Learning Outcomes

- Students will describe, explain, and compute the magnitude of radioactivity associated with nuclear reactions and reactor operation.
- Students will calculate the critical size of a nuclear reactor based on the specification of materials present in the reactor.
- Students will describe and compute reactivity effects of control materials, temperature changes, and fission product poisoning.
- Students will describe and compute neutron slowing down and thermalization processes for generating neutron cross data needed in modern reactor physics codes for designing and analyzing nuclear reactors.
- Students will evaluate fuel cycles in terms of processing, costs, and relative benefits.
- Students will evaluate fuel cycles for sustainability including resource availability and external costs such as environmental impact.
- Students will evaluate fuel management and refueling options in terms of cost and resource requirements.
- Students will describe the mechanisms involved in and compute quantities related to the interaction of various forms of radiation with matter and the methods of characterizing radiation fields and sources.
- Students will design radiological shielding for radioactive sources, accelerators, and nuclear reactors.
- Students will describe and explain the current PWR and BWR power plants' operating and protection systems.
- Students will describe and explain the new generation of PWR and BWR power plants' enhanced systems' features and capabilities.
- Students will thermodynamically analyze current reactor system, plus future concepts being proposed and developed.
- Students will use one- and two-group diffusion theory to compute the critical size of a nuclear reactor based on the specification of materials present in the reactor.
- Students will describe and compute the time-dependent behavior of a nuclear reactor, including computation and control of reactivity changes.
- Students will describe, explain, and compute the effect of irradiation on materials behavior.
- Students will describe, explain, and compute quantities related to the in-reactor material degradation.
- Students will describe, explain, and compute how neutronics and thermal-hydraulics are coupled through heat generation rate and its distribution for both full power and shutdown conditions.
- Students will describe, explain, and compute the individual thermal-hydraulic behavior of key reactor system components (e.g., core, steam generator, containment, condenser, etc.) and their interaction with neighboring components within a power cycle.
- Students will compute pressure drops and heat transfer coefficients within single to two-phase flow channels under forced convection conditions.
- Students will compute fuel element temperatures (e.g., fuel centerline) and thermal transition criteria (e.g., critical heat flux) within reactor core "Hot" Channels.
- Students will analyze of the safety of nuclear energy facilities focusing on reliability and probabilistic risk analysis.
- Students will assess the reliability of an energy system from its basic elements.
- Students will describe the major features of nuclear reactors. Describe, explain, and compute fundamental materials behavior including phase equilibria, crystal structure, mechanical properties, and chemical thermodynamics.
- Students will calculate quantities related to heat transfer in a fuel pin, mass diffusion within cladding, radiation damage, uranium enrichment, and thermomechanical behavior in oxide fuels.
- Students will describe, explain, and compute the behaviour of irradiated nuclear fuel.
- Students will identify and explain the design criteria for materials selection in nuclear reactor systems.
- Students will describe, explain, and compute atomic and nuclear physics concepts such as nuclear structure and radioactive decay, and radiation sources in general.
- Students will describe, explain, and compute irradiation effects on materials at the microscopic level.
- Students will describe, explain, and compute radiation effects on materials at the macroscopic level.
- Students will describe, explain, and compute materials degradation mechanisms due to irradiation in nuclear cladding and structural materials.
- Students will combine experiments and computations, including associated uncertainties to predict best-estimate results with reduced uncertainties.
- Students will apply the adjoint method for computing sensitivities of model results to model parameters, initial and boundary conditions.
- Students will describe, explain, and compute radiation interaction with matter.
- Students will describe, explain, and compute quantities related to radiation detection and measurement, and nuclear instruments and detectors.
- Students will describe and explain an aspect of nuclear fuel properties and behavior.
- Students will explain the underlying principles of thermodynamics and the concepts of energy, enthalpy, entropy, and heat capacity.
- Students will use equilibrium calculations to predict behavior and be able to draw and interpret phase diagrams from free energy curves.
- Students will use a chemical equilibrium software package, FactSage, and apply it to practical problems.
- Students will compute uncertainties (variances, covariances) in model parameters and propagate these to compute uncertainties in model responses (results).
- Students will have the ability to execute a research plan, to generate and analyze original research results, and to communicate those results through oral presentations and written publications.
- The graduates shall have the basic skills needed for life-long learning and professional development.

**Degree Requirements (30 Hours)**

*For master’s degrees in nuclear engineering:* An M.S. student must complete 24 hours of graded graduate courses and 6 hours of thesis credit leading to a thesis. An M.E. student must complete 30 hours of graded graduate courses. All master’s degree students will have the core of three required common nuclear engineering courses and one required math course from a given list and will choose the remaining courses from a given list.