NUCLEAR, PLASMA, RADIOLG ENGR (NPRE)

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 ENVS 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 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 GLBL 201.
Prerequisite: MATH 220 or MATH 221; one of PHYS 101, PHYS 211, CHEM 104, CHEM 204, ME 200.

NPRE 241 Intro to Radiation Protection  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/241)
Elements of radiation protection and health physics, emphasizing practical applications. Prerequisite: MATH 220 or MATH 221; one of CHEM 102, IB 150, MCB 150, PHYS 211.

NPRE 247 Modeling Nuclear Energy System  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/247)

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 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: For engineering or physical science majors with junior standing.

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 431 Materials in Nuclear Engrg  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/431)
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. 3 undergraduate hours. 3 graduate hours.

Information listed in this catalog is current as of 10/2018
NPREE 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 431.

NPREE 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: NPREE 446.

NPREE 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: NPREE 446.

NPREE 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.

NPREE 444  Nuclear Analytical Methods Lab  credit: 2 or 3 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/444)
Experiments relating to nuclear analytical methods and techniques. Emphasis on neutron activation analysis, energy dispersive x-ray fluorescence and particle spectroscopy. Use of radiation for medical and materials imaging. 2 or 3 undergraduate hours. 2 or 3 graduate hours. Credit of 2 hours is given if NPREE 451 or equivalent has been taken. Prerequisite: CHEM 102 and NPREE 446.

NPREE 446  Radiation Interact w/Matter I  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/446)
Experimental and theoretical foundations of interaction of neutrons, photons, and charged particles with matter. Emphasis on topics that underlie the following applications: radiation detection, biological effects and radiation dosimetry, radiation damage and nuclear materials, neutron activation analysis, and fission and fusion energy systems. Classical theory of charged particle cross sections. Introductory quantum mechanics. Exact and numerical solutions of the Schroedinger equation. Quantum theory of cross sections. Photon interactions with atomic electrons and nuclei. Radioactive-series decay. Computer assignments illustrate fundamental concepts. 3 undergraduate hours. 3 graduate hours. Credit is not given to NPREE majors for graduate hours. Prerequisite: MATH 285 and ME 200.

NPREE 447  Radiation Interact w/Matter II  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/447)
Continuation of NPREE 446. Quantum theory of ionization of matter by charged particles. Nuclear models and structure. Alpha decay, fission and fusion reactions. Beta and gamma decay. Nuclear reactions. Radiation damage effects. Special topics. Computer assignments to illustrate fundamental concepts. 3 undergraduate hours. 3 graduate hours. Prerequisite: NPREE 446.

NPREE 448  Nuclear Syst Engrg & Design  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/448)
Engineering principles underling 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 NPREE 455.

NPREE 451  NPREE 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: NPREE 446.

NPREE 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: NPREE 247.

NPREE 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: NPREE 402 or NPREE 247.

NPREE 458  Design in NPREE  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: NPREE 448.
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.

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.

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.

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 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. Prerequisite: NPRE 431.

**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 556 Reactor Theory II** credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/556)
Advanced treatment of the theory of slow-neutron scattering, neutron thermalization, Doppler broadening, fuel depletion and fuel loadings, properties of neutron migration operators, and mathematical neutron transport theory; interpretation of related experiments; advanced topics. Prerequisite: NPRE 521 and NPRE 555 (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 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 & Engr** 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.