

PhD Qualifying Exam Fission Engineering Topics

The PhD fission engineering exam is based on applying the principles of radiation interaction with matter, reactor physics, reactor materials, and reactor engineering to the analysis, design, and operation of nuclear reactor systems. Reactor engineering principles include thermodynamics, fluid flow, heat transfer, design, and integrated systems operation.

Specific reactor engineering principles include:

Thermodynamics – theory and application of energy methods in engineering; conservation of mass and energy; energy transfer by heat, work and mass; thermodynamic properties; analysis of open and closed systems; first and second laws of thermodynamics; Rankine and Brayton power conversion cycles.

Fluid flow – laws of statics, buoyancy, energy and momentum applied to the behavior of real and ideal fluids; dimensional analysis and similitude, and their application to flow through ducts and piping; laminar and turbulent pressure drop and pumping power; system pressure drop characteristic curve, pump characteristic curve and stable system operating point; two phase flow homogeneous equilibrium modeling, slip modeling, and drift flux modeling; choked critical flow; two phase flow pressure drop: frictional, hydrostatic, and spatial acceleration.

Heat transfer – conduction, convection and radiation; steady and transient; reactor material state dependent properties; fuel restructuring; fuel conductivity integral; forced and natural convection; laminar and turbulent velocity and temperature distributions; boiling and condensation phenomenology and heat transfer coefficients; boiling curve; critical heat flux phenomenology; heat exchangers.

Integrated reactor system design – PWR, BWR, HTGR and next generation systems; steady state and transient design methodology; component selection and layout; temperature and heat flux design limits; statistical, engineering and neutronic peaking factors; steady state temperature distributions in coolant/fuel element; system temperature and pressure distributions; accident scenario impact on steady state design; reactivity effects and feedback mechanisms : control rods, fuel Doppler, moderator temperature coefficient, moderator void coefficient, installed and soluble poisons, xenon, samarium, and fission product effects; coupled neutronic/thermal hydraulic transients; non-equilibrium neutron kinetics, “power turning.”

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