Physics

02-02-2020

Charge q unit – C (Coulomb's), e.s.u

Coulomb's law :- A law stating that like charges repel and opposite charges attract, with a force proportional to the product of the charges and inversely proportional to the square of the distance between them.

$$F = C \frac{q_1 q_2}{r^2}$$

if $r = 1$ cm, $F = 1$ dyne, $C = 1$

$q_1 = q_2 = q$ $\therefore q = \pm 1$ e.s.u

or if $r = 1$ m $F = 1$ N

$q_1 = q_2 = q = 1$ C $1C = 9 \times 10^9$ e.s.u

$$\vec{F} = C \frac{q_1 q_2}{r^3} \cdot \vec{r}$$

L-01 13-02-20

Waves:-

Hooke's law: Hooke's law is a principle of physics that states, the force needed to extend on compress a spring by same distance is proportional to that distance.

$$F \propto -x$$

$$\Rightarrow F = -kx \qquad k = \text{proportional constant in case}$$

of spring it is called spring constant or stiffness constant.

" Within elastic limit the strain (deformation) of a elastic body in proportional to the stress applied to it."

বিকৃতি

Oscillatory motion (স্পন্দনগতি)

Oscillatory motion can be defined as the repeated motion in which an object repeats the some movement and passes a point again and again

স্থিতিস্থাপকতা $\propto \frac{1}{\text{বিকৃতি}}$

Class- 08

Vector magnetic potential :- ($\vec{A}$)

$$\vec{\nabla} \cdot \vec{B} = ? \qquad \vec{B} = \vec{\nabla} \times \vec{A}$$

• Grad ✗ $\longrightarrow$ × सही

We know from Biot-Savart law

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{\vec{dl} \times \vec{r}}{r^3} \quad \text{.......(i)}$$

and $\vec{\nabla}\left(\frac{1}{r}\right) = -\frac{\vec{r}}{r^3}$ (Vector Algebra) $\quad \vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

From (i) and (ii) we have

$$\vec{B} = -\frac{\mu_0 I}{4\pi} \int \vec{dl} \times \vec{\nabla}\left(\frac{1}{r}\right)$$

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int \vec{\nabla}\left(\frac{1}{r}\right) \times \vec{dl}$$

Again using the identity

$$\vec{\nabla} s \times \vec{A} = \vec{\nabla} \times (s\vec{A}) - s(\vec{\nabla} \times \vec{A})$$

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int \left[\vec{\nabla} \times \frac{\vec{dl}}{r} - \frac{1}{r}(\vec{\nabla} \times \vec{dl})\right]$$

$$= \frac{\mu_0 I}{4\pi} \int \vec{\nabla} \times \frac{\vec{dl}}{r}$$

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Simple harmonic motion:

If an oscillatory particle moves back and forth about an equilibrium position such ~~as~~ oscillator is called simple harmonic ~~motion~~ oscillator and its motion is called simple harmonic motion (S.H.M)

The S.H.M has the following characteristics

(i) The motion is oscillatory and is repeated after equal interval at time.

(ii) The restoring force is proportional to displacement

(iii) The acceleration is always directed to mean position

Differential equation of simple harmonic oscillator:

Suppose the force F is applied on a body of mass 'm' displacement is x. Then from's Hooke' law $F \propto -x$ or $F = -Kx$ .. (i)

From Newton's 2nd law of motion $F = ma$

$$= m.\frac{dv}{dt} = m.\frac{d}{dt}.\frac{dx}{dt} = m.\frac{d^2x}{dt^2} \quad \ldots (ii)$$

From (i) and (ii) $m \cdot \frac{d^2x}{dt^2} = -Kx$ or $m\frac{d^2x}{dt^2} + Kx = 0$.

$$\Rightarrow \frac{d^2x}{dt^2} + \frac{k}{m}x = 0$$

$$\Rightarrow \frac{d^2x}{dt^2} + \frac{K}{m}.x = 0 \quad \Big| \quad \sqrt{\frac{K}{m}} = \omega \quad \therefore \omega^2 = \frac{K}{m}$$

$$\Rightarrow \frac{d^2x}{dt^2} + \omega^2 x = 0 \text{ ..... (iii)}$$ This is the equation of motion of S.H.O

Multiplying both sides of (iii) by $2.\frac{dx}{dt}$ we obtain :

$$2.\frac{dx}{dt}.\frac{d^2x}{dt^2} + \omega^2 x.2.\frac{dx}{dt} = 0$$

or $\frac{d}{dt}\left(\frac{dx}{dt}\right)^2 + \omega^2 \frac{d}{dt}(x^2) = 0$ Integrating w.r.t t

$$\Rightarrow \left(\frac{dx}{dt}\right)^2 + \omega^2 x^2 = c \text{ .....(iv)}$$

If $x = A$, maximum displacement that is constant then $\frac{dx}{dt} = 0$

$\therefore c = \omega^2 A^2$ .... (v) putting into (iv)

$\left(\frac{dx}{dt}\right)^2 + \omega^2 x^2 = \omega^2 A^2$ or $\left(\frac{dx}{dt}\right)^2 = \omega^2 A^2 - \omega^2 x^2$

or $\left(\frac{dx}{dt}\right)^2 = \omega^2 (A^2 - x^2)$

or $\frac{dx}{dt} = \pm \omega\sqrt{A^2-x^2}$ considering the +ve value only

$\frac{dx}{dt} = \omega\sqrt{A^2-x^2}$

$\Rightarrow \frac{dx}{\sqrt{A^2-x^2}} = \omega\, dt$ ....(vi) Integrating we get

$\sin^{-1}\frac{x}{A} = \omega t + \delta$

or $\frac{x}{A} = \sin(\omega t + \delta)$

$\therefore x = A\sin(\omega t + \delta)$ .....

