NUCLEAR SCIENCE & ENGINEERING (NSE)

NSE 114. INTRO TO NUCLEAR ENGINEERING AND RADIATION HEALTH PHYSICS I. (3 Credits)
Introduction to the nuclear engineering and radiation health physics fields; problem-solving techniques; careers in the nuclear industry; nuclear history; elementary nuclear and reactor physics; basic nuclear fission and fusion theory; reactor types; nuclear safety; nuclear fuel cycle; and radiation protection.

NSE 115. INTRO TO NUCLEAR ENGINEERING AND RADIATION HEALTH PHYSICS II. (3 Credits)
Introduction to the nuclear engineering and radiation health physics fields; problem-solving techniques; careers in the nuclear industry; nuclear history; elementary nuclear and reactor physics; basic nuclear fission and fusion theory; reactor types; nuclear safety; nuclear fuel cycle; and radiation protection.

NSE 233. MATHEMATICAL METHODS FOR NSE. (3 Credits)
Development and application of analytical and numerical methods with applications to problems in the NE/RHP field. Major topics will include solution of ODEs and systems of ODEs, root finding techniques and numerical integration and differentiation. Major applications will include solution of the Bateman Equations and solution of the diffusion equation.
Prerequisites: MTH 254 (may be taken concurrently) with C or better or MTH 254H (may be taken concurrently) with C or better

NSE 234. NUCLEAR AND RADIATION PHYSICS I. (3 Credits)
Relativistic dynamics; basic nuclear physics; basic quantum mechanics; radioactivity; electromagnetic waves; interaction of ionizing radiation with matter; cross sections; basic atomic structure.
Prerequisites: MTH 251 with C or better or MTH 251H with C or better

NSE 235. NUCLEAR AND RADIATION PHYSICS II. (3 Credits)
Radioactivity; radioactive decay modes; decay kinetics, interaction of neutrons with matter; nuclear reactions; fission and fusion basics; cross sections.
Prerequisites: (NSE 234 with C or better or NE 234 with C or better or RHP 234 with C or better) and (MTH 252 [C] or MTH 252H [C])

NSE 236. NUCLEAR RADIATION DETECTION AND INSTRUMENTATION. (4 Credits)
Principles and mechanisms underlying nuclear radiation detection and measurements; operation of nuclear electronic laboratory instrumentation; application of gas-filled, scintillation and semiconductor laboratory detectors for measurement of alpha, beta, gamma, and neutron radiation; experimental investigation of interactions of radiation with matter. Lec/lab.
Prerequisites: NSE 235 with C or better or NE 235 with C or better or RHP 235 with C or better

NSE 311. INTRODUCTION TO THERMAL-FLUID SCIENCES. (4 Credits)
Basic concepts of fluid mechanics, thermodynamics and heat transfer are introduced. Conservation of mass, energy, moment and the second law of thermodynamics are included. CROSSLISTED as ME 311H.
Equivalent to: ME 311, NSE 311H

NSE 311H. INTRODUCTION TO THERMAL-FLUID SCIENCES. (4 Credits)
Basic concepts of fluid mechanics, thermodynamics and heat transfer are introduced. Conservation of mass, energy, moment and the second law of thermodynamics are included. CROSSLISTED as ME 311H.
Attributes: HNRS – Honors Course Designator
Prerequisites: (ENGR 212 with C or better or ENGR 212H with C or better) and (MTH 256 [C] or MTH 256H [C])
Equivalent to: ME 311H, NSE 311

NSE 312. THERMODYNAMICS. (4 Credits)
Energy destruction, machine and cycle processes, law of corresponding states, non-reactive gas mixtures, reactive mixtures, thermodynamics of compressible fluid flow. CROSSLISTED as ME 312.
Equivalent to: ME 312, NSE 312H

NSE 312H. THERMODYNAMICS. (4 Credits)
Energy destruction, machine and cycle processes, law of corresponding states, non-reactive gas mixtures, reactive mixtures, thermodynamics of compressible fluid flow. CROSSLISTED as ME 312H.
Attributes: HNRS – Honors Course Designator
Prerequisites: (NSE 311 with C or better or NSE 311H with C or better or NE 311 with C or better or NE 311H with C or better or ME 311 with C or better or ME 311H with C or better) and (MTH 256 [C] or MTH 256H [C])
Equivalent to: ME 312, ME 312H, NSE 312

NSE 319. *SOCIETAL ASPECTS OF NUCLEAR TECHNOLOGY. (3 Credits)
Description and discussion of nuclear-related issues as they impact society. (Bacc Core Course)
Attributes: CSST – Core, Synthesis, Science/Technology/Society

