LECTURE NOTES

PHYSICS

ELECTROSTATS,

CURRENT ELECTRICITY,

ELECTRICAL INSTRUMENT,

CADACITANCE

BY

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BOOK - I

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"ELECTROSTAT'S"

⊛ Fundamental Forces of Nature:-

	Force	Relative strength.
①	Gravitational.	1
②	Electromagnetic.	10^{36}
③	Nuclear.	10^{39}
④	weak	10^{14}

*For Proton - Proton only.

Qus> what is Relative strength of Electromagnetic force w.r.t

① Nuclear force

② weak force

③ Gravitational force.

Ans>

① Nuclear Force $= \frac{10^{36}}{10^{39}} = \underline{\underline{10^{-3}}}$

② weak Force $= \frac{10^{36}}{10^{14}} = \underline{\underline{10^{22}}}$

③ Gravit. Force $= \frac{10^{36}}{1} = \underline{\underline{10^{36}}}$

⊛⇒ charge :-

⇒ It is the excess 'or' Deficiency of electrons.

⇒ Charge = current × time.

$\boxed{q = I \times t}$

→ scalar quantity.

→ Unit
- MKS ; coloumb (C), Amp × sec.
- CGS
  - ESU ; static 'C', Franklin.
  - EMU ; Absolute 'C' (AbC)

= 1C = 3×109 st'C'.

= $1C = \frac{1}{10}$ AbC.

**special unit 1 F = 96500 C.

= $(N_A)(e)$

1 Faraday is a charge Required to shift 1-gram equivalent mass from one electrode to another in electrolysis.

Dimension :- A · T

Ques> 10 Amp current is passed through a wire upto 10 min, than calculate charge?

Ans> $q = A \times t$

$= 10 \times (10 \times 60)$ sec

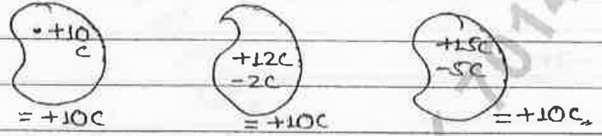
$= 6000$ C,,

⊛⇒ Property of charge:-

① charge is addative in Nature.

② charge is Invarient. (It means it's speed value doesn't depends on its speed.)

③ Total charge of isolated system is alway's conserved.



Total charge is conserved but Total Possative "or" Negative charge May change.

④ Quantasiation of charged:-

(i) Minimum possible charge $= \boxed{e} = 1.6\times10^{-19}\ c$
(Quanta of charge)

(ii) Any other charge

$$\boxed{q = ne}$$

where; $n = \pm1, \pm2, \pm3, \ldots\ldots$

(iii) Exception of Quantisation:-

"Quark" → Up (U) $(+2e/3)$
"Quark" → Down (D) $(-e/3)$

eg:- ① $2U \oplus 1D \longrightarrow 1$ proton

$$2\times\left(\frac{+2e}{3}\right) + 1(-e/3) = +e$$

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② 1 U + 2D ⟶ 1 Neutron

$1\left(+\frac{2e}{3}\right) + 2\left(-\frac{e}{3}\right) =$ zero.

Ques> which of the following charges are possible:-

✓① $+5e$

✓② $-3e$

×③ $+5.2e$

×④ $+7/3e$

✓⑤ $-\frac{57}{19}e = -3e$

✓⑥ $3.2\times10^{-19}\,c = n = \frac{q}{e} = \frac{3.2\times10^{-19}}{1.6\times10^{-19}} = 2c$

×⑦ $6.4\times10^{-20}\,c = n = \frac{q}{e} = \frac{6.4\times10^{-19}}{1.6\times10^{-20}} = 0.4c$

✓⑧ $1.6\times10^{-18}\,c = n = \frac{q}{e} = \frac{1.6\times10^{-18}}{1.6\times10^{-19}} = 10c$

⑤ charge produces:

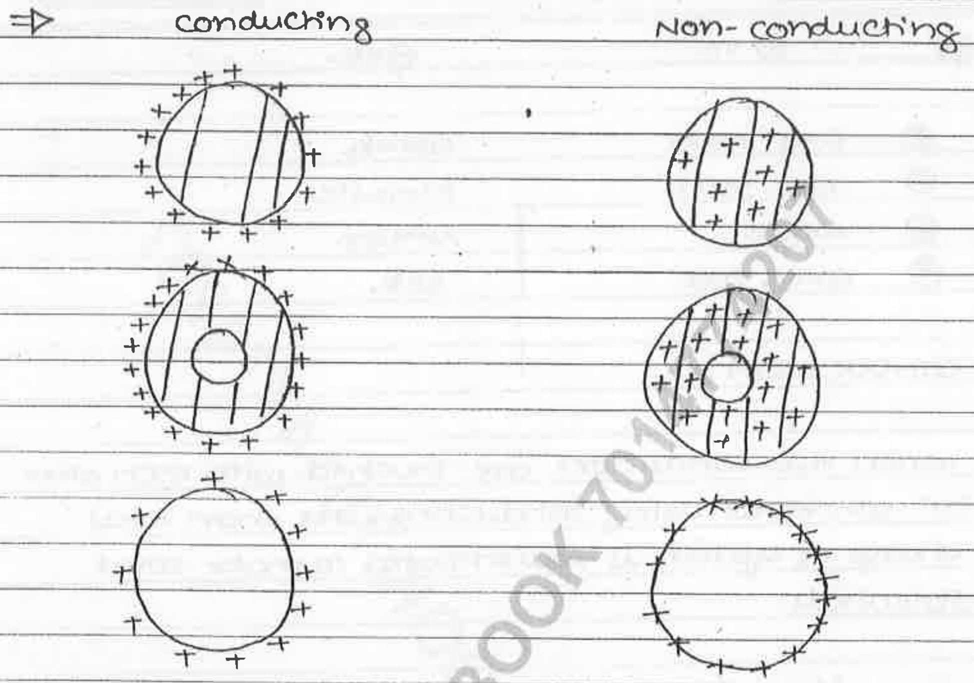
At Rest ⇒ only 'E'

V = const ⇒ 'E' and 'B'

V ≠ const ⇒ "E", "B" & E.M.W

**⑥ charge cannot exist without mass.

⑦ In conductor's charge is distributed at outer-surface only, while in non-conductor charge is distributed in inside volume.



⇒ Electrical Behaviour of charged object is decided by charge Distribution only.

⊛ ⇒ Methods of charging:-

① Friction:-

$q_A = \oplus ne.$
$q_B = \ominus ne$ } ⇒ same Magnitude and opposite. nature of charges are produced in friction.

eg:-

	⊕ve	⊖ve.
①	Dry-Hair	comb.
②	cat skin.	Ebonite.
③	wool.	Amber.
④	Glass Rod.	silk.

② CONDUCTION :-

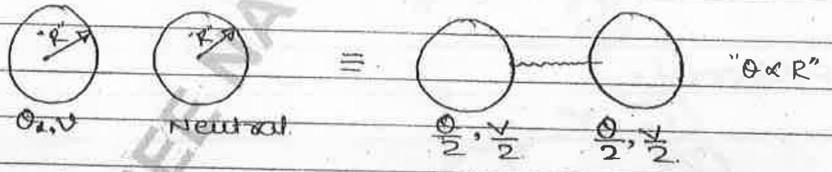
when two conductor's are Touched with each other "or" connected using conducting wire than total charge of system is Redistributed to make same Potentials.

$$\because \quad \cancel{V} = \frac{\cancel{K}Q}{R}$$

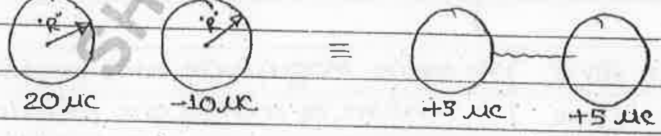
$\boxed{Q \propto R}$ Here; R = Radius.

Ques> Two Metal sphere:-

①



②



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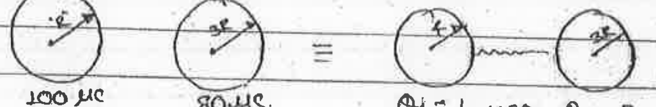

$\because$ Q_Total = 180 μc.

$\because$ $Q_1 : Q_2 = 1:3$

$Q_1 = \frac{1}{4} \times 180$ $= 45 \mu c.$

$Q_2 = \frac{3}{4} \times 180$ $= 135 \mu c.$

→* After conduction Potential definately become same, while charges may be Diffreut.

Ques> Three Idential conducting sphere :-

"TOUCH"	"Q" A R	"0" B R	"-Q" C R
"A" & "B"	$Q/2$	$Q/2$	$-Q$.
"B" & "C"	$Q/2$	$-Q/4$	$-Q/4$.
A & C.	$+Q/8$	$-Q/4$	$+Q/8$.

☆⇒ CHARGE DENSITY :-

① Linear charge Density (λ) = $\frac{\text{charge}}{\text{Length}}$ C/m

② surface charge Density (σ) = $\frac{\text{charge}}{\text{surface Are}}$ C/m^2

③ volume charge Density (ρ) = $\frac{\text{charge}}{\text{Volume}}$ C/m^3

"**" Ques> Two metal sphere ;

If these are touched by each other than find charge density of each other?

⇒ ⊕ charged :- Move from High Potential to low Potential.

⇒ ⊖ charged :- Move from Low Potential to Higher Potential.

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Ans> $Q_{total} = \sigma(4\pi R^2) + \sigma[4\pi(2R)^2]$

$= 20\sigma\pi R^2$

$Q_1 : Q_2 = 1 : 2 \quad (R_1 : R_2)$

$Q_1 = \frac{1}{3} \times 20\sigma\pi R^2$

$Q_2 = \frac{2}{3} \times 20\sigma\pi R^2$

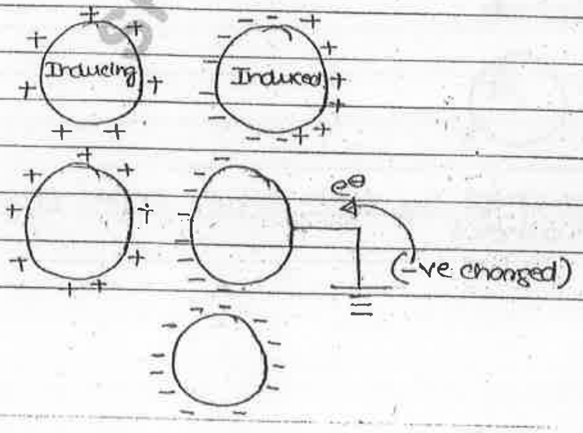
$\sigma_1 = \frac{Q_1}{4\pi R^2} = \frac{1/3 \times \overset{5}{\cancel{20}}\,\sigma\,\cancel{\pi R^2}}{\cancel{4}\,\cancel{\pi R^2}} = \frac{5\sigma}{3}$

$\sigma_2 = \frac{Q_2}{16\pi R^2} = \frac{2/3 \times \overset{5}{\cancel{20}}\,\sigma\,\cancel{\pi R^2}}{4\,\cancel{16}\,\cancel{\pi R^2}} = \frac{\cancel{10}\,5\sigma}{\cancel{12}\,6}$

$\frac{\sigma_1}{\sigma_2} = 2 : 1$

***** ② INDUCTION :-**

When ②- Bodies are Placed close To each other than their charge Distribution is affected, this is called "Induction."



(*) $Q_{induced} = Q_{inducing}\left(1-\frac{1}{\epsilon_r}\right)$

① If metal than; ($\epsilon_r = \infty$)

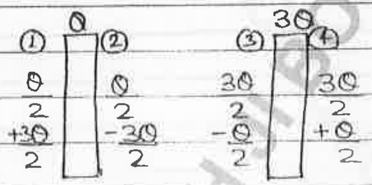
∴ $Q_{induced} = Q_{inducing}$.

② If Non-Metal than; ($\epsilon_r \neq \infty$)

∴ $Q_{induced} \boxed{>} Q_{inducing}$

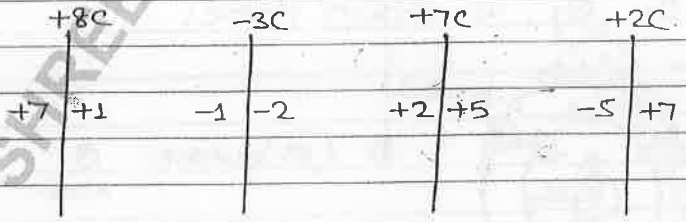
**Ques> Two Metalic plate Q and 3Q are placed parllel and close to each other than;

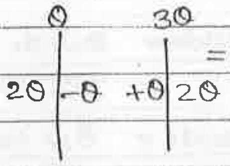
Ans>



$q_1 = +2Q$
$q_2 = -Q$
$q_3 = +Q$
$q_4 = +2Q$

Ques> "Multiplate system":-





=(Above question)

$\frac{5}{2}$

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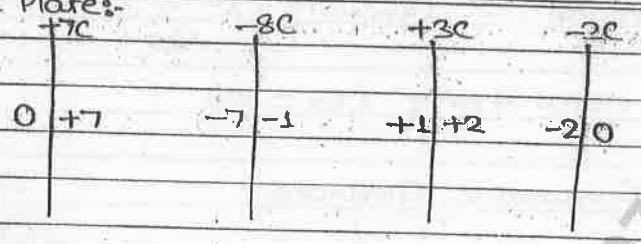
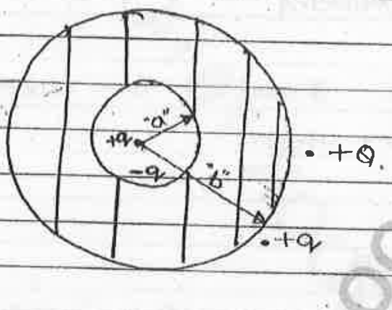
Ques> Multiple Plate:-



Ques> Hollow Metal sphere:-

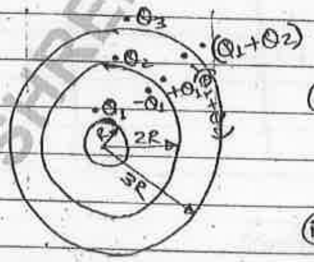


small +q is placed at centre and +Q is given to sphere:-

$$\sigma_{inner} = \frac{-q}{4\pi a^2}$$

$$\sigma_{outer} = \frac{Q+q}{4\pi b^2}$$

AIEEE Ques> Three concentric Metal shell, are given charges Q_1, Q_2, Q_3, as shown there;



(i) $(\sigma_1)\text{outside} = \frac{Q_1}{4\pi R^2}$

(ii) $(\sigma_2)\text{outside} = \frac{Q_1+Q_2}{4\pi (2R)^2}$

(iii) $(\sigma_3)\text{outside} = \frac{Q_1+Q_2+Q_3}{4\pi (3R)^2}$

⊛ Important Points • Of INDUCTION:-

*(i) Induction Takes Place In Facing Layer's only.

(ii) Induction does not affect's the magnitude of charge But it affect's only Distribution of charge.

(iii) Their will be attraction b/wn charged and Neutral Bodies.

*(iv) Their May be attraction b/wn Two Bodies of same Nature charges, Provided that Magnitude of charges must be Different.

(charged)

(v) Sure Test of Electrification is *Repulsion only, Not the Repulsion. Attraction.

✡ ⇒ COULOMB'S LAW:-

$$F \propto q_1 q_2$$

$$F \propto \frac{1}{r^2}$$

$$F \propto \frac{q_1 q_2}{r^2}$$

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

$$K = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ (MKS)}$$

$$K = 1 \text{ (CGS)}$$

⊛ q_1 "Air" q_2

$$\boxed{F_{air} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}}$$

q_1 |||| ϵ_r |||| q_2

$$\boxed{F_{med} = \frac{1}{4\pi\epsilon_0\epsilon_r} \cdot \frac{q_1 q_2}{r^2}}$$

$$\boxed{F_{med} = \frac{F_{air}}{\epsilon_r}}$$

$\because \epsilon_r > 1 \Rightarrow \boxed{F_{med} < F_{air}}$

⊛ Electric Permiablity (ϵ) :-

- $\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N \times m^2}$
- ϵ = (Diffrent for Diffrent medium) $\frac{C^2}{N \times m^2}$
- $\epsilon_r = \frac{\epsilon}{\epsilon_0}$ (unit less)

$\boxed{1 \leq \epsilon_r \leq \infty}$ $\boxed{\epsilon_r (\text{metal}) = \infty}$

Ques> q_1 'Air' q_2

$F_{air} = 18N$

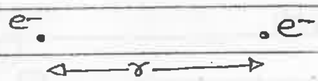
(i) If $\epsilon_r = 6$ is filled than F_{med} :-

$F_{med} = \frac{F_{air}}{\epsilon_r} = \frac{18}{6} = 3N.$

(ii) If Metallic medium is filled :-

$$F_{med} = \frac{18}{\infty} = 0.$$

Ques>



$\frac{F_e}{F_g} = ?$

Ans> $$\frac{F_e}{F_g} = \frac{\left\{\frac{k(e)(e)}{r^2}\right\}}{\left\{\frac{G(m_e)(m_e)}{r^2}\right\}}$$

$$= \frac{9\times10^{9}\,(1.6\times10^{-19})^2}{6.6\times10^{-11}\,(9.1\times10^{-31})^2}$$

$$= 4\times10^{42}.$$
$$= 10^{42}.$$

** ⊛ ⇒ $F_e/F_g = ?$

$$\left.\begin{array}{l} p - p \rightsquigarrow 10^{36} \\ p - e \rightsquigarrow 10^{39} \\ e - e \rightsquigarrow 10^{42} \end{array}\right\}$$

Ques> calculate Minm electric force Betwn Two point charge placed at 1cm seperatn?

Ans> $$F_{min} = \frac{k(q_1\cdot q_2)_{min}}{r^2}$$

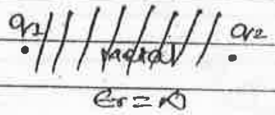
$$= \frac{9\times10^{9}\,(1.6\times10^{-19})^2}{(1\times10^{-2})^2} = 23.9\times10^{-25}$$
$$\simeq 0.23\times10^{-23}\ N$$

Ques> Given; q_1 . "Air" . q_2 $F_{air} = 18N$

①

$$F_{med} = \frac{F_{air}}{\varepsilon_r} = \frac{18}{6} = 3N.$$

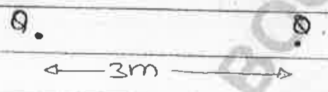
(ii)



$$F_{med} = \frac{F_{air}}{\infty} = 0$$

Ques> Two equal charges Placed at seperatn 3m and force b/wn them is 1.6 N, calculate each charge?

Ans>



Given; $F = 1.6N$

$Q = ?$

$$F = \frac{K\, Q_1 Q_2}{r^2}$$

$$1.6 = \frac{9 \times 10^9 (Q)(Q)}{(3)^2}$$

$$Q^2 = \frac{1.6 \times 9}{9 \times 10^9} = 1.6 \times 10^{-9} = 16 \times 10^{-10}$$

$Q^2 = 16 \times 10^{-10}$

~~$Q/7$ 0.4×10^{-3}~~ $Q = 4 \times 10^{-5}$

***Ques> what should be two part's of charge so that there is max^m force b/w^n them when placed at Fixed seperation?

Ans> $Q \rightarrow q = \frac{Q}{2}$ $F = \frac{K q (Q - q)}{r^2}$

$Q \rightarrow Q - q = \frac{Q}{2}$ $F = \frac{K (Qq - q^2)}{r^2}$

⇒ Maxima – Minima :-

$$y = f(x)$$

① $\frac{dy}{dx} = 0$

$x = x_1, x_2, \ldots\ldots$

(ii) $\left(\frac{d^2y}{dx^2}\right)_{x=x_1} = \ominus ve$ (Maxima).

$= \oplus ve$ (Minima).

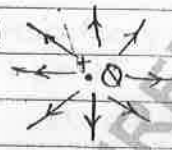
$$\frac{dF}{dq} = \frac{K}{r^2}(Q - 2q) = 0$$

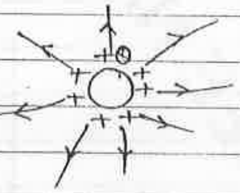
$$\therefore q = \frac{Q}{2}$$

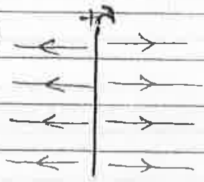
$$\frac{d^2F}{dq^2} = \frac{K}{r^2}(0-2) = \frac{-2K}{r^2} = \ominus ve.$$

$$\therefore \boxed{q = \frac{Q}{2}} \text{ Maxima}$$

***⊛ ⇒ Important :-

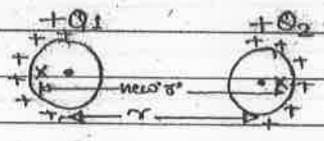
①


②


③


→ Electrical Behaviour of ②spherical charge is similar to ①point charge, while ③Linear charge have diffrent Behaviour so coloumbs law is valid for "point charge" and "spherical charge".

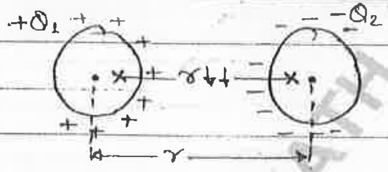
Ques>



$\frac{KQ_1Q_2}{r^2}$	$\frac{KQ_1Q_2}{r^2}$ ✓(correct)
$\frac{2KQ_1Q_2}{r^2}$	$< \frac{KQ_1Q_2}{r^2}$ (more correct) Here r↑↑; so F↓
$\frac{KQ_1Q_2}{2r^2}$	$> \frac{KQ_1Q_2}{r^2}$
$\frac{KQ_1Q_2}{4r^2}$	None

⇒ Here; Due to Induction "centre of charges" shifted away. so Repulsion increases (means r↑) and Force↓

Ques>



① $\frac{KQ_1Q_2}{r^2}$ ✓(correct)

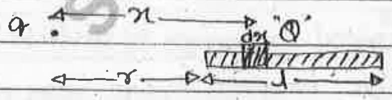
② $< \frac{KQ_1Q_2}{r^2}$

③ $> \frac{KQ_1Q_2}{r^2}$ (more correct)

∵ attraction ↑ r↓ so; F↑

④ None

Ques> calculate Electric Force :-



Ans> $F = \frac{KQq}{r^2}$ ✗ $F = \frac{KQq}{(r+l/2)^2}$ ✗ ∵ (Coloumb's charge not applicable)

✓

Force on Element:-

$$dF = \frac{K(q)\left(\frac{Q}{l}dx\right)}{x^2}$$

$$F_{net} = \int_{r}^{r+l} \frac{KQq}{l}\frac{dx}{x^2}$$

$$F_{net} = \frac{KQq}{l}\left[\frac{-1}{x}\right]_{r}^{r+l}$$

$$= \frac{-KQq}{l}\left[\frac{1}{r+l} - \frac{1}{r}\right]$$

$$= \frac{-KQq}{\cancel{l}}\frac{\cancel{r}-\cancel{r}+\cancel{l}}{(r+l)r}$$

$$\boxed{F_{net} = \frac{KQq}{r(r+l)}}$$

⊛ ⇒ If $F_{air} = F_{medium}$:-

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r_{air}^2} = \frac{1}{4\pi\varepsilon_0\varepsilon_r} \cdot \frac{q_1 q_2}{r_{med}^2}$$

$$r_{air}^2 = \varepsilon_r \cdot r_{med}^2$$

$$\boxed{r_{air} = \sqrt{\varepsilon_r} \cdot r_{med}}^{**}$$

Ques) $r_{med} = 5cm$; $\varepsilon_r = 9$; $r_{air} = ?$

Ans) $r_{air} = \sqrt{\varepsilon_r}\, r_{med} \Rightarrow r_{air} = \sqrt{9} \times 5 = 15cm$

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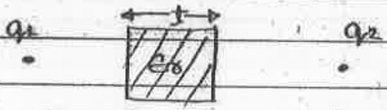
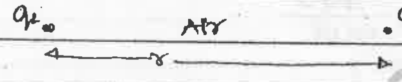
⊛ ⇒ **Partial Medium:-**



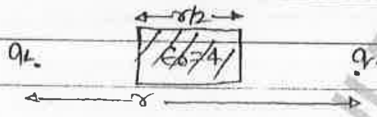
$$\boxed{F_{partial} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{[\underbrace{(r-t)}_{r_{med}} \oplus \underbrace{t\sqrt{\epsilon_r}}_{r_{air}}]^2}}$$ ✓

Ques> Force b/wⁿ 2-charges in air is F. If half seperatⁿ is filled by medᵐ of $\epsilon_r = 4$; than calculate force?

Ans>



$$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}$$



$$F' = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{[(r-\frac{r}{2}) + \frac{r}{2}\sqrt{4}]^2}$$

$$F' = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{[\frac{r}{2}+r]^2}$$

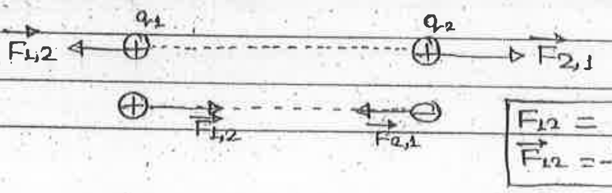
$$F' = \frac{1}{4\pi\epsilon_0}\frac{4q_1 q_2}{9r^2}$$

$$\boxed{F' = \frac{4}{9}F}$$ ✓

⇒ Coloumb Force is Due to "Mutual Interactⁿ" b/wⁿ charges so;-

① It is not affected by ⊕nce of other charges.

② It obey's Newton's action-Reaction.



$$\boxed{\begin{array}{l} F_{12} = F_{21} \\ \vec{F}_{12} = -\vec{F}_{21} \end{array}}$$

AIPMT
Ques> $q_1 = 1\mu C$ $q_2 = 5\mu C$.
• ← 10 cm → •

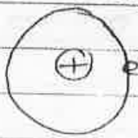
$$\frac{F_{1,2}}{F_{2,1}} = ? = 1:1.$$
(Action Reaction)

⊛ vector Form:-

$$\boxed{\begin{aligned}\vec{F} &= \frac{K q_1 q_2}{r^2}\hat{r}\\ \vec{F} &= \frac{K q_1 q_2}{r^3}\vec{r}\end{aligned}}$$

∴*** In any vector Formula; charge must Be with sign.

Ques> H-atom



$\vec{F} = ?$ (Ans in vector Form)

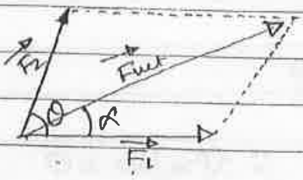
Ans>
***Must take with sign.

$$\vec{F} = \frac{K(\oplus e)(\ominus e)}{r^2}\hat{r}$$

$$= \frac{-Ke^2}{r^3}\vec{r}$$

⊛ ⇒ SUPERPOSITION PRINCIPAL:-

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \ldots.$$

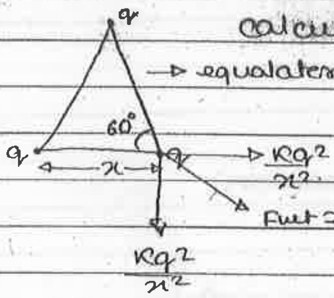


If $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2$

∴ $F_{net} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$

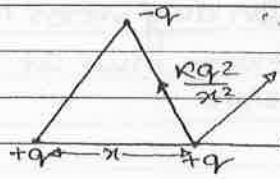
∴ $\tan\alpha = \frac{F_2\sin\theta}{F_1 + F_2\cos\theta}$

Ques> calculate force on any one charge.