This is the differential equation of SHO

For Initial phase $\delta = 0$

$$\left.\begin{aligned} x &= A\sin(\omega t) \\ \text{or } \frac{x}{A} &= \sin \omega t \end{aligned}\right\} \dots (1)$$

$v = \frac{dx}{dt} = A\omega\cos(\omega t)$

or $v = A\omega\sqrt{1-\sin^2\omega t} = A\omega\sqrt{1-x^2/A^2}$

$\Rightarrow v = \frac{A \cdot 2\pi}{T \cdot A}\sqrt{A^2-x^2} = \omega\sqrt{A^2-x^2}$

$$\boxed{\therefore v = \omega\sqrt{A^2-x^2}}$$

At $x = 0$, $v = \frac{2\pi A}{T}$

At $x = A$, $v = \frac{2\pi}{T}(0-0) = 0$

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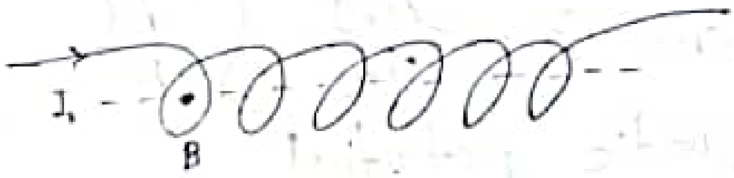
9-03-20

Class-09

Magnetic field inside a magnetic material :-

$$\int \vec{B} \cdot \vec{dl} = \mu_0 I_0 \quad \cdots \text{(i)}$$



$$B = \mu_0 n I_0 \quad \cdots \text{(ii)}$$

where I_0 is the current ~~th~~ flowing through the solenoid of turns n per unit length.

When the solenoid is filled with a magnetic material (iron) the magnetic field

$$B = B_0 + B_m \quad \cdots \text{(iii)}$$

B_0 is the magnetic field absence of magnetic material, B_m is the induced magnetisation

But we know $\boxed{B = \mu H}$

From (3)

$$B = \mu_0 H + \mu_0 M \qquad B_0 = \mu_0 H$$

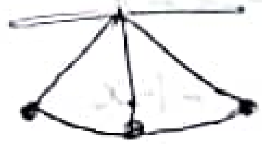
$$= \mu_0 H \left(1 + \frac{M}{H}\right) \quad \text{(5)} \qquad B_m = \mu_0 M$$

E D P

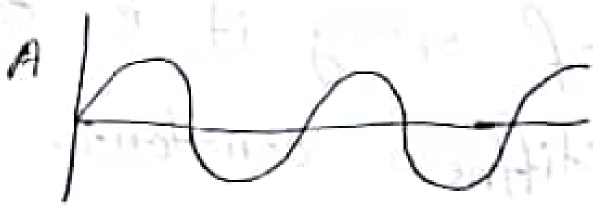
Simple harmonic motion (SHM) :-

If an oscillatory particle moves backant and forth about an equilibrium position such as oscillator is called simple harmonic oscillator and its motion is called SHM.

Characteristics of SHM :-



(i) The motion is oscillatory and is repeated after equal interval of time.



(ii) ~~The res~~ Restoring force is proportional to displacement

(iii) acceleration is always directed towards the mean position

Characteristic parametors of SHM :-

(i) time period ([illegible] [illegible]

$v t = s$

~~(ii)~~ $\omega T = 2\pi$

$$T = \frac{2\pi}{\omega}$$

From Fig:-

$$x = a\tan\theta$$

$$dx = a\sec^2\theta \, d\theta$$

$p^2 = a^2 + x^2$

$x = +\alpha \quad \theta = +\pi/2$

$x = -\alpha \quad \theta = -\pi/2$

$$E_p = \frac{\lambda a}{4\pi\epsilon_0} \int_{-\pi/2}^{+\pi/2} \frac{a\sec^2\theta \, d\theta}{(a^2+x^2)^{3/2}}$$

$$= \frac{\lambda a^2}{4\pi\epsilon_0} \int_{-\pi/2}^{+\pi/2} \frac{\sec^2\theta \, d\theta}{a^3(1+\tan^2\theta)^{3/2}}$$

$$= \frac{\lambda a^2}{4\pi\epsilon_0} \int_{-\pi/2}^{\pi/2} \frac{\sec^2\theta \, d\theta}{a^3 \cdot \sec^3\theta}$$

$$= \frac{\lambda}{4\pi\epsilon_0 \cdot a} \int_{-\pi/2}^{\pi/2} \cos\theta \, d\theta$$

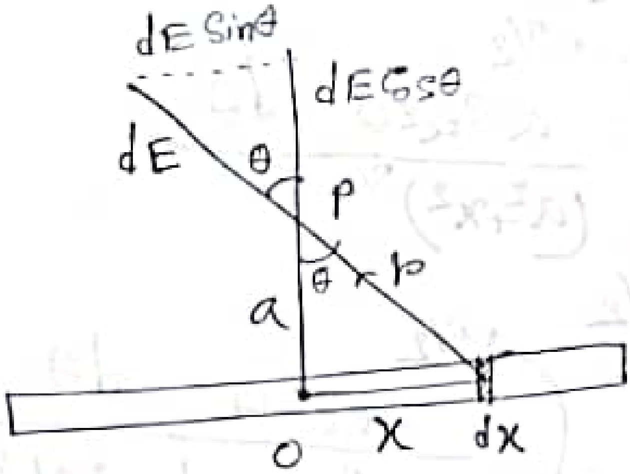
$$= \frac{\lambda}{4\pi\epsilon_0 \cdot a} \left[\sin\theta\right]_{-\pi/2}^{+\pi/2}$$

$$\boxed{\therefore E_p = \frac{\lambda}{2\pi\epsilon_0 a}}$$

V.V.I

* Electric field due to a straight charge. wire:

