# NUCLEAR ENGINEERING (N E)

## N E 1 – COOPERATIVE EDUCATION PROGRAM

1 credit.

Work experience which combines classroom theory with practical knowledge of operations to provide students with a background upon which to base a professional career.

**Requisites:** Sophomore standing

**Course Designation:** Workplace - Workplace Experience Course **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Fall 2023

**Learning Outcomes:** 1. Identify and respond appropriately to real-life engineering ethics cases relevant to co-op work Audience: Undergraduate

2. Synthesize and apply appropriate technical education to real world technical work Audience: Undergraduate

3. Communicate effectively in writing and speaking with a range of audiences in the workplace, including those without disciplinary expertise Audience: Undergraduate

4. Develop professional and transferable habits like time management skills, collaborative problem-solving skills, and research skills for learning new information Audience: Undergraduate

#### N E 231 – INTRODUCTION TO NUCLEAR ENGINEERING 3 credits

Nuclear fission/fusion, medical applications of radiation, radiation safety. Socio-economic topics including environmental justice, community engagement, nuclear policy. Brief history of and controversies in nuclear engineering. Career paths and ethics in engineering, and introduction to professional communication.

### Requisites: None

Repeatable for Credit: No

### Last Taught: Spring 2024

**Learning Outcomes:** 1. Describe how nuclear science and technology are used in our world today Audience: Undergraduate

2. Identify different career paths in nuclear engineering Audience: Undergraduate

3. Distinguish the technological and socio-economic context and challenges of nuclear engineering Audience: Undergraduate

4. Analyze problems in nuclear engineering ethics and arrive at defensible actions Audience: Undergraduate

5. Produce a deliverable relevant to the class curriculum, designed by a team Audience: Undergraduate

# N E 234 – PRINCIPLES AND PRACTICE OF NUCLEAR REACTOR OPERATIONS

4 credits.

Presents the theoretical and practical information required to understand operation of nuclear reactors. Content includes all subjects which must be known by a person seeking an operating license for the university reactor. Instructors integrate information on similar operations and systems in a nuclear power plant.

Requisites: Declared in Nuclear Engineering

## Repeatable for Credit: No

## Last Taught: Fall 2023

**Learning Outcomes:** 1. Solve problems involving radioactive decay, radiation attenuation, neutron activation and the time dependent behavior of reactors Audience: Undergraduate

2. Describe the units and methods of detecting ionizing radiation, the principles of radiation protection and applicable federal regulations Audience: Undergraduate

3. Describe reactor components and systems and their relevance to reactor operations Audience: Undergraduate

4. Manipulate the reactivity controls of a reactor Audience: Undergraduate

### N E 305 – FUNDAMENTALS OF NUCLEAR ENGINEERING

3 credits.

Properties of nuclei, nuclear structure, radioactivity, nuclear reactions, fission, resonance reactions, moderation of neutrons.

**Requisites:** PHYSICS 205, 241, 244, or 249, or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S **Repeatable for Credit:** No

#### Last Taught: Fall 2023

**Learning Outcomes:** 1. Solve steady wave mechanics problems beginning from the appropriate form of Schrodinger's equation Audience: Undergraduate

2. Describe the Semi Empirical Mass Formula as well as the features of the "binding energy/nucleon" curve Audience: Undergraduate

3. Explain why the "magic numbers" of nuclear physics differ from those of atomic physics Audience: Undergraduate

4. Explain the correlation between the half-lives for alpha-decay and the Q-value Audience: Undergraduate

5. Describe the energy spectrum of beta-decay Audience: Undergraduate

6. List the different absorption mechanism of gamma-rays Audience: Undergraduate

7. Compare the kinematics of elastic scattering with that of charged particle scattering Audience: Undergraduate

## N E 405 – NUCLEAR REACTOR THEORY

3 credits.

The neutronics behavior of fission reactors, primarily from a theoretical, one-speed perspective. Criticality, fission product poisoning, reactivity control, reactor stability and introductory concepts in fuel management, followed by slowing down and one-speed diffusion theory.

