Govt. P. G. College,Ambala Cantt

Course File: (Session 2023-24)
Name of Professor: Dr. Priyanka
Class: B.Sc.-III (NM& CS), Semester – Vth
Subject code and Name: Physics- PH-501, Paper – IX : Quantum and Laser Physics

Syllabus

Paper – IX : Quantum and Laser Physics

Max. Marks: 40 **Internal Assessment: 10**
Time: 3 hours

Note:- 1. Nine Questions will be set in total 2. Question number 1 will be compulsory and will be based on the conceptual aspects of entire syllabus. This question may have five parts and the answer should be in brief but not in Yes/ No. 3. Four more questions are to be attempted, selecting one question out of two questions set from each unit. Each question may contain two or more parts. 4. 20% numerical problems are to be set. 5. Use of scientific (non-programmable) calculator is allowed.

Unit I: Origin quantum physics (Experimental basis) Overview, scale of quantum physics, boundary between classical and quantum phenomena, Photon, Photoelectric effect, Compton effect (theory and result), FrankHertz experiment, de-Broglie hypothesis. Davisson and Germer experiment, ·G.P. Thomson experiment. Phase velocity, group velocity and their relation. Heisenberg's uncertainty principle. Time energy and angular momentum, position uncertainty. Uncertainty principle from de Broglie wave. (Wave-particle duality). Gamma Ray Microscope, Electron diffraction from a slit. Derivation of 1-D time-dependent Schrodinger wave equation (subject to force, free particle). Time-independent Schrodinger wave equation, eigen values, eigen functions, wave functions and its significance. Orthogonality and Normalization of function, concept of observer and operator. Expectation values of dynamical quantities, probability current density.

Unit II: Application of Schrodinger wave equation: (i) Free particle in one-dimensional box (solution of Schrodinger wave equation, eigen functions, eigen values, quantization of energy and momentum, nodes and anti nodes, zero point energy). (ii) One dimensional step potential $E > Vo$ (Reflection and Transmission coefficient) (iii) One dimensional step potential $E < Vo$ (penetration depth calculation). (iv) One dimensional potential barrier, $E > Vo$ (Reflection and Transmission coefficient) (v) One-dimensional potential barrier, $E < Vo$ (penetration or tunneling coefficient). (vi) Solution of Schrodinger equation for harmonic oscillator (quantization of energy, Zero-point energy, wave equation for ground state and excited states).

Unit III: Laser Physics –I Absorption and emission of radiation, Main features of a laser: Directionality, high intensity, high degree of coherence, spatial and temporal coherence, Einstein's coefficients and possibility of amplification, momentum transfer, life time of a level, kinetics of optical absorption ((two and three level rate equation, Fuchbauer landerburg formula).population inversion: A necessary condition for light amplification, resonance cavity, laser pumping, Threshold condition for laser emission, line broadening mechanism, homogeneous and inhomogeneous line broadening (natural, collision and Doppler broadening).

Unit IV: Laser Physics – II He-Ne laser and RUBY laser (Principle, Construction and working), Optical properties of semiconductor, Semiconductor laser (Principle, Construction and working), Applications of lasers in the field of medicine and industry.

References:

1. L I Schiff, Quantum Mechanics 2. Bransden B H and Joachain C J, Quantum Mechanics (2000), Pearson Education, New Delhi 3. Liboff R L, Introductory Quantum Mechanics 4. Eisberg R M and Resnick R, Quantum Physics of Atoms Molecules, Solids, Nuclei and Particles, Wiley Eastern Ltd, New Delhi 5. Verdeyen J T, Laser Electronics PHI, New Delhi 6. Thorenton S T and Rex A, Modern Physics, (2007) Cengage Learning, New Delhi 7. Taylor J R, Zafiratos C D and Dubson M A, Modern Physics, 2nd Ed (2004), PHI, New Delhi 8 Laud B B, Laser Physics.

Course Objectives:

1. To introduce the Quantum Mechanical postulates for physical systems.
2. To make students aware about the basic formulations in quantum mechanics.
3. To provide students insight to solve Schrodinger wave equation in three dimensions and its applications
4. To understand the fundamental concepts of Laser principle.
5. To be able to differentiate between types of lasers.
6. To develop knowledge of applications of laser.

Course Outcomes:

CO-1 Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and understand the theory of quantum measurements, wave packets and uncertainty principle.