$F_{net} = \sqrt{3}\left(\frac{kq^2}{x^2}\right)$

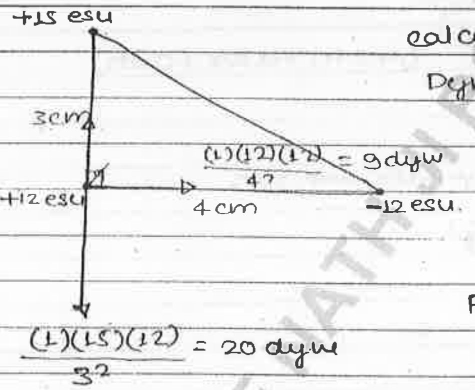
Ques>



$F_{net} = \frac{kq^2}{x^2}$

Ques>

calculate force on +12 esu in Dyne?



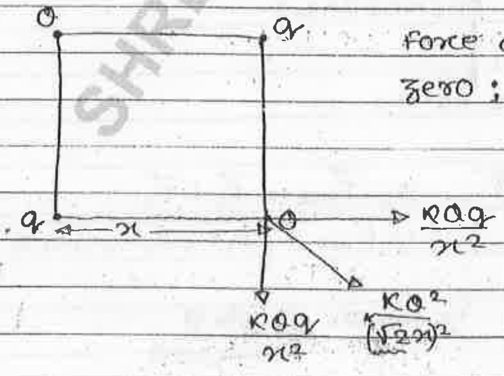
$F_{net} = \sqrt{20^2+9^2}$

$= \sqrt{481}$

$\simeq 22$ dyne.

NEET Ques>

Force on each capital 'Q' is zero ; than $\frac{Q}{q} = 2$



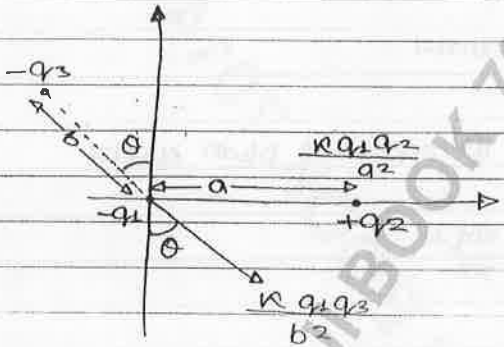
$\because (F_Q)_{net} = 0$

$$\sqrt{2}\left(\frac{KQq}{x^2}\right) + \frac{KQ^2}{(\sqrt{2}x)^2} = 0.$$

$$\sqrt{2}\left(\frac{\cancel{K}\cancel{Q}q}{\cancel{x^2}}\right) = -\frac{\cancel{K}Q^{\cancel{2}}}{\sqrt{2}\cancel{x^2}}$$

$$\boxed{\frac{Q}{q} = -2\sqrt{2}}$$

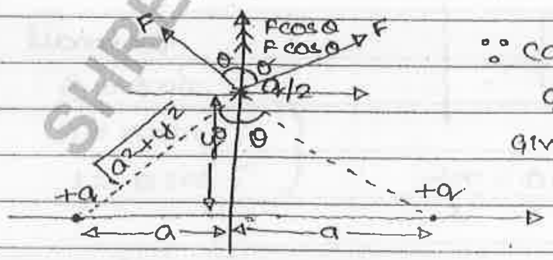
Ques> calculate x-component of Force on charge $-q_1$?



$$(F_{-q_1})_{x\text{-comp}} = \frac{Kq_1q_2}{a^2} + \frac{Kq_1q_3}{b^2}\sin\theta$$

$$(F_{q_1})_{y\text{-com}} = \frac{Kq_1q_3}{b^2}\cos\theta$$

Ques ✓



∵ calculate Force on charge $q/2$.

given:- $y \ll a$.

$$F_{net} = 2F\cos\theta$$

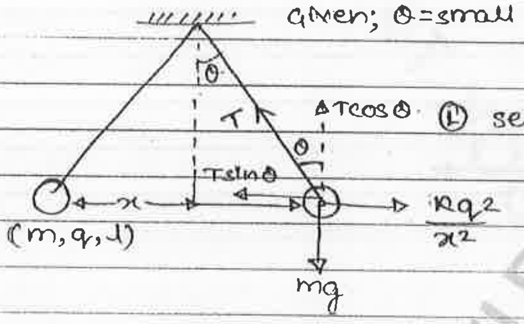
$$= 2\left\{\frac{K(q)(q/2)}{(\sqrt{a^2+y^2})^2}\right\}\left\{\frac{y}{\sqrt{a^2+y^2}}\right\}$$

$$F_{net} = \frac{Kq^2}{(a^2+y^2)^{3/2}} \cdot y = \frac{Kq^2}{a^3} \cdot y \quad \because (y<<a)$$

$$\boxed{F_{net} \propto y}$$

***Qus> 2- Identical simple Pendulam, (m,q,l) are suspended From common point, In equilibrium strings are making "small angle" with verticle than;

✓



At Balance condition (equilibrium):-

$$T \sin\theta = \frac{Kq^2}{x^2} \quad \text{---①}$$

$$T \cos\theta = mg \quad \text{---②}$$

by ①/②:- $\boxed{\tan\theta = \frac{Kq^2}{x^2 mg}}$

*** θ = small
∵ $\sin\theta = \theta$
∵ $\tan\theta \simeq \theta$
∵ $\cos\theta \simeq 1$

given θ = very small

$$\tan\theta = \theta \approx \sin\theta = \frac{x/2}{l}.$$

$$\frac{x}{2l} = \frac{Kq^2}{x^2 . mg}.$$

$$x^3 = \frac{2Kq^2 l}{mg} \Rightarrow x = \left[\frac{2Kq^2 l}{mg}\right]^{1/3}$$

$$\boxed{x \propto l^{1/3}}$$

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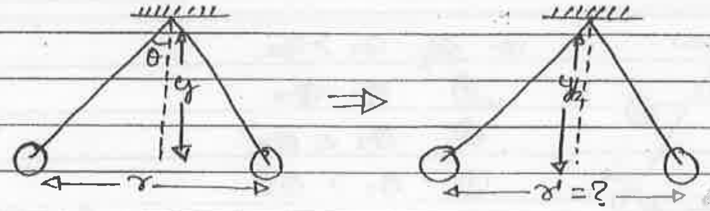

$$\tan\theta = \frac{kq^2}{r^2mg} = \frac{r/2}{y}$$

$$r^3 \propto y \Rightarrow r \propto y^{1/3}$$

$$\frac{r'}{r} = \left(\frac{y/2}{y}\right)^{1/3} = \frac{1}{2^{1/3}}$$

$$\boxed{r' = \frac{r}{2^{1/3}}} = \frac{r}{\sqrt[3]{2}}$$

$\because 2\sqrt{2} = 2^{1/2}$

$\because \sqrt[3]{2} = 2^{1/3}$

Ques> If charge of balls start's to lieque at a constant rate and Ball's come closser, with speed v than Relation b/w "v" and "x"

Ans> $x^3 = \frac{2kq^2 l}{mg}$ ∵ (see पहले वाला question)

$\because x^3 \propto q^2$

$\because q \propto x^{3/2}$

$$\underset{\text{const.}}{\frac{dq}{dt}} \propto \left(\frac{3}{2}\right) x^{1/2} \cdot \frac{dx}{dt} = v$$

$$v \cdot x^{1/2} = \text{const}$$

$\because \boxed{v \propto x^{1/2}}$

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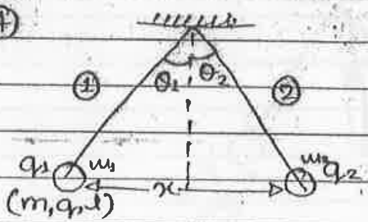
④



⇒ If $q_1 > q_2$

✓① $\theta_1 = \theta_2$

② $\theta_1 < \theta_2$

③ $\theta_1 > \theta_2$

④ None

*⑤ If $m_1 > m_2$

① $\theta_1 = \theta_2$

✓② $\theta_1 < \theta_2$ $\quad \because \tan\theta \propto \frac{1}{m}$

③ $\theta_1 > \theta_2$

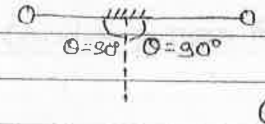
④ Now

⑥ If this system in taken in space "or" artificial satalite ?

Here; $g = 0$

$$\tan\theta = \frac{Kq^2}{x^2 m(g)} = \infty$$

⇒



$\theta = 90°$

① seperation b/w balls = $L + L = 2l$.

② Angle b/w strings = $90° + 90° = 180°$

③ $F_e = \frac{Kq^2}{(2l)^2} = \frac{Kq^2}{4l^2}$

④ Tension in each string = $T = F_e = \frac{Kq^2}{4l^2}$

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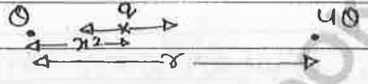
✡ ⇒ To locate Equilibrium Possition :-

① If Q_1 and Q_2 is of "same Nature" than b/w the choges.

(ii) If Q_1 and Q_2 is of opposite Nature than outside the charges.

(iii) Alway's close to small "Magnitude" charges.

Ques>



→ Right side of Q (small charg)

$$\frac{KqQ}{x^2} = \frac{Kq\,4Q}{(r-x)^2}$$

$$\frac{1}{x^2} = \frac{4}{(r-x)^2}$$

$$\frac{1}{x} = \frac{2}{r-x}$$

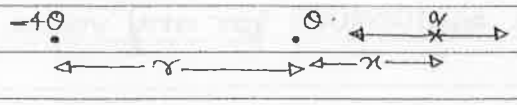
$$r-x = 2x$$

$$\boxed{x = \frac{r}{3}}$$

r/3 from Q

r − r/3 = 2r/3 from 4Q

Ques>



① Right side of 'Q'.

② $\frac{K\cancel{Q}\cancel{q}}{x^2} = \frac{K\cancel{q}(4\cancel{Q})}{(r+x)^2}$ ⇒ $\boxed{x = r}$

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

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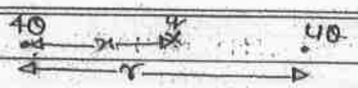
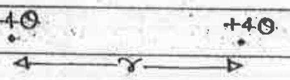
Ques>



$x = \frac{r}{2}$ (Mid point)

Ques>



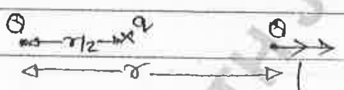
Here; equilibrium Does not exist.
It means equilibrium point at "Infinite"

⊛ ⇒ EQUILIBRIUM :-

① Particle equilibrium. (Fnet on "given Particle" is zero)

② System equilibrium. (Fnet on "each particle" of system is zero)

AIPMT
Ques>



Find Posⁿ and value of charge 'q'.

⊳ $\frac{KQ^2}{r^2} + \frac{KQq}{(r/2)^2}$

① For it's equilibrium
② For system equilibrium

Ans> ① $x = \frac{r}{2}$ (Mid point)

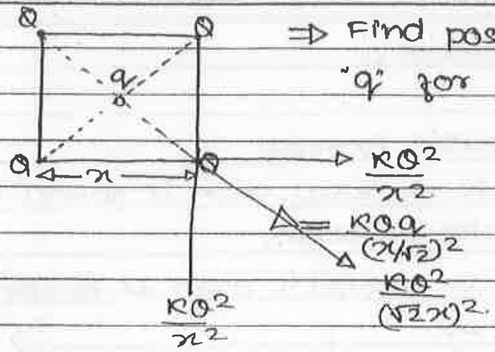
⇒ 'q' is in equilibrium for any value.

② $(F_Q)_{net} = 0$

$$\frac{KQ^2}{r^2} + \frac{4KQq}{r^2} = 0$$

$$\frac{\cancel{KQ}^{2}}{\cancel{r^2}} - \frac{4\cancel{KQ}q}{\cancel{r^2}} \Rightarrow \boxed{q = \frac{-Q}{4}}$$

AIEEE
Ques> ⇒ Find positn and value of small "q" for system equbrium?



$$(F_a)_{net} = \text{"}0\text{"}$$

$$\sqrt{2}\left(\frac{KQ^2}{x^2}\right) + \frac{KQq}{(x/\sqrt{2})^2} + \frac{KQ^2}{(\sqrt{2}x)^2} = 0$$

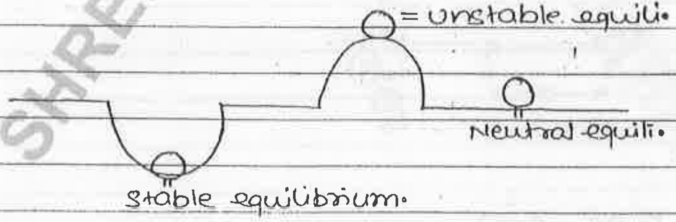
$$\frac{2KQq}{x^2} = -\frac{KQ^2}{2x^2} - \frac{\sqrt{2}\,KQ^2}{x^2}$$

$$= -\frac{KQ^2}{x^2}\left(\frac{1}{2} + \sqrt{2}\right)$$

$$\frac{2\cancel{K}\cancel{Q}q}{\cancel{x^2}} = -\frac{\cancel{K}Q^{\cancel{2}}}{\cancel{x^2}}\left(\frac{2\sqrt{2}+1}{2}\right)$$

$$\boxed{q = \frac{-Q}{4}\left(2\sqrt{2}+1\right)}$$

✡ ⇒ TYPE OF EQUILIBRIUM :-



Ⓛ

① Stable Equilibrium:-

(i) "Minimum" Potential Energy.

(ii) when particle is displaced, than it comes back and perform oscillatory Motion.

(iii) If Displacement is Negligible than it performs S.H.M where;

$$F \propto -x$$

$$F = -Kx.$$

$$ma = -Kx$$

$$a = (-K/m)x.$$

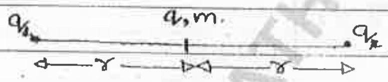
$$S.H.M\ [a = -\omega^2 x] \Rightarrow \text{standard}.$$

② Un-stable Equilibrium:-

(i) "Maximum" Pototential Energy.

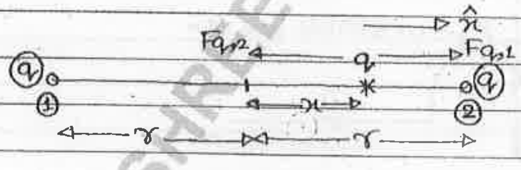
(ii) when particle is displaced, than it moves away.

Ques>



If mid particle is displac slightly than calculat Frequency of It's oscillat^n?

Ans>



$$\vec{F}_{q,1} = \frac{Kq^2}{(r+x)^2}\,(\hat{x})$$

$$\vec{F}_{q,2} = \frac{Kq^2}{(r-x)^2}\,(-\hat{x})$$

$$\vec{F}_{net} = \vec{F}_{q,1} + \vec{F}_{q,2}$$

$$= Kq^2\left[\frac{1}{(r+x)^2} - \frac{1}{(r-x)^2}\right]\hat{x}$$

$$Kq^2\left[\frac{-4rx}{(r^2-x^2)^2}\right]\hat{x}$$

$$\vec{F}_{net} = -\frac{4Kq^2}{(r^2-x^2)^2}\cdot x\,\hat{x}$$

$\Rightarrow$ stable equilibrium.

$F_{net} \propto -x \Rightarrow$ oscillation motion

Given; $x << r$

$$\vec{F}_{net} = -\left(\frac{4Kq^2}{r^3}\right)x\,\hat{x}$$

$\vec{F}_{net} \propto -x \Rightarrow$ SHM.

$$m\vec{a} = -\left(\frac{4Kq^2}{r^3}\right)\cdot x\,\hat{x}$$

$$\vec{a} = -\left(\frac{4Kq^2}{mr^3}\right)\cdot x\,\hat{x}$$

S.H.M ; $a = -\omega^2 x$

$$\therefore \omega = \sqrt{\frac{4Kq^2}{mr^3}}$$

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{\cancel{4}\left(\frac{1}{\cancel{4}\pi\varepsilon_0}\right)q^2}{mr^3}}$$

$$\boxed{f = \frac{q}{2\pi}\sqrt{\frac{1}{\pi\varepsilon_0 m r^3}}}$$

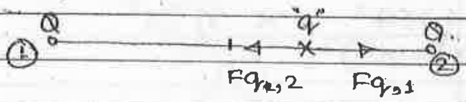
Ques>

① Axial Direction.

② Equatorial Directn

**[If not given considered Axial Directn]

Ans> ① Axial Direction:-



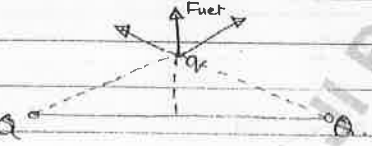
∵ $r_1 > r_2$

∴ $F_{q,1} < F_{q,2}$

$F_{net} \neq 0$ [∵ left-ward]

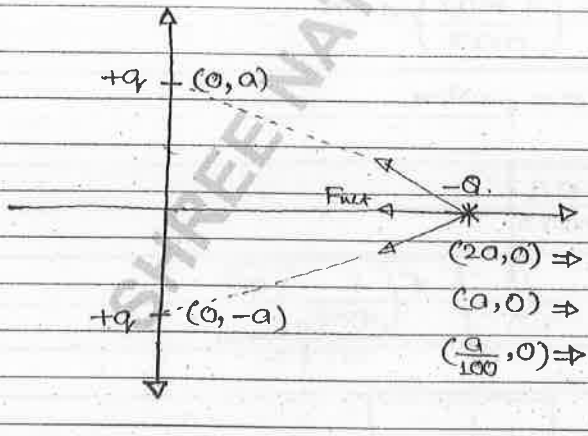
⇒ stable equilibrium.

② Equatorial Direction:-



⇒ Un-stable equilibrium.

Ques>



(2a, 0) ⇒ Displac. not Negligible = oscil.

(a, 0) ⇒ Displ. not Negligible ⇒ oscill

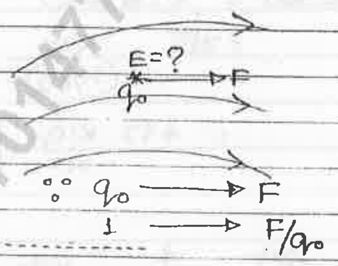
$(\frac{a}{100}, 0)$ ⇒ Displ. Negligable = SHM

✡ ⇒ ELECTRIC FIELD INTENSITY (E):-

= It Represent's the strength of Effect of charge at given Point.

= It is equal to Force acting on "unit Possative Test charge" Placed at given point.

$$\vec{E} = \lim_{q_0 \to 0} \frac{\vec{F}}{q_0}$$



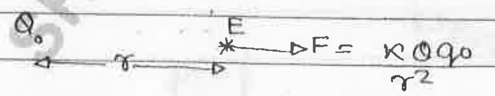
⊛ *Vector (HP to L.P)
+ve to −ve
*Alway's from ⊕ve toward's ⊖ve.

"Unit":- $\frac{N}{C}$, $\frac{volt}{m}$

E → Uniform. (Position Indipendent)
→ Non-Uniform. (Position Dependent)

Ques> $\vec{E}_{room} = (2x)i + (5)j - \overset{①}{k}$ ⇒ Non-Uniform.
$\vec{E}_{room} = ②i + ③j - \underset{①}{k}$ ⇒ Uniform.

① Electric Field (E) due to point charge:-



$$E = \lim_{q_0 \to 0} \frac{F}{q_0} = \lim_{q_0 \to 0} \frac{\frac{KQ\cancel{q_0}}{r^2}}{\cancel{q_0}}$$

$$\boxed{E = \frac{KQ}{r^2}} \quad \boxed{\vec{E} = \frac{KQ}{r^2}\hat{r}} \Rightarrow \text{vector Form.}$$

$2E \times \frac{2\sqrt{2}}{\sqrt{2}\sqrt{2}} : \frac{\sqrt{2}}{2}$

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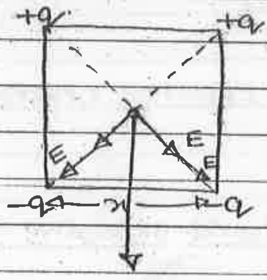
Ques>



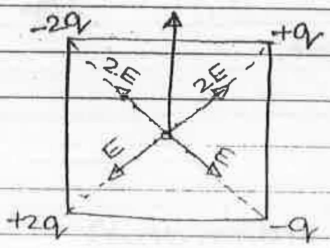
Ecentre = ?

$E_{cent} = \sqrt{2}(2E)$

$= 2\sqrt{2} \frac{Kq}{(x/\sqrt{2})^2}$

$= 4\sqrt{2} \frac{Kq}{x^2} \downarrow$ (vt. downword)

Ques>



Ecentre = ?

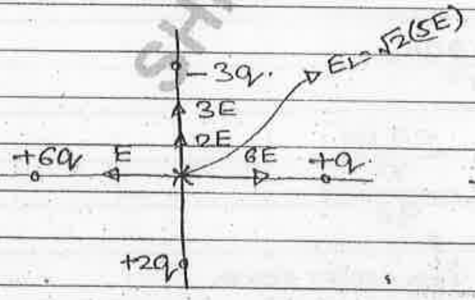
Ans>

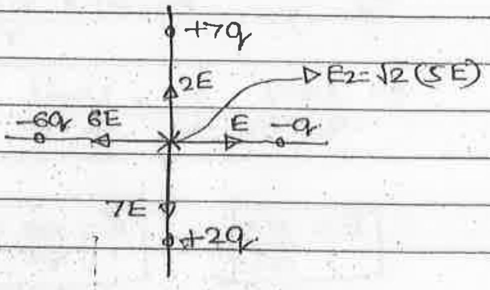
$E_{net} = \sqrt{2} E$,,

$= \sqrt{2}\left\{\frac{Kq}{(x/\sqrt{2})^2}\right\}$

$= 2\sqrt{2} \frac{Kq}{x^2} \uparrow$ vt. upword.

Ques>





Each charges is at same distamtance from origin?

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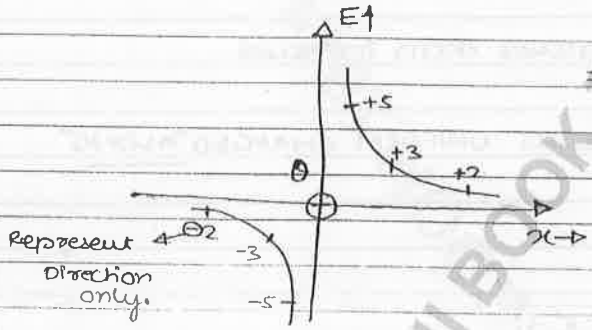
Ans> ① $E_1 = E_2$ ✓
② $\vec{E_1} = \vec{E_2}$ ✗
③ $\vec{E_1} = -\vec{E_2}$ ✓

Ques> $E = \frac{KQ}{r^2}$; $\propto \boxed{\frac{1}{r^2}}$

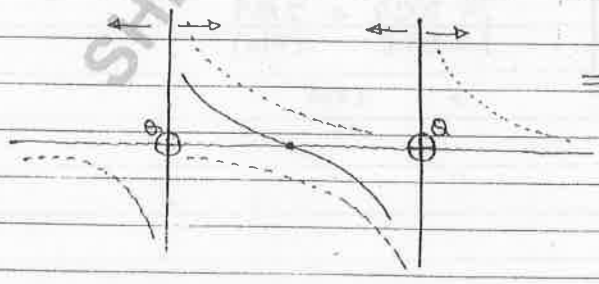


⇒ when Moving away from charge, electric field continiously Decreases

eg:- $-3\ V/m > +2\ V/m$
$-1\ V/m < -5\ V/m$

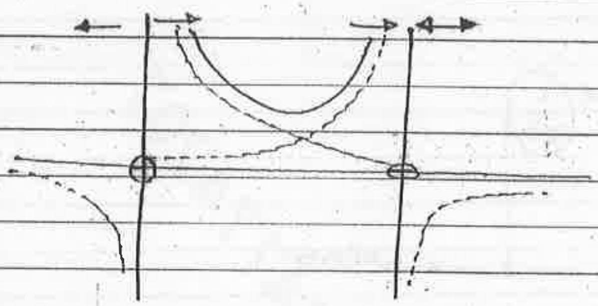
Ques> "E" v/s "r"

① +Q 'x' +Q



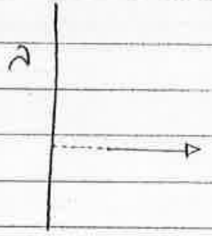
⇒ Electric field 1st Decreases than increases.

(ii) $+Q$ $\overset{r}{}$ $-Q$



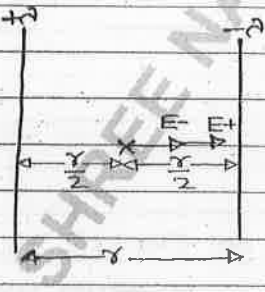
⇒ Electric Field 1st Decreases than increases

(III) ELECTRIC FIELD DUE TO UNIFORM CHARGED "ALONG" LONG WIRE :-



$$\boxed{E = \frac{2K\lambda}{r}}$$

Ques>



$E_{mid} = ?$

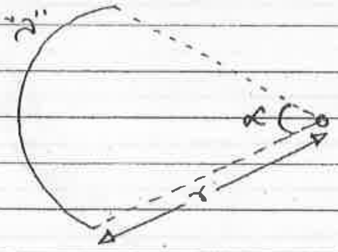
$$= E_+ + E_-$$

$$= \frac{2K\lambda}{(r/2)} + \frac{2K\lambda}{(r/2)}$$

$$= \frac{8K\lambda}{r}$$

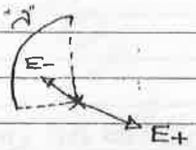
~~Ques> Uniform charged arc :-~~

(III) ELECTRIC FIELD DUE TO UNIFORM-CHARGED ARC ?



$$\boxed{E = \frac{2K\lambda}{r}\sin\left(\frac{\alpha}{2}\right)}$$

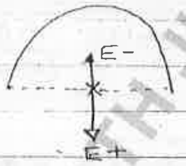
case :- ① :-



$\alpha = 90°$

$$\boxed{E = \frac{\sqrt{2}K\lambda}{r}}$$

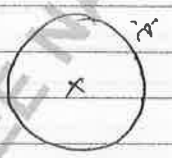
case :- (II) :-



$\alpha = 180°$ sin 90

$$\boxed{E = \frac{2K\lambda}{r}}$$

case :- (III) :-

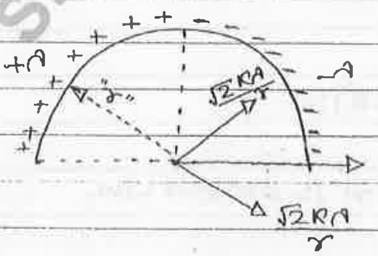


$\alpha = 360°$

$E = \frac{2K\lambda}{r}\sin\left(\frac{360}{2}\right)$

$$\boxed{E = 0}$$

*** Ques>

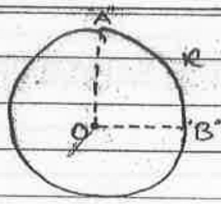


$E_{centre} = ?$

$E_{net} = \sqrt{2}\left(\frac{\sqrt{2}K\lambda}{r}\right)$

$$\boxed{E_{net} = \frac{2K\lambda}{r}}$$

Ques>



If $\vec{E}_{ARB} = E\,[R \text{ to } O]$

$E_{remaining\ ring} = ?$

A pO

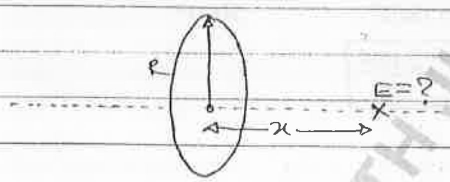
Ans> $\vec{E}_{ring} = 0$

$\vec{E}_{ARB} + \vec{E}_{remaining} = 0$

$\vec{E}_{remaining} = -\vec{E}_{ARB}$

$= E\,(O \text{ to } R)$

Ⓘⓥ ELECTRIC FIELD AT AXIAL POINT ~~@~~ OF UNIFORM CHARGED RING:-



$$\boxed{\begin{array}{l} E_{axis} = \dfrac{KQ(x)}{(R^2+x^2)^{3/2}} \\[2ex] \vec{E}_{axis} = \dfrac{KQ}{(R^2+x^2)^{3/2}}\,\vec{x} \end{array}}$$

case: Ⓘ :- At centre $(x=0)$:-

$$\boxed{E_{centre} = 0}$$

case: Ⓘⓘ :- Nearby Point $(x \ll R)$:-

$E = \dfrac{KQ}{R^3}\,x \Rightarrow [E \propto x]$:- straight Line.

