IQRA NATIONAL UNIVERSITY PESH.

Final Term

Name : Javed

ID : 13151

Submitted to : Sir Latif Jan

Programe : B S (Telecom)

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Q1. Answer the following short questions briefly.

PART. 1). Write down the Maxwell's Equations?
Maxwell's equations comprise the fundamental tenets of electromagnetic theory.

Answer:-
Maxwell's equations describe how electric charges and electric currents create electric and magnetic fields. Further, they describe how an electric field can generate a magnetic field, and vice versa. The first equation allows you to calculate the electric field created by a charge.

⇒ Maxwell's Equations
Differential form

$$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$$

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

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

$$\nabla \times \vec{B} = \mu_0 \vec{J} + \boxed{\mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t}}$$

Maxwell's Equations:

Integral form:

$$\oint \vec{E} \cdot \vec{da} = \frac{Q_{enc}}{\varepsilon_0}$$

$$\oint \vec{E} \cdot \vec{dl} = \boxed{-\int \frac{\partial \vec{B}}{\partial t} \cdot \vec{da}}$$

$$\oint \vec{B} \cdot \vec{da} = 0$$

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I_{enc} + \boxed{\mu_0 \varepsilon_0 \int \frac{\partial \vec{E}}{\partial t}}$$

⇒ 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.

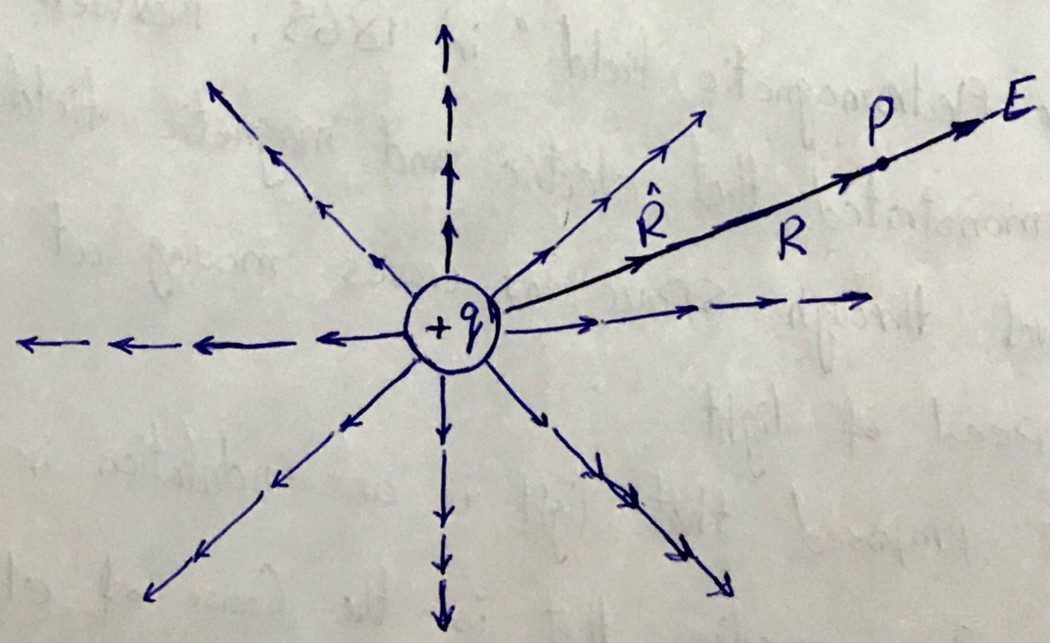
PART. 2). Explain the Coulombs Law?

Also state it with the help of expressions.

(Ans). Coulomb's Law states that

1. An isolated charge q induces an electric field E at very Point in Space, and at any Specific Point P, E is given by.

$$E = \hat{R}\frac{q}{4\pi\varepsilon R^2} \text{ V/m}$$



2. In the presence of electric field E, at a given Point in Space, Which may due to a Single charge or a distribution of may charges. q', When the charge, is placed at that Point, is given by

$$\vec{F} = q\vec{E} \quad (N)$$

- With F measured in newtons (N) and q' in Coulomb's (C), the unit of E is (N/C), Which is Same as volt per meter (V/m).
- For a material with electrical Permitivity ε, the electric field quanties D and E are related by

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

PART.3). What is the difference between Convection and Conduction Currents?

