Programme: M. Sc. (Physics)
Course Code: PHO-302 **Title of the Course:** Neutron Physics
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites for the course:	Should have basic knowledge of electrodynamics, thermodynamics and quantum mechanics, and solid state physics	
Objective:	To develop the equations that describe the neutron population in a critical nuclear reactor; calculation of critical size with and without a reflector blanket; kinetics of the reactor including all factors affecting criticality during operation; description of reactor types; radiation dose units; reactor economics; fuel reprocessing and radioactive waste disposal.	
Content:	**I. Interaction of Neutrons with Matter:** Interaction of neutrons with matter, cross-section and variation with neutron energy. Neutron flux. Maxwellian distribution. Fissile and fertile materials. Chain reaction and neutron life cycle. Fermi four factor formula keff.	5 hours
	II. Neutron Diffusion: Diffusion theory approximation, derivation of diffusion equation. Neutron balance and critical equation. Boundary conditions and extrapolation distance. Diffusion length and its measurement.	6 hours
	III. Slowing down of Neutrons: Slowing down length, lethargy, slowing down in a mixture. Moderations. Slowing down models.	8 hours
	IV. Calculation of Critical Size of Reactors: Critical equation. One group model, four factor formula and calculation of parameters. Critical size of sphere and cylinder. Effect of reflector.	5 hours
	V. Power Operation: Reactor kinetics, mean neutron lifetime. The "In-Hour" equation and stable reactor period. Reactivity changes due to temperature. Fission product poisoning. Fuel burn-up. Measurement or reactor power and period.	11 hours
	VI. Reactor Types and Economics: Descriptions of MAGNOX, CANDU, fast reactor. Calculation of total generation cost. Comparison with economics of oil fired plant. Influence of economics on nuclear plant design.	5 hours
	VII. Radiological Protection: Units of radiation and radioactivity. Concept and derivation of safe working levels. Monitoring instruments and methods.	3 hours
	VIII. Reactor Fuels and Materials: Uranium resources and requirements. Isotope separation.	3 hours

	(one method). Fuel reprocessing. Storage and disposal of nuclear waste – consideration of different methods. **IX. Nuclear Policy**: Elements of India's Nuclear Policy. Examples of Policy of other countries. **X. Field trip** to a nuclear establishment such as the Dhruva Reactor, Bhabha Atomic Research Centre, Mumbai or Kaiga Nuclear Plant, Karwar or any other nuclear reactor establishment which gives permission for the visit of students accompanied by the teacher(s) of the course. The visit is to be organized with the aim of helping students better understand and appreciate the layout and complexity of a nuclear reactor. The assessment of the student's understanding is to be done through an essay on a choice of topics relevant to the particular nuclear establishment that is visited. It shall be considered as a compulsory Intra Semester Assessment of the course.	
Pedagogy:	Lectures, Tutorials, Field trip	
References/Readings	1. S. Glasstone and A. Sesonske, Nuclear Reactor Engineering , Van Nostrand Reinhold Co., (1963). 2. E. E. Lewis, Fundamentals of Nuclear Reactor Physics, Elsevier (2008). 3. Safe Handling of Radioisotopes (Safety Series no. 1) (1958). 4. Atomic Energy Waste. Editor E. Glueckauf, (Butterworths) (1961).	
Learning Outcomes	Familiarity with the main features of a nuclear reactor and conditions that determine its criticality. Awareness of the many uses of neutrons and radioactive materials.	