Let



Electric field at P for $\lambda . dx$ charge

$$\therefore dE = \frac{1}{4\pi\epsilon_0} \times \frac{\lambda dx}{r^2}$$

For the wire :-

$$dE \cos\theta = \frac{1}{4\pi\epsilon_0} \cdot \frac{\lambda dx}{r^2} \cdot \cos\theta$$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{\lambda dx}{r^2} \cdot \frac{a}{r}$$

The total

$$E_P = \int \frac{1}{4\pi\epsilon_0} \cdot \frac{\lambda dx . a}{r^3}$$

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The net flux is

$$\int d\varphi = \frac{\mu_o I}{2\pi} \int_a^b \frac{dr}{r}$$

$$\varphi = \frac{\mu_o I}{2\pi} \ln\frac{b}{a}$$

We know the e.m.f

$$\mathcal{E} = \frac{d\varphi}{dt}$$

$$= \frac{d}{dt}\left\{\frac{\mu_o I}{2\pi} \ln\left(\frac{b}{a}\right)\right\}$$

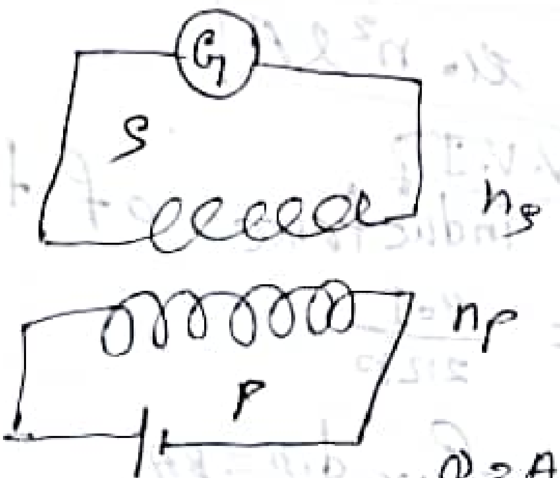
$$\mathcal{E} = \frac{\mu_o}{2\pi} \ln\frac{b}{a} \cdot \frac{dI}{dt} \quad \ldots (i)$$

and $\mathcal{E} = L \cdot \frac{dI}{dt} \quad \ldots (ii)$

comparing (i) and (ii)

$$L = \frac{\mu_o}{2\pi} \ln\frac{b}{a}$$

Mutual induction :-



$n_s \varphi \propto I$

$n_s \varphi = M I$.

where M is the mutual inductance

$$\boxed{\mathcal{E} = M \cdot \frac{dI}{dt}}$$

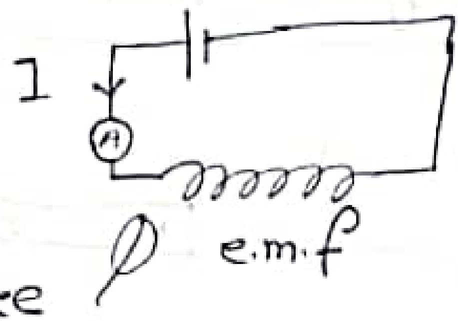
$\varphi = AB = \mu_o$

$\varphi_P = \mu_o . n_P . A_P . I$

Self induction :-

$N\phi \propto I$

$N\phi = LI$



where L is the self inductance

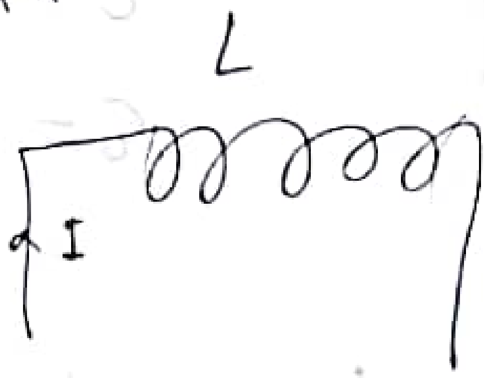
Again we know

$$\mathcal{E} = \frac{d}{dt}(N\phi) = \frac{d}{dt}(LI)$$

$$\therefore \mathcal{E} = -L \cdot \frac{dI}{dt}$$

$$\therefore L = \frac{\mathcal{E}}{dI/dt}$$

Self inductance of a solenoid :- *** V.V.I



$B = \mu_0 n I$ $\quad n = \frac{N}{l}$

where n is the number of turns per unit length and I is the current flowing through the solenoid

The flux induced in the solenoid

$$\phi = BA = \mu_0 n I A$$

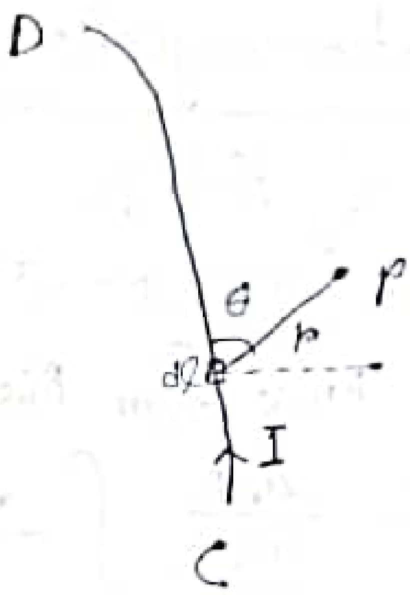
If N is the total number of turns in the solenoid

