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10ES36

Third Semester B.E. Degree Examination, Jan./Feb. 2021
Field Theory

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting atleast TWO questions from each part.***

PART – A

1 a. Derive an expression for force due to 'N' number of charges using principle of superposition. **(06 Marks)**

b. Two particle each of mass 'm' and having a charge 'q' are suspended by a string of length ℓ' from a common point. Show that the angle θ which each string makes with the vertical is obtained from : $\frac{\tan^3\theta}{1+\tan^2\theta} = \frac{\theta^2}{16\pi \in_0 mgl^2}$. **(07 Marks)**

c. Deduce workdone is independent of path selected in any electrostatic field by assuming charge Q = 2C, moved from point B(1, 0, 1) to A(0.8, 0.6, 1) in electric field intensity $E = y\hat{a}_x + x\hat{a}_y + z\hat{a}_z$. **(07 Marks)**

2 a. State and prove Divergence theorem applicable for a differential volume element. **(06 Marks)**

b. Surface charge densities of 200, –50 and P_{sx} $\mu C/m^2$ are located at r = 3, 5 and 7 cm respectively. Find $\overline{E}$ and $\overline{D}$ at

i) r = 2cm ii) r = 4cm iii) r = 6cm iv) find P_{sx} if $\overline{D} = 0$ at r = 7.32cm. **(08 Marks)**

c. Prove the divergence theorem for the region r ≤ a (in spherical co-ordinate system) having the flux density $\overline{D} = \frac{5r}{3}\hat{a}_r$. **(06 Marks)**

3 a. Derive an expression for continuity equation of the current in terms of integral and point form. **(06 Marks)**

b. Obtain suitable expression for tangential electric field is continuous across boundary and $\overline{D}$ is discontinuous across boundary and also deduce normal component of flux density $\overline{D}$ is continuous at the boundary between two dielectric and normal components of electric field inversely proportional to relative permittivity of two media. **(06 Marks)**

c. Use Laplace equation to find the capacitance per unit length of co-axial cable of inner radius 'a' m and outer radius 'b'm. Assume $v = v_0$ at r = a and v = 0 at r =b. **(08 Marks)**

4 a. State and prove Ampere's circuital law. **(06 Marks)**

b. Given field $\overline{A} = \rho^2 \sin^2\phi\hat{a}_\rho + \rho^2\cos^2\phi\hat{a}_\phi + 2z^2\hat{a}_z$ evaluate both sides of Stoke's theorem for the path formed by the intersection of the cylinder ρ = 2 and plane z = 1 and for the surface $\rho = 2, 1 \le z \le 3$ and $z = 3, 0 \le \rho \le 2$ **(07 Marks)**

c. Find $\overline{H}$ and $\overline{B}$ inside a long straight non magnetic conductor of radius 8mm carrying a uniform current density of 100KA/m^2.

i) Show that $\overline{\nabla} \times \overline{H} = \overline{J}$. Find the total magnate flux crossing the surface

ii) $z = 0$ for $0.2 < \rho < 8mm$ $\pi < \phi < 2\pi$

iii) $\phi = 0$, $0 < \rho < 8mm$, $0 < z < 10mm$. **(07 Marks)**

PART – B

5 a. Obtain an expression for torque on a current loop placed in magnetic field. **(06 Marks)**

b. A point charge of Q = –1.2c has velocity $\bar{v} = (5\bar{a}_x + 2\bar{a}_y - 3\bar{a}_z)$ M/S find the magnitude of force excreted on charge if,

i) $\bar{E} = -18\bar{a}_x + 5\bar{a}_y - 10\bar{a}_z$ V/M

ii) $\bar{B} = -4\bar{a}_x + 4\bar{a}_y + 3\bar{a}_z$ T

iii) Both are present simultaneously. **(06 Marks)**

c. Region 1 has semi–infinite space in which 2x – 5y > 0, while region 2 is defined by 2x – 5y < 0. Let $\mu_{r1} = 3$, $\mu_{r2} = 4$ and $\bar{H}_1 = 30\bar{a}_x$ A/M.

Find : i) $|\bar{B}_1|$ ii) $|\bar{B}_{N1}|$ iii) $|\bar{H}_{tan1}|$ iv) $|\bar{H}_2|$. **(08 Marks)**

6 a. Explain physical significance of displacement current applied to magnetostate. **(05 Marks)**

b. Given the retarded potentials : $v = -y(x + at)v$ and $\bar{A} = y\left(\frac{x}{a} + t\right)\bar{a}_x$ Wb/m where $a = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$. i) Show that $\nabla \cdot \bar{A} = -\mu \epsilon \frac{\partial v}{\partial t}$ ii) Find $\bar{B}$, $\bar{H}$, $\bar{E}$ and $\bar{D}$. **(08 Marks)**

c. A circular loop conductor lies in plane z = 0 and has radius of 0.1m and resistance of 5Ω. Given $\bar{B} = 0.2\sin 10^3 t\,\bar{a}_z$ T. Determine the current in the loop. **(07 Marks)**

7 a. Derive the point and integral form of the Poynting theorem starting from Maxwell's equation. **(06 Marks)**

b. The electric field of uniform plane wave propagating in a sea water (σ = 4S/m, $\epsilon = 80\epsilon_0$ and $\mu = \mu_0$) in positive z direction is given by $\bar{E} = \cos(5\times10^4 \pi t)\bar{a}_\pi$ V/M at z = 0 calculate :

i) The instantaneous power flow per unit area normal to the z – direction as a function of z

ii) Time average power flow per unit area normal to the z –direction as a function of z. **(08 Marks)**

c. Obtain an expression for uniform plane wave in practical discretric. **(06 Marks)**

8 a. Explain reflection of uniform plane waves with normal incidence at a plane of dielectric boundary and also obtain an expression for transmission and reflection coefficient. **(08 Marks)**

b. An airplane flies over the surface of ocean for which σ = 4S/M, ϵ_r = 81 and μ_r = 1. The airplane transmits the signal in the form of 1MHz plane wave having an electric filed intensity of 1000V/M and propagating vertically downward. If a submarine requires a minimum signal of 10 μv/m for adequate reception. Determine maximum communication depth of submarine?

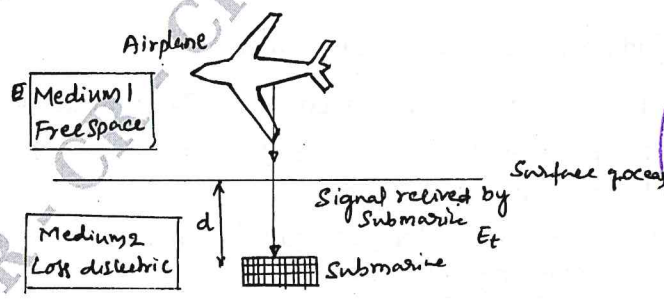

Fig.Q8(b) **(08 Marks)**

c. Write a short notes as wave propagation in dispersive media. **(04 Marks)**

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