Semester: 2nd
Programme: B.Tech
Branch: Scheme-B

SPRING END SEMESTER EXAMINATION-2024

2nd Semester B.Tech

PHYSICS

PH10001

(For 2023 & Previous Admitted Batches)

Time: 2 Hours 30 Minutes Full Marks: 50

Answer any FIVE questions.
Question paper consists of two SECTIONS i.e. A and B.
Section A is compulsory.
Attempt any Four question from Sections B.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable and all parts of a question should be answered at one place only.

SECTION-A

1. Answer the following questions: [1 × 10]

   (a) What is the effect of damping force on the amplitude and frequency of a simple harmonic oscillator?

   (b) Define logarithmic decrement and write its mathematical expression in terms of damping constant.

   (c) Mention one similarity and one difference between the beam splitter and the compensating glass plate used in Michelson interferometer.

   (d) How will Newton's rings be affected if a red light source is used in place of the yellow light source?

   (e) Outline any two differences between Fraunhofer's diffraction and Fresnel's diffraction.

   (f) For a given vector function $\vec{A} = \hat{\imath}A_x + \hat{\jmath}A_y + \hat{k}A_z$, write the expressions for $\vec{\nabla}.\vec{A}$ and $\vec{\nabla} \times \vec{A}$.

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(g) If the uncertainty in finding the position of an electron is equal to thrice of its' de Broglie wavelength, calculate the uncertainty in the measurement of its velocity.

(h) What is the relation between phase velocity and group velocity in dispersive and non-dispersive mediums?

(i) Calculate the de Broglie wavelength associated with an electron moving with a speed 2.42×10^5 m/s.

(j) List two differences between step index and graded index optical fibres.

SECTION-B

2. (a) Explain the formation of Newton's rings due to reflected rays with a neat diagram. Derive an expression for the radius of n^{th} order dark ring. Hence, prove that the diameters of the dark rings are proportional to the square root of natural numbers. [8]

(b) Two coherent light rays of wavelength 6000Å traveling through different optical paths with path difference of 1.2×10^{-4} cm superpose. Do they produce constructive or destructive interference? Justify the answer. [2]

3. (a) In Fraunhofer diffraction due to a narrow slit of width 'e', obtain the expression for resultant intensity illuminated by monochromatic light of wavelength 'λ'. Also deduce the conditions of principal maximum, secondary maxima, and minima and hence draw the intensity distribution curve. [8]

(b) Time period of a simple harmonic oscillator is 2 seconds. It is subjected to a damping force proportional to speed with a damping coefficient of 1 sec^{-1}.Find the time period of oscillation. What should be the value of damping coefficient for the motion to be critically damped? [2]

4. (a) State Faraday's law of electromagnetic induction and Ampere's circuital law. Use them to establish Maxwell's 3^{rd} and 4^{th} electromagnetic equations in differential form. [8]

(b) Write the electromagnetic wave equations in terms of electric and magnetic fields in free space. Hence, show that the velocity of an electromagnetic wave is equal to the velocity of light in vacuum. [2]

5. (a) Explain how population inversion helps in the production of laser beam. Discuss in detail the construction and working of ruby laser with neat diagrams. [8]

(b) An electron is constrained to move in a one-dimensional potential box of length 1Å. Find the first two energy eigen values and the corresponding de Broglie wavelengths. [2]

6. (a) Set up the time-independent Schrodinger's equation for a particle of mass 'm' and energy 'E' confined to a one-dimensional potential box of length 'L' and infinite height. Apply appropriate boundary conditions to obtain the expressions for energy eigenvalues and normalized eigenfunctions. Also, show graphically the variation of eigenfunctions of the particle along the length of the box in the first three eigenstates. [8]

(b) Do you think the energy of a particle in a one-dimensional box (refer to question 6(a)) differs from the predictions of classical physics? Justify your answer. [2]

Mass of electron = $9.1 \times 10^{-31}\ kg$

Planck's constant = $6.62 \times 10^{-34}\ J.sec$

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