DEPARTMENT OF NUCLEAR, PLASMA, & RADIOLOGICAL ENGINEERING

department website: Nuclear, Plasma, & Radiological Engineering (https://npre.illinois.edu)
department faculty: Nuclear, Plasma, & Radiological Engineering Faculty (http://npre.illinois.edu/directory)
email: nuclear@illinois.edu
college catalog page: Engineering Catalog (http://catalog.illinois.edu/engineer)
college website: College of Engineering (https://engineering.illinois.edu)

Nuclear, plasma, and radiological engineering is a branch of engineering that is concerned with the development and use of nuclear energy and radiation sources for a wide variety of applications in energy production, in materials processing and science, and for biomedical and industrial uses. Areas of interest include the continued safe and reliable application of fission reactors as central electric power plant thermal sources; plasma processing applications and the longer term development of fusion reactors for electric power generation; and the use of radiation sources in such areas as materials, biological systems, medical treatment, radiation instrumentation, environmental systems, and activation analysis.

The first two years of the curriculum provide a strong foundation in basic sciences (physics, mathematics, and chemistry), engineering sciences (analytical mechanics and thermodynamics), an introduction to digital computer use, and introduction to nuclear energy systems. Most technical concentration takes place in the third and fourth years of the curriculum according to the educational and career interest of the students. The curriculum provides three professional concentration areas: power, safety and the environment; plasma and fusion science and engineering; and radiological, medical, and instrumentation applications. Each concentration area allows flexibility in developing advanced technical expertise but also requires depth of understanding in the area. The third path meets pre-med requirements and facilitates the minor in bioengineering. To complete this concentration area, students should take certain chemistry and biology courses in the first two years of the curriculum.

Undergraduate Programs:

- **major: Nuclear, Plasma, & Radiological Engineering, BS** (http://catalog.illinois.edu/undergraduate/bs_npre)

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Graduate Programs: (http://catalog.illinois.edu/graduate/graduate-majors/npre)

- **degree: Engineering: Energy Systems, MEng** (http://catalog.illinois.edu/graduate/graduate-majors/npre/ms-engineering-concentration-energy-systems)
- **degree: Nuclear, Plasma, & Radiological Engineering** (http://catalog.illinois.edu/graduate/graduate-majors/npre/ms-nuclear-plasma-radiological-engineering)**, MS** (http://catalog.illinois.edu/graduate/graduate-majors/mechse/ms-mech-eng)
- **online degree: Mechanical Engineering, MS - online** (http://catalog.illinois.edu/graduate/graduate-majors/mechse/#onlinetext)
- **degree: Nuclear, Plasma, & Radiological Engineering** (http://catalog.illinois.edu/graduate/graduate-majors/npre/ms-nuclear-plasma-radiological-engineering)**, PhD** (http://catalog.illinois.edu/graduate/graduate-majors/mechse/dr-philo-mech-eng)
- **joint program: MBA** (http://catalog.illinois.edu/graduate/graduate-majors/npre/#jointprogramstext)

Graduate Degree Programs

The Department of Nuclear, Plasma, and Radiological Engineering (NPRE) offers programs leading to Master of Science and Doctor of Philosophy degrees in Nuclear, Plasma, and Radiological Engineering. The Master of Science and Doctor of Philosophy degree programs are centered around three theme areas:

- nuclear power engineering
- fusion and plasma science and engineering
- radiological engineering and medical physics

Advanced course work and active research programs are offered in all of these areas.

The NPRE department also administers for the College of Engineering a Master of Engineering degree program with a Concentration in Energy Systems.

The Faculty of the Department are internationally recognized experts in the areas of: nuclear science and engineering, radiation processes and transport, materials science, thermal sciences, systems engineering, energy conversion processes and systems, plasma sciences and processing, fusion energy, radiation-based medical imaging and therapy, dosimetry and radiation protection, radiation detection analysis, reliability and risk analysis, energy systems, and international security. Graduate students in the Department are active participants and contributors to these areas of education and research and typically pursue careers in one of these areas. Graduate students in the Department are also encouraged to take part in course work and research activities in other engineering and science departments to complement their professional development in the nuclear engineering field. Opportunity also exists for specializing in:

1. computational science and engineering via the Computational and Science and Engineering (http://www.cse.illinois.edu) (CSE) graduate transcriptable concentration
2. energy and sustainability engineering via the Energy and Sustainability Engineering (http://ease.illinois.edu) (EaSE) graduate certificate option.