(Ans). Convection and Conduction

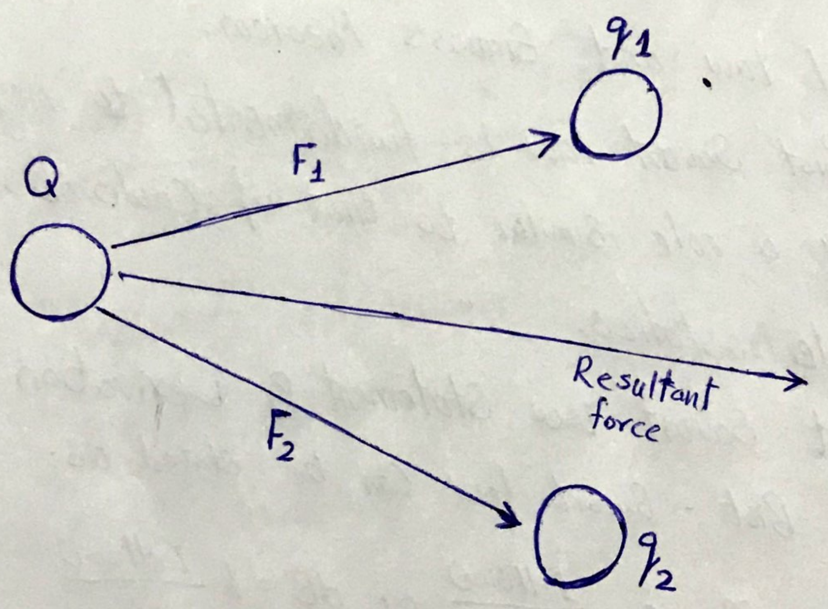
Difference :-

⇒ The difference between conduction and convection is that in convection heat is actually transfered by moving particles as when a fan is used to move heat from one place to another by blowing air.

⇒ In conduction heat is transfered through solids by means of the vibrating mollecules in a substance.

PART. 4). state the principle of linear Superposition as it applies to the electric field due to a distribution of electric charge?

(Ans). The principle of Superposition states that every charge in Space creates an electric field at point independent of the presence of other charges in that medium.
The resultant electric field is a vector Sum of the electric field due to individual charges.



PART. 5). What is Biot – Savart Law?
Also state it with the help of expression?

(Ans). ⇒ Biot - Savart law :

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 is consistent with both Ampere's Circuital Law and Gauss's theorem.
The Biot Savart law is fundamental to magnetostatics, playing a role similar to that of Coulomb's law in electrostatics.

⇒ Biot Savart Law Statement & Derivation :
The Biot - Savart law can be stated as:

Hence, $dB \propto \frac{I\,dl\sin\theta}{r^2}$ or $dB = k\,\frac{I\,dl\sin\theta}{r^2}$

Where, k is a constant, depending upon the magnetic properties of the medium and system of the units employed. In the SI system of unit,

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

Q2
(Part A) A 2mm diameter copper ----- ($m_2/v\text{-}s$) .... the free electron.

(Ans) Given data

The density of diameter copper wire conductivity of $58\times10^7 S/m$ and mobility of 0.00032 (m_2/vs)

we know carriers concentration (n)

$$\frac{\text{Avengdro number} \times \text{Density}}{\text{Atomic weight}}$$

The Conductivity of copper

$$n = 84.6\times10^{25} m^3$$

The electrical Conductivity

$$\sigma = \frac{1}{P} = \frac{1}{1.73\times10^{8}}$$

We know $\sigma = \frac{ne^2}{m}$

Averagtime collision

$$\tau = \frac{\sigma m}{ne2}$$

Q2. PART. b). The x-y Plane is a charge-free boundary separating two dielectric media with permittivities ϵ_1 and, ϵ_2 as show in Fig. 4-19.

If the electric field in medium 1 is $E_1 = \hat{x}E_{1x} + \hat{y}E_{1y} + \hat{z}E_{1z}$, find

(a). the electric field E_2 in medium 2 and

(b). the angles θ_1 and θ_2.

(Ans).

Free interface, the tangential components of E and the normal components of D are continuous. Consequently,

$$E_{2x} = E_{1x}, \qquad E_{2y} = E_{1y},$$

and

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

Hence,

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

(b) The tangential components of E_1 and E_2 are $E_{1t} = \sqrt{E_{1x}^2 + E_{1y}^2}$ and $E_{2t} = \sqrt{E_{2x}^2 + E_{2y}^2}$.

The angles θ_1 and θ_2 are then given by

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

$$\tan\theta_2 = \frac{E_{2t}}{E_{2z}} = \frac{\sqrt{E_{2x}^2 + E_{2y}^2}}{E_{2z}} = \frac{\sqrt{E_{1x}^2 + E_{1y}^2}}{(\epsilon_1/\epsilon_2)\, E_{1z}}$$

and the two angles are related by

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

: PART (a):-

Q3 -(a) The Semi - Circular Conductor shown in fig 5-4 lies in the x-y ------- Current I.