NSE 331. INTRODUCTORY FLUID MECHANICS. (4 Credits)
Introduces the concepts and applications of fluid mechanics and dimensional analysis with an emphasis on fluid behavior, internal and external flows, analysis of engineering applications of incompressible pipe systems, and external aerodynamics. CROSSLISTED as ME 331.
Prerequisites: (MTH 254 with C or better or MTH 254H with C or better) and (MTH 256 [C] or MTH 256H [C]) and (ENGR 212 [C] or ENGR 212H [C]) and (ENGR 311 [C] or ENGR 311H [C] or ME 311 [C] or ME 311H [C] or NSE 311 [C] or NSE 311H [C] or NE 311 [C] or NE 311H [C])
Equivalent to: ME 331, NSE 331H

NSE 331H. INTRODUCTORY FLUID MECHANICS. (4 Credits)
Introduces the concepts and applications of fluid mechanics and dimensional analysis with an emphasis on fluid behavior, internal and external flows, analysis of engineering applications of incompressible pipe systems, and external aerodynamics. CROSSLISTED as ME 331H.
Attributes: HNRS – Honors Course Designator
Prerequisites: (MTH 254 with C or better or MTH 254H with C or better) and (MTH 256 [C] or MTH 256H [C]) and (ENGR 212 [C] or ENGR 212H [C]) and (ENGR 311 [C] or ENGR 311H [C] or ME 311 [C] or ME 311H [C] or NSE 311 [C] or NSE 311H [C] or NE 311 [C] or NE 311H [C])
Equivalent to: ME 331, ME 331H, NSE 331

