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-:(Applied Physics):-

Chapter # 01:-

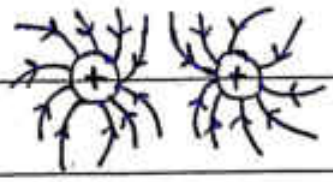
Qno1:-

Define the electric charge hence difference b/w conductor and insulator:-

Answer:-

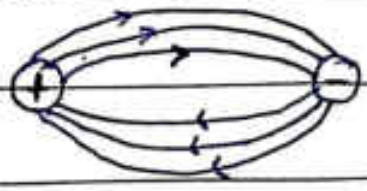
Electric Charge:-

- "The strength of (charge)× electrical interaction of a particle with objects arounds it depends upon its electric charge."
- Charges with same sign repel each other.



(Repel)

- Charges with opposite sign always attract each other.



(Attraction)

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Electrostatics:-

"The study of electric charges at rest under the action of electric force is called Electrostatics."

Types of Charges:-

The charge has two types called positive charge and negative charge.

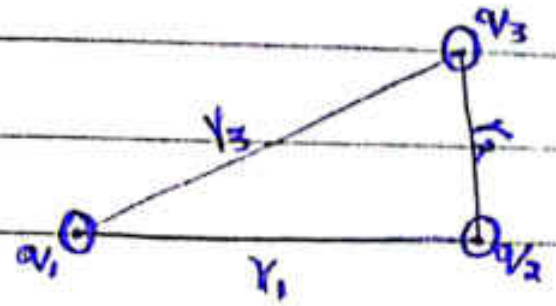
- The similar (Like) charges repel each other with electric force.
- The unlike charges attract each other with electric force.

Explanation:-

If we have two point charges positive and negative, then the electric force by these charges is given by:

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

Here the K is the constant of proportionality. The value of K is $9\times10^{9}\ Nm^2C^{-2}$.



If we have 3rd point charge then the electric force produced by these 3 charges is given by.

$$F = K\frac{q_1 q_2}{r_1^2} + K\frac{q_2 q_3}{r_2^2} + K\frac{q_1 q_3}{r_3^2}$$

we Know that

$$K = \frac{1}{4\pi\varepsilon_0}$$

But in case of 3 charges or more than two charges, The value of K is changed.

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Like:

$$K = \frac{1}{4\pi\varepsilon_0\varepsilon_r}$$

Then the force is given by:

$$F = \frac{1}{4\pi\varepsilon_r\varepsilon_0}\frac{q_1q_2}{r_1^2} + \frac{1}{4\pi\varepsilon_r\varepsilon_0}\frac{q_2q_3}{r_2^2} + \frac{1}{4\pi\varepsilon_0}\frac{q_1q_3}{r_3^2}$$

Conductor:-

The materials through which charges can flow easily are called conductors. Some properties of conductor are:

- The copper and aluminum are good examples of conductors.
- The resistivity of conductor is of the order of $10^{-8}\,\Omega^{-1}m$.
- The resistivity of Cu is $1.77 \times 10^{-8}\,\Omega^{-}m$.
- The conduction band and valence band overlaps in conductors so electrons can easily move.

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Insulator:-

The materials through which charges cannot flow are called insulators.

Properties:-

- The electron are tightly bound in such materials.
- The well-Known insulators are glass and plastic.
- The insulator has only one conduction electron/cm^3.
- The resistivity of insulator is the order of 10^{11} to 10^{16} $\Omega^{-1}m$. The resistivity of glass is 2×10^{11} $\Omega^{-1}m$.

Semiconductor:-

The partial conductors are called Semiconductors

Properties:-

- The well-Known semiconductors are silicon and germanium.
- A typical semiconductor has 10^{12} conduction electron/cm^3
- The resistivity of germanium is $0.5\ \Omega^{-1}m$.

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-:(Applied Physics):-

Chapter # 01:-

QNo2:-

Discuss Quantization of electric charge in details

Answer:-

Quantization of Charge:-

The electric Charge was thought to be a continuous fluid in Benjamin Franklin's day. Nowadays we Know that fluids such as air and water are not continous but are made of atoms and molecules.

Experiment shows that electrical fluid is also not continuous but is made up of multiples of a certain elementary charges. Any positive or negative charges 'q' can be written as:

$$q = ne$$

where $n = \pm 1, \pm 2, \pm 3, \ldots\ldots$ and

$e = 1.6 \times 10^{-19} C$

Importance of 'e' :-

The elementary charge 'e' is one of the important constant of nature.

The electron and proton both have a charge of magnitude. The quarks ~~wil~~ which are consititueut particles of protons and neutrons have charges of $\pm \frac{e}{3}$ or $\pm \frac{2e}{3}$, but they cannot be detected individually.

That's why we do not take their charges to be the elementary charges.

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Explanation:-

We say a physical quantity such as charge is quantized when it can have only discrete values rather than any value. For Example, it is possible to find a particle that have no charge at all or a charge of +10e or -6e but not a particle with a charge of say 3.57e.

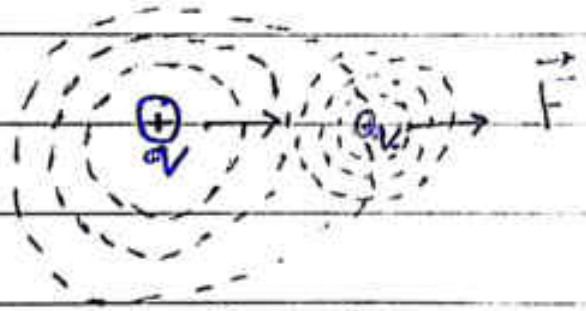
The quantum of charges is small. For Example, in a ordinary 100 W light bulb about 10^{19} elementary charges enter the bulb every second and just as many leaves.

However, the graininess of electricity does not show up in such large-scale phenomenon just as you cannot feel

the individual molecules of water with your hands.

Electric Field Intensity:-

The field intensity around a charge at a point P is defined as force per unit charge at that point.



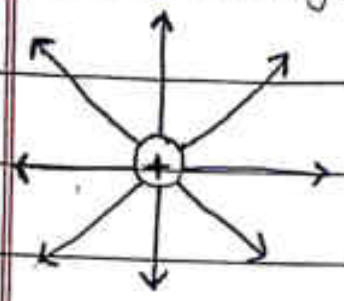
$$\vec{E} = \frac{\vec{F}}{q}$$

The unit of Electric Field Intensity is NC^{-1}. It is a vector Quantity.

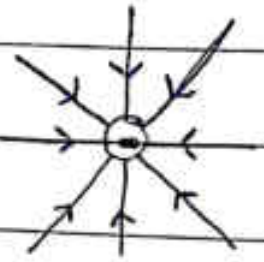
~~Elect~~

Electric Field Lines:-

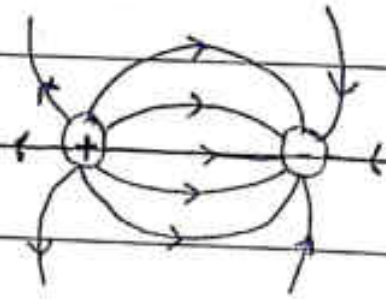
Michkel Faraday traced the electric field of a charge by using a test charge.
The field lines of positive and negative charges can be drawn as following:



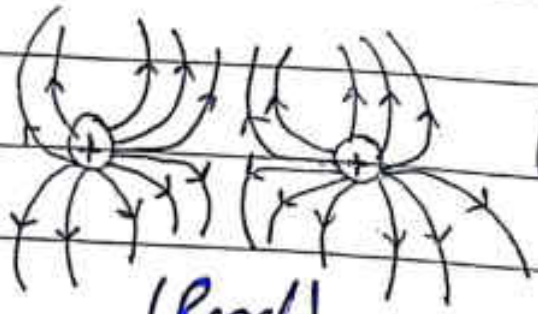
(Radialy Outward)



(Radialy Inward)



(Force of Attraction)



(Force of Repulsion)

(Repel)

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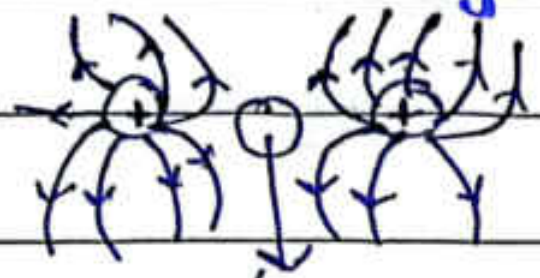
Field Free Region:-



(Free space Region)

In this Region no electric field lines exists.

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:(Applied Physics):-

Chapter # 01:-

QNo3:-

Discuss law of conservation of electric charge in detail with Example?

Answer:-

Conservation of Charge:-

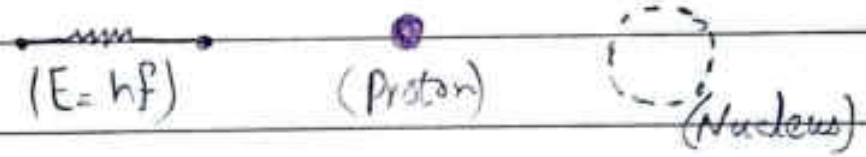
The positive charge appears on the rod when you rub a glass rod with silk. The measurements shows that negative charges of same magnitude appears on silk. This shows that rubbing does not create charge but only transfers it from one body to another body.

"According to law of conservation of electric charge the charges cannot be generate and cannot be destroyed it just transform

one object to another object."
This law of conservation of charge was first put forward by Benjamin Fraklin. Some Examples of charge conservation are:

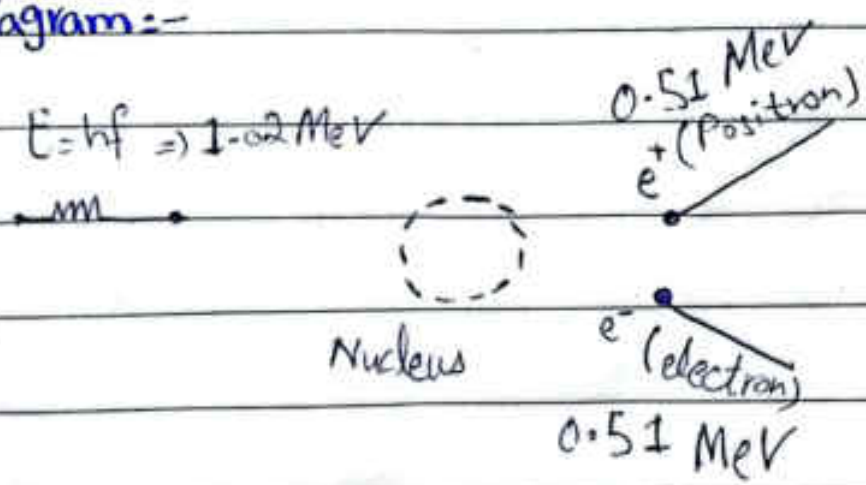
(i) Radioactive decay.
(ii) Pair Production.
(iii) Annihilation of Matter.

Pair Production:-



The charge is conserved in Pair Production. In this process the energy is transform into electron and positron.

Diagram:-

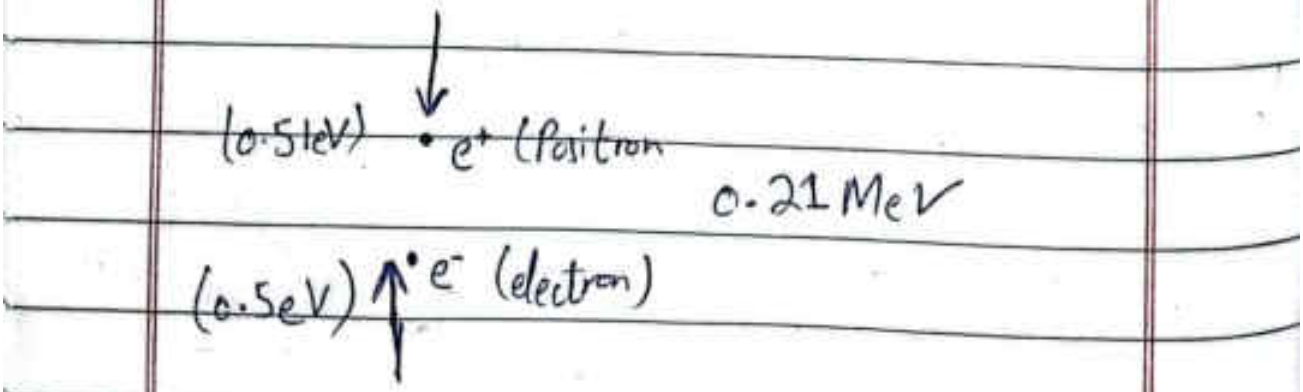


The net charge of the system is zero both before and after the event. Hence, The charge is conserved.

Annihilation of Matter:-

The charge conservation occurs in Annihilation process when an electron having a charge '-e' and its antiparticle called positron having charge '+e' annihilates in such a way that they transform into Energy.

Diagram:-



The annihilation process is the conserved process of pair production.

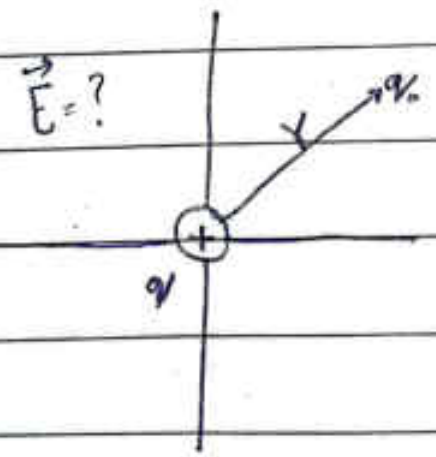
The net charge of the system is zero both before and after the event. Hence, The charge is conserved.

QNo4:-

Explain Electric field at a point due to a point charge in detail?

Answer:-

Diagram:-



Let us make a diagram to electric field due to a point charge. (q).

Now take a test point charge

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q_0 The distance of q_0 is 'r'
The force is given by the columb's law:

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

$$F = K\frac{q q_0}{r^2} \quad \text{—— (i)}$$

$$\boxed{\frac{F}{q_0} = \frac{Kq}{r^2}} \quad \text{—— (ii)}$$

we Know that the expression of electric field Intensity is:

$$\vec{E} = \frac{F}{q_0}$$

So, eq. (ii) becomes

$$\boxed{E = \frac{Kq}{r^2}} \quad \text{Magnitude}$$

In vector Form:-

$$\vec{E} = K\frac{q}{r^2}(\hat{r})$$

:(Applied Physics):-

Smester # 01:-

Q No 5 :-

Calculate electric field due to continous charge distribution:-

Answer:-

The electric charge is quantized. The collection of large number of charges is called continous charge distribution. The continous charge distribution has three types.

(i) Linear charge density.

(ii) Surface charge density.

(iii) Volume charge density.

