

NUEN - NUCLEAR ENGINEERING

NUEN 601 Nuclear Reactor Theory

Credits 3. 3 Lecture Hours. Neutron-nucleus interactions; neutron energy spectra; transport and diffusion theory; multigroup approximation; criticality calculations; cross-section processing; buildup and depletion calculations; modern reactor analysis methods and codes. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 604 Radiation Interactions and Shielding

Credits 3. 3 Lecture Hours. Basic principles of radiation interactions and transport, especially as related to the design of radiation shields; radiation sources, nuclear reactions, radiation transport, photon interactions, dosimetry, buildup factors and fast neutron shielding. **Prerequisites:** Graduate classification or approval of instructor.

NUEN 605 Radiation Detection and Nuclear Materials Measurement

Credits 3. 2 Lecture Hours. 3 Lab Hours. Laboratory-based course studying the fundamentals of nuclear materials measurements; advanced radiation detection instrumentation with a specific focus on measuring nuclear materials (uranium, plutonium, and other actinides); nuclear material measurements include detection, identification, and quantification of the materials in a fuel cycle facility and in the field. **Prerequisite:** Graduate classification.

NUEN 606 Reactor Analysis and Experimentation

Credits 4. 3 Lecture Hours. 3 Lab Hours. Perturbation theory; delayed neutrons and reactor kinetics; lattice physics calculations; full core calculations; analysis and measurement of reactivity coefficients; analysis and measurement of flux distribution; analysis and measurement of rod worths; critical and subcritical experiments. **Prerequisite:** Approval of instructor.

NUEN 608 Fast Spectrum Systems and Applications

Credits 3. 3 Lecture Hours. Design and analysis of nuclear systems and nuclear fuel cycles; data, methods and tools for advanced nuclear system modeling; systems analysis; sustainable development of nuclear energy, fast spectrum systems; partitioning & transmutation; hybrid systems; Advanced Fuel cycle program; Generation IV fast reactors; design aspects of Advanced Fast Reactors: neutronics; heat removal; safety; materials; systems. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 609 Nuclear Reactor Safety

Credits 3. 3 Lecture Hours. Analysis and evaluation applied to reactor design for accident prevention and mitigation; protective systems and their reliability, containment design, emergency cooling requirements, reactivity excursions and the atmospheric dispersion of radioactive material; safety problems associated with light-water power reactors and proposed fast reactor systems. **Prerequisite:** NUEN 601 and NUEN 623 or approval of instructor.

NUEN 610 Design of Nuclear Reactors

Credits 4. 4 Lecture Hours. Application of fundamentals of nuclear physics and reactor theory with engineering fundamentals to design of nuclear reactors. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 612 Radiological Safety and Hazards Evaluation

Credits 3. 3 Lecture Hours. State and Federal regulations concerning radioactive materials; radiation safety as applied to accelerators, nuclear reactors, medical therapy and diagnostic devices, and radioactive byproducts; rigorous methods of analysis applied to computation of biological radiation dose and dose rates from various sources and geometries; radiation effects on physical systems. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 613 Principles of Radiological Safety

Credits 3. 3 Lecture Hours. Rigorous mathematical and physical approach to various aspects of radiological safety; derivation of equations involving radiation absorption, radiation dosimetry and calculations of radiation dose due to internal emitters; mathematical models relating to radionuclide concentrations in tumor, normal tissue, air or water to whole body dose. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 614 Probabilistic Risk Assessment Techniques in Nuclear Systems

Credits 3. 3 Lecture Hours. Current and proposed techniques for determining the reliability of nuclear plant systems and the risk associated with the operation of these advanced technology systems. **Prerequisites:** NUEN 612 and NUEN 613.

NUEN 616 Small Modular Reactors and Microreactors

Credits 3. 3 Lecture Hours. Advanced topics in small modular reactors and microreactors; new roles in the field of nuclear energy; consideration of new systems and the possibilities for non-carbon emitting sources of electricity; examination of issues for emerging countries with small electrical grids; overview of modularity for construction, economics and staging of plants; analysis of designs, technologies, approaches, utilization, financial considerations and regulatory implications. **Prerequisites:** Graduate classification; approval of instructor.

