for multigroup diffusion equations; reactor dynamics perturbation theory; reactivity coefficients; introductory transport theory. 4 undergraduate hours. 4 graduate hours. Prerequisite: NPRE 247.

NPRE 457 Safety Anlys Nucl Reactor Syst credit: 3 or 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/457/>)

Basic safety philosophy in nuclear reactor systems; brief review of nuclear reactor systems; regulatory processes; siting considerations; safety problems related to reactor dynamics; evaluation of postulated accidents; risks associated with nuclear fuel cycle; methods of systems safety analysis. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: NPRE 402 or NPRE 247.

NPRE 458 Design in NPRE credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/458/>)

Design in nuclear, plasma, and radiological engineering systems; basic principles of definition, organization, constraints, modeling and optimization of system design; case studies; class design projects applying these basic principles. 4 undergraduate hours. 4 graduate hours. Prerequisite: NPRE 449.

NPRE 461 Probabilistic Risk Assessment credit: 3 or 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/461/>)

Multidisciplinary theories and techniques of risk, safety, and reliability of complex systems and state-of-the-art Probabilistic Risk Assessment (PRA), which provides input for risk-informed decision-making for design, operation, and regulatory oversight in diverse high-consequence industries such as nuclear power, aviation, space, chemical processes, oil and gas, and healthcare. Topics include: Systematic Risk Scenario Modeling, Consequence Analysis, Bayesian Updating, Bayesian Belief Network, Binary Decision Diagram, Uncertainty Propagation, Hardware Reliability, Human Error Modeling, Failure Causal Modeling, Maintenance and Repair Modeling, Risk Importance Ranking, and Data Analytics. PRA and Reliability Engineering software codes will be utilized for assignments. 3 undergraduate hours. 4 graduate hours. Prerequisite: Junior, Senior or Graduate Standing in any Engineering Department.

NPRE 470 Fuel Cells & Hydrogen Sources credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/470/>)

The role of hydrogen as a global energy form, hydrogen production by nuclear, fossil and renewable energy sources; hydrogen handling, safety; transportation and storage methods including high-pressure, cryogenic, metal hydrides and chemical hydrides; basic science and technology of fuel cells, including electrochemical processes; fuel cell thermodynamics; low- and high-temperature fuel cells; applications including portable electronics, automotive vehicles, distributed and back-up power, and space power. 3 undergraduate hours. 3 graduate hours. Prerequisite: CHEM 102, MATH 285, and PHYS 212.

NPRE 475 Wind Power Systems credit: 3 or 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/475/>)

Overview of wind energy systems; historical development, safety aspect, environmental considerations, wind properties and measurement, site selection, and wind turbine design; transmission systems considerations; mechanical, electrical, control aerodynamic and environmental engineering of modern wind turbines; fatigue failure; annual power production; economics and environmental aspects and accident prevention and mitigation; computational fluid dynamics (CFD) analysis of wind flow and blade interactions; energy storage options; hydrogen production; electrical power transmission issues; licensing issues; alternative wind energy systems; design project involving a wind farm or the construction of a specific type of wind turbine based on a wind park site visit. 3 undergraduate hours. 4 graduate hours. Prerequisite: CS 101, MATH 241; one of CHBE 421, ECE 110, ECE 205, ME 310, TAM 335.

NPRE 480 Energy and Security credit: 3 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/480/>)

Security and supplies of energy, mineral resources, and water. Evolution of the importance of various fuels in conflicts (including coal, oil, uranium, and natural gas) starting with the Franco-Prussian Wars. Theories of international conflict and examination of the role of individual leaders versus institutional factors in the precipitation and outcome of pivotal wars. Econometric analyses relevant to past and projected future energy use. Same as GLBL 480 and PS 480. 3 undergraduate hours. 3 graduate hours. Prerequisite: Composition I and Quantitative Reasoning I.

