23ECT205 Electromagnetic Fields and Waves

Question Bank

UNIT I STATIC ELECTRIC FIELD

TWO MARK QUESTIONS & ANSWERS

1. State Stokes's theorem.

Stokes's theorem states that the circulation of a vector field $\vec{A}$ around a closed path is equal to the surface integral of curl of $\vec{A}$ over the open surface S bounded by the path L.

$$\oint \vec{A} \cdot \vec{dl} = \int (\vec{\nabla} \times \vec{A}) \cdot \vec{dS}$$

2. State Coulomb's law.

Coulombs law states that the force between any two point charges is directly proportional to the product of their magnitudes and inversely proportional to the square of the distance between them. It is directed along the line joining the two charges.

$$F = Q1Q2 / 4\pi\varepsilon r^2$$

3. State Gauss law for electric fields.

The total electric flux Ψ passing through any closed surface is equal to the total charge enclosed by that surface.

$$\Psi = Q_{enc}$$

$$\oint \vec{D}.\vec{dS} = \int \rho_v dv \quad \text{(Integral form)}$$

$$\vec{\nabla} \cdot \vec{D} = \rho_v \quad \text{(Point form)}$$

4. State Divergence Theorem.

The divergence theorem states that the total outward flux of a vector field $\vec{A}$ through the closed surface S is the same as the volume integral of the divergence of $\vec{A}$.

$$\oint \vec{A} \cdot \vec{dS} = \int \vec{\nabla} \cdot \vec{A}\, dv$$

5. Define electric field intensity.

Electric field intensity is defined as the electric force per unit positive charge. Its unit is V/m.

$$\vec{E} = \vec{F} / Q$$

$$\vec{E} = (Q/4\pi\varepsilon r^2)\, \hat{ar}$$

6. Define electric potential.

Potential at any point is defined as the work done in moving a unit positive charge from infinity to that point in an electric field.

Its unit is Volts.

$$V = \frac{Q}{4\pi\varepsilon r}$$

7. Define Gradient

The gradient of a scalar field V is a vector that represents both the magnitude and the direction of the maximum space rate of increase of V.

$$\textbf{Gradient of } V = \nabla V = \frac{\partial V}{\partial x}\widehat{a_x} + \frac{\partial V}{\partial y}\widehat{a_y} + \frac{\partial V}{\partial z}\widehat{a_z}$$

8. Write the relationship between electric field (E) and potential (V)

The relation between Electric field intensity and potential is given by

$$\vec{E} = -\vec{\nabla}V$$

Where $\vec{E}$ – Electric field intensity, V – Potential.

9. Define line, surface and volume charge densities.

Line charge density : It is the charge per unit length at a point on the line charge.

$$\rho_l = \frac{dQ}{dl}$$

Surface charge density: It is the charge per surface area at a point on the surface charge

$$\rho_s = \frac{dQ}{dS}$$

Volume charge density: It is the charge per volume at a point on the volume of the charge

$$\rho_v = \frac{dQ}{dv}$$

10. Define electric flux and electric flux density.

The total number of lines of electric force in an electric field is called as electric flux. Its unit is Coulombs(C).

Electric flux density is defined as electric flux per unit area. Its unit is C/m^2

$$\vec{D} = Q/4\pi r^2\ \widehat{a_r}$$

11. Name few applications of Gauss law in electrostatics.

- Gauss law is applied to find the electric field intensity due to symmetric charge distributions such as line charge, sheet of charge.
- Electric Field can be determined for shell, two concentric shell or cylinders etc.

12. Define potential difference.

Potential difference is defined as the work done in moving a unit positive charge from one point to another point in an electric field. Its unit is Volts.

Potential difference $V = -\int_B^A \vec{E} \cdot \vec{dl}$

13. What is the physical significance of div D?

The divergence of a vector field A at a given point is a measure of how much the field diverges or emanates from that point. It also gives the limit of field's source strength per unit volume/source density.

14. State the principles of superposition of force.

The principle of superposition states that if there are N charges Q_1, Q_2,…Q_n at points with position vectors r_1,r_2,…r_N, the resultant force F on a charge located at point r is the vector sum of the forces exerted on Q by each of the charges.

15. What is the relation between D and E in free space?

The relation between D and E is given by

$$\vec{D} = \varepsilon_o \vec{E} \ \text{C/m}^2$$

$\vec{D}$ - Electric flux density

$\vec{E}$ - Electric fnsity

ε_o - permittivity of free space

16. Explain the conservative property of electric field.

The work done in moving a point charge around a closed path in a electric field is zero. Such a field is said to be conservative.

$$\oint \vec{E} \cdot \vec{dl} = 0$$

17. Define electric dipole and dipole moment. (May/June 2016)

The two point charges of equal magnitude and opposite sign, separated by a very small distance is called as electric dipole.