Biot-savart Law :- Class-07 23-02-20

$$dB \propto \frac{I dl \sin\theta}{r^2}$$

$$dB = K \frac{I dl \sin\theta}{r^2}$$

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



$$B = \frac{\mu_0}{4\pi} \int \frac{I dl \sin\theta}{r^2}$$

$$\Rightarrow \vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{dl \sin\theta}{r^2} \frac{\vec{r}}{r}$$

$$\Rightarrow \vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{\vec{dl} \times \vec{r}}{r^3}$$

$$\Rightarrow \vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{dl\, r \sin\theta}{r^3}$$

(i) $B = \frac{\mu_0 I}{2\pi a}$

(ii) $B = \frac{\mu_0 I}{2r}$

Magnetic $\boxed{\text{vector}}$ potential :-

Curl $= 0$

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

electric potential

$$\vec{\nabla} \times \vec{E} = 0$$

$B = \nabla$? magnetic potential

$$V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r}$$

$$\therefore \vec{B} = \vec{\nabla} \times \vec{A}$$

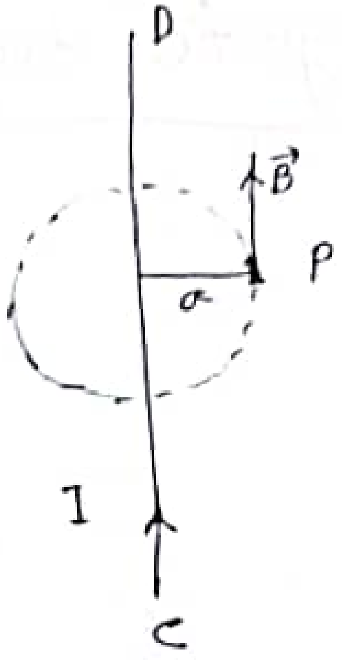
$$\vec{A} = A ? \quad \frac{\mu_0}{4\pi} \int \frac{J\, dv}{r}$$

From ampere's law

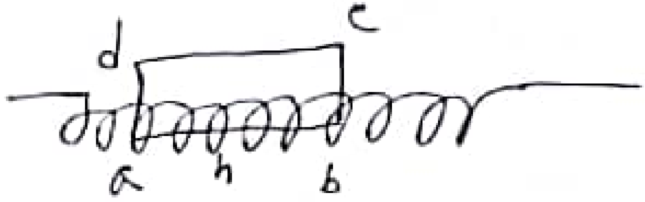
$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I$$

$$\Rightarrow B \oint dl = \mu_0 I$$

$$\Rightarrow B = \frac{\mu_0 I}{2\pi a}$$



(ii) magnetic field for solenoid :-



$$\oint \vec{B}\cdot\vec{dl} = \mu_0 I$$

$$\Rightarrow \int_a^b \vec{B}\cdot d\vec{l} + \int_b^c \vec{B}\cdot d\vec{l} + \int_c^d \vec{B}\cdot\vec{dl} + \int_d^a \vec{B}\cdot\vec{dl} = \mu_0 I$$

num. of turns per unit length

$$n = \frac{N}{l}$$

$$\Rightarrow Bh + 0 + 0 + 0 = \mu_0 I$$

$$\Rightarrow Bh = \mu_0 h n I_0$$

$$\boxed{\Rightarrow B = \mu_0 n I_0}$$

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Relative magnetic permeability

$$K_m = \frac{\mu_m}{\mu_0} \quad \ldots\ldots (6)$$

dielectric cons. $K = \frac{F_0}{F_m} = \frac{\varepsilon_m}{\varepsilon_0}$

and

$$B = \mu_m H \quad \text{———} \quad (7)$$

$$\Rightarrow B = K_m \mu_0 H \quad \ldots\ldots (7)$$

Using equation (5) and (7)

$$K_m \mu_0 H = \mu_0 H\left(1 + \frac{M}{H}\right)$$

$$\Rightarrow K_m = 1 + \frac{M}{H}$$

$$\Rightarrow M = (K_m - 1) H$$

$$\Rightarrow M = \chi H$$

$\chi = (K_m - 1)$ is the magnetic susceptibility.

$B = \mu H$, $M = \chi H$

M, H - Both are parallel

(iii) magnetic field for ~~toluite~~ toroid :-

Class-06

16-02-20

** Ampere's Law :-

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I$$

$$\Rightarrow \oint \vec{B}\cdot \vec{dl} = \mu_0 \oint \vec{J}\cdot d\vec{s}$$ stock Theo

$$\Rightarrow \oint (\vec{\nabla}\times\vec{B})\cdot d\vec{S} = \mu_0 \oint \vec{J}\cdot d\vec{s}$$

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

$B \propto \frac{I}{r}$

$B = K\frac{I}{r}$

$B = \frac{\mu_0}{2\pi}\cdot\frac{I}{r}$

$B(2\pi r) = \mu_0 I$

$\oint \vec{B}\cdot d\vec{l} = \mu_0 I$

$\frac{I}{A} = J$ → Vector Ejमक

$J \propto I$

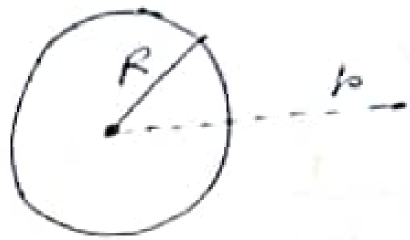
Class-07

20-02-20

Application of Ampere's law

(i) Magnetic field for a current carrying long wire :-

(ii) Sphere



$$\sigma = \frac{q}{A}$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$$

$$\Rightarrow \oint E \times 4\pi r^2 = \frac{q}{\epsilon_0}$$

$$\Rightarrow E = \frac{q}{4\pi r^2 \epsilon_0}$$

$$\therefore E = \frac{\sigma}{\epsilon_0}$$

Add:- ***

volum density charge

$$q = \rho V$$

$$\Rightarrow \int dq = \rho \int dv$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$$

$$\Rightarrow \epsilon_0 \oint \vec{E} \cdot d\vec{A} = q \quad \oint \rho \, dv$$

