Reactor Physics

Instructors

Eleodor Nichita
Room UA 3041
Phone (905)721-8668 ext. 2968
e-mail: WebCT e-mail (for course-related issues)
eleodor.nichita@uoit.ca (other issues)

Benjamin Rouben
e-mail: WebCT e-mail (for course-related issues)
roubenb@alum.mit.edu (any issues)

Study materials

Course notes and additional files.

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

Additional good book

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

Assignments/Quizzes

- Part I (Nichita)
  - Two assignments (Nov 3, Nov 18),
  - Graded by way of quiz. (Nov. 17, Dec 1)
  - Collaboration is permitted in solving the problems, but not during the quiz.
  - Try to solve problems by yourself! Only way to prepare for exams.
  - Make up 20% of the final grade
- Part II (Rouben)
  - Two assignments (Nov 4, Nov 18 or Dec 1),
  - Graded by way of quiz (Dec. 1, Dec 2)
  - Collaboration is permitted in solving the problems, but not during the quiz.
  - Make up 20% of the final grade

Overall Grades

- 40% Quizzes (20% 1st part, 20% 2nd part)
- 60% Final
- Each quiz or exam will be graded on a 0%-100% scale.
- Each quiz or exam will be first assigned a “raw” mark m_0 based strictly on the number of points corresponding to the problems that were solved correctly. A “corrected” mark will then be calculated as: $m' = 40 + 0.6m_0$

Final Exam

- December 15

Course Objective

Obtain familiarity with:

- nuclear structure
- radioactivity
- nuclear reactions
- interaction of radiation with matter
- 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

How to Study

- Read chapter from the textbook in advance, also any files provided by the instructors
- In Class:
  - Listen to lecture
  - Ask questions about points you did not understand at home and/or in class
  - Take notes
- At home:
  - Annotate the course notes
  - Re-read annotated course notes
  - Write the main points and derivations by yourself
  - Go over the points that you couldn't reproduce
  - Rewrite derivations by yourself
  - Skim quickly through the notes/text just recapitulating quickly the main points
  - Solve assignment problems

How to Solve Problems

- Attempt problem
- Think about it the next day
- If unable to solve it, talk to a friend, but understand it
- If still unable to solve/understand, post discussion group question
- If not, e-mail professor

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.

Approximate Course Outline

1. Atomic And Nuclear Physics
   - 1.1. Elements of Relativity
   - 1.2. Relativistic Mass Formula
   - 1.3. Relativistic Energy
   - 1.4. Relativistic Momentum
   - 1.5. Nuclear Constituents
   - 1.6. Notations of Isotopes
   - 1.7. Descriptions of Nuclear Particles (Mass, Charge, Spin)
   - 1.8. Binding Energy
   - 1.9. The Liquid Drop Nuclear Model
   - 1.10. The Decay Process
   - 1.11. Natural Radioactivity
   - 1.12. Induced Radioactivity
   - 1.13. Radioactive Families

2.Interaction of Radiation With Matter

- 2.1. Interactions of Heavy Charged Particles
- 2.2. Interactions of Light Charged Particles
- 2.3. Interactions of Gamma Radiation
- 2.4. Interactions of Neutrons
- 2.5. Types of Nuclear Reactions
- 2.6. Kinematics of Nuclear Reactions
- 2.7. 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. Solutions to the Diffusion Equation
- 4.6. The Group Diffusion Model
- 4.7. Two-Energy-Group Neutron Moderation

5.Nuclear Reactor Theory
- 5.1. Fundamental Neutronic Problems (Fixed-Source and Eigenvalue)
- 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

6. Discussion of Basic CANDU Design

7. Discussion of CANDU Computational Schemes

8. Discussion of CANDU Full-Core Calculations

9. Evolution of Fuel and Lattice Properties

10. Hands-on Calculations with POWDERPUFS-V Lattice Computer Code, In-Class And Home Exercises

11. Nuclear Reactor Kinetics/Dynamics
    11.1. Classification of Time-Dependent Problems.
    11.2. Point Kinetics
    11.3. Reactivity Devices (if time allows)
    11.4. Temperature Effects on Reactivity (if time allows)

12. Xe-I Kinetics, Calculations and Exercises

13. CANDU Fuel Management (if time allows)