$\frac{2kq}{3\sqrt{3}R^2}$

case :- Ⅲ :- For Away Points :- $(x >> R)$

$$E = \frac{KQ}{x^2} \Rightarrow \boxed{E \propto \frac{1}{x^2}} \Rightarrow \text{Hyperbola.}$$

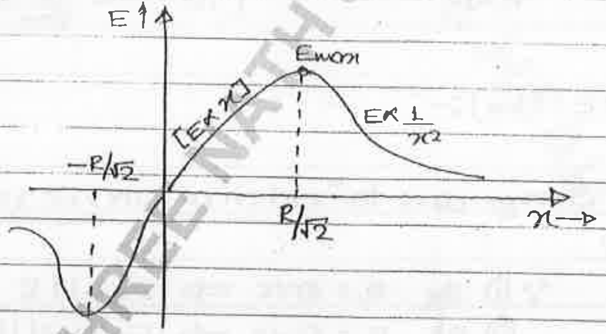
case :- Ⅳ :- For Emax :-

$$\frac{dE}{dx} = 0$$

$$\boxed{x = \pm \frac{R}{\sqrt{2}}}$$

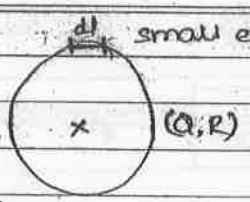
$$E_{max} = \frac{KQ(R/\sqrt{2})}{\left(R^2 + \frac{R^2}{2}\right)^{3/2}} = \frac{KQ(R/\sqrt{2})}{\left(\frac{3R^2}{2}\right)^{3/2}} = \frac{KQ(R/\sqrt{2})}{\left(\frac{3R^2}{2}\right)\left(\frac{\sqrt{3}R}{\sqrt{2}}\right)}$$

$$\boxed{E_{max} = \frac{2KQ}{3\sqrt{3}R^2}}$$



Que> For a uniformly charged ring (Q, R) of small (section) element, (dl) is remove from ring than Electric field at centre due to Remaining Part ?

Ans> small element, dl. ∵ Ring (Q,R)



$$∵\ \vec{E}_{ring} = 0$$

$$\vec{E}_{dl} + \vec{E}_{ring\,remaining} = 0$$

$$∵\ \vec{E}_{ring} = -\vec{E}_{dl}$$

$$\vec{E}_{remaining} = E_{dl} = \frac{K(dq)}{R^2} = \frac{K\left(\frac{Q}{2\pi R}dl\right)}{R^2} ✓$$

$$∵\ E_{remaining\ part} \propto \frac{1}{R^3} ✓$$

$2\pi R \longrightarrow Q$

$1 \longrightarrow \frac{Q}{2\pi R}$

$dl \longrightarrow \frac{Q}{2\pi R}dl$

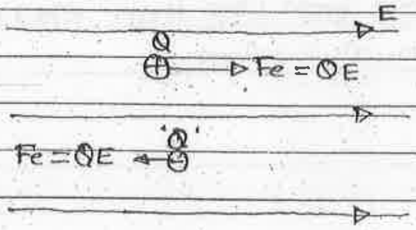
✡ ⇒ ELECTRIC FORCE (Fe):-

→ It is force on charge due to "external Electric field."

$$\boxed{\begin{aligned} F_e &= q.E \\ \vec{F_e} &= q.\vec{E} \end{aligned}}$$

∵ ① If $q = ⊕ve$ ⇒ $F_e \parallel E$

② If $q = ⊖ve$ ⇒ F_e Anti $\parallel E$



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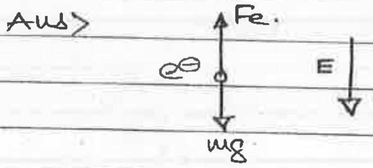
*Ques> Find direction and Magnitude of Required electric Field to balange weight of electron in air?

Ans>



At Balance:-

$Fe = mg.$

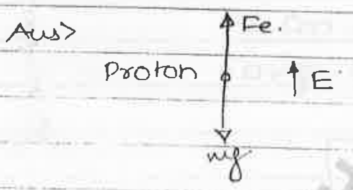
$qE = mg.$

$E = \frac{mg}{q} = \frac{9.1 \times 10^{-31} \times 10}{1.6 \times 10^{-19}}$

$= 5.6 \times 10^{-11}$ N/C.

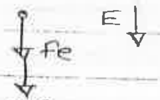
*Ques> A proton is balanced in external electric field, if dir^n of Electric field is Reverse than find accn of Proton?

Ans>



$Fe = mg$ .... ①

Proton;

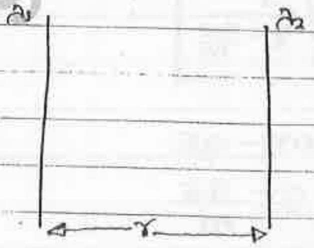


$F_{net} = Fe + mg = mg + mg$

$= 2mg.$

$a = \frac{F}{m} = 2g.$

**Ques AIPMT Find force on unit length of each wire:-



$\frac{F_{2,1}}{l_2} = \frac{q_2 E_1}{l_2}$

$= (\lambda_2)\left(\frac{2K\lambda_1}{r}\right)$

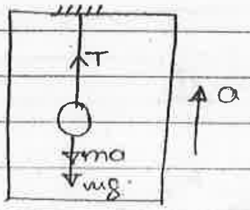
$= \frac{2K\lambda_1\lambda_2}{r}$

Ques> simple Pendulum

$$\boxed{T = 2\pi\sqrt{\frac{l}{g_{eff}}}}$$

⊛ => $g_{effective}$:- Acceleratn corrospondin to net Force except Tension.

(i)

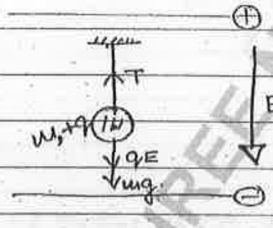


$F_{net} = mg + ma.$

$g_{eff} = \frac{F}{m} = g + a$

$$\boxed{T = 2\pi\sqrt{\frac{l}{g+a}}}$$

(ii)

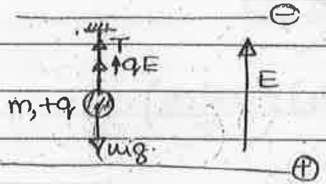


$F_{net} = mg + qE$

$g_{eff} = g + \frac{qE}{m}$

$$\boxed{T = 2\pi\sqrt{\frac{l}{g+\frac{qE}{m}}}}$$

(iii)

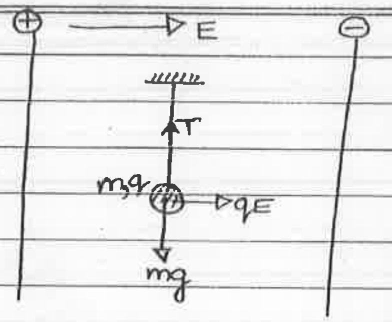


$F_{net} = mg - qE$

$g_{eff} = g - \frac{qE}{m}$

$$\boxed{T = 2\pi\sqrt{\frac{l}{g-\frac{qE}{m}}}}$$

(iii)



$$F_{net} = \sqrt{(mg)^2 + (qE)^2}$$

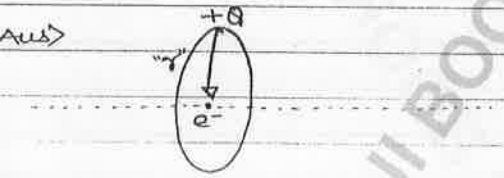
$$g_{eff} = \sqrt{g^2 + \left(\frac{qE}{m}\right)^2}.$$

$$\boxed{T = 2\pi \sqrt{\frac{l}{\sqrt{g^2 + \left(\frac{qE}{m}\right)^2}}}}$$

*IMP ***

Ques> A uniformly charged Ring $(+Q, r)$ an electron is placed at it's centre, if $e^{\ominus}$ is displaced slightly than calculate "angular frequency of its oscillatn?

Ans>



$E_{cent} = 0$

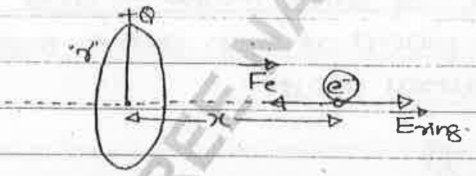
At centre $F_{e^{\ominus}} = qE$

$= (e)(0)$

$= 0$

$[e^{\ominus}$ is in equilibrium$]$

① If displace by "x"



$$\vec{F_e} = q\vec{E}$$

$$= (-e)\left\{\frac{KQ}{(r^2+x^2)^{3/2}}\right\}\vec{x}.$$

$$\vec{F_e} = -\left\{\frac{KQe}{(r^2+x^2)^{3/2}}\right\}\vec{x}.$$

$F_e \cancel{\propto} -x \Rightarrow$ oscillation (so only)

② ∵ Given $x << r$

$$\vec{F_e} = -\left(\frac{kQe}{r^3}\right)\vec{x}$$

$$F_e \propto -x \quad (SHM)$$

$$a = -\left[\frac{kQe}{mr^3}\right]\vec{x}$$

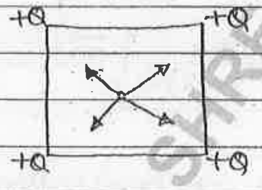
$$a = -\omega^2 x.$$

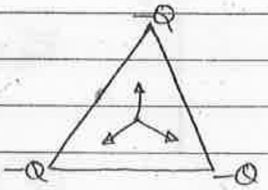
$$\therefore \boxed{\omega = \sqrt{\frac{kQe}{mr^3}}}$$

✡ ⇒ NEUTRAL POINT:-

→ ** where $E_{Net} = 0$.

→ In any Regular Polygon, If **"same Magnitue and same Nature" charges is placed at each corner than goemetrical centre is Neutral Point.





→ ** Neutral Point and equilibrium point are same Point.

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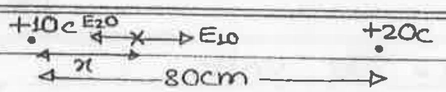
Ques>



Find Neutral point?

Ans> Right side of +10C ;

$$E_{10} = E_{20}$$

$$\frac{K(10)}{x^2} = \frac{K(20)}{(80-x)^2}$$

$$\frac{1}{x^2} = \frac{2}{(80-x)^2}$$

$$\frac{1}{x} = \frac{1.4}{80-x}$$

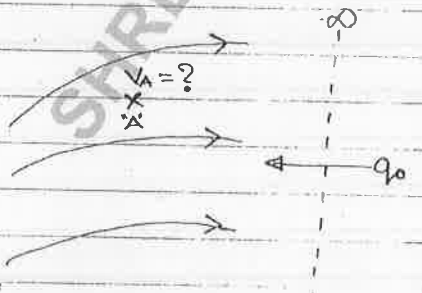
$$80-x = 1.4x.$$

$$80 = 2.4x.$$

$$x = \frac{800}{24} = 33cm_{\prime\prime}$$

✡ ⇒ ELECTRIC POTENTIAL :- (V) :-

⇒ It is equal to work done in shifting unit +ve charge from Reference to given point, where Kinetic Energy of charge should be constant.



q_0 —— work $= W_{\infty \to A}$

$+1$ —— work $= \frac{W_{\infty \to A}}{q_0}$

⊛ $\boxed{V_A = \frac{W_{\infty \to A}}{q_0}}$

⇒** q_0 scalar Quantity.

⊛ $\boxed{V_A = -\int_{\infty}^{r_A} \vec{E} \cdot \vec{dr}}$

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⇒ Unit:- ① MKS = J/C , Volt.

② CGS = stat V.

$$\boxed{1V = \frac{1}{30}\ stV}$$

∵ $V_{reference} = 0$

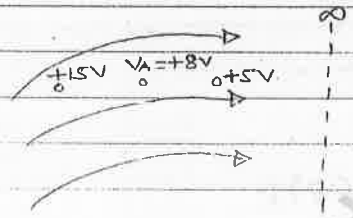
∵ $V_{\infty\ position} = 0$

∵ $V_{earth} = 0$

→* Potential is Defined for "conservative Fields" only.

→* Potential depend on Refrence, so it is Relative Parametr.

eq:-



① Refrence = ∞ position

$V_A = \oplus 8V.$

② Refrence = ⊕8V

$V_A = 0$

③ Refrence = ⊕5V

$V_A = \oplus 3V$

④ Refrence = ⊕15V.

$V_A = \ominus 7V$

Ques> which is more:-

① $-1V > -3V$

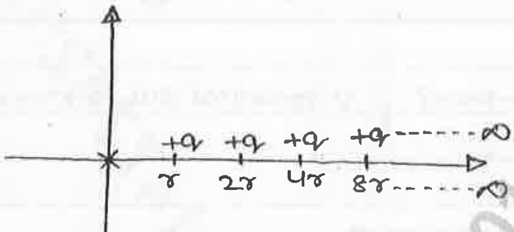
② $+3V > -3V$

① Potential due to Point charge :-

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

***[Charge must be with sign.]

Ques>



$V_{origin} = ?$

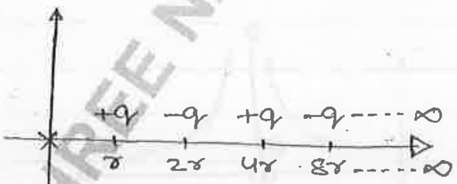
Ans> $V_{origin} = \frac{kq}{r} + \frac{kq}{2r} + \frac{kq}{4r} + \frac{kq}{8r} \cdots\cdots \infty$

$= \frac{kq}{r}\left[1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} \cdots\cdots \infty\right]$ **[Geometric Progression]

$$\boxed{\begin{array}{l} S_\infty = \frac{a}{(1-r)} \quad (r<1) \text{ **(keep it with its sign)} \\ S_\infty = \infty \quad (r \geq 1) \end{array}}$$

$= \frac{2kq}{r}$

Ques>

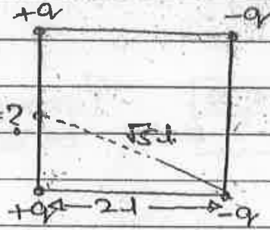


Ans> $V_{origin} = \frac{kq}{r} - \frac{kq}{2r} + \frac{kq}{4r} - \frac{kq}{8r}$

$= \frac{kq}{r}\left[1 - \frac{1}{2} + \frac{1}{4} - \frac{1}{8}\right]$

$= \frac{kq}{r}\left[\frac{1}{1-(-1/2)}\right] = \frac{2}{3}\left(\frac{kq}{r}\right)$,,

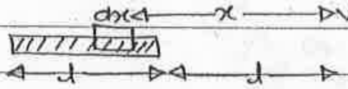
Ques>



$$V = \frac{kq}{l} + \frac{kq}{l} - \frac{kq}{\sqrt{5}l} - \frac{kq}{\sqrt{5}l}$$

$$= \frac{2kq}{l}\left(1 - \frac{1}{\sqrt{5}}\right)$$

**Ques>



∵ Potential due to Element?

Ans> Potential due to element

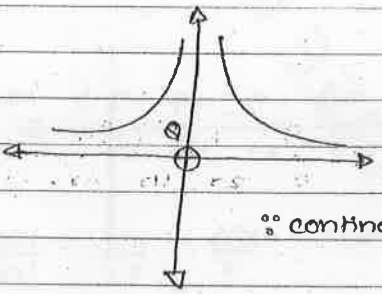
$$= \frac{k\left(\frac{Q}{l}.dx\right)}{x}$$

$$V_{net} = \int_{l}^{2l} \frac{kQ}{l}\cdot\frac{dx}{x} = \frac{kQ}{l}\left[\log_e x\right]_{l}^{2l}$$

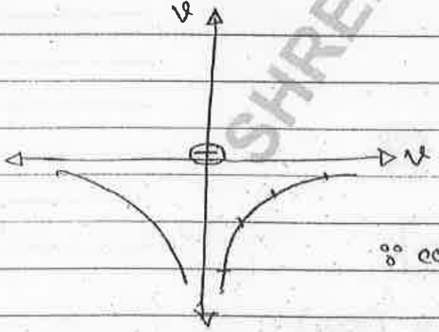
$$= \frac{kQ}{l}\left[\log 2l - \log l\right]$$

$$= \frac{kQ}{l}\log_e 2$$

**Ques> $V = \frac{kQ}{r} \propto \frac{1}{r} \Rightarrow$

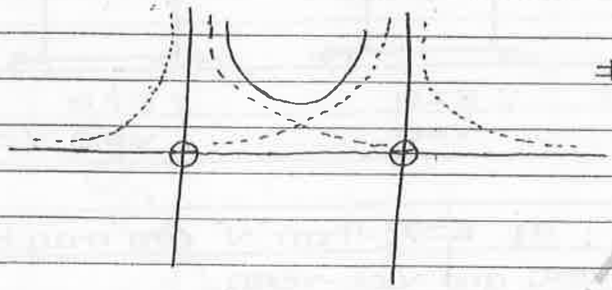


∵ continuous Decreasing.

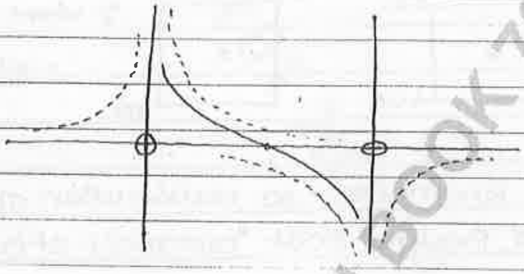


∵ continious Increasing.

⊛ ⇒ "V" v/s "r"

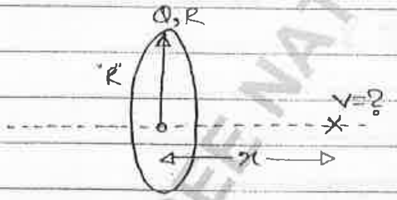


⇒ 1st Decreases than Increases.



⇒ constantly Decreasing.

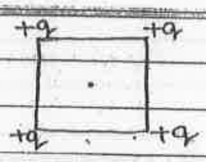
(II) POTENTIAL AT AXIAL POINTS OF CHARGED RING:-



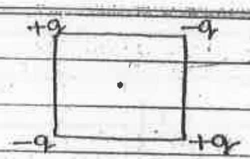
$$\Rightarrow \boxed{V_{axis} = \frac{KQ}{\sqrt{R^2+x^2}}}$$

$$^{**}\Rightarrow \left[\begin{array}{l} V_{centre} = \frac{KQ}{R} \neq 0 \\ E_{centre} = 0 \end{array}\right]$$

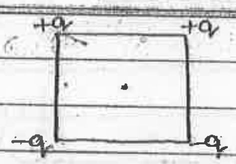
Ex:-



∴ $E=0$
$V\neq0$



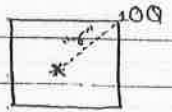
∴ $E=0$
$V=0$

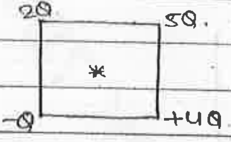


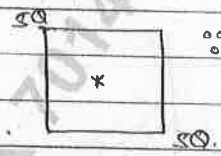
∴ $E\neq0$
~~$V\neq0$~~ $V=0$

⇒ At any point; If $E=0$; than "V" can may be zero "or" Non-zero and vice-versa.

eg:-



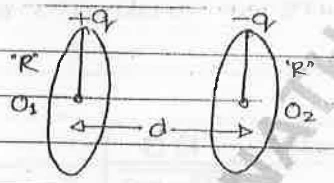




∴ $V_{cent} = \frac{K(100)}{r}$
= same.

→ Potential is a scalar parameter, so Distribution of charge doesn't matter, Provided that "Distances should be same.

Ques>



→ Potential Difference b/wn centre ?

Ans>

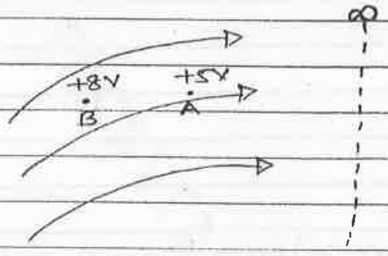
$$V_{O1} = \frac{Kq}{R} - \frac{Kq}{\sqrt{R^2+d^2}}$$

$$V_{O2} = -\frac{Kq}{R} + \frac{Kq}{\sqrt{R^2+d^2}}$$

$$V_{O1}-V_{O2} = 2\left[\frac{Kq}{R} + \frac{Kq}{\sqrt{R^2+d^2}}\right]$$

✡⇒ POTENTIAL DIFFRENCE :- (P.D) :-

It is equal to workdone, in shifting unit ⊕ve charge from "one point" to "other" keeping it's K.E constant.



$$\boxed{V_B - V_A = -\int_{r_A}^{r_B} \vec{E}\cdot\vec{dr}}$$

Ques :-

Refrence = ∞ posn	Refrence = +2V
$V_A = +5V$	$V_A = +3V$
$V_B = +8V$	$V_B = +6V$
$V_B - V_A = +3V.$	$V_B - V_A = +3V$

**NOT :- Potential Difference (P.D) does not depend on Refrence so it is "absolute Parameter."

⊗⇒ Relation b/w E & V :-

**⇒ "Electric-field" is Negative of "Potential gradient."

Type :1 :- If $v = f(r) \Rightarrow E = ?$

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

$$\boxed{\vec{E} = -\frac{dV}{dr}\,\hat{r}}$$

Qus> In space ; Potential is $\left[V = \frac{K}{r}\right]$ than E=?, at $\vec{r} = 2\hat{i} + 3\hat{j} + 6K$

Ans> $\vec{E} = -\frac{dv}{dr}\,\hat{r}$

$= -\frac{d}{dr}\left(\frac{K}{r}\right)\hat{r}$

$= -\left(-\frac{K}{r^2}\right)\frac{\vec{r}}{r}$

$\boxed{\vec{E} = \frac{K}{r^3}\,\vec{r}}$ ⇒ Non-Uniform Electric field.

$\vec{E}(2\hat{i}+3\hat{j}+6\hat{K}) = \frac{K}{7^3}(2\hat{i}+3\hat{j}+6\hat{K})$

$\vec{E}(3\hat{i}-4\hat{k}) = \frac{K}{5^3}(3\hat{i}-4\hat{k})$

Type:-②:- If $V = f(x,y,z)$ ⇒ E=?

$$\vec{E} = -\left[i\frac{\partial V}{\partial x} + j\frac{\partial V}{\partial y} + K\frac{\partial v}{\partial z}\right]$$

Qus> $V = 6x - 8xy^2 + 6yz - 8y - 4z^2$ ⇒ $\vec{E}_{(0,0,0)} = ?$

Ans> $\frac{\partial V}{\partial x} = 6(1) - 8y^2(1) + 0 - 0 - 0$

$\frac{\partial V}{\partial y} = ~~0 + 8x(1) + 6z + 8~~\ 0 - 8x(2y) + 6z - 8 - 0$

$\frac{\partial v}{dz} = 0 - 0 + 6y(1) - 0 - 4(2z)$

⇒ Depend's on variable Position, so Non-uniform

$$\vec{E} = -[i(6-8y^2) + j(-16xy+6z-8) + k(6y-8z)]$$

A: $\vec{E}_{origin} = -[i(6) + j(-8) + k(0)]$

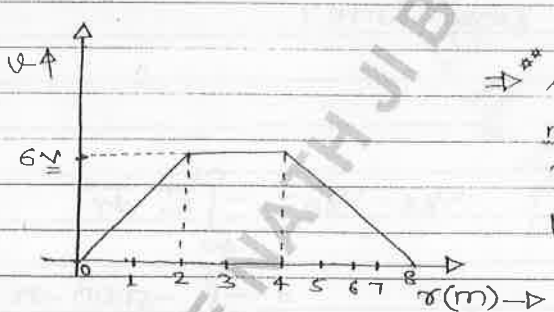
$= -6i + 8\hat{j}$

$|E| = \sqrt{6^2+8^2} = 10$ unit

TYPE:- ③ :- If v-r graph ⇒ E = ?

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

$$\boxed{E = -\text{slope}}$$



⇒** At r = 2m & 4m, graph is not Differentiable, so electric field is "undefined" at these points.

	slope: $\left(\frac{y_2-y_1}{x_2-x_1}\right)$	E = -(slope)
① 0-2 ⇒	$\frac{6-0}{2-0} = +3$	-3 V/m.
② 2-4 ⇒	$\frac{6-6}{4-2} = 0$	0
③ 4-8 ⇒	$\frac{0-6}{8-4} = -1.5$	+1.5 V/m.

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TYPE:- ④ :- If $E = f(r) \Rightarrow$ P.D = ?

P.D = $-\int \vec{E}\cdot\vec{dr}$

$V_B - V_A = -\int_{r_A}^{r_B} \vec{E}\cdot\vec{dr}$

$V_A - V_B = -\int_{r_B}^{r_A} \vec{E}\cdot\vec{dr}$

** ⊳ If "E" is uniform $\Rightarrow$ P.D = $-\vec{E}\cdot\vec{dr}$

Ques> Electric-field due to charged wire is $\frac{-5000}{r}$ $\frac{\text{volt}}{\text{m}}$. Than calculate Potential Difference between 30cm. and 60cm. distance from wire?

Ans> $E = -\frac{5000}{r}$ $\frac{\text{volt}}{\text{m}}$

~~V~~ = $-5000 \int \frac{1}{r}$

$V_{60} - V_{30} = -\int_{0.3}^{0.6} \vec{E}\cdot\vec{dr}$

$= -\int_{0.3}^{0.6} \frac{-5000}{r}\cdot dr$

$= +5000\left[\log_e r\right]_{0.3}^{0.6}$

$= 5000 \log_e 2$

$= 5000 \times 0.693$

$=$ 3465 volt.

