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AN AUTONOMOUS INSTITUTION
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECT202 - ELECTROMAGNETIC FIELDS AND WAVES

CLASS/SEM: II ECE/IV SEM

UNIT I - REVIEW OF STATIC ELECTRIC FIELD

Part A - Two Marks

1. Define scalar field?

A field is a system in which a particular physical function has a value at each and every point in that region. The distribution of a scalar quantity with a defined position in a space is called scalar field.

Ex: Temperature of atmosphere.

2. Define Vector field?

If a quantity which is specified in a region to define a field is a vector then the corresponding field is called vector field.

3. Define scaling of a vector?

This is nothing but, multiplication of a scalar with a vector. Such a multiplication changes the magnitude of a vector but not the direction.

4. What are co-planar vector?

The vectors which lie in the same plane are called co-planar vectors.

5. Define base vectors?

The base vectors are the unit vectors which are strictly oriented along the directions of the coordinate axes of the given coordinate system.

6. What is a position vector?

Consider a point $p(x, y, z)$ are Cartesian coordinate system. Then the position vector of point p is represented by the distance of point p from the origin directed from origin to point. This is also called as radius vector.

7. Define Divergence.

Divergence is defined as the net outward flow of the flux per unit volume over a closed incremental surface.

8. State Divergence Theorem.

The integral of the normal component of any vector field over a closed surface is equal to the integral of the divergence of this vector field throughout the volume enclosed that closed surface.

9. What is physical significance of curl of a vector field?

Curl gives rate of rotation. Curl F gives work done per unit area.

10. What is physical significance of divergence?

Divergence of current density gives net outflow of current per unit volume. Divergence of flux density gives net outflow per unit volume. In general, divergence of any field density gives net outflow of that field per unit volume.

11. State the conditions for a field to be a) solenoidal b) irrotational.

a) Divergence of the field has to be zero.

b) Curl of the field has to be zero.

12. Define scalar and vector quantity?

The scalar is a quantity whose value may be represented by a single real number which may be positive or negative. e.g, temperature, mass, volume, density .A quantity which has both a magnitude and a specified direction in space is called a vector.

e.g. force, velocity, displacement, acceleration.

13. What is a unit vector? What is its function while representing a vector?

A unit vector has a function to indicate the direction. Its magnitude is always unity, irrespective of the direction which it indicates and the coordinate system under consideration.

14. Name 3 coordinate systems used in electromagnetic engineering?

1) Cartesian or rectangular coordinate system.

2) Cylindrical coordinate system.

3) Spherical coordinate system.

15. How to represent a point in a Cartesian system?

A point in rectangular coordinate system is located by three coordinates namely x, y and z coordinates. The point can be reached by moving from origin, the distance x in x direction then the distance y in y direction and finally z in z direction.

16. What is separation of vector?

The distance vector is also called as separation vector. Distance vector is nothing but the length of the vector.

18. Show how a point p represented in a spherical coordinate system.

The point p can be defined as the intersection of three surfaces in spherical coordinate system.

r - Constant which is a sphere with centre as origin

θ – Constant which is a right circular cone with apex as origin and axis as z axis.

Φ – Constant is a plane perpendicular to xy plane.

19. State the relationship between Cartesian and spherical system?

$x = r \sin\theta \cos\Phi$

$y = r \sin\theta \sin\Phi$

$z = r \cos\theta$

Now r can be expressed as

$x^2 + y^2 + z^2 = r^2 \sin^2\theta \cos^2\Phi + r^2 \sin^2\theta \sin^2\Phi + r^2$

$\cos^2\theta = r^2 \sin^2\theta [\sin^2\Phi + \cos^2\Phi] + r^2 \cos^2\theta$

$= r^2 [\sin^2\theta + \cos^2\theta] = r^2$

20. What are the types of integral related to electromagnetic theory?

1. Line integral
2. Surface integral
3. Volume integral

21. Define point charge.

A point charge means that electric charge which is separated on a surface or space whose geometrical dimensions are very small compared to other dimensions, in which the effect of electric field to be studied.

