ELEMENTS OF MODERN PHYSICS

Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. (8 Lectures)

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle - application to virtual particles and range of an interaction. (3 Lectures)

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension; (9 Lectures)

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier; (11 Lectures)

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy; (5 Lectures)

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay - energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. (9 Lectures)

Cosmic rays - composition and energy spectrum, possible origin, observed time dilation of secondary particle's life-time (brief qualitative discussions) (1 Lecture)

Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). (2 Lectures)

Suggested study: (1) Application of matter waves to electron microscopy, electrons and neutrons scattering off crystal lattices and their interference patterns, (2) Application of energy-time uncertainty relation to analysis of natural width of a spectral line, (3) Introduction to Nanomaterials, (4) Pritchard's interference experiments with atoms; two slit interference experiments with fullerenes; Scully et al. `which way' interference experiments using microwave-cavities, (5) Quantum mechanical scattering: Gamow's theory of alpha decay, scanning tunnelling microscope, quantum wires, (6) Mossbauer effect- sharp γ photon emission lines because of crystal taking up the recoil during γ - emission, (7) Radioactive dating: Cobalt-60.

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
- Physics for scientists & Engineers with Modern Phys., Jewett & Serway, 2010, Cengage Learning.
- Quantum Mechanics: Theory & Applications, A.K. Ghatak and S. Lokanathan, 2004, Macmillan.

- Modern Introductory Physics,C.H.Holbrow, J.N.Lloyd, J.C.Amato, E.Galvez et.al.2010, Springer.

Additional Books for Reference

- Modern Physics, John R.Taylor, Chris D.Zafiratos, Michael A.Dubson, 2004, PHI Learning.
- Introduction of Modern Physics, H.S. Mani and G.K. Mehta, 1988, Affiliated East-West Press.
- Quantum Physics, Berkeley Physics Course Vol.4. E.H. Wichman, 1971, Tata McGraw-Hill Co.
- Six Ideas that Shaped Physics:Particle Behave like Waves, Thomas A.Moore, 2003, McGraw Hill.
