

# UN 0802

## Nuclear Reactor Analysis

**Dates:** January 23 - March 7, 2010

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### Study materials:

Course notes

**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, curl, Laplacian)
- First and second order differential equations with constant coefficients
- Partial differential equations with constant coefficients
- Systems of linear algebraic equations

**Assignments:** Assignments will consist on homework problems and projects.  
Assignments make up 30% of the final grade.

### Grading:

Assignments: 30%  
Midterm exam: 35%  
Final exam: 35%

Grading scale: 0-100%.

### Schedule:

January 23 – lecture (EN)  
January 24 – lecture (EN)  
February 6 – lecture (BR)  
February 7 – lecture (BR)  
February 20 – **midterm** + lecture (EN)  
February 21 – lecture (EN)  
March 6 – lecture (BR)  
March 7 – lecture (BR) + **final exam**

## **Learning objective**

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
- discussion of 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.

## **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

## 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