NSE 332. HEAT TRANSFER. (4 Credits)
A treatement of conductive, convective and radiative energy transfer using control volume and differential analysis and prediction of transport properties. CROSSLISTED as ME 332.
Prerequisites: (MTH 256 with C or better or MTH 256H with C or better) and (ENGR 212 [C] or ENGR 212H [C]) and (NSE 311 [C] or NSE 311H [C] or NE 311 [C] or NE 311H [C] or ME 311 [C] or ME 311H [C] or ME 311H [C]) and (ME 331 [C] or ME 331H [C] or NSE 331 [C] or NSE 331H [C] or NE 331 [C] or NE 331H [C])
Equivalent to: ME 332, ME 332H, NSE 332H
NSE 332H. HEAT TRANSFER. (4 Credits)
A treatment of conductive, convective and radiative energy transfer using control volume and differential analysis and prediction of transport properties. CROSSLISTED as ME 332H.
Attributes: HNRS – Honors Course Designator
Prerequisites: (MTH 256 with C or better or MTH 256H with C or better) and (ENGR 212 [C] or ENGR 212H [C]) and (NSE 311 [C] or NSE 311H [C] or NE 311 [C] or NE 311H [C] or ME 311 [C] or ME 311H [C] or ME 331 [C] or ME 331H [C] or NSE 331 [C] or NSE 331H [C] or NE 331 [C] or NE 331H [C]).
Equivalent to: ME 332, ME 332H, NSE 332.
NSE 401. RESEARCH. (1-16 Credits)
Graded P/N.
This course is repeatable for 99 credits.
NSE 403. THESIS/DISSERTATION. (1-16 Credits)
This course is repeatable for 16 credits.
NSE 405. READING AND CONFERENCE. (1-16 Credits)
This course is repeatable for 16 credits.
NSE 406. PROJECTS. (1-16 Credits)
This course is repeatable for 16 credits.
NSE 407. SEMINAR. (1 Credit)
Graded P/N.
This course is repeatable for 16 credits.
NSE 410. INTERNSHIP. (1-12 Credits)
Supervised technical work experience at approved organizations. Graded P/N.
This course is repeatable for 12 credits.
NSE 415. NUCLEAR RULES AND REGULATIONS. (2 Credits)
An introduction to the key nuclear regulatory agencies; major nuclear legislation; current radiation protection standards and organizations responsible for their implementation. Offered alternate years.
Recommended: NSE 481 or NE 481 or RHP 481.
NSE 429. SELECTED TOPICS IN NUCLEAR ENGINEERING. (1-3 Credits)
Topics associated with nuclear engineering not covered in other undergraduate courses; topics may vary from year to year.
This course is repeatable for 45 credits.
NSE 435. RADIATION SHIELDING AND EXTERNAL DOSIMETRY. (4 Credits)
Theoretical principles of shielding for neutron and gamma radiation; external dosimetry fundamentals for neutrons, photons, and charged particles; applications to problems of practical interest; analytical, numerical, and computer solutions emphasized.
Prerequisites: (NSE 234 with C or better or NE 234 with C or better or RHP 234 with C or better) and (NSE 235 [C] or NE 235 [C] or RHP 235 [C]) and (NSE 481 [C] or NE 481 [C] or RHP 481 [C])
NSE 440. NUCLEAR FUEL CYCLE AND WASTE MANAGEMENT. (4 Credits)
Mining, milling, conversion, enrichment, fuel fabrication, reprocessing, and waste management of nuclear fuel, including disposal of low- and high-level radioactive waste.
Prerequisites: NSE 235 with C or better or NE 235 with C or better or RHP 235 with C or better
NSE 450. PRINCIPLES OF NUCLEAR MEDICINE. (3 Credits)
Basic principles of nuclear medicine; detectors; radiopharmaceutical; dosimetry; imaging procedures.
NSE 451. NEUTRONIC ANALYSIS I. (3 Credits)
Physical models of neutronic systems; nuclear physics; steady state and transient neutronic system behavior; introductory neutron transport theory, one speed diffusion theory; numerical methods; fast and thermal spectrum calculations; multigroup methods; transmutation and burnup; reactor fuel management; reactivity control; perturbation theory; neutronic laboratory sessions.
Prerequisites: (MTH 256 with C or better or MTH 256H with C or better) and (NSE 234 [C] or NE 234 [C] or RHP 234 [C]) and (NSE 311 [C] or NE 235 [C] or NE 235H [C] or NE 231 [C] or NE 331 [C] or NE 331H [C] or NE 331 [C] or NE 331H [C]).
NSE 452. NEUTRONIC ANALYSIS II. (3 Credits)
Physical models of neutronic systems; nuclear physics; steady state and transient neutronic system behavior; introductory neutron transport theory, one speed diffusion theory; numerical methods; fast and thermal spectrum calculations; multigroup methods; transmutation and burnup; reactor fuel management; reactivity control; perturbation theory; neutronic laboratory sessions. Lec/lab.
Prerequisites: NSE 451 with C or better or NE 451 with C or better.
NSE 455. REACTOR OPERATOR TRAINING I. (3 Credits)
The Oregon State University TRIGA reactor Operator Training I class is one of a two-course series. Students interested in participating in this course are expected to enroll in both the NSE 455/NSE 555 and NSE 456/NSE 556 classes taught during spring and summer terms. Students successfully completing the NSE 455/NSE 555 and NSE 456/NSE 556 series will culminate their course work with the opportunity to take a certification test proctored by the Nuclear Regulatory Commission.
Prerequisites: (NSE 236 with C or better or NE 236 [C] or NE 236H [C]) and (NSE 452 [C] or NSE 552 [C] or NE 452 [C] or NE 552 [C] or NE 451 [C] or NE 551 [C] or NE 451 [C] or NE 551 [C]) and (MTH 256 [C] or MTH 256H [C])
NSE 456. REACTOR OPERATOR TRAINING II. (4 Credits)
The Oregon State University TRIGA reactor Operator Training II class is one of a two-course series. Students interested in participating in this course must have already taken and successfully passed NSE 455/NSE 555. Students successfully completing NSE 455/NSE 555 will culminate their course work with the opportunity to take a certification test proctored by the Nuclear Regulatory Commission.
Prerequisites: NSE 455 with C or better or NE 455 with C or better.
NSE 457. NUCLEAR REACTOR LABORATORY. (2 Credits)
Experimental investigation of the principles of nuclear reactor operation. Use of the OSU TRIGA Reactor and other laboratory facilities. Preparation and presentation of laboratory reports. Lec/lab.
Prerequisites: (NSE 451 with C or better or NE 451 [C] or NE 551 with C or better or NE 551 [C] or NE 551H [C] or NE 551 [C] or NE 551H [C] or NE 551 [C] or NE 551 [C] or NE 551H [C] or NE 551H [C] or NE 551H [C] or NE 551H [C]).
NSE 467. NUCLEAR REACTOR THERMAL HYDRAULICS. (4 Credits)
Hydrodynamics and conductive, convective and radiative heat transfer in nuclear reactor systems. Core heat removal design; critical heat flux, hot spot factors, single- and two-phase flow behavior. Advanced thermal hydraulic computer codes.
Prerequisites: ME 332 with C or better or ME 332H with C or better or NSE 332 with C or better or NE 332H with C or better or NE 332 with C or better or NE 332H with C or better.
NSE 473. NUCLEAR REACTOR SYSTEMS ANALYSIS. (3 Credits)
Analysis of nuclear light water reactor (pressurized water reactor and boiling water reactor) design and operation, including the nuclear steam supply system, engineered safety features and balance of plant systems; regulatory design requirements; industry standards; plant engineering and instrumentation drawings. Advanced reactor system designs.
Prerequisites: NSE 452 with C or better or NE 452 with C or better.
NSE 474. **NUCLEAR SYSTEMS DESIGN I.** (4 Credits)
Part I of a two-part series aimed at developing the student’s ability to utilize fundamental nuclear and radiation protection skills to transform concepts into practical designs. Design projects involve the integration of neutronics, thermal hydraulics, safety and risk analysis, power production, materials, radiation protection, economic optimization, statistics and other skills. (Writing Intensive Course)
Attributes: CWIC – Core, Skills, WIC