The closed ------------- $B = \hat{y} B_0$.

Determine (a) ------ F_1 ---------- and

(b) ---- F_2 on the curved section?

(Ans). Solution : a) To evaluate F_1, Consider that the Straight Section of the Circuit is of length $2r$ and its Current flows along the $+x$ direction. Application of with $\ell = \hat{x} 2r$ gives

$$F_1 = \hat{x}(2Ir) \times \hat{y} B_0 = \hat{z}\, 2Ir B_0 \quad (N).$$

The $\hat{z}$ direction in Fig. 5-4 is out of the Page.

(b). To evaluate F_2, consider a Segment of differential length dl on the Curved Part of the Circle. The direction of dl is chosen to coincide with the direction of the Current.

Since dl and B are both in the x-y Plane, their cross product $dl \times B$ points in the negative z direction, and the magnitude of $dl \times B$ is Proportional to $\sin\phi$, where ϕ is the angle between dl and B. Moreover, the magnitude of dl is $dl = r\, d\phi$. Hence,

$$F_2 = I \int_{\phi=0}^{\pi} dl \times B$$

$$= -\tilde{z} I \int_{\phi=0}^{\pi} r B_0 \sin\phi \, d\phi = -\tilde{z}\, 2 I r B_0 \ (N).$$

The $-\tilde{z}$ direction of the force acting on the curved part of the conductor is into the Page. We note that $F_2 = -F_1$, implying that no net force acts on the closed loop, although opposing forces act on its two sections.

Q3. PART. (b). A free - standing linear Conductor of length l Carries a Current I along the z axis as Shown in fig 5-10.
Determine the magnetic flux density B at a point P located at a distance r in the x-y plane.

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

Application

$$H = \frac{1}{4\pi} \int_{z=-l/2}^{z=l/2} \frac{dI \times \hat{R}}{R^2} = \hat{\Phi} \frac{I}{4\pi} \int_{-l/2}^{l/2} \frac{\sin\theta}{R^2}\, dz$$

Both R and θ are dependent on the integration variable z, but the radial distance r is not.
For Convenience, we Convert the integration variable from z to θ by using the transformations

$R = r \cos\theta,$

$z = -r \cos\theta,$

$dz = r\csc^2\theta\, d\theta.$

Where θ_1 and θ_2 are the limiting angles at $z = -l/2$ and $z = l/2$, respectively.

Form the right triangle in Fig. 5-10 (b), it follows that

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

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

Hence

$$B = \mu_0 H = \hat{\phi}\,\frac{\mu_0 I l}{2\pi r\sqrt{4r^2 + l^2}} \quad (T).$$

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For an infinitely long write with $l \gg r$, reduces to

$$B = \hat{\phi}\,\frac{\mu_0 I}{2\pi r} \quad \text{(infinitely long wire).}$$

Q4. PART a). Explain the Faraday's law?
Also explain in brief its Differential and Integral forms.

(Ans). Faraday's law states that the absolute value or magnitude of the circulation of the electric field E around a closed loop is equal to the rate of change of the magnetic flux through the area enclosed by the loop.
The equation below expresses Faraday's law in mathematical form.
Starting with the differential form of Faraday's law

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

It is a local 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,

$\int_{\Sigma} \nabla \times E \cdot da = \oint_{\partial\Sigma} E \cdot dl$. Where $\partial\Sigma$ is the boundary of the Surface.

on the right hand side, We argue that the Surface doesnt change with time, there fore the derivative sign can be moved outside of the integral sign; in addition, the integral is now only a function of time, therefore it is justified to use the total derivative symbol.

So we obtain

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

Which is the integral form of the Faraday's law.

Q.4 PART. (b). Determine voltage V_1 and V_2

across the 2Ω and 4Ω register ....

..... . The loop .... -- x-y

Plane. .... is $4m^2$ .... $B = -\hat{z}0.3t$ (T)

.... wire may be ignored.

(Ans). Solution :- The flux flowing through the loop is

$$\phi = \int_S B \cdot ds = \int_S (-\hat{z}0.3t) \cdot \hat{z}\, ds$$

$$= -0.3t \times 4 = -1.2t \quad (Wb).$$

and the corresponding transformer emf is

$$V_{emf}^{tr} = -\frac{d\phi}{dt} = 1.2 \quad (V).$$