

## Core X

# Nuclear and Particle Physics

### Course Outcomes

- Understanding the properties of atoms in electric and magnetic field.
- Understanding the concept Nuclear physics.
- Conceptual understanding nuclear models and nuclear reactions.
- Conceptual understanding of particle physics.
- To Apply the acquired knowledge in conducting the experiments.

### Unit I

**Atoms in Electric and Magnetic Fields:** Electron angular momentum. Space quantization, Electron Spin and Spin Angular Momentum, Larmor's Theorem, Spin Magnetic Moment, Stern Gerlach Experiment, Vector Atom Model, L-S and J-J coupling, Zeeman Effect, Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect, Paschen back and Stark-Effect (qualitative Discussion only).

### Unit II

**Nuclear Physics- :** Nuclear composition, charge, size, shape, mass and density of the nucleus; Nuclear angular momentum; Nuclear magnetic dipole moment; Electric quadrupole moment; Mass defect; Packing fraction and Binding energy; Stability of nuclei (N vs Z curve), Binding energy curve. semi empirical mass formula; Nuclear Forces: General concept of nuclear force; Yukawa Meson field theory of nuclear forces; Properties of Nuclear forces.

Radioactive disintegration; Properties of alpha, beta, gamma rays; law of radioactive decay; successive radioactive decay; radioactive equilibrium; Radioisotopes; application of radioactivity (Agriculture, Medicinal, Industrial and Archaeological).

### Unit III

- **Nuclear models:** Liquid Drop model; Shell model; magic number in the nucleus; Alpha decay: Alpha particles spectra; Gamow's theory of Alpha decay; Beta decay: Shape of Beta ray spectrum; Explanation of Beta decay on the basis of Neutrino and Antineutrino hypothesis; Fermi theory of Beta decay; Selection rules; Gamma ray emission,

- **Nuclear reactions:** Kinds of Nuclear reactions; Nuclear reaction kinematics; Q-value; Compound Nucleus and concept of direct reactions; Conservation laws; Nuclear reaction cross- sections. Nuclear energy: Nuclear Fission; Chain reaction and Critical Mass; Nuclear Reactors and its basic components; Nuclear Fusion; Condition for the maintained Fusion reactions; Energy production in stars; Fusion reaction in Sun, Principle of atomic bomb and hydrogen bomb.

## Unit IV

### Particle Physics

Classification of particles-antiparticles and their interactions; Conservation laws; Charges; Isospin; Baryon number; Lepton number; Strangeness; Hyper charge; Parity; Charge conjugation; CPT theorem; Conservation laws; Quark as the building blocks of Hadrons; Quark Model; Colour degree of freedom, Symmetry Classification of elementary particles; Higgs Boson Particle (God particle), elementary idea on Large Hadron collider (LHC), The future of universe, Dark matter and dark energy.

### Text Books

- ✓ *Concepts of Modern Physics Arthur Beiser (McGrawHill)*
- ✓ *Modern Physics Murugesan and Sivaprasad(S.Chand)*
- ✓ *Cohen B. L., "Concepts of Nuclear Physics", McGraw Hill Education.*
- ✓ *Tayal D. C., "Nuclear Physics", Himalaya Publishing House.*
- ✓ *Patel S. B., "Nuclear Physics: An Introduction", New Age International Publishers.*
- ✓ *Singh Jahan, "Fundamental of Nuclear Physics", Pragati Publications*

### Reference Books

- ✓ *Quantum Mechanics: Theory and Applications, A.K.Ghatak and S.Lokanathan, (Macmillan)*
- ✓ *Introduction to Quantum Theory, David Park (Dover Publications)*
- ✓ *Theory and Problems of Modern Physics, Schaum's outline, R.Gautreau and W.Savin- (Tata McGraw-Hill)*
- ✓ *Modern Physics-Serway (CENGAGE Learnings)*
- ✓ *Physics of Atoms and Molecules Bransden and Joachim (Pearson India)*
- ✓ *Atomic and Nuclear Physics-A.B.Gupta (New Central)*
- ✓ *Theoretical Nuclear Physics, J.M.Blatt and V.F. Weisskopf (Springer)*

## **LAB: Credit-1**

**(Minimum 4 experiments are to be done)**

1. Study of photoelectric effect.
2. Basics of GM counter characteristics and counting statistics.
3. Study of Gamma ray spectroscopy by SCA and MCA.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the value of  $e/m$  by (a) Magnetic focusing or (b) Bar magnet.
6. To setup the Millikan oil drop apparatus and determine the charge of an electron.

### **Reference Books:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Books Book of Practical Physics, I.Prakashand Ramakrishna, 11th Edn, 2011, Kitab Mahal