NSE 475. **NUCLEAR SYSTEMS DESIGN II.** (4 Credits)
Part II of a two-part series aimed at developing the student’s ability to utilize fundamental nuclear and radiation protection skills to transform concepts into practical designs. Design projects involve the integration of neutronics, thermal hydraulics, safety and risk analysis, power production, materials, radiation protection, economic optimization, statistics and other skills. (Writing Intensive Course)
Attributes: CWIC – Core, Skills, WIC
Prerequisites: (NSE 452 with C or better or NE 452 with C or better) and (NSE 474 [C] or NE 474 [C] or RHP 474 [C])

NSE 481. **RADIATION PROTECTION.** (4 Credits)
Fundamental principles and theory of radiation protection; regulatory agencies, dose units; source of radiation; biological effects and risk; dose limits; applications of external and internal dosimetry; shielding and atmospheric dispersion.
Prerequisites: NSE 235 with C or better or NE 235 with C or better or RHP 235 with C or better

NSE 483. **RADIATION BIOLOGY.** (3 Credits)
Biological effects of ionizing radiation at the molecular, cellular, and organismal levels with emphasis on vertebrates; both acute and chronic radiation effects are considered.
Prerequisites: NSE 481 with C or better or RHP 481 with C or better or MP 481 with C or better

NSE 488. **RADIOECOLOGY.** (3 Credits)
Radioecologies in the environment: their measurement and identification, uptake and transfer through food chains. Effect of radiation on natural populations of plants and animals.
Prerequisites: NSE 481 with C or better or RHP 481 with C or better or NE 481 with C or better

NSE 499. **SPECIAL TOPICS.** (0-16 Credits)
This course is repeatable for 16 credits.

NSE 501. **RESEARCH.** (1-16 Credits)
This course is repeatable for 99 credits.

NSE 503. **THESIS.** (1-16 Credits)
This course is repeatable for 999 credits.

NSE 505. **READING AND CONFERENCE.** (1-16 Credits)
This course is repeatable for 16 credits.

NSE 506. **PROJECTS.** (1-16 Credits)
This course is repeatable for 16 credits.

NSE 507. **SEMINAR.** (1 Credit)
Graded P/N.
This course is repeatable for 16 credits.

NSE 510. **INTERNSHIP.** (1-12 Credits)
Supervised technical work experience at approved organizations. Graded P/N.
This course is repeatable for 16 credits.

NSE 515. **NUCLEAR RULES AND REGULATIONS.** (2 Credits)
An introduction to the key nuclear regulatory agencies; major nuclear legislation; current radiation protection standards and organizations responsible for their implementation. Offered alternate years.

NSE 516. **RADIOCHEMISTRY.** (4 Credits)
Selected methods of radiochemical analysis. Actinide chemistry, activation analysis, radionuclide solvent extraction, and microbial reactions with radionuclides. Designed for majors in chemistry, chemical engineering, nuclear engineering, and radiation health physics. Lec/lab. CROSSTLISTED as CH 516.
Prerequisites: (NSE 531 with C or better or NE 531 with C or better or RHP 531 with C or better) and (NSE 536 [C] or NE 536 [C] or RHP 536 [C])

NSE 517. **RADIOISOTOPES IN LIFE SCIENCES.** (4 Credits)
Chemistry of actinides and fission products, radioseparations, selected medical generators, radiolabeling of organic molecules. Designed for majors in medical physics, radiation health physics, chemistry, pharmacy.
Prerequisites: (NSE 531 with C or better or NE 531 with C or better or RHP 531 with C or better) and (NSE 536 [C] or NE 536 [C] or RHP 536 [C])

NSE 519. **RADIOCHEMICAL ANALYSIS.** (4 Credits)
Hands-on learning of radiochemistry, practical training with open radiation sources for preparation of irradiation targets, counting samples from contaminated soils or separation of medical radionuclides. Fundamentals of chemical dosimetry are also covered. Designed for a broad range of majors in chemistry, nuclear engineering, radiation health physics, radioecology, chemical and environmental engineering. Lec/lab. The lecture part of the course also is delivered online as video stream via Canvas.
Prerequisites: NSE 536 with C or better or NE 536 with C or better or RHP 536 with C or better
Recommended: NSE 516

NSE 521. **RADIOLOGICAL ANATOMY AND PHYSIOLOGY.** (4 Credits)
Anatomy and physiology with correlating images for use by medical physicists, therapists, dosimetrists. This course adheres to the AAMD requirements for Cross Sectional Anatomy.