∴ $\log_e a - \log b = \log \frac{a}{b}$

so; $V_{60} - V_{30} = 3465.V$

$V_{30} - V_{60} = -3465.V$

**∴ P.D = 3465 volt *(always ⊕ve)

⊛ $V_{60} > V_{30}$

⊛ If $V_{30} = -2000$ than find $V_{60} = ?$

$V_{60} - V_{30} = +3465 \Rightarrow V_{60} - (-2000) = +3465$

$V_{60} = +3465 - 2000$

$= 1465$

*Que> In space electric field is $= 2\hat{i} + 3\hat{j} + 4\hat{k}$, and $\vec{r_a} = \hat{i} - 2j + k$ and $\vec{r_b} = 2\hat{i} + \hat{j} - 2\hat{k}$.

Than; $V_a - V_b = ?$

Ans> $V_a - V_b = -\vec{E} \cdot \vec{dr}$

$V_a - V_b = -\vec{E} \cdot (\vec{r_a} - \vec{r_b})$

$= -(2\hat{i} + 3\hat{j} + 4\hat{k}) \; (-\hat{i} - 3\hat{j} + 3\hat{k})$.

$= -[-2 - 9 + 12]$

$= -1$ volt.

⊛ $V_a - V_b = -1$ volt

⊛ $V_b - V_a = +1$ volt.

⊛ P.D = +1 volt (always ⊕ve)

⊛ $V_b > V_a$

⊛ If $V_b = +3$ volt than find $V_a = ?$

$\Rightarrow V_a - 3 = -1$

$V_a = -1 + 3 = +2$ volt

***Type:-⑤: If $E = f(x, y, z) \Rightarrow$ P.D = ?

$PD = -\int \vec{E} \cdot \vec{dr}$

$(E_x i + E_y j + E_z k) \; (dx i + dy j + dz k)$

$P.D = -\int E_x \cdot dx - \int E_y \cdot dy - \int E_z \cdot dz$

Ques> Due to a charge wire at origin, Electric field is:-

$\vec{E} = \frac{100}{x^2}\hat{i}$ $\frac{\text{volt}}{m}$

$V_{x=20cm} - V_{x=10cm} = -\int_{0.1}^{0.2} \frac{100}{x^2} \cdot dx.$

$V_{20} - V_{10} = -100 \left[\frac{-1}{x}\right]_{0.1}^{0.2}$

$= +100 \left[\frac{1}{0.2} - \frac{1}{0.1}\right]$

$= +100 [5-10].$

$= -500$

$V_{20} - V_{10} = -500$ volt

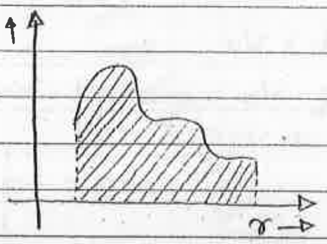
$V_{10} - V_{20} = 500$ volt.

P.D = 500 volt. (always in ⊕ve)

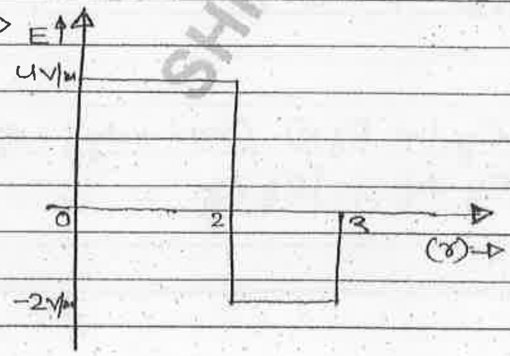
TYPE :- ⑥ :- If E-r graph ⇒ P.D = ?

$P.D = -\int \vec{E} \cdot \vec{dr}$

∴ P.D = ***Area under the curve.



Ques>



① $(P.D)_{0-2}$

② $(P.D)_{2-3}$

③ $(P.D)_{0-3}$

Ans> ① $(P.D)_{0-2} = 2\times4 = 8$ volt.

② $(P.D)_{2-3} = -2\times1 = -2$ volt

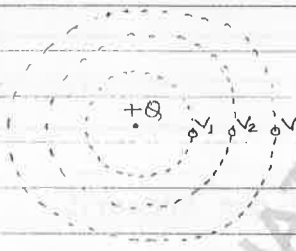
③ $(P.D)_{0\cdot3} = +8-2 = 6$ volt.

✡ ⇒ Equipotential surface :-

① It has same potential at each point.

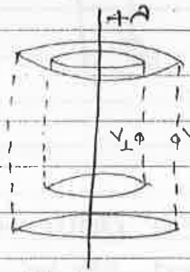
** (ii) "conductor's" are equipotential surface, it mean potential at surface and all inside points are same

ⓐ spherical :-



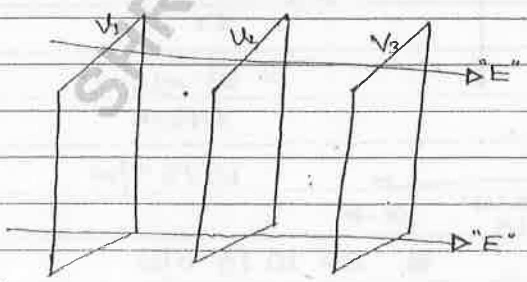
$V_1 > V_2 > V_3$

ⓑ cylendrical :-



$V_1 > V_2$.

ⓒ Plane surface :-



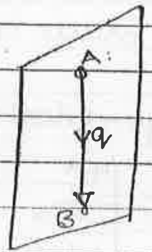
$V_1 > V_2 > V_3$

⊛ Properties of Equipotential surface :-

① Never Intersect each other.

** ② Electric field and Line of Force are always "⊥" to equipotential surfaces.

③ Work-done for Moving a charge b/w^n two points of Equipotential surface is alway's zero.

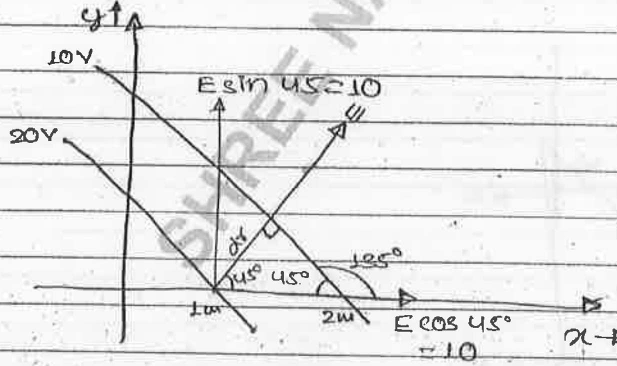


$\because W = q(V_B - V_A)$

$\because V_A = V_B$

$\because \boxed{W = 0}$

*** Ques> Two plane equipotential surface are shown :-
W Find electric field b/w^n surface :-



$|E| = \dfrac{dV}{dr}$

$= \dfrac{10\ \text{volt}}{1/\sqrt{2}\,m}$

$10\sqrt{2}\ V/m.$

$\sin 45 = \dfrac{d\vec{r}}{1}$

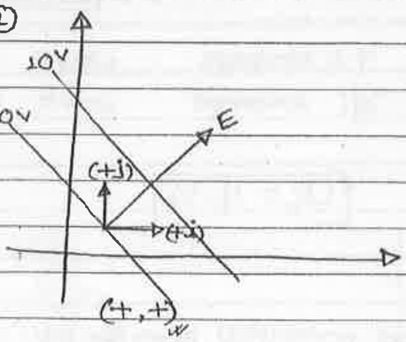
$dr = \dfrac{1}{\sqrt{2}} m.$

⊛ $E = 10\sqrt{2}\ V/m$

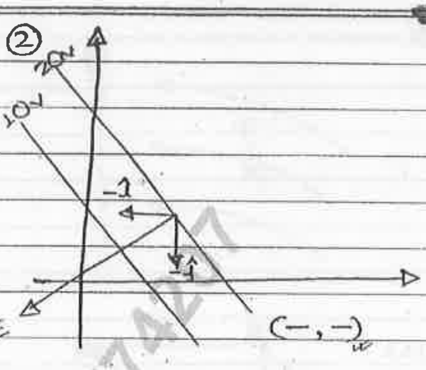
(At +45° from +x axis)

⊛ $\vec{E} = 10\hat{i} + 10\hat{j}$.

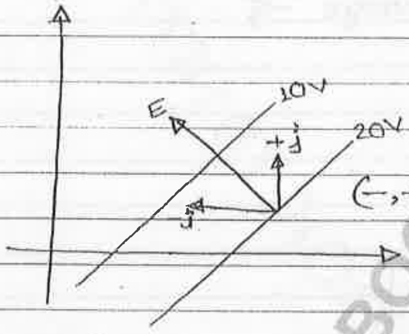
⊛ ⇒ ①



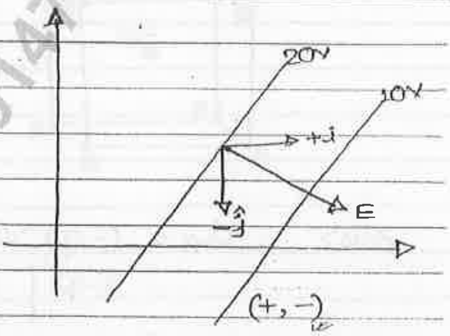
②



③



④



✡ ⇒ ELECTROSTATIC POTENTIAL ENERGY (U):-

① It is defined for "conservative fields only."

ⓘⓘ It depends on Refrence ; so a "Relative Parameter."

ⓘⓘⓘ It is energy of system due to it's configuration.

(I) Potential Energy of single Point charge:-

It is equal to workdone, in shifting that charge from Refrence to it's position.

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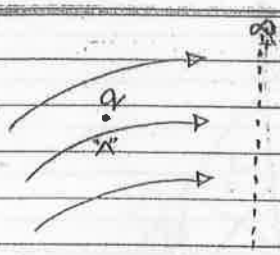
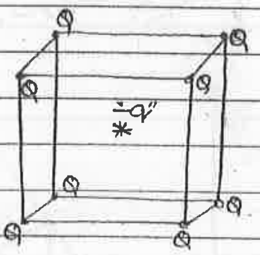


∵ +1 charge work = V_A.

∵ "q" charge work = qV_A.

$$\boxed{U_q = q \cdot V_A}$$

*AIPMT Ques> Find potential energy of charge "$-q$"



Ans> $U_q = (-q)\, V_{centre}$

$$(-q)\left[\frac{KQ}{\frac{\sqrt{3}x}{2}} \times 8\right]$$

$$= \frac{-16\, KQq}{\sqrt{3}x}.$$

(II) Potential energy of system having (2) point charges:-

(i) $U = \dfrac{Kq_1 q_2}{r}$

(ii) $U_\infty = \dfrac{Kq_1 q_2}{\infty} = 0$

** ⇒ $U = \oplus$ve, $\ominus$ve, zero.

** ⇒ $-3J > -5J$

** AIEEE Ques> $\oplus\rightarrow \quad \leftarrow\oplus$ $\qquad\qquad$ $\oplus\rightarrow \quad \leftarrow\ominus$

If $r \downarrow$ $\qquad\qquad$ If $r \downarrow$

$\Rightarrow U$ (+ve) $\uparrow$ $\qquad\qquad$ $\Rightarrow U$ (−ve) $\uparrow$

$\Rightarrow$ P.E $\uparrow$ $\qquad\qquad$ $\Rightarrow$ P.E $\downarrow$

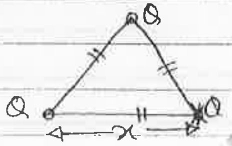
** → when two charges are brought close to each other than Potential energy may "Increase" or "Decrease".

(III) Potential Energy of system having "n" point charges:-

It is algebric sum of all Potential Energy of all possible pairs of ②-point charges.

$\Rightarrow$ no. of possible pairs = $\boxed{\frac{n(n-1)}{2}}$

*** Ques>



$\Rightarrow$ Find potential energy of any one charge:-

Ans> (i) $U_Q = [Q]\left[\frac{KQ}{x} + \frac{KQ}{x}\right]$

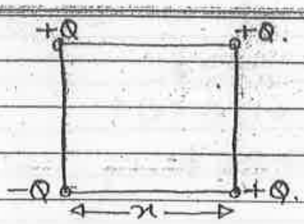
$= \frac{2KQ^2}{x}$.

(ii) $U_{system} = \frac{KQ^2}{x} + \frac{KQ^2}{x} + \frac{KQ^2}{x}$.

$= \frac{3KQ^2}{x}$.

$-q$

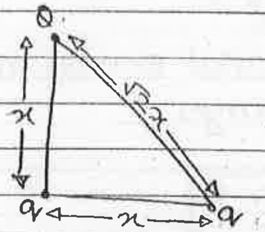
Ques>



$$U_{system} = -\frac{KQ^2}{x} + \frac{KQ^2}{x} + \frac{KQ^2}{x} - \frac{KQ^2}{x} - \frac{KQ^2}{\sqrt{2}x} + \frac{KQ^2}{\sqrt{2}x}.$$

$$= \underline{\underline{0}}$$

IIT
Ques>



$U_{system} = 0$ than find $Q = ?$

Ans>
$$\frac{Kq^2}{x} + \frac{KQq}{x} + \frac{KQq}{\sqrt{2}x} = 0$$

$$\frac{KQq}{\cancel{x}}\left(1 + \frac{1}{\sqrt{2}}\right) = -\frac{Kq^{\cancel{2}}}{\cancel{x}}$$

$$Q\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right) = -q.$$

$$Q = -\frac{\sqrt{2}q}{\sqrt{2}+1} \times \frac{\sqrt{2}}{\sqrt{2}} = \frac{-2q}{2+\sqrt{2}}$$

Ques>

Ans> $U_{system} = -\frac{Kq^2}{r} + \frac{Kq^2}{r} + \frac{Kq^2}{2r} = \frac{-2Kq^2}{r} + \frac{Kq^2}{2r}$

$$= \frac{-3Kq^2}{2r}$$

Ques> / ω

✡ ⇒ WORK DONE BY ELESTROSTATIC FIELD:-

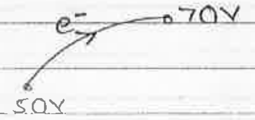
when conservative field works, energy is spent so stored potential energy decreases.

$W_{conservative} = -\Delta U$ *(always)

$$\boxed{\begin{aligned} W_{elect.\ field} &= -\Delta U \\ &= -q(\Delta V) \\ &= -q(V_f - V_i) \end{aligned}}$$

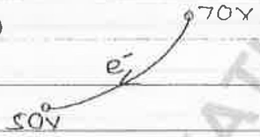
Ques> calculate work done by electric field if:-

①



$$\omega_{50\to70} = -q(V_F - V_i) = -(-e)(70V - 50V) = +20eV.$$

②



$$\omega_{70\to50} = -(-e)(50V - 70V) = -20\,eV.$$

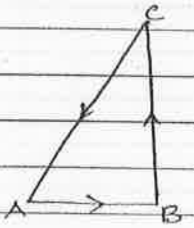
③ If $e^{\ominus}$ is shifted from 70V to 70V in closed loop

$$\omega_{70\to70} = -(-e)(70V - 70V) = 0.$$

⇒ $\omega_{70\to70} = \omega_{70\to50} + \omega_{50\to70}$
$= +20 - 20$
$= 0$

⇒ work done in a closed loop is zero and work is independent of Actual path **(depends on initial "&" Final posⁿ only), so electrostatic field is "conservative Fields".

Ques> A charge is shifted as shown :-



$W_{A\to B} = -2J$

$W_{B\to C} = +3J$

$W_{C\to A} = ?$

$W_{lope} = 0$

$-2+3+W_{C\to A}=0$

$W_{C\to A} = -1J$ **

$W_{A\to C} = 1J$

✡ ⇒ WORK ENERGY RELATION :-

$W_{Total} = \Delta K.E$

$W_{external} + W_{conservative} + \cancel{W_{non-conservative}} = \Delta K.E$

$W_{external} - \Delta U = \Delta K.$

$\boxed{W_{ext} = \Delta K + \Delta U}$

TYPE :- ① If $W_{ext} = ?$

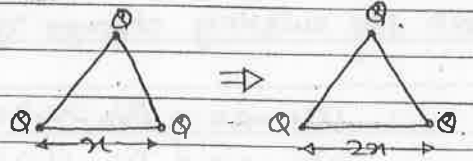
Keeping **K.E = constant.

$\therefore \Delta K = 0$

$$\boxed{\begin{aligned} W_{ext} &= \Delta U \\ &= q(\Delta V) = q(V_f - V_i) \end{aligned}}$$

TYPE-III

Ques>



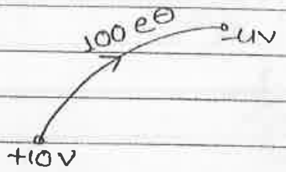
⇒ calculate work for making seperatn Double?

Ans> $U_i = \frac{3KQ^2}{x}$ $\quad U_F = \frac{3KQ^2}{2x}$

$W_{ext} = U_F - U_i$

$= \frac{-3KQ^2}{2x}$

Ques>



calculate work done in Joule?

Ans> $W_{ext} = q(V_F - V_i)$

$= (-100 \times 1.6 \times 10^{-19})(-4-10)$

$= +2.24 \times 10^{-16}$ J

*Ques>

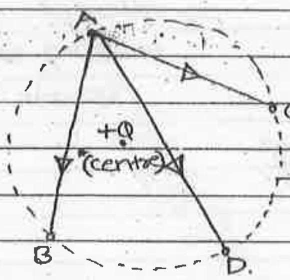
calculate work for shifting +Q from B→D

Ans> $W = (+Q)(V_D - V_B)$

$= (+Q)\left[\frac{Kq}{3L} - \frac{Kq}{L}\right] - \left[\frac{+Kq}{L} / \frac{Kq}{L}\right]$

$= +Q\left(\frac{-2Kq}{3L}\right) \Rightarrow \frac{-2KQq}{3L} = \frac{-2}{3}\frac{1}{4\pi\varepsilon_0}\frac{Qq}{L}$

Ques> calculate work for shifting charge "q" as shown:



$W_{A\to B} = q\,(V_B - V_A) = 0$

$W_{A\to C} = q\,(V_C - V_A) = 0$

$W_{A\to D} = q\,(V_D - V_A) = 0$

$\because\ V_A = V_B = V_C = V_D.$

TYPE:- (II) :- If $K.E \neq$ constant

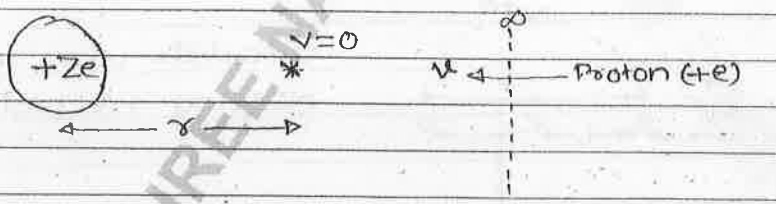
$\Rightarrow W_{ext} = 0$

$W_{ext} = \Delta K + \Delta U$

$$\boxed{\begin{array}{l}\Delta K + \Delta U = 0 \\ K + U = const\end{array}}^{*} \text{(COME)}$$

***

Ques> A proton is thrown with velocity "v" towards a nucleus of atomic no "Z", calculate closed distance of approach



$K.E \neq const.$

$K+U = const.$

$(K+U)_\infty = (K+U)_r$

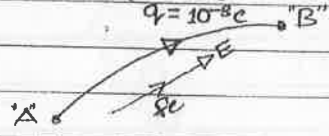
$\frac{1}{2}mv^2 + 0 = 0 + \frac{K(Ze)(e)}{r}$

$\because \boxed{r = \frac{2KZe^2}{mv^2}}$ $\quad \because \boxed{r \propto \frac{1}{m}}$ $\quad \because \boxed{r \propto \frac{1}{v^2}}$

Date ______ Page ___

#Ques> A particle (1gm, 10^{-8}c) is moving from 600V posn to 0 V posn. At 0 V posn it's speed become 20 cm/sec, Than find its speed at 600 V posn. ?

Ans> (m=1gm,)
$q = 10^{-8}c$



$V_B = 0$ volt.
$v_B = 20$ cm/sec.

$V_A = 600$ volt.
$v_A = ?$

$$K.E \neq const$$

$$\Delta K + \Delta U = 0$$

$$\Delta K = -\Delta U.$$

$$\frac{1}{2} m v_B^2 - \frac{1}{2} m v_A^2 = -q (V_B - V_A)$$

$$\frac{m}{2} (v_B^2 - v_A^2) = -q (0 - 600)$$

$$v_B^2 - v_A^2 = \frac{1200\, q}{m}$$

$$(0.2)^2 - v_A^2 = \frac{1200 \times 10^{-8}}{1 \times 10^{-3}}$$

$$0.04 - v_A^2 = 0.012.$$

$$v_A^2 = 0.04 - 0.012$$

$$= 0.028$$

$$= 280 \times 10^{-4}$$

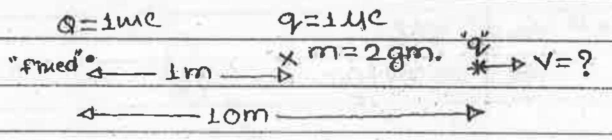
$$v_A = 16.8 \times 10^{-2} \text{ m/sec.}$$

$$= 16.8 \text{ cm/sec.}$$

Date ________ Page ____

*Ques> ② point charges "Q" and "q" are placed at 1m, seperation, If small "q" is Released than find its speed at 10m distance from "Q"?

Ans>



(I) $\because K.E \neq const$

$$(K+U)_{1m} = (K+U)_{10m}.$$

$$0 + \frac{KQq}{1} = \frac{1}{2}mV^2 + \frac{KQq}{10}$$

$$\frac{9}{10}(KQq) = \frac{1}{2}mV^2$$

$$V^2 = \frac{9}{5}\frac{KQq}{m}.$$

$$V^2 = \frac{9}{5} \times \frac{9 \times 10^9 \times 1 \times 10^{-3} \times 1 \times 10^{-6}}{2 \times 10^{-3}}$$

$$V^2 = 9 \times 10^7 \times 10^-$$

$$V^2 = \frac{81}{10^{-2}} = 8100$$

$$V = 90 \text{ m/sec.}$$

(II) If 'q' is released than find it's terminal velocity (Maxm velocity) :-

→ It aquires maxm velocity at "∞" only.

$$(K+U)_{1m} = (K+U)_{\infty}$$

$$0 + \frac{KQq}{1} = \frac{1}{2}mV_{max}^2 + 0$$

$$V_{max}^2 = \frac{2 \times 9 \times 10^9 \times 1 \times 10^{-3} \times 1 \times 10^{-6}}{2 \times 10^{-3}}$$

$$V_{max} = \sqrt{9000}$$

$$= 90\sqrt{10} = 95 \text{ m/sec}$$

*** Ques> ② particles having "same mass" and charges "+q", "+4q" are at Rest, If these are passed through same Potential Difference (P.D) than find Ratio of K.E ?

Ans> $\Delta K + \Delta U = 0$

$\Delta K = -q(\Delta V)$

$K\cdot E_f - \cancel{K\cdot E_i} = -q(\Delta V)$

$K\cdot E_f = = -q(\Delta V)$

$$\frac{K\cdot E_1}{K\cdot E_2} = \frac{-(+q)(\Delta V)}{-(4q)(\Delta V)} = \frac{1}{4}$$

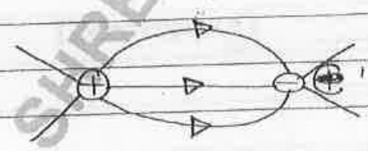
$$\frac{\cancel{\frac{1}{2}}\cancel{m}V_1^2}{\cancel{\frac{1}{2}}\cancel{m}V_2^2} \Rightarrow \frac{1}{4} \Rightarrow \frac{V_1}{V_2} = \frac{1}{2}$$

✡ ⇒ ELECTRIC LINE OF FORCE (ELF):-

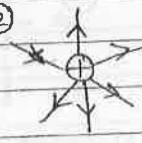
① * It is an Imaginary Lines.

② ** start's from ⊕ve charge and terminates on ⊕ve charge ⊖

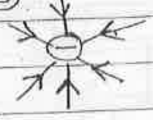
①



②



③



*** ③ Never Form's close loop.

④ Tangent Drawn on any point of ELF, Indicates Direction of Field.

⑤ Never Intersect each other.

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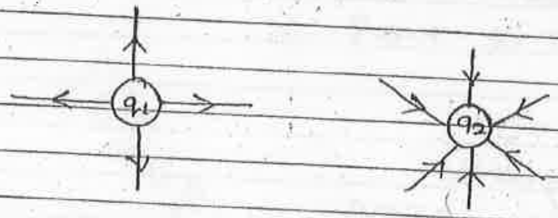
⑥ NO. of El.F $\propto$ Mass of charge.

Ques>

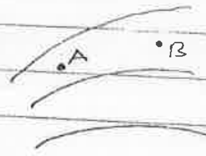


$q_1 = \oplus ve$ / $q_2 = \ominus ve$.

$\frac{|q_1|}{|q_2|} = \frac{4}{6} = \frac{2}{3}$

*⑦ "E" $\propto$ $\frac{1}{\text{"seperatn b/w Lines"}}$

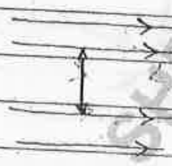
Ques>



$E_A > E_B$

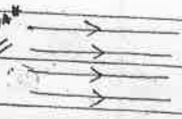
⑧ *Equi-distant parallel lines Represent *uniform Electric field.

(i)



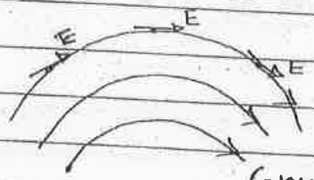
(Non-uniform E)
[Bcz value is Diffrent]

(ii)*



[Uniform E]

(iii)

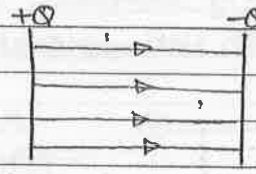


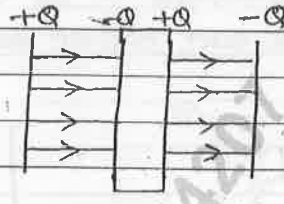
(Non-Uniform E)
[Directn Diffrent]

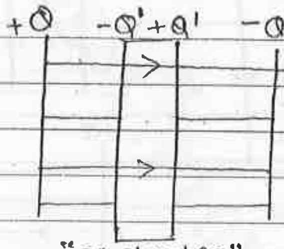
(iv)

(Non-Uniform E)
*(Directn & value both diffrent)

**⑨ In ~~ELNF~~ conductor's E.L.F can not enter, In Non-conductor, Few E.L.F can Enter.







⇒ $(Q' < Q)$

Metal.