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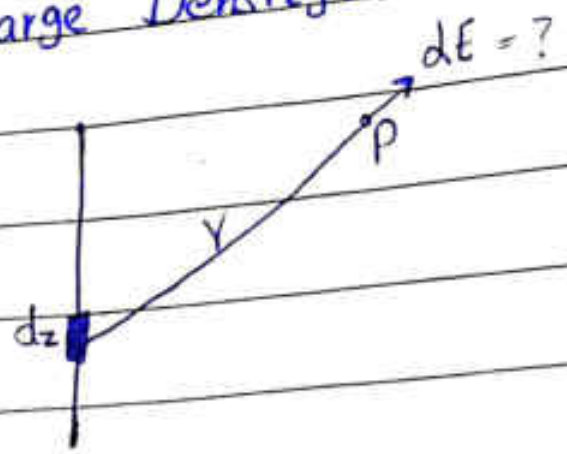
Linear Charge Density:-



Take a small element dz of this distribution having charge dq.

The Linear charge density is:

$$\lambda = \frac{dq}{dz}$$

$$dq = \lambda dz$$

The equation for electric field is:

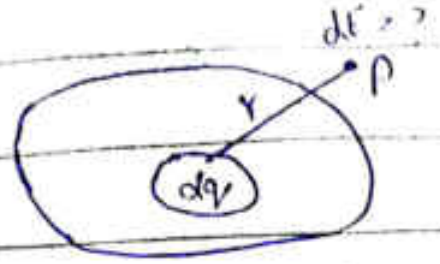
$$E = \frac{Kq}{r^2}$$

$$dE = \frac{K\,dq}{r^2} \Rightarrow dE = \frac{K\lambda dz}{r^2}$$

The net electric field at P is:

$$E = K\int \frac{\lambda}{r^2} dz$$

Surface Charge Density:-



Consider a surface charge (density) distribution. Take a small area 'da' of this distribution having charge 'dq'

Surface charge density $= \sigma = \frac{dq}{da}$

$$\sigma = \frac{dq}{da}$$

$$dq = \sigma da \quad \text{——— (i)}$$

we Know that:

$$E = \frac{Kq}{r^2} \Rightarrow dE = \frac{K\,dq}{r^2}$$

$$dE = \frac{K\sigma da}{r^2}$$

The net electric field at P is:

$$E = K\int \frac{\sigma}{r^2}\, da$$

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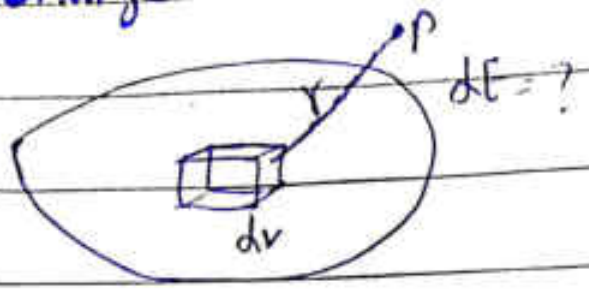
Volume Charge Density:-



Consider a volume charge distribution. Take a small volume element dv of this distribution having charge dq.

Volume charge density $= \rho = \frac{q}{v}$

$$\rho = \frac{dq}{dv} \Rightarrow dq = \rho\, dv \quad (1)$$

we Know that:

$$E = \frac{Kq}{r^2} \Rightarrow dE = \frac{K\,dq}{r^2}$$

$$dE = \frac{K\rho\, dv}{r^2}$$

The net electric field at P is:

$$\boxed{E = K\int \frac{\rho}{r^2}\, dv}$$

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Q No 6:-

What is an electric dipole? Calculate electric field at a point due to electric dipole?

Ans:-

Electric Dipole:-

A pair of positive charge and negative charge of same magnitude having constant distance between them is called Electric Dipole. It is useful concept in dielectrics and other applications in solid and liquid materials.

Electric Dipole Moment:-

The product of magnitude of charge and seperation between them is called electric dipole moments and It is written as:

$$P = qd$$

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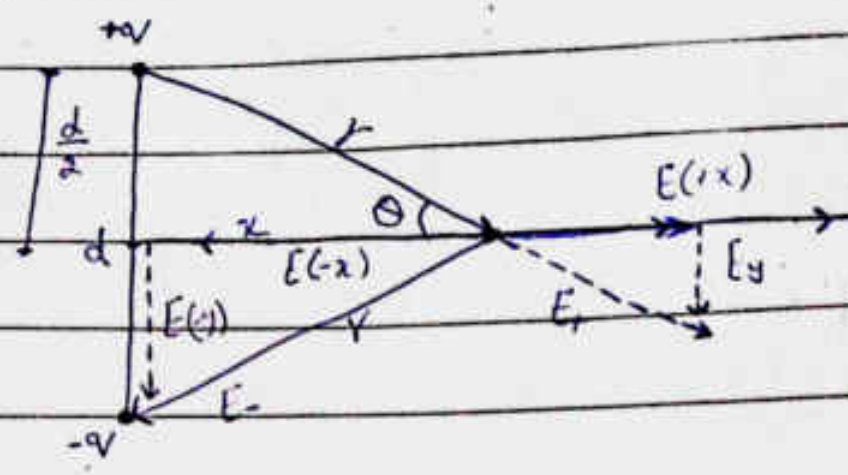
Electric field due to electric dipole:-

Diagram:-



Consider a charge +q and -q having distance b/w them. This is called dipole. The dipole moment is given as $P = qd$.

Take a point P having distance 'x' which is perpendicular bisector of distance.

The magnitude of electric field at P due to +q charge having distance r is:

$$E_+ = \frac{Kq}{r^2} \quad \text{(i)}$$

The magnitude of electric field due to -q charge having

distance 'r' is:

$$E_- = \frac{Kq}{r^2} \quad \text{——— (ii)}$$

Compairing (i) and (ii)

$$E_+ = E_- \quad \text{——— (iii)}$$

To calculate net electric field at 'P' due to dipole, resolve the electric field E_+ and E_- into components.

Rectangular component of E_+ is:

$$E(+x) = E_+ \cos\theta \quad , \quad E(+y) = E_+ \sin\theta$$

Rectangular components of E_- is:

$$E(-x) = E_- \cos\theta \quad , \quad E(-y) = E_- \sin\theta$$

The resultant x-component of electric field is:

$$E_x = (+E(+x)) + (E(-x))$$

$$E_x = +E\cos\theta + (-E\cos\theta)$$

$$E_x = +\cancel{E\cos\theta} - \cancel{E\cos\theta}$$

$$\boxed{E_x = 0} \quad \text{——— (a)}$$

The resultant y-component of electric field is:

$$E_y = (E(y)) + (E(-y))$$

$$E_y = -E\sin\theta + (-E\sin\theta)$$

$$E_y = -E\sin\theta - E\sin\theta$$

$$\boxed{E_y = -2E\sin\theta} \quad \text{(b)}$$

Magnitude of resultant electric field E is:

$$E = \sqrt{(E_x)^2 + (E_y)^2}$$

$$E^2 = (E_x)^2 + (E_y)^2$$

$$E^2 = (0)^2 + (-2E\sin\theta)^2$$

$$E^2 = (-2E\sin\theta)^2$$

Taking $\sqrt{\ }$ on b. sides

$$E = -2E\sin\theta$$

From (i)

$$E = -2\frac{Kq}{r^2}\frac{d/2}{r}$$

$$E = -\frac{\cancel{2}K(qd)}{\cancel{2}r^3}$$

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from dipole moment

$$E = -\frac{KP}{r^3}$$

$$E = -KPr^{-3} \quad \text{——— (iv)}$$

By Phytagerous theorem:-

$$c^2 = a^2 + b^2$$

$$r^2 = \left(\frac{d}{2}\right)^2 + x^2$$

$$r^2 = x^2 + \frac{d^2}{4} \Rightarrow r = \sqrt{\frac{d^2}{4} + x^2}$$

$$r = \left(x^2 + \frac{d^2}{4}\right)^{\frac{1}{2}}$$

Put in eq (iv)

$$E = -KP\left(x^2 + \frac{d^2}{4}\right)^{-3/2}$$

$$E = -KP\left[x^2\left(1 + \frac{d^2}{4x^2}\right)\right]^{-3/2}$$

$$E = -KP\left[(x^2)^{-3/2} \cdot \left(1 + \frac{d^2}{4x^2}\right)^{-3/2}\right]$$

$$E = -KPx^{-3}\left(1 + \frac{d^2}{4x^2}\right)^{-3/2}$$

By Binomial Series:-

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$$E = -KPx^{-3}\left(1 + \frac{3}{2}\frac{d^2}{4x^2} + \cdots\right)$$

Neglect the higher order terms, we get:

$$\boxed{E = \frac{KP}{x^3}}$$

This is the electric field at P due to electric dipole.
Where x is distance between point P and bisecting point d of distance b/w +q and -q.

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:(Applied Physics):-

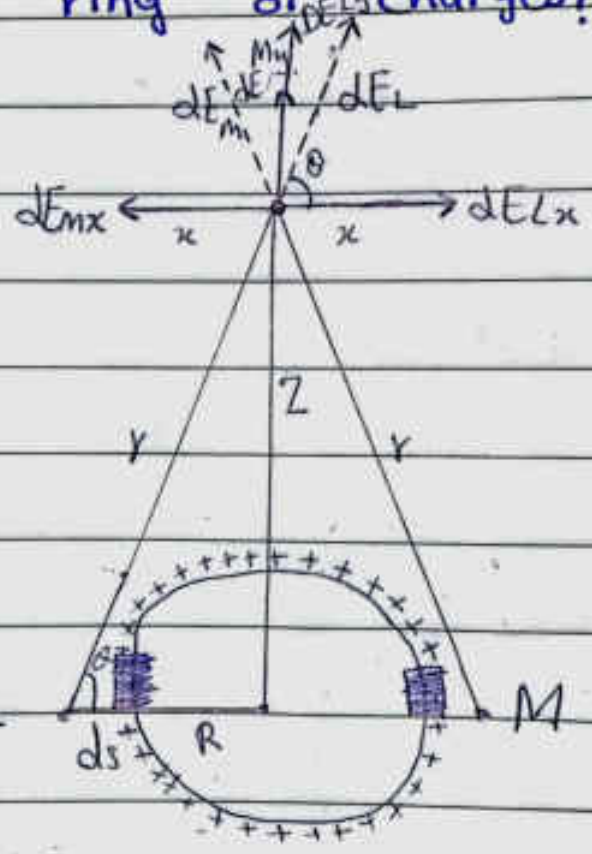
Assignment 01:-

QNo1:-

Explain the electric field due to ring of charges?

Ans:-

Diagram:-



Explanation:-

Consider a positively charged ring having radius 'R' on which positive charge 'q' is distributed uniformly. This is called Linear charge distribution. Take a small

length element ds of ring having charge dq.

The linear charge density is defined as:

$$\lambda = \frac{dq}{ds}$$

$$dq = \lambda ds \quad \text{——— (i)}$$

It is given:

$$dE_L = \frac{K dq}{r^2} \quad \text{——— (a)}$$

$$dE_M = \frac{K dq}{r^2} \quad \text{——— (b)}$$

Compairing (a) and (b)

$$dE_L = dE_M$$

To find magnitude of electric field

$$dE = \sqrt{dE_x^2 + dE_y^2} \quad \text{——— (ii)}$$

Component of dE_L:-

$$dE_{Lx} = dE_L \cos\theta$$

$$dE_{Ly} = dE_L \sin\theta$$

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Components of dE_M:-

$$dE_{Mx} = dE_M \cos\theta$$

$$dE_{My} = dE_M \sin\theta$$

Resultant x-component:-

$$dE_x = dE_L \cos\theta + (-dE_M \cos\theta)$$

$$dE_x = \cancel{dE_L \cos\theta} - \cancel{dE_M \cos\theta}$$

$$\boxed{dE_x = 0}$$

Resultant Y-component:-

$$dE_y = dE_L \sin\theta + dE_M \sin\theta$$

$$\boxed{dE_y = 2dE \sin\theta}$$

Now eq. (ii) becomes

$$dE = \sqrt{(0)^2 + (2dE \sin\theta)^2}$$

$$dE = 2dE \sin\theta$$

$$dE = \frac{2K\,dq}{r^2} \sin\theta$$

$$\left\{ \because \sin\theta = \frac{P}{H} = \frac{z}{r} \right\}$$

$$dE = \frac{2K\,dq\,z}{r^3}$$

From eq (i)

$$dE = \frac{2K\lambda ds\, z}{r^3} \quad \text{—— (iii)}$$

The value of r is:

$$c^2 = a^2 + b^2$$

$$r^2 = z^2 + R^2$$

$$r = \sqrt{z^2 + R^2}$$

$$r = (z^2 + R^2)^{\frac{1}{2}}$$

Put r in (iii)

$$dE = \frac{2K\lambda ds\, z}{(z^2 + R^2)^{3/2}}$$

Integrating

$$\int dE = \int \frac{2K\lambda ds\, z}{(z^2 + R^2)^{3/2}}$$

$$E = \frac{2zK}{(z^2+R^2)^{3/2}} \int \lambda ds$$

$$\boxed{E = \frac{2z\lambda K}{(z^2+R^2)^{3/2}} \pi R} \quad \text{—— (iv)}$$

we know that

$$\lambda = \frac{dq}{ds} \Rightarrow dq = \lambda ds \Rightarrow q = \lambda \int ds$$

$$q = \lambda(2\pi R)$$

The equation (iv) is

$$E = \frac{zK\lambda(2\pi R)}{(z^2+R^2)^{3/2}}$$

$$\boxed{E = \frac{zKq}{(z^2+R^2)^{3/2}}}$$

This is called electric field at point P due to ring of charges. When the point P lies at large distance $z >> R$ The Term R^2 can be neglected as compare to z^2:-

$$E = \frac{zKq}{(z^2+0)^{3/2}}$$

$$E = \frac{zKq}{(z^2)^{3/2}} \Rightarrow E = \frac{\cancel{z}Kq}{z^{\cancel{3}}}$$

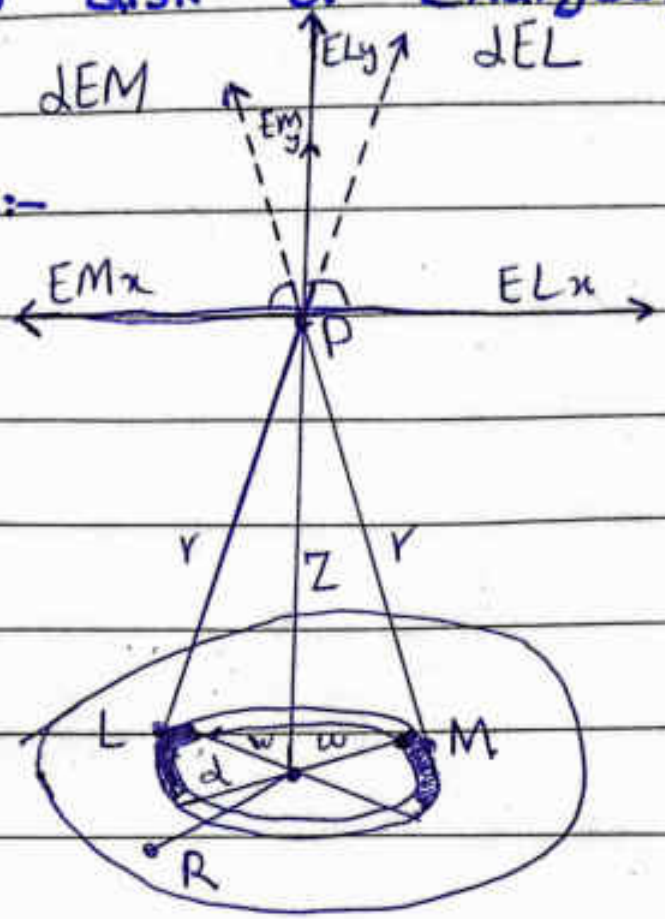
$$\boxed{E = \frac{Kq}{z^2}}$$

Q.No 2:-

Explain the electric field due to disk of charges?

