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Total Number of Pages: 02

Integrated Dual Degree (B.Tech and M.Tech)

Sub_Code: 23BS1002

2nd Semester Regular Examination: 2023-24

SUBJECT: PHYSICS

BRANCH(S): ALL

Time: 3 Hour

Max Marks: 100

Q.Code:P296

Answer Question No.1 (Part-1) 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)

- What is the criterion for the motion to be simple harmonic?
- In an RLC Circuit, inductance is 5 mH, the capacitance is 6 μ F, and resistance is 200 Ω , then, is the circuit underdamped, critically-damped, or over-damped?
- What is the basis of Huygens' principle?
- A wave is represented by $y(x,t) = [8\text{cm}] \sin [(10 \text{ rad/cm}) x - (10 \text{ rad/s}) t]$
Determine the amplitude, wavelength, angular frequency, and velocity of the wave.
- If $V = 3x^2y - y^3x^2$, Calculate grad V at point (1, -2, -1)?
- State Gauss divergence theorem and write the mathematical form.
- State de-Broglie hypothesis for matter wave.
- The probability that a system can be in the states represented by Eigen functions ψ_1, ψ_2, ψ_3 , are 1/2, 1/3, 1/4 respectively. Write the wave function for the system. If the energy eigen values for the given states are 2 eV, 3 eV and 4 eV respectively. Find the energy expectation value.
- What is population inversion in LASER?
- Write down the differences between spontaneous emission and stimulated emission of radiation.

Part-II

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

- Setup the differential equation for a one-dimensional simple harmonic oscillator. Show that the total energy of the oscillator is constant in time. Draw the variation of kinetic energy and potential energy with displacement.
- With suitable ray diagram explain the formation of Newton's rings. Why the fringes in Newton's rings interference pattern are circular?
- Set up the differential equation for a one-dimensional oscillator, subjected to a damping force proportional to velocity and an external periodic force. Discuss about frequency, phase, and amplitude of the forced oscillation.
- In Fraunhofer diffraction due to single slit, obtain the conditions for principal maximum, secondary maxima and minima. Show the distribution of intensity graphically in this diffraction pattern.

- e) Derive a relation between magnitudes of electric vector and magnetic vector.
- f) Calculate displacement current in terms of displacement current density using Maxwell idea and differentiate between conduction current and displacement current.
- g) Define divergence of a vector field. Write its physical significances. A vector field is given by $\vec{A} = \hat{i} 2xy + \hat{j} x^2y + \hat{k} xyz$,
Find the divergence and curl of the vector at the point (1, 1, -1).
- h) Define phase velocity and group velocity. Find a relation between group velocity and phase velocity?
- i) What is a wave function ψ ? What are the characteristics of ψ ? Explain if the wavefunction $\psi(x) = e^x$ is quantum mechanical wavefunction or not.
- j) Derive an expression for Schrodinger's time-independent wave equation. Explain the significance of a wave function.
- k) Draw the energy level diagram of the Helium-Neon laser. Explain the operation principle of the He-Ne laser
- l) Specify three possible types of transitions between two atomic energy levels and derive relations between Einstein's coefficients.

Part-III

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

- Q3** a) What do you mean by damped oscillations? A mechanical damped oscillator is subjected to a damping force proportional to its velocity. Set up the differential equation of the oscillation. Discuss the underdamped, overdamped, and critical damped motions of the oscillator. (12)
- b) In Newton's Rings experiment, the diameter of the 15th ring was found to be 0.59 cm, and that of the 5th ring was 0.33 cm. If the radius of the plano-convex lens is 100 cm, calculate the wavelength of light used. What happens to ring diameter if air film is replaced with liquid of refractive index 1.5? (4)
- Q4** a) Write Maxwell's electromagnetic equations in integral and differential form. From Maxwell's electromagnetic equations in a conducting medium; obtain the electromagnetic wave equations for electric and magnetic field. (10)
- b) Prove the transverse nature of Electromagnetic Wave. (6)
- Q5** a) Starting from the Schrödinger equation for a particle confined in a one dimensional box of infinite height, develop an expression for the normalized wave function. (8)
- b) Calculate the expectation value of position x and linear momentum p_x for the wave function (8)

$$\psi(x) = \sqrt{\frac{2}{L}} \sin \frac{\pi x}{L} \quad 0 < x < L$$

- Q6** (a) With a suitable diagram explain the construction and working of ruby laser. Draw the energy level diagram showing the operation of the ruby laser. Write limitations of ruby laser. (12)
- (b) The energy difference ΔE between two energy levels in a particular atom is 4 eV. If the electron moves from the higher level to the lower level, find the wavelength and frequency of the photon emitted in the emission process. (4)