**Requisites:** N E 305 and (MATH 319, 320, 321, or 375), or graduate/ professional standing, or member of Engineering Guest Students **Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci reg

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

Last Taught: Spring 2024

**Learning Outcomes:** 1. Write neutron balance conditions describing the temporal, spectral and spatial behavior of (neutron) multiplying systems Audience: Undergraduate

2. Explain how stability issues manifest themselves in choices of reactor design and operation in light water reactors Audience: Undergraduate

3. Assess whether or not a system containing fissile material is critical Audience: Undergraduate

4. Estimate the lifetime of a core based on the initial excess reactivity; prescribe control materials for maintaining criticality over the core lifetime Audience: Undergraduate

5. Solve simple temporal reactor kinetics problems and explain the shape of the reactor power curve Audience: Undergraduate

6. Solve simple spectral problems and explain the shape of the neutron spectrum in a light water reactor Audience: Undergraduate

7. Find the spatial neutron distribution and associated power distribution for a given combination of constituent materials using one-group and twogroup diffusion theory Audience: Undergraduate

## **N E 408 – IONIZING RADIATION**

3 credits.

Sources, interactions, and detection of ionizing radiation. Biological effects, shielding, standards of radiation protection.

**Requisites:** N E 305, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S **Repeatable for Credit:** No

## Last Taught: Spring 2024

**Learning Outcomes:** 1. Explain the modes by which uncharged radiation (photons and neutrons) interacts with matter Audience: Undergraduate

2. Describe how heavy and light charged particles interact with matter Audience: Undergraduate

3. Determine radiological quantities associated with radiation protection (e.g., exposure, absorbed dose, and dose equivalent) for external sources of radiation (unshielded and shielded) Audience: Undergraduate

4. Determine committed doses for internal sources of radiation Audience: Undergraduate

5. Design a shield to protect occupational workers from radiation exposure due to simple photon and neutron sources Audience: Undergraduate

## **N E 411 – NUCLEAR REACTOR ENGINEERING**

3 credits.

Reactor heat generation and removal; steady- and unsteady-state conduction in reactor elements; single phase, two-phase, and liquid metal cooling, core thermal design.

**Requisites:** N E 305, M E 361, and (M E 363 and M E 364 or CBE 320) or graduate/professional standing, or member of Engineering Guest Students

## Repeatable for Credit: No

Last Taught: Fall 2023

**Learning Outcomes:** 1. Solve steady-state, coupled conduction and convection heat transfer problems in geometric configurations relevant to nuclear reactors Audience: Undergraduate

2. Describe the temperature excursion experienced by the fuel during an uncontrolled accident sequence using relevant approximations Audience: Undergraduate

3. Perform mass, momentum, and energy balances on different reactor components Audience: Undergraduate

4. Assess the safety margin of different reactor components during normal and off-normal conditions, with reference to the concept of "defense-in-depth" Audience: Undergraduate

## N E 412 – NUCLEAR REACTOR DESIGN

5 credits.

Reactor design projects, reactor hazards, economics. **Requisites:** N E 405 and (E P 271 or COMP SCI 300, 302, or 310), or graduate/professional standing **Repeatable for Credit:** No **Last Taught:** Spring 2024 **Learning Outcomes:** 1. Apply nuclear engineering technical skills in the context of design Audience: Undergraduate

2. Apply design thinking methodology within engineering design Audience: Undergraduate

3. Practice quality assurance and documentation Audience: Undergraduate

4. Build and work within a team, practicing leadership and project management Audience: Undergraduate

5. Practice managing uncertainty in decision-making. "How do you take risks?" Audience: Undergraduate

### N E/M S & E 423 – NUCLEAR ENGINEERING MATERIALS 3 credits.

Fundamentals of fuel and cladding behavior in terms of thermal properties, chemical behavior and radiation damage.

**Requisites:** M S & E 350 or 351, graduate/professional standing, or member of Engineering Guest Students **Repeatable for Credit:** No

Last Taught: Fall 2023

### N E 424 - NUCLEAR MATERIALS LABORATORY

1 credit.