NUEN 618 Multiphysics Computations in Nuclear Science and Engineering

Credits 3. 3 Lecture Hours. Tightly coupled multiphysics simulation techniques and application to typical problems arising in nuclear science and engineering (reactor dynamics and safety transients, conjugate heat transfer, radiative transfer, fluid structure interaction). **Prerequisites:** MATH 609 and NUEN 606.

NUEN 621 Nuclear Criticality Safety Fundamentals

Credits 3. 3 Lecture Hours. Study of the criticality safety discipline; focus on neutronics fundamentals and best analytical practices. **Prerequisites:** Graduate classification or approval of instructor.

NUEN 623 Nuclear Engineering Heat Transfer and Fluid Flow

Credits 3. 3 Lecture Hours. Thermodynamics and unified treatment of mass, momentum and energy transport with applications to nuclear engineering systems; velocity and temperature distributions in laminar and turbulent flow; flow and thermal stability. **Prerequisites:** MEEN 334, MATH 346 or MATH 461 and MATH 601 or registration therein or approval of instructor.

NUEN 624 Nuclear Thermal Hydraulics and Stress Analysis

Credits 3. 3 Lecture Hours. Unified treatment of advanced heat transport in solids and fluids including boiling phenomena; thermal stress phenomena with applications to nuclear sources; isothermal elasticity; thermoelasticity; viscoelasticity; plasticity. **Prerequisites:** NUEN 623 or equivalent; MATH 601 or registration therein.

NUEN 625 Neutron Transport Theory

Credits 4. 4 Lecture Hours. Analytical treatment of neutron transport theory; solution methods of integrodifferential and integral Boltzmann equations, adjoints; energy dependent methods using singular eigenfunctions, variational methods, orthogonal polynomials and thermalization; current analytical techniques in transport theory. **Prerequisites:** Graduate classification or approval of instructor.

NUEN 627 Radiation-Hydrodynamics

Credits 3. 3 Lecture Hours. Coupling of the Euler equations of compressible fluid dynamics with the equations of thermal radiation transport; the equilibrium-diffusion limit; radiative shock waves; and numerical methods for one-dimensional calculations. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 628 Computational Fluid Dynamics in Nuclear Thermal Hydraulics

Credits 3. 3 Lecture Hours. Computational fluid dynamics (CFD) as it relates to thermal hydraulics in nuclear power generation; computational model of important flow scenarios using appropriate mesh generation techniques; assessment of result validity through standard verification and validation practices. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 629 Numerical Methods in Reactor Analysis

Credits 4. 4 Lecture Hours. Solution of variable dimension multigroup discrete representation problems including Sn, Pn, An, variational and Monte Carlo techniques; techniques in reactor kinetics, fuel cycle and optimization. **Prerequisites:** Graduate classification or approval of instructor.

NUEN 630 Monte Carlo Methods for Particle Transport

Credits 3. 2 Lecture Hours. 2 Lab Hours. Principles of Monte Carlo method; random number generation; random variable sampling; particle tracking; statistical error estimation; ACE format cross-sections; introduction to MCNP code; MCNP applied to radiation shielding, criticality safety, reactor physics and detector modeling; MCNP output analysis, statistical tests, and tallying procedures; variance reduction techniques; Monte Carlo algorithm development. **Prerequisites:** Approval of Instructor, MCNP/MCNPX code single user license from RSICC, ORNL, USA.

NUEN 632 Nuclear Criticality Safety Evaluation

Credits 3. 3 Lecture Hours. Advanced topics in Nuclear Criticality Safety (NCS); assessment of Nuclear Criticality Process Safety; principles of Nuclear Criticality Safety Evaluation (NCSE); analysis of nuclear criticality accidents; application of nuclear material accountancy and control in NCSE; evaluation of criticality alarm and detection systems; examination of contingency in NCS; consideration of USDOE-STD-113599 standard and its derivatives (such as LANL Report LA-UR-20127); application of the Monte Carlo Computer Code (MCNP) simulations for NCS. **Prerequisites:** NUEN 601; NUEN 630; NUEN 621; MCNP code single user license from RSICC, ORNL, USA.

