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

Total Number of Pages: 03

Course: B.Tech
Sub_Code: RPH1A001

1st Semester Back Examination: 2025-26
SUBJECT: PHYSICS
BRANCH(S): AEIE, AG, CIVIL, CSE, CSEAIML, CSEDS, CSIT, CST, EEE, ELECTRICAL, ELECTRICAL & C.E, ETC, MANUTECH, MECH, PT
Time: 3 Hours
Max Marks: 100
Q.Code: U585
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) What is meant by a coupled oscillatory system and why do these systems have more than one natural frequency?

b) What is meant by damping in vibrations? What happens to the natural frequency of an oscillator when damping is introduced?

c) Explain why alternate half-period zones produce waves of opposite phase at the observation point.

d) Why is monochromatic light preferred for observing clear interference fringes and state the condition for destructive interference in a two-source interference pattern.

e) How acceptance angle and numerical aperture are related and mention the factors on which the numerical aperture of an optical fibre depends?

f) Why does each set of parallel lattice planes in real space correspond to a single point in reciprocal space?

g) How does displacement current differ from conduction current?

h) State Maxwell's first equation in integral form and explain the physical significance of each term.

i) How does the Heisenberg uncertainty principle rule out the presence of electrons inside the nucleus?

j) A wave function is given by $\psi = A(x^2 + 1)$. Is it an acceptable wave function? Give reason.

Part-II

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

a) With the help of a resonance curve, explain the behaviour of amplitude of a forced oscillator at low, resonant, and high driving frequencies. If the bandwidth of a resonant system is 4 rad.s^{-1} and the resonant frequency is 100 rad.s^{-1}, calculate the quality factor of the system.

b) Derive differential equation of a damped harmonic oscillator and obtain its solution for the underdamped case. If the logarithmic decrement of an oscillator is 0.05, 0.05, find the ratio of amplitudes after 10 oscillations.

- **c)** Derive an expression for the focal length of a zone plate and discuss the formation of multiple foci. A zone plate has a first-order focal length of 40 cm. Calculate the positions of the third and fifth order foci.
- **d)** Describe the experimental arrangement of Fresnel's bi-prism for producing interference. If the fringe width observed is 1.2 mm, the distance between the sources and the screen is 1 m, and the wavelength is 500 nm calculate the separation between the virtual sources.
- **e)** Explain the three basic atomic processes absorption, spontaneous emission, and stimulated emission using suitable energy-level diagrams. If an excited state has a mean lifetime of 10^{-8} s, calculate the spontaneous emission probability coefficient.
- **f)** Explain the energy-level transitions involved in the operation of a Ruby laser. Why is a high pumping power required for Ruby laser operation? Calculate the energy of a photon emitted by a Ruby laser operating at a wavelength of 694.3 nm. ($h = 6.63 \times 10^{-34}$ J.s)
- **g)** Explain the Bose–Einstein distribution function and discuss its characteristic features. Calculate the occupation probability of an electron at energy equal to the Fermi energy at 300 K.
- **h)** Explain the significance of divergence and curl in electromagnetic theory. State the condition for a vector field to be solenoidal and irrotational. For the vector field $\vec{A} = yz\hat{i} + xz\hat{j} + xy\hat{k}$, verify whether the field is solenoidal and irrotational.
- **i)** State Gauss's law of electrostatics in free space. Write the corresponding statement in a linear, homogeneous, isotropic dielectric medium and explain the physical significance of permittivity. Calculate the electric field intensity at a distance of 0.2 m from a point charge of 1×10^{-9} C placed in free space.
- **j)** State and explain the Poynting theorem. Define the Poynting vector and explain its physical significance in electromagnetic energy flow.
- **k)** Explain the phenomenon of Compton scattering and describe the experimental arrangement used to observe it. Calculate the Compton shift when X-rays are scattered through an angle of 90°. (Given: Compton wavelength of electron $\lambda_c = 2.43 \times 10^{-12}$ m)
- **l)** Explain why a particle in a harmonic oscillator potential cannot have zero energy. Relate this to the Heisenberg uncertainty principle. Calculate the minimum energy of a quantum harmonic oscillator if its angular frequency is $\omega = 1 \times 10^{13}$ rad.s^{-1}

Part-III

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

Q3 Consider a system of two coupled oscillators with masses m_1 and m_2 and spring constants k_1 and k_2. **(8 + 4 + 4)**

- **a)** Obtain the coupled differential equations for the displacements x_1 and x_2.
- **b)** Find the normal frequencies of oscillation.
- **c)** Sketch the mode shapes for in-phase and out-of-phase oscillations.

Q4 **(6 + 6 + 4)**

- **a)** Derive the electromagnetic wave equation for the electric field E and B in free space starting from Maxwell's equations.
- **b)** Derive the ground state wave function of a one-dimensional quantum harmonic oscillator.
- **c)** Show that the Heisenberg uncertainty principle is satisfied in the ground state.

Q5 A student performs a Newton's rings experiment with a plano-convex lens of known radius of curvature R using sodium light. **(6 + 4 + 6)**

a) Derive the relation between the diameter of the m^{th} dark ring and the wavelength of light.

b) Explain the graphical method for determining the wavelength using the squared diameter vs. ring number plot.

c) How would the presence of a liquid of refractive index n between the lens and plate modify the observed ring diameters?

Q6 **a)** With a suitable diagram describe the construction and the working principle of a semiconductor laser. **(7 + 5 + 4)**

b) Discuss the role of p-n junction and stimulated emission in laser action.

c) Mention two engineering applications of semiconductor lasers in telecommunication and data storage