CO-2 Understand the central concepts of quantum mechanics: wave functions, Interpretation of Wave Function, momentum and energy operator, expectation values, the Schrodinger equation, time dependent and time independent cases, probability density, the normalization techniques, Eigen functions, Eigen values and their significance.

CO-3 Understanding the behaviour of quantum particle encountering a i) barrier & ii) potential.

CO-4 Solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one dimensional and three dimensional potentials.

CO-5 Familiar with optical phenomena and different concepts related laser physics.

CO-6 Qualitative understanding of basic lasing mechanism, characteristics of Laser Light, types of Lasers and their applications.

Lesson Plan 2023-24 (Odd Semester)

S.No	Week	Topic
1.	26th July 23 – 29 July 23	Unit III: Laser Physics –I Absorption and emission of radiation, Main features of a laser: Directionality, high intensity, high degree of coherence, spatial and temporal coherence, Einstein's coefficients. **Numericals & Discussions**
2.	31st July 23 – 5th August 2023	Possibility of amplification, momentum transfer, life time of a level, kinetics of optical absorption ((two and three level rate equation, Fuchbauer landerburg formula).Population inversion: A necessary condition for light amplification. **Doubts & Discussions**
3.	7th August 2023-12 August 2023	Resonance cavity, laser pumping, Threshold condition for laser emission Line broadening mechanism, homogeneous and inhomogeneous line broadening (natural, collision and Doppler broadening).
4.	14th August 2023-19 August 2023	**Assigment & Test** Unit IV: Laser Physics – II He-Ne laser and RUBY laser (Principle, Construction and working), Optical properties of semiconductor, Semiconductor laser (Principle, Construction and working), Applications of lasers in the field of medicine and industry.
5.	21st August 2023 – 26th August 2023	Unit I: Origin quantum physics (Experimental basis) Overview, scale of quantum physics, boundary between classical and quantum phenomena, Photon, Photoelectric effect
6.	28th August 2023-2nd September 2023	**Numericals & Discussions** Compton effect (theory and result), FrankHertz experiment, de-Broglie hypothesis.
7.	4th September 2023 – 9th September 2023	Davisson and Germer experiment, ·G.P. Thomson experiment. Compton effect (theory and result), FrankHertz experiment, de-Broglie hypothesis.
8.	11th September 2023 – 16th September 2023	**Numericals & Discussions** Phase velocity, group velocity and their relation. Heisenberg's uncertainty principle, Time energy and angular momentum, position uncertainty. Uncertainty principle from de Broglie wave. (Wave-particle duality).
9.	18th September 2023 – 23th September 2023	**Assignment & Test** Gamma Ray Microscope, Electron diffraction from a slit. Derivation of 1-D time-dependent Schrodinger wave equation (subject to force, free particle).

10.	25th September 2023 – 30th September 2023	Time-independent Schrodinger wave equation, eigen values, eigen functions, wave functions and its significance.
11.	2nd October 2023- 7th October 2023	**Numericals & Doubts and Discussions:** Orthogonality and Normalization of function, concept of observer and operator Expectation values of dynamical quantities, probability current density Test
12.	9th October 2023- 14th October 2023	**Unit II: Application of Schrodinger wave equation:** (i) Free particle in one-dimensional box (solution of Schrodinger wave equation, eigen functions, eigen values, quantization of energy and momentum, nodes and anti nodes, zero point energy).
13.	16th October 2023- 21st October 2023	**Doubts and Discussions,** (ii) One dimensional step potential E > Vo (Reflection and Transmission coefficient) (iii) One dimensional step potential E < Vo (penetration depth calculation).
14.	23rd October 2023- 28th October 2023	iv) One dimensional potential barrier, E > Vo (Reflection and Transmission coefficient) **Doubts and Discussions**
15.	30th October 2023- 4th November 2023	(v) One-dimensional potential barrier, E < Vo (penetration or tunneling coefficient).
16.	6th November 23 to 9th November 23	(vi) Solution of Schrodinger equation for harmonic oscillator (quantization of energy, Zero-point energy, wave equation for ground state and excited states).
17.	10th -16th November 23	**Diwali Break**
18.	17th & 18th November 23	**Revision & Tests**
19.	20th November – 25th November 23	**Revision & Tests**