Registration No.: | | | | | | | | | | |

Total Number of Pages: 03

Course: B.Tech/IDD
Sub_Code: 23BS1002

1st Semester Regular/Back Examination: 2024-25
SUBJECT: PHYSICS
BRANCH(S): PLASTIC, MINING, METTA, MECH, ME, MANUTECH, ELECTRICAL, ELECTRICAL & C.E, EEE, ELECTRONICS & C.E, ETC, ECE, CST, CSEDS, CSEAIML, CSEAI, CSE, CSE, AUTO, AERO, AEIE, AE, CSIT, CIVIL, CHEM, CE, CE
Time: 3 Hours
Max Marks: 100
Q.Code: R466

Answer Question No.1 (Part-I) which is compulsory, any eight from Part-II and any two from Part-III. The figures in the right hand margin indicate marks.

Part-I

Q1 Answer the following questions: **(2 x 10)**

a) A mass attached to a spring undergoes simple harmonic motion. What would happen to the period of oscillation if the mass is halved? Justify your answer.

b) In a driven RLC circuit, how does the power dissipated change as the driving frequency moves away from resonance?

c) Why do thin films exhibit interference effects when illuminated by monochromatic light? A thin film of oil has a refractive index of n = 1.5 and is illuminated with light of wavelength λ = 600 nm. What is the minimum thickness of the film required for constructive interference in the reflected light?

d) What is the role of the grating spacing d in determining the position of diffraction maxima? A diffraction grating has 6000 lines per inch. A monochromatic light of wavelength λ = 500 nm is incident on it. Calculate the angle of the first-order maximum.

e) In a transverse electromagnetic wave, if the electric field oscillates in the vertical direction, in which direction does the magnetic field oscillate? In an electromagnetic wave, the electric field has a maximum value of E_0 = 3 V/calculate the corresponding magnetic field strength at the same point, assuming the wave propagates in free space.

f) How does Ampère's law with Maxwell's correction relate to the magnetic field generated by both current and changing electric fields? If the magnetic field in a region changes with time as $B = 2t\hat{k}$ T, calculate the induced electric field (in differential form) at a distance of 1 m from the origin, using Faraday's law.

g) Why is it incorrect to think of an electron as simply a particle or a wave? An electron is moving at a speed of 2×10^6 m/s. Calculate the wavelength associated with it.

h) What does it mean to normalize a wave function in quantum mechanics? Why is normalization important for the physical interpretation of the wave function?

i) What are the key characteristics that differentiate laser light from ordinary light? How does the coherence impact the applications of laser in fields like communication and medical treatments?

j) Why does the three-level system typically require more power to achieve population inversion compared to the two-level system?

Part-II

Q2 **Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)** **(6 x 8)**

a) Difference between heavy, critical, and light damping in an oscillating system. A system with mass m = 2 kg and spring constant k = 16 N/m is subjected to a damping force. If the system is critically damped, calculate the value of the damping coefficient γ.

b) Explain the working principle of a forced electrical oscillator. How does the driving frequency affect the amplitude of oscillations in a driven RLC circuit?

c) With a suitable diagram obtain the relation between thickness of air film enclosed between the Plano-convex lens and plane glass plate of Newton's ring apparatus. In a Newton's ring experiment, the radius of the 5th ring is measured to be 2.5 mm, and the radius of the 10th ring is 5.0 mm. If the radius of curvature of the lens is 1.2 m, calculate the wavelength of the light used.

d) Explain the phenomenon of Fraunhoffer diffraction due to a single slit. Obtain the condition for the formation of minima and maxima in the diffraction pattern.

e) Mention the significance of Maxwell's electromagnetic equation. Obtain Maxwell's equation which is derived from Faraday's law of electromagnetic induction.

f) Starting from Ampere's circuital law with Maxwell's correction, derive its differential form. What is the significance of the displacement current term in this equation?

g) Difference between group velocity and phase velocity. Establish the relationship between group velocity and phase velocity.

h) Derive the time-dependent Schrödinger equation for a free particle starting from the energy operator and wave function representation. Discuss the assumptions involved in the derivation.

i) Explain the concept of population inversion in a three-level and four-level laser system. Why is population inversion a necessary condition for laser action?

j) Difference between spontaneous and stimulated emission. In a laser system, what is the role of the pumping mechanism in achieving population inversion?

k) Set up one-dimensional wave equation for a vibrating string under tension. Discuss the physical assumptions made during the derivation.

l) Define the quality factor (Q) of an oscillatory system. Derive the expression for the quality factor of an LCR circuit

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four)

Q3 **a)** Derive the equation of motion for a forced damped harmonic oscillator and solve it to find the steady-state solution. **(7+5)**

b) A forced damped harmonic oscillator is driven by a sinusoidal force of amplitude F_0 = 10 N at a driving frequency ω = 3 rad/s. If the mass is 2 kg, damping coefficient is 1 Ns/m, and spring constant is 20 N/m, calculate: I. The amplitude of steady-state oscillation and II. The phase angle between the driving force and displacement. **(2+2)**

Q4 **a)** Derive the expression for the diameter of the nth bright ring in Newton's rings. Compare and contrast the expressions for the diameters of bright and dark rings. **(5+3)**

b) Explain the applications of Newton's rings in determining the wavelength of monochromatic light. **(5)**

c) In a Newton's rings experiment, the diameter of the 20^{th} bright ring is 0.8 cm. If the light source is changed to a wavelength λ_2 such that the diameter of the 20^{th} bright ring becomes 1.0 cm, calculate the new wavelength λ_2. **(3)**

Q5 **a)** Derive Maxwell's wave equation for a conducting medium. Incorporate the conductivity σ of the medium and discuss how it affects the propagation of electromagnetic waves. **(6+2)**

b) Show how Maxwell's wave equation in a vacuum leads to the conclusion that electromagnetic waves propagate at the speed of light. Derive the expression for the speed of light c in terms of ε_0 and μ_0. **(5)**

c) In a vacuum, an electromagnetic wave has an electric field amplitude $E_0 = 50$ V/m. Calculate the corresponding magnetic field amplitude B_0 of the wave. **(3)**

Q6 **a)** Derive the expression for the allowed energy levels of a particle confined in a one-dimensional box of width L. Discuss the quantization of energy and its physical significance. **(7)**

b) Establish the relationship between Einstein's coefficients A_{21}, B_{21}, and B_{12} for a system in thermal equilibrium. **(5)**

c) With the help of an energy level diagram, explain the lasing action in a He-Ne Laser. Why is it classified as a four-level laser system? **(4)**