NSE 522. **NUCLEAR SECURITY SCIENCE.** (4 Credits)
Explores the nuclear fuel cycle from the perspective of nuclear security and safeguards and in the context of current international nuclear policies. Nuclear threats are balanced with the past history of nuclear weapons use, current nonproliferation technology, and the future international growth of the nuclear industry. Critical thinking will be assessed by way of in-class discussions, journal article reviews, written analysis of fuel cycle signatures, and conducting research. Signatures including radiological and morphological characteristics of nuclear material is introduced as well as the techniques for the detection of special nuclear materials.

NSE 525. **NUCLEAR SECURITY SYSTEM DESIGN.** (3 Credits)
Studies the science and engineering associated with the design, evaluation, and implementation of systems to secure nuclear and radiological materials. Topics include adversary characterization, target categorization and the consequences of failure to protect targets, detection and delay technologies, on-site and off-site response and response strategies, insider threat evaluation, and mathematical methods for evaluating risk due to the threat and the security system design. Students will become familiar with the components of a sustainable nuclear security program and their interconnections, and learn about the planning of nuclear security activities at both the state and facility level.
**NSE 526. NUMERICAL METHODS FOR ENGINEERING ANALYSIS.** (3 Credits)
Numerical solutions of linear equations, difference equations, ordinary and partial differential equations. CROSSTLISTED as ME 526.
**Recommended:** Programming experience and previous exposure to numerical methods

**NSE 531. RADIPHYSICS.** (3 Credits)
Expands understanding of concepts and applications of atomic and nuclear physics to enable continued study in nuclear engineering and health physics. Includes fundamental concepts of nuclear and atomic physics, atomic and nuclear shell structure, radioactive decay, radiation interactions, radiation biology, and the characteristics of fission.

**NSE 533. DETECTION OF SPECIAL NUCLEAR MATERIALS.** (3 Credits)
Designed for students interested in radiation measurements and nuclear security, especially those considering PhD-level work in this area. Covers topics including special nuclear material characteristics, radiation background and it interferences with SNM, an introduction to MCNPX, a brief introduction to Geant4, detection of SNM via counting or imaging, localization of SNM, and characterization of SNM.

**Prerequisites:** NSE 536 with C or better

**Recommended:** MTH 251 or MTH 251H

**NSE 535. RADIATION SHIELDING AND EXTERNAL DOSIMETRY.** (4 Credits)
Theoretical principles of shielding for neutron and gamma radiation; external dosimetry fundamentals for neutrons, photons, and charged particles; applications to problems of practical interest; analytical, numerical, and computer solutions emphasized.

**NSE 536. ADVANCED RADIATION DETECTION AND MEASUREMENT.** (4 Credits)
Principles and mechanisms underlying nuclear radiation detection and measurements; operation of nuclear electronic laboratory instrumentation; application of gas-filled, scintillation and semiconductor laboratory detectors for measurement of alpha, beta, gamma, and neutron radiation, liquid scintillation equipment; use of Bonner spheres for neutron energy profiles; experimental investigation of interactions of radiation with matter. Lec/lab.

**Prerequisites:** NSE 531 with C or better or NE 531 with C or better or RHP 531 with C or better or MP 531 with C or better

**NSE 537. DIGITAL RADIATION MEASUREMENT AND SPECTROSCOPY.** (3 Credits)
Principles of digital spectroscopy; application of digital filters in digital processing of detector pulses; hardware implementation of a typical digital spectrometer; introduction of Field-Programmable Gate Array (FPGA) devices programming a digital spectrometer using Hardware Description Language (VHDL); simulation, synthesis and spectroscopy; experimental design tests and evaluation. Lec/lab.

**Prerequisites:** NSE 536 with C or better or NE 536 with C or better or RHP 536 with C or better

**NSE 539. SELECTED TOPICS IN INTERACTION OF NUCLEAR RADIATION.** (1-6 Credits)
Topics associated with interactions of nuclear radiation not covered in other graduate courses; topics may vary from year to year.

**NSE 540. NUCLEAR FUEL CYCLE AND WASTE MANAGEMENT.** (4 Credits)
Mining, milling, conversion, enrichment, fuel fabrication, reprocessing, and waste management of nuclear fuel, including disposal of low- and high-level radioactive waste.