Answer:- dEM

Diagram:-



Explanation:-

Consider a positivily charged disk of radius R having surface charge density σ. & Divide the disk into small rings. Now consider such a small ring having radius 'w' and 'dw'.

The surface charge density is:

$$\sigma = \frac{dq}{da}$$

$$\boxed{dq = \sigma da}$$

integrate:

$$q = \sigma \int da$$

$$q = \sigma (da\, dw) \quad \text{(i)}$$

we have to calculate electric field at point P having distance z from the plane of disk.

$$dE_L = \frac{K dq}{r^2}$$

$$dE_M = \frac{K dq}{r^2}$$

Compairing:-

$$dE_L = dE_M$$

To calculate electric field dE at P resolve the electric field into components.

along x-axis:-

$$dE_x = E_{Lx} + (-E_{Mx})$$

$$dE_x = \cancel{E_{Lx}} - \cancel{E_{Mx}}$$

$$\boxed{dE_x = 0}$$

along y-axis

$$dE_y = E_{Ly} + E_{My}$$

$$dE_y = 2E_{Ly} \qquad \{\because E_{Ly} = E_{LM}\}$$

$$dE_y = 2E_{Ly} \sin\theta$$

The magnitude of electric field is:

$$dE = \sqrt{dE_x^2 + dE_y^2}$$

$$dE = \sqrt{(0)^2 + (2E_{Ly}\sin\theta)^2}$$

$$dE = 2E_{Ly}\sin\theta$$

$$dE = \frac{2K\,dq}{r^2}\sin\theta \qquad \left\{\sin\theta = \frac{P}{H} = \frac{Z}{r}\right\}$$

from eq (i)

$$dE = \frac{2K\sigma\,da}{r^2}\left(\frac{Z}{r}\right)$$

$$dE = \frac{2ZK\sigma\,da}{r^3}$$

For 'r' By phytogoron Theorem:-

$$c^2 = a^2 + b^2$$

$$r^2 = z^2 + R^2$$

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$r = (z^2 + R^2)^{\frac{1}{2}}$

Put in :

$$dE = \frac{2zK\sigma\, da}{r^3}$$

$$dE = \frac{2zK\sigma\, da}{(z^2+R^2)^{3/2}}$$

Integrate

$$\int dE = \int_0^R \frac{2zK\sigma(d\alpha\, dw)}{(z^2+R^2)^{3/2}}$$

$$\int dE = 2K\sigma z \int_0^R \frac{2w\,dw}{(z^2+R^2)^{3/2}} \int_0^{\pi} d\alpha$$

$$\int dE = K\sigma z \int_0^R (z^2+R^2)^{-3/2}\, 2w\,dw\, (\pi)$$

$$\int dE = K\sigma z \left| \frac{(z^2+R^2)^{-\frac{1}{2}}}{-\frac{1}{2}} \right|_0^R$$

$$\int dE = \frac{\pi\sigma z}{4\pi\varepsilon_0} \left| -2(z^2+R^2)^{-\frac{1}{2}} \right|_0^R$$

$$\int dE = \frac{-2\pi\sigma z}{4\pi\varepsilon_0} \left(\frac{1}{(z^2+R^2)^{\frac{1}{2}}} - \frac{1}{(z^2+0^2)^{\frac{1}{2}}} \right)$$

$$\int dE = \frac{-\sigma z}{2\varepsilon_0}(-1)\left(\frac{1}{z} - \frac{1}{(z^2+R^2)^{\frac{1}{2}}}\right)$$

$$\int dE = \frac{\sigma}{2\varepsilon_0}\left(\frac{z}{z} - \frac{z}{(z^2+R^2)^{\frac{1}{2}}}\right)$$

$$\int dE = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{z}{(z^2+R^2)^{\frac{1}{2}}}\right)$$

if $R \to \infty$

$$E = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{z}{\infty}\right)$$

$$E = \frac{\sigma}{2\varepsilon_0}(1)$$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

if $z << R$

then $z \to 0$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

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-:(Applied Physics):-

QNO7:-

Define and explain electric flux?

Ans:-

Electric Flux:-

The total number of electric field lines passing through unit area is called Electric Flux. It is denoted by 'ϕ'.

In Mathematically:-

The dot product of Electric field intensity and vector Area is Known as Electric Flux.

$$d\phi_e = \vec{E} \cdot \vec{A}$$

$$d\phi_e = EA\cos\theta$$

B The net electric flux is:-

$$\phi_e = \int EA\cos\theta$$

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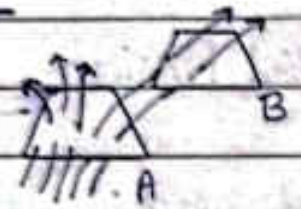
Diagram:-



Formula: $\phi = E \cdot A \cos\theta$

Unit: Nm^2C^{-1}

It is a scalar quantity.

Maximum Flux:-

If area is ~~(perpendicular)~~ (Parallel) to the direction of electric field then flux will be maximum.

$\theta = 0$

Mathematically:-

$$\phi = EA\cos\theta$$

$$\phi = EA\cos(0^\circ)$$

$$\boxed{\phi = EA}$$

Date: / /20

Minimum Flux:-

If the area is ~~(parallel)~~ (Perpendicular) to the direction of electric fields lines then flux will be minimum.

Mathematically:-

$$\phi = EA\cos\theta$$

$$\phi = EA\cos(90^\circ)$$

$$\boxed{\phi = 0}$$

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-:(Applied Physics):-

Semestor 01:-

Qno8:-

State and prove Gauss's law and write integral and differential form?

Answer:-

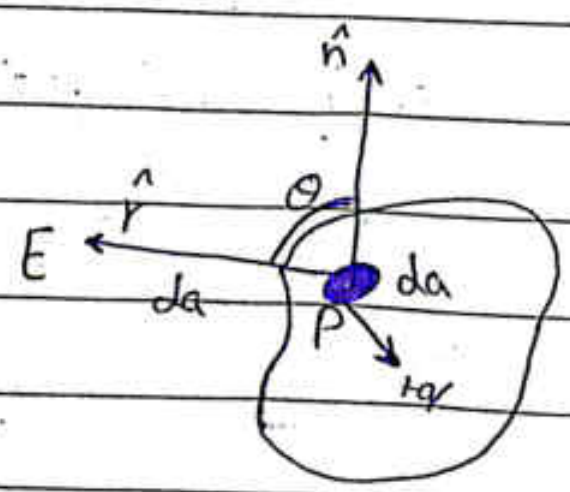
Gauss's Law:-

The Gauss's law state that:
The electric flux passing through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times charge enclosed by that surface.

$$\phi = \frac{q}{\varepsilon}$$

Proof:-

Diagram:-



Consider a +q charge is placed in a closed surface. The electric field lines come out of the surface. Take small element $\vec{da} = da\,\hat{n}$ of the surface at point P.

The electric field at point 'P' due to +q charge having distance 'r' is given by:

$$\vec{E} = \frac{Kq}{r^2}\hat{r}$$

The electric flux is:

$$d\phi = \vec{E}\cdot\vec{da}$$

Integrate:

$$\phi = \int \vec{E}\cdot\vec{da}$$

$$\phi = \int \frac{Kq}{r^2}\hat{r}\cdot da\,\hat{n}$$

$$\phi = \frac{Kq}{r^2}\int da\,(\hat{r}\cdot\hat{n})$$

$$\phi = \frac{Kq}{r^2}\int da\,(\hat{r}\cdot\hat{n})$$

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$$\phi = Kq \int \frac{da}{r^2} (\hat{r} \cdot \hat{n})$$

$$\phi = Kq \int d\Omega$$

$$\phi = Kq (4\pi) \longrightarrow \text{steradian}$$

Putting value of K:-

$$\phi = \frac{1}{4\pi\varepsilon_0} q (4\pi)$$

$$\boxed{\phi = \frac{q}{\varepsilon_0}}$$ Hence proved.

i) **Integral form of Gauss's law:-**

we know that, the volume charge density is:

$$\rho = \frac{dq}{dv}$$

$$dq = \int dv \quad \text{(a)}$$

The net electric flux is:

$$\phi = \int \vec{E} \cdot \vec{da} \quad \text{(b)}$$

put eq (a) and (b) in:

$$\phi = \frac{q}{\varepsilon_0}$$

Putting values:

$$\boxed{\int \vec{E}\cdot\vec{da} = \frac{1}{\varepsilon_0}\int(\rho\, dv)}$$

This is called Integral form of Gauss's law.

(ii) **Differential form of Gauss's law:-**

we Know that:

$$\int \vec{E}\cdot\vec{da} = \frac{1}{\varepsilon_0}\rho\left(\int dv\right) \quad \text{—— (i)}$$

Applying divergence theorem:

$$\int \vec{E}\cdot\vec{da} = \int(\vec{\nabla}\cdot\vec{E})\,dv \quad \text{—— (ii)}$$

Compairing eq (i) and (ii)

$$\frac{1}{\varepsilon_0}\rho\left(\int dv\right) = \int(\vec{\nabla}\cdot\vec{E})\,dv$$

$$0 = \int(\vec{\Delta}\cdot\vec{E})\,dv - \frac{1}{\varepsilon_0}\rho\left(\int dv\right)$$

$$0 = \int\left((\vec{\Delta}\cdot\vec{E}) - \frac{\rho}{\varepsilon_0}\right)dv$$

$$\boxed{\frac{\rho}{\varepsilon_0} = \vec{\Delta}\cdot\vec{E}}$$

This is called differential form of gauss's law.

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:(Applied Physics):-

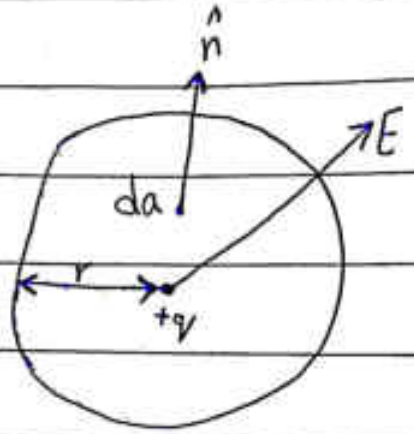
Semester 01:-

Qno9:-

Derive Columb's law from Gauss's law?

Ans:-

Diagram:-



Explanation:-

Consider a +q charge is placed at the center of the sphere having radius r. The sphere is called gussasian sphere.

Take small area element $\vec{da}$ of sphere. The unit vector $\hat{n}$ indicates the direction of 'da'.

The angle between $\hat{n}$ and $\vec{E}$ is zero.

The flux through surface of sphere is:

$$\phi_e = E.A$$

$$d\phi_e = E \cdot da$$

$$d\phi_e = E da \cos(0)^\circ$$

$$d\phi_e = E da$$

Integration:-

$$\phi_e = E \int da$$

$$\phi_e = E(4\pi r^2) \quad \text{(i)}$$

According to Gauss's law:

$$\phi_e = \frac{q}{\varepsilon_0} \quad \text{(ii)}$$

Compairing (i) and (ii)

$$E(4\pi r^2) = \frac{q}{\varepsilon_0}$$

$$E = \frac{q}{4\pi r^2 \varepsilon_0} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$

$$E = \frac{Kq}{r^2} \quad \text{(iii)}$$

we know that $\Rightarrow$ $E = \frac{F}{q_0}$

So,

$$\frac{F}{q_0} = \frac{Kq}{r^2}$$

$$\boxed{F = \frac{Kqq_0}{r^2}}$$

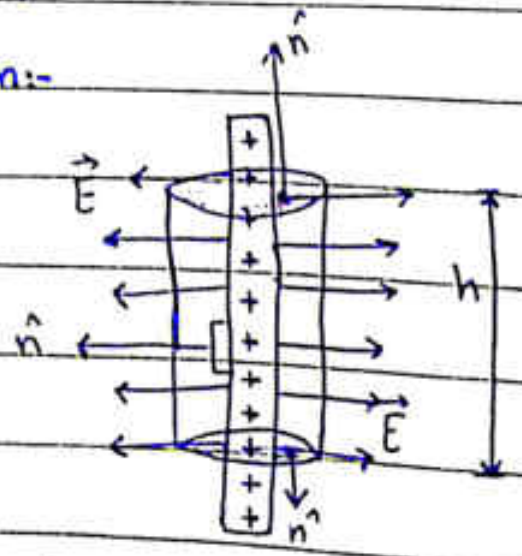
This is statement of Columb's law.

Q No 10:-

Calculate electric field due to infinite line of charges by using Gauss's law?

Answer:-

Diagram:-



Explanation:-

Consider a straight positively charged wire having infinite length

Now take a cylinder called gussian surface having radius 'r' and height 'h'

Take a small length element 'dz' of the line having charge 'dq'.

The linear charge density is:

$$\lambda = \frac{dq}{dz}$$

$$dq = \lambda dz$$

Integration :-

$$q = \lambda \int dz$$

$$q = \lambda h \quad \text{——— (i)}$$

The flux through surface is:

$$d\phi = \vec{E} \cdot \vec{da} = E da \cos(0^\circ)$$

$$d\phi = E da$$

Integration:-

$$\phi = E \int da = E(L \times W)$$

$$\phi = E(2\pi r h) \quad \text{——— (ii)}$$

by Gauss's law :-

$$\phi = \frac{q}{\varepsilon_0}$$

From eq (i)

$$\phi = \frac{\lambda h}{\varepsilon_0} \quad \text{(iii)}$$

Compairing eq (ii) and (iii)

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

$$E = \frac{\lambda}{2\pi r \varepsilon_0} = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$$

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

In vector form:-

$$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r} \times \hat{r}$$

-:Long:-

Qno11:-

Calculate the electric field intensity due to infinite sheet of charges?

