## BSC. PHYSICS ELECTIVE-EC-2: NUCLEAR AND PARTICLE PHYSICS

**4 hrs./ Week**

Work load: **60 hrs./ Semester**

**CREDIT: Theory -04 / Practical -01**

### COURSE OBJECTIVES

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem-based skills.

### COURSE LEARNING OUTCOME

- Learn the ground state intrinsic properties of a nucleus.
- Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model (ii) the shell model.
- Learn about the process of radioactivity, the radioactive decay law, the emission of alpha, beta and gamma rays.
- Learn the basic aspects of nuclear reactions, the Q-value of such reaction and its derivation from conservation laws, The reaction cross-sections.
- Learn some basic aspects of interaction of nuclear radiation with matter- interaction of gamma ray by photoelectric effect, Compton scattering and pair production, energy loss due to ionization, Cerenkov radiation.
- Learn about the basic features of nuclear radiations.
- Gain knowledge on the basic aspects of particle Physics – the fundamental interactions, elementary and composite particles, the classifications of particles.

### BROAD CONTENTS OF THE COURSE

- General properties of nuclei
- Nuclear models
- Radioactive decays
- Nuclear reactions
- Interaction of nuclear radiation with matter
- Elementary particles and their properties

### SKILLS TO BE LEARNED

- Skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure.
- To understand, explain and derive the various theoretical formulation of nuclear disintegration like $\alpha$ decay, $\beta$ decay and $\gamma$ decays.
- Develop basic understanding of nuclear reactions and decays with help of theoretical formulateand laboratory experiments.
- Skills to develop basic understanding of the interaction of various nuclear radiation with matter in low and high energy.
- Develop basic knowledge of elementary particles as fundamental constituent of matter, theirproperties, conservation laws during their interactions with matter

## SYLLABUS OF THE COURSE

### UNIT-I (12 Lectures)

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

### UNIT-II (12 Lectures)

**Radioactivity decay:** (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow Theory, Geiger Nuttall law. (b) β -decay: energy kinematics for β decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays' emission & kinematics, internal conversion.

### UNIT-III (12 Lectures)

**Nuclear Models:** Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, 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, residual interaction, concept of nuclear force and its properties.

### UNIT-IV (6 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.

**Interaction of Nuclear Radiation with matter:** (6 Lectures)

Energy loss due to ionization (Bethe-Block formula), Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

### UNIT-V (12 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, color quantum number and gluons.

**Text 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).


**Reference Books**


- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press.
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute ofPhysics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991).