University of California, Berkeley
Department of Nuclear Engineering

NE-150 Nuclear Reactor Theory

Spring 2018
Prof. Jasmina Vujic

SCHEDULE (Preliminary)

LE – Lewis Elmer; LB – Lamarsh&Barata;

Lecture	*Date*	*Topic*	*NOTES*
1	Jan 16	Introduction. Review of the current status in nuclear energy in the world.	Notes 1 LB Ch. 4
2	Jan 18	Review of historical development. Review of fundamental concepts. Atomic and nuclear structure and excited states. Atomic mass unit, number and mass density. Abundance and enrichment. Atom and weight percent.	Notes 2 LE Ch.1 LB Ch.2
3	Jan 23	Nuclear models. Binding energy. Fission and fusion processes. Energy release. Radioactive decay modes and decay chains. Simple reactor power formula.	Notes 3 LE Ch.1 LB Ch.2
4	Jan 25	Basic nuclear reactions; Neutron cross sections; Formation of compound nucleus; Potential scattering; Kinematics of elastic scattering;	Notes 4 LE Ch.2 LB Ch.3
5	Jan 30	Neutron attenuation. Mean free path. Collision frequency. Neutron activation. Discussion of various neutron spectra as a function of neutron energy.	Notes 5 LE Ch.2 LB Ch.3
6	Feb 1	Radiative capture. Resonances. Bright-Wigner formula. Doppler broadening. 1/v absorption cross sections. Polyenergetic neutrons. Reaction rates.	Notes 6 LE Ch.2 LB Ch.3
7	Feb 6	Nuclear fission reaction, fissile, fissionable, fertile nuclides, prompt and delayed neutrons, fission yields, nu-bar. Fission spectrum. Prompt and delayed neutrons. Delayed neutron precursors. Delayed neutron groups. Examples of fission cross sections.	Notes 7 LE Ch.3 LB Ch.3
8	Feb 8	Neutron population distribution in energy. Fast neutrons fission spectra. Thermal neutrons Maxwell-Boltzmann spectra. Average and most probable neutron energies. Neutron spectra in fast and thermal reactors. Energy-averaged cross sections and reaction rates.	Notes 8 LE Ch.3 LB Ch.2
9	Feb 13	Elastic scattering mechanics, energy loss, average logarithmic energy decrement, effect of inelastic scattering, collision and slowing down densities, and resonance absorption evaluation. Average scattering cosine. Slowing down of neutrons, neutron letargy, neutron moderators, neutron upscattering. Slowing-down equations.	Notes 9 LE Ch.2
10	Feb 15	Chain reaction. Neutron multiplication factor. Neutron cycle in nuclear reactor. Four and six factor formula.	Notes 10 LE Ch.4 LB Ch.4,6
	Feb 20	Criticality considerations. Conversion and breeding. Neutron economy in thermal and fast reactors.	Notes 11 LE Ch.4
11	Feb 22	MIDTERM I	LE Ch. 1-3

12	Feb 27	Introduction to Monte Carlo Method	Notes 12
13	March 1	Introduction to MCNP. MCNP Tutorial. On-Line MCNP Manual Running MCNP on DECF Clusters SERPENT Tutorial. Running Serpent on DECF Cluster.	Notes 13
14	March 6	Simple reactor kinetics. Neutron balance equation. Infinite medium non-multiplying systems. Infinite medium multiplying systems. Finite multiplying systems. Multiplying systems behavior in time. Critical, supercritical and subcritical systems.	Notes 14 LE Ch.5 LB Ch.7
15	March 8	Delayed neutron kinetics. Point reactor kinetics equations. In-hour equation. Reactivity formulation. Step reactivity changes. Reactor period. Prompt jump approximation. Rod drop. Source jerk. Rod oscillations.	Notes 15 LE Ch.5 LB Ch.7
16	March 13	Spatial neutron balance. Diffusion approximation, equation of continuity, derivation of Fick's law with transport correction. Solutions of 1D forms of Neutron Diffusion Equation. Examples of the 1D solutions: non-multiplying systems in plane geometry. Boundary conditions, interface conditions.	Notes 16 LE Ch.6 LB Ch.5
17	March 15	Diffusion equation in1D spherical geometry, boundary conditions. Diffusion equation in 1D cylindrical geometry, boundary conditions. Diffusion approximation validity. Review and examples.	Notes 17 LE Ch.6 LB Ch.5
	March 20	Partial currents in diffusion approximation. One-speed diffusion equation in multiplying media. Time-dependent diffusion equation. Solution of the time-dependent diffusion in multiplying media. Criticality conditions. Time eigenvalue and k-eigenvalue. Geometrical buckling.	Notes 18 Textbook Ch. 6
	March 22	Criticality condition. Concept of k-eigenvalue. Slab reactor. Fundamental flux mode. Criticality conditions for other reactor shapes: Infinite and finite cylinders, sphere, rectangular parallelepiped. Maximum-to-average flux. Neutron leakage, diffusion length and mitigation length.	Notes 19 LE Ch.7 LB Ch.6
18	March 27	SPRING BREAK	
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20	April 3	Reflected 1D geometries. Criticality conditions for reflected cores. Reflector savings. More on geometric and material bucklings. Reactor power and flux distributions. Leakage and reactor design. Reflector savings and flux flattening.	Notes 20 LE Ch.7 LB Ch.6
21	April 5	Energy dependent diffusion equation. Derivation of multigroup diffusion equations. Definition of group quantities. Various models for scattering and sources in the multigroup diffusion equation.	Notes 21 LB Ch.5 LB Ch.6
	April 10	MIDTERM II	Notes 10-18 LE Ch. 4-6 LB Ch. 4, 5
22	April 12	Two group approximation for the diffusion equation. Criticality condition. One group modified diffusion equation. Examples.	Notes 22 LE Ch.9 LB Ch.5
25	April 17	Reactivity feedback. Reactivity and temperature coefficients. Composite coefficients, power coefficient. Excess reactivity and shutdown margin. Reactor transients.	Notes 23 LE Ch.10 LB Ch.7
26	April 19	Fission product buildup and decay. Xenon and samarium poisoning. Startup of a clean reactor core. Equilibrium concentrations. Reactor	Notes 24 LE Ch.10

		shutdown and startup. Fuel Depletion. Fuel burnup equations. Fissionable nuclide concentrations, burnable poison. Fission product and actinide inventories. Steady-state Bateman equations.	LB Ch.7
27	April 24	Reactivity Control. Movable control rods, soluble poison, burnable poison. Spent nuclear fuel. Separation and reprocessing. Open and closed fuel cycles. Review of some advanced reactor designs.	Notes 25 LB Ch.7
28	April 26	Review of important concepts.	-
	May 7- May 11	FINAL EXAMINATIONS	