Total Number of Pages: 03

Course: B.Tech/IDD
Sub_Code: 23BS1002

1st Semester Regular/Back Examination: 2025-26
SUBJECT: PHYSICS
BRANCH(S): CE, CSE, ME, AE, AEIE, AERO, AI, AIML, AME, AUTO, BIOTECH, CIVIL, CSE, CSEAI, CSEAIML, CSEDS, CSIT, CST, CST, ECE, EEE, EEVDT, ELECTRICAL, ELECTRICAL & C.E, ELECTRONICS & C.E, ENV, ETC, IT, MANUTECH, MECH, METTA, MINING, MME, MMEAM, PLASTIC
Time: 3 Hours
Max Marks: 100
Q.Code: U584
Answer Q1 (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) Define the term resonance in a forced damped harmonic oscillator and explain how does damping affects the amplitude of steady-state oscillations.

b) Why does an LC (tank) circuit produce electrical oscillations, whereas RC and RL circuits do not?

c) State the two conditions required for two sources to be coherent and give one practical method of producing coherent sources.

d) What is meant by order of diffraction? Light of wavelength 600 nm is incident normally on a grating with spacing 2×10^{-6} m. Calculate the maximum order of diffraction possible.

e) Mention the condition for the charge free conducting medium and write down the dissipative terms present in EM wave in a conducting medium.

f) Write Maxwell's fourth equation in integral form. Why was Maxwell's displacement current term introduced?

g) Why is wave–particle duality important in quantum mechanics? An electron is accelerated through a potential difference of 100 V. Calculate its de Broglie wavelength.

h) Write the normalization condition for a one-dimensional wave function. A particle is described by a wave function $\psi(x) = Ae^{-x^2}$. Find the value of "A" using the normalization condition.

i) What physical processes represented by Einstein's coefficients A_{21}, B_{12}, and B_{21}? If the Einstein coefficient A_{21} is doubled, how does the lifetime of the excited state change?

j) What is lasing action? State the two essential conditions required for laser action.

Part-II

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

a) Explain the concept of a forced electrical oscillator using a series LCR circuit driven by an alternating emf and hence derive the condition for resonance in a series LCR circuit.

b) Distinguish between light damping, critical damping, and heavy damping. Show that the energy of a lightly damped oscillator decays exponentially with time.

c) Distinguish between interference in reflected light and transmitted light from a thin film and explain why color patterns are observed in soap bubbles and oil films.

d) What is meant by logarithmic decrement? Derive the relation between logarithmic decrement and damping constant. If the logarithmic decrement of an oscillator is 0.05, calculate the ratio of energies after two successive oscillations.

e) Explain the physical meaning of the wave equation. Obtain the general solution of the one-dimensional wave equation. A progressive wave has an amplitude of 2 cm, wavelength 0.5 m, and frequency 20 Hz. Find its maximum particle velocity.

f) Why are circular fringes obtained in Newton's rings experiment? Explain the effect of introducing a liquid between the lens and glass plate. If the diameters of a particular dark ring are 0.60 cm in air and 0.52 cm in liquid, calculate the refractive index of the liquid.

g) What is meant by a solenoidal vector field? Show that the divergence of a curl of any vector field is zero. Calculate the divergence of $\vec{A} = (x^2 y)\hat{\imath} + (y^2 z)\hat{\jmath} + (z^2 x)\hat{k}$.

h) State Gauss' divergence theorem and explain the physical significance of it. Using Gauss' divergence theorem, find the flux of the vector field $\vec{F} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$ out of a sphere of radius a.

i) Distinguish between phase velocity and group velocity. Write the expressions for phase velocity and group velocity in terms of ω and k. For a wave packet, if ω = 6k², find the expressions for phase velocity and group velocity.

j) What are expectation values? Find the expression for the expectation value of position ⟨x⟩ for a particle in a box. Calculate the expectation value of position for a particle in a box of length 1 nm in the ground state.

k) Compare three-level and four-level lasers. State one example each of a three-level and a four-level laser. In a four-level laser, the lifetime of the metastable state is 3 × 10⁻³ s. Calculate the spontaneous emission probability from that level.

l) What is meant by pumping in a laser? Explain the role of a metastable state in laser action. If the lower laser level of a four-level system has only 2 % population, calculate the population inversion when the upper laser level has 30 % population.

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

Q3 **a)** Explain the motion of a forced damped harmonic oscillator subjected to a sinusoidal external force. **(4)**

b) Starting from the equation of motion, obtain the expression for the steady-state amplitude of oscillation and discuss its dependence on driving frequency. **(8)**

c) A mechanical oscillator stores 2 J of energy and loses 0.05 J of energy per cycle due to damping. Calculate the quality factor of the oscillator and state whether it is lightly or heavily damped. **(4)**

Q4 **a)** State the difference between Fresnel and Fraunhoffer diffraction. **(3)**

b) With a suitable theory derive the expression for the intensity distribution and explain the formation of principal maxima and minima, and intensity distribution curve. **(9)**

c) A parallel beam of monochromatic light of wavelength 600 nm is incident normally on a single slit of width 0.2 mm. Calculate the angular position of the first minimum and the angular width of the central maximum. **(4)**

Q5 **a)** What do you mean by Maxwell's electromagnetic wave equation? Write down Maxwell's electromagnetic equations in differential form in free space. **(4)**

b) Set up EM wave equation in an ionized medium and explain why the EM waves cannot propagate through conducting medium. **(9)**

c) If the electric field amplitude of an electromagnetic wave in vacuum is 300 V m^{-1}, calculate the corresponding magnetic field amplitude. (Given: c = 3×10^8 m.s^{-1}) **(3)**

Q6 **a)** Derive the time-dependent Schrödinger wave equation and explain the physical significance of the wave function ψ. **(6)**

b) Define Einstein's A and B coefficients and explain their physical meaning. Derive the relation between them using Planck's radiation law. **(7)**

c) Describe how population inversion is achieved in a He–Ne laser and explain its laser action. **(3)**