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

Total Number of Pages: 02 **Course: IDD (B.Tech and M.Tech)**
Sub_Code: 23BS1002

2nd Semester Regular/Back Examination: 2024-25
SUBJECT: PHYSICS
BRANCH(S): AE, AEIE, AERO, AUTO, BIOMED, BIOTECH, CHEM, CIVIL, CSE, CSEAI, CSEAIML, CSEDS, CSEIOT, CSIT, CST, ECE, EEE, EEVDT, ELECTRICAL, ELECTRICAL & C.E, ELECTRONICS & C.E, ETC, IT, MECH, METTA, MINERAL, MINING, MME, EE
Time: 3 Hours
Max Marks: 100
Q.Code: S402

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) Show graphically under-damped, over-damped, and critically damped harmonic oscillations.

b) A 4 kg mass is hung on the end of a helical spring, pulled down, and let go to vibrate vertically. The mass completes 100 vibrations in 55 seconds. Calculate the force constant to the spring.

c) What is a wavefront? How is it produced according to Huygens' principle?

d) A light of wavelength 6000Å normally on a straight slit of 0.1mm. Calculate the total angular width of the central maximum.

e) Show that the vector field $\vec{F} = (x^2 + xy^2)\hat{i} + (y^2 + x^2y)\hat{j}$ is irrotational.

f) State Gauss divergence theorem in vector field and write the mathematical form.

g) Calculate the de Broglie wavelength of a particle traveling at a speed of 50 ms^{-1}, given that its mass is 150 g.

h) Explain the wave-particle duality.

i) What do you mean by population inversion?

j) Explain the meaning of metastable state.

Part-II

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

a) A forced oscillator is in resonance with the external periodic force ($F = F_0 \sin \omega t$). What is the amplitude of the oscillator and the phase difference between the driving force and the velocity of the oscillator?

b) Determine the differential equation of an electrical simple harmonic oscillator, damped harmonic oscillator, and forced electrical oscillator.

c) In Fraunhofer diffraction due to a single slit, obtain the conditions for principal maximum, secondary maxima, and minima. Show the distribution of intensity graphically in this diffraction pattern.

d) An LCR circuit contains an inductor of inductance 20.0 mH, a capacitor of capacitance 5.0 mF, and a resistor of resistance 0.2 ohm. Calculate the angular frequency of oscillation. After how long time the charge oscillation will decay to half of its initial amplitude. Assume the initial phase angle to be zero.

e) Write Maxwell's electromagnetic equations in a conducting medium and obtain the electromagnetic wave equations for electric and magnetic fields.

f) Show that the following functions satisfy the wave equation
I) $y(x, t) = a \sin(kx + \omega t)$ II) $y(x, t) = a\, e^{i(kx - \omega t)}$

g) Show that the electromagnetic waves are transverse in nature.

h) A particle trapped in a one-dimensional box of length L is described by the normalized wave function

$$\psi(x) = \sqrt{2/L} \sin \frac{n\pi x}{L}$$

What is the expectation value of the momentum of the particle?

i) What are the characteristics of a quantum wave function ψ? Derive an expression for the probability of finding a particle described by the wave function ψ in a certain region.

j) Define phase velocity and group velocity. Find a relation between group velocity and phase velocity.

k) Specify three possible types of transitions between two atomic energy levels and derive relations between Einstein's coefficients.

l) With a suitable diagram, explain the construction and working of a three-level laser.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four) **(16 x 2)**

Q3 **a)** Explain the formation of Newton's rings. Obtain an expression for the diameter of dark rings. What will happen to the diameter of the n^{th} dark ring if the air is replaced by water film? Explain. **(12)**

b) Newton's rings are observed in the light of λ = 5900 Å. The diameter of the 10^{th} dark ring is 0.005 m. Find the radius of curvature of the lens and the thickness of the air film. **(4)**

Q4 **a)** Derive the four Maxwell's equations in differential form. Discuss the significance of each Maxwell's equation. **(12)**

b) What is the physical significance of the divergence of a vector field? Find the divergence of a vector field $\vec{F} = (xyz)\hat{\imath} + (3x^2y)\hat{\jmath} + (xz^2 - y^2z)\hat{k}$ at point (1, 1, 1). **(4)**

Q5 **a)** Explain with a suitable diagram the construction and working mechanism of a He-Ne laser. What are the advantages and limitations of a He-Ne laser? **(12)**

b) If laser action occurs by the transition from an excited state to the ground state and it produces light of 6930 Å wavelength, what is the energy of the excited state? Take the energy of the ground state to be zero. **(4)**

Q6 **a)** Write Schrodinger's equation for a particle in a box and find an expression for the wave function and energy of the particle. **(10)**

b) The wave function of a particle is $\psi(x) = (2/L)^{0.5} \sin(\pi x/L)$; $0 < x < L$. Find the probability of finding the particle in the region $0 < x < L/2$. **(6)**