Practical application of materials issues for nuclear systems including welding, non-destructive examination, optical microscopy, electron microscopy, to understand radiation damage and corrosion. **Requisites:** M S & E 350 or 351, graduate/professional standing, or member of Engineering Guest Students

Repeatable for Credit: No

## Last Taught: Spring 2024

**Learning Outcomes:** 1. Conduct metallographic sample preparation and follow it up with optical and scanning electron microscopy for microstructural characterization and analysis Audience: Undergraduate

2. Perform hardness and tensile and impact toughness testing of materials to assess their mechanical behavior Audience: Undergraduate

3. Use the x-ray diffraction technique to determine the crystal structure of materials, identify the phases present, and measure residual stresses Audience: Undergraduate

4. Perform simulations of ion-material interaction to determine the penetration depth of ions as a function of ion energy, type, and substrate material Audience: Undergraduate

5. Comprehend the various components and work of the ion beam accelerator Audience: Undergraduate

6. Describe the operational issues of a nuclear reactor and some of its inner workings Audience: Undergraduate

7. Identify and address the challenges of radioactive sample handling and characterization Audience: Undergraduate

## N E 427 – NUCLEAR INSTRUMENTATION LABORATORY

2 credits.

Experiments on nuclear instrumentation, counting, data analysis. **Requisites:** N E 305 or graduate/professional standing **Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req Level - Intermediate L&S Credit - Counts as Liberal Arts and Science credit in L&S **Repeatable for Credit:** No

Last Taught: Spring 2024

**Learning Outcomes:** 1. Explain the operational principles of nuclear radiation detectors in the context of how radiation interacts with matter Audience: Undergraduate

2. Identify the best choice of detector for a given type of radiation and its limitations Audience: Undergraduate

3. Operate basic nuclear counting instrumentation: gas-ionized and solid-state detectors, nuclear instrumentation module, power supplies, signal amplifiers, oscilloscopes, and single- and multi-channel analyzers Audience: Undergraduate

4. Estimate experimental uncertainties in counting measurements and calculate errors associated with quantities derived from such measurements Audience: Undergraduate

5. Take laboratory notes and prepare clearly written experimental reports Audience: Undergraduate

## N E 428 - NUCLEAR REACTOR LABORATORY

2 credits.

Experiments on reactor operation, flux measurement, measurements of reactor parameters, using pool type reactor. **Requisites:** N E 405 and 427, or graduate/professional standing **Repeatable for Credit:** No **Last Taught:** Spring 2024 **Learning Outcomes:** 1. Analyze, through experiment, the timedependent behavior of reactors in the subcritical state, the critical state and the supercritical state Audience: Undergraduate

2. Analyze, through experiment, the spatial shape and energy spectrum of neutron fluxes Audience: Undergraduate

3. Measure neutron and reactor parameters Audience: Undergraduate

4. Describe the extent to which theory and experiment agree, and what approximations or uncertainty result in deviations between the two Audience: Undergraduate

### N E/M S & E 433 – PRINCIPLES OF CORROSION

3 credits.

Thermodynamics and kinetics of metallic corrosion. The common forms of corrosion and corrosion susceptibility tests. Electrochemical measurement of corrosion rates. Corrosion prevention, economic considerations. High temperature oxidation and sulphidation. Corrosion case histories.

**Requisites:** M S & E 330, or graduate/professional standing, or member of Engineering Guest Students

**Repeatable for Credit:** No **Last Taught:** Fall 2023

## N E 489 – HONORS IN RESEARCH

1-3 credits.

Undergraduate research and senior honors thesis in nuclear engineering. **Requisites:** Declared in Nuclear Engineering Honors in Undergraduate Research program

**Course Designation:** Honors - Honors Only Courses (H) **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Spring 2014

## N E 505 - NUCLEAR REACTOR ANALYSIS

3 credits.

The neutronics behavior of fission reactors, both from a theoretical and computational multi-group perspective. Multi-group diffusion theory, finite-difference and nodal methods, core heterogeneous effects, pin power reconstruction, thermal neutron spectra, fine group whole spectrum calculations and coarse group constant generation.

