

Indian Institute of Engineering Science and Technology, Shibpur

B.Tech 1st semester Mid Semester Examination, 2022

Physics (PH 1101)

Full Marks: 30

Time: 45 min

Answer all the questions

(Use separate papers for Group I & II and upload them separately.)

Group-I

- Q.1. a If $\vec{v} = \vec{\omega} \times \vec{r}$, prove that $2\vec{\omega} = \text{Curl } \vec{v}$. 1
- b Prove $\iiint_V \frac{dV}{r^2} = \oint_S \frac{\vec{r} \cdot \hat{n}}{r^2} dS$, where V is the volume enclosed by the surface S . 1
- c A magnetic field is given by $\vec{B} = 2Pxyz^2\hat{i} + 3Qyz^2\hat{j} + 5N\hat{k}$. Find the relation between P and Q. 1
- d Find the charge density at $x = 3.5m$ if the electric field in a region is given by, 1

$$\vec{E}(x) = 4ax^3\hat{i} \text{ V/m for } 0 < x < 3m$$

$$= 3b\hat{i} \text{ V/m for } x > 3m$$

- e How much will be the electric flux through the two flat surfaces of a cylinder of radius ' r ' and height ' h ' surrounding a linear charge along its axis if the electric field at a distance ' r ' from an infinite line charge with linear charge density ' λ ' is $\vec{E} = \frac{\lambda \hat{r}}{2\pi\epsilon_0}$? 1
- Q.2. a Using Stoke's theorem, evaluate $\int_C [(x^2 + y^2)\hat{i} - 2xy\hat{j}] \cdot d\vec{r}$ taken around the rectangular surface on the x-y plane bounded by the lines $x=1$, $x=3$, $y=0$, $y=2$. 3
- b Represent the vector $\vec{A} = 4y\hat{i} + 2z\hat{j} - 5x\hat{k}$ in cylindrical coordinates (ρ, ϕ, z) and determine A_ρ, A_ϕ, A_z . 2
- Q.3. a A monochromatic plane electromagnetic wave is propagating along z-direction in free space. The vector potential of the field is $\vec{A} = \hat{j}A_0 e^{i(\omega t - kz)}$, where $i = \sqrt{-1}$, A_0 is a constant. Find the electric field, magnetic field and Poynting vector. 3
- b Write down equation of continuity and explain the inconsistency existing between this equation and Ampere's law. 2

Group-II

1. a) Calculate the average power of a forced oscillator.
- b) In forced oscillator define Sharpness of resonance.
- c) In stiffness coupled system, two oscillators of equal mass m coupled with three springs of same spring constant k oscillate longitudinally. Find the frequencies of oscillation. [3+1.5+3]
2. a) Obtain the expression for group velocity considering superposition of two waves of equal amplitudes but of slightly different frequencies and wavelengths.
- b) A standing-wave pattern is observed in a thin wire with a length of 2.00 m. The equation of the wave is $y = (0.002\text{m}) \sin(2\pi x) \cos(160\pi t)$ where x is in meters and t is in seconds.
 - i. Sketch a diagram that shows the standing wave pattern
 - ii) Find the amplitude of the two travelling waves that make up this standing wave
 - iii. What is the fundamental frequency of vibration of the wire?
 - iv. Find the maximum velocity for a particle in the string. [3+(1+1+1+1.5)]