Course: Department Specific Elective 2- HPHDS5021T

Semester	V
Paper Number	HPHDS5021T
Paper Title	NUCLEAR AND PARTICLE PHYSICS
No. of Credits	06 (Theory – 5, Tutorial-1)
Theory/ Composite	Theory
No. of periods assigned	Th:5 periods/week Tutorial:1 period/week
Name of Faculty member(s)	
Course description/ objective	1) To teach the principles of nuclear radiation deterctors like GM tubes and multi wire chambers. 2) To teach the principles of operation of both circular and linear accelerators. 3) To introduce the elementary particles, quarks and leptons, their properties, the quark model description of baryons and mesons. 4) To acquaint the students with the size, shape, structure of a nucleus and their effects upon its binding energy, magnetic and electric moments. 5) To teach various Nuclear Models to explain the energetics of a nucleus and its stability. 6) To make them understand the processes of various radioactive decays. 7) To teach them the mechanism of nuclear reactions and the corresponding production of energy. 8) To make them learn the interaction of nuclear radiation with matter and the loss of energy due to ionization.
Syllabus	As enclosed
Textss	As enclosed
Reading/ Reference List	As enclosed
Evaluation	Total – 100 Theory-80, CIA – 20 **Group A : (50 marks)** Three 10 marks qs out of five qs Four 5 mark qs out of six qs **Group B (30 marks)** Two 10 mark qs out of three qs Two five mark qs out of three qs

Syllabus:

HPHDS5021T - NUCLEAR AND PARTICLE PHYSICS [Credits: Theory-05, Tutorials-01; Lectures : Theory - 65, Tutorial – 13]

Modules A [39 lectures]

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **[8 Lectures]**

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

[10 Lectures]

Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttal law, α-decay spectroscopy. (b) β-decay: energy Gamma decay: Gamma rays emission & kinematics, internal conversion. [**7 Lectures]**

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **[7 Lectures]**

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe- Bloch formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. [**7 Lectures]**

Module B **[26 lectures]**

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT).Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector, Cherenkov detectors, multiwire chambers, silicon microstrip detectors.

[8 Lectures]

Particle Accelerators: Accelerator facility available in India and abroad: Van-de Graaff Generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **[5 Lectures]**

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, charmed quark, bottom quark, discovery of top quark, color quantum number and gluons. Classification of weak interactions. **[13 Lectures]**

Reference Books:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).

2.Concepts of nuclear physics by Bernard L. Cohen. (Tata McGraw Hill, 1998).

3.Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).

4.Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press

5.Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

6.Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi

7.Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP, 2004).

8.Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

9.Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).

10.Theoretical Nuclear Physics, J.M. Blatt &V.F.Weisskopf (Dover Pub.Inc., 1991)

11. Introduction to elementary particle physics, Alexandro Bettini.(2008)

12. Nuclear Radiation Detectors, Kapoor & Ramamurthy, New Age International.

13. Techniques for Nuclear and Particle Physics Experiments, William R. Leo, Narosa