**Requisites:** N E 405, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

Repeatable for Credit: No

### Last Taught: Fall 2023

**Learning Outcomes:** 1. Analyze the performance of a nuclear fuel assembly throughout its lifetime Audience: Both Grad Undergrad

2. Explain and demonstrate the changes in nuclear fuel assembly performance as operational parameters vary Audience: Both Grad Undergrad

3. Use an industry-relevant software package to perform lattice calculations for analysis and design of a nuclear fuel assembly Audience: Both Grad Undergrad

4. Explain and demonstrate the changes in nuclear fuel assembly performance as design parameters vary Audience: Both Grad Undergrad

5. Compare different forms of analysis for the same application Audience: Graduate

## **N E/MED PHYS 506 – MONTE CARLO RADIATION TRANSPORT** 3 credits.

Use of Monte Carlo technique for applications in nuclear engineering and medical physics. Major theory of Monte Carlo neutral particle transport is discussed. Standard Monte Carlo transport software is used for exercises and projects. Major emphasis is on analysis of real-world problems. **Requisites:** N E 305 and (N E 405, N E 408, PHYSICS/B M E/H ONCOL/ MED PHYS 501 or N E/MED PHYS 569) or graduate/professional standing

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** No

Last Taught: Spring 2024

**Learning Outcomes:** 1. Use an industry-relevant software package to perform Monte Carlo radiation transport simulations for analysis of fixed source and/or multiplying systems Audience: Both Grad Undergrad

2. Explain how random processes are used to simulate a single particle transport history through an engineering system, including source, streaming and collisions Audience: Both Grad Undergrad

3. Explain how the paths of many particle transport histories are combined to provide estimates of engineering results Audience: Both Grad Undergrad

4. Analyze the statistical performance of a simulation and suggest ways to improve that performance Audience: Both Grad Undergrad

5. Apply Monte Carlo radiation transport to a problem related to your research Audience: Graduate

### N E/M E 520 – TWO-PHASE FLOW AND HEAT TRANSFER 3 credits.

Two-phase flow and heat transfer in engineering systems. Pool boiling and flow boiling. Phenomenological modeling.

**Requisites:** M E 361 and (M E 364 or CBE 320), or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No **Last Taught:** Spring 2024

## N E/E C E/PHYSICS 525 – INTRODUCTION TO PLASMAS

3 credits.

Basic description of plasmas: collective phenomena and sheaths, collisional processes, single particle motions, fluid models, equilibria, waves, electromagnetic properties, instabilities, and introduction to kinetic theory and nonlinear processes. Examples from fusion, astrophysical and materials processing processing plasmas.

**Requisites:** (E C E 320 or PHYSICS 322), graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci reg

Level - Advanced L&S Credit - Counts as Liberal Arts and Science credit in L&S Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** No

Last Taught: Spring 2024

## N E 526 – LABORATORY COURSE IN PLASMAS

3 credits.

Provides a background in the techniques for creating, exciting, and measuring the properties of lab plasmas and using the associated apparatus.

**Requisites:** PHYSICS/E C E/N E 525 or graduate/professional standing **Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S

Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** No

### Last Taught: Spring 2024

Learning Outcomes: 1. List the necessary hardware to generate and measure ultra-high vacuum conditions Audience: Both Grad Undergrad

2. Describe the plasma formation process when using a biased electrode or wave-heating Audience: Both Grad Undergrad

3. Explain the working principle of Langmuir plasma diagnostics Audience: Both Grad Undergrad

4. Perform data analysis in the framework of self-driven and independent research Audience: Both Grad Undergrad

5. Prepare a clearly written experimental report Audience: Both Grad Undergrad

6. Interpret experimental data based on comparisons with theory and modelling results Audience: Graduate

## N E/E C E/PHYSICS 527 – PLASMA CONFINEMENT AND HEATING 3 credits.

Principles of magnetic confinement and heating of plasmas for controlled thermonuclear fusion: magnetic field structures, single particle orbits, equilibrium, stability, collisions, transport, heating, modeling and diagnostics. Discussion of current leading confinement concepts: tokamaks. tandem mirrors. stellarators. reversed field pinches. etc.

**Requisites:** E C E/N E/PHYSICS 525, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** No **Last Taught:** Spring 2024

## N E/E C E 528 – PLASMA PROCESSING AND TECHNOLOGY 3 credits.

Introduction to basic understanding and techniques. Plasma processing of materials for semiconductors, polymers, plasma spray coatings, ion implantation, etching, arcs, extractive metallurgy and welding. Plasma and materials diagnostics.

