Paper / Subject Code: 24253 / Physics: Electrodynamics

TY BSc Sem V Univ exam 23-24

Time: 3 hrs. **Marks:100**

N.B.:

1. **All** questions are **compulsory**.
2. **Figures** to the **right** indicate **full** marks.
3. Draw **neat** diagrams wherever **necessary**.
4. Symbols have usual meaning unless otherwise stated.
5. Use of **non-programmable** calculator is allowed.

Constants: Boltzmann Constant: $k = 1.38 \times 10^{-23}\,J/K$
Planck's Constants: $h = 6.63 \times 10^{-34}\,Js$

Q1. Attempt any **two**

(i) Obtain the expression for the divergence and curl of electrostatic field in free space. **10**

(ii) Find the potential of a uniformly charged spherical shell of radius R for points outside the sphere. **10**

(iii) Derive and explain First and second uniqueness theorem. **10**

(iv) Suppose a point charge q is held a distance d above an infinitely grounded conducting plane. What is the potential in the region above the plane? **10**

Q2 Attempt any **two**

(i) Using Ampere's circuital law for an infinite solenoid carrying current I show that the magnetic field is parallel to the axis of the solenoid. Also obtain an expression for magnetic field inside and outside the solenoid. **10**

(ii) Using Biot-Savart's law, show that $\vec{\nabla} \cdot \vec{B} = 0$. Also explain the physical significance of the result. **10**

(iii) Find an expression for electrostatic energy stored in a linear, homogenous and isotropic dielectric material. **10**

(iv) Obtain an expression for the potential due to polarized object in-terms of surface charge density (σ_b) and volume charge density (ρ_b). **10**

Q3 Attempt any **two**

(i) Why do we need to modify Ampere's circuital law? Derive the expression for Maxwell correction to the Ampere's circuital law. **10**

(ii) For the magnetized object containing magnetic moment **m** show that its vector potential leads to the concept of surface and volume bound currents densities $K_b = M \times \hat{n}$ and $J_b = \nabla \times M$ **10**

(iii) Starting with relation $\nabla \times \boldsymbol{B} = \mu_0(\boldsymbol{J}_b + \boldsymbol{J}_f)$ for Ampère's law, Derive the relation $\nabla \times \boldsymbol{H} = \boldsymbol{J}_f$ (The symbols have their usual meaning). A long copper rod of radius R carries a uniformly distributed (free) current I. Find **H** inside and outside the rod. **10**

(iv) Prove the following relation for energy stored in magnetic field. **10**

$$W = \frac{1}{2\mu_0}\int_{All\,space} B^2 d\tau$$

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Q4 Attempt any **two**

(i) Consider a wave travelling in a medium with refractive index $\boldsymbol{n_1}$. If it is to be incident on the medium with refractive index $\boldsymbol{n_2}$ obliquely. Starting with the boundary conditions, show that the transmission coefficient is given as $T = \alpha\beta\left(\frac{2}{\alpha+\beta}\right)^2$, where symbols have their usual meaning. **10**

(ii) Show that $\frac{dw}{dt} = -\frac{\partial}{\partial t}\int_v (u_e + u_m)\, dv - \oint_s \bar{S}.\hat{n}da$. **10**

(iii) Derive the electromagnetic wave equation in vacuum, where there are no free charges or currents. Also show that the electric field, magnetic field and the direction of propagation are mutually perpendicular. **10**

(iv) Obtain equation of continuity from the principle of conservation of charge. Determine the Poynting vector, if a 6 mW laser illuminates a spot of radius 2 x10^{-10} m. **10**

Q5. Attempt any **four**

(i) Define electric flux. State Gauss law in electrostatics. Write any one merit of Gauss law. **05**

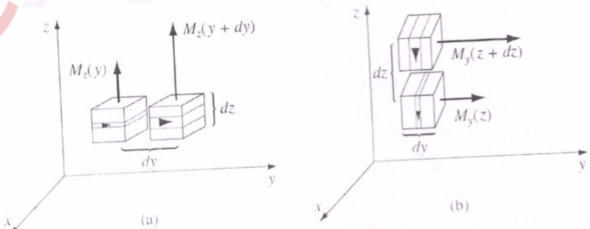
(ii) Determine electric field due to potential V= $2x^2 + 5y^3 + 6z^4$. **05**

(iii) Define energy density for a dielectric system. A uniform electric field 500 V/cm exist in a linear, homogenous and isotropic dielectric of constant 5. Find the energy density stored in the dielectric region. $(\varepsilon_0 = 8.85 \times 10^{-12}\ SI\ units)$ **05**

(iv) A vector field in vacuum is given by; $\vec{B} = 2\,yz\,\hat{x} + 4\,xz\,\hat{y} + 6xy\,\hat{z}$. Show that it could be a magnetostatic field. Find current density in the field at (3, 4, -5) **05**

(v) Choosing the *z* axis along the direction of magnetization **M**, find the magnetic field of a uniformly magnetized sphere. **05**

(vi) Figure (a) and (b) shows two adjacent chunks of magnetized material. Show that the volume bound current density in both case is $\mathbf{J_b} = \nabla \times \mathbf{M}$ **05**



(vii) If $\bar{E} = E_0\, e^{i(kz-wt)}\hat{x}$ and $\bar{B} = B_0\, e^{i(kz-wt)}\hat{y}$. Find the energy per unit time per unit area transported by the fields in free space. **05**

(viii) An electromagnetic wave is incident normally on the surface of water with refractive index 1.33 from air. Calculate the percentage of incident intensity reflected & transmitted from air. **05**

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