Admission

Application for admissions to the master's and doctoral degree programs is open to all graduates in engineering, mathematics, and the physical sciences with a grade point average of at least 3.00 (A = 4.00) for the last two years of undergraduate work and any graduate work completed. Prerequisites for admission include a course in ordinary differential equations plus one other mathematics course beyond calculus; an intermediate course in atomic and nuclear physics or interaction of radiation with matter; a course in electrical circuit theory; a course in thermodynamics; a course in fluid mechanics or continuum mechanics; and a course introducing nuclear engineering. A student may be admitted before completion of these prerequisites, but he or she must allow additional time to make up for these deficiencies; courses taken to make up such deficiencies will not count toward the number of units required for the graduate degree. Transcripts and letters of recommendation are required. The Graduate Record Exam (GRE) (http://www.ets.org) is required. Information such as undergraduate class rank is recommended.

For full consideration of fall admission with financial aid, application receipt deadline is January 1st. Students who wish to enter in the spring term should contact the Department before applying.

All applicants whose native language is not English are required to have a minimum TOEFL (http://www.toefl.org) score of 79 (iBT), 213 (CBT), or 550 (PBT); or minimum International English Language Testing System (IELTS) (https://www.ielts.org) academic exam scores of 6.5 overall and 6.0 in all subsections. Applicants may be exempt from the TOEFL if certain criteria (http://grad.illinois.edu/admissions/instructions/04c) are met. For those taking the TOEFL or IELTS, full admission status (http://grad.illinois.edu/admissions/instructions/04c) is granted for scores greater than 102 (TOEFL iBT), 253 (TOEFL CBT), 610 (TOEFL PBT), or 6.5 (IELTS). Limited status (http://grad.illinois.edu/admissions/instructions/04c) is granted for lesser scores and requires enrollment in English as a Second Language (ESL) courses (http://linguistics.illinois.edu/students/esl/guidelines) based on an ESL Placement Test (EPT) taken upon arrival to campus.

Applicants to the joint M.B.A. degree program must meet the admissions standards for both programs and be accepted by both programs.

Faculty Research Interests

Faculty research interests cover a wide range including, but not limited to, those listed above under the Graduate Degree Programs section. Faculty in other related fields are available to supervise research for students through formal "affiliate faculty" appointments. For a detailed list of current research interests of the faculty, visit the department's Research web site (https://npre.illinois.edu/research).

Facilities and Resources

A wide range of major research resources are available for nuclear engineering research. These are described at the department's Research Facilities website (https://npre.illinois.edu/research/research-facilities).

Financial Aid

Most graduate students receive some form of financial aid. Fellowships are available to support the best applicants. Other students are supported as graduate research, teaching, or general assistants. Financial aid includes federally sponsored traineeships and fellowships and University and industry fellowships. The University is approved for several fellowships including those from the Department of Energy, Nuclear Regulatory Commission, the National Science Foundation, and Hertz. Part- and full-time assistantships include exemption from tuition and partial fees. All applicants, regardless of U.S. citizenship, whose native language is not English and who wish to be considered for teaching assistantships must demonstrate spoken English language proficiency (http://grad.illinois.edu/admissions/taengprof.htm) by achieving a minimum score of 24 on the speaking subsection of the TOEFL iBT or 8 on the speaking subsection of the IELTS. For students who are unable to take the iBT or IELTS, a minimum score of 4CP is required on the EPI test (http://cte.illinois.edu/testing/oral_eng/epi_overview.html), offered on campus. All new teaching assistants are required to participate in the Graduate Academy for College Teaching (http://cte.illinois.edu/programs/ta_train.html) conducted prior to the start of the semester.

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)
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: PHYS 212; credit or concurrent registration in MATH 285.

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.

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 431.

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 446.

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 446.

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 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 NPRE 451 or equivalent has been taken. Prerequisite: CHEM 102 and NPRE 446.

NPRE 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 NPRE majors for graduate hours. Prerequisite: MATH 285 and ME 200.

NPRE 447 Radiation Interact w/Matter II credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/447)
Continuation of NPRE 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: NPRE 446.

NPRE 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 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 446.

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 448.

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 529 Interact of Rad w/Matter II credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/NPRE/529)
Continuation of NPRE 521. Multiple events and computational methods of the interaction of radiation (heavy and light charged particles, electromagnetic wave, photons, and neutral particles) with matter. Same as CSE 529. Prerequisite: NPRE 521 or MSE 500.

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 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.