**NSE 541. DIAGNOSTIC IMAGING PHYSICS I.** (3 Credits)
An introduction to the production and usage of ionizing radiation in medicine. The course will cover x-ray production, x-ray spectrum, characteristics and manipulation, and how x-rays are utilized to obtain anatomical information in diagnostics imaging. Imaging modalities to be covered in this course are general and portable planar radiography, mammography, and fluoroscopy (including interventional radiography).

**Prerequisites:** NSE 531 with C or better or MP 531 with C or better or RHP 531 with C or better

**NSE 542. DIAGNOSTIC IMAGING PHYSICS II.** (3 Credits)
An introduction to Computed Tomography (CT) and Ultrasound (US) imaging, and their applications in medicine. The course will cover x-ray production, detection, and image processing as it relates specifically to CT, as well as general acoustic physics principles and how they are applied to US imaging. Additionally, clinical radiation protection and dosimetry in diagnostic imaging will be taught.

**Prerequisites:** NSE 531 with C or better or PP 531 with C or better or RHP 531 with C or better

**NSE 543. ADVANCED DIAGNOSTIC IMAGING PHYSICS.** (3 Credits)
An introduction to the areas of health informatics and magnetic resonance imaging (MRI). The health informatics portion of the course will specifically cover picture archiving and communication systems (PACS), including DICOM standards, data transfer and storage, digital image displays, and clinical implementation of PACS systems. The MRI portion of the course will provide instruction on the physical principles behind nuclear magnetic response (NMR) and how these phenomenon are exploited in MRI. Advanced MRI techniques and applications, along with clinical testing requirements, will also be covered.

**Prerequisites:** NSE 531 with C or better or MP 531 with C or better or RHP 531 with C or better

**NSE 544. NUCLEAR MEDICINE IMAGING.** (3 Credits)
An introduction to the uses of radionuclides in medical imaging. The theory and application of detectors and imaging systems in nuclear medicine including collimators, scintillation probes, cameras, SPECT, PET, and hybrid technologies (SPECT/CT, PET/CT, and PET/MRI) will be covered.

**Prerequisites:** (NSE 541 with C or better or MP 541 with C or better) and (NSE 531 [C] or RHP 531 [C])

**NSE 545. DIAGNOSTIC IMAGING PRACTICUM.** (3 Credits)
Provides an introduction to the medical physicist’s role in a clinical department; an opportunity to integrate principles learned throughout the graduate program as they apply to diagnostic imaging physics. Observations of procedures in radiography, fluoroscopy, ED, OR, interventional radiology, CT, MRI, ultrasound, and nuclear medicine. Experience in regulatory testing of x-ray equipment; observations of testing of CT and other x-ray modalities. Graded P/N.

**Prerequisites:** (NSE 541 with C or better or MP 541 with C or better) and (NSE 531 [C] or MP 531 [C] or RHP 531 [C])

**NSE 549. SELECTED TOPICS IN NUCLEAR FUEL CYCLE ANALYSIS.** (1-6 Credits)
Topics associated with the nuclear fuel cycle not covered in other graduate courses; topics may vary from year to year.

**This course is repeatable for 45 credits.**

**NSE 550. PRINCIPLES OF NUCLEAR MEDICINE.** (3 Credits)
Basic principles of nuclear medicine; detectors; radiopharmaceutical; dosimetry; imaging procedures.
NSE 551. NEUTRONIC ANALYSIS I. (3 Credits)
Physical models of neutron systems; nuclear physics; steady state and transient neutron system behavior; introductory neutron transport theory; one speed diffusion theory; numerical methods; fast and thermal spectrum calculations; multigroup methods; transmutation and burnup; reactor fuel management; reactivity control; perturbation theory; neutronic laboratory sessions.

NSE 552. NEUTRONIC ANALYSIS II. (3 Credits)
Physical models of neutron systems; nuclear physics; steady state and transient neutron system behavior; introductory neutron transport theory; one speed diffusion theory; numerical methods; fast and thermal spectrum calculations; multigroup methods; transmutation and burnup; reactor fuel management; reactivity control; perturbation theory; neutronic laboratory sessions.

Prerequisites: NSE 551 with C or better or NE 551 with C or better

NSE 553. ADVANCED NUCLEAR REACTOR PHYSICS. (3 Credits)
Advanced analytic and numerical techniques for the prediction of the neutron population in nuclear reactor systems. Topic will include long characteristic neutron transport, collision probabilities, nodal methods, equivalence theory, and perturbation theory.