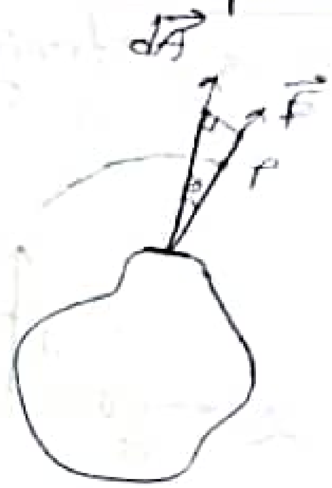
[divergence theorem]

$$\Rightarrow \epsilon_0 \int_V \vec{\nabla} \cdot \vec{E} \, dv = \int_V \rho \, dv$$

$$\Rightarrow \vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$ it's also gauss law

Differential form of gauss law

Gauss Law :-   Class - 03   16-02-2020



~~Electric flask~~ $\phi_E = \frac{q}{\varepsilon_0}$

The component of E along the direction of $\vec{dA}$ is $E\cos\theta$

$E_n = E\cos\theta$

$E_n dA = E\cos\theta \, dA$

$E_n dA = \frac{q}{4\pi\varepsilon_0} \times \frac{\cos\theta \, d\theta}{r^2}$

$d\Omega = \frac{dA}{r^2}$

$\Rightarrow \oint E_n dA = \frac{q}{4\pi\varepsilon_0} \oint \frac{\cos\theta \, dA}{r^2}$

$\Rightarrow \oint E\cos\theta \, dA = \frac{q}{4\pi\varepsilon_0} \times \oint d\Omega$

E_n = Number of flask

$\Rightarrow \oint \vec{E} \cdot \vec{dA} = \frac{q}{4\pi\varepsilon_0} \times 4\pi$

$\Rightarrow \oint \vec{E} \cdot \vec{dA} = \frac{q}{\varepsilon_0}$

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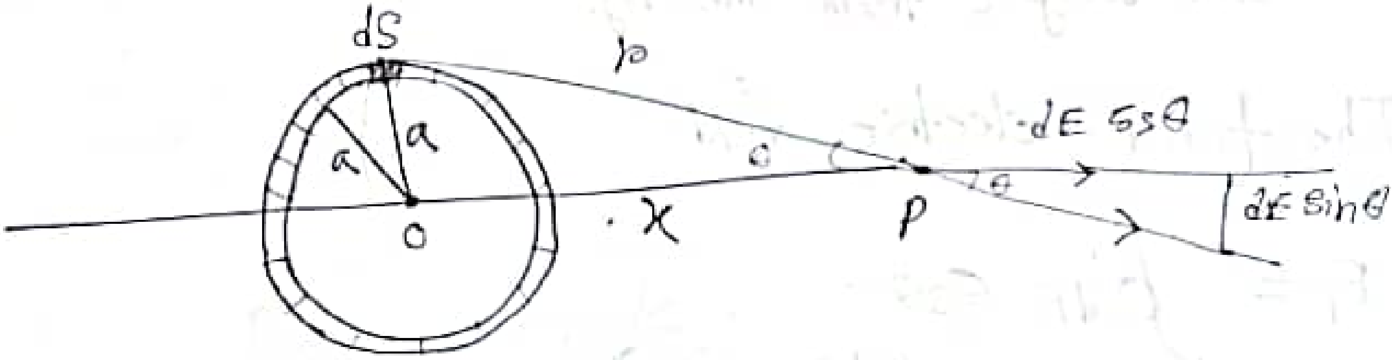
Class-02

3-02-2020

Electric field at a point on the axis of charged ring

concept of electricity and magnetism
Rafikul DU
electricity and magnetism
KK TEWARI



The amount of charge in dS is $= \frac{q\,dS}{2\pi a}$

The electric field at point p for $\frac{q\,dS}{2\pi a}$ charge

$$dE = \frac{1}{4\pi\epsilon_0} \cdot \frac{q\,dS}{2\pi a r^2}$$

$$\vec{B} = \vec{\nabla} \times \frac{\mu_0 I}{4\pi} \int \frac{d\vec{l}}{r}$$

$$\vec{B} = \vec{\nabla} \times \vec{A}$$

where $\vec{A} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{l}}{r}$ is the vector magnetic potential

we know, current density

$$J = \frac{I}{ds}$$

$$I = J\, ds = J \cdot \frac{dV}{dl}$$

$$\therefore \vec{A} = \frac{\mu_0}{4\pi} \int \frac{I\, dl}{r}\, \hat{n}$$

$$\vec{A} = \frac{\mu_0}{4\pi} \int \frac{J\, dV}{r}\, \hat{n}$$

Magnetisation :-

dipole moment $= m_i$

$$\sum_{i=1}^{N} m_i = m$$

$N \rightarrow S$

$$q(2l) = p$$

$$\varphi_i\, 2l = m$$

magnetisation vector $M = \frac{m}{V} = \frac{1}{V} \sum_{i=1}^{N} m_i$

Then the net flux

$\phi_B = \mu_0 n I A N$

we know the e.m.f induced

$$\mathcal{E} = \frac{d\phi_B}{dt}$$

$$\mathcal{E} = \frac{d}{dt}(\mu_0 n I A N)$$

$$\mathcal{E} = \mu_0 n A N . \frac{dI}{dt} \quad \dots (i) \quad \text{and} \quad \mathcal{E} = L . \frac{dI}{dt} \dots (ii)$$

comparing (i) and (ii)

$$\boxed{L = \mu_0 n A N}$$ (Proved)

$$L = \mu_0 . \frac{N}{l} . A . N$$

$$= \mu_0 \frac{N^2}{l} . A$$

$$\boxed{L = \mu_0 n^2 l A}$$

V.V.I

Self inductance of two co-axial cylinder:

