Advanced Reactor Physics Analysis Methods
NSEG 6134

I -- Catalogue Description

Neutron physics in a nuclear reactor. Neutron slowing down theory and thermalization. Neutron behavior in resolved and unresolved energies. Multigroup cross-section generation. Homogenization theory. Fuel depletion and burnable poison burnup. Finite-difference and nodal diffusion methods. Method of Characteristics. Theory of SCALE6 code system and its limitations. Pre: 6124 (3H, 3C).

Course Number: 6124

ADP TITLE: Adv Reactor Phys. Analysis Mth

II - Learning Objectives

Having successfully completed this course, the student will be able to:

- Explain the concept neutron spectrum
- Explain the concept of slowing down theory and its use
- Derive neutron spectrum formulations in resolved and unresolved resonance energies
- Explain neutron spectrum in thermal energy range and its behavior as a function temperature
- Derive different methods for generation multigroup cross sections, and understand their limitations and applications in reactors
- Explain the impact of homogenous vs. heterogeneous fuel cell on six factor formula parameters resonance absorption in a heterogeneous fuel-moderator lattice on spatial and energy self-shielding,
- Explain the homogenization theory and derive formulations for generation of homogeneous cross sections. Also derive formulations to account for spatial and energy self-shielding.
- Derive finite-difference and nodal diffusion equations, and understand their areas of application and limitations
- Explain the concept fuel depletion and burnable poison burnup and their impact on core physics, and derive depletion formulations
- Derive the methods characteristic formulation for reactor physics calculations, and understand its limitations
- Use the SCALE6 code system for reactor physics application, and understand its limitations

III - Justification

Nuclear reactor physics is a core discipline of the field of nuclear engineering. This course builds on NSEG 5124 and NSEG 6124 course, and provides in-depth discussion on theory of neutron physics and methodologies enabling development of specialized advanced computational approaches for reactor physics modeling and analysis. It is intended primarily for those who would become specialists in nuclear reactor physics and reactor physics computations. Mastery of this material provides the background for creating the new physics concepts necessary for developing new reactor types and for understanding and extending the computational methods in existing reactor physics codes.

This course provides a comprehensive, detailed and advanced development of the principal topics of nuclear reactor physics.

IV - Prerequisites and Corequisites

6124

V - Texts and Special Teaching Aids

A. Required Text

- "Nuclear Reactor Theory," by G.I. Bell and S. Glasstone, 1970, Van Nostrand Reinhold Company
- Methods for Steady-State Reactor Physics in Nuclear Design by R.J.J. Stammler and M.J. Abatte, 1983, Academic Press.

VI - Syllabus

Topic	Percent of Course
Discuss physics of neutrons in a nuclear reactor, derive formulation of neutron spectra in different ranges and conditions	13%
Discuss different methods for generation of multigroups cross-sections, and derive the corresponding formulations, and analyze their limitations	13%
Through analytical derivations, analyze the impact of homogeneous and heterogeneous fuel cells on the physics of a reactor core	7%
Discuss methodologies used for material homogenization in a nuclear reactor, and derive the corresponding formulations	10%
Discuss the concept of fuel depletion and burnable poisons and their impact on core physics, and derive the corresponding formulations	10%
Derive the finite-difference and nodal diffusion formulations for reactor physics applications, discuss their use and limitations	20%
Derive the characteristic formulation for reactor physics applications, and discuss its use	13%
Review the theory of SCALE6 code system and evaluate its limitations through application to real-world problems	13%