B.E. Electrical (Electronics & Power) Engineering (Model Curriculum) Semester - III

005 - Electromagnetic Fields

P. Pages : 3 **GUG/S/23/13851**

Time : Three Hours Max. Marks : 80

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Notes :
1. All questions carry equal marks.
2. Due credit will be given to neatness and adequate dimensions.
3. Assume suitable data wherever necessary.
4. Illustrate your answers wherever necessary with the help of neat sketches.
5. Use of slide rule, Logarithmic tables, Steam tables, Mollier's chart, Drawing instruments, Thermodynamic tables for moist air, Psychrometric charts and Refrigeration charts is permitted.
6. Use of non programmable calculator is permitted.
7. Answer **any five** questions as per internal given choice.

1. a) The surfaces $\rho = 3$, $\rho = 5$, $\phi = 100^\circ$, $\phi = 130^\circ$, $z = 3$, and $z = 4.5$ define a closed surface. Find (a) the enclosed volume; (b) the total area of the enclosing surface; (c) the total length of the twelve edges of the surfaces; (d) the length of the longest straight line that lies entirely within the volume. **8**

b) Express the unit vector a_x in spherical components at the point: (a) r = 2, $\theta = 1\text{rad}$, $\phi = 0.8$ rad; (b) x = 3, y = 2, z = -1; (c) $\rho = 2.5, \phi = 0.7$ rad, $z = 1.5$. **8**

OR

2. a) Point $A(-4, 2, 5)$ and the two vectors, $R_{AM} = (20, 18 - 10)$ and $R_{AN} = (-10, 8, 15)$, define a triangle. Find (a) a unit vector perpendicular to the triangle; (b) a unit vector in the plane of the triangle and perpendicular to R_{AN}; (c) a unit vector in the plane of the triangle that bisects the interior angle at A. **8**

b) Given point $P(r = 0.8, \theta = 30^\circ, \phi = 45^\circ)$ and $E = 1/r^2[\cos\phi\, a_r + (\sin\phi / \sin\theta)\, a_\phi]$, find (a) E at P; (b) |E| at P; (c) a unit vector in the direction of E at P. **8**

3. a) A charge of -1nC is located at the origin in free space. What charge must be located at $(2, 0, 0)$ to cause E_x to be zero at (3, 1, 1)? **8**

b) Given the surface charge density, $\rho_s = 2\mu C / m^2$, existing in the region $\rho < 0.2\text{m}$, $z = 0$, find E at (a) $P_A(\rho = 0, z = 0.5)$; (b) $P_B(\rho = 0, z = -0.5)$. Show that (c) the field along the z axis reduces to that of an infinite sheet charge at small values of z; (d) the z axis field reduces to that of a point charge at large values of z. **8**

OR

4. a) Calculate $\nabla \cdot D$ at the point specified if **8**

(a) $D = (1/z^2)\,[10xyz\, a_x + 5x^2 z\, a_y + (2z^3 - 5x^2 y)\, a_z]$ at $P(-2, 3, 5)$;

(b) $D = 5z^2\, a_\rho + 10\rho z\, a_z$ at $P(3, -45^\circ, 5)$;

(c) $D = 2r\sin\theta\sin\phi\, a_r + r\cos\theta\sin\phi\, a_\theta + r\cos\phi\, a_\phi$ at $P(3, 45^\circ, -45^\circ)$.

b) Given the flux density $D = \frac{16}{r}\cos(2\theta)a_\theta \, C/m^2$, use two different methods to find the total charge within the region $1 < r < 2m, 1 < \theta < 2\,\text{rad}$, $1 < \phi < 2\,\text{rad}$. **8**

5. a) An electric field in free space is given by $E = xa_x + ya_y + za_z \, V/m$. Find the work done in moving a $1-\mu C$ charge through this field (a) from (1, 1, 1) to (0, 0, 0); (b) from $(\rho = 2,\ \phi = 0)$ to $(\rho = 2,\ \phi = 90^\circ)$; (c) from $(r = 10,\ \theta = \theta_0)$ to $(r = 10,\ \theta = \theta_0 + 180^\circ)$. **8**

b) In spherical coordinates $E = 2r/(r^2 + a^2)^2 a_r \, V/m$. Find the potential at any point, using the reference (a) V = 0 at infinity; (b) V = 0 at r = 0; (c) V = 100 V at r = a. **8**

OR

6. a) Let $V = 2xy^2z^3 + 3\ln(x^2 + 2y^2 + 3z^2)$ V in free space. Evaluate each of the following quantities at $P(3, 2, -1)$ (a) V; (b) $|V|$; (c) E; (d) $|E|$; (e) a_N; (f) D. **8**

b) Two point charges, $1\,nC$ at (0, 0, 0, 1) and $-1\,nC$ at (0, 0, -0.1), are in free space. (a) Calculate V at P(0.3, 0, 0.4). (b) Calculate $|E|$ at P. (c) Now treat the two charges as a dipole at the origin and find V at P. **8**

7. a) Given the potential field $V = (A\rho^4 + B\rho^{-4})\sin 4\phi$: (a) Show that $\nabla^2 V = 0$. (b) Select A and B so that V = 100V and $|E|$ = 500V/m at $P(\rho = 1, \phi = 22.5^\circ . z = 2)$. **8**

b) An air-filled parallel-plate capacitor with plate separation d and plate area A is connected to a battery that applies a voltage V_0 between plates. With the battery left connected, the plates are moved apart to a distance of 10d. Determine by what factor each of the following quantities changes: (a) V_0; (b) C; (c) E; (d) D; (e) Q; (f) ρ_s; (g) W_E. **8**

OR

8. a) Let $J = 400\sin\theta/(r^2 + 4)a_r A/m^2$. (a) Find the total current flowing through that portion of the spherical surface r = 0.8, bounded by $0.1\pi < \theta < 0.3\pi, 0 < \phi < 2\pi$. (b) Find the average value of J over the defined area. **8**

b) Given the potential, **8**

$$V = 100(x^2 - y^2)$$

and a point $P(2, -1, 3)$ that is stipulated to lie on a conductor-to-free-space boundary, find V, E, D, and ρ_s at P, and also the equation of the conductor surface.

9. a) Find H in rectangular components at P(2, 3, 4) if there is a current filament on the z axis carrying 8 mA in the a_z direction. (b) Repeat if the filament is located at $x = -1, y = 2$. (c) Find H if both filaments are present. **8**

b) A rectangular loop of wire in free space joins point A(1, 0, 1) to point B(3, 0, 1) to point C(3,0, 4) to point D(1, 0, 4) to point A. The wire carries a current of 6 mA, flowing in the a_z direction from B to C. A filamentary current of 15A flows along the entire z axis in the a_z direction. (a) Find F on side BC. (b) Find F on side AB. (c) Find F_{total} on the loop. **8**

OR

10. a) Write the Maxwell's equation in point form and in integral form for time varying magnetic and electric fields. **8**

b) A 9375 MHz uniform plane wave is propagating in polystyrene. If the amplitude of the electric field intensity is 20 V/m and the material is assumed to be lossless, find: **8**

i) Phase constant.

ii) Wavelength

iii) Velocity of propagation

iv) Intrinsic impedance

v) Propagation constant.

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