MSMF GATE CENTRE

SUBJECT: EMT

Basics of EM fields
(Electro Statics and Steady Magnetics)

Time: 30 min **Marks= 15**

---

01. A point charge 'Q' in located at the origin in free space, produces a field = $\overline{E} = 20\,\hat{a}_r\ V/m$ for r = 1m, then Q is

(a) 3. 33 468 n.c (b) 2.22312 nc
(c) 1.11156 nc (d) 0.55578 nc

Where 'r' is spherical coordinate and $\hat{a}_r$ is the unit vector in the radial direction.

02. A point charge 'Q' lies at the origin. Following is true

(a) $\nabla.\overline{D} = 0$ every where (b) $\nabla.\overline{D} = 0$ every where except at the origin
(c) $\nabla \times \overline{D} = 0$ every where (d) $\nabla \times \overline{D} = 0$ every where except at the origin.

03. The potential of an electric dipole at a large but finite distance 'r' from the mid-point of a dipole.

(a) is inversely professional to r^3 (b) is inversely professional to r
(c) is inversely professional to r^2 (d) independent of r

04. A filamentary current 10 A is directed in from infinity to the origin on the +ve X–axies. Find the magnetic field intensity on Z-axis at z = 1 m

(a) $\frac{10}{4\pi}\hat{a}_y$ (b) $\frac{10}{4\pi}\hat{a}_z$ (c) $\frac{10}{4\pi}\hat{a}_x$ (d) $\frac{10}{4\pi}\left(\hat{a}_y + \hat{a}_z\right)$

05. Identify the current statement

(a) Electric field in the –ve gradient of scalar electric potential function
(b) Electric field projects normal to an equipotential surface and project from a higher potential surface to towards lower potential surface
(c) Both (a) and (b)
(d) None.

06. A line charge with charge density of 50 nC/ m is located at x = 2m, y =5m. If a surface x = 4m contains a uniform surface charge density of 18 nC/ m^2, at what point in the z = 0 plane, the total electric field is zero.

(a) (1.44, 2.5, 0)m (b) (1.44, 5, 0)m (c) (2.88, 2.5, 0)m (d) (2.88, 5, 0)m

07. A non-uniform surface charge density of $\frac{5\rho}{\rho^2+1} nc/m^2$ lines in the plane z = 2m wherever ρ < 5m ; $\rho_s = 0$ for ρ > 5m. How much electric flux leaves the circular region ρ < 5 m z = 2.

(a) 113.9 nC (b) 226.9 nC (c) 139.9 nC (d) 339.9 nC

08. The region z<0 contains a perfect dielectric for which $\in_{r1} = 2.5$, while the region z>0 is characterized by $\in_{r2} = 4.0$ Let

$\overline{E}_1 = -30\hat{a}_x + 50\hat{a}_y + 70\hat{a}_Z$ V / m Find $\overline{D}_2$

(a) $-1.062\ \hat{a}_x + 1.77\hat{a}_y + 1.54\ \hat{a}_z$ nc / m

(b) $1.06\ \hat{a}_x - 1.77\ \hat{a}_y + 1.54\ \hat{a}_z +$ nc / m^2

(c) $-1.06\ \hat{a}_x + 1.77\ \hat{a}_y + 1.54\ \hat{a}_z$ nc / m^2

(d) $1.06\ \hat{a}_x + 1.77\ \hat{a}_y + 1.54\ \hat{a}_z$ nc / m^2.

09. Let $\overline{D} = \left(6xyz^2\ \hat{a}_x + 3x^2z^2\ \hat{a}_y + 6x^2y\hat{a}_z\right)$C/m^2 Find the total charge lying with in the region bounded by x =1 and 3, y = 0 and 1 and z = -1 and 1

(a) 32.5C (b) 28C (c) 65C (d) 56C

10. Let $\overline{D} = x\hat{a}_x$ C/m^2. Find the value of $\oint \overline{D}.\overline{ds}$ over the surface of the sphere of r = 1m.

(a) 4.19C (b) 8.38 C (c) 12.57C (d) 16.76C

11. If E = $-8xy\hat{a}_x - 4x^2\hat{a}_y + \hat{a}_z$ V/m. Find the work done in carrying a 6C charge from M(1, 8, 5) to N(2, 18, 6)m along the path y = 3x^2 + z, z = x + 4.

(a) 3058J (b) 1550J (c) 152J (d) 3100J

12. A current sheet $6.5\hat{a}_z$ A/m, at x = 0 separate region 1, x < 0, where $\overline{H_1} = 10\hat{a}_y$ A/m and region 2, x > 0. Find $\overline{H_2}$ at x < 0+

(a) $16.5\hat{a}_y$ A/m (b) $3.5\hat{a}_z$ A/m (c) $16.5\hat{a}_z$ A/m (d) $3.5\hat{a}_z$ A/m

13. In cylindrical co-ordinate, $\overline{B_1} = \frac{2.0}{\rho}\hat{a}_\phi$ Tesla. Determine the magnetic flux crossing the surface defined by 0.5 < ρ < 2.5, 0 ≤ z ≤2m, ϕ = Constant.