**Requisites:** PHYSICS 322 or E C E 320, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No **Last Taught:** Fall 2021

## N E 536 – FEASIBILITY ST OF POWER FROM CONTROLLED THERMONUCLEAR FUSION

3 credits.

Introduction to the use and design of possible fusion reactors. Problems of the plasma confinement and energy density, neutronics of blanket design, and radiation damage.

**Requisites:** N E 405 and 411, or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S **Repeatable for Credit:** No

### Last Taught: Fall 2023

**Learning Outcomes:** 1. Evaluate and compare important characteristics of magnetic fusion energy systems under different configurations Audience: Undergraduate

2. Evaluate the technological performance challenges to the key components of a magnetic fusion energy system Audience: Undergraduate

3. Describe the challenges to the feasibility of magnetic fusion energy Audience: Undergraduate

4. Discuss the role of fusion energy as part of future energy systems, including its economic viability Audience: Undergraduate

### **N E 541 – RADIATION DAMAGE IN METALS**

3 credits.

A survey of the nature of point defects, how these defects are produced, how the defects migrate and cluster, and what effects point defects and defect clusters have on the physical and mechanical properties of metals. **Requisites:** M S & E 350 or 351, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate L&S Credit - Counts as Liberal Arts and Science credit in L&S Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** No **Last Taught:** Spring 2024

# N E 545 – MATERIALS DEGRADATION IN ADVANCED NUCLEAR REACTOR ENVIRONMENTS

3 credits.

Overview of materials (cladding and structural materials) used in advanced reactor systems and the associated degradation. Interactions between the advanced nuclear reactor environment and materials. Surface degradation, corrosion, oxidation, dissolution, vaporization, mass transfer, diffusion, and hands-on examples related to advanced reactors.

**Requisites:** M S & E 350, 351, or 352, graduate/professional standing, or member of Engineering Guest Students

Course Designation: Grad 50% - Counts toward 50% graduate

coursework requirement

Repeatable for Credit: No

Last Taught: Spring 2023

**Learning Outcomes:** 1. Describe the effects of environmental degradation on structural integrity of material used in advanced nuclear reactors Audience: Both Grad Undergrad

2. Identify and describe the mitigation strategies to prevent such degradation Audience: Both Grad Undergrad

3. Solve complex problems related to materials degradation using analytical and numerical techniques Audience: Graduate

## N E 550 – ADVANCED NUCLEAR POWER ENGINEERING 3 credits.

Analysis of nuclear systems for the production of useful power. Emphasis: thermodynamic cycles, reactor types, coupling of reactor and power plant, design synthesis, and plant economics.

**Requisites:** N E 405 and (N E 411 or concurrent enrollment), graduate/ professional standing, or member of Engineering Guest Students **Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

## Repeatable for Credit: No

#### Last Taught: Fall 2022

**Learning Outcomes:** 1. Identify the key features of a range of advanced reactor technologies Audience: Undergraduate

2. Analyze advanced reactors using theory applicable to multiple technologies Audience: Undergraduate

3. Describe the design philosophy of advanced reactor technologies and be able to discuss the extent to which each of the reactor design types embodies those principles Audience: Undergraduate

4. Identify the drivers and goals for advanced reactors and assess critically whether they meet these goals Audience: Undergraduate

5. Synthesize information from multiple sources to make informed judgements about the relative merits and challenges of the various advanced reactor technologies Audience: Graduate

### **N E 555 – NUCLEAR REACTOR DYNAMICS**

3 credits.

Basic equations and physical parameters of point reactor kinetics without feedback effects; the nuclear reactor as a total system; reactor excursions, Fuchs-Nordheim and Bethe-Tait models; space-time reactor dynamics; synthesis methods.

**Requisites:** N E 405, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

Last Taught: Fall 2020

**Learning Outcomes:** 1. Determine the behavior of the reactor power due to control element movement in the PRKE 1 group and 6 group models Audience: Both Grad Undergrad

2. Examine the behavior of the reactor in the presence of reactivity feedback effects (Resonance behavior, Doppler Broadening, density effects) Audience: Both Grad Undergrad

3. Analyze the power and temperature level behaviors due to the rapid injection and sinusoidal inputs of reactivity using the Nordheim-Fuchs models Audience: Both Grad Undergrad

4. Analyze the stability of a reactor using the Routh and Nyquist stability criterion and the singe and two temperature models Audience: Both Grad Undergrad

5. Examine numerical methods for the solution of the PRKEs and the reactor dynamics equations with feedback Audience: Both Grad Undergrad

6. Apply the reactor dynamics equations with feedback to a reactor design Audience: Graduate

## N E/M E 565 – POWER PLANT TECHNOLOGY

3 credits.