NPRE 481 Writing on Technol & Security credit: 3 or 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/481/>)
Development of writing skills in standard computer, desktop publishing, and electronic publishing formats. On themes such as, global and regional security environments, arms control, nuclear energy, and climate change. For graduate credit, writing projects include documentation of computational work using software appropriate for typesetting of mathematical formulas. Same as GLBL 481. 3 undergraduate hours. 3 or 4 graduate hours. 4 graduate hours with consent of instructor. This course satisfies the General Education Criteria for: Advanced Composition

NPRE 483 Seminar on Security credit: 1 Hour. (<https://courses.illinois.edu/schedule/terms/NPRE/483/>)
Preparation of reports on a set of introductory lectures and student choices from various on-campus seminar series relevant to technology of domestic and international security and the regional and international contexts that influence the nature of security problems. Same as GLBL 483. 1 undergraduate hour. 1 graduate hour. May be repeated in separate terms to a maximum of 2 hours. Prerequisite: Composition I.

NPRE 498 Special Topics credit: 1 to 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/498/>)
Subject offerings of new and developing areas of knowledge in nuclear, plasma, and radiological engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary.

NPRE 501 Fundamentals of Nuclear Engrg credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/501/>)
Background for advanced work in nuclear engineering; problems in materials, heat transfer, and fluid flow; special emphasis on basic ideas and the mathematical similarity of problems in heat transfer, fluid flow, and neutron diffusion. Lecture-problem format. Prerequisite: NPRE 247; credit or concurrent registration in NPRE 446.

NPRE 511 Nuclear Reactor Heat Transfer credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/511/>)
Selected topics in nuclear reactor heat transfer: thermal analysis of fuel elements under steady and transient operation; convective energy transport from reactor cores; two-phase flow and boiling in reactor cores; liquid metal coolant systems. Prerequisite: NPRE 501.

NPRE 521 Interact of Radiation w/Matter credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/521/>)
Topics in the interaction of radiation with matter of interest to the nuclear engineering field: the kinematics, kinetics, and cross sections involved in the interaction of charged particles, electromagnetic radiation, and neutrons. Prerequisite: NPRE 446.

NPRE 522 Controlled Fusion Systems credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/522/>)
Development of plasma models for fusion analysis; treatment of plasma heating and confinement with applications to current experiments; energy balances; energy extraction. Prerequisite: NPRE 421.

NPRE 523 Plasma Waves credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/523/>)
The course covers the fundamentals of plasma waves and plasma heating, including an overview of the techniques and the technologies used in thermonuclear fusion reactors for heating and current drive. The first part of the semester covers the linear theory of plasma waves, including: the cold plasma tensor, cold dispersion relation, normal modes, frequency plots, Clemmow-Mullaly-Allis diagram, acoustic modes, kinetic theory of plasma waves, hot tensor, Bernstein modes, electrostatic damping, cyclotron modes. The course then offers an introduction to non-linearities, with major emphasis on the quasi-linear theory as a natural extension from the kinetic theory of plasma waves. The final portion of the course provides a qualitative and quantitative description of the major techniques used to deliver energy and momentum to a plasma (heating and current drive), namely ion cyclotron heating, electron cyclotron, lower hybrid, electron Bernstein, and neutral beam injection. Examples of heating technologies are provided for both thermonuclear and industrial applications. The course comprises simple analytical and computational homework assignments. 4 graduate hours. No professional credit. Prerequisite: ECE 329 or PHYS 435; NPRE 421.

NPRE 526 Plasma-Material Interactions credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/526/>)
The course will introduce the student to fundamental concepts in plasma-materials interactions (PMI) and extend these concepts into practical methods for PMI. The course connects the concepts of surface science to irradiation-driven modification used in plasma nanosynthesis of advanced materials and PMI phenomena encountered in extreme environments (e.g. nuclear fusion, star and planetary formation, among others). The course is designed to lay the foundation of mastering selected techniques and methods for PMI. The organization of this course will: 1) prepare the student with the fundamentals aspects of plasma-surface interaction and surface science, 2) apply these fundamental concepts and expand into PMI of nanosynthesis and extreme plasma-based environments and 3) master methods and characterization techniques used in plasma-material interactions including: techniques for in-situ analysis and simulated plasma experiments. 4 graduate hours. No professional credit. Prerequisite: NPRE 429 or equivalent.