Inside slab:-

∵ $E_{App} \rightarrow$

∵ $E_{induced} \leftarrow$

∵* $E_{indu.} < E_{App}$

⇒ $E_{net} \neq 0$

} "Di-electric" (Non-Metal)

"Di-electric"

Inside slab:-

∵ $E_{App} \rightarrow$

∵ $E_{induced} \leftarrow$

∵* $E_{ind.} = E_{App}$

⇒ $E_{net} = 0$

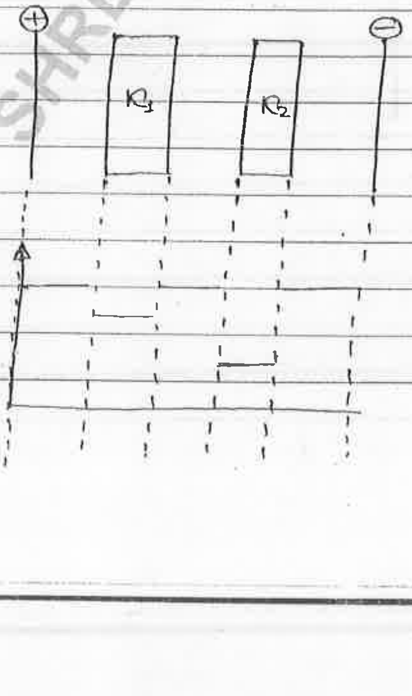
} "Metal"

⊗ ⇒** $E_{med} = \frac{E_{air}}{\epsilon_r}$

$\epsilon_r > 1$

∴ $E_{med} < E_{air}$

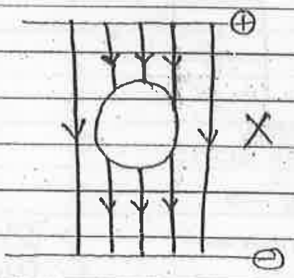
AIPMT Qus>



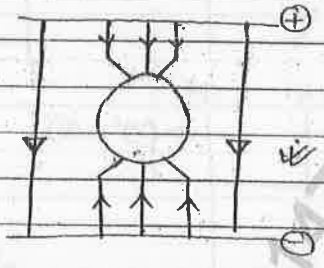
Given; $K_1 < K_2$

∴ $E_{air} > E_1 > E_2$

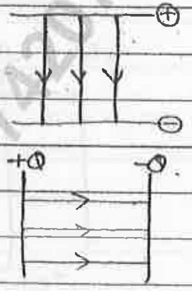
⑩ Electric Field at / E.L.o.F and Electric Line Force are always's "⊥" to conducting surface, while these can make angle with Non-conducting surfac

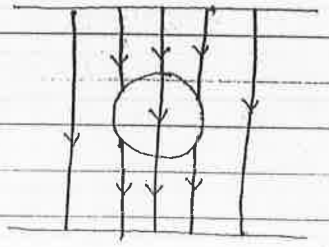


"Metal"



"Metal"





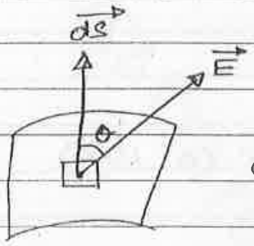
"Dielectric"

✡⇒ ELECTRIC FLUX (ϕ) :-

It is number of line of force passing through surface placed normally in Electric Field.

⊛⇒ Scalar

⇒ Unit = $\frac{V}{m} \times m^2 = V.m$

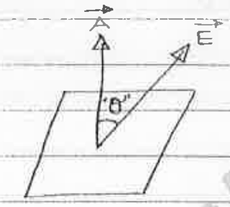


$\vec{ds}$ ⊥ to surface

Flux with element

$$\boxed{\begin{aligned} d\phi &= E \cdot ds\cos\theta \\ d\phi &= \vec{E}\cdot\vec{ds} \end{aligned}}$$

✡⇒ case:- I:- If surface is plane and $\vec{E}$ is uniform:-



$\theta = \int E \cdot ds\cos\theta$

$= E\cos\theta \int ds$

$$\boxed{\begin{aligned} \phi &= EA\cos\theta \\ \phi &= \vec{E}\cdot\vec{A} \end{aligned}}$$

Ques> surface of Area 10 cm² is placed in electric field 10^5 V/m, when field is making 30° with surface, than flux?

should from Normal from surface

Ans> $\phi = EA\cos\theta$

$= 10^5 \times 10 \times 10^{-4} \times \cos \underline{60^\circ}$

$= 10^5 \times 10 \times$ [illegible] $\frac{1}{2} = 50$

*Qus> surface of Area; $10m^2$, placed in $\vec{E} = 2\hat{i}+3\hat{j}+6\hat{k}\ \frac{V}{m}$
calculate Flux if :-
① surface is in (x-z) plane. $(A = 10\hat{j})$

Ans> ① A $\phi = \vec{E}\cdot\vec{A}$
$= (2\hat{i}+3\hat{j}+6\hat{k})\cdot(10\hat{j})$
$= \underline{30}$ $\underline{V\cdot m.}$

② surface is in (x-y) plane :- $(A = 10\hat{k})$

$\phi = \vec{E}\cdot\vec{A}$
$= (2\hat{i}+3\hat{j}+6\hat{k})\cdot(10\hat{k})$
$= \underline{60}$ V/m

⊛ case:-II:- Flux with closed surface :-

→ $\phi_{net} = \oint \vec{E}\cdot\vec{ds}$

→ $\phi_{net} = \phi_1 + \phi_2 + \phi_3 + \text{------}$

→ $\vec{A}$ → Normal "A" outword

→ $\phi_{incoming} = -ve$
$\phi_{outgoing} = +ve$

Qus> A cylendrical close surface is placed in Uniform electric Field $\vec{E}$ as shown; calculate flux with cylin.?

Ans>

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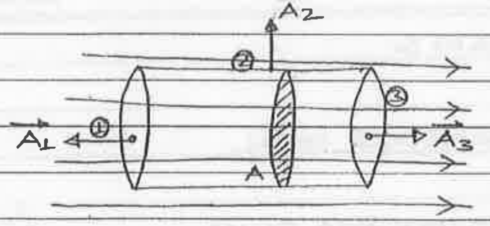
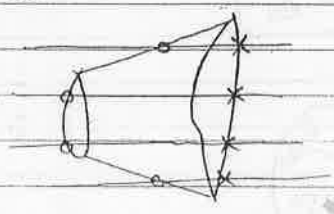


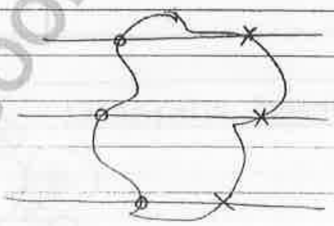
$\phi_1 = EA\cos 180 = -EA$
$\phi_2 = EA\cos 90 = 0$
$\phi_3 = EA\cos 0 = +EA.$

$\phi_{net} = \phi_1 + \phi_2 + \phi_3 = \underline{0}$

⊛ ⇒



(−4)+(+4)



(−3)+(+3)

⇒ Net Flux of closed surface is Decided by Inside charges only, "Not" by "External Field" and "Exte. charges".

q_{inside} = ⊕ve ⇒ $\left.\begin{array}{r}-10\\+15\end{array}\right]+5.$

q_{inside} = ⊖ve ⇒ $\left.\begin{array}{r}-10\\+5\end{array}\right]-5.$

q_{inside} = zero ⇒ $\left.\begin{array}{r}-10\\+10\end{array}\right]$zero.

(+q) = also Released Line (Extra)

(−q) = Abosrb Lines

✡ ⇒ GAUSE THEORAM :-

① valid for "close surfaces" only.

ⓘⓘ valid for all conservative Force.

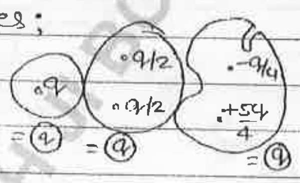
ⓘⓘⓘ Net Flux (ϕ_{net}) with close surface is $\left(\frac{1}{\epsilon_0}\right)$ time of total charge Enclosed in the surface.

$$\boxed{\phi_{net} = \frac{\Sigma q}{\epsilon_0}} \qquad \phi_{net} = \oint \vec{E} \cdot \vec{ds}$$

$$\boxed{\oint \vec{E} \cdot \vec{ds} = \frac{\Sigma q}{\epsilon_0}}$$

→ submission sign Σ

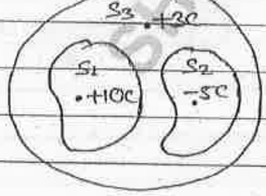
Ques> "3" closed surfaces;



$$\phi_{net} = \frac{\Sigma q}{\epsilon_0} = \frac{q}{\epsilon_0}$$

⇒ Net Flux (ϕ_{net}) is indipendent of shape & size of Gaasian surface and Inner charge Distribution.

Ques>



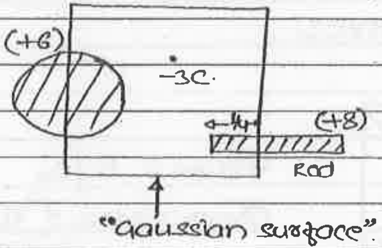
ⓘ $\phi_{S_1} = \frac{+10}{\epsilon_0}$

ⓘⓘ $\phi_{S_2} = \frac{-5}{\epsilon_0}$

ⓘⓘⓘ $\phi_{S_3} = \frac{8}{\epsilon_0} = [+10 + 3 + (-5)]$

$\phi_{net} = \frac{8}{\epsilon_0}$

IIT
Ques>

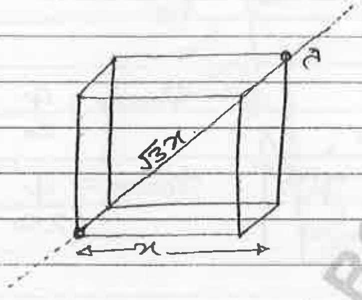


$$\phi_{net} = \frac{\Sigma q}{\varepsilon_0} = \frac{-3+3+2}{\varepsilon_0}$$

$$= \frac{2}{\varepsilon_0}$$

Ques> A long wire of charge density "λ", passing through a cube; calculate Max^m flux with cube?

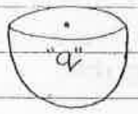
Ans>



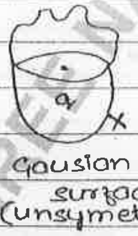
$$(\phi_{net})_{max} = \frac{(\Sigma q)_{max}}{\varepsilon_0}$$

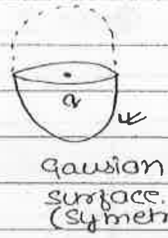
$$= \frac{(\sqrt{3}x)\lambda}{\varepsilon_0}$$

*** Ques> $\phi_{Bowl} = ?$



Ans>





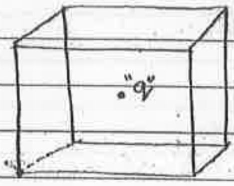
$$\phi_{Gaussian} = \frac{q}{\varepsilon_0}$$

$$\phi_{Bowl} = \frac{q}{2\varepsilon_0}$$

Qube>

Bmodl ⊗

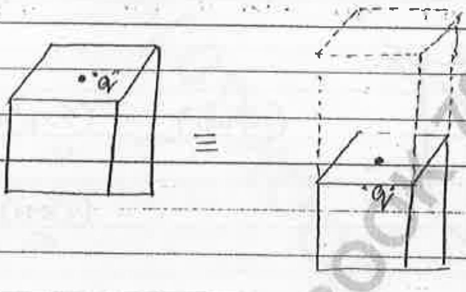
*//Ques> cube:- ① "q" at centre:-



$\phi_{cube} = q/\epsilon_0$

$\phi_{each\ surface} = \frac{q}{6\epsilon_0}$

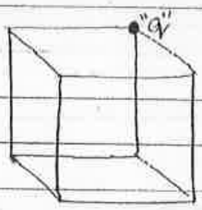
② "q" at the centre of one Face :-



$\phi_{gause} = \frac{q}{\epsilon_0}$

$\phi_{cube} = \frac{q}{2\epsilon_0}$

③ "q" at one corner:-



Gausian has 8 cube.

so;

$\phi_{cube} = \frac{q}{8\epsilon_0}$

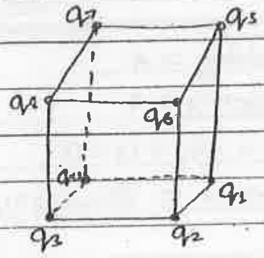
*/⇒ surface in which charges lies, Flux Remains Zero.

$\phi_{each\ shaded\ face} = 0$

$\phi_{each\ unshaded\ face} = \frac{1}{3}\left(\frac{q}{8\epsilon_0}\right)$

$= \frac{q}{24\epsilon_0}$.

Ques>



$$\phi_{cube} = \frac{q_1}{8\epsilon_0} + \frac{q_2}{8\epsilon_0} + \frac{q_3}{8\epsilon_0} \cdots\cdots \frac{q_8}{8\epsilon_0}$$

$$= \frac{1}{8\epsilon_0}(q_1+q_2+q_3 \cdots\cdots q_8)$$

Ques> In a close surface; 5×10^5 entring and 4×10^5 leaving than calculate enclosed charge?

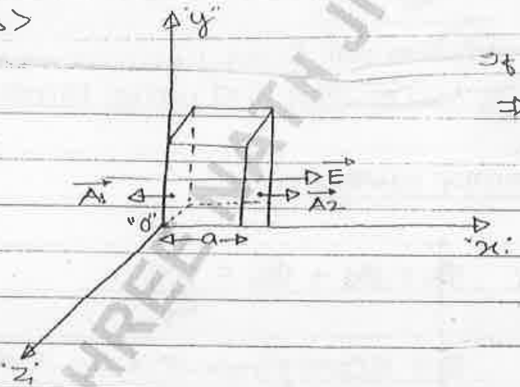
Ans> $\phi_{net} = -1\times10^5$

$\frac{\Sigma q}{\epsilon_0} = -1\times10^5$

$\Sigma q = -1\times10^5\times(8.85\times10^{-12})$

$= -8.85\times10^{-7}$

"IIT" Ques>



If; $\vec{E} = 600\sqrt{a}\,\hat{i}$

⇒ enclosed charge in cube = ?

Ans> $\phi_3 = \phi_4 = \phi_5 = \phi_6 = 0$ bcz ∵ $(E \perp A)$

$\phi_1 = E_1 A_1 \cos\theta_1$

$(0)(A_1)\cos\theta_1$

$= 0$

$\phi_2 = E_2 A_2 \cos\theta_2$

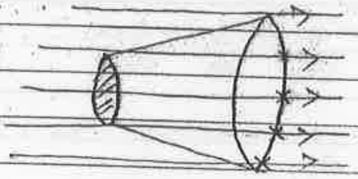
$= (600\sqrt{a})(a^2)\cos 0°$

$= 600\, a^{5/2}$

$\phi_{net} = \phi_1 + \phi_2 + \cdots\cdots \phi_6$

$\frac{\Sigma q}{\epsilon_0} = 600\, a^{5/2} \Rightarrow \boxed{\Sigma q = 600\, a^{5/2}\epsilon_0}$

Ques>



$\phi_{incoming} = 4$

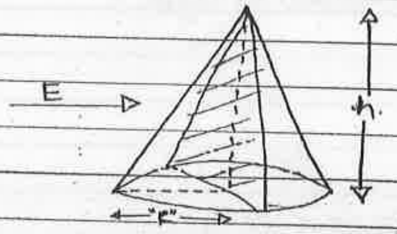
$\phi_{outgoing} = 4$

$\phi_{net} = -4 + 4 = 0$

$\because \phi_{incom.} = \phi_{outgoing}$

***⇒ E × ***Maxm "cross-section" Area.

***Ques> CONE :-



$\phi_{incoming} = \phi_{outgoing}$

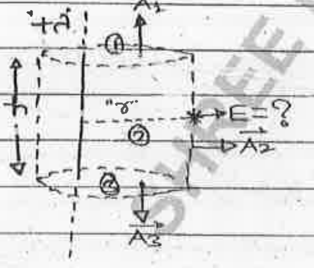
$= E \times \left(\frac{1}{2} \times 2R \times h\right)$

$= ERh$

**⇒ APPLICATION OF GAUS THEORAM :-

① It is used to calculate Electric Field [illegible] charge Distribution of Large size and Large Dimension

Ⓘ LONG WIRE (UNIFORMLY CHARGED) :-

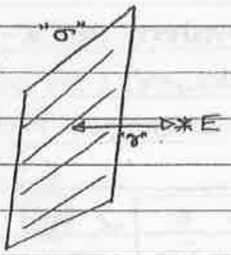


$\because \phi_1 + \phi_2 + \phi_3 = \frac{\Sigma q}{\epsilon_0}$

$0 + E(2\pi r h)\cos 0^\circ + 0 = \frac{\lambda h}{\epsilon_0}$

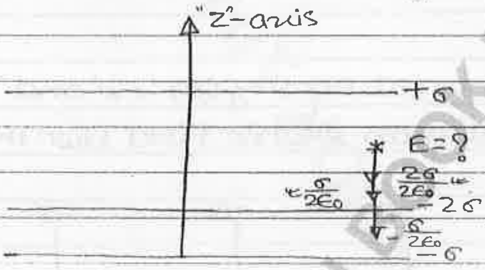
$E = \frac{\lambda}{2\pi\epsilon_0 r} \Rightarrow \boxed{E = \frac{2K\lambda}{r}}$

(II) UNIFORMLY CHARGED NON-CONDUCTING SHEET :-



$\boxed{E = \frac{\sigma}{2\epsilon_0}} \propto r^0$ *(Distance Does not Matter Here)

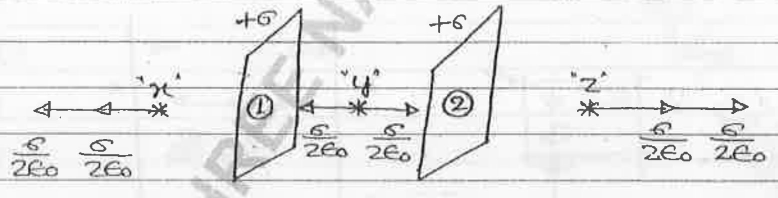
(III) Ques> ③- Non conducting layers are placed as shown:-



$E = \frac{4\sigma}{2\epsilon_0} = \frac{2\sigma}{\epsilon_0}$

$\vec{E} = \frac{2\sigma}{\epsilon_0}(-\hat{k})$

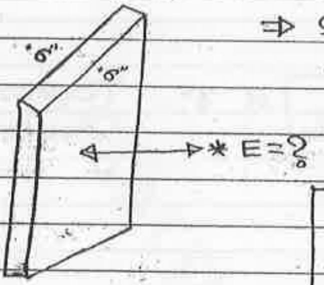
Ques> ② Non conducting layers are placed as shown:-



Ans> Here;

$$\boxed{\begin{array}{l} E_x = E_z = \frac{\sigma}{\epsilon_0} \\ E_y = 0 \end{array}}$$

Ⅲ UNIFORMLY CHARGED CONDUCTING PLATE :-

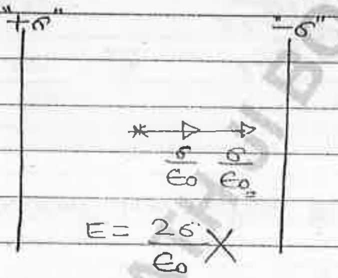


⇒ It is equivalent to "2"-parallel charged layer's; so according to above Question :- Previous Questⁿ

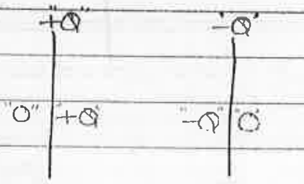
$$\boxed{\begin{matrix} E_{outside} = \dfrac{\sigma}{\epsilon_0} \\ E_{inside} = 0 \end{matrix}} \propto (r^0)$$

AIIMS 2005 Ques> ② conducting Metal plates charged Density (σ) "+σ" and "−σ" are placed parallel than electric field b/w them.

Ans>

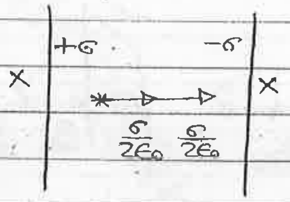


$E = \frac{2\sigma}{\epsilon_0}$ ✗



(Induction will occur)

∴ $\boxed{E = \frac{\sigma}{\epsilon_0}}$



AIEEE Ques> conducting Plate :- (+σ) In equilibrium "σ" is proportional to :-

$qE = q\left(\frac{\sigma}{\epsilon_0}\right)$

At Balance :- $T \sin\theta = \frac{q\sigma}{\epsilon_0}$ ---- ①

$T\cos\theta = mg$ ---- ②

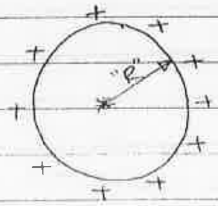
$\frac{①}{②}$ $\tan\theta = \frac{q\sigma}{\epsilon_0 mg} \Rightarrow \sigma \propto \tan\theta$ Ans

$\therefore$ $T\sin\theta = \frac{q\sigma}{\epsilon_0} \Rightarrow \sigma \cancel{\propto} \sin\theta$

$T = \frac{q\sigma}{\epsilon_0 \sin\theta} \neq$ const ; so:-

variable

(IV) ALL CONDUCTING SPHERE AND HOLLOW NON-CONDUCT. SPHERE :-

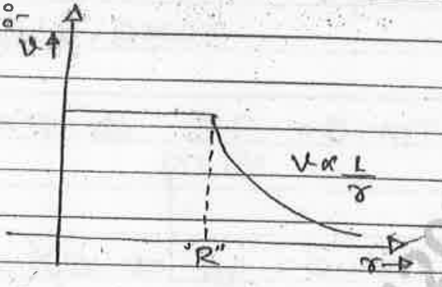


"r" ⇒ Distance of Observation Point from centre of sphere.

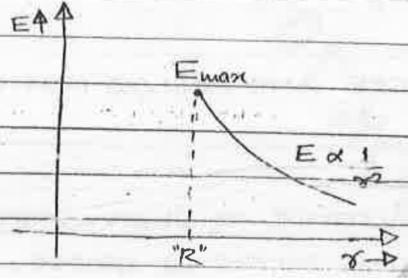
	Position	"E"	V
①	$r > R$	$\frac{KQ}{r^2}$	$\frac{KQ}{r}$
②	$r = R$	$\frac{KQ}{R^2}$	$\frac{KQ}{R}$
③	$r < R$	0	$\frac{KQ}{R}$
④	$r = 0$	0	$\frac{KQ}{R}$

V.V.IMP

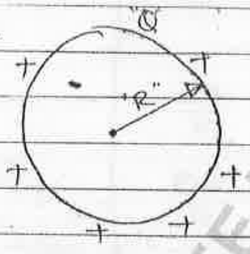
Ques> (i) "V" v/s "r" :-



(ii) "E" v/s "r" :-



Ques>



$\sigma = \frac{Q}{4\pi R^2}$

$\boxed{Q = \sigma \cdot 4\pi R^2}$

① $E_{surface} = \frac{KQ}{R^2}$

$= \frac{1}{4\pi\epsilon_0} \times \frac{\sigma \cdot \cancel{4\pi}\cancel{R^2}}{\cancel{R^2}} = \frac{\sigma}{\epsilon_0}$

② $V_{surface} = \frac{KQ}{R} = \frac{1}{\cancel{4\pi}\epsilon_0} \times \frac{\sigma \times \cancel{4\pi} R^{\cancel{2}}}{\cancel{R^2}} = \frac{\sigma R}{\epsilon_0}$

****

⇒ FOR CONDUCTOR of ANY SHAPE ⇒ $E_{surface} = \frac{\sigma}{\epsilon_0}$

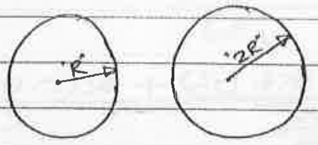
Qus> $E_{surface} = \frac{KQ}{R^2} \propto \frac{1}{R^2}$ ⇒ (If $Q = const.$)

$E_{surface} = \frac{\sigma}{\epsilon_0} \propto R^0$ ⇒ (If $\sigma = const.$)

$E_{surface} = \frac{V_{surface}}{R} \propto \frac{1}{R}$ ⇒ (If $V = const.$)

***

Qus> ② Metal sphere; A there surface; $\frac{E_1}{E_2} = ?$ If:-



① Both have same charges

② 'σ' = same

③ If Both are Touched with each other?

Ans> ① $E = \frac{KQ}{R^2} \propto \frac{1}{R^2}$ ⇒ $E_1 : E_2 = 4 : 1$.

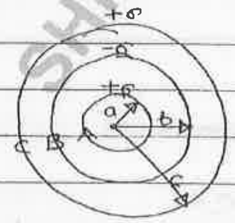
② $E_{surfac} = \frac{\sigma}{\epsilon_0} \propto R^0$ ⇒ $E_1 : E_2 = 1 : 1$,,

③ If Touched than V = same for Both sphere; (V = const.)

$E = \frac{V}{R} \propto \frac{1}{R}$

⇒ $E_1 : E_2 = 2 : 1$,,

NPMT
* Qus



3- conducting concentric spheres;

If; $c = a + b$ than; V_A, V_B & V_C ?

① $V_A = \frac{K(\sigma \cdot 4\pi a^2)}{a} + \frac{(K - \sigma \cdot 4\pi b^2)}{b} + \frac{K(\sigma \cdot 4\pi c^2)}{c}$

$= K \cdot \sigma \cdot 4\pi \ (a - b + c)$

$= K \cdot \sigma \cdot 4\pi \ a - \cancel{b} + a + \cancel{b}$

$= K \cdot \sigma \cdot 4\pi (2a)$ --- ①

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$$V_B = \frac{K\cdot(\sigma\cdot 4\pi a^2)}{b} + \frac{K(-\sigma\cdot 4\pi b^2)}{b} + \frac{K(\sigma\cdot 4\pi c^2)}{c}$$

$$= K\cdot\sigma\cdot 4\pi\left(\frac{a^2-b^2}{b}+c\right)$$

$$= K\cdot\sigma\cdot 4\pi\left(\frac{a^2-b^2}{b}+a+b\right)$$

$$= K\cdot\sigma\cdot 4\pi\left(\frac{a^2-\cancel{b^2}+ab+\cancel{b^2}}{b}\right)$$

$$K\cdot\sigma\cdot 4\pi\left(\frac{a^2+ab}{b}\right) \text{ --- } ②$$

$$V_C = \frac{K\cdot(\sigma\cdot 4\pi\cdot a^2)}{c} + \frac{K(-\sigma\cdot\pi 4\, b^2)}{c} + \frac{K(\sigma\cdot 4\pi\cdot c^2)}{c}$$

$$= K\cdot\sigma\cdot 4\pi\left(\frac{a^2-b^2}{c}+c\right)$$

$$= K\cdot\sigma\cdot 4\pi\left(\frac{a^2-b^2}{a+b}+a+b\right)$$

$$= K\sigma\cdot 4\pi\,(a-b+a+b)$$

$$= K\sigma\cdot 4\pi\,(2a) \text{ ---- } ③$$

$\Rightarrow \quad V_A = V_C \neq V_B$

AIEEE

Ques> If $V_A = V_C$ than; Relate a, b, c ?

