UN 0802
Nuclear Reactor Analysis
2022 - Fall

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Dates:

Lectures:
September 3-4 (BR)
September 17-18 (BR)
October 1-2 (EN)
October 15-16 (EN)

Exams:
Midterm 1– September 18
Midterm 2 – October 16
Final – November 5

Study materials:

Course notes and recordings

Textbook:
Introduction to Nuclear Engineering (third edition)
J.R. Lamarsh & A.J. Baratta
Prentice-Hall, 2001
ISBN: 0-201-82498-1

Additional reading:
Nuclear Reactor Analysis
James J. Duderstadt & Louis J. Hamilton
ISBN: 0471223638

Prerequisite Topics in Mathematics

- Vector algebra
- Differential operators (gradient, divergence, Laplacian) in Cartesian, spherical and cylindrical coordinates
- Surface and volume integrals in Cartesian, spherical and cylindrical coordinates
- First and second order differential equations with constant coefficients
- Partial differential equations with constant coefficients
- Systems of linear algebraic equations

Grading:

Midterm exam 1 : 30%
Midterm exam 2 : 30%
Final exam : 40%

Grading scale: 0-100%.
This is a graduate course. Passing mark is 70%, not 50%.

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Learning objectives

To provide students with an understanding of basic concepts and quantities related to the physics of nuclear reactors.

To train students to use critical, independent thinking.

To train students in problem solving and in applying studied concepts to completely new problems and situations.

To provide students with primary knowledge on the following topics:
- neutron-induced nuclear reactions
- nuclear fission as used for power production
- basic quantities and methods used to describe the behaviour of neutrons in a nuclear reactor.
- static and time-dependent diffusion equation
- elements of CANDU-reactor design
- basic codes used for nuclear reactor neutronic design

Learning outcomes

After taking the course, students should be able to:

- Understand the concept of chain reaction and each component of the four(six)-factor formula.
- Formulate the neutron diffusion equation.
- Describe and use methods of solution for the static diffusion equation.
- Describe and use methods of solution for the time-dependent diffusion equation
- Describe fission-product poisoning (Xe, Sm)
- Describe reactivity effects of temperature and void
- Describe the components of a CANDU reactor
- Utilize simple codes employed in reactor neutronic design.
- Prepare a structured plan for tackling and solving an engineering problem.
- Cast simple engineering problems in analytical form and solve resulting equations symbolically.
- Check plausibility of code results using simple analytical calculations.
- Apply acquired knowledge creatively to solve problems which they have not encountered before.

Academic misconduct

Academic misconduct includes, but is not limited to:

> Cheating on examinations, assignments, reports, or other work used to evaluate student performance. Cheating includes copying from another student's work or allowing one's own work to be copied, submitting another person's work as one's own, fabrication of data, consultation with an unauthorized person during an examination, or use of unauthorized aids.

Tentative Course Outline (order of topics may change)

1. Introduction

PART 1

2. Neutron interactions
    2.1. Interactions of Neutrons

- 2.2. Types of Nuclear Reactions
- 2.3. Kinematics of Nuclear Reactions
- 2.4. Reaction Cross Sections

3. Nuclear Reactors and Nuclear Power
   - 3.1. The Fission Chain Reaction
   - 3.2. Reactor Fuel, Moderator and Coolant
   - 3.3. Main Nuclear Plant Components

4. Basic Concepts of Neutron Physics
   - 4.1. Fission
   - 4.2. Flux, Current, Source
   - 4.3. Reaction Rate Densities
   - 4.4. Fick's Law and the Diffusion Equation
   - 4.5. The Group Diffusion Model
   - 4.6. Solutions to the Diffusion Equation (fixed-source problems)
   - 4.7. Two-Energy-Group Neutron Moderation

PART 2

5. Nuclear Reactor Theory
   - 5.1. Fundamental Eigenvalue Neutronic Problems
   - 5.2. Criticality
   - 5.3. Homogeneous Reactors - Flux Separability in Energy And Space
   - 5.4. One-Group Reactor Equation
   - 5.5. One-Group Flux Solution for Different-Shape Homogeneous Reactors (Slab, Parallelepiped, Cylinder, Sphere)
   - 5.6. Multiregion Problems - Reflector

PART 3

6. Nuclear Reactor Kinetics/Dynamics
   - 6.1. Classification of Time-Dependent Problems.
   - 6.2. Reactor Kinetics
   - 6.3. Reactivity Devices
   - 6.4. Temperature Effects On Reactivity

PART 4

7. Discussion of Basic CANDU Design

8. Discussion of CANDU Computational Schemes

9. Discussion of CANDU LOCA Calculations

10. Fission-Product Poisoning (Xe & Sm). Calculations, Exercises and Assignments