Answer:-

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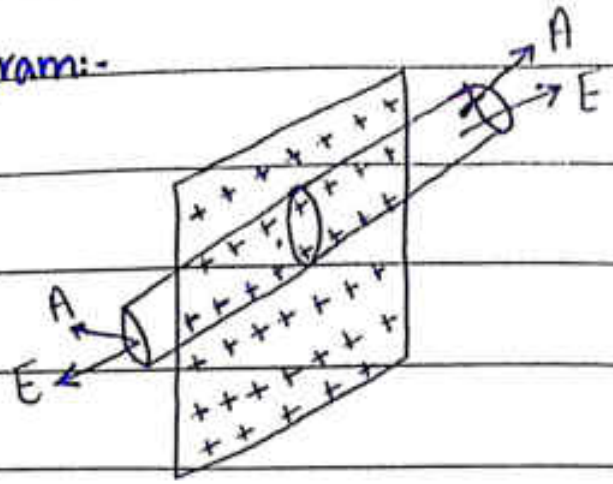
Diagram:-



Explanation:-

Consider a positively charged sheet having infinite length. We have to calculate electric field $\vec{E}$ at points near the sheet by Gauss's law:
Imagine a célender/cylinder called guassian surface having cross-sectional Area 'A'.
Take small area element 'da' of sheet having charge 'dq'.
The surface charge density is:

$$\sigma = \frac{dq}{da} \Rightarrow dq = \sigma da$$

Integration:-

$$q = \sigma \int da$$

$$q = \sigma A \quad \text{(i)}$$

The flux through surface is:

$$d\phi_e = E da \cos(0^\circ) + E da \cos(0^\circ)$$

$$d\phi_e = E da + E da$$

$$d\phi_e = 2E da$$

Integration:-

$$\phi_e = 2E \int da$$

$$\phi_e = 2EA \quad \text{——— (ii)}$$

By Gauss's law:

$$\phi_e = \frac{q}{\varepsilon_0}$$

from (i)

$$\phi_e = \frac{\sigma A}{\varepsilon_0} \quad \text{——— (iii)}$$

Compairing (ii) and (iii)

$$2EA = \frac{\sigma A}{\varepsilon_0}$$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

In vector form

$$\vec{E} = \frac{\sigma}{2\varepsilon_0} \times \hat{n}$$

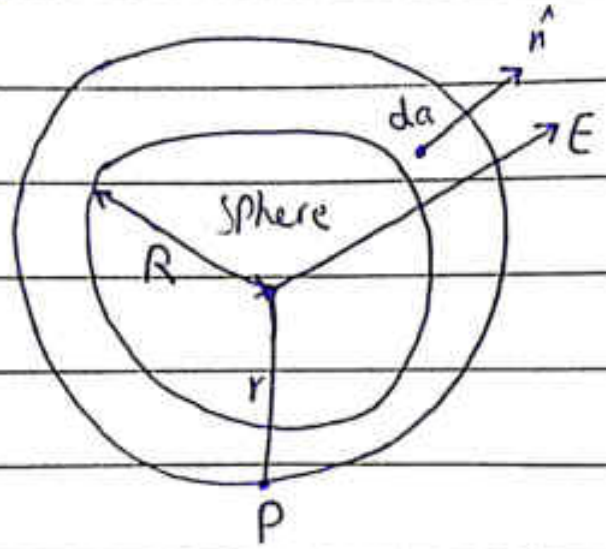
-: Long :-

Q No 12:-

Calculate the electric field at a point due to spherical volume charge distribution?

Answer:-

Diagram:-



Explanation:-

Consider a sphere of rudius R having uniform positive charge. Take a small volume element 'dV' of the sphere having charge 'dq'.

The volume charge density is:

$$\rho = \frac{dq}{dv}$$

$$dq = \rho dv$$

By Integration:-

$$q = \rho \int dv$$

$$q = \rho\left(\frac{4}{3}\pi R^3\right) \quad \text{(i)}$$

The flux through surface is:

$$d\phi = \vec{E}\cdot d\vec{a} = E\,da\cos(0^\circ)$$

$$d\phi = E\,da$$

Integrate:

$$\phi = E\int da$$

$$\phi = E(4\pi r^2) \quad \text{(ii)}$$

By Gauss's law:

$$\phi = \frac{q}{\varepsilon_0} \quad \text{(from (i))}$$

$$\phi = \frac{\rho\, 4\pi R^3}{3\varepsilon_0} \quad \text{(iii)}$$

Compairing eq (ii) and (iii).

$$E(4\pi r^2) = \frac{\rho\, 4\pi R^3}{3\varepsilon_0}$$

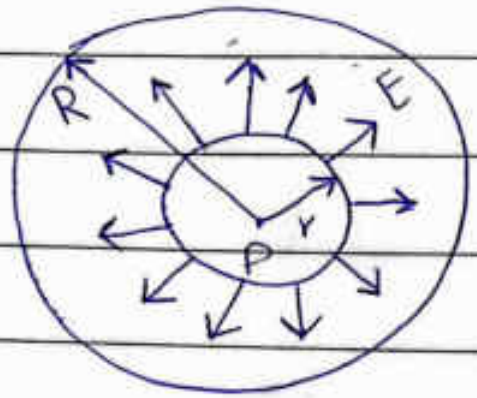
$$\boxed{E = \frac{\rho R^3}{3\varepsilon_0 r^2}}$$

-:(Applied Physics):-

Semester 01:-

13:- Electric field inside spherical charge distribution:-

Diagram:-



Explanation:-

Consider a uniformly charged sphere having radius R. Take a small volume element dv of the sphere having charge dq. The volume charge density is defined as:

$$\rho = \frac{dq}{dv}$$

$$dq = \rho\, dv$$

Integration:-

$$q = \int \rho \, dv$$

$$q = \frac{4}{3}\pi R^3 \rho \quad \text{——— (i)}$$

Now take a point P inside charged sphere having distance 'r' from central charged sphere.

$$q' = \frac{4}{3}\pi r^3 \rho \quad \text{——— (ii)}$$

divided eq(ii) by eq(i)

$$\frac{q'}{q} = \frac{r^3}{R^3}$$

$$q' = \frac{q r^3}{R^3} \quad \text{——— (iii)}$$

The electric flux is:

$$\phi = \int E \, da \cos\theta \quad \{\theta = 0^\circ\}$$

$$\phi = E \int da$$

$$\phi = E(4\pi r^2) \quad \text{——— (iv)}$$

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By Gauss's law:

$$\phi = \frac{q'}{\varepsilon_0}$$

Putting values

$$E(4\pi r^2) = \frac{q r^3}{R^3 \varepsilon_0}$$

$$E = \frac{q r^3}{4\pi\varepsilon_0 r^2 R^3}$$

$$E = \frac{q r}{4\pi\varepsilon_0 R^3}$$

Electric field at surface of sphere:

$$E = \frac{q r}{4\pi\varepsilon_0 R^3}$$

Put $r = R$, to calculate electric field at the surface of sphere.

$$E = \frac{q R}{4\pi\varepsilon_0 R^3} = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}$$

$$\boxed{E = \frac{Kq}{R^3}}$$

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-:(Applied Physics):-

Semester # 01:-

Qno24:-

Calculate electric field intensity due to spherical charged shell of constant surface charge density?

Answer:-

SHELL Theorem:-

There are two shell theorems established by using Gauss's law for uniform spherical shell of charges having constant surface charge density.

1st SHELL Theorem:-

"A uniform spherical shell of charges behaves for external points in such a way that all its charges was concentrated at its center."

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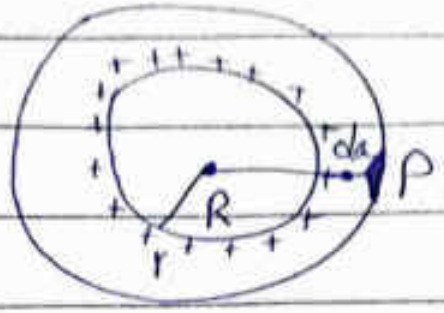
Proof:-



The surface charge density is:

$$\sigma = \frac{dq}{da}$$

$$dq = \sigma\, da$$

Integral:

$$q = \sigma \int da$$

$$q = \sigma\,(4\pi R^3) \quad \text{——— (i)}$$

Now consider a point P outside shell having distance r from the center of spherical charged shell.

The electric flux is:

$$\phi = \int E\, da$$

$$\phi = E(4\pi r^2) \quad \text{——— (ii)}$$

By Gauss's law:

$$\phi = \frac{q}{\varepsilon_0}$$

Putting values from (i) and (ii)

$$\phi = \frac{q}{\varepsilon_0}$$

$$E(4\pi r^2) = \frac{\sigma(4\pi R^3)}{\varepsilon_0}$$

$$E = \frac{\sigma(4\pi R^3)}{4\pi r^2 \varepsilon_0}$$

$$E(4\pi r^2) = \frac{q}{\varepsilon_0}$$

$$\boxed{E = \frac{Kq}{r^2}}$$

This is electric field at point P due to point charge q.

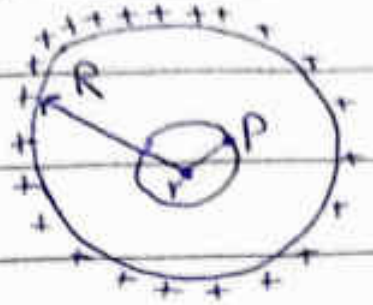
First shell theorem is proved.

2nd SHELL Theorem:-

"A uniform charged spherical shell exerts no electrostatics force on charged particle placed inside the shell."

Proof:-

Diagram:-



Consider a positively charged spherical shell having radius R and uniform surface density σ. The net charge on shell is q.

Take a point 'P' inside the shell where we want to evaluate electric field.

Electric flux is:

$$d\phi = E\,da$$

Integrate:

$$\phi = E\int da$$

$$\phi = E(4\pi r^2) \quad \text{——— (i)}$$

By Gauss's law:

$$\phi = \frac{q}{\varepsilon_0}$$

Put value

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$$E(4\pi r^2) = \frac{q}{\varepsilon_0}$$

$$E = \frac{q}{4\pi\varepsilon_0 r^2}$$

Inside the guassian surface, charge is zero ($q=0$)

$$E = \frac{0}{4\pi\varepsilon_0 r^2} = 0$$

$$\boxed{E = 0}$$

The electric force on charged placed inside guassian shell.

$$F = qE$$

$$F = q(0)$$

$$\boxed{F = 0}$$

Hence, the 2nd shell theorem is proved.

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-:(Applied Physics):-

Semester 01:-

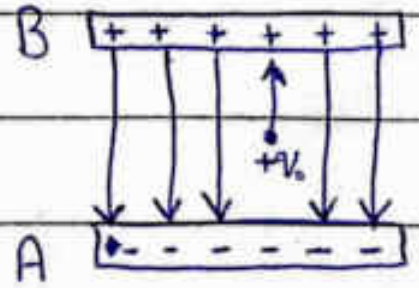
Q No 25:-

What is electric potential?

Ans:-

Electric Potential:-

Consider a +ve test charge is placed between two oppositely charged plates A and B.
The electric field lines come out from positive plate and enter into negative plate.



$$\Delta U = U_f - U_i$$

$$\Delta U = -W$$

"The negative work done by the electric force to move unit test charge with constant velocity from one point to other point is called Potential Difference between these points."

$$\Delta V = -\frac{W}{q_0}$$

$$V_f - V_i = -\frac{W}{q_0}$$

The electric potential V_f is zero when final position f is shifted at infinity. So,

$$0 - V_i = -\frac{W}{q_0}$$

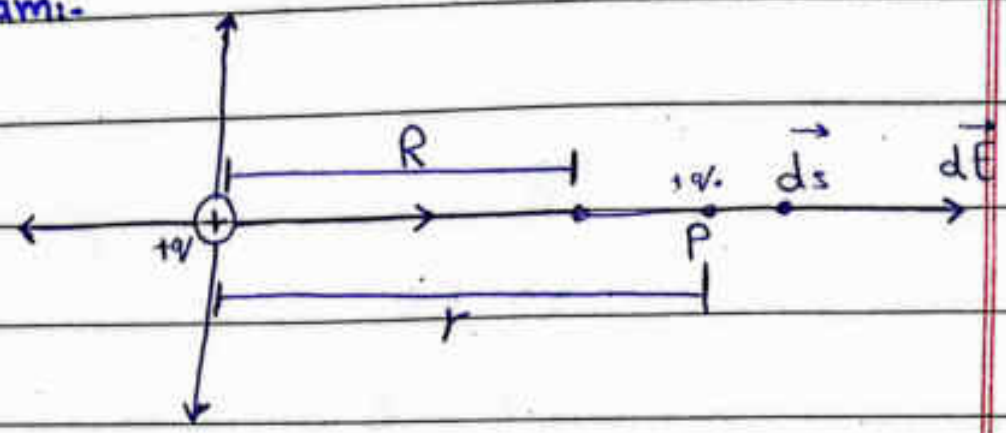
$$\boxed{V = \frac{W}{q_0}}$$

Q.No26:-

Calculate electric potential due to point charge?

Ans:-

Diagram:-



The electric field lines come out radially from positive charge

Consider such a line which extends radially from charge +q through point P to infinity distance.

Now place a test charge +q₀ at point P having distance 'r' from charge +q.

The work done on test charge +q₀ due to electric force $\vec{F_e}$ when it moves +q₀ through displacement $\vec{ds}$

between Initial position and final position is:

$$W = \int \vec{F} \cdot d\vec{r}$$

$$\{\because \theta = 180\}$$

$$W = \int F dr \cos(180)$$

$$W = -\int F dr$$

we Know that:

$$E = \frac{F}{q_0} \Rightarrow F = Eq_0$$

$$W = -\int Eq_0 \, dr$$

$$\left\{E = \frac{Kq}{r^2}\right\}$$

$$W = -q_0 \int \frac{Kq}{r^2} dr$$

$$\frac{W}{q_0} = -\int \frac{Kq}{r^2} dr$$

$$\Delta V = -Kq \int r^{-2} dr$$

Applying Limit...

$$\Delta V = -Kq \int_{r_A}^{r_B} r^{-2} dr$$

$$\Delta V = -Kq\left[\frac{r^{-1}}{-1}\right]_{r_A}^{r_B}$$

$$\Delta V = Kq\left[\frac{1}{r}\right]_{r_A}^{r_B}$$

$$\Delta V = Kq\left(\frac{1}{r_B} - \frac{1}{r_A}\right)$$

if $r_A = \infty$; $V_A = 0$

$\{\because \Delta V = V_B - V_A\}$

$$V_B - V_A = Kq\left(\frac{1}{r_B} - \frac{1}{\infty}\right)$$

$$V_B - 0 = Kq\left(\frac{1}{r_B}\right)$$

$$\boxed{V_B = \frac{Kq}{r_B}}$$

$$\boxed{V = \frac{Kq}{r}} \Rightarrow \boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}}$$

..(Applied Physics):-

Semester 01:-

QNo17:-

What is electric dipole? Calculate electric potential due to dipole at a point having diameter?

Answer:-

Electric Dipole:-

"Two equal charges of opposite sign ($\pm q$) seperated by distance 'd' is called Electric Dipole."

Electric dipole Moment:-

"The product of magnitude of either charge and separation between them is called electric dipole moment."

$$P = qd$$

It is a vector quantity. Its direction is from negative charges towards positive charges.