NUEN 640 Severe Accident Analysis of Nuclear Facilities

Credits 3. 3 Lecture Hours. Severe accident phenomena from initial fuel heat up to the source term; complexity of accident progression and safety issues; severe accident codes with respect to the modeling philosophy, techniques, assumptions and limitations; development of skills in analysis methodologies/techniques. **Prerequisite:** Graduate classification in the college of engineering or approval of instructor.

NUEN 644/MEEN 644 Finite Volume Techniques for Heat Transfer and Fluid Flow

Credits 3. 3 Lecture Hours. Introduction to finite volume techniques, iterative techniques and grid convergence index, advection-diffusion, two-node and three-node formulations, staggered and non-staggered grid concept, SIMPLE family of algorithms and periodically fully developed flow and heat transfer. **Prerequisite:** MEEN 357 and MEEN 461; NUEN 430 or equivalent. **Cross Listing:** MEEN 644/NUEN 644.

NUEN 646 Fundamentals of Space Life Sciences

Credits 3. 3 Lecture Hours. Integrates nutrition, physiology, and radiation biology to define major biological problems in long duration space flight; provide an overview of the problems of bone loss, muscle wasting, and radiation-enhanced carcinogenesis along with potential countermeasures; focus on nutritional interventions and exercise protocols. **Cross Listing:** NUTR 646 and KINE 646.

NUEN 647 Uncertainty Quantification and Data Science for Engineering Applications

Credits 3. 3 Lecture Hours. Predictions of computer codes when the inputs to those codes are uncertain; development of surrogate models for multi-query problems; demonstration on building confidence in computer models and making a qualified prediction. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 650 Nuclear Nonproliferation and Arms Control

Credits 3. 3 Lecture Hours. Studies the political and technological issues associated with nuclear proliferation and arms control; history of arms control treaties and verification, proliferation resistance in the nuclear fuel cycle, international and domestic safeguards, material accountancy, containment and surveillance, and physical protection. **Prerequisite:** Graduate classification or approval of the instructor.

NUEN 651 Nuclear Fuel Cycles and Nuclear Material Safeguards

Credits 3. 3 Lecture Hours. Study of civilian and military nuclear fuel cycles and application of nuclear material safeguards to secure these cycles; topics include the physics of the fundamental fuel cycle components; the application of nuclear material measurements systems; and the technical and legal basis for material protection, control and accounting systems. **Prerequisite:** NUEN 601 or equivalent.

NUEN 657 Emergency Response Dose Assessment

Credits 2. 2 Lecture Hours. The U.S. Nuclear Emergency Response program; assessment of radiation doses to the public and emergency responders following an event; topics include U.S. response teams, radioecology, U.S. guidelines, dose assessment techniques and useful software packages; capstone exercise simulating a radiological release. **Prerequisites:** Graduate classification or approval of instructor.

NUEN 660/MSEN 619 Materials Modeling of Phase Transformation and Microstructural Evolution

Credits 3. 3 Lecture Hours. Modeling and simulation of microstructural evolution during phase transformation in solids; spinodal decomposition, ordering, martensitic transformation, ferroelectric and ferromagnetic domain evolution, dislocation dynamics and crack propagation; primary focus on finite-element and phase-field methods. **Prerequisites:** Graduate classification and approval of instructor. **Cross Listing:** MSEN 619/NUEN 660.

NUEN 661 Nuclear Fuel Performance

Credits 3. 3 Lecture Hours. Reviews basic phenomena that govern nuclear fuel performance; includes structural changes and rate controlling phenomena for oxide and metal fuels as well as cladding and other structural materials. **Prerequisites:** Graduate classification or consent of the instructor.