(a) 3.22Wb (b) 6.44Wb (c) 9.66Wb (d) 12.88Wb.

14. Within the region 1 < ρ < 5m, 0 ≤ ϕ ≤ 0.3π, 0 ≤ z ≤ 2 cm, current density is given as

$\overline{J} = \dfrac{200}{\rho + 0.01}\cos\phi \; \hat{a}_\phi$ A/m^2. What total current in the $\hat{a}_\phi$ direction crosses the surface $\phi = 0$, $1 < \rho < 5$m, $0 \le z \le 2$ cm.
(ρ, ϕ, z are cylindrical coordinates) .

(a) 4.39A (b) 8.39A (c) 12.39A (d) 16.39A

15. Let $\overline{H} = - y(x^2 + y^2)\, \hat{a}_x + x(x^2 + y^2)\, \hat{a}_y$ A/m in z = 0 plane for $-5 \le x, y \le 5$m. Find the total current passing through z = 0 plane in the $\hat{a}_z$ direction inside the rectangle $-1 \le x \le 1$, $-1 \le y \le 2$m.
(a) 5.333A (b) 53.33A (c) 533.3A (d) 5333A.

**** THE END ****

MSMF GATE CENTRE

SUBJECT: EMT

Basics of EM fields
(Electro Statics and Steady Magnetics)

SOLUTIONS

01. Ans: (b)

Hint: $\bar{E} = \dfrac{Q}{4\pi\varepsilon_0 r^2}\hat{a}_r$ $\qquad |\bar{E}| = 20$

$r = 1, \qquad \varepsilon_0 = \dfrac{10^{-9}}{36\pi} F/m,$

Q = (20) 4π $(10^{-9}/36\pi)(1)^2$

= 2.22212 nc.

02. Ans: (b)

Hint: $\bar{D} = \dfrac{Q}{4\pi r^2}\hat{a}_r = D_r\,\hat{a}_r$; $\qquad \nabla.\bar{D} = \dfrac{1}{r^2}\dfrac{\partial}{\partial r}\left(r^2 D_r\right) + ... = 0.$

03. Ans: (c)

Hint: $V = \dfrac{Qd\ \cos\theta}{4\pi\varepsilon_0 r^2}$

(Where 'd' is the distance between dipole)

04. Ans: (a)
Hint: Use Biot-Savart's law

05. Ans: (c)

Hint: $\bar{E} = -\nabla V$

$dV = \bar{E}.\bar{dl}$

06. Ans: (d)

Hint: Calculate $\bar{E}$ due to line charge and surface charge at some point in z = 0 plane add them algebraically to zero, them find the coordinates

07. Ans: (a)
Hint: Calculate the total charge for ρ < 5m.

$$Q = \iint \frac{5\rho}{\rho^2 + 1}\rho d\rho d\phi$$

08. Ans : (a)

Hint: Use $E_{t_1} = E_{t_2}, D_{n_1} = D_{n_2}$ (*Boundary Conditions*)

$\hat{a}_z$ is the normal unit vector, $\hat{a}_x$ and $\hat{a}_y$ are Tangential to the interface

09. Ans : (d)

Hint: Use $\nabla.\bar{D}$ to calculate ρ_v then find 'Q' by integrating ρ_v over the given limits.

10. Ans : (a)

Hint: Calculate $\nabla.\bar{D}$ to find ρ_v then integrate ρ_v over the sphere by considering the limits

$0 \le r \le 1$, $0 \le \phi \le 2\pi$, $0 \le \theta \le \pi$.

11. Ans: (c)

Hint: $\bar{dl} = dx\,\hat{a}_x + dy\,\hat{a}_y + dz\,\hat{a}_z$ Calculate $-Q\int \bar{E}.\bar{dl}$

12. Ans : (a)

Hint: $\left(\bar{H}_1 - \bar{H}_2\right) \times \hat{a}_{n12} = \bar{J}_s$

$\bar{J}_s$ is the current sheet and $\hat{a}_{n12} = \hat{a}_x$

13 Ans : (b)

Hint: $\bar{ds} = d\rho\, dz\, \hat{a}_\phi$

Use $\phi = \int_s \bar{B}.\bar{ds}$, to calculate the flux.

14. Ans : (a)

Hint: $\bar{ds} = d\rho\, dz\, \hat{a}_\phi$

Calculate $I = \int_s \bar{J}.\bar{ds}$

15. Ans: (b)

Hint: Compute $\nabla \times \bar{H}$,

$I = \int_s \left(\nabla \times \bar{H}\right).\bar{ds}$, $\quad \bar{ds} = dx\, dy\, \hat{a}_z$