Nuclear and Particle Physics

Programme: M.Sc. (Physics)	Year: 2nd year	Semester : 3rd
Course : Core Course	Credits : 4	Hours (LTP): 40+12+0

Course Context and Overview:
The Nuclear and Particle Physics course is intended to give the student a strong basis for understanding the smallest constituents of the universe. The properties of the atomic nucleus are discussed in terms of the forces involved, with models to explain the same. Radioactive decay and methods of dating are discussed. The course touches upon fission and fusion as sources of nuclear energy and power. A basic flavor of particle physics is given, with a description of the fundamental forces in nature, the particle zoo, conservation laws in particle reactions, the Standard Model and neutrino physics. Finally particle accelerators and detectors are explained at both a basic level and in terms of current facilities across the world.

Prerequisite Courses:

Quantum Physics-I and II, Mathematical Physics

Course Topics and contact hours allotment:

Topics	Contact Hours
Overview of nuclear properties and nuclear forces: Nuclear radius, nuclear mass and binding energy, angular momentum, charge distribution, spin and parity. Nucleon-nucleon-force, deuteron, pi-meson exchange model, Yukawa hypothesis. Nuclear models – liquid drop model, single-particle shell model, validity and limitations, spin-orbit interactions, collective model, nuclear rotation and vibration.	8
Radioactive decays and nuclear reactions: General properties, radioactive dating, Alpha, Beta and Gamma decay. Nuclear reactions, conservation laws, cross-sections, Coulomb scattering, nuclear scattering. Compound nuclei and direct reactions.	8
Nuclear power and reactors: Nuclear fission and fusion, nuclear power, mechanism and types of nuclear reactors, present-day reactors and their uses. Other applications of nuclear technology – nuclear medicine, agriculture, industrial and commercial applications.	8
Overview of elementary particle theory: The four fundamental forces. Parity non-conservation in weak interaction. Elementary particles - mesons and baryons, leptons and quarks. Quark model of elementary	8

particles, strong isospin, strange quark, Gell-Mann- Okubo mass relation, Gellmann Nishijima formula, colour charge. C, P and T invariance. Application of symmetry arguments to particle reactions. The Standard Model of Particle Physics. Neutrino Physics. Cosmic rays.	
Particle accelerators and detectors: Linear accelerators, cyclotrons, synchrotrons, basic particle detectors, modern complex detectors. The Linear Hadron Collider as a probe for fundamental Physics. Current neutrino detectors. Latest theories and results.	8

Textbook references (IEEE format):

Text Books:

1. A. Beiser, S. Mahajan, S. Rai Choudhury – *Concepts of Modern Physics*.

2. K. Krane – *Introductory Nuclear Physics*

Reference Books:

1. W.E. Burcham – *Nuclear and Particle Physics*.
2. S.S.M. Wong – *Introductory Nuclear Physics*.
3. A. Das, T. Ferbel – *Introduction to Nuclear and Particle Physics*.

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):

Information of relevant videos and web resources will be given during the course.