NPRE 527 Plasma Technology of Gaseous Electronics credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/527/>)
This course will help students to develop an advanced theoretical understanding of Low-Temperature Plasma (LTP) processing systems, with an emphasis on system design. Whereas prerequisite coursework focused on developing a framework for the analysis of LTP systems, in this course students will build upon that foundation to develop more advanced theoretical models for LTP dynamics, including electron collisions, plasma transport, sheath dynamics, and plasma and surface chemistry. Students will be able to apply this advanced LTP theory for the design of systems for etching, advanced deposition, and others important in modern materials processing applications. Same as ECE 523. 4 graduate hours. No professional credit. Prerequisite: ECE 452 or PHYS 485 or NPRE 429.

NPRE 531 Nuclear Materials credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/531/>)
Metallurgical principles applied to materials problems in nuclear engineering; topics in production of uranium, corrosion, radiation damage, fuel element fabrication, and fuel reprocessing. 4 graduate hours. No professional credit. Prerequisite: NPRE 430.

NPRE 554 Independent Lab Investigations credit: 1 to 8 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/554/>) Individual experimental investigation in areas of nuclear, plasma, and radiological engineering. May be repeated. Prerequisite: Consent of instructor.

NPRE 555 Reactor Theory I credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/555/>) Advanced development of neutron transport theory; neutron slowing-down and resonance absorption; approximations to the transport equation; direct numerical methods and other techniques of approximation theory applied to the neutron transport equation; advanced topics. Prerequisite: NPRE 455 (waived for Physics majors).

NPRE 558 Advanced Design in NPRE credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/558/>) Classroom exercise in the conceptual design of a nuclear engineering system involving a synthesis of previous learning in the field of nuclear engineering and related disciplines. The design includes all necessary ingredients for the system, such as core, thermal-hydraulics, shielding, material selection, and control. Prerequisite: NPRE 448 and NPRE 501.

NPRE 560 Reactor Kinetics and Dynamics credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/560/>) Diffusion and transport neutron balances with delayed neutrons; formal development of the point reactor kinetics equations; analytic and numerical solutions of the point reactor kinetics equations; space-dependent, multigroup reactor kinetics; reactivity measurements; reactor noise analysis; advanced topics. Prerequisite: NPRE 555.

NPRE 561 Advanced Risk Analysis for Technological Systems credit: 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/561/>) This course covers advanced modeling techniques for Probabilistic Risk Assessment (PRA), which provides input for risk-informed decision-making in design, operation, and regulatory oversight of complex technological systems such as nuclear power, space, chemical processes, oil and gas. Main topics: risk scenario modeling, common cause failure analysis, Bayesian updating, uncertainty analysis, Bayesian Belief Network, simulation-based PRA, probabilistic physics of failure, human reliability analysis, and expert elicitation & aggregation. PRA and Bayesian analysis software codes are utilized for assignments. 4 graduate hours. No professional credit. Prerequisite: NPRE 461 or NPRE 457 or GE 411 or CEE 491.

NPRE 595 Student Research Seminar credit: 1 Hour. (<https://courses.illinois.edu/schedule/terms/NPRE/595/>) Seminar on current research and development activities in NPRE related fields, presented by students. 1 graduate hour. No professional credit. Approved for Letter and S/U grading. May be repeated in separate terms up to 2 hours.

NPRE 596 Seminar in Nuclear Sci & Engrg credit: 1 Hour. (<https://courses.illinois.edu/schedule/terms/NPRE/596/>) Lectures and discussions on current work in research and development in nuclear engineering and related fields by staff, advanced students, and visiting lecturers. Approved for S/U grading only. May be repeated.

NPRE 597 Independent Study credit: 1 to 8 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/597/>) Individual study in areas of nuclear engineering and closely related fields not covered by regular course offerings. The work is carried out under the supervision of a member of the faculty. May be repeated. Prerequisite: Consent of instructor.

NPRE 598 Special Topics credit: 2 to 4 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/598/>) Subject offerings of new and developing areas of knowledge in nuclear, plasma, and radiological engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

NPRE 599 Thesis Research credit: 0 to 16 Hours. (<https://courses.illinois.edu/schedule/terms/NPRE/599/>) Approved for S/U grading only. May be repeated.