Design and performance of power plants for the generation of electric power; fossil and nuclear fuels, cycle analysis, component design and performance, plant operation, control, economics and environmental impact. Advanced concepts.

**Requisites:** M E 361, or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced L&S Credit - Counts as Liberal Arts and Science credit in L&S

Repeatable for Credit: No

Last Taught: Fall 2023

# N E/MED PHYS 569 – HEALTH PHYSICS AND BIOLOGICAL EFFECTS

3-4 credits.

Physical and biological aspects of the use of ionizing radiation in industrial and academic institutions; physical principles underlying shielding instrumentation, waste disposal; biological effects of low levels of ionizing radiation.

**Requisites:** MATH 234 and (PHYSICS 241 or 249), graduate/professional standing, or declared in Medical Physics VISP

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No **Last Taught:** Fall 2023

## N E 571 – ECONOMIC AND ENVIRONMENTAL ASPECTS OF NUCLEAR ENERGY

3 credits.

Economics of the nuclear fuel cycle. Economic and environmental impact the nuclear fuel cycle. Impact on design, plant siting and regulation. **Requisites:** N E 405, graduate/professional standing, or member of

Engineering Guest Students Course Designation: Breadth - Physical 9

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S **Repeatable for Credit:** No

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Last Taught: Spring 2024
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**Learning Outcomes:** 1. Recognize and describe the relationships between different sectors of the nuclear energy industry and nuclear fuel cycle Audience: Undergraduate

2. Perform economic and/or environmental analysis of energy systems Audience: Undergraduate

3. Communicate the results of economic and/or environmental analyses to multiple audiences Audience: Undergraduate

4. Explain the social, economic, and/or environmental dimensions of the sustainability challenge(s) of providing electricity Audience: Undergraduate

5. Describe the social, economic, and environmental dimensions of nuclear energy and identify potential tradeoffs and interrelationships among these dimensions at a level appropriate to the course Audience: Undergraduate

## N E/I SY E 574 – METHODS FOR PROBABILISTIC RISK ANALYSIS OF NUCLEAR POWER PLANTS

3 credits.

Methods for risk and reliability analysis of engineered systems, particularly as applied in the nuclear power industry. Fault trees and event trees, Bayesian data analysis, probabilistic risk management. Some familiarity with nuclear plant safety systems is helpful, but not required. **Requisites:** (STAT/MATH 309, STAT 311, 224, 324, or STAT/MATH 431),

graduate/professional standing, or member of Engineering Guest Students

Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement Repeatable for Credit: No Last Taught: Spring 2023

# **N E 602 – SPECIAL TOPICS IN REACTOR ENGINEERING** 0-3 credits.

Special Topics in Reactor Engineering. **Requisites:** None **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Fall 2021

## N E 699 – ADVANCED INDEPENDENT STUDY

0-3 credits.

Directed study projects as arranged with instructor. **Requisites:** Consent of instructor **Course Designation:** Level - Advanced L&S Credit - Counts as Liberal Arts and Science credit in L&S **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Spring 2024

#### **N E 705 – ADVANCED REACTOR THEORY** 3 credits.

The neutron transport equation and its application to the analysis of nuclear reactors. Numerical solution methods, including the multi-group model, one-group equations, energy-averaged constants, discrete ordinates, and Monte Carlo methods. Perturbation theory and variational techniques for practical problems. Knowledge of Nuclear Reactor Theory [such as N E 405] required.

Requisites: Graduate/professional standing

Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement Repeatable for Credit: No Last Taught: Fall 2022

## N E/C&E SOC/I SY E/SOC 708 – SOCIETAL RISK MANAGEMENT OF TECHNOLOGICAL HAZARDS

3 credits.