Ans> $V_A = K\cdot\sigma\cdot 4\pi\,(a-b+c)$

$V_C = K\,\sigma\cdot 4\pi\left(\frac{a^2-b^2}{c}+c\right)$

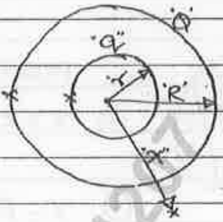
$V_A = V_C \Rightarrow (a-b+c) = \frac{a^2-b^2+c^2}{c}$

$\Rightarrow ca - cb + \cancel{c^2} = a^2 - b^2 + \cancel{c^2} \Rightarrow c(a-b) = a^2 - b^2$

$\Rightarrow c\,\cancel{(a-b)} = \cancel{(a-b)}(a+b)$

$c = a+b$

IIT Qus> Two Metalic concentric shell, with Radius r and R"s charges "Q" and "q" ?



$$V_{small} = \frac{Rq}{\boxed{r}\downarrow} + \boxed{\frac{KQ}{R}}$$

$$V_{BIG} = \frac{Rq}{\boxed{R}\uparrow} + \boxed{\frac{KQ}{R}}$$

$$V_x = \frac{Kq}{x} + \frac{KQ}{x}.$$

① $V_{small} > V_{BIG}$ $(R > r)$

⑪ Potential Difference b/wn spheres

$$P.D = V_{small} - V_{BIG}$$

$$P.D = K\boxed{q}\left(\frac{1}{r} - \frac{1}{R}\right)$$

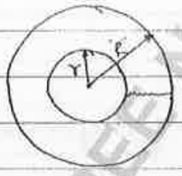
*$\boxed{P.D \propto q}$ ⇒ P.D is not dependent of Q"(outside charge)

This P.D is Indipendent of "outer sphare charge" so;

If : $Q \longrightarrow -3Q$

than; P.D = Remain's same

\# ⓘⓘⓘ



⇒ If sphere's are connected Internaly as shown, than :- conduction's takes place and finaly Potential become same (P.D=0)

$$\Rightarrow PD = 0 \Rightarrow \because Kq\left(\frac{1}{r} - \frac{1}{R}\right) = 0$$

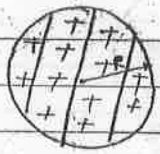
① $K = 0$ ✗ (not possble) **② $q = 0$ ✓ (possible) ③ $r = R$ ✗ (not possible)

$$SO;\ q_{small} = 0$$

$$q_{BIG} = Q + q$$

⇒ This is only Method to transfer Total charge of one conductor to Another.

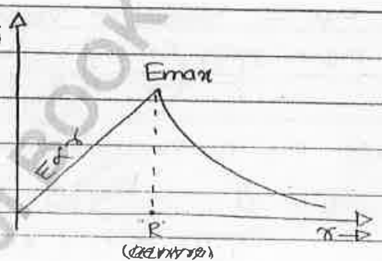
⑤ SOLID NON-CONDUCTING SPHERE:-



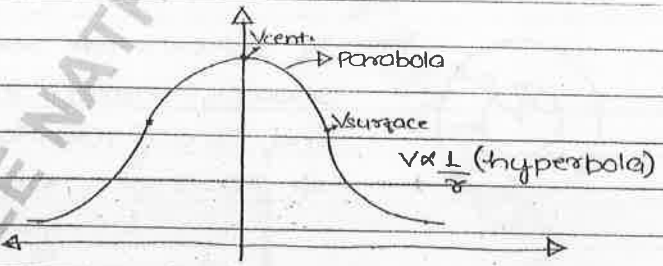
Position	Ⓔ	Ⓥ
① $r > R.$	$\frac{KQ}{r^2}$	$\frac{KQ}{r}.$
② $r = R.$	$\frac{KQ}{R^2}$	$\frac{KQ}{R}.$
③ $r < R.$	$\frac{KQ \cdot r}{R^3}$	$\frac{KQ\,(3R^2 - r^2)}{2R^3}.$
④ $r = 0$	0	$\frac{3}{2}\left(\frac{KQ}{R}\right)$

⊛⇒ GRAPH'S:

① "E" v/s "R" ⇒



② V v/s r ⇒



Ques> A uniformly ⊕ve charged sphere of Radius "R", If Vsurface = V_0 than find Distance from centre where:-

① $V_1 = \frac{5V_0}{4}$ ③ $V_3 = \frac{V_0}{2}$

② $V_2 = \frac{3V_0}{4}$ ④ $V_4 = \frac{3V_0}{2}$

⇒** If Nothing given than take sphere as a solid sphere.

Ans> ① $V_1 = \frac{5V_0}{4}$

$\cancel{KQ}\left(\frac{3R^2 - r_1^2}{\cancel{2}R^3}\right) = \frac{5}{\cancel{4}_2}\left(\frac{\cancel{KQ}}{\cancel{R}}\right)$

$6R^2 - 2r_1^2 = 5R^2$

$2r_1^2 = R^2$

$\therefore \boxed{r_1 = \frac{R}{\sqrt{2}}}$

H.W ③ $V_3 = \frac{V_0}{2}$

$\frac{KQ}{r_3} = \frac{KQ}{2R}$

② $V_2 = \frac{3}{4}V_0$

$\frac{KQ}{r_2} = \frac{3}{4}\left(\frac{KQ}{R}\right)$

$r_2 = \frac{4R}{3}$

H.W ④ $V_4 = \frac{3}{2}V_0$

$KQ\left(\frac{3R^2 - r_4^2}{2R^3}\right) = \frac{3}{2}\left(\frac{KQ}{R}\right)$

$\therefore r = 0$ (centre)

Qus> $e = \frac{Q}{4/3\pi R^3}$ than; $E_{inside} = ?$

Ans> $E_{inside} = \frac{KQr}{R^3} = \frac{1}{4\pi\epsilon_0}\frac{(e \times 4/3\pi R^3)r}{R^3}$

$= \frac{er}{3\epsilon_0}$

*Qus> For a Uniformly charged ~~sphere~~ :- $V_{inside} = ar^2 + b$ than, Find volume charge Density ?

Ans> $V_{inside} = \frac{-dV}{dr} = -2ar$

$\frac{e\cancel{r}}{3\epsilon_0} = -2a\cancel{r}$

$\therefore \boxed{e = -6\epsilon_0 a}$

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✡ ⇒ BIG LIQUID DROP $\rightleftharpoons$ "n"- Identical small Drop

① $R_{BIG} = n^{1/3} r_{small}$.

② $Q_{BIG} = n\, q_{small}$.

③ $\sigma_{BIG} = n^{1/3} \sigma_{small}$.

④ $E_{BIG} = n^{1/3} E_{small}$.

⑤ $C_{BIG} = n^{1/3} C_{small}$.

⑥ $V_{BIG} = n^{2/3} V_{small}$.

eg:- ① $\frac{4}{3}\pi R^3 = n\left(\frac{4}{3}\pi r^3\right)$

$$R^3 = n r^3.$$

$$R = n^{1/3} r.$$

② $\sigma = \frac{Q}{4\pi R^2} \propto \frac{n}{(n^{1/3})^2} \propto n^{1/3}$

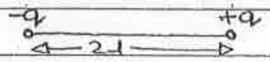
③ $E = \frac{\sigma}{\epsilon_0} \propto \sigma \propto n^{1/3}$

④ $C = 4\pi\epsilon_0 R \propto R \propto n^{1/3}$

⑤ $V = \frac{KQ}{R} \propto \frac{n}{n^{1/3}} \propto n^{2/3}$

★⇒ ELECTRIC DIPOLE :-

→ It has TWO CHARGES of "some magnitude" and "opposite Nature" at some Distances.



⇒ $\vec{2l}$ length vector (−q to +q)

① DIPOLE MOMENT (P) :-

$\boxed{P = \text{charge} \times \text{length}}$

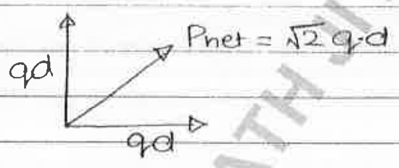
vector = "−q" to "+q"

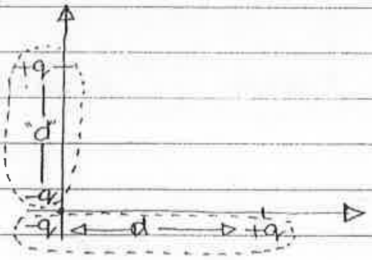
unit = c×m.

1 Debye(D) = 3.3×10^{-30} c×m

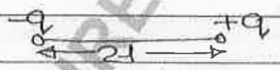
$$\boxed{\begin{array}{l} P = q\,2l \\ \vec{P} = q\,\vec{2l} \end{array}}$$

Ques> Net Dipole Moment = ?



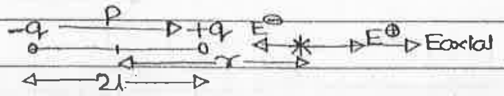


② 'E' due to DIPOLE:-



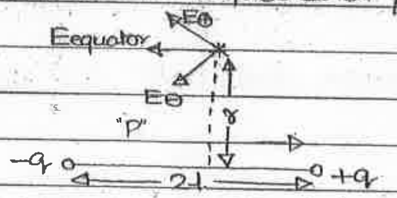
P = q(2l)

case:- I ⇒ Axial | End on | Longitudnal | Tan A



$^*E_{axis} = \dfrac{2\cdot KPr}{(r^2-l^2)^2} \simeq \dfrac{2KP}{r^3}$ (Along $\vec{P}$)

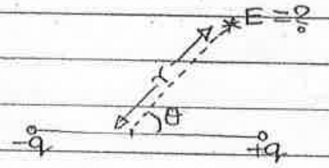
② case:- 2 ⇒ Equatorial | Broadside | Transverse | Tan B



$$E_{equator} = \frac{KP}{(r^2+l^2)^{3/2}} \simeq \frac{KP}{r^3}$$

Direction:- (opposite to $\vec{P}$)

③ case:- 3 ⇒ GENERAL POINT (r, θ):-



① $E = \frac{KP}{r^3}\sqrt{(1+3\cos^2\theta)}$

** ② Angle b/wn "E" and "P"

$= \theta + \tan^{-1}\left(\frac{1}{2}\tan\theta\right)$

Qus> For a short Dipole at same Distance : $\frac{E_{axis}}{E_{equator}} = ?$

Ans> $\frac{E_{axis}}{E_{equator}} = \frac{2KP/r^3}{KP/r^3} = \frac{2}{1}$ ⇒ 2:1 ✓ correct

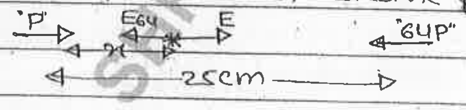
= 2:1 (Approx) ✓✓ More correct

= −2:1 (Approx) ✓✓✓ More, Max correct

Imp **

Qus> ① $E_{dipole} \propto \frac{1}{r^3}$ ② $E_{point\ charge} \propto \frac{1}{r^2}$ ③ $E_{long\ wire} \propto \frac{1}{r}$ ④ $E_{sheet} \propto r^0$

Qus> "2" Dipole "P" & "64P" are placed as shown; Find Distance from 'P' at which Electric field is 'zero' ?



$E_P = E_{64P}$

$\frac{2KP}{x^3} = \frac{2K(P64)}{(25-x)^3} \Rightarrow x^3 = \frac{(25-x)^3}{64}$

$x = \frac{25-x}{4}$

$\boxed{x = 5cm.}$

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Ques> $-q_0$ $\quad$ $_0+q$ ⇒ Find Ratio of Electric Fiel at Axis and Equatoral Distance 4cm from centre.

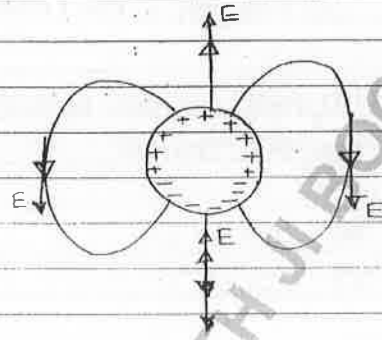
← 6m →

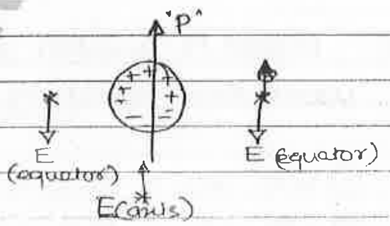
Ans> $\frac{E_{axis}}{E_{equat}} = ?$

$$\frac{E_{axis} = \left[\frac{2KPr}{(r^2+l^2)^2}\right]}{E_{equat} = \left[\frac{KP}{(r^2+l^2)^{3/2}}\right]} = \frac{2r\,(r^2+l^2)^{3/2}}{(r^2+l^2)^2} = \frac{2\times4\,(4^2+3^2)^{3/2}}{(4^2+3^2)^2}$$

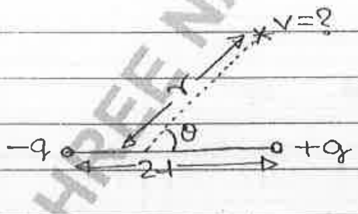
$$= \frac{2\times4\times125}{49} = \boxed{\frac{1000}{49}} \simeq \frac{20}{1}$$

Ques>





③ Potential Due to DIPOLE:-



$$V = \frac{KP\cos\theta}{r^2-l^2\cos^2\theta} \simeq \frac{KP\cos\theta}{r^2}$$

(i) At "AXIS":- (θ=0)

$$V_{axis} = \frac{KP}{r^2-l^2} = \frac{KP}{r^2}$$

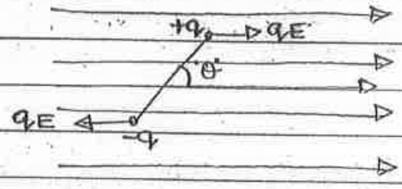
(ii) At Equator (θ=90)

$$V_{Equator} = 0$$

⇒*(So; work for Moving a charge on Equator of Dipole is always zero)

Date ______ Page ___

✡ ⇒ BEHAVIOUR IN EXTERNAL UNIFOR-ELECTRIC FIELD:-



(i) $F_{Net} = 0$

(ii) $\tau = PE\sin\theta$

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

(iii) $U = -PE\cos\theta$

$U = -\vec{P}\cdot\vec{E}$

(iv) $W_{\theta_1\to\theta_2} = PE(\cos\theta_1 - \cos\theta_2)$

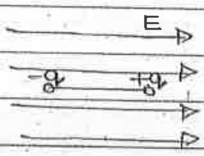
*Qus> Dipole is makin 30° with Field, than calculate work for Rotating it ① by 60°. ② to 60°

Ans> ① $W_{\theta_1\to\theta_2} = P.E\ (\cos 30° - \cos 90°)$

② $W_{\theta_1\to\theta_2} = P.E\ (\cos 30° - \cos 60°)$

⊛ ⇒ SPECIAL CASE:-

① If $\theta = 0$;



$F_{net} = 0$

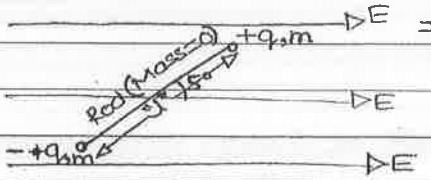
$\tau = PE\sin 0 = 0$

$U = -PE\cos 0 = -PE$ (Minim.)

⇒ Dipole is in stable Equilibrium.

⇒ If Dipole is given "small Angular Displacement" than it Perform's "Angular S.H.M" with Time Period $(T) = 2\pi\sqrt{\frac{I}{PE}}$

Ques>



⇒ If Dipole is Released, than calculate Time, when it becomes "Along the Field" 1st Time?

Ans> $T = 2\pi\sqrt{\dfrac{m\times\left(\frac{l}{2}\right)^2 + m\left(\frac{l}{2}\right)^2}{(q\cdot l)E}} = 2\pi\sqrt{\dfrac{ml}{2qE}}$

And Dipole Becomes along 'E' at "t" = $\dfrac{T}{4}$

$$\boxed{t = \frac{\pi}{2}\sqrt{\frac{ml}{2qE}}}$$

✡ ⇒ CONDUCTOR OF IRREGULAR SHAPE:-

"R" → "Radius of curvature".

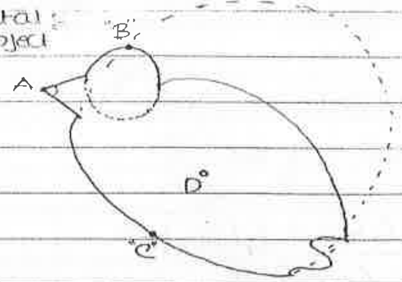
① "Q" ∝ "R".

② $\sigma \propto \dfrac{1}{R}$

③ $E = \dfrac{\sigma}{\epsilon_0} \propto \dfrac{1}{R}$

④ $V \propto R^0$

Ques> Metal object:



Ans> ⊛ $R_C > R_B > R_A$

① $q_C > q_B > q_A > q_D = 0$

② $\sigma_A > \sigma_B > \sigma_C$.

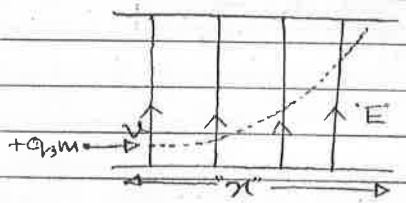
③ $E_A > E_B > E_C > e_D = 0$

④ $V_A = V_B = V_C = V_D$ *(conductor's are equi-potential surface!)

✡ ⇒ CORONA DISCHARGE

In conductor's likage of charge and Aproach of charge takes place at "sharp corner" 1st (First).

✡ ⇒ Path of charge Particle in Uniform Transverse Electric Field (Gravity = Negligable) :-



⊛ x-Direction :-

$u_x = v$

$a_x = 0$

"x" distance in time "t"

$s = ut + \frac{1}{2}at^2$

$x = vt + \cancel{\frac{1}{2}0(t^2)}$

$x = vt$ ------ ①

⊛ ⇒ Y-direction :-

$u_y \quad 0$

$a_y \quad \frac{qE}{m}$

"y" height in time "t"

$s = ut + \frac{1}{2}at^2$

$y = 0(t) + \frac{1}{2}\left(\frac{qE}{m}\right)t^2$

$y = \left(\frac{qE}{2m}\right)t^2$

$y = \frac{qE}{m} \times (x/u)^2$

Deviation (y)

AIPMT 2005 $\boxed{y = \left(\frac{qE}{2mv^2}\right)x^2}$ *(Parabola) $\therefore y = \left(\frac{qE}{4(K \cdot E)}\right)x^2$

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QUESTION DISCUSSION(ELECTROSTAT):-

Pg 37 (32) :- 6.75 $\overset{(\mu)}{\text{micro}}$ columb.

(34) $F = q \cdot E \Rightarrow E = \frac{F}{T} = \frac{3000}{30} = 1000 = \frac{dv}{dr} = \frac{dV}{\cdot 1 \times 10^{-2}}$

$dv = \underline{10}$ volt.

(41) $E = \frac{dv}{dr} = 0$

$\textcircled{V} = \text{const}$

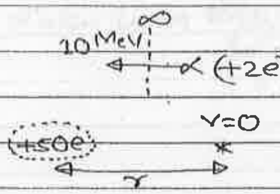
(51) $\Delta K + \Delta U = 0$

$\Delta K = -q(\Delta V)$

$= -(+2e)(50V - 70V)$

$= +40$ eV.

(52)

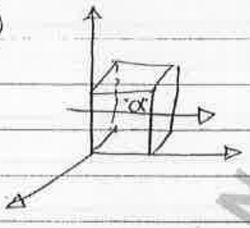


$(K+U)_\alpha = (K+U)_r$

$\Rightarrow 10\text{ MeV} + 0 = 0 + \frac{K(50e)(2e)}{r}$

$10 \times 10^6 \times 1.6 \times 10^{-19} = \frac{K(50e)(2e)}{r}$

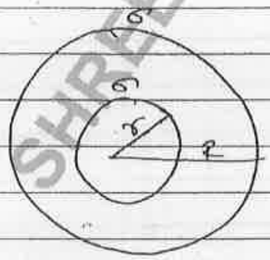
(58)



$\phi_{\text{Fwe}} = \frac{Q}{6\epsilon_0}$

$\phi_x = \frac{Q}{6\epsilon_0} \times 2$

(68)

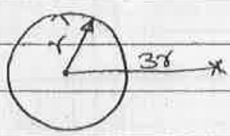


$\sigma(4\pi r^2) + \sigma(4\pi R^2) = Q.$

$\sigma = \frac{Q}{4\pi(R^2+r^2)}$ ......①

$V_c = \frac{\sigma}{\epsilon_0} r + \frac{\sigma}{\epsilon_0} R. \Rightarrow V_c = \frac{\sigma}{\epsilon_0}(R+r)$

(106)



$\frac{KQ}{r} - \frac{KQ}{3r} = V$

$\frac{2KQ}{3r} = V$ ---①

$\frac{KQ}{(3r)^2} = E$ ---②

$E = \frac{V}{6r}$

(116) $\sqrt{3} = PE \sin 30^\circ$ ----①

$U = -PE \cos 30^\circ$ ---②

(115) $e^- \leftarrow r \rightarrow e^-$ $(K+U)_\infty = (K+U)_r$

$$2\left(\frac{1}{2}mv^2\right) + 0 = 0 + \frac{Kqq}{r}$$

EX:-②:-

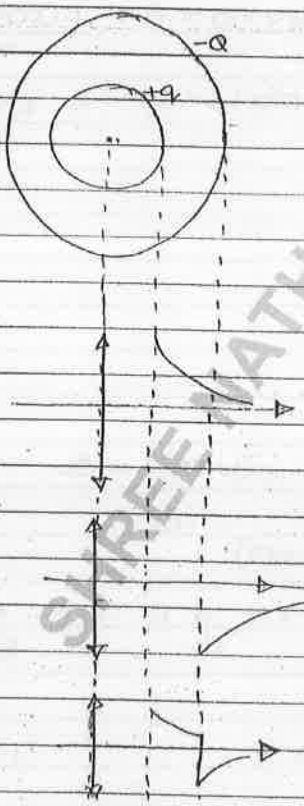
** (48) $U = \frac{Kq_1 q_2}{r}$ "q, 2q"

2q ______ 8q ⊛ Find neutral point while placing "q"

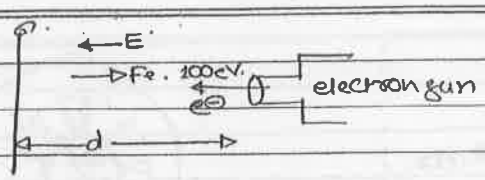
← 9cm →

EX:- 3"A":

(20) ① and ③ options both same.



E ʼʼ ö B ʼʼ B ʼʼ (56)



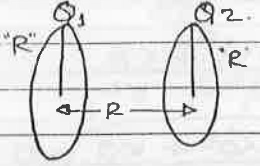
$\Delta K + \Delta U = 0$

$\Delta K = -q(\Delta V).$

$0 - 100\,eV = -(-e)(E \cdot d)$

$= +e\left(\frac{\sigma}{\epsilon_0} \cdot d\right).$

(76)

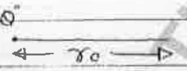


$w = q\,[V_2 - V_1]$

(101) $\boxed{\left(\frac{N_A \times 10}{63}\right) \times \frac{1}{10^6}} = \text{"n"}$

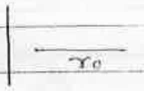
$\frac{K\,(ne)(ne)}{r^2}$

**(134) (i)



$E_1 = \frac{KQ}{r_0^2} = E$

(ii)



$E_2 = \frac{2K\lambda}{r_0} = E$

(iii)

$E_3 = \frac{\sigma}{2\epsilon_0} = E.$

(i) $E_1 = E_3 \Rightarrow \frac{Q}{4\pi\epsilon_0 r_0^2} = \frac{\sigma}{2\epsilon_0}$

$Q = \sigma\,(2\pi r_0^2)$

(ii) $E_2 = E_3 \Rightarrow \frac{\lambda}{2\pi\epsilon_0 r_0} = \frac{\sigma}{2\epsilon_0}$

$r_0 = \frac{\lambda}{\pi\sigma}$

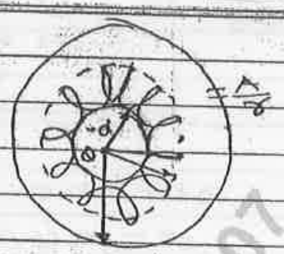
$\left.\begin{array}{l} E_1' = 4E \\ E_2' = 2E \end{array}\right] = E_1' = 2E_2'$

⑬⑧ $\int \rho \, (4\pi r^2) \cdot dr$

$\int_a^r \frac{A}{x} \cdot 4\pi x^2 \cdot dx$

$4\pi A \left[\frac{x^2}{2}\right]_a^r$

$2\pi A (r^2 - a^2)$



$\oint \vec{E} \cdot ds = \frac{\Sigma q}{\epsilon_0}$

$E (4\pi r^2) = \frac{1}{\epsilon_0} \cdot 2\pi A (r^2 - a^2)$

$E = \frac{A(r^2 - a^2)}{2\epsilon_0 r^2} + \frac{KQ}{r^2}$

$= \frac{A}{2\epsilon_0} \left(- \frac{Aa^2}{2\epsilon_0 r^2} + \frac{KQ}{r^2} \right) = 0$

$\frac{Aa^2}{2\epsilon_0 r^2} = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{r^2}$

$\boxed{A = \frac{Q}{2\pi a^2}}$ ✓

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J.M.S J.M.D

"CURRENT ELECTRICITY"

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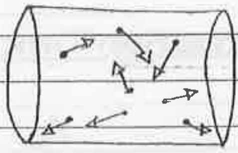
✡ ⇒ CONDUCTOR WITHOUT BATTERY :-



⇒ Due to Thermal speed, Free electron perform Random motion, and collid's with Metal Ion, so Net Displacement of charge Remain's '0' so, charge = 0.

① Free $e^{\ominus}$ Density (n) :-

⇒ It is No. of Free $e^{\ominus}$ in "Unit Volume of Metal."

$n = 10^{28}\ e^{\ominus}/m^3$ "or" $(10^{22}\ e^{\ominus}/cm^3)$

⇒* "n" depend's on Nature of Metal.

② Thermal speed (V_T) :-

⇒ speed's of Free $e^{\ominus}$ Due to surrounding Temprature.

K.E of one Free $e^{\ominus}$

$$\frac{1}{2} m V_T^2 = \frac{3}{2} KT$$

$$\boxed{V_T = \sqrt{\frac{3KT}{m.}}}$$

∵ If T = 300 K ; $V_T = 10^5$ m/sec.

∵ Temp. ↑ ⇒ V_T ↑

③ Relaxation Time (τ) :-

The "Average Free Time" b/w '2' consecutive - collisions

$\tau = 10^{-14}$ sec.

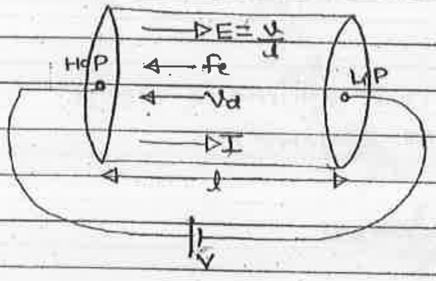
τ Depends = ① T ↑ ⇒ τ ↓

④ Mean Free Path (λ) :-

Distance covered $\overset{b/w^n}{\text{in}}$ One Relaxation Time

$\boxed{\lambda = 10\,Å}$

☆⇒ CONDUCTOR WITH BATTERY :-



⑤ Drift velocity :- (V_d)

After applying Batter, Free e⊖ moves ahead with almost constant velocity is called "Drift velocity".

$\boxed{V_d = 10^{-4}\ m/sec}$ = 0.1 mm/sec

$V_d = \left(\frac{e\tau}{m}\right)E \Rightarrow \boxed{V_d = \left(\frac{e\tau}{m}\right)\left(\frac{V}{l}\right)}$

⑥ Mobility (μ) :-

It is Drift velocity for Unit Applied Electric Feild.

