M.Sc. Physics Semester III Paper XVI
Nuclear and Particle Physics 23PHY23C1

Theory Marks: 80
Internal Assessment Marks: 20
Time: 3 Hours

COURSE OUTCOMES

CO1 Students would be able to realize the nature of nuclear force and nuclear reactions.
CO2 Students would be able to understand the structure of the nucleus and would be able to find out the spin, parity, magnetic moments etc. of different nuclei.
CO3 Students would be able to understand different nuclear decays.
CO4 Students would gain basic knowledge about Elementary Particles and their interactions.

Unit-I

Two nucleon problem: Common potentials used for calculation of nuclear forces viz. Wigner, Majorana, Bartlett and Heisenberg potentials, The ground state of deuteron, Square well solution for the deuteron, Qualitative features of Nucleon – nucleon scattering, Effective range theory in n – p scattering and Significance of sign of scattering length; Meson theory of nuclear force (Qualitative discussion);Types of nuclear reactions: compound and direct nuclear reactions, Reaction cross – section, Reaction cross-section in terms of partial wave treatment, Balance of mass and energy in nuclear reactions, Q equation and its solution.

Unit-II

Liquid drop model: Similarities between liquid drop and nucleus, Semi-empirical mass formula, Mass Parabolas (Prediction of stability against β-decay for members of an Isobaric family), Stability limits against spontaneous fission, Merits and limitations of Liquid drop model; Shell model: Experiment evidences for shell effect, Magic numbers, Main assumptions of the single particle shell model, Spin-orbit coupling in single particle shell model, Estimation of spin, parities and magnetic moments of nuclei by single particle shell model.

Unit-III

Nuclear Decays: Alpha (α) decay, α- disintegration energy, Range of α-particles, Range – energy relationship for α-particles and Geiger – Nuttall law; Beta decay, Pauli's neutrino hypothesis, Fermi theory of beta decay, Curie plot, selection rules for beta decay, Fermi and Gamow-Teller Transitions, Detection and properties of neutrino; Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules; Internal conversion, Nuclear isomerism.

Unit-IV

Elementary Particle Physics: Classifications of elementary particles: fermions and bosons, particles and antiparticles; Fundamental interactions in nature; Type of interaction between elementary particles: Symmetry and conservation laws; Classification of hadrons: Strangeness, Hypercharge, Gelleman - Nishijima formula, Elementary ideas of CP and CPT invariance; Quark model, Baryon Octet, Meson Octet, Baryon Decuplet, Gell-Mann-Okubo formula for octet and decuplet, the necessity of introducing the colour quantum number, SU (2) and SU (3) multiples (qualitative only).

Note: The syllabus is divided into four units. Nine questions will be set in all. Question No.1 will be compulsory having four to eight parts covering the whole syllabus. In addition there will be two questions from each unit and the student is to answer one question from each unit. A student has to attempt five questions in all.

Text and Reference Books:

[1] Nuclear Physics Theory and Experiment by R.R. Roy and B.P. Nigam (New Age International (P) Limited, Publishers)
[2] Nuclear Physics- An introduction by S B Patel (New Age International (P) Limited, Publishers)
[3] Concepts of Modern Physics by Arthur Beiser, S Mahajan, and S Rai Choudhury (Mc Graw Hill Education)
[4] Introductory Nuclear Physics by Kenneth S. Krane (Wiley, New York)
[5] Introductory Nuclear Physics by Y.R. Waghmare (Oxford – IBH, Bombay)
[6] Nuclear Physics, 2nd addition by Kapaln (Narosa, Madras)
[7] Introduction to Nuclear Physics by F.A. Enge (Addison-Wesley)
[8] Nucleon Interaction by G.E. Brown and A.D. Jackson (North-Holland, Amsterdam)
[9] Nuclear and Particle Physics by S L Kakani and Shubhra Kakani (Viva Books)
[10] Introduction to High Energy Physics by P.H. Perkins (Addison-Wesley, London, 1982)
[11] Introduction to Elementary Particles by D. Griffiths (Harper and Row, New York, 1987)