NUEN 662 Nuclear Materials Under Extreme Conditions

Credits 3. 3 Lecture Hours. Fundamentals of materials degradation under reactor environments; linkage from radiation induced microstructure changes to materials thermal properties, mechanical properties, corrosion resistance, swelling, creep, and overall integrities; materials issues of nuclear fuel, cladding, out-core structural components and waste storage managements. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 663 Fundamentals of Ion Solid Interactions

Credits 3. 3 Lecture Hours. Fundamentals of neutron and ion interactions with solid state materials, and subsequent damage cascade formation, defect clustering, and structural changes; electronic stopping and nuclear stopping mechanisms based on classic and quantum mechanics treatments; development of basic modeling capabilities to carry out simulations for relevant research topics. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 669 Nuclear Terrorism Threat Assessment and Analysis

Credits 3. 3 Lecture Hours. Study the manner in which we conduct threat assessments and the analysis of non-state actors in the fields of nuclear and radiological security; examine the history of threats and security issues in an effort to better understand terrorist groupings, their motivations and attack methodologies. **Prerequisite:** Graduate classification.

NUEN 670 Introduction to Radiotherapy Physics

Credits 4. 3 Lecture Hours. 4 Lab Hours. Examination of radiation physics necessary for understanding modern radiation therapy; perform theoretical foundations of physical dose calculation for megavoltage energy photons and electrons, biological predictions of therapy outcomes, and brachytherapy; methods of modeling and implementing radiation therapy treatment includes planning, evaluation, and delivery; emphasis on intensity modulated radiation therapy and TomoTherapy. **Prerequisites:** Graduate classification; NUEN 613 or approval from academic advisor.

NUEN 673 Radiation Biology

Credits 3. 3 Lecture Hours. Response of biological systems to ionizing radiation at the molecular, cellular, tissue and organismal levels; effects of different doses and dose rates with emphasis on the underlying mechanisms relevant to accidental, environmental and medical exposures. **Prerequisite:** Graduate classification or approval of the instructor.

NUEN 674 Radiation Carcinogenesis

Credits 3. 3 Lecture Hours. Examines the experimental models and mathematical simulations for the investigation of radiation-induced cancer, the current scientific literature concerning the intersection of risk analysis and the interpretation of disparate data from varied biological systems. **Prerequisite:** Graduate classification or approval of instructor.

NUEN 675 Internal Dose Techniques

Credits 3. 3 Lecture Hours. Current and proposed techniques for assessing the absorbed dose due to internally deposited radionuclides; techniques recommended for international and national bodies, as well as those used in nuclear medicine. **Prerequisites:** Graduate classification or approval of instructor.

NUEN 678 Waste Management in the Nuclear Industry

Credits 3. 3 Lecture Hours. Management of radioactive, hazardous and mixed waste generated by all segments of the nuclear fuel cycle and users of radioisotopes; includes treatment, storage and disposal technologies and the political and socioeconomic issues; evaluation of current practices and regulations using a holistic approach. **Prerequisites:** Graduate classification and approval of instructor.

NUEN 681 Seminar

Credit 1. 1 Lecture Hour. Topics in nuclear engineering and health/medical physics not covered by formal coursework; whenever possible, guest lectures will discuss topics which they have personally investigated. **Prerequisite:** Graduate classification.

NUEN 684 Professional Internship

Credits 1 to 6. 1 to 6 Other Hours. Training under the supervision of practitioners in settings appropriate to the student's professional objectives. **Prerequisites:** Approval of chair of student's advisory committee and department head.

NUEN 685 Directed Studies

Credits 1 to 12. 1 to 12 Other Hours. Offered to enable students to undertake and complete limited investigations not within their thesis research and not covered by any other courses in curriculum. **Prerequisite:** Graduate classification.

NUEN 689 Special Topics in...

Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 4 Lab Hours. Selected topics in an identified area of nuclear engineering. May be repeated for credit. **Prerequisite:** Approval of instructor.

NUEN 691 Research

Credits 1 to 23. 1 to 23 Other Hours. Research toward thesis or dissertation.