Indian Institute of Engineering Science and Technology, Shibpur

B.Tech 2nd Semester Endsem, July, 2021

Physics (PH 1201)

Full Marks: 50 **Time: 90 mins**

Answer all the questions

Please submit Group A and Group B as separate pdf file

Group-A

1. (a) $\left([(\vec{A}.\vec{\nabla})\varphi - (\vec{\nabla}.\vec{A})\varphi]\right) = ?$ (b) State the mathematical form of Divergence Theorem. (c) Evaluate $\oint_S \vec{R}.\hat{N}ds$ where S is the surface of a sphere $x^2 + y^2 + z^2 = 9$ and $\vec{R}$ is the position vector.

[1+2+2]

2. (a) Find out the value of $\vec{\nabla} \times \vec{E}$ for a time-independent magnetic field. (b) State Gauss's law for electrostatics in differential form. (c) Find the charge density (in S.I units) at *(2, 0)* and at *(7, 0)* if the electric field in a region is given by, $\vec{E} = 4x^2\hat{\imath} + 2y\hat{\jmath}$ for 0 < x < 3

$= 4b^2\hat{\imath}$ for x > 3. [1+1+3]

3. (a) The mean lifetime of a μ meson when it is at rest is $\tau_0 = 2.2 \times 10^{-6}\ sec$. Calculate the average distance it travels in vacuum before decaying, if its velocity be 0.99c. (b) The measured volume of a cube is l_0^3 when kept at rest. One side of the cube is aligned to x-axis. Find its volume measured by an observer who is moving with a constant speed of v (v~c) along positive x-axis with respect to it. (c) Write down energy-momentum relation in relativistic mechanics. (d) An electron of energy 10 MeV (>> greater than rest energy, 0.511 MeV). Calculate its momentum and corresponding de-Broglie wave length. [2+3+1+3]

4. (a) Calculate the change in the wavelength of an x-ray of wave length 0.04 nm that undergoes a 90^o Compton scattering from an electron. (b) Find out the energy eigenvalue of the given wave function: $\psi = Ae^{-i\omega t}$,where A is a constant. (c) Find out the expectation value of momentum operator of a wave function given as $\varphi = \sqrt{\frac{2}{L}}\sin\left(\frac{2\pi}{L}x\right)$ in the range (0, L). [1+2+3]

Group-B

4. (a) Show that the average power in forced oscillation is $F^2R/2Z_m^2$, and at resonance it is: $F^2/2R$. Here the notations have their usual meanings. (b) Find out the normal frequencies and normal coordinates of a stiffness coupled system of two simple harmonic oscillators.

[3+(4+2)]

5. (a) Derive the expression of intensity distribution of Fraunhofer N-slit diffraction pattern. Find the conditions of maxima and minima. What is meant by a plane polarized light?
(b) Draw the energy level diagram of a four-level laser system. Obtain the frequency of oscillation of a wave in an optical resonator.

[(4+4+2) + (3+3)]