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

A=dr.l
=dr

l=1m

Then flux $d\phi = BA$
$= B dr$

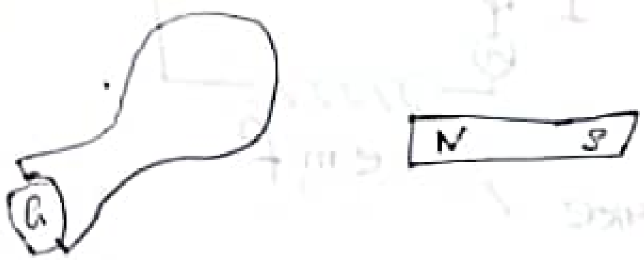
$$\therefore d\phi = \frac{\mu_0 I}{2\pi r} . dr$$

15-03-20

Class-10

Electromagnetic ~~flask~~ induction:

Induise



flux

electric flux | magnetic flux

E-field $\rightleftharpoons$ B-field

Faraday's law :-

1st law :-

2nd law :-

$$\mathcal{E} \propto \frac{d\phi}{dt}$$

$$\mathcal{E} = K \cdot \frac{d\phi}{dt}$$

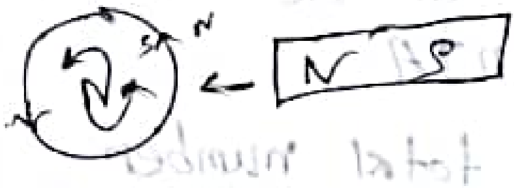
or $\mathcal{E} = -\frac{d\phi}{dt}$

If N is the number of turns

$$\mathcal{E} = N \cdot \frac{d\phi}{dt}$$

Lenz's law :-

N ⟶ S



The result $E_\theta // E_r$

$$E = \sqrt{E_\theta^2 + E_r^2 + 2E_\theta \cdot E_r \cos 90^\circ} \to 0$$

$$= \frac{p}{4\pi\epsilon_0 r^3}\sqrt{4\cos^2\theta + \sin^2\theta}$$

$$= \frac{p}{4\pi\epsilon_0 r^3}\sqrt{1 + 3\cos^2\theta}$$

Torque (τ)

$$\tau = F \cdot 2l \sin\theta$$

$$\tau = Eq(2l)\sin\theta$$

$$\tau = pE\sin\theta$$

$$\tau = \vec{p} \times \vec{E}$$

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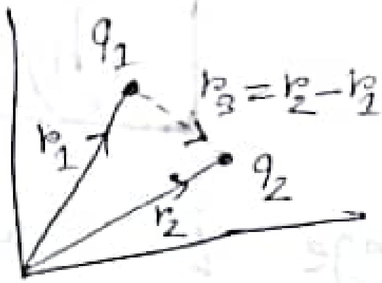
$$F_2 = C \cdot \frac{q_1 q_2}{|r_2 - r_1|^3}(r_2 - r_1)$$



For discreate charge distribution

$$\vec{F}_1 = \sum_{i \neq j}^{j=N} \frac{q_i \, q_j}{|r_i - r_j|^3}(r_i - r_j)$$

<u>charge density</u>

$$\lambda = \frac{q}{l}$$

$$\sigma = \frac{q}{A}$$

$$\rho = \frac{q}{V}$$

$$\vec{F}_q = Cq \int \frac{\rho_{(r')} \, dv}{|\vec{r} - \vec{r'}|^3}(r - r') + Cq \oint_S \frac{\sigma(r'') \, da}{|r - r''|^3}(r - r'')$$

Electric field :

$$\vec{E} = \frac{\vec{F}}{q} \qquad E = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2}$$

Frequency: $f = \frac{1}{T}$

Amplitude:

phase :-

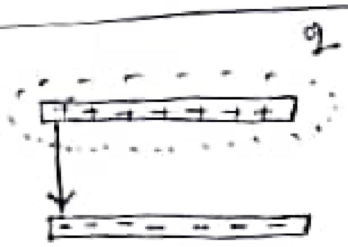
Initial phase is called epoch.

13-02-20

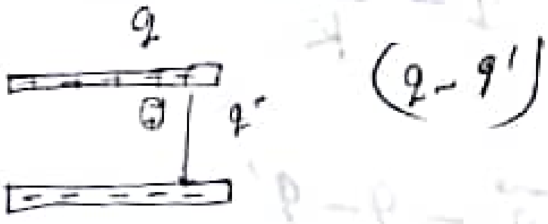
Class-05

V.V.I. Sure

Gauss law for dielectric medium:-



(a)



(b)