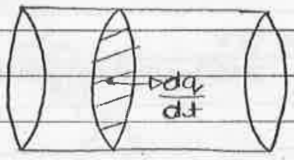
∵ E —— V_d

∵ 1 —— $\frac{V_d}{E}$ ∴ $\boxed{\mu = \frac{V_d}{E} = \frac{e\tau}{m}}$

Temp↑ ⇒ τ↓ ⇒ V_d↓ ⇒ μ↓

⑦ Electric current (I) :-

It is Rate of charge Flow, through cross section of current carrieng system.



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

→ scalar

→ unit
- → M.K.S = C/sec, *Ampear.
- → C.G.S = AbA, Biot (Bi)

$1\,A = \frac{1}{10}\,AbA.$

Qus> $q = 3t^2 + 2t$; $\underline{I = ?}$ at $t = 2sec$.

Ans> $I = \frac{dq}{dt} = 6t + 2 \Rightarrow I_{(t=2)} = 6(2)+2$

$= 14$ Units

Qus> calculate total charge Flow from 2sec to 4sec;
$I = 3t^2 + 2t$?

Ans> $I = \frac{dq}{dt} \Rightarrow dq = I \cdot dt \Rightarrow q = I \cdot dt$.

$q = \int_2^4 (3t^2 + 2t)$

$= \int_2^4 t^3 + t^2)$

$= (4^3 + 4^2) - (2^3 + 2^2)$

$= (64 + 16) - (8 + 4)$

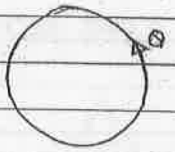
$= 68$ Units.

Qus> $Q = at - bt^2$; Find Instance when current become "ZERO"?

Ans> $I = \frac{dQ}{dt} = a - 2bt = 0$

$\therefore t = \frac{a}{2b}$

⊛ ⇒ CURRENT DUE TO CIRCULATING CHARGE:-

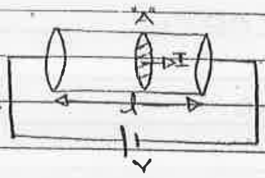


$v = \omega r$

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

*** $I = \frac{dq}{dt} = \frac{Q}{T} = Qf = \frac{Q\omega}{2\pi} = \frac{Qv}{2\pi \textcircled{r}}$ — used only in this Formula.

⊛ ⇒ CURRENT IN CONDUCTOR:-



$\boxed{I = neAV_d}$

** $\because I = \left(\frac{N}{Vol.}\right) eAV_d \Rightarrow I = \left(\frac{N}{l}\right) eV_d$

*** Ex:- $V_d = \frac{I}{neA} = \frac{I}{ne(\pi r^2)}$

$V_d = \frac{e\tau}{m} \cdot \frac{V}{l}$

(i) If current(I) = constant $\Rightarrow V_d = \frac{I}{ne(\pi r^2)}$ → (use this only)

$r' = 2r \Rightarrow V_d' = \frac{V_d}{4}$

$l' = 2l \Rightarrow V_d' = V_d$ (some)

(ii) If voltage(V) = constant $\Rightarrow V_d = \frac{e\tau}{m} \cdot \frac{V}{l} \Rightarrow$ *(use this only)

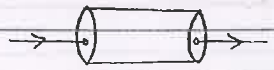
$r' = 2r \Rightarrow V_d' = V_d$

$l' = 2l \Rightarrow V_d' = \frac{V_d}{2}$

⇒ In current carrying conductor, NO of electron's entering at one End is equal to NO. of e^- leaving at other end.

SO; *(i) current carrying cunductor is alway Neutral.

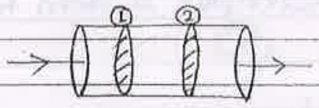
(iii)



$E_{outside} = 0.$

$E_{inside} \neq 0$ (Due to *Battery.) not wire.

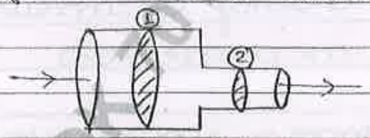
*(ii) Current at each point of conductor Remains same, Irrispective of cross-section Area.



$I_1 = I_2$

∵ $V_d = \frac{I}{neA}$

∵* $V_{d1} = V_{d2}$



$I_1 = I_2$

∵ $V_d = \frac{I}{neA} \propto \left(\frac{1}{A}\right)^*$

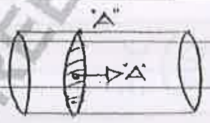
∵ * $V_{d1} < V_{d2}$ ∵ $(A_1 > A_2)$

⑧ CURRENT DENSITY (J) :-

It is current through "Unit cross section Area"

$\boxed{J = \frac{I}{A}}$ → Unit = A/m^2

→ vector (Along the current flow)



⇒ $J = \frac{I}{A} = \frac{neAV_d}{A}$

A ⟶ I

1 ⟶ I/A

$J = ne\left(\frac{e\tau}{m}\right)E$

$J = \left(\frac{ne^2\tau}{m}\right)E$

$\boxed{J = \sigma E}$

⑨ CONDUCTIVITY OR SPECIFIC-CONDUCTANCE (σ) :-

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

"σ" Depends on :- ① Metal.
② Temprature.

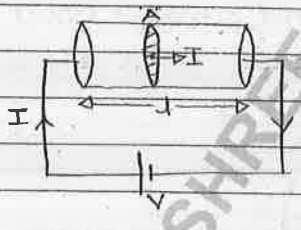
*** ⑩ RESISTANCE (R) :-

It is Tendency of current carrying system to oppose the charge flow.

$$\text{Resistance} = \frac{\text{Applied Voltage}}{\text{Resulting current}} \Rightarrow \boxed{R = \frac{V}{I}}$$ ✓✓

- ⇒ Scalar Quantity.
- ⇒ Unit = ohm (Ω)
- ⇒ conductance $(G) = \frac{1}{R}$ (ohm^{-1}, mho, siemen)

⊛ ⇒ Resistance of conductor :-



$$I = neAV_d$$

$$= neA\left(\frac{e\tau}{m}\right)\frac{V}{l}.$$

$$\frac{V}{I} = \left(\frac{m}{ne^2\tau}\right) \times \frac{l}{A}$$

$$\boxed{R = \left(\frac{m}{ne^2\tau}\right)\frac{l}{A}}$$ ✓✓

$$\boxed{R = \frac{\rho l}{A}}$$ ** ✓✓

⊛ ⇒ Resistivity (ρ) :-

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

② unit = $\Omega \times m$.

③ "ρ" depends on :- ① Metal.
② Temprature.

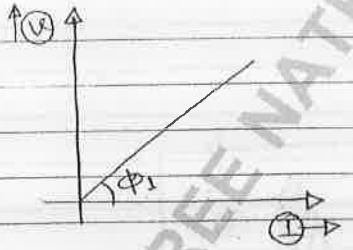
ex:- *Temp.↑ ⇒ $\tau\downarrow$ ⇒ $\rho\uparrow$ ⇒ $R\uparrow$.

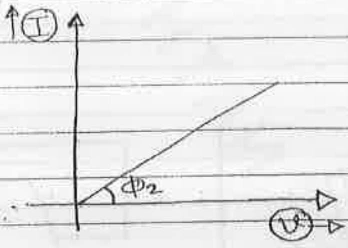
✡ ⇒ OHM'S LAW :-

At **"constant Temprature in Metal, current is "Directly Proportional" to Applied voltage.

At; const. Tempr. ; $V \propto I$

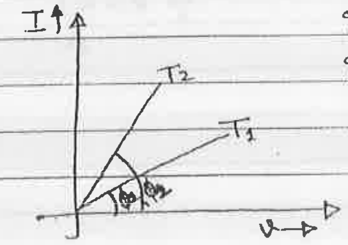
$$\boxed{\frac{V}{I} = R = \text{constant}}$$





$\tan\phi_1 = \frac{V}{I} = R$ $\tan\phi_2 = \frac{I}{V} = \frac{1}{R}$.

**Ex:- For some metal at two temp; graphs are:



∵ $\phi_1 < \phi_2$

∴ $\tan\phi_1 < \tan\phi_2$. ∵ $\uparrow\tan\phi = \frac{1}{R\downarrow}$

∴ $\frac{1}{R_1} < \frac{1}{R_2}$

∴ $R_1 > R_2$ ∵ $T_1 > T_2$

✡ ⇒ DEPENDANCE OF CONDUCTOR RESISTANCE :-

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

① Length :- (l) ⇒ ** seperation b/w Terminal Point's.

(i) If "Area = const. ⇒ $R = \frac{\rho l}{A}$ ⇒ $R \propto l$

(ii) If "Volume = const ⇒ $R = \frac{\rho l}{A} \times \frac{l}{l}$ ⇒ $R = \frac{\rho l^2}{\text{volm.}}$ ⇒ $R \propto l^2$

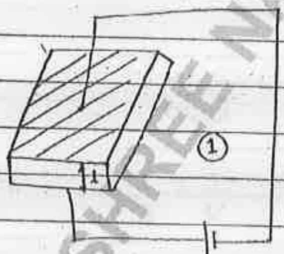
② Cross section (A) :-

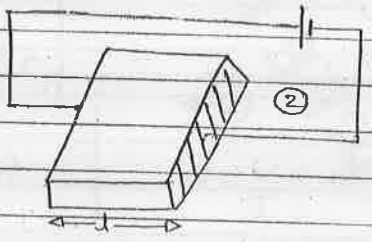
If l = const. ⇒ $R = \frac{\rho l}{A}$ ⇒ $R \propto \frac{1}{A} \propto \frac{1}{r^2}$

If vol. = const. ⇒ $R = \frac{\rho\, \text{volm.}}{A^2}$ ⇒ $R \propto \frac{1}{A^2} \propto \frac{1}{r^4}$

③ Metal
④ Temp. } 'ρ' depends.

AIEEE Ques>



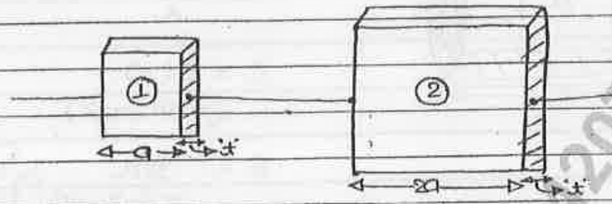


$\left(\frac{l}{A}\right)_{①} < \left(\frac{l}{A}\right)_{②}$ ∵ $R = \frac{\rho l}{A}$

$\left(\frac{\rho l}{A}\right)_{①} < \left(\frac{\rho l}{A}\right)_{②}$

$R_{①} < R_{②}$

NPMT * Ques> Two square shape metal Plates, same metal same Thikness are shown, compare their Resistance ?



$R_1 = \frac{\rho(\cancel{a})}{\cancel{a} \times t} = \frac{\rho}{t}$ $\quad R_2 = \frac{\rho(\cancel{2a})}{(\cancel{2a} \times t)} = \frac{\rho}{t}$

$\therefore R_1 = R_2$

Ques> Find Ratio of Maxm and Minm Resistance b/w Parallel Faces Metal Block (2×3×4) cm

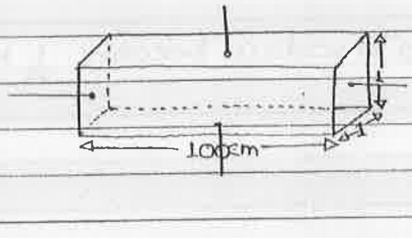
Ans> $\frac{R_{max}}{R_{min}} = ?$ $\quad R = \frac{\rho l}{A}$

$R_{max} = \frac{\rho\, l_{max}}{A_{min}} = \frac{\rho\,(4cm)}{(2\times3)cm} = \frac{\rho\cdot 2}{3}$

$R_{min} = \frac{\rho\, l_{min}}{A_{max}} = \frac{\rho\,(2cm)}{(3cm\times4cm)} = \frac{\rho}{6}$

$\frac{R_{max}}{R_{min}} = \frac{\cancel{\rho}2\times\cancel{6}4}{\cancel{3}\cancel{\rho}} \Rightarrow 4:1$

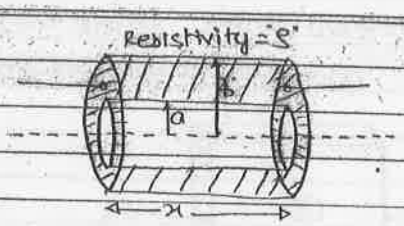
Oues> Metal Block (1cm×1cm×100 cm)



$R_{square\ face} = \frac{\rho\,(100cm)}{(1cm\times1cm)}$

$R_{rectang\ face} = \frac{\rho\,(1cm)}{(1cm\times100cm)}$

Ques>



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

$$R = \frac{\rho(x)}{(\pi b^2 - \pi a^2)}$$

$$R = \frac{\rho x}{\pi(b^2 - a^2)}$$

Ques> 22/P8 last ques

$$R_{Fe} = \frac{\rho_{Fe}\, l}{(a_{Fe})^2}$$

$$R_{Al} = \frac{\rho_{Al}\, l}{(a_{Al})^2 - (a_{Fe})^2}$$

$$R_{AL} \parallel R_{Fe}$$

**Note:- ① Bending ② Melting ③ compresing ④ streching
⑤ Moulding
In all Above cases volume = constant

Ques> Resistance of a wire = "R", than Find New Resistance; if:-
① It's length becomes "n" times by streching it.

$\because l' = nl$
$\because$ volume = constant.
$\because R \propto l^2$
$\therefore \boxed{R' = n^2 R}$

② By streching a wire its radius become $\frac{1}{n}$ times;

$\because r' = \frac{r}{n}$
$\because$ volume = const.
$\because R \propto \frac{1}{r^4} \Rightarrow \boxed{R' = n^4 R}$

Ques> By streching a wire, its length is increased by 50% than % change in Resistance ?

Ans> $l' = l + 0.5l = 1.5l$

$\because$ volume = constant

$R \propto l^2$

$R' = (1.5)^2 R = 2.25R$

$\% \text{ change} = \frac{2.25R - R}{R} \times 100 = 125\%$

Ques> By streching a wire length is increased by 100% than find % change in Resistance?

Ans> $\because l' = l + l = 2l$

$\because$ volume = consta

$\because R \propto l^2$

$\because R' = (2)^2 R = 4R$

$\therefore \% \text{ change} = \frac{4R - R}{R} \times 100 = 300\%$

Note:- SMALL % change *(upto 5%) at constant volume:-

(i) If $\Delta l = x\%$ $\Rightarrow$ $\Delta R = 2x\%$ *$(R \propto l^2)$

(ii) If $\Delta A = x\%$ $\Rightarrow$ $\Delta R = \ominus 2x\%$ *$(R \propto A^{-2})$

(iii) If $\Delta r = x\%$ $\Rightarrow$ $\Delta R = \ominus 4x\%$ *$(R \propto r^{-4})$

eg: ① By streching a wire:- $l = 3\% \uparrow$ than; $R = 6\% \uparrow$

② By streching a wire:- $r = 2\% \downarrow$ than; $R = 8\% \uparrow$

Ques> By streching a wire; Length is ↑sed by 10% than Percentage change in Resistance?

Ans> $l' = l + 0.1l = 1.1l$

∵ volm = const.

∵ $R \propto l^2$.

∴ $R = (1.1)^2 R = 1.21 R$

∴ $\% = \frac{1.21R - R}{R} \times 100 = 21\%$

EX:- $P = I^2 R$.

If $\Delta I = x\%$ (small change) $\Rightarrow \Delta P = 2x\%$.

① If I 10%↑
$\Rightarrow$; P 2%↑

(ii) If; I 0.5↓
$\Rightarrow$; P 1%↓

⟹ DEPENDENCE OF RESISTANCE ON TEPRATURE:-

① In Metals; *(conductor)

Temp.↑ $\Rightarrow \tau\downarrow \Rightarrow \rho\uparrow \Rightarrow R\uparrow$

② In; semiconductor:-

Temp. ↑ ⟹ No. of charge carrier↑ ⟹ R↓

③ Temprature Resistance coefficient (α):-

① $\alpha = \frac{\Delta R / R}{\Delta t}$ per unit Temprature. (°C or K)

(ii) If ; $\alpha = \oplus ve \Rightarrow Temp.\uparrow \Rightarrow R\uparrow$ eg:- conductor (Metl)

If ; $\alpha = \ominus ve \Rightarrow Temp.\uparrow \Rightarrow R\downarrow$ eg:- semi-conductor.

If ; $\alpha = "0" \Rightarrow Temp.\uparrow \Rightarrow R$ (const) eg:- Non-conductor.

(iii) High $\alpha \Rightarrow$ Effect of Tempr. on Resistance is High.

$$\alpha = \frac{\Delta R/R}{\Delta t}$$

$$\int_{R_{t_1}}^{R_{t_2}} \frac{\Delta R}{R} = \int_{t_1}^{t_2} \alpha \cdot \Delta t$$

$$\boxed{R_{t_2} = R_{t_1}\left[1+\alpha(t_2-t_1)\right]} \rightarrow \text{Rarely used (at only } \underline{20^\circ C})$$

If $t_1 = 0°C$ and $t_2 = t$

$$\boxed{R_t = R_0(1+\alpha t)} \rightarrow \text{Most of the time. } (t=0°C)$$

Important Points:-

① Temprature should be in °C only.
② Refrence tempo is 0°/20° °C only.
③ These Eqn are valid for "small Temprature Diffrences".

IMP
Ques> For a Metal; At 300 K $\rightarrow R = 1\Omega$ than find Temp.
Temp. (Kelvin) $\rightarrow R' = 2\Omega$.
Given; $\alpha = 0.00125$ per °C

Ans> $1 = R_0[1+\alpha(27)]$:- 0°C to 27°C.
$2 = R_0[1+\alpha t]$:- 0°C to t°C.
$1+\alpha t = 2+54\alpha$.

$\alpha t - 54\alpha = 2-1$

$\alpha(t-54) = 1$

$t - 54 = \frac{1}{\alpha} = \frac{1}{0.00125}$

$= 800$

$t = 854°C.$

$t = 854+273$

$= \underline{1127\,K}.$

** Ques> "2"- wires ; wire ① R_1 t α_1 ; wire ② R_2 t α_2 $\Big\}$ $\alpha_{series} = ?$

Ans> $t°C \rightarrow R_{series} = R_1 + R_2$

$t'°C \rightarrow R'_{series} = R'_1 + R'_2$

$$= R_1[1+\alpha_1(t'-t)] \oplus R_2[1+\alpha_2(t'-t)]$$

$$= (R_1+R_2) + (R_1\alpha_1 + R_2\alpha_2)(t''-t)$$

$$(R_1+R_2)\ 1 + \left(\frac{R_1\alpha_1+R_2\alpha_2}{R_1+R_2}\right)(t'-t)$$

$$\underline{R'_{series}} = \underline{R_{series}}\left[1+(\quad)(t'-t)\right]$$

$$\boxed{{}^{**}\alpha_{series} = \frac{R_1\alpha_1+R_2\alpha_2}{R_1+R_2}}$$

** IEEE Ques> $R_1 = R_2 = R$

than $\alpha_{series} = \frac{\alpha_1+\alpha_2}{2}$

** ⇒ If series, Resistance is "INDIPENDENT OF TEMPRATURE" in than condition:- $\alpha_{series} = 0$

$$\underline{\frac{R_1\alpha_1+R_2\alpha_2}{R_1+R_2}} = 0$$

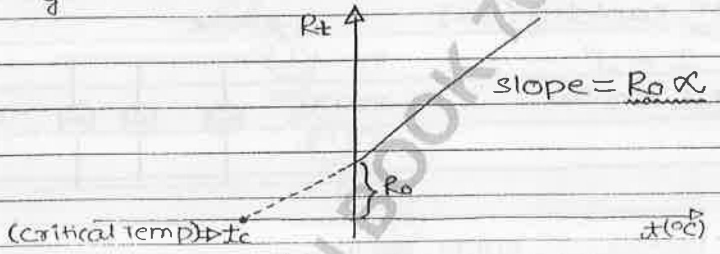
$$\boxed{\begin{array}{l} R_1\alpha_1 + R_2\alpha_2 = 0 \\ \frac{R_1}{R_2} = \frac{\ominus\alpha_2}{\oplus\alpha_1} \end{array}}$$ ⇒ **SO; one wire should be "conductor" ($\alpha = \oplus ve$) and other should must be "semi-conductor" ($\alpha = \ominus ve$)

✡ ⇒ GRAPHS :-

① Resistance (R) v/s Temprature

Ⓐ $R_t = R_0\,(1 + \alpha t)$

$$\underset{\text{"y"}}{\boxed{R_t}} = \underset{\text{"C"}}{R_0} + \underset{\text{"m"}}{(R_0\alpha)}\,\underset{\text{"x"}}{\boxed{t}}$$



(i) If; $t > t_c$ ⇒ $R \neq 0$ ⇒ "CONDUCTOR".

(ii) If; $t \leq t_c$ ⇒ $R = 0$ ⇒ "SUPER-CONDUCTOR".

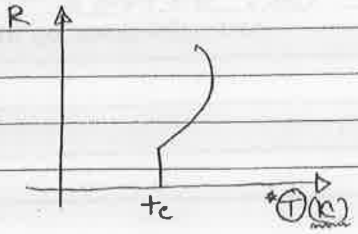
⇒ If super-conductor would be Fisable (or existance) at ordinary Temprature than;

① A small cell could Provide Large current. ∵ $\left[I = \frac{V}{R} = \frac{0.01}{0} = \infty \right.$

② And For "LONG LASTING" periods.

Note :- $(Hg)\,t_c = -269°C \;(= 4K)$

$$t_c \begin{cases} \text{°C} & (\text{Always } \ominus ve) \\ \text{K} & (\text{Always } \oplus ve) \end{cases}$$



✡ ⇒ STUDY OF CURCUITS:-

①⊛ ⇒ FUSE WIRE:-

(i) It is Used to Protect the Curcuit's From "Excess Curren"

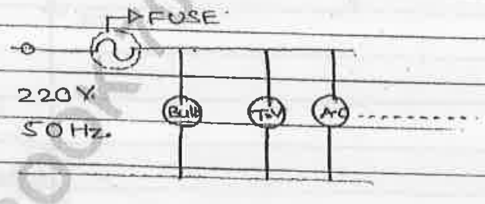
(ii) Alway connected in series and at starting of curcuit.

⇒ $\underset{(63\%}{Sn} + \underset{37\%)}{Pb}$ ⊛ Fuse wire should have Low Melting Pnt.

(iii) current capicity (I):-

AIPMT $I \propto l^{\circ}$

$* I \propto r^{3/2}$



NEET Ques> 10 Bulbs ; each 60 W

5 Fans ; each 80 W

1 Heater ; each 1 kW (1000 W)

soln = $P = VI \Rightarrow I = \frac{P}{V}$

$$I_{total} = \left(\frac{60 \times 10}{220}\right) + \left(\frac{80 \times 5}{220}\right) + \left(\frac{1000 \times 1}{220}\right)$$

$$I_{total} = \frac{200}{22} = \boxed{9.1} A.$$

SO; Required Minimum current capicity of Fuse. $\rightarrow * (>9.1)$

① 9 A ③ 10 A ✓

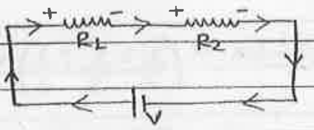
② 11 A ④ 12 A

(If; 9.5 has given than Ans will goes to that 9.5)

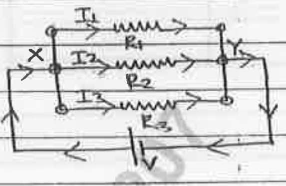
⇒ जिधर Battery का ⊕ उधर सब का Plus.*(Everywhere)

② GROUPING OF RESISTANCE :-

SEREIS



PARLLEL



→ Ⓘ = same. (Due to single Route)

→ Ⓥ = same.

→ $R_{eq} = R_1 + R_2 + R_3 + \cdots$
*(Biger than the Bigest)

→ $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

$R_{eq} = \frac{R_1 * R_2}{R_1 + R_2}$
⇓
*(Smaller than the smallest)

→ voltage Distribution:-*(I=same)

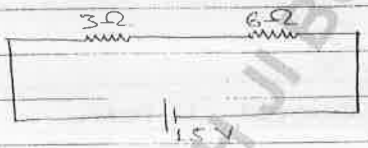
$V = IR \Rightarrow V \propto R$

$V_1 : V_2 : V_3 = R_1 : R_2 : R_3$

→ current Distributn*(bcz V=same)

$V = IR \Rightarrow I \propto \frac{1}{R}$

Qus>



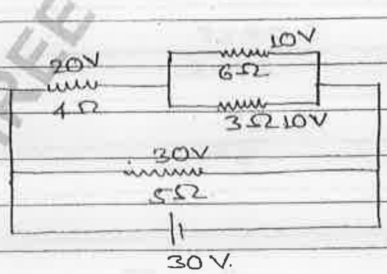
⇒ Voltage Across Eeach "R"?

Solⁿ ⇒ $V \propto R$

$V_3 : V_6 = 3 : 6 \Rightarrow 1 : 2$

$V_3 = \frac{1}{3} \times 15 = 5V.$ $V_6 = \frac{2}{3} \times 15 = 10V.$

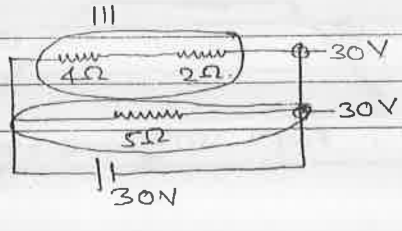
Que>



⇒ Voltage Across each 'R'?

$V \propto R.$

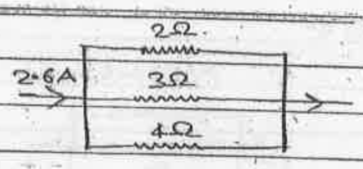
$V_4 : V_2 = 4 : 2$
$= 2 : 1.$



$V_4 = \frac{2}{3} \times 30 = 20V.$

$V_2 = \frac{1}{3} \times 30 = 10V.$

Qus>



$I \propto \frac{1}{R}$

$I_2 : I_3 : I_4 = \left(\frac{1}{2} : \frac{1}{3} : \frac{1}{4}\right) \times \textcircled{12}$ LCM

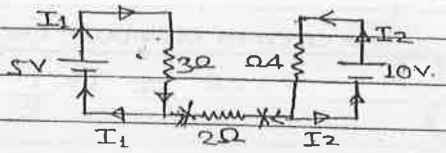
$= 6 : 4 : 3.$

$I_2 = \frac{6}{13} \times 2.6 = 1.2A.$

$I_3 = \frac{4}{13} \times 2.6 = 0.8A.$

$I_4 = \frac{3}{13} \times 2.6 = 0.6A.$

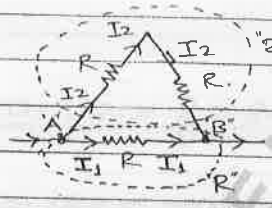
Qus> ✓



$I_{2\Omega} = ? = \text{zero},$

V.IMP ** ⇒ Because:- current does not Reepeat its Path.

