SEMESTER-VI

PHYDSC351T

NUCLEAR AND PARTICLE PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The objective of this course is to build the concepts of ground state properties of a nucleus, the nuclear models and their roles in explaining the various properties of the nucleus, basic aspects of interaction of nuclear radiation with matter. The emphasis of the course is also on understanding the principles and basic constructions of particle accelerators and gain knowledge on the elementary features of Particle Physics.*

Unit 1: General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density, matter density, binding energy, packing fraction, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, dipole & quadrupole moments.

Alpha Decay: Basics of α-decay processes, theory of α-emission, Gamow's theory of alpha decay. Geiger Nuttall law, α-ray spectra. Range of alpha particle and its determination.

(12 Lectures)

Unit 2: Beta & Gamma decays: Beta-decay: energy kinematics for β-decay, β spectrum, positron emission, electron capture, neutrino hypothesis, Rein & Cowans experiment of detection of neutrino. Gamma decay: Gamma ray emissions and internal conversion.

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, Q value of alpha, beta and gamma decay, endothermic & exoergic reaction, Expression of scattering cross-section. **(12 Lectures)**

Unit 3:

Nuclear Models: Liquid drop model. Nuclear fission & Bohr-wheeler theory of nuclear fission. semi empirical mass formula and significance of its various terms, condition of nuclear stability. Nuclear shell model and basic assumption of shell model, evidences for nuclear shell model, nuclear magic numbers. Nuclear force & its properties, Meson theory of nuclear force (detail).

(12 Lectures)

Unit 4: Interaction of Nuclear Radiation with matter: Cerenkov radiation. Gamma ray interaction through matter: Detailed theory of photoelectric effect, Compton scattering and pair production. Mossbauer effect (qualitative idea only).

Detector for Nuclear Radiations: Ionization chamber, proportional counter, GM Counter and Cerenkov radiation detector.

Particle Accelerators: Cyclotron, Betatron. **(13 Lectures)**

Unit 5: Particle physics: Fundamental Particle interactions, relative strengths of these interactions and their basic features, types of particles and its families. Symmetries and Conservation Laws, Spin, baryon number, Lepton number, Isospin, Strangeness, hyper charge and charm. Concept of quark model, Standard model. Concepts of charge conjugation, parity, time reversal and CPT theorem. **(11 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to develop the skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure. The students are also expected to understand, explain and derive the various theoretical formulation of nuclear disintegrations like α, β and γ decays, understand the construction and operation of detectors and particle accelerators and finally to develop the basic knowledge of elementary particles as fundamental constituent of matter, their properties, conservation laws during their interactions.*

Reference Books:

i. Introductory Nuclear Physics by Kenneth S. Krane. (Wiley-India Publication, 2008)

ii. Concepts of Nuclear Physics by Bernard L Cohen. (Tata McGraw Hill Publication, 1998).

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

iv. Introduction to elementary particles, David J Griffiths, John Wiley & Sons.

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

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

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

viii. Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.

ix. Nuclear Physics by S. N. Ghosal, S. Chand Publication, 2010.

x. Modern Physics by R. Murugaeshan. S. Chand Publication, 2010.

xi. Principles of Modern Physics, A K Saxena, Narosa Publishing House.

xii. Atomic & Nuclear Physics by A. B. Gupta, Books & allied publisher.