From Fig (a) $\quad \epsilon_0 \oint \vec{E_0} \cdot d\vec{A} = q$

$$\Rightarrow E_0 = \frac{q}{\epsilon_0 A} \quad \text{—(i)}$$

(i) if $x \gg a$

$$E_p = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{x^2}$$

$\sqrt{2^3}$

(ii) $x \ll a$, then $E_p = 0$

(iii) $x = a$

$$E_p = \frac{1}{4\pi\epsilon_0} \cdot \frac{qa}{2^{3/2} \cdot a^3}$$

Electric dipole

$\cancel{p}=$

$$P = q \times 2l$$

$$V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r}$$

$$V = Ed$$

$$E = -\frac{dv}{dr}$$

E and V for electric dipoles :-

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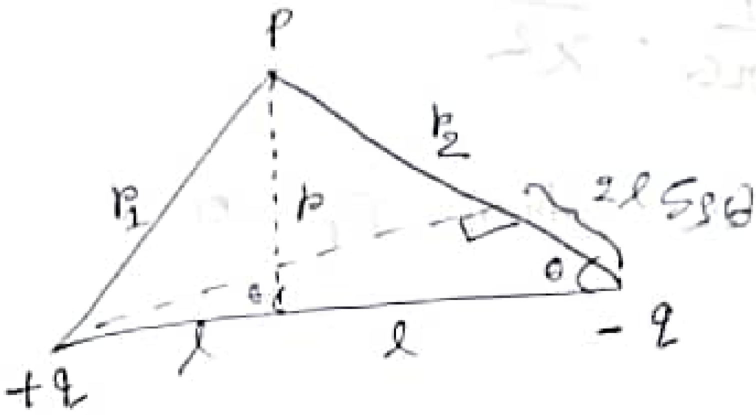
E and V for electric dipole :-



The potential at point P for dipole

$$V = \frac{1}{4\pi\epsilon_0} \cdot \left(\frac{q}{r_1} - \frac{q}{r_2}\right)$$

$$= \frac{q}{4\pi\epsilon_0} \cdot \frac{r_2 - r_1}{r_1 \cdot r_2}$$

$$= \frac{q}{4\pi\epsilon_0} \cdot \frac{2l\cos\theta}{r^2} \qquad [r_1 \approx r_2 \approx r]$$

$$\therefore V = \frac{1}{4\pi\epsilon_0} \cdot \frac{p\cos\theta}{r^2} = \frac{1}{4\pi\epsilon_0} \cdot \frac{\vec{p}\cdot\vec{r}}{r^3}$$

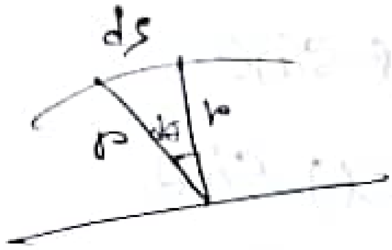
With variation r, We have

$$E_r = -\frac{dv}{dr}$$

$$= -\frac{d}{dr}\left(\frac{1}{4\pi\epsilon_0}\cdot\frac{P\cos\theta}{r^2}\right)$$

$$= -\frac{P\cos\theta}{4\pi\epsilon_0} \times -\frac{2}{r^3}$$

$$\therefore E_r = \frac{2P\cos\theta}{4\pi\epsilon_0 \cdot r^3}$$ Redian component



$$S = r\theta$$
$$ds = r\,d\theta$$

With variation θ

$$E_\theta = -\frac{dv}{r\,d\theta}$$

$$= -\frac{d}{r\,d\theta}\cdot\left(\frac{P\cos\theta}{4\pi\epsilon_0 \cdot r^2}\right)$$

$$= -\cancel{\frac{d}{r\,d\theta}} = -\frac{P}{4\pi\epsilon_0 \cdot r^3}\cdot -\sin\theta$$

$$E_\theta = \frac{P\sin\theta}{4\pi\epsilon_0 \cdot r^3}$$

Again, $\lambda = \frac{q}{l}$

$$C = \frac{\lambda}{V}$$

$$\Rightarrow C = \frac{\lambda}{\frac{\lambda}{2\pi\epsilon_0} \cdot \ln\frac{b}{a}} \qquad \boxed{V = \frac{\lambda}{2\pi\epsilon_0} \cdot \ln\frac{b}{a}}$$

$$\Rightarrow C = \frac{2\pi\epsilon_0}{\ln\frac{b}{a}}$$

For l Length

$$C = \frac{2\pi\epsilon_0 l}{\ln\frac{b}{a}}$$

Capacitance for sphere

$$C = 4\pi\epsilon_0 r$$

We can wrighte from the fig.

The total electric field

$$E_p = \oint dE \cos\theta$$

$$= \oint \frac{1}{4\pi\epsilon_0} \times \frac{q\,ds}{2\pi a \cdot r^2} \times \frac{x}{r}$$

$$= \frac{q}{4\pi\epsilon_0} \times \frac{1}{2\pi a} \cdot \frac{x}{r^3} \oint ds$$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{2\pi a} \cdot \frac{x}{(a^2+x^2)^{3/2}} \cdot 2\pi a$$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{qx}{(a^2+x^2)^{3/2}}$$

From Fig (b) :-

$$\epsilon_0 \oint \vec{E} \cdot \vec{dA} = (q - q')$$

$$\Rightarrow E = \frac{q}{\epsilon_0 A} - \frac{q'}{\epsilon_0 A} \quad \text{— (ii)}$$

Dielectric cons. $K = \frac{E_0}{E}$

$$\Rightarrow E = \frac{E_0}{K}$$

From (ii) $\frac{E_0}{K} = \frac{q}{\epsilon_0 A} - \frac{q'}{\epsilon_0 A}$

$$\Rightarrow \frac{q}{\epsilon_0 A K} = \frac{q}{\epsilon_0 A} - \frac{q'}{\epsilon_0 A}$$

$$\Rightarrow \frac{q}{K} = q - q'$$

$$\Rightarrow q' = q - \frac{q}{K}$$

Now

$$\epsilon_0 \oint \vec{E} \cdot \vec{dA} = q - q'$$

$$\Rightarrow \epsilon_0 \oint \vec{E} \cdot \vec{dA} = q - q + \frac{q}{K}$$

$$\Rightarrow \epsilon_0 K \oint \vec{E} \cdot \vec{dA} = q$$

But differentiate

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$$\Rightarrow \frac{Q}{V} = \frac{\epsilon_0 A}{d}$$

$$\Rightarrow C = \frac{\epsilon_0 A}{d} \qquad \text{other medium } C = \frac{\epsilon_0 K A}{d}$$

