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(Q1) Answer the following short questions briefly.

Part.
i) Write down the Maxwell's equations comprise the fundamental tenets of electromagnetic theory Explain.

Ans) 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 calculat the electric charge.

* Maxwell's equation. Differential form

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

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

$$\bar{\nabla} \cdot \bar{B} = 0 \qquad \bar{\nabla} \times B = \mu_0 j + \mu_0 \varepsilon_0 \frac{\partial E}{\partial t}.$$

* Integral form

$$\oint \bar{E} \cdot d\bar{a} = \frac{Q_{enc}}{\varepsilon_0}$$

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

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

$$\oint \bar{B} \cdot d\bar{l} = \mu_0 I_{enc} + \boxed{\mu_0 \varepsilon_0 \int \frac{\partial \bar{E}}{\partial t}}$$

⇒ with the publication of A dynamical theory of the electromagnetic Field in 1865 Maxwell demonstrated that electric and magnetic Field travel through space as waves moving at the speed of Light. He proposed that Light is an Undulation in the same medium that cause of electric and magnetic phenomena.

Part

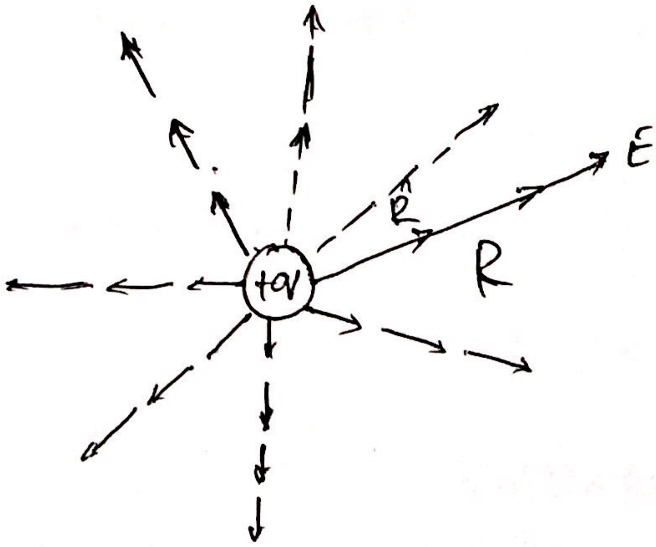
ii) Explain the Coulombs law? Also state it with help of expression?

(Ans) Coulomb's law states that

An isolated charge q induces an electric field E at every point in space, and at any specific point P, E is given by.

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

⇒ Where R is a unit vector pointing from q to p (in the fig) R is the distance between them and ε is the electrical permitively of the medium containing the observation point. p.



(2) In the presence of electric field E, at a given point in space which may due to a single or a distribution of many charges the force acting on a test charge q': when the charge is placed at that point is given

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

⇒ When 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)

⇒ For a material with electrical permittivity the electric field quantities D and E are related by. $\vec{D} = \varepsilon\vec{E}$

Part (iii) What is the difference between Convection and conduction currents?

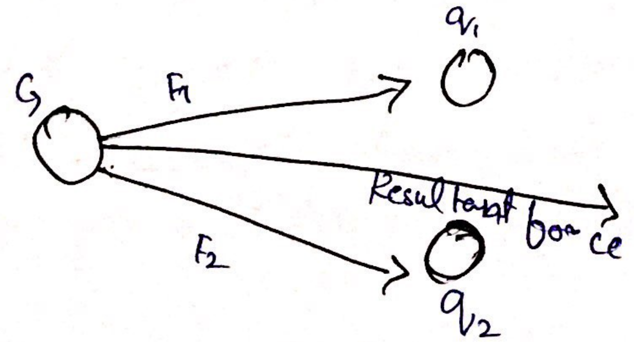
(Ans) Convection and Conduction Difference:.

⇒ 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 transferred through solids by means of the vibrating molecules in a substance.

Part (iv) State the principle of linear superposition as it applies to the electric field due to a distrubtion of electric charges

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



(Part V) what is Biot - savart law's Also stat it with 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 held to the magnitude, direction, length, and proximity of electric current.

Biot savart law is consistant with both Ampere's circuital law and Gauss's theorem

The Biot savart law is fundamental magnetostics playing a role similar to that of Coulombs low in electrostatics

* The Biot savart law statement and Derivation

The Biot - savart law can be stated as

Hence, $dB \propto \frac{Idl\sin\theta}{r^2}$ or $dB = \frac{KIdl\sin\theta}{r^2}$

where, K is a constant, depending upon the magnetic properties of the medium and system

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

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(Q2)
part(a) A 2mm diameter copper wire with conductivity of 5.8x 109 S/m and electrons .... (m2/v-s) ---- the free electrons.

