

Q → [1] Explain the colombs Law? Also
Part 2 state it with the help of
expression?

Ans:- Colomb's Law:- State that
An isolated q induces an electric
field E at every point in space
and at any specific point P , E
is given by $E = \frac{1}{4\pi\epsilon R^2} \frac{q}{R^2} \text{ V/m}$

In the presence of electric feild
 E , at the given point in space which
may due to a single charge or a
distribution of many charges

$$F = q = E \text{ (N)}$$

With F measured in newtons (N)
and q in coulombs (C) the unit
of E is (N/C) which is same as
volt per meter (V/m).

$$\vec{D} = \epsilon \vec{E}$$

with:

$$\epsilon = \epsilon_r \epsilon_0$$

where

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ } \equiv (1/36\pi) \times 10^{-9} \text{ (F/m)}$$

Part
(1)

Write down the Maxwell's Equations
Maxwell expression comprise the

Fundamental tenets of electromagnetic theory. Explain.

Ans:-
F

Maxwell's equations: Describe how electric charges and electric current create electric and magnetic field. The first equations allow you to calculate the electric field create by a charge.

Maxwell's Equation
Differential form: 2

Maxwell's Equation
Integral form:-

$$\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\epsilon_0}$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\oint \vec{E} \cdot d\vec{l} = -\int \frac{\partial \vec{B}}{\partial t} \cdot d\vec{a}$$

$$\nabla \cdot \vec{B} = 0$$

$$\oint \vec{B} \cdot d\vec{a} = 0$$

$$\nabla \times \vec{B} = \mu_0 \vec{J}$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 \int \vec{J} \cdot d\vec{a}$$

$$\boxed{\mu_0 \epsilon_0 \int \frac{\partial E}{\partial t}}$$

Maxwell's equation in electromagnetic theory:-

With the publication of 'A Dynamical theory of the electromagnetic field' in 1865 Maxwell demonstrated that electric and magnetic fields travel through space as waves moving at the speed of light. He proposed that light is an undulation in the same medium that is the cause of electric and magnetic phenomena.

Part:

Q(3)

What is the difference between convection and conduction currents?

Ans:

An example of a convection current is a cloud bearing free electrons that moves through the atmosphere driven by wind

3

Conduction Current: Consist of charged particles moving in response to the electric field not merely being carried by motion of the surrounding material.

Part

(4)

State the principle of linear superposition as it applies to the electric field distribution of electric charge?

Ans:

When two or more point charges are present,

the total force is equal to the vector sum of the forces due to each of their other point charges.

→ As force is a vector we cannot algebraically add forces if there is more than one point charge.

The principle of superposition of forces in electrostatics state that when a number of charge are interacting the electrostatic force between two charges and the total electrostatic charge in the vector sum of all force due to other charge.

Part
(5)

What is Biot-Savart Law? Also state it with the help of expression.

Ans:-

The Biot Savart law is an equation describing the magnetic field generated by a constant electric current. It relates the magnetic field to the magnitude, direction, length and proximity of the electric current.

Biot-Savart Law Statement

& Derivation:-

The biot-Savart law can be stated as:

Hence $dB \propto \frac{Idl \sin \theta}{r^2}$ or $dB = k \frac{Idl \sin \theta}{r^2}$
Where, k is the constant depending upon the magnetic properties of the medium and system of the unit employed

$$k = \frac{\mu_0 \mu_r}{4\pi}$$

Q.03
Part B)

A free standard linear conductor of length l carries I along the z axis as shown in the Fig. 5-10. Determine the magnetic flux density B at point P located at a distance r in the $x-y$ plane.

Ans:

Solution: The differential length vector $dl = dz \hat{z}$. Hence, $dl \times R = dz (z \times R) = \phi \sin \theta dz$ where ϕ is the azimuth direction and θ is the angle between dl and R .

$$H = \frac{1}{4\pi} \int \frac{dl \times R}{R^2} = \phi \frac{1}{4\pi} \int \frac{\sin \theta}{R^2} dz$$

Both R and θ are dependent on the integration variable z but the radial distance r is not

$$R = r \csc \theta \quad (5.26a)$$

$$z = -r \cos \theta \quad (5.26b)$$

$$dz = r \csc^2 \theta d\theta \quad (5.26c)$$

where θ_1 and θ_2 are the limited angle at $z = -l/2$ $z = l/2$ respectively from the right triangle in Fig it follows that

$$\cos \theta_2 = -\cos \theta_1 = \frac{-l/2}{\sqrt{r^2 + (l/2)^2}}$$

Hence,

$$B = \mu_0 H = \phi \frac{\mu_0 I}{2\pi r \sqrt{4r^2 + l^2}}$$

$$B = \mu_0 H = \phi \frac{\mu_0 I}{2\pi r \sqrt{4r^2 + 12}}$$

For an infinitely long wire with
 $l \gg r$

$$B = \phi \frac{\mu_0 I}{2\pi r} \quad \text{Ans.}$$

Q → 03 The semi-circular conductor shown
 Part (a) lies in the plane and carries a
 current. The closed circuit is exposed
 — — — the curved section:-