Prerequisites: (NSE 551 with C or better or NE 551 with C or better) and (NSE 552 [C] or NE 552 [C])

Recommended: Computer programming experience

NSE 555. REACTOR OPERATOR TRAINING I. (3 Credits)
The Oregon State University TRIGA Reactor Operator I class is one of a two-course series. Students interested in participating in this course are expected to enroll in both the NSE 455/555 and NSE 456/556 classes taught during spring and summer terms. Students successfully completing the NSE 455/555 and NSE 456/556 series will culminate their course work with the opportunity to take a certification test proctored by the Nuclear Regulatory Commission.

NSE 556. REACTOR OPERATOR TRAINING II. (4 Credits)
The Oregon State University TRIGA Reactor Operator Training II class is one of a two-course series. Students interested in participating in this course must have already taken and successfully passed NSE 455/555. Students successfully completing NSE 456/556 will culminate their course work with the opportunity to take a certification test proctored by the Nuclear Regulatory Commission.

Prerequisites: NSE 555 with C or better or NE 555 with C or better

NSE 557. NUCLEAR REACTOR LABORATORY. (2 Credits)
Experimental investigation of the principles of nuclear reactor operation. Use of the OSU TRIGA Reactor and other laboratory facilities. Preparation and presentation of laboratory reports. Lec/lab.

Prerequisites: (NSE 551 with C or better or NE 550 with C or better) and (NSE 552 [C] or NE 552 [C])

NSE 559. SELECTED TOPICS IN NUCLEAR REACTOR ANALYSIS. (1-3 Credits)
Topics associated with nuclear reactor theory not covered in other graduate courses; topics may vary from year to year.

This course is repeatable for 45 credits.

NSE 561. NUCLEAR REACTOR SYSTEMS LABORATORY. (3 Credits)
Operational aspects of nuclear reactor systems; neutronic and thermal-hydraulic characterization of nuclear reactors; examination of design basis accident prevention and mitigation; loss of coolant accidents; loss of flow accidents; station blackouts. Lec/lab.

Prerequisites: (NSE 553 with C or better or NE 553 with C or better) and (NSE 567 [C] or NE 567 [C])

NSE 562. RADIATION THERAPY. (3 Credits)
The physics of radiation generation and delivery relevant to the field of clinical radiation oncology. Topics will include external beam radiation therapy, dosimetric calculations; high dose-rate and low dose-rate brachytherapy; electron beam dosimetry and treatment planning; special techniques in radiotherapy, and clinical radiation protection and quality assurance.

Prerequisites: NSE 531 with C or better or MP 531 with C or better or NE 531 with C or better or RHP 531 with C or better

NSE 563. APPLIED RADIATION THERAPY PHYSICS LABORATORY I. (3 Credits)
The applied practice of therapeutic radiation physics for clinical radiation oncology. Topics will include current methodologies in treatment delivery and planning algorithms, best practices and protocols for quality assurance, special techniques in radiotherapy, and oncology.

Prerequisites: NSE 562 with C or better or MP 562 with C or better

NSE 564. APPLIED RADIATION THERAPY PHYSICS LABORATORY II. (3 Credits)
Covers the applied practice of therapeutic radiation physics for clinical radiation oncology. Topics include current methodologies in SRS and ARC QA, treatment planning QA, adaptive radiotherapy, eye plaque brachytherapy and HDR brachytherapy.

NSE 565. APPLIED THERMAL HYDRAULICS. (3 Credits)
Advanced topics in the computational modeling of the hydrodynamic and heat transfer phenomena of nuclear reactors. Steady-state and transient solutions of one-dimensional nuclear reactor thermal hydraulic models. Nuclear reactor behavior analysis during various accident scenarios.

NSE 567. NUCLEAR REACTOR THERMAL HYDRAULICS. (4 Credits)
Hydrodynamics and convective, convective and radiative heat transfer in nuclear reactor systems. Core heat removal design; critical heat flux, hot spot factors, single- and two-phase flow behavior. Advanced thermal hydraulic computer codes.

NSE 568. NUCLEAR REACTOR SAFETY. (3 Credits)
Focused on probability risk assessment and system reliability analysis techniques applied to nuclear reactor safety. Application of these methods will be performed specifically through examination of neutronics and thermal hydraulic transients, effectiveness of emergency systems, accident prevention and mitigation, and assessment of radioactive release to the environment.

Prerequisites: (NSE 551 with C or better or NE 551 with C or better) and (NSE 567 [C] or NE 567 [C])

NSE 569. SELECTED TOPICS IN NUCLEAR REACTOR ENGINEERING. (1-6 Credits)
Advanced nuclear engineering design concepts, reactor systems analysis techniques and innovative nuclear engineering applications. Artificial intelligence and expert system applications to nuclear engineering problems. Topics may vary from year to year.