(Ans) Given data

The density of diameter copper wire conductivity of 58x 107 S/m

and mobility of 0.0032 (m2/vs)

we know carries concentration (n)

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

The conductivity of coppers

$$n = 84.6 \times 10^{25} m^{-3}$$

The electrical conductivity

$$\sigma = \frac{1}{\rho} = \frac{1}{1.73 \times 10^{8}}$$

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 sparating two dielectric media with Permittivities ε_1 and ε_2 as shown in fig 4-19
If the electric field in medium 1 is
$E_1 = x E_{1x}$.
$y E_{1y} + z E_{1z}$. 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 conquesently

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

and

$$D_{1z} = D_{2z} \quad \text{or} \quad \varepsilon_2 E_2 = \varepsilon_1 E_{1z}$$

Hence

$$E_2 = x E_{2x} + y E_{2y} + \bar{z} \frac{\varepsilon_1}{\varepsilon_2} E_{1z}$$

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The tangential components of E_1 and E_2

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

$E = \sqrt{E_{2x}^2 + E_y^2}$ the angles

Q_1 and Q_2 are then given by

$$\tan Q_1 = \frac{E_{1t}}{E_{1z}} = \sqrt{E_{1x}^2 + E_{1y}^2}$$

$$\tan Q_2 = \frac{E^{2t}}{E'^z} = \frac{\sqrt{E_{1x}^2 + E_{2y}^2}}{E_{2z}}.$$

$$= \frac{\sqrt{E_{1x}^2 + E_{1y}^2}}{(E_1/E_2)\, E_{12}}$$

and the law angles are related by

$$\frac{\tan Q_2}{\tan Q_1} = \frac{E_2}{E_1}$$

(Q3) The semi circular conductor
Part (a) shown in fig . . . .
. . . . wire and b
the force F_2 on the curved

* 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 Eq (5.12) with $e = \hat{x}\,2r$ gives

$$F_1 = \hat{x}(2Ir) \times \hat{y} B_0 = \hat{z}\,2IrB_0 \ (N)$$

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 chossen to coincide with the direction of the current. Since dl and B are the both in the x-y plane.

Their cross product dl ×B point in the negative z direction and the magnitude of dl×B is proportional to $\sin\phi$ where is the angle between dl and B. Moreover, the magnitude of dl is $dl = r\, d\phi$. Hence

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

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

⇒ The 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 act on the closed loop. although opposing forces act act on it two sections.

Q3 part (B) A free standing linear conductor of length l carries ..... -- distance r in the x - y plane.

Solution:

The differential length vector $dl = 2 \hat{k}_z$

Hence, $dl \times R = d = (2 \times R) = \phi \sin d$ = where ϕ is the azimuth direction and θ is the angle between dl and R

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

Both R and θ are dependent on the integration variable 2 but the redical 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 $z = -l/2$ $z = l/2$ repectively from the right triangle in Fig it follow that

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

Hence -

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

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

Pg #15

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

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

(Q4)
Part(a) Explain the Faraday's law? Also explain in brief it differential and integral forms.

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

Starting with differential form of Faraday's

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

It is a local statement. we find integrate on both sides about on arbitrary surface.

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

on the left hand side of the above equation we use states theorem.

$$\int_{\Sigma} \bar{\nabla} \times E \, da = \oint_{\partial E} E \cdot dl$$ where ∂E is the boundary of the surface

on the right hand side. we argue that the surface doesnt change with time, there fore the derivation sign can be moved outside of the integral sign in addition, the integral is ~~new~~ only a function of tim therefore it is justified to the total derivative symbol

so we obtain

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

which is integral form of the faraday's Law.

18 of 18

(Q4) (Part b) Determine voltages V_1 and V_2 across the 2Ω and 4Ω resistors shown in F.4. The loop is located in the x-y plane. Its area is $4m^2$. The magnitude flux density is $B = -20.3t\ (\hat{z})$ and the internal resistance of the wire may be ignored.

(Ans) The flux flowing through the loop is

$$\Phi = \int B \cdot ds = \int_S (-20.3t) \cdot \hat{z}\, ds$$

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

and the corresponding transformer emf is

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