22. Define one coulomb.

One coulomb of charge is defined as the charge possessed by $(1/1.602 \times 10^{-9})$ i.e 6×10^{18} number of electrons.

23.What are the various types of charge distribution? Give an example for each.

1. Point charge - Ex. Positive charge

2. Line charge - Ex. A sharp beam in a cathode ray tube.

3. Surface charge - Ex. The plate of a charged parallel plate capacitor.

4. Volume charge - Ex. The charged cloud.

24.State the assumptions made while defining a Coulomb's law.

1) The two charges are stationary.

2) The two charges are point charge.

25.. What is an electric flux?

The total number of lines of force in any particular electric field is called electric flux. It is represented by the symbol ψ. Similar to the charge, unit of electric flux is also Coulomb.

26. Define electric flux density.

The net flux passing normal through the unit surface area is called electric flux density. It is denoted as D. It has a specified direction which is normal to the surface area under consideration hence it is a vector field.

27. Check whether the vectors $\bar{A} = 6\bar{a}_x - 4\bar{a}_y + \bar{a}_z$ and $\bar{B} = -6\bar{a}_x + 3\bar{a}_y - 3\bar{a}_z$ are parallel or perpendicular to each other.

$\mathbf{A} = 6\hat{a}_x - 4\hat{a}_y + \hat{a}_z$

$\mathbf{B} = -6\hat{a}_x + 3\hat{a}_y - 3\hat{a}_z$

Two vectors are perpendicular if their **dot product** is zero:

$$\mathbf{A} \cdot \mathbf{B} = A_x B_x + A_y B_y + A_z B_z$$

Substituting values:

$$\begin{aligned}(6)(-6) + (-4)(3) + (1)(-3) \\ = -36 - 12 - 3 \\ = -51 \neq 0\end{aligned}$$

Since the dot product is **not zero**, the vectors are **not perpendicular**.

Two vectors are parallel if one is a scalar multiple of the other, i.e.,

$$\mathbf{B} = k\mathbf{A}$$

for some scalar k. Checking component-wise:

$$\begin{aligned}-6 = k(6) \quad &\Rightarrow \quad k = -1 \\ 3 = k(-4) \quad &\Rightarrow \quad k = -\frac{3}{4} \\ -3 = k(1) \quad &\Rightarrow \quad k = -3\end{aligned}$$

Since we get different values of k, the vectors are **not parallel**.

The vectors $\mathbf{A}$ and $\mathbf{B}$ are **neither parallel nor perpendicular**.

Part B - Sixteen Marks

1. Derive an expression for the electric field due to a straight and infinite uniformly charged wire of length 'L' meters and with a charge density of +λ c/m at a Point P which lies along the perpendicular bisector of wire.

2. A circular disc of radius 'a' m is charged uniformly with a charge density of σ c/ m^2.find the electric field at a point 'h' m from the disc along its axis.

3. Two point charges – 4 μC and 5 μC are located at (2 , -1 , 3) and (0 , 4 , -2) respectively. Find the potential at (1 , 0 , 1) assuming zero potential at infinity.

4. Calculate the potential at a point P(0,0) m due to point charge Q1 and Q2. Q1 = 10^{-12} Coulomb is located at (0.5,0) m and Q2 = - 10^{-11} Coulomb is located at ((- 0.5,0)m.

5. Derive the expressions for the electric field intensity at a point P which is situated „h" metre away from the disc along its axis. The disc is charged uniformly with a charge density of ρs C/m^2

6. A charge Q1 = 100 nC is located in vacuum at P1 (−0.03, 0.01, 0.04) m. Find the force on Q1 due to (i) Q2 = 120 μC at P2 (0.03, 0.08, −0.02) m; (ii) Q3 = 120 μC at P3 (−0.09, −0.06, 0.01) m.

7. If two charges of 50μC and 10μC are located at (−1, 1, 3) and (3, 1, 0) respectively. Determine the nature of force and its magnitude and direction, existing between the two point charges.

8. Determine the electric field intensity at P(−0.2, 0, −2.3) due to a point charge of 5 nC at Q(0.2, 0.1, −2.5) in air. All dimensions are in meters.