MIE407H1F/1129H – Nuclear Reactor Theory & Design Fall 2017

Outline

A first course in nuclear reactor theory, which introduces students to the scientific principles of nuclear fission chain reactions and lays a foundation for the application of these principles to the nuclear design and analysis of reactor cores. Topics covered include basic nuclear concepts, atomic fission, neutron propagation and interaction with matter, neutron thermalization, diffusion model of a nuclear reactor, criticality, nuclear reactor kinetics, and reactivity effects.

Syllabus

Lecture†	**Description**
1	The atomic nucleus, stability of isotopes, types of radioactive decay, binding energy, nuclear reactions and the compound nucleus.
2	Liquid drop model of the atomic nucleus, nuclear fission, energetics of nuclear fission, and the characteristics of uranium fission.
3	Parameters describing the interaction of neutrons with matter including cross sections, neutron flux, and reaction rates.
4	Propagation of a neutron beam in a passive medium. Mean free path. Scalar neutron flux and neutron current.
5	The one-group neutron diffusion equation.
6	Solution of the neutron diffusion equation for passive media with an external neutron source.
7	Elastic scattering kinematics.
8-10	Slowing down of neutrons in a thermal nuclear reactor.
11	Neutron multiplication factors, critical state, bare homogeneous spherical reactor, geometric buckling, and criticality equation.
12	Homogeneous thermal reactors. Fermi age, four and six-factor formula, and neutron migration length.
Midterm	
13	Inhomogeneous reactors. Neutron spectrum in fast and thermal reactors. Reflected spherical reactor.
Grads only 2 lectures	Multigroup theory. Solution of the multigroup neutron diffusion equation. The transverse leakage approximation, and the zero-dimensional solution.
14	Reactivity feedback
15, 16	Reactor kinetics. Point kinetics equation, neutron lifetime, and delayed neutrons. Solution of the point kinetics equation. The inhour equation.

17	One-group perturbation theory.
18	Xenon poisoning in thermal nuclear reactors.
19	Samarium poisoning in thermal nuclear reactors.
20	Xenon oscillations and fuel burnup.
Examination	

† The duration of each lecture is 1½ to 2 hours.

Textbook

The following reference books are available on-line via the U of T library catalogue:

E.E. Lewis, *Fundamentals of Nuclear Reactor Physics*, Elsevier, Amsterdam, 2008.

A.E. Waltar *et al.*, *Fast Spectrum Reactors*, Springer, New York, 2012. (Grads only)

Evaluation

	Undergraduates	*Graduates*
Problem sets[1]	20%	20%
Mini Project[2]		10%
Midterm Test	30%	30%
Final Examination	50%	40%

[1] Graduate students will be assigned additional problems.

[2] Numerical solution of the multigroup diffusion equations.

Tutorials

The application of theoretical concepts will be demonstrated in a series of tutorials that will be held at the conclusion of each major topic.

Prerequisites

All mathematical concepts will be explained in the lectures. However, students are expected to have basic knowledge of integral and differential equations. The course will be taught at a level appropriate for Masters-level students with reduced expectations for senior undergraduates.

Schedule	Tuesdays	1-2 PM	WB144	Tutorials & supplementary lectures
	Thursdays	3-5 PM	BAB026	Lectures
	Fridays	3-5 PM	BA2179	Lectures

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