Question Paper

Exam Date & Time: 02-Jul-2022 (09:00 AM - 12:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

SECOND SEMESTER B.TECH. EXAMINATIONS (MIT MANIPAL) - JUNE/JULY 2022
SUBJECT : PHY 1051 - ENGINEERING PHYSICS

Marks: 50 **Duration: 180 mins.**

Answer all the questions.

1A) Obtain an expression for linear position of bright fringes and fringe width in the case of double-slit interference. Sketch the plot of intensity versus path difference. (4)

1B) i) Light of wavelength 500 nm is incident normally on a diffraction grating. If the third-order maximum of the diffraction pattern is observed at 32.0°, (a) what is the number of rulings per centimeter for the grating? (b) Determine the total number of primary maxima that can be observed in this situation. (4)
ii) The intensity on the screen at a certain point in a double-slit interference pattern is 25.0% of the maximum value. (i) What minimum phase difference (in radians) between sources produces this result? (ii) Express this phase difference in terms of path difference(take wavelength as 486.1nm).
(2+2 = 4 marks)

1C) Why are the following wave functions not physically possible for all values of x? (2)
(a) $\psi(x) = Ae^{x}$ (b) $\psi(x) = A\tan(x)$

2A) Using the energy and momentum conservation, derive an expression for the wavelength of the scattered photon (λ') in Compton effect experiment. (4)

2B) i) We wish to use a plate of glass (n = 1.50) in air as polarizer. Find the polarizing angle and angle of refraction. (4)
ii) Show that the group speed of a wavepacket is equal to the particle speed for a free non- relativistic quantum particle.
(2+2 = 4 marks)

2C) An electron with energy 2.5 eV is incident on potential barrier of height 4.5 eV and width 1 nm. If the width of the barrier is increased to ten times, how will the transmission and reflection probability will be affected? (2)

3A) Derive the expression for the wave function for a free particle of mass m confined in a one-dimensional box between $x = 0$ and $x = L$. Sketch the wave function for the 1st excited state. (4)

3B) The atoms of an NaCl molecule are separated by a distance r = 0.280 nm. Calculate (a) the reduced mass of an NaCl molecule, (b) the moment of inertia of an NaCl molecule, and (c) the wavelength of radiation emitted when an NaCl molecule undergoes a transition from the $J = 2$ state to the $J = 1$ state. (Mass of Na = 22.99 u, Cl= 35.45u) (4)

3C) List the possible sets of quantum numbers for the hydrogen atom associated with (a) the 3*d* subshell and (b) the 3*p* subshell. (2)

4A) Show that the 1s wave function for an electron in hydrogen, satisfies the Schrödinger equation in the cylindrical coordinates given by (4)

$$-\frac{\hbar^2}{2m_e}\left(\frac{d^2\psi}{dr^2}+\frac{2}{r}\frac{d\psi}{dr}\right)-\frac{k_e e^2}{r}\psi = E\psi$$

What is the energy of the atom for this state?

4B) Derive an expression for density-of-states. (4)

4C) Justify the requirement of population inversion for production of laser. (2)

5A) Show that the average kinetic energy of a conduction electron in a metal at 0 K is: (4)

$E_{av} = \frac{3}{5}E_F$

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The average kinetic energy is

$$E_{AV} = \frac{1}{n_e} \int E\, N(E)\, dE$$ where the density of particles is,

$$n_e = \int_0^\infty N(E)\, dE$$

5B) Sodium is a monovalent metal having a density of 0.971 g/cm^3 and a molar mass of 23.0 g/mol. Use this information to calculate (a) the density of charge carriers and (b) the Fermi energy of sodium. (4)

5C) Why graphite is soft compared to that of diamond, even if both are made up of carbon atoms? (2)

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