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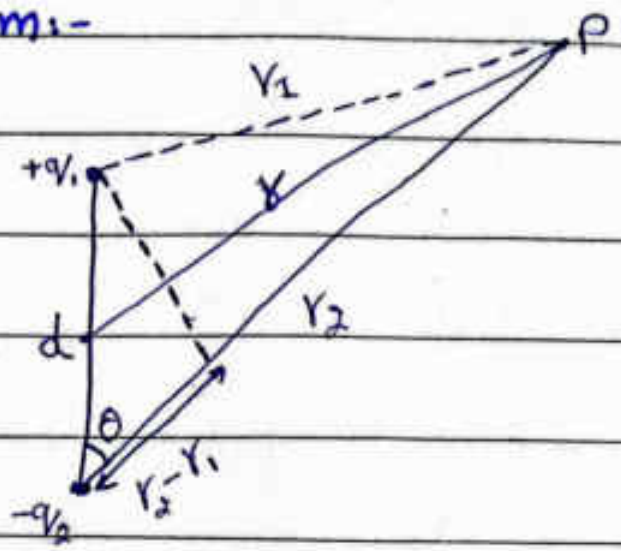
Electric Potential due to electric dipole:-

Diagram:-



Consider a $+q$ charge and $-q$ charge seperated by distance 'd' placed on x-axis. Take a point P having distance r_1 from $+q$ and r_2 from $-q$ charge

The electric potential due to $+q$ charge is:

$$V_1 = \frac{Kq}{r_1}$$

The electric potential due to $-q$ charge is: $V_2 = -\frac{Kq}{r_2}$

The net electric potential is:

$$V = V_1 + V_2$$

$$V = \frac{Kq}{r_1} - \frac{Kq}{r_2}$$

$$V = Kq\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$V = Kq\left(\frac{r_2 - r_1}{r_1 r_2}\right)$$

from the diagram

$$r_2 - r_1 = d\cos\theta$$

So,

$$V = Kq\left(\frac{d\cos\theta}{r_1 r_2}\right)$$

$$V = K\left(\frac{qd\cos\theta}{r_1 r_2}\right)$$

$$\{\because P = qd\}$$

$$\boxed{V = K\left(\frac{P\cos\theta}{r_1 r_2}\right)}$$

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-:(Applied Physics):-

Semester 01:-

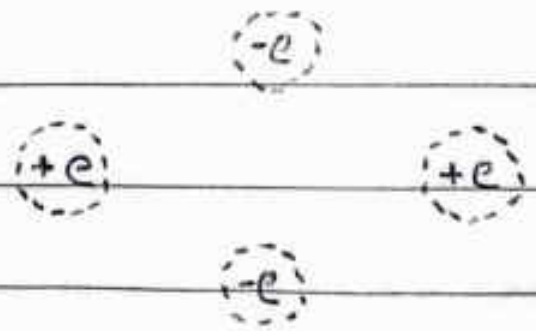
QNo18:-

Calculate Electric Potential due to quadrupole?

Answer:-

The two electric dipoles arranged in such a way that they almost cancel electric effects of each other at distant points is called Quadrupole.

Diagram:-



An elementary quadrupole can be represented as two dipoles oriented antiparallel. The most important uses of quadrupole is the characterization of nuclei.

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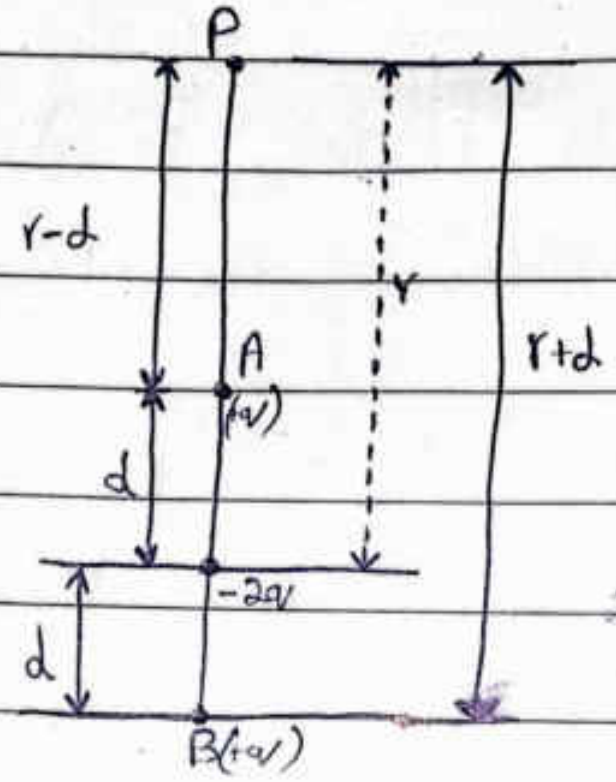
Electric Potential due to Quadrupole:-

Diagram:-



Explanation:-

Consider two charges each of value -q are placed at origin on x-axis.

Now place +q charge at point A having distance 'd' from '-2q'.

Similarly place an other charge (+q) at point B having distance 'd' from '-2q'.

Now take a point P on z-axis having distance 'r' from $-2q$ and (diameter)* distance $(r+d)$ from $+q$ charges at B.

The electric potential at P due to $+q$ at A is:

$$V_1 = \frac{Kq}{r-d}$$

Similarly due to $+q$ at B.

$$V_2 = \frac{Kq}{r+d}$$

due to $-2q$ charge:

$$V_3 = \frac{K(-2q)}{r}$$

The total electric potential is:

$$V = V_1 + V_2 + V_3$$

$$V = \frac{Kq}{r-d} + \frac{Kq}{r+d} - \frac{2Kq}{r}$$

$$V = Kq\left(\frac{1}{r-d} + \frac{1}{r+d} - \frac{2}{r}\right)$$

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$$V = Kq\left(\frac{r^2 + \cancel{dr} + r^2 - \cancel{dr} - 2(r^2 - d^2)}{r(r-d)(r+d)}\right)$$

$$V = Kq\left(\frac{\cancel{2r^2} - \cancel{2r^2} + 2d^2}{r(r^2 - d^2)}\right)$$

$$V = \frac{Kq(2d^2)}{r(r^2 - d^2)}$$

$$V = \frac{K(2qd^2)}{r^3\left(1 - \frac{d^2}{r^2}\right)}$$

$$\left\{\because \begin{array}{l} P = qd \\ Q = 2qd^2 \end{array}\right\}$$

$$V = \frac{KQ}{r^3}\left(1 - \frac{d^2}{r^2}\right)^{-1}$$

By Binomial :-

$$V = \frac{KQ}{r^3}\left(1 + (-1)\left(\frac{-d^2}{r^2}\right) + \ldots\ldots\right)$$

The term $\left(\frac{-d^2}{r^2}\right) = 0$ because $r >>> d$

$$\boxed{V = \frac{KQ}{r^3}}$$

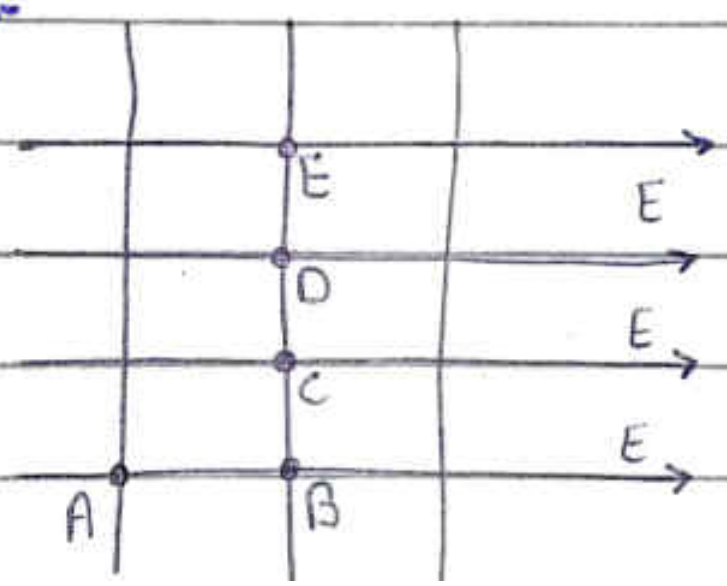
Topic:-

Equipotential Surfaces:-

The family of surfaces that connect points having same value of the electric potential are called equipotential surfaces.

Due to Uniform field:-

Diagram:-



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DAY:

Explanation:-

Consider uniform electric field indicated by horizontal electric lines of force. The perpendicular dashed lines are cross-section of equipotential surface.

Take two points having distance l.

$$\Delta V = -\int_A^B E \cdot ds$$

$$\Delta V = -EL$$

Potential difference b/w B and C:

Electric potential at B is $V_B = \frac{Kq}{r_B}$

Electric potential at C is $V_C = \frac{Kq}{r_C}$

$$\Delta V = V_B - V_C$$

$$V_B - V_C = \frac{Kq}{r_B} - \frac{Kq}{r_C} \quad \{\because r_B = r_C\}$$

$$V_B - V_C = \frac{Kq}{r_B} - \frac{Kq}{r_B}$$

$$V_B - V_C = 0$$

$$\boxed{V_B = V_C}$$

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Since $\Delta V = \frac{-W_{BC}}{q_0} = 0$, So $W_{BC} = 0$

Hence no work is done by electric field when q_0 is moved from B to C.

(ii) Due to positive point charge:-

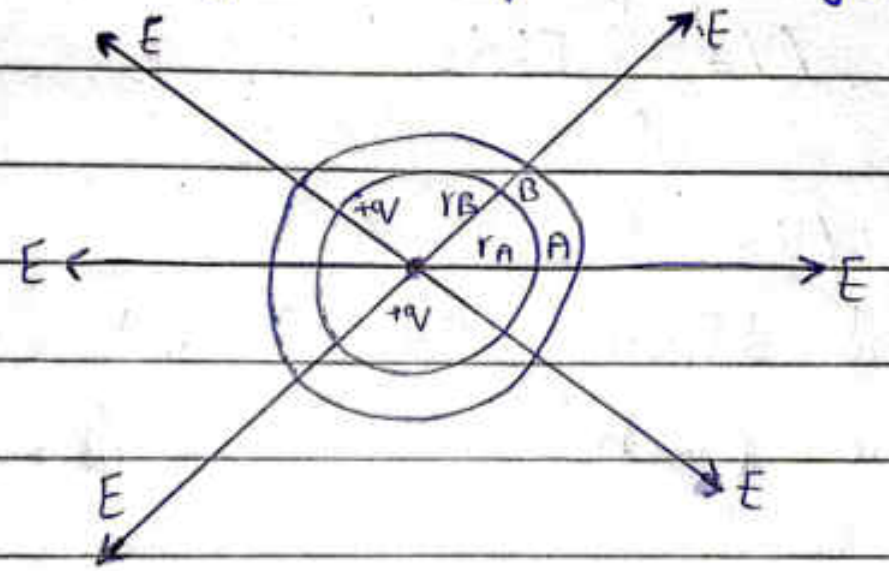

Diagram:-

In this way all the points on the line containing points A, B, C etc have same potential. The surface passing through these points are called equipotential surface.

Consider a +q charge is placed at the center of sphere. The electric field is along radius direction.

Potential difference b/w A and B.

$$V_A - V_B = Kq\left(\frac{1}{r_A} - \frac{1}{r_B}\right)$$

when points A and B lies on the surface of same sphere $r_A = r_B$

In this case:-

$$V_A - V_B = Kq\left(\cancel{\frac{1}{r_A}} - \cancel{\frac{1}{r_A}}\right)$$

$$V_A - V_B = 0$$

$$\boxed{V_A = V_B}$$

It means all points at a given radius have the same potential. Therefore, the equipotential surface of a given charge from a family of concentric sphere.

For a dipole, the equipotential surfaces are more complicated.

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-:(Applied Physics):-

Semester 01:-

QNo19:-

What is continous charge distribution? Derive an expression to calculate electric potential at a point due to continous charge distribution?

Ans:-

Electric Potential due to Continous charge distribution:-

The electric charge is quantized. The collection of large number of charges is called continous charge distribution. The continous charge distribution has three types.

- Linear charge distribution
- Surface charge distribution
- Volume charge distribution

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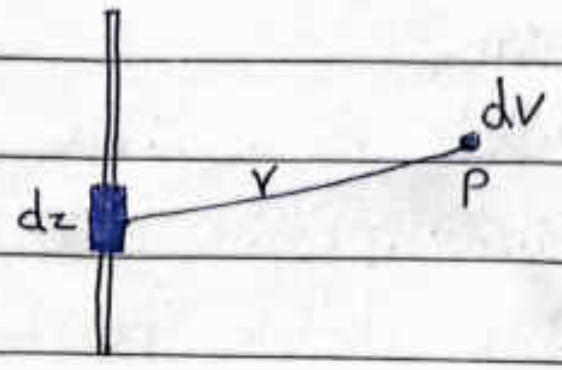
(i) Electric Potential due to Linear charge Distribution:-



Consider a linear charge distribution. Take a small length element 'dz' of this distribution having charge 'dq'.

$$\lambda = \frac{dq}{dz} \Rightarrow dq = \lambda dz$$

The electric potential at P due to charge dq is

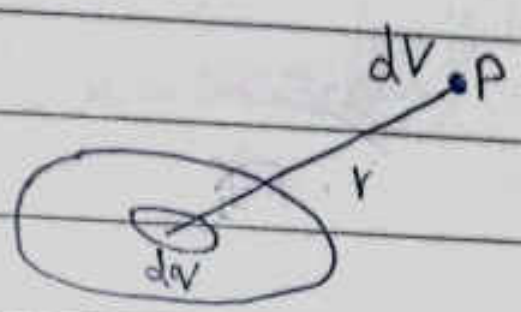
$$dV = \frac{K\,dq}{r}$$

$$dV = \frac{K\lambda dz}{r}$$

Integrate:-

$$\boxed{V = \int \frac{K\lambda}{r}\, dz}$$

(ii) Electric Potential due to Surface charge Distribution:-



Consider a surface charge distribution. Take a small area element 'da' of this distribution having charge 'dq'.

$$\sigma = \frac{dq}{da} \Rightarrow dq = \sigma da$$

The electric potential at P due to charge dq is:

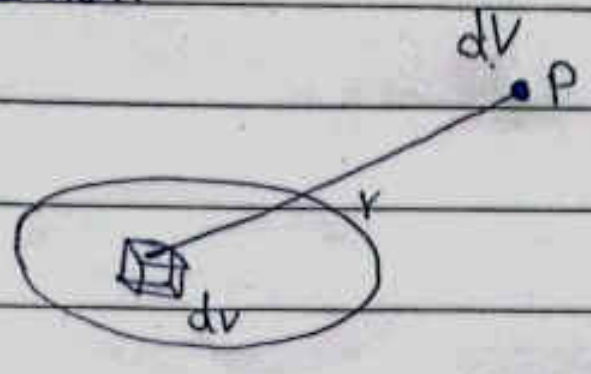
$$dV = \frac{K dq}{r}$$

$$dV = \frac{K \sigma da}{r}$$

Integrate:

$$\boxed{V = \int \frac{K \sigma da}{r}}$$

Electric Potential due to Volume charge distribution:-



Consider a volume charge distribution. Take a small volume element 'dV_e' of the distribution having charge 'dq'.

$$\rho = \frac{dq}{dV} \Rightarrow dq = \rho\, dV_e$$

The electric potential at P due to charge dq is:

$$dV = \frac{K\,dq}{r}$$

$$dV = \frac{K\rho\, dV_e}{r}$$

Integrate:

$$\boxed{V = \int \frac{K\rho}{r}\, dV_e}$$

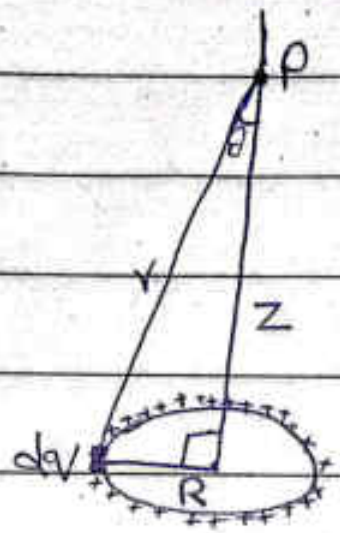
-:(Applied Physics):-

Semester 01:-

Qno20:-

Calculate electric potential at a point due to ring of charges?