Capacitance of a co-axial cylinder :-

সম অক্ষ

$$\epsilon_0 \oint \vec{E} \cdot \vec{dA} = q$$

$$\Rightarrow \epsilon_0 E \cdot 2\pi r l = q \qquad \boxed{\frac{q}{l} = \lambda}$$

$$\Rightarrow E = \frac{\lambda}{2\pi \epsilon_0 \cdot r}$$

$$V = V_a - V_b$$

$$= \int_a^b \vec{E} \cdot \vec{dr}$$

$$= \int_a^b E \, dr$$

$$\Rightarrow V = \int_a^b \frac{\lambda}{2\pi \epsilon_0 \cdot r} \, dr$$

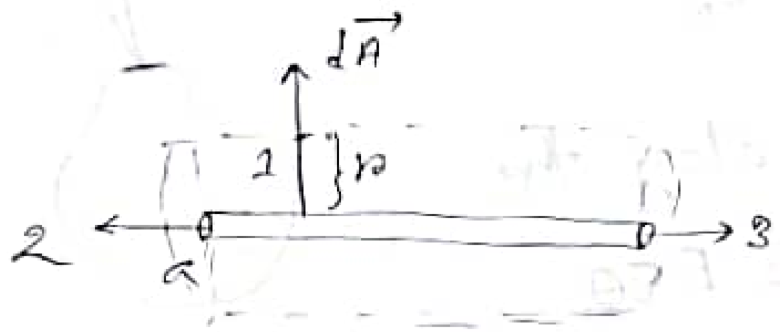
r^{-1-1}

$-\frac{1}{r^2}$

$$= \frac{\lambda}{2\pi \epsilon_0} \ln \frac{b}{a}$$

Calcution:- Applications:-

(i) For a straight cylindrical wire



$$\lambda = \frac{q}{l}$$

Applying Gauss law

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$$

$$\Rightarrow E \cdot \oint dA = \frac{q}{\varepsilon_0}$$

$$\Rightarrow E \cdot 2\pi r l = \frac{q}{\varepsilon_0}$$

$$\Rightarrow E = \frac{q}{2\pi r l \varepsilon_0}$$

$$\Rightarrow E = \frac{\lambda}{2\pi r \varepsilon_0}$$

if (i) $r < a$ $E = 0$

(ii) $r > a$ $E = \frac{\lambda}{2\pi r \varepsilon_0}$

(iii) $r = a$ $E = \frac{\lambda}{2\pi a \varepsilon_0}$

$$\varphi_s = \varphi_p \cdot n_s$$

$$= \mu_0 n_p \cdot A_p \cdot I \cdot n_s$$

$$\boxed{\begin{aligned} B &= \mu_0 n I \\ \varphi &= BA \end{aligned}}$$

$$\therefore \mathcal{E} = \frac{d\varphi_s}{dt} = \mu_0 n_s n_p A_p \cdot \frac{dI}{dt}$$

$$\therefore M = \mu_0 n_s n_p A_p$$

We know,

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

$$\therefore \vec{\nabla} \cdot \vec{\nabla} V = -\frac{\rho}{\epsilon_0}$$

$$\Rightarrow \nabla^2 V = -\frac{\rho}{\epsilon_0}$$ Poisson's equation

if $\rho = 0$

$$\vec{\nabla}^2 V = 0$$ Laplace equation

Class-09

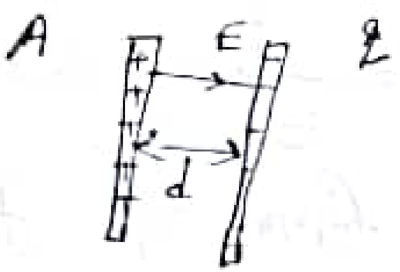
9-02-2020

Capacitor:

$C = \frac{Q}{V}$ একক $F = CV^{-1}$

V.V.I ***

Capacitance of two parallel plates:-



$$\overset{\text{potential}}{V} = \overset{\text{Electric field}}{E} d$$

$$\Rightarrow V = \frac{\sigma}{\epsilon_0} d$$

$$= \frac{Qd}{\epsilon_0 A}$$

ρ_p = ~~For~~ Dipole এর জন্য

Again

$$\epsilon_0 \oint \vec{E} \cdot d\vec{A} = \oint (\rho + \rho_p)\, dv \qquad [\rho_p = -\vec{\nabla} \vec{P}]$$

$$\Rightarrow \epsilon_0 \oint \vec{E} \cdot d\vec{A} = \oint \rho\, dv - \oint \vec{\nabla} \cdot \vec{P}\, dv$$

$$\Rightarrow \epsilon_0 \oint \vec{\nabla} \cdot E\, dv + \oint \vec{\nabla} \cdot \vec{P}\, dv = \oint \rho\, dv$$

$$\Rightarrow \oint \vec{\nabla} \cdot (\epsilon_0 \vec{E} + \vec{P})\, dv = \oint \rho\, dv$$

Displacement current $= \vec{D}$

$$\Rightarrow \oint \vec{\nabla} \cdot \vec{D}\, dv = \oint \rho\, dv$$

$$\Rightarrow \boxed{\vec{\nabla} \cdot \vec{D} = \rho}$$

capacitors. cap and its ব্যবহার Applications

Gauss's law and its "

Coloumb's law