

- N.B. : (1) All questions are compulsory.  
 (2) Figures to the right indicate full marks.  
 (3) Use of non programmable calculators and log tables is allowed.  
 (4) Symbols have the usual meaning unless stated otherwise.

1. (a) Attempt any one of the following:
- i) Given that  $\text{div } \vec{E} = \rho / \epsilon_0$  show how the integral form of Gauss' Law can be obtained. Hence find the electric field  $\vec{E}$  due to an infinitely long, straight wire carrying uniform linear charge density  $\lambda$ . Also calculate the electric potential using a suitable reference point. 10
- ii) A charge 'q' is held at a distance 'd' above an infinite grounded, conducting plane. Find potential at a point above the plane, the total charge induced on the plane and the force on the charge 'q'. 10
- (b) Attempt any one of the following: 5
- i) Show that for electrostatic field,  $\text{curl } \vec{E} = 0$ . 5
- ii) Find the electric field inside a uniformly charged sphere of radius R carrying charge density  $\rho$ . 5
2. (a) Attempt any one of the following:
- i) Discuss the physical significance of bound charges produced due to polarization of a dielectric. 10
- ii) Using Ampere's circuital law, show that for an infinitely long solenoid carrying steady current, the magnetic field is parallel to the axis of solenoid. Also obtain expressions for magnetic field inside and outside the solenoid. 10
- (b) Attempt any one of the following.
- i) Using straight line currents obtain Ampere's circuital law. 5
- ii) For a dipole in an electric field, show that the net force is  $\vec{F} = (\vec{p} \cdot \nabla) \vec{E}$ . 5

3. (a) Attempt any one of the following:
- Beginning from Maxwell's equations inside matter, obtain boundary conditions for fields  $\vec{E}$ ,  $\vec{B}$ ,  $\vec{D}$  and  $\vec{H}$ . 10
  - Write Ampere's law in its original form. What is the deficiency of this law? Explain how Maxwell modified it. 10
- (b) Attempt any one of the following:
- Find the total energy required to set up a uniform magnetic field of 2.0 Tesla in a cube of sides 20cm each ( $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$ ). 5
  - The magnetic susceptibility of a linear sample of tungsten is  $7.8 \times 10^{-5}$ . If an auxiliary field of 50000 ampere turns/m is applied along z-axis, Find the magnetisation  $\vec{M}$  and magnetic field  $\vec{B}$  in the medium. ( $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$ ). 5
4. (a) Attempt any one of the following:
- Using the expression for the energy density in the electromagnetic field as  $u = \frac{1}{2} \left( \epsilon_0 E^2 + \frac{1}{\mu_0} B^2 \right)$ , obtain the expression for the average values of energy density  $\langle u \rangle$ , Poynting vector  $\langle \vec{S} \rangle$  and the momentum density, for plane monochromatic wave. Explain the term radiation pressure. 10
  - State Poynting's theorem. Obtain the differential version of Poynting's theorem and compare it with the continuity equation. 10
- (b) Attempt any one of the following:
- Explain how Newton's third law appears to be violated in case of electrodynamics. 5
  - If  $\vec{E} = E_0 e^{i(kz - \omega t)} \hat{x}$  and  $\vec{B} = B_0 e^{i(kz - \omega t)} \hat{y}$ , find the energy per unit time per unit area transported by the fields in free space. 5
5. (a) Attempt any one of the following:
- A charge  $q$  sits at the back corner of a cube. What is the flux of  $\vec{E}$  through an adjoining face and through a front (non-adjoining) face? 4

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- (ii) Find the electric field at a distance 'd' from an infinite plane carrying a uniform surface charge density  $\sigma_0$ . 4
- (b) Attempt any one of the following:
- (i) If electric field of intensity 8.5 V/m exists in a linear, homogeneous medium of dielectric constant 5.7, calculate energy density of the field. Given  $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$  4
- (ii) Find the magnitude of magnetic field due to a long straight conductor 2.5m away, when current of 1.5A is flowing through it. Given  $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$  4
- (c) Attempt any one of the following:
- (i) Show that divergence of volume bound current density  $\vec{J}_b$  is zero. 4
- (ii) The magnetic vector potential at a point is given by  $\vec{A} = 3xy\hat{x} + 5xz^2\hat{z}$ . Find the magnetic field. 4
- (d) Attempt any one of the following:
- (i) A plane electromagnetic wave is incident normally from air ( $n_1=1$ ) in to glass ( $n_2=1.5$ ) find the reflection coefficient R and transmission coefficient T. 3
- (ii) Electromagnetic waves in empty space have a maximum electric field  $E= 900 \text{ V/m}$ . What is the maximum value of the corresponding magnetic field? ( $c=3 \times 10^8 \text{ m/s}$ ). 3