Answer:-



Consider a uniformly charged ring having radius R. Take a small length element ds of ring having charge dq. The linear charge density is:

$$\lambda = \frac{dq}{ds} \Rightarrow dq = \lambda ds$$

By Integration:

$$q = \lambda(2\pi R)$$

Now take a point on z-axis having distance 'z' from the plane of ring. Electric potential dV due to charge dq is:

$$dV = \frac{K\,dq}{r}$$

$$dV = \frac{K\lambda ds}{r}$$

By Integration:

$$V = \int \frac{K\lambda ds}{r}$$

$$\left\{\begin{array}{l} c^2 = a^2 + b^2 \\ r^2 = R^2 + z^2 \\ r = \sqrt{R^2 + z^2} \end{array}\right\} \rightarrow V = \frac{K\lambda}{(R^2+z^2)^{\frac{1}{2}}} \int ds$$

$$V = \frac{K\lambda(2\pi R)}{(R^2+z^2)^{\frac{1}{2}}}$$

$$\boxed{V = \frac{Kq}{\sqrt{R^2+z^2}}}$$

This is the electric potential due to a ring of charges.

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The electric field at point P due to ring of charges is:

$$E = -\frac{dV}{dz} = -\frac{d}{dz}\left(\frac{Kq}{(R^2+z^2)^{\frac{1}{2}}}\right)$$

$$E = -Kq\frac{d}{dz}(R^2+z^2)^{-\frac{1}{2}}$$

$$E = -Kq\left(\frac{-1}{2}\right)(R^2+z^2)^{-3/2}(2z)$$

$$E = \frac{Kq\cancel{2}z}{\cancel{2}(R^2+z^2)^{3/2}}$$

$$\boxed{E = \frac{Kqz}{(R^2+z^2)^{3/2}}}$$

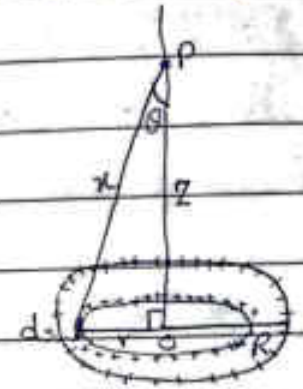
-:(Applied Physics):-

Semester 01:-

Q No 21:-

Calculate electric Potential due to disk of charges?

Ans:-



Consider a disk of radius R having uniform charge density 'σ' on its top surface.

Take a point P on the central axis of disk having distance 'z'.

Now, take such a ring having radius 'r'.

The surface charge density is:

$$\sigma = \frac{dq}{da}$$

$$dq = \sigma\, da \Rightarrow \{ da = (2\pi r)dr \}$$

$$dq = \sigma(2\pi r)dr \quad \text{——— (i)}$$

The electric potential at a point P due to charge dq of ring having distance 'x' is:

$$dV = \frac{K\,dq}{x}$$

Value of 'x' by phtcogeron theorem:

$$c^2 = a^2 + b^2$$

$$x^2 = r^2 + z^2$$

$$x = \sqrt{r^2 + z^2}$$

So,

$$dv = \frac{K\,dq}{\sqrt{r^2+z^2}}$$

$$dV = \frac{K\sigma\, da}{\sqrt{r^2+z^2}} = \frac{K\sigma(2\pi r)dr}{\sqrt{r^2+z^2}}$$

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$$dV = \frac{1}{4\pi\varepsilon_0} \frac{\sigma(2\pi r)dr}{\sqrt{r^2+z^2}}$$

$$dV = \frac{\sigma r}{2\varepsilon_0} \frac{dr}{\sqrt{r^2+z^2}}$$

By Integration:

$$V = \frac{\sigma}{2\varepsilon_0} \int_0^R \frac{r\,dr}{(r^2+z^2)^{\frac{1}{2}}}$$

$$V = \frac{\sigma}{2\varepsilon_0} \int_0^R (r^2+z^2)^{-1/2}\, r\,dr$$

$$V = \frac{\sigma}{2\varepsilon_0} \frac{1}{2} \int_0^R (r^2+z^2)^{-\frac{1}{2}} (2r)\,dr$$

$$V = \frac{\sigma}{4\varepsilon_0} \left[\frac{(r^2+z^2)^{\frac{1}{2}}}{\frac{1}{2}} \right]_0^R$$

$$V = \frac{\sigma}{4\varepsilon_0} \cdot 2 \left[(r^2+z^2)^{\frac{1}{2}} \right]_0^R$$

$$V = \frac{\sigma}{2\varepsilon_0} \left[(R^2+z^2)^{\frac{1}{2}} - (0^2-z^2)^{\frac{1}{2}} \right]$$

$$\boxed{V = \frac{\sigma}{2\varepsilon_0} \left(\sqrt{R^2+z^2} - z \right)} \quad \text{(ii)}$$

By Binomial Series

$$(z^2+R^2)^{\frac{1}{2}} = z\left(1+\frac{R^2}{z^2}\right)^{\frac{1}{2}}$$

$$= z\left(1+\frac{1}{2}\frac{R^2}{z^2}+\ldots\ldots\right)$$

$$= z\left(1+\frac{R^2}{2z^2}\right)$$

$$(z^2+R^2)^{\frac{1}{2}} = \left(z+\frac{R^2}{2z}\right)$$

Put in eq (ii)

$$V = \frac{\sigma}{2\varepsilon_0}\left(\cancel{z}+\frac{R^2}{2z}-\cancel{z}\right)$$

$$\boxed{V = \frac{\sigma R^2}{4z\varepsilon_0}}$$

Let make assumption:-

$$V = \frac{\sigma \pi R^2}{4\pi\varepsilon_0 z}$$

$$V = K\sigma\left(\frac{\pi R^2}{z}\right)$$

$$\begin{cases} dq = \sigma da \\ q = \sigma(2\pi R^2) \end{cases}$$

$$\boxed{V = \frac{K\sigma}{z}}$$

-:(Physics):-

Semester 01:-

Chapter 06:-

QNo1:-

What is electric current and current density and write its unit?

Answer:-

"The rate of flow of charges through a conductor is called electric current."

$$I = \frac{dq}{dt}$$

The SI unit of electric current is called Ampere.

"The current established in conductor is equal to one ampere when one coulomb charges flows through a conductor in one second.

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Current Density:-

The current per unit cross sectional area of a conductor is called current density.

It is denoted by $\vec{J}$. It is a vector quantity. SI unit is Am^{-2}

$$J = \frac{dI}{da} \Rightarrow dI = \vec{J} \cdot \vec{da}$$

$$I = \int \vec{J} \cdot \vec{da}$$

$$I = JA$$

$$\boxed{J = \frac{I}{A}}$$

QNo2:-

What is drift velocity? Establish a relation between drift velocity and current density?

Ans:-

"The constant average velocity acquired during this process by free electron against electric field is called Drift velocity." (V_d)

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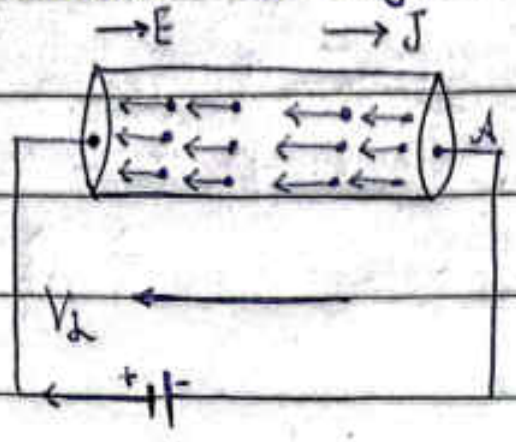
The drift velocity is of the order $10^{-3} ms^{-1}$.

Relational between drift velocity and current density:-



One carrier charge = e

nAL carrier charge = ALne

The total charge q on conductor is:

$$q = nALe \quad \text{(i)}$$

$$I = \frac{q}{t}$$

$$q = It \quad \text{(ii)}$$

$$I \times t = nALe$$

$$\{\because L = V_d t\}$$

$$I \cancel{t} = nAV_d \cancel{t} e$$

$$I = nAV_d e$$

$$\frac{I}{A} = nV_d e$$

$$J = neV_d$$

$$\boxed{V_d = \frac{J}{ne}}$$

QNo3:-

Define electrical resistance, conductance, resistivity, conductivity and write their units?

Answer:-

Electrical Resistance:-

"The measurement of opposition to flow of charges through a conductor due to collision with ionic cores of conductor is called Electrical resistance."

"The conductor used in a circuit to provide specified resistance is called Resistor."

$$R = \frac{V}{I}$$

Unit: ohm (Ω)

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Conductance:-

The reciprocal of resistance is called conductance. It is denoted by G.

$$G = \frac{1}{R} = \frac{I}{V}$$

Unit: mho (Ω^{-1}) or siemen

Resistivity:-

"The ratio of electric field E applied to a conductor and current density J is called resistivity."

"The resistance of one $(meter)^3$ of a material is called resistivity."

It is denoted by ρ.

$$\rho = \frac{E}{J}$$

Unit: Ohm-meter (Ωm)

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Date: / /20

Conductivity:-

The reciprocal of resistivity is called conductivity. It is denoted by σ.

$$\sigma = \frac{1}{\rho} = \frac{J}{E}$$

Unit: mho-meter $(\Omega m)^{-1}$

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:(Applied Physics):-

Chapter 06:-

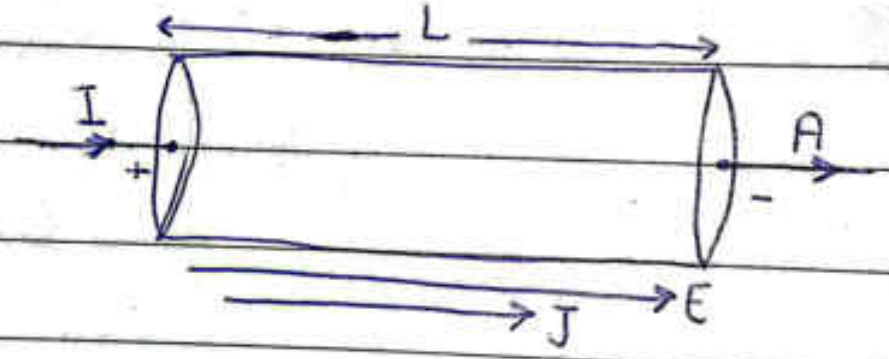
Q.No4:-

A potential V is applied across length L of a conductor. Relate:

(i) J with ρ and E with V and L.

(ii) Prove that $\rho = RA/L$?

Answer:-



Consider a cylinderical conductor having length L and cross sectional Area A. The current I flows through conductor when V is applied at the end of a conductor.

The electric field E and Pd V are related as:

$$E = \frac{V}{L}$$

$$E = \frac{IR}{L} \quad \text{——— (i)}$$

Resistivity is given as:

$$\rho = \frac{E}{J}$$

$$E = \rho J \quad \text{——— (ii)}$$

Compairing eq (i) and (ii)

$$\rho J = \frac{IR}{L}$$

$$J = \frac{IR}{\rho L} \quad \text{——— (iii)}$$

The current density is:

$$J = \frac{I}{A} \quad \text{——— (iv)}$$

Compairing eq (iii) and (iv)

$$\frac{\cancel{I}}{A} = \frac{\cancel{I}R}{\rho L} \Rightarrow A = \frac{\rho L}{R}$$

$$R = \frac{\rho L}{A} \Rightarrow \boxed{\rho = \frac{RA}{L}}$$

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This is the relation between resistivity and resistance.

Q.No5:-

What is temprature coefficient of resistivity. Derive its formula and explain effect of temprature variation on resistivity?

Answer:-

"The fractional change in resistivity per unit charge in tempreture is called temperature coefficient of resistivity."

It is denoted by α. Its SI unit is $(Kelvin)^{-1}$"

Explanation:-

Consider a conductor having resistivity ρ_0 at temperature T_1. The resistivity of conductor increased by amount

$d\rho = \rho_t - \rho_0$

It is experimently found that

increase in resistivity $d\rho$ is directly proportional to the changes in temperature dT and original resistivity ρ_0.

$$\cancel{d\rho \; d\rho \propto \rho}$$

$$d\rho \propto \rho_0 \, dT$$

$$d\rho = \alpha \rho_0 dT$$

$$\alpha = \frac{d\rho}{\rho_0 \, dT}$$

The final resistivity of material is given by:

~~Resistance = Original~~

Final ρ = original ρ + Increase in ρ

$$\rho_t = \rho_0 + d\rho$$

$$\rho_t = \rho_0 \; \alpha \rho_0 dT$$

$$\rho_t = \rho_0 (1 + \alpha dT)$$

Using the relation of resistivity and resistance, we get

$$R_t = R_0 (1 + \alpha dT)$$

-:(Applied Physics):-

Chapter 06:-

Q.No06:-

Define current density. State and explain Ohm's law and write its macroscopic and microscopic form in terms of current density and electric field intensity?

Answer:-

"The current flowing through a conductor per unit area is called current density."

It is a vector quantity.

$$\boxed{J = \frac{I}{A}}$$

Am^{-2} = Unit

OHM's Law:-

The Ohm's law can be stated in two ways called macroscopic form and microscopic form:

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(i) **Macroscopic Form:-**

The macroscopic form of ohm's law states that current flows through a conductor when ρd is applied at the ends of this conductor. The amount of this current is directly proportional to the applied ρd provided that physical state of conductor such as temperature remains constant.

$$V \propto I$$

$$V = IR$$

where R is proportionality constant called resistance of conductor.

Ohmic and Non-Ohmic Circuits:-

The material or circuit elements which obeys ohm's law is called ohmic. The graph b/w current and voltage is a straight line.

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The material or circuits elements such as diode, bulb which does not obey ohm's law is called non-ohmic. The graph b/w current and voltage is non linear.

(ii) Microscopic form:-

The microscopic form of Ohm's law states that current density established in conductor is directly proportional to the electric field which is applied at the end of a conductor.

Explanation:-

Consider a conductor having length L and cylindrical cross sectional area A. The current I flows through conductor whe Pd 'V' is applied at its end.

$$V = IR$$

As $R = \frac{\rho L}{A}$

So,

$$V = I \frac{\rho L}{A}$$

$$\left\{ J = \frac{I}{A} \right\}$$

$$V = \rho J L$$

$$\frac{V}{L} = \rho J \quad \text{——— (i)}$$

Potential difference per unit length is equal to electric field.

$$\frac{V}{L} = E \quad \text{——— (ii)}$$

$$\boxed{E = \rho J}$$

This is called microscopic form of Ohm's law.

