Question Paper

Exam Date & Time: 04-Dec-2023 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

FIRST SEMESTER B.TECH. DEGREE EXAMINATIONS - NOVEMBER / DECEMBER 2023
SUBJECT: PHY 1071 / PHY-1071 - ENGINEERING PHYSICS

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

Answer all the questions.

1A)	Describe the essential requirements for a consistent interference pattern. Using a suitable diagram of Young's double-slit experiment, derive an expression for the vertical distance of the nth bright fringe from the center.	(5)
1B)	In Michelson's interferometer, the yellow sodium line is composed of two wavelengths, $\lambda_1 = 589.0$ nm and $\lambda_2 = 589.6$ nm was used. In the translational displacement of one of the mirrors, the interference pattern vanished periodically. a) Explain the reason for the vanishing of the interference pattern. b) Find the displacement of the mirror between two successive appearances of the sharpest pattern.	(3)
1C)	A free particle has the initial wave function, $\psi(x) = \left(\frac{2a}{\pi}\right)^{1/4} e^{-ax^2}$. Calculate the expectation value of *x* for the particle.	(2)
2A)	Explain Einstein coefficients and derive the condition under which stimulated emission is more likely than spontaneous emission for low-energy photons $(hf << kT)$.	(5)
2B)	Given a glass optical fiber with a core refractive index of 1.450, find the highest value of the cladding refractive index that ensures total internal reflection for light rays within 5 degrees of the fiber axis. Also, compute the fractional refractive index difference between the core and the cladding.	(3)
2C)	Explain the formation of the Cooper pair in the superconductors.	(2)
3A)	Using the energy and momentum conservation, derive an expression for the wavelength of the scattered photon in Compton effect experiment. For what value of photon scattering angle, we may obtain maximum Compton shift?	(5)
3B)	A black body at T = 7500 K consists of an opening of diameter d = 0.050 mm, looking into an oven. Find the number (n) of photons per second escaping the hole and having wavelengths between 500 nm and 501 nm.	(3)
3C)	Illustrate the de Broglie concept of wave properties of particles. Mention the experiment which proved this conceptual idea.	(2)
4A)	By applying the Schrodinger equation, find the wavefunctions and energies of a particle in a one-dimensional infinite potential box of length L.	(5)
4B)	A quantum simple harmonic oscillator consists of an electron bound by a restoring force proportional to its position relative to certain equilibrium point. The proportionality constant is k = 9.1 N/m. What is the wavelength of light emitted if the harmonic oscillator de-excites from the second	(3)

excited state to the first excited state?

4C)	What happens to the rotational energy level of a diatomic molecule when the internuclear separation is altered?	(2)
5A)	Derive an expression for density-of-states function using free electron theory of metals.	(5)
5B)	Taking the effective force constant of a vibrating HCl molecule as k = 480 N/m, find the energy difference between the ground state and the first excited vibrational energy level. The atomic masses of H and Cl are 1amu and 35 amu respectively. 1amu = 1.66×10^{-27} kg.	(3)
5C)	Consider a bulk material in the shape of a cube with a length of 1 meter. This bulk material is crushed into 10^{27} nanoparticles, each having the shape of cube with length of 1 nm. Calculate the surface to volume ratio (SVR) of the material in the bulk and nano form. Comment on the variation of SVR and its effect on the properties of nanomaterials.	(2)

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