The product of electric charge and distance is known as dipole moment. It is donated by m.

$$m = Qd$$

where Q is the charge and d is the distance between point charges.

18. Define divergence.

The divergence of $\vec{A}$ at a given point P is the outward flux per unit volume as the volume shrinks about P.

Divergence of $\vec{A}$ is given by,

$$\vec{\nabla} \cdot \vec{A} = \lim_{\Delta v \to 0} \frac{\oint \vec{A} \cdot \vec{dS}}{\Delta v}$$

Divergence of a vector field is a scalar.

19. Define curl

The curl of $\vec{A}$ is an axial or rotational vector whose magnitude is the maximum circulation of $\vec{A}$ per unit area as the area tends to zero and whose direction is the normal direction of the area.

Curl of $\vec{A}$ is given by,

$$\vec{\nabla} \times \vec{A} = \left(\lim_{\Delta v \to 0} \frac{\oint \vec{A} \cdot \vec{dl}}{\Delta S} \right)_{max} \hat{a}_n$$

20. Define Scalar quantity.

A scalar is a quantity which is characterized by its magnitude. The direction is not required to describe the scalar. The examples of scalar are temperature, mass, volumes, speed, charge etc.

21. Define vector quantity.

A vector is a quantity which is characterized by both magnitude and direction. The examples of vector are forces, velocity, electric field intensity, acceleration etc.

22. Name three co-ordinate systems used in electromagnetic engineering.

1. Cartesian co-ordinate system
2. Cylindrical co-ordinate system
3. Spherical co-ordinate system

23. How to represent a point and vector in Cartesian systems?

A point in Cartesian system is represented by three co-ordinates namely x co-ordinate in x direction, y co-ordinate in y-direction and z co-ordinate in z-direction.

Co-ordinates (x, y, z)

Vector $\vec{A} = A_x\hat{a}_x + A_y\hat{a}_y + A_z\hat{a}_z$

24. What is electrostatic force?

The force between any two particles due to existing charges is known as electrostatic force, repulsive for like and attractive for unlike.

25. What is meant by equipotential surface?

It is an imaginary surface in an electric field of a given charge distribution in which all the points on the surface area at the same electric potential.

26. What is energy density?

Electrostatic energy density is the energy stored per unit volume as volume tends to zero. Its unit is J/m^3. It is given by w_E as

$$w_E = \frac{1}{2}\vec{D} \cdot \vec{E} = \frac{1}{2}\varepsilon_o E^2 = \frac{1}{2\varepsilon_o} D^2$$

27. Write the equation for energy stored in electrostatic field in terms of field quantities. (Apr/May 2017)

$$W_E = \frac{1}{2}\int D \cdot E \, dv = \frac{1}{2}\int \varepsilon_o E^2 \quad \text{Joules}$$

D – Electric flux density

E – Electric field intensity

PART B QUESTIONS

1. Derive divergence theorem and stokes theorem.
2. Find the electric field intensity of a straight uniformly charged wire of length 'L'm and having a linear charge density of +ρ C/m at any point at a distance of 'h' m.
3. State and Prove Gauss's law. And explain applications of Gauss's law. 4.Verify stokes theorem for a vector field $F = r^2 \cos\varphi \, a_r + z \sin\varphi \, a_z$ around a closed path L defined by 0 ≤ r ≤3 , 0 ≤ φ ≤ 45º and z=0.
5. If V=$\left[2x^2y + 20z - \frac{4}{x^2+y^2}\right]$ volts, find E and D at P (6,-2.5, 3).
6. Explain briefly about gradient, divergence and curl.
7. Explain coulomb's Law. Three equal positive charges of 4* 10^{-9} coulomb each are located at three corners of a square, side 20cm. determine the electric field intensity at the vacant corner point of the square.
8. Derive the expression for potential due to an electric dipole at any point P. Also find electric field intensity at the same point.
9. Two point charges 1.5 nC at (0, 0, 0.1) and -1.5 nC at (0, 0,-0.1) are in free space. Treat the two charges as a dipole at the origin and find potential at P (0.3, 0, and 0.4).
10. Derive an expression for electric field intensity due to an infinite uniformly charged sheet.
11. i. Define electric potential. Derive an expression for potential due to point charge.
    ii. Derive the relation between potential and electric field intensity.
12. Explain applications of Gauss law.
13. Derive an expression for Electric field on the axis of a uniformly charged circular disc.
14. Define potential difference and electric field. Give the relation between potential and electric field intensity. Also derive an expression for potential due to infinite uniformly charged line and potential due to electric dipole**.**
15. Given two vectors A=3ax+4ay+-5az and B=-6ax+2ay+45az , determine the unit vector normal to the plane containing two vectors A and B.
16. i. Using gauss law find the electric filed intensity for the uniformly charged sphere of radius 'a' find the E everywhere.
    ii. Derive the equation for the scalar electric potential