Issues involved in decision-making regarding technological risks and risk management in areas such as nuclear power, hazardous waste disposal, and pollution control. Risk perception and cognitive biases; risk analysis and decision analysis; political issues in risk management; regulatory mechanisms; and risk communication. Selected case studies. **Requisites:** Graduate/professional standing **Course Designation:** Grad 50% - Counts toward 50% graduate

course Designation: Grad 50% - Counts toward 50% graduate coursework requirement Repeatable for Credit: No

Last Taught: Spring 2020

# N E/E C E/PHYSICS 724 – WAVES AND INSTABILITIES IN PLASMAS

3 credits.

Waves in a cold plasma, wave-plasma interactions, waves in a hot plasma, Landau damping, cyclotron damping, magneto-hydrodynamic equilibria and instabilities, microinstabilities, introduction to nonlinear processes, and experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged. **Requisites:** Graduate/professional standing

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** No

Last Taught: Fall 2023

## N E/E C E/PHYSICS 725 – PLASMA KINETIC THEORY AND RADIATION PROCESSES

3 credits.

Coulomb Collisions, Boltzmann equation, Fokker-Planck methods, dynamical friction, neoclassical diffusion, collision operators radiation processes and experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged.

Requisites: Graduate/professional standing Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement Repeatable for Credit: No

## Last Taught: Spring 2024

## N E/E C E/PHYSICS 726 – PLASMA MAGNETOHYDRODYNAMICS 3 credits.

MHD equations and validity in hot plasmas; magnetic structure and magnetic flux coordinates; equilibrium in various configurations; stability formulation, energy principle, classification of instabilities; ideal and resistive instability in various configurations, evolution of nonlinear tearing modes; force-free equilibria, helicity, MHD dynamo; experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/ N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged.

Requisites: Graduate/professional standing Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement Repeatable for Credit: No Last Taught: Spring 2023

## **N E 741 – INTERACTION OF RADIATION WITH MATTER** 3 credits.

Review of topics in electrodynamics and special relativity; ionization and energy loss during scattering of charged particles; radiation from charged particles including Bremstrahlung, Cerenkov, and Synchrotron radiation; Thomson scattering of electromagnetic waves by charged particles. Knowledge of Dynamics [such as E M A 202 or PHYSICS 311] and Electromagnetics [such as PHYSICS 322] required.

**Requisites:** Graduate/professional standing

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

Repeatable for Credit: No

Last Taught: Spring 2015

# N E/E C E/PHYSICS 749 – COHERENT GENERATION AND PARTICLE BEAMS

3 credits.

Fundamental theory and recent advances in coherent radiation charged particle beam sources (microwave to X-ray wavelengths) including free electron lasers, wiggler/wave-particle dynamics, Cerenkov masers, gyrotrons, coherent gain and efficiency, spontaneous emission, beam sources and quality, related accelerator concepts experimental results and applications.

#### Requisites: E C E 740

Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement Repeatable for Credit: No Last Taught: Fall 2019

## N E 790 – MASTER'S RESEARCH AND THESIS

1-9 credits.

Directed study projects as arranged with instructor. **Requisites:** Graduate/professional standing **Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Spring 2024

## N E 890 – PRE-DISSERTATOR'S RESEARCH 1-9 credits.

Research by the Ph.D. students prior to becoming dissertators. **Requisites:** Graduate/professional standing **Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Spring 2024

## N E 903 - SPECIAL TOPICS-PLASMA PHYSICS

0-3 credits.

Special Topics in Plasma Physics. Knowledge of Plasma Physics [such as PHYSICS/E C E/N E 525] required **Requisites:** Graduate/professional standing **Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Fall 2022

## N E/E C E/PHYSICS 922 – SEMINAR IN PLASMA PHYSICS 0-1 credits.

Current topics in plasma physics. **Requisites:** Graduate/professional standing **Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Spring 2024

## N E 990 - RESEARCH AND THESIS

1-6 credits.

Directed study projects as arranged with instructor. **Requisites:** Graduate/professional standing **Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement **Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Spring 2024

**N E 999 – ADVANCED INDEPENDENT STUDY** 1-3 credits.

Directed study projects as arranged with instructor. **Requisites:** Consent of instructor **Course Designation:** Grad 50% - Counts toward 50% graduate

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**Repeatable for Credit:** Yes, unlimited number of completions **Last Taught:** Spring 2024