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:(Applied Physics):-

Chapter 06:-

QNo7:-

Describe the relation b/w macroscopic and microscopic Parameter of Ohm's law?

Answer:-

(i) The macroscopic parameter current I and microscopic parameter current density of ohm's law are related as:

$$I = \int \vec{J} \cdot \vec{da}$$

(ii) The macroscopic parameter potential difference 'V' and microscopic parameter electric field E is related as:

$$V = \int \vec{E} \cdot \vec{dr}$$

(iii) The macroscopic parameter resistance R and microscopic parameter resistivity ρ of ohm's law is

related as:

$$R = \frac{\rho L}{A}$$

Q No 8:-

Show that metals obey Ohm's law taken into account microscopic form of Ohm's law, Prove $\rho = m/ne^2\tau$.

Answer:-

Metals Obey Ohm's law:-

The ohm's law is not a fundamental law of electromagnetism. It depends upon the properties of conducting material. Almost all the metals are conductors and having conduction electrons and ionic cores. The assembly of conduction electrons is called electron gas.

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The electric force F_e experienced by electron having charge e due to applied electric field E is:

$$F_e = eE$$

This electric force F_e produces acceleration 'a' in electron having mass 'm'.

$$F_e = ma$$

Compairing both eq.

$$ma = eE$$

$$a = \frac{eE}{m} \quad \text{——— (i)}$$

The acceleration in term of drift velocity V_d and mean free time τ b/w collision is:

$$a = \frac{V_d}{\tau} \quad \text{(Put in (i))}$$

$$\frac{V_d}{\tau} = \frac{eE}{m}$$

$$V_d = \frac{eE\tau}{m} \quad \text{——— (ii)}$$

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The drift velocity in term of current density is:

$$V_d = \frac{J}{ne} \quad \text{(Put in eq (ii))}$$

$$\frac{J}{ne} = \frac{eE\tau}{m}$$

$$J = \frac{ne^2 E\tau}{m} \quad \text{——— (iii)}$$

The microscopic form of ohm's law is:

$$E = \rho J$$

$$J = \frac{E}{\rho} \quad \text{(Put in (iii))}$$

$$\frac{\cancel{E}}{\rho} = \frac{ne^2 \cancel{E}\tau}{m}$$

$$\frac{1}{\rho} = \frac{ne^2\tau}{m}$$

$$\boxed{\rho = \frac{m}{ne^2\tau}}$$ Hence proved

where m, n, e^2 and τ is constant of proportionality. So,

ρ = constant

Therefore, It is concluded that parameter ρ is constant for metals. The microscopic form of Ohm's law is:

$$E = \rho J$$

$$\rho \longrightarrow \text{constant}$$

$$E \propto J$$

Hence, it is concluded that all metals obey ohm's law.

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Date: / /20 SHEET # 01 Day:

Name Hamza Ali
Class BSIT 1st Semes
Roll No 143 IT-G1-(M)
Assignment Physics

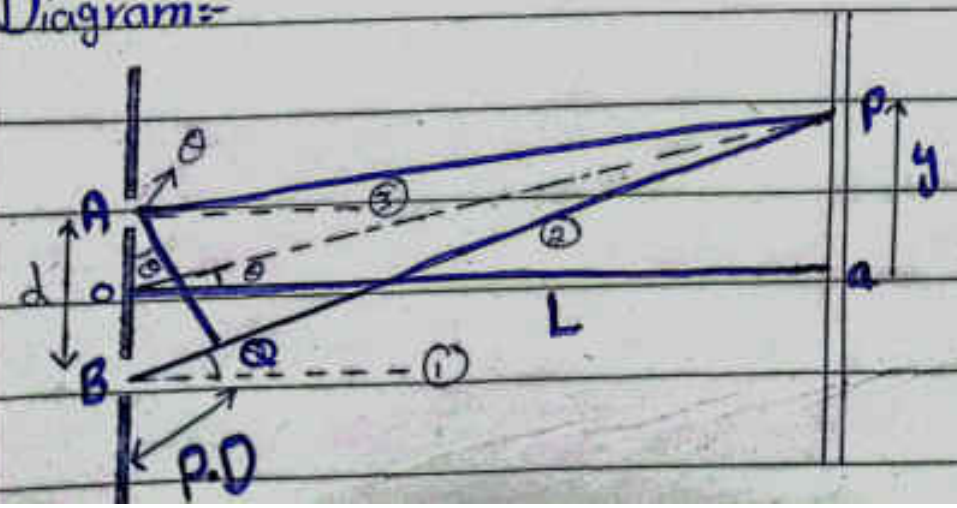
Topic 01:-

Young's Double Slit Experiment

Young's Double Slit Experiment is depend upon three Steps:-

(i) Condition for dark and bright Fringes.
(ii) Position for dark and bright Fringes.
(iii) Spacing of dark and bright Fringes.

Diagram:-



1. Condition for Bright & Dark Fringes:-

Bright Fringe:-

To understand the double slit interference pattern. Each slit is a different distance from a point. Waves start out from the slits in phase (crest to crest), but they may end up out of phase (crest to trough).

To obtain constructive interference for a double slit, the path difference must be an integral multiple of wavelength.

$$d\sin\theta = m\lambda$$

The line $\overline{BC}$

$$\overline{BC} = d\sin\theta$$

$$d\sin\theta = m\lambda \quad \text{(i)}$$

(Constructive Interference)

For $m = 0, 1, 2, 3, 4, \ldots$

$= 1\lambda, 2\lambda, 3\lambda, 4\lambda, \ldots$

Dark Fringe :-

Similarly, To obtain destructive interference of double slit, the path length difference must be a half-integral multiple of the wavelength.

$$\overline{BC} = d\sin\theta = \left[m + \frac{1}{2}\right]\lambda$$

$$d\sin\theta = \left[m + \frac{1}{2}\right]\lambda \quad \text{——— (ii)}$$

(destructive Interference)

For $m = 0, 1, 3, 5, 7, \ldots$

$$= \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \frac{7\lambda}{2}, \ldots$$

2:- Position for Dark and Bright Fringes

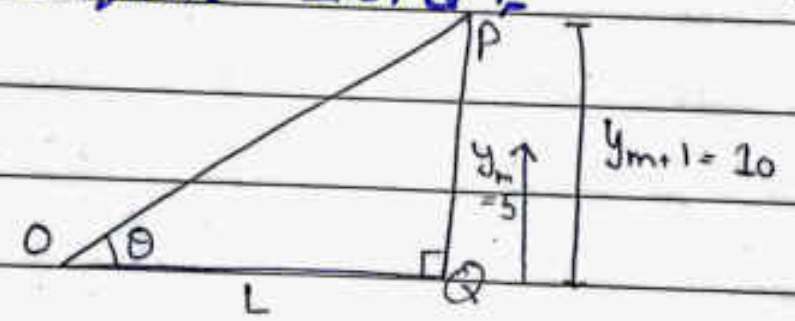
The main cause of the formation of dark fringes is destructive interference and the main cause for Bright Fringes is Constructive

Interference. Its position is denoted by calculating the distance between two adjacent Fringes known as "Fringes Width".

Bright Fringe Position :-

The distance between 2 dark or bright fringes is mainly denoted as "Fringes Width", calculated as:

From Diagram ΔOPQ :-



$$\tan\theta = \frac{y}{L}$$

$$\{\because \tan\theta \approx \sin\theta\}$$

$$\sin\theta = \frac{y}{L}$$

$$y = L\sin\theta \quad \text{—— (a)}$$

From equation (i)

$$\sin\theta = \frac{m\lambda}{d} \quad \text{(Put in 'a')}$$

$$y = \frac{L m \lambda}{d} \quad \text{(iii)}$$

B Dark Fring Position :-

For the position of dark fringes, use equation (a)

$$y = L \sin\theta \quad \text{(b)}$$

from eq. (ii)

$$d \sin\theta = \left[m + \frac{1}{2}\right] \lambda$$

$$\sin\theta = \left[m + \frac{1}{2}\right] \frac{\lambda}{d} \quad \text{(Put in 'b')}$$

$$y = L \left[m + \frac{1}{2}\right] \frac{\lambda}{d}$$

$$y = \left[m + \frac{1}{2}\right] \frac{\lambda L}{d} \quad \text{(iv)}$$

3:- Spacing of Bright & Dark Fringes

Basically, The "Fringes Width" is also known as "Spacing ~~to~~ of Fringes".

Spacing of Bright Fringe:-

From equation (iii)

$$y_m = \frac{m\lambda L}{d} \quad (c)$$

$$y_{m+1} = \frac{(m+1)\lambda L}{d}$$

$$y_{m+1} = \frac{\lambda L m}{d} + \frac{\lambda L}{d} \quad (d)$$

Eq (d) - Eq (c):-

$$y_{m+1} - y_m = \cancel{\frac{m\lambda L}{d}} + \frac{\lambda L}{d} - \cancel{\frac{m\lambda L}{d}}$$

$$\boxed{y_{m+1} - y_m = \frac{\lambda L}{d}}$$

Spacing of Dark Fringes:-

To calculate the spacing of Dark Fringes use equation (iv)

By Eq. (iv)

$$y_m = \left[m + \frac{1}{2}\right]\frac{\lambda L}{d} \quad (e)$$

$$y_{(m+1)} = \left[m+1 + \frac{1}{2}\right]\frac{\lambda L}{d}$$

$$y_{m+1} = \frac{m\lambda L}{d} + \frac{\lambda L}{d} + \frac{\lambda L}{2d}$$

$$y_{m+1} = \frac{m\lambda L}{d} + \frac{2\lambda L + \lambda L}{2d}$$

$$y_{m+1} = \frac{m\lambda L}{d} + \frac{3\lambda L}{2d} \quad (f)$$

Eq(f) - Eq(e)

$$y_{m+1} - y_m = \left[m + \frac{1}{2}\right]\frac{\lambda L}{d}$$

$$y_{m+1} - y_m = \frac{m\lambda L}{d} + \frac{3\lambda L}{2d} - \frac{m\lambda L}{d} - \frac{\lambda L}{2d}$$

$$y_{m+1} - y_m = \frac{3\lambda L}{2d} - \frac{\lambda L}{2d}$$

$$y_{m+1} - y_m = \frac{3\lambda L - \lambda L}{2d} = \frac{2\lambda L}{2d}$$

$$\boxed{y_{m+1} - y_m = \frac{\lambda L}{d}}$$

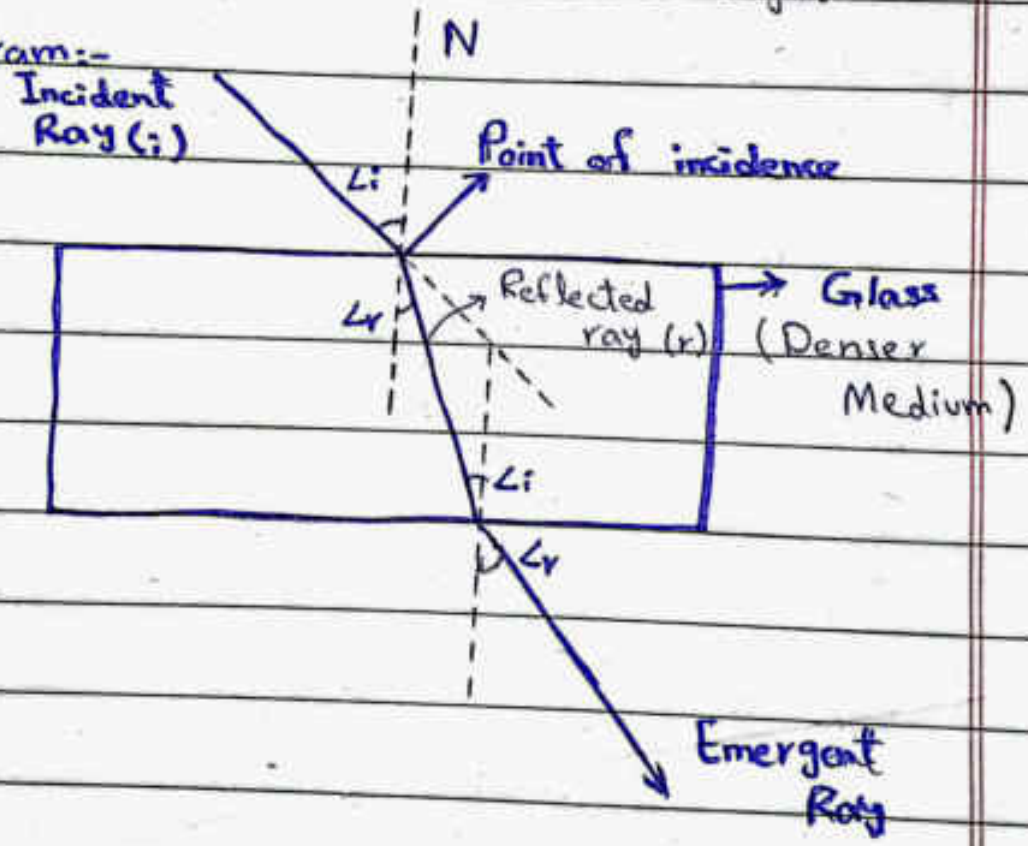
The Bright and dark fringes have same space.

Topic # 02:-
Refraction of Light waves:-

Definition:-

The process of bending of light as if passes from one medium to another and vice versa is called Refraction of light.

Diagram:-



Laws of Refraction:-

(i) The incident ray, refracted ray and the normal at the point of incidence all lie in the same plane.

(ii) The ratio of the sine of the angle of incidence 'i' to the sine of the angle of refraction 'r' is always equal to the constant.

$$\boxed{\frac{\sin(i)}{\sin(r)} = \text{constant } (n)}$$

This ratio is also known as the refrective index of the second medium with respect to the first medium.

$$\boxed{\frac{\sin i}{\sin r} = n}$$

It is called Snell's law.

Speed of light in a Medium:-

Speed of light in air = $3.0 \times 10^8 \, ms^{-1}$

Speed of light in water = $2.3 \times 10^8 \, ms^{-1}$

Speed of light in glass = $2.0 \times 10^8 \, ms^{-1}$

Refractive Index:-

The refractive index 'n' of a medium is the ratio of the speed of light 'c' in air to the speed 'v' of light in the medium.

