Course: Core Paper IX–HPHCR4092T & HPHCR4092P

Semester	IV
Paper Number	HPHCR4092T & HPHCR4092P
Paper Title	ELEMENTS OF MODERN PHYSICS
No. of Credits	06 (Theory – 4, Lab – 2)
Theory/ Composite	Composite
No. of periods assigned	Th:4 periods/week Pr:3 periods/week
Name of Faculty member(s)	
Course description/ objective	The objectives for the first module of the course are: i)To acquaint the students with the concepts of wave-particle duality through a discussion of experimental findings regarding the particle properties of waves and the wave properties of particles. ii) To impart knowledge regarding the properties of waves associated with a particle (i.e. matter waves), through an elaborate discussion of de Broglie hypothesis. iii) To establish (or verify) the wave nature of this matter wave, through a discussion of experiments showing the diffraction of this wave. It includes the experimental verification of de Broglie hypothesis. iv) To familiarize the students with the uncertainties (originating from wave nature) in the simultaneous determination of two canonically conjugate variables, through an elaborate discussion of Heisenberg's uncertainty principle. v) To make the students understand the importance of the uncertainty principle by discussing its various applications. vi) To acquaint the students with the mathematical ways to represent (or describe) the de Broglie wave through a function (wave function), to show them how to determine the work function by solving Schrodinger equation and finally to make them learn the techniques of extracting information regarding a system from its wave function. The second module is a mixture of nuclear physics and laser physics. In this course student will learn about 1) nuclear size and structure 2) nuclear models 3) radioactivity 4) fission and fusion 5) spontaneous and stimulated emission 6) three level and four level lasers
Syllabus	As enclosed
Texts	As enclosed
Reading/ Reference Lists	As enclosed
Evaluation	Total – 100 (Theory – 60, Practical – 40) Theory – CIA – 10 Semester Examination – 50 Group A (25 marks) Group B (25 marks) One 10 marks qs out of two qs One 10 mark qs out of two qs Three 5 mark qs out of five qs Three 5 mark qs out of five qs

Syllabus:

HPHCR4092T –ELEMENTS OF MODERN PHYSICS(Credits – Theory – 04, Practicals – 02)

Module – A [26 Lectures]

Planck's quantum hypothesis, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering; De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets.Group and Phase velocities and relation between them. Wave amplitude and wave functions. Probability. Two slit interference experiment with particles (qualitative discussion); linear superposition principle as a consequence

[10 Lectures]

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving a canonical pair of variables): Derivation from Wave Packets. Impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle

[7 Lectures]

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.

[7 Lectures]

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization.Delta function potential, Quantum dot as example. **[3 Lectures]**

Module – B [26 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, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shells and magic numbers (qualitative discussion).

[9 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. **[8 Lectures]**

Fission and fusion- mass deficit, 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). **[5 Lectures]**

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three level and Four level Lasers. Ruby Laser and He-Ne Laser.

[4 Lectures]

Reference Books:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill.
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W.Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
5. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
6.Quantum Physics, Eisberg and Resnick, Wiley (Second edition, 2006).
7. Nuclear Physics, S.N. Ghoshal, S. Chand & Co.
8. Atomic Physics, S.N. Ghoshal, S. Chand & Co.

HPHCR4092P - Elements of Modern Physics Lab ; Credits 2 **[39 periods]**

1. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the wavelength of laser source using diffraction of single slit.
4. To determine the wavelength of laser source using diffraction of double slit.
5. To determine the Planck's constant using LEDs of at least 4 different colours.
6. To determine the value of e/m by Bar magnet.
7. To setup the Millikan oil drop apparatus and determine the charge of an electron.

Reference Books:

1. Advanced Practical Physics (Volume-1 & 2), B. Ghosh & K. G. Majumdar, Sreedhar Publishers.
2. Advanced Practical Physics, Chattopadhyay and Rakshit, New Central Book Agency.
3. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
5. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Edn, 2011,Kitab Mahal.

Paper Structure

(a) Marks for experiment : 30 marks

(i) Class performance on any one expt. – 8

(ii) Lab. Viva on the same experiment as (i) - 7

(iii) LNB for each of the three experiments - 5 x 3 = 15

(b) Grand Viva – 8 marks

(c) Attendance – 2 marks