Ans
 ↓
 The evaluate F_1 consider straight
 section of the circuit is of
 length $2r$ and its current flows
 along the $+x$ direction. Application
 of Eq. (5.12) with $l = x 2r$ gives

$$F_1 = \mu (2r) \times y B_0 = 2 \cdot 2I r B_0$$

The z direction of out of page
 The direction length $d\vec{l}$ on the
 curved part of circle. The direction
 of $d\vec{l}$ is chosen to coincide with
 the direction of the current.

$$F_2 = I \int d\vec{l} \times B$$

$$= -2I \int_0^\pi r B_0 \sin \theta d\theta = -2I r B_0$$

$\theta = 0$

Q → 04
Part (A)

Explain the Faraday's Law Also explain in brief its Differential and integral forms.

Faraday's Law states that the absolute value or magnitude of the circulation of the electrical field E around a closed loop is equal to the rate change of the magnetic flux through the area enclosed by the loop

The equation below expresses Faraday's Law in mathematical form

$$\nabla \times E = - \frac{\partial B}{\partial t}$$

It is a local^{pt} statement. We first integrate on both sides about an arbitrary surface Σ

$$\int_{\Sigma} \nabla \times E \cdot da = - \int_{\Sigma} \frac{\partial B}{\partial t} \cdot da$$

On the left hand side of the above equation we use Stokes theorem.

$\int_{\Sigma} \nabla \times E \cdot da = \int_{\partial \Sigma} E \cdot ds$
where $\partial \Sigma$ is the boundary of the surface. On the right hand side

we argue that the surface doesn't change with time therefore the derivative sign can be moved outside of derivative symbols

$$\oint_{\partial \Sigma} E \cdot dl = - \frac{d}{dt} \int_{\Sigma} B \cdot da$$

Q 704
Part B)

Determine voltage V_1 and V_2 across the 2Ω and 4Ω resistor show in 6.4. The loop is located in the $x-y$ plane. its area is 4m^2 . The magnetic flux density is $B = -20.3t(\hat{i})$ and the internal resistance of the wire may be ignored.

Ans

Determine voltage V_1 and V_2 across the 2Ω and 4Ω resistors show in Fig 6.4. The loop is located in the $x-y$ plane its area is 4m^2 . The magnetic flux density is $B = -20.3r(\hat{i})$ and the internal resistance of the wire may be ignored.

$$\phi = \int_S \mathbf{B} \cdot d\mathbf{s} = \int_S (-20.3r) \cdot 2 ds$$

$$= -0.3r \times 4 = -1.2r$$

and the corresponding transformer emf is

$$V_{\text{emf}} = -\frac{d\phi}{dt} = 1.2$$

Q → 02 | The x-y plane is a charge free boundary E_2 in medium
 Part (B) 2 and (b) the angles θ_1 and θ_2

Ans

$$E_{2x} = E_{1x} \quad E_{2y} = E_{1y}$$

and

$$D_{1z} = D_{2z} \quad \text{or} \quad \epsilon_2 E_{2z} = \epsilon_1 E_{1z}$$

Hence

10

$$E_2 = x E_{2x} + y E_{2y} + z \frac{\epsilon_1}{\epsilon_2} E_{1z}$$

The tangential components of E_1
 and E_2

$$E_1 = \sqrt{E_{1x}^2 + E_{1y}^2} \quad \text{and}$$

$E_2 = \sqrt{E_{2x}^2 + E_{2y}^2}$ The angles
 θ_1 and θ_2 are then given by

$$\tan \theta_1 = \frac{E_{1t}}{E_{1z}} = \frac{\sqrt{E_{1x}^2 + E_{1y}^2}}{E_{1z}}$$

$$\tan \theta_2 = \frac{E_{2t}}{E_{2z}} = \frac{\sqrt{E_{2x}^2 + E_{2y}^2}}{E_{2z}}$$

$$= \frac{\sqrt{E_{1x}^2 + E_{1y}^2}}{(\epsilon_1/\epsilon_2) E_{1z}}$$

and the two angles are related

$$\frac{\tan \theta_2}{\tan \theta_1} = \frac{\epsilon_2}{\epsilon_1}$$