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Refractive Index = $\frac{\text{Speed of light in air}}{\text{Speed of light in glass}}$

$$n = \frac{c}{v}$$

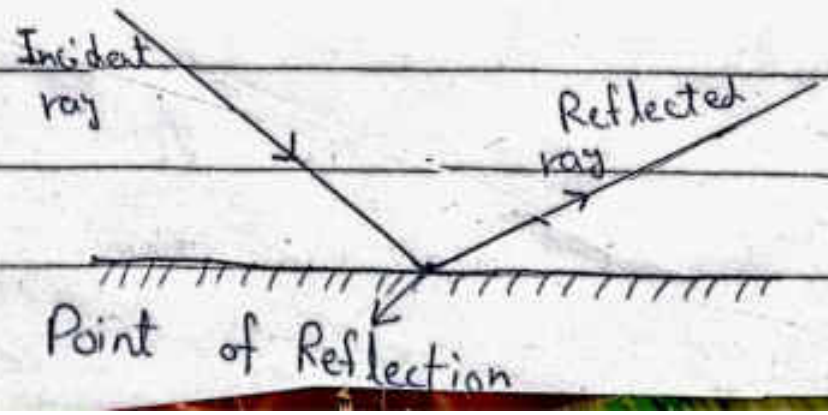
Topic 03:-

Reflection of Light

Definition:-

When light travelling in a certain medium falls on the surface of another medium, a part of it turns back in the same medium is called Reflection of light.

Diagram:-

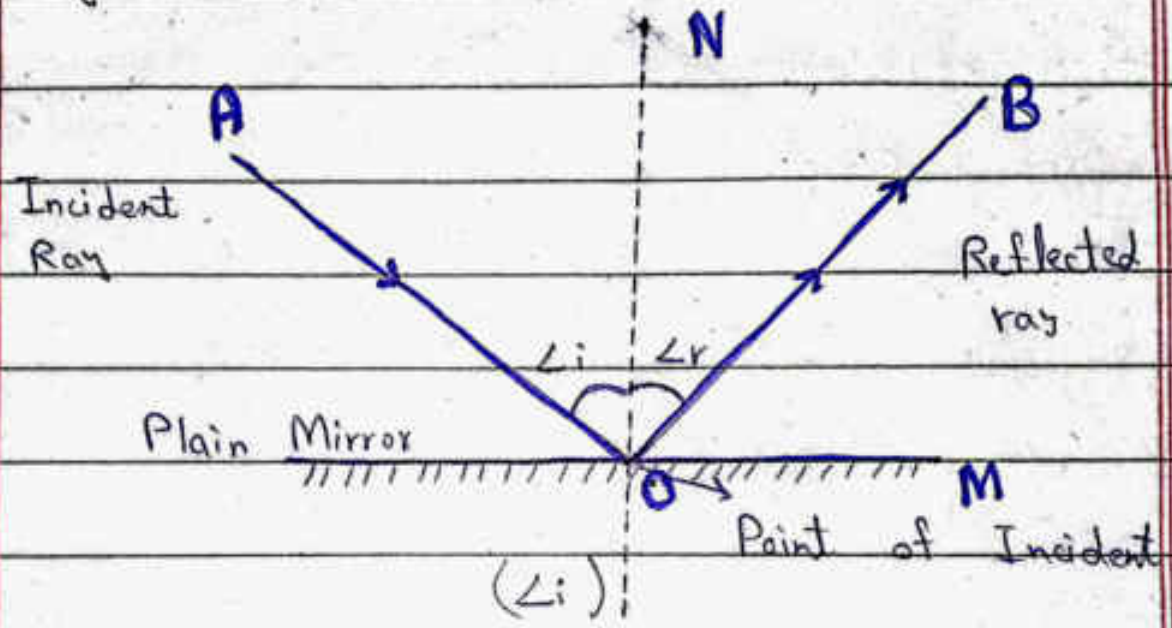


Incident Ray:-

The ray AO is called incident ray.

Reflected Ray:-

The ray OB is called reflected ray.



Angle of Incidence:- (∠i)

The angle between incident ray AO and normal N (i.e ∠AON) is called angle of incidence.

Angle of Reflection (∠r):-

The angle between normal N and reflected ray OB (i.e ∠BON) is called angle of reflection.

Normal (N) = Normal is the line which is perpendicular on the surface of another medium.

Laws of Reflection:-

The incident ray, the normal and the reflected ray at the point of incidence all lie in the same plane.

The angle of incidence is equal to the angle of reflection.

$$\boxed{\angle i = \angle r}$$

-: Types of Reflection :-

Reflection depends upon smoothness of the surface. There are two types of reflection

(i) **Regular Reflection:-**

The reflection by the smooth surface is called Regular reflection.

(ii) **Irragular Reflection:** The reflection by the rough surface is called Irragular reflection.

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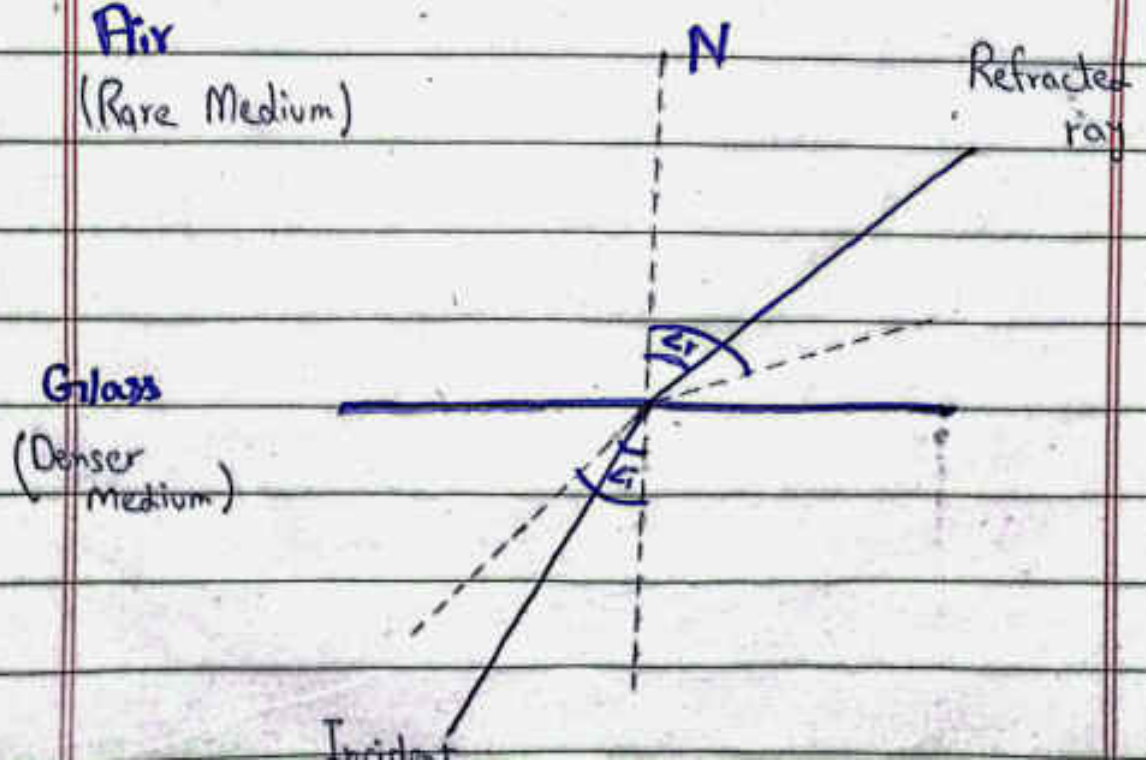
Topic # 04:-

Total Internal Reflection

Definition:-

When the angle of incidence becomes larger than the critical angle, then the entire light is reflected back into the same medium. This is called Total Internal Reflection.

Diagram:-



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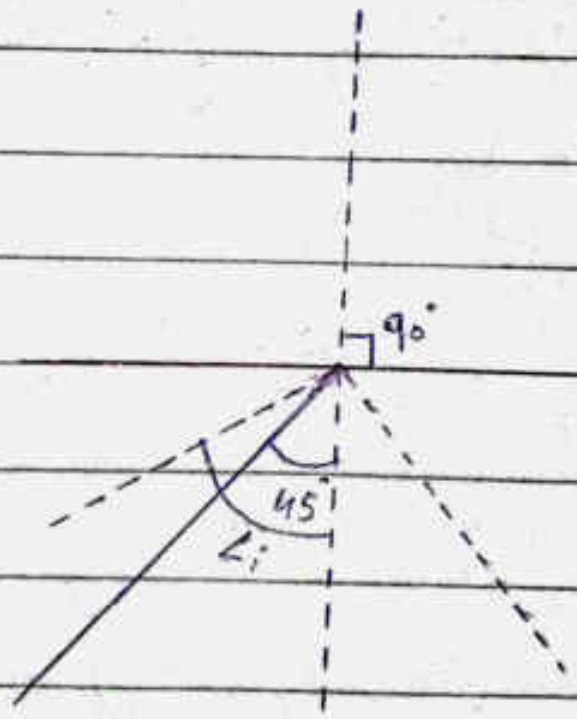
$\angle i > \angle c^\circ$

Critical Angle:-

The angle of incidence, that cause the refrected ray in the rare medium to bend through 90° is called Critical angle.

Diagram:-



Critical angle of glass 42°

Critical angle of water 48.8°

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Topic 05:-

Electro-Magnetic Induction

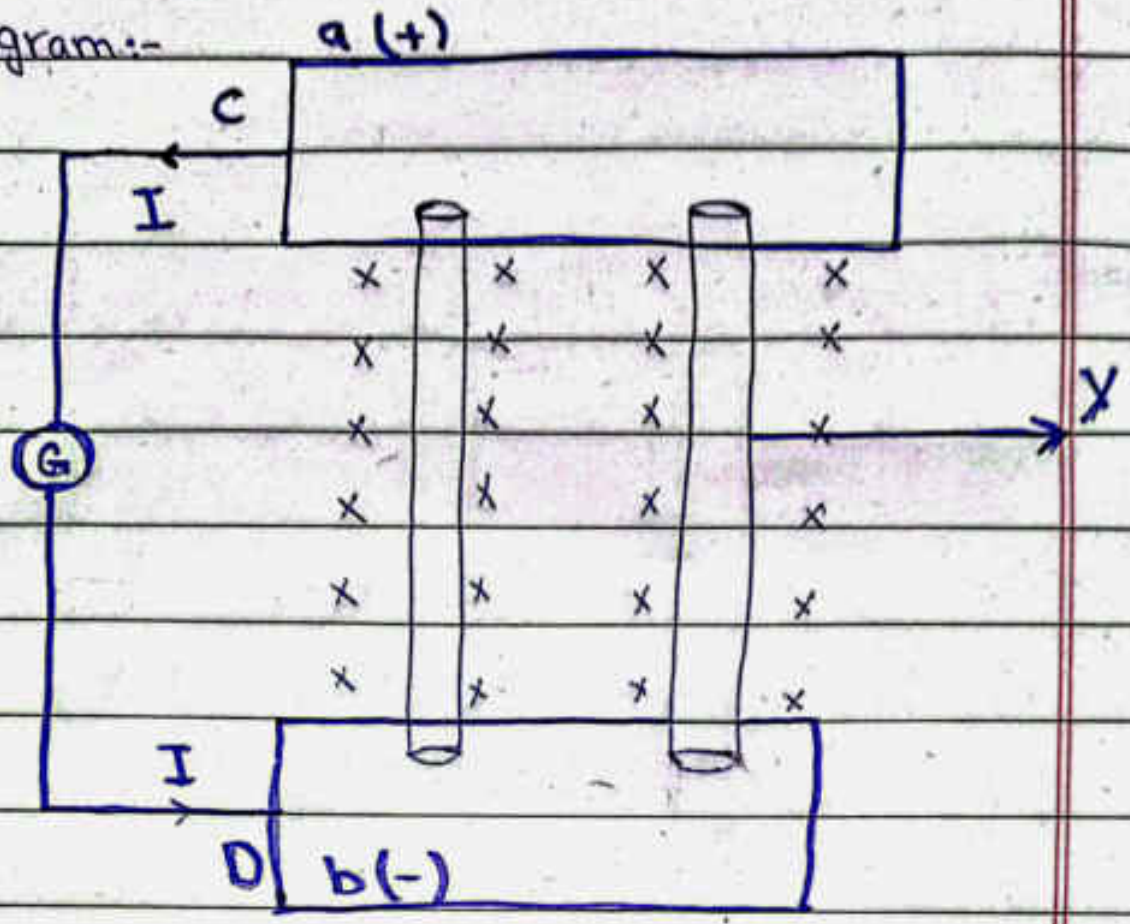
Faraday's Law Of Electro-Magnetic Induction

The Faraday's law of electromagnetic induction states that whenever magnetic flux changes in a coil or loop, emf is induced in it which lasts only for for the time, the flux change continuously. The magnitude of induced emf is directly proportional to the rate of change in magnetic flux.

The emf is induced in a coil or loop due to change in magnetic flux. The magnetic flux in a coil or loop can be changed by the number

of ways.

Diagram:-



Explanation:-

Consider a conductor having length L is placed on a conducting rail as shown. The ends of conducting rail are connected with galvanometer. The magnetic field B is directed into plane of paper and denoted by (x).

$$\mathcal{E} = -VBL \quad \text{(i)}$$

Velocity V of rod which travel distance dx in time dt is:

$$V = \frac{dx}{dt} \quad \text{(Put in eq (i))}$$

$$\mathcal{E} = -\left(\frac{dx}{dt}\right) BL$$

$$\{\because L\,dx = da\}$$

$$\mathcal{E} = -B\frac{da}{dt}$$

$$\left\{\begin{array}{l} \because \phi = \bar{B}\cdot\bar{A} \\ d\phi = \bar{B}\cdot d\bar{a} \end{array}\right\}$$

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

For Number of turns:-

$$\boxed{\mathcal{E} = -N\frac{d\phi}{dt}} \quad \text{(ii)}$$

The magnetic flux is:

$$d\phi = \vec{B}\cdot d\vec{a}$$

Integrate:

$$\phi = \int \vec{B}\cdot d\vec{a} \quad \text{(Put in ii)}$$

$$\boxed{\mathcal{E} = -N\frac{d}{dt}\int \vec{B}\cdot da} \quad \text{(iii)}$$

Integral form:-

we know that:

$$\boxed{\mathcal{E} = \int \vec{E}\cdot d\vec{r}} \quad \text{(iv)}$$

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Compairing eq (iii) and (iv)

$$\int \vec{E}\cdot\vec{dr} = -N\frac{d}{dt}\int \vec{B}\cdot\vec{da}$$

$$\boxed{\int \vec{E}\cdot\vec{dr} = -\frac{d}{dt}\int \vec{B}\cdot\vec{da}}$$

Differential form:-

$$\int \vec{E}\cdot\vec{dr} = -\frac{d}{dt}\int \vec{B}\cdot\vec{da} \quad \text{(v)}$$

$$\boxed{\int \vec{E}\cdot\vec{dr} = \int (\vec{\nabla}\times\vec{E})\cdot da} \text{ (Put in v)}$$

$$\int (\vec{\nabla}\times\vec{E})da = -\frac{d}{dt}\int \vec{B}\cdot\vec{da}$$

$$\int (\vec{\nabla}\times\vec{E})da + \frac{d}{dt}\int \vec{B}\cdot\vec{da} = 0$$

$$\int \left((\vec{\nabla}\times\vec{E}) + \frac{d\vec{B}}{dt}\right)da = 0$$

$$(\vec{\nabla}\times\vec{E}) + \frac{d\vec{B}}{dt} = 0$$

$$\boxed{\vec{\nabla}\times\vec{E} = -\frac{dB}{dt}}$$

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