This course is repeatable for 30 credits.

NSE 573. NUCLEAR REACTOR SYSTEMS ANALYSIS. (3 Credits)
Analysis of nuclear light water reactor (pressurized water reactor and boiling water reactor) design and operation, including the nuclear steam supply system, engineered safety features and balance of plant systems; regulatory design requirements; industry standards; plant engineering and instrumentation drawings. Advanced reactor system designs.

Prerequisites: NSE 552 with C or better or NE 552 with C or better
NSE 574. NUCLEAR SYSTEMS DESIGN I. (4 Credits)
Part I of a two-part series aimed at developing the student's ability to utilize fundamental nuclear and radiation protection skills to transform concepts into practical designs. Design projects involve the integration of neutronics, thermal hydraulics, safety and risk analysis, power production, materials, radiation protection, economic optimization, statistics and other skills.

NSE 575. NUCLEAR SYSTEMS DESIGN II. (4 Credits)
Part II of a two-part series aimed at developing the student's ability to utilize fundamental nuclear and radiation protection skills to transform concepts into practical designs. Design projects involve the integration of neutronics, thermal hydraulics, safety and risk analysis, power production, materials, radiation protection, economic optimization, statistics and other skills.

Prerequisites: (NSE 551 with C or better or NE 551 with C or better) and (NSE 552 [C] or NE 552 [C]) and (NSE 574 [C] or NE 574 [C])

NSE 582. APPLIED RADIATION SAFETY. (4 Credits)
Application of radiation protection as practiced in the fields of nuclear science and engineering; application of health physics principles to reduce health hazards at each of the following stages: design, prevention, assessment, and post-incident. A history of key nuclear regulatory agencies; early and current radiation protection standards and organizations responsible for their formulation; major nuclear legislation; pertinent nuclear rules and regulations and their application. Lec/lab.

NSE 583. RADIATION BIOLOGY. (3 Credits)
Biological effects of ionizing radiation at the molecular, cellular, and organismal levels with emphasis on vertebrates; both acute and chronic radiation effects are considered.

NSE 584. RADIATION BIOLOGY II. (3 Credits)
Application of radiobiological models in radiation therapy. Some background in radiation biology is strongly recommended.

NSE 588. RADIOECOLOGY. (3 Credits)
Radionuclides in the environment: their measurement and identification, uptake and transfer through food chains. Effect of radiation on natural populations of plants and animals.

Recommended: NSE 481 or RHP 481 or NE 481

NSE 590. INTERNAL DOSIMETRY. (3 Credits)
Further development and more in-depth treatment of internal dosimetry concepts introduced in NE/RHP 582, in NE/RHP 582, theoretical basis of energy deposition, biokinetics, and estimation of radiation risk from ingested, inhaled, or injected radionuclides.

Prerequisites: (NSE 531 with C or better or NE 531 with C or better or RHP 531 with C or better) and (NSE 535 [C] or NE 535 [C] or RHP 535 [C])

NSE 599. SPECIAL TOPICS. (0-16 Credits)
This course is repeatable for 16 credits.

NSE 601. RESEARCH. (1-16 Credits)
Graded P/N.
This course is repeatable for 99 credits.

NSE 603. THESIS. (1-16 Credits)
This course is repeatable for 999 credits.

NSE 605. READING AND CONFERENCE. (1-16 Credits)
This course is repeatable for 16 credits.

NSE 606. PROJECTS. (1-16 Credits)
This course is repeatable for 16 credits.

NSE 607. SEMINAR. (1-16 Credits)
Graded P/N.
This course is repeatable for 16 credits.

NSE 610. INTERNSHIP. (1-16 Credits)
This course is repeatable for 16 credits.

NSE 654. COMPUTATIONAL PARTICLE TRANSPORT. (3 Credits)
Properties of and methods for solution of the linear Boltzmann equation for nuclear reactors; spherical and double-spherical harmonics; integral equation methods; Monte Carlo methods.

Prerequisites: (NSE 551 with C or better or NE 551 with C or better) and (NSE 552 [C] or NE 552 [C])

NSE 667. ADVANCED THERMAL HYDRAULICS. (3 Credits)
Advanced topics in single- and two-phase hydrodynamics and heat transfer for nuclear reactors. Two-phase flow patterns, flow instabilities, condensation induced transients, convective boiling heat transfer, and current topics in reactor safety thermal hydraulics. Offered alternate years.

Prerequisites: NSE 567 with C or better or NE 567 with C or better

NSE 699. SPECIAL TOPICS. (0-16 Credits)
This course is repeatable for 16 credits.

NSE 808. WORKSHOP. (1-4 Credits)
This course is repeatable for 16 credits.