

**Indian Institute of Engineering Science and Technology, Shibpur**

**B.Tech 1<sup>st</sup> 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  $\vec{B} = 2Pxz^2\hat{i} + 3Qyz^2\hat{j} + 5N\hat{k}$ . 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

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

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

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 ' $\lambda$ ' 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  $(\rho, \varphi, z)$  and determine  $A_\rho, A_\varphi, A_z$ . 2

Q.3. a A monochromatic plane electromagnetic wave is propagating along z-direction in free space. The vector potential of the field is  $\vec{A} = jA_0ie^{i(wt-kz)}$ , where  $j = \sqrt{-1}$ ,  $A_0$  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  $y = (0.002m) \sin(2\pi x) \cos(160\pi t)$  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)]