Qus>



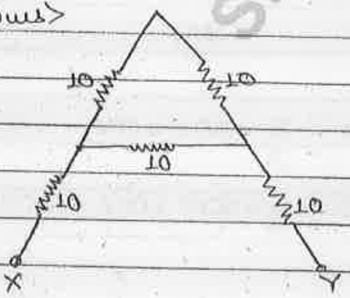
$R_{AB} = ?$

$R_{AB} = 2R \parallel R$

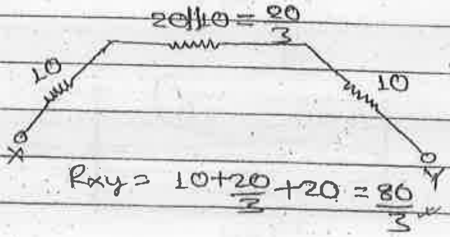
$= \frac{2R \times R}{2R + R}$

$= \frac{2R}{3}$ ✓

Qus>

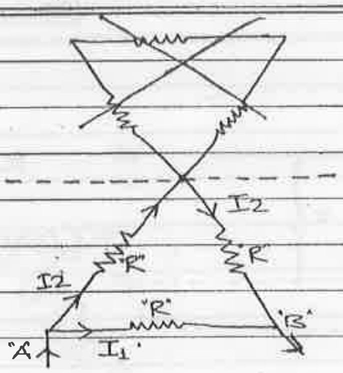


≡



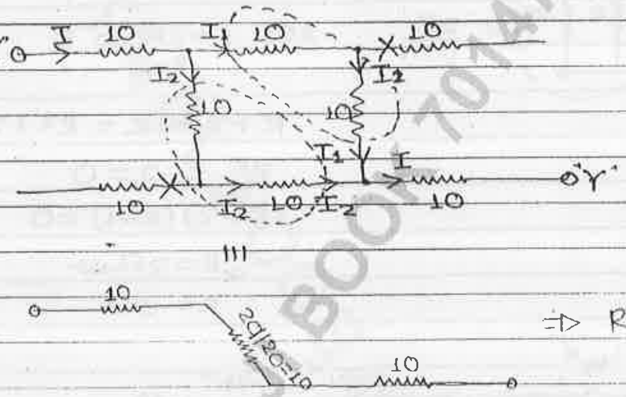
$R_{xy} = 10 + \frac{20}{3} + 20 = \frac{80}{3}$ ✓

Qus>
4



$R_{AB} = 2R \parallel R$
$= \frac{2R}{3}$

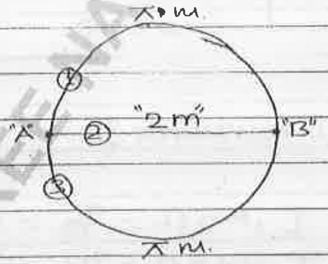
Qus> "X"



$R_{XY} = ?$

$\Rightarrow R_{xy} = 10 + 10 + 10$
$= 30$

**Qus> This loop is made of conducting wire :-



"Radius" = 1m.
Resistance = $\frac{1}{2}$ Ω/m
$\Rightarrow R_{AB} = ?$

circumference = $2\pi r = 2\pi \times 1 = 2\pi$ m

$\frac{1}{R_{eq}} = \frac{2}{\pi} + \frac{1}{1} + \frac{2}{\pi}$

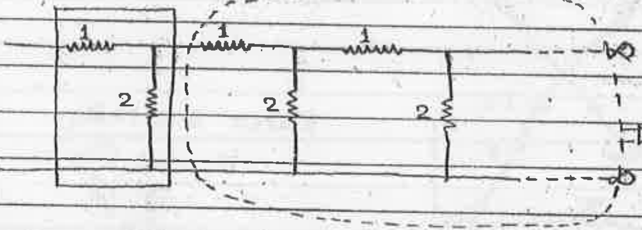
$= \frac{2 + \pi + 2}{\pi} = \frac{\pi + 4}{\pi}$

$R_{eq} = \frac{\pi}{\pi + 4}$"

∵ 1m. $\longrightarrow$ $1/2$ Ω.
2m. $\longrightarrow$ $1/2 \times 2 = 1$ Ω
πm $\longrightarrow$ $1/2 \times \pi = \pi/2$ Ω

*** ⊛ ⇒ "INFINITE LADDER":-

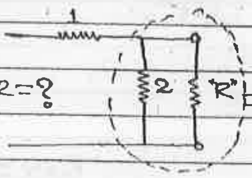
Qus>



R = ?

⇒ "R"(Let)*

R = ?



$\Rightarrow \frac{2R}{R+2}$

so; $1 + \frac{2R}{R+2} = \text{"}R\text{"}$

$R+2+2R = R^2+2R.$

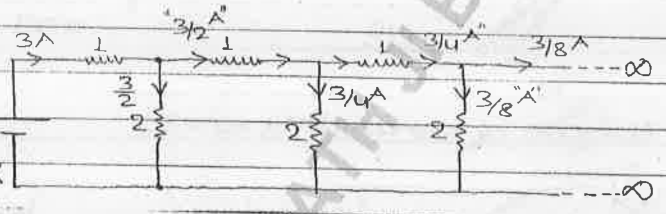
$R^2-R-2=0$

$(R-2)(R+1)=0$

$^{*}R = 2\Omega$

$R = -1\Omega$

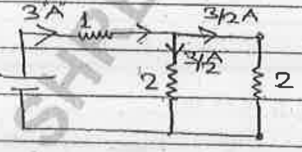
*Qus>



$I = \frac{6}{②} = 3A$

Find current in 1st 2Ω Restistance?

solutn:-



$I_{1^{st}\ 2\Omega} = 3/2 = 3/2^1$

$I_{2^{nd}\ 2\Omega} = 3/4 = 3/2^2$

$I_{3^{rd}\ 2\Omega} = 3/8 = 3/2^3$

$I_{n^{th}\ 2\Omega} = 3/2^n$

$I_{1^{st}\ 1\Omega} = 3 = 3/2^0$

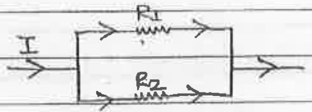
$I_{2^{nd}\ 1\Omega} = 3/2 = 3/2^1$

$I_{3^{rd}\ 1\Omega} = 3/4 = 3/2^2$

$I_{n^{th}\ 1\Omega} = \frac{3}{2^{n-1}}$

⊛⇒ SHORT CURCUIT (CKT) :-

⇒



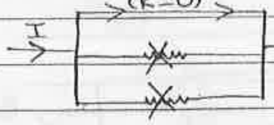
(Normal CKT)

$$I \propto \frac{1}{R}$$

$$R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

⇒

**(short CKT)
(R=0)



$\therefore R_{eq} = \underline{0}$

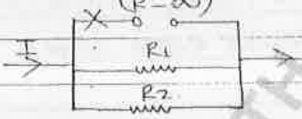
CONCLUSION:-

① It is the Path of "zero" (0) Resistance so total current passes through it.

② so; All component parllel to short curcuit are useless.

⊛⇒ OPEN CURCUIT (CKT) :-

**(R = ∞)

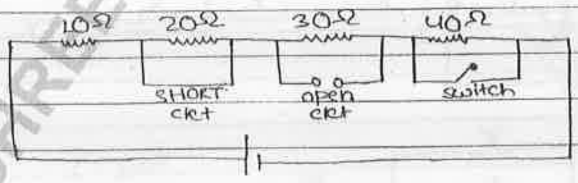


$I \propto 1/R$

$$R_{eq} = \frac{R_1 * R_2}{R_1 + R_2}$$

→ It is path of $\underline{R = \infty}$; so, current is zero through it.

Qus>



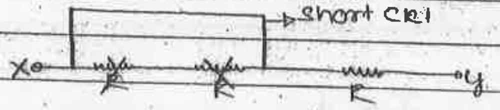
① switch off :- $R_{eq} = 10 + 0 + 30 + 40 = 80\,\Omega.$

② switch on :- $R_{eq} = 10 + 0 + 30 + 0 = 40\,\Omega$

$\frac{R \times R}{3R}$

Date_______ Page ____

Ques>

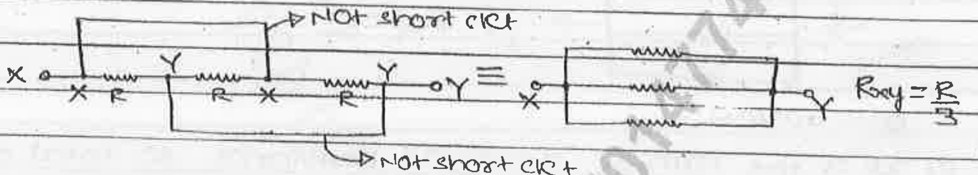


R_{xy} = "R"

Ques>

R_{xy} = "R"

Ques>



$R_{xy} = \frac{R}{3}$

V.Imp.

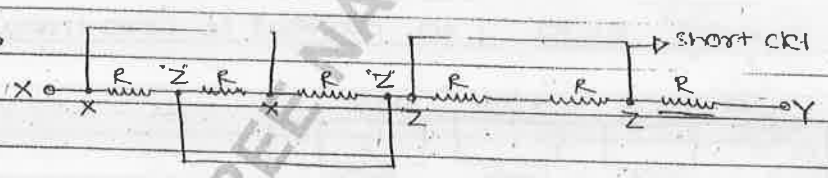
* ⊛ ⇒ Point potential Method :-

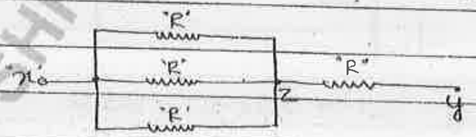
Usefull in ckts having Direct Wire (component (R) Free)

Step① :- Numbering of all Junctions is Done, where Junction connected by a Direct wire should have same No.

Step② :- Rearranged the ckts component in the New Diagram

Ques>





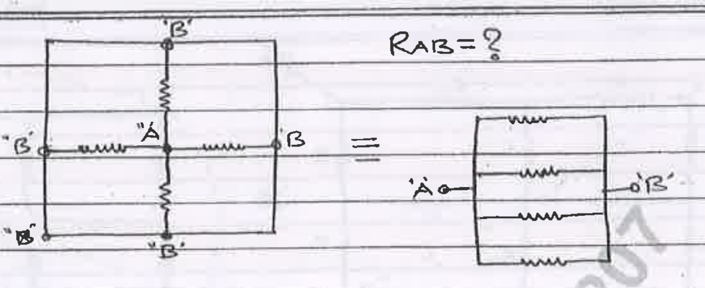
R_{xy} = ?

$R_{xy} = \frac{R}{3} + R = \frac{4R}{3}$

$\frac{2R\times2R\times4}{5R} = \frac{4R}{5}$

Date ______ Page ___

Ques>



$R_{AB} = ?$

$R_{AB} = \frac{R}{4}$

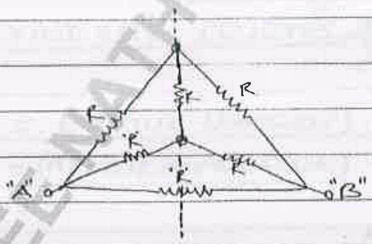
✡ ⇒ SYMMETRICAL LINE METHEDS:-

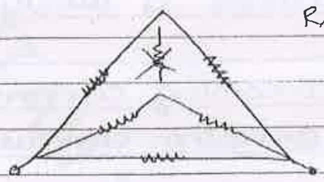
Only Useful in symmetrical curcuits.

step:①: Draw the "⊥ Bisector" of the line, joiuing terminal point's. And this symmetrical line should must divide the ckt into "TWO MIRROR IMAGES".

step:②: strech the CKT along symmetrical line to Removes all Junction lyieng on symmetrical line.

Ques>

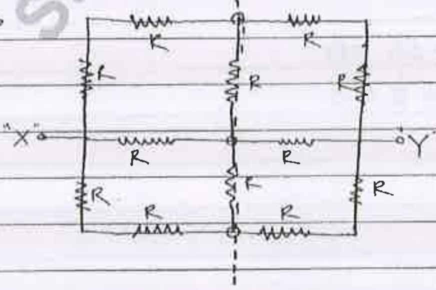


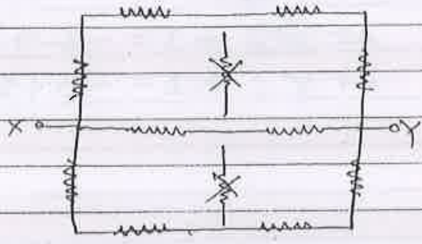


$R_{AB} = ?$

$R_{AB} = 2R \| 2R \| R = R/2$

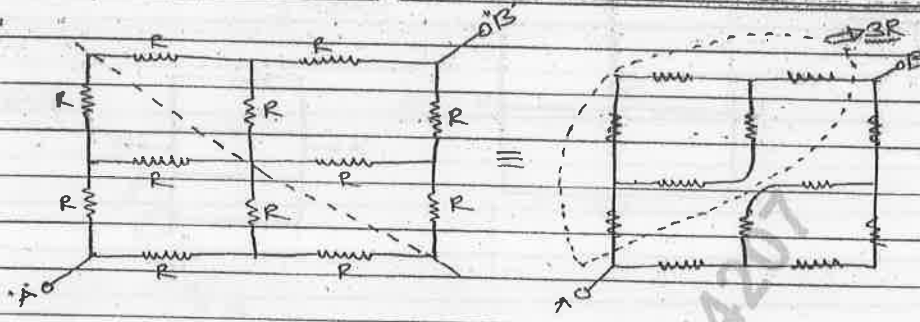
Ques>





$R_{XY} = 4R \| 2R \| 4R =$ "R"

Ques>



$R_{AB} = 3R \,||\, 3R = 1.5R$

✡ ⇒ KIRCHOFF'S LAW :- → KVL
→ KCL

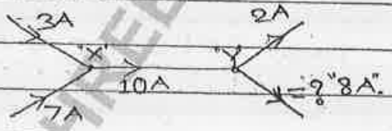
① First / current / Junction Law (K.C.L) :-

→ *Based on "Charge conservation."

→ At Junction "Algebric sum" of all current "or" all charges is always zero(0). [At Juncth = $\Sigma I = 0$]

✓ (i) Incoming current (Towards Juncth) = ⊖ve.
(ii) Outgoing current (Away from Juncth) = ⊕ve.

eg :-

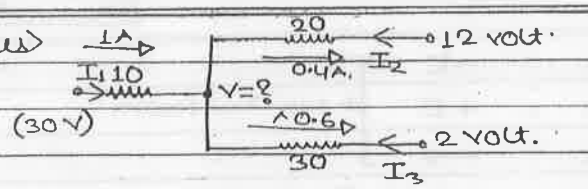


At "x" ; $\Sigma I = -3 - 7 + 10 = 0$.

At "Y" ; $\Sigma I = -10 + 2 + 8 = 0$.

Date______ Page ___

*Ques



⇒ Find Potential of common Point and current at each Resist

By KCL:-

$$\Sigma I = 0$$

$$-I_1 - I_2 - I_3 = 0$$

$$I_1 + I_2 + I_3 = 0$$

$$\left(\frac{30-V}{10}\right) + \left(\frac{12-V}{20}\right) + \left(\frac{2-V}{30}\right) = 0$$

$$180 - 6V + 36 - 3V + 4 - 2V = 0$$

$$220 = 11V \Rightarrow V = 20 \text{ volt.}$$

$I_1 = \frac{30-V}{10} = \frac{30-20}{10} = 1A$ (1A, towards Junctⁿ)

$I_2 = \frac{12-20}{20} = -0.4A$ (0.4A, Away from Junctⁿ)

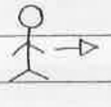
$I_3 = \frac{2-20}{30} = -0.6A$. (0.6A, Away from Junctⁿ)

② Second / voltage / Loop Law (KVL):-

(i)* Based on "energy conservation."

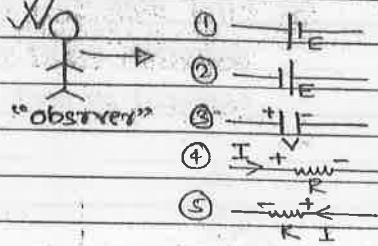
(ii) "Algebric sum" of all Potential Differences (P.Des) is alway zero (0) in a close loop.
In close loop: Σ PD's = 0

⇒ Sign convention:-



(+) to (−) = ⊖ve (se alway's final positⁿ)

(−) to (+) = ⊕ve



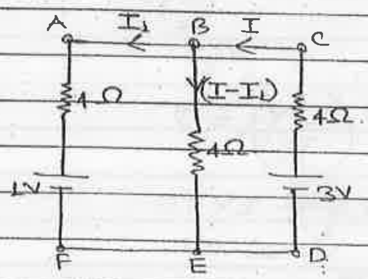
① = $-E$
② = $+E$
③ = $-V$

⇒ see Final Positn

④ = $-IR$
⑤ = $+IR$

∴ [current/observer same Dirn = −ve
current's observ. oppst Dirn = ⊕ve

eg:-



loop ABEFA:-

$-4(I-I_1)+1+4I_1=0$

$8I_1-4I=-1$ ---- ①

loop. BCDEB:-

$+4I-3+4(I-I_1)=0$

$8I-4I_1=3$ ---- ②

① × 2 + ②

$+12I_1=+1$

$I_1=\frac{1}{12}A$

eqn-① $8\left(\frac{1}{12}\right)-4I=-1.$

$\frac{8}{12}+1=4I \Rightarrow I=\frac{5}{12}A$

$I_{left\,4\Omega}=I_1=1/12.$

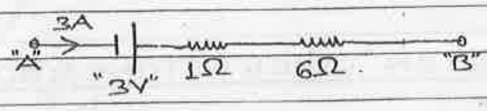
$I_{middle\,4\Omega}=I-I_1=\frac{5}{12}-\frac{1}{12}=\frac{4}{12}=\frac{1}{3}A$

$I_{right\,4\Omega}=I=\frac{5}{12}A.$

⊛ ⇒ "KVL" BETWEEN TWO POINTS:-

** ⇒ Potential of "Initial Point" ± (All PD's) = Potential of Final Point.

NEET 2016 Ques>

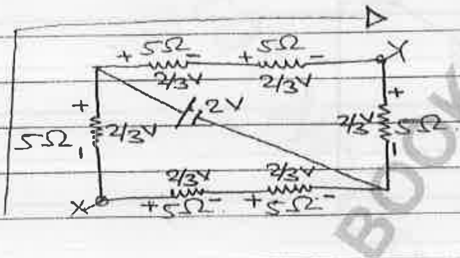


$V_A - V_B = ?$

Ans> $V_A \cancel{+3} \cancel{-3}\times 1 - 3\times 6 = V_B$

$V_A - V_B = 18$ volt

**Ques>

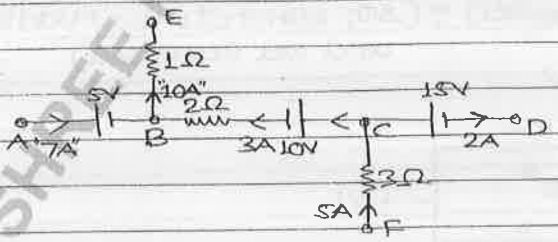


$V_x - V_y = ?$

soln:- $V_x + \frac{\cancel{2}}{\cancel{3}} - \frac{\cancel{2}}{\cancel{3}} - \frac{2}{3} = V_y$

$V_x - V_y = \frac{2}{3}V = 0.67V$

Ques>



(i) $V_A - V_B = ?$

$V_A - 5 + 2\times 3 + 10 - 15 = V_D$

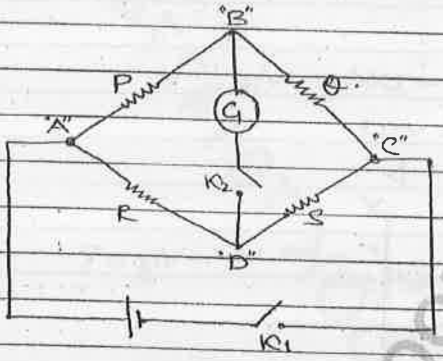
$V_A - V_D = 4$

(ii) $V_E - V_F = ?$

$V_E + 10 + 3\times2 + 10 + 5\times3 = V_F$

$V_E - V_F = -41$

✡ ⇒ CURCUITS BASED ON "WHEET-STONE BRIDGE":-



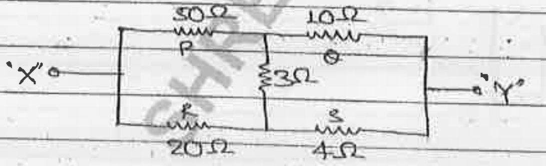
V.Imp. CASE:-① ⇒ "BIALANCE" BRIDGE:-

If; $\frac{P}{Q} = \frac{R}{S}$

⇒ $V_B = V_D$

⇒ $I_{MIDDLE} = 0$ ∵ (SO; Eliminate the Middle arm and get Resultout)

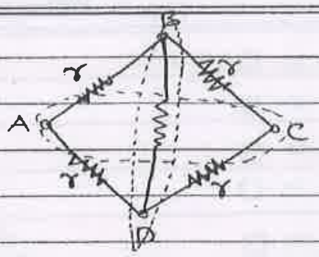
Ques>



∵ $\frac{50}{10} = \frac{20}{4}$ ∵ (Balanced wheatstone Bridge)

$R_{XY} = 60 || 24 = \frac{120}{7}$

**Ques>



① $R_{AC} = ?$

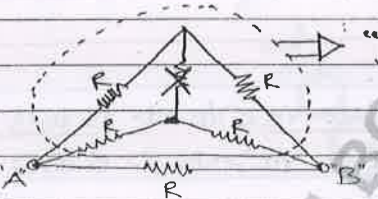
② $R_{BD} = ?$

① R_{AC} = "Bialoance" Wheatstone Bridge

*② R_{BD} = It is "Not - wheat stone Bridge" but it is 3-parllel Path ; so:-

$$R_{BD} = 2r \| r \| 2r = \frac{r}{2}$$

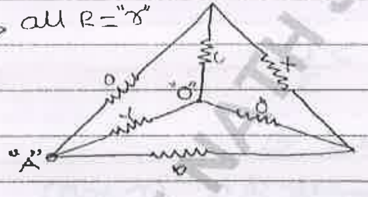
Ques>



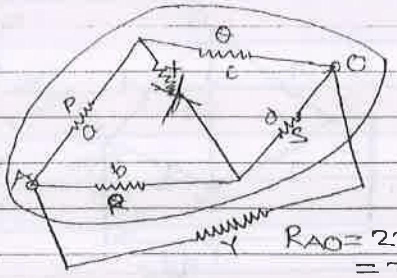
⟹ "Balanced" wheat stone Bridge
*(symetrical line aft chalega)

$R_{AB} = 2r \| 2r \| r = r/2$

**Ques> all R = "r"



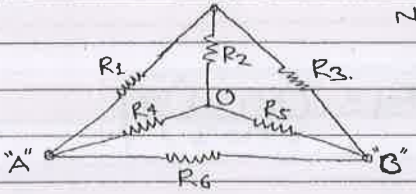
≡



$R_{AO} = 2r \| 2r \| r$
$= r/2$

Reason's:- Remove the Resistance b/wn "A" & "O" and "Unfold" the ckt as shown above.

AIIMS ** Ques>



Note:- $R_1 = R_2 = R_3 = R_4 = R_5 = R_6$

In which "Resistance" current is "O" If Battery is Applied b/wn ①

Date_______ Page ___

Soln :- (i) A "X" C $\Rightarrow I_{R2} = 0$

(ii) A "X" B $\Rightarrow I_{R5} = 0$

(iii) B "X" C $\Rightarrow I_{R4} = 0$

(iv) A "X" O $\Rightarrow I_{R3} = 0$

(v) B "X" O $\Rightarrow I_{R6} = 0$

(vi) C "X" O $\Rightarrow I_{R1} = 0$

* Not v. Imp. for EXAM

CASE :- ② ⇒ "UNBALANCED" WHEATSTONE BRIDGE :-

If; $\frac{P}{Q} \neq \frac{R}{S}$

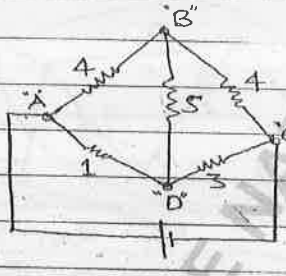
$\Rightarrow V_B \neq V_D$

$\Rightarrow I_{middle} \neq 0$

** ⇒ If $P/Q > R/S \Rightarrow V_B < V_D \Rightarrow$ D to B

⇒ If $P/Q < R/S \Rightarrow V_B > V_D \Rightarrow$ B to D

Ques>



$\because \frac{4}{4} > \frac{1}{3}$

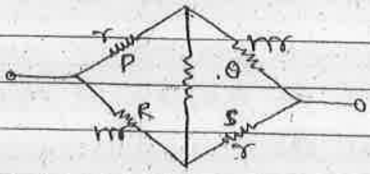
$\therefore V_B < V_D$

$\therefore I_{middle} \neq 0$ (D to B)

⊛ ⇒ Equivalent Resistance:-

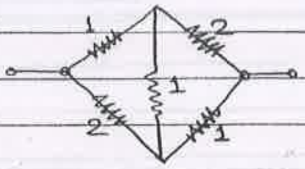
(i) KVL

(ii)



$$\boxed{R_{eq} = \left(\frac{3n+1}{n+3}\right) r}$$

Qus>



$\because r=1 \quad \because n=2$

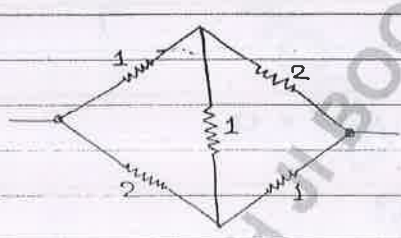
$$R_{eq} = \left(\frac{3n+1}{n+3}\right) r = \frac{7}{5} = 1.4\,\Omega.$$

⊛⇒ SHORTCUT'S :- (For Unbialanced wheat stone Bridge):-

→ Eliminate the "Middle Arm" and Get Equivalent Resista. (which is Approx Answer) an than;

① Req. is slightly less than Rapprox.
② Ceq. is sligtly more than Capprox.

Qus>



$R_{Approx} = 3 \| 3 = 1.5\,\Omega$

Req. is "slightly less" than 1.5
$\simeq 1.4$

✡⇒ IMPORTANT POINTS OF WHEATSTONE BRIDGE :-

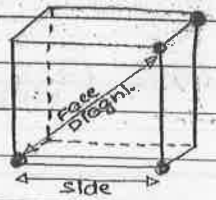
① In Bialance condition; Battery Branch and Galvanometer Branch are Interchangable.

② To avoid the confusion (about difflectn in Ⓖ) (Due to Induced current), Battery Key is made ONN 1st (First). than Ⓖ key

③ It is Most sensative, if all ④ Resistance are made up of same value. (not same order).

R→ Resistance & R→ Reduced

⇒ FOR; CUBE:-



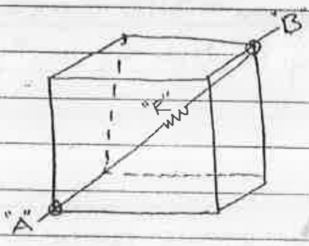
Each Resistance = "R" Each capacitance = "C"

$R_{\text{Main Diagonl. (largest)}} = \frac{5}{6}R = 0.82$ "Impor." $C_{\text{Main Diagonl.}} = \frac{6}{5}C = 1.5$ "Not so imp"

$R_{\text{Face Diagonl. (Medium)}} = \frac{3}{4}R = 0.75$ $C_{\text{Face Diagonl.}} = \frac{4}{3}C = 1.3$

$R_{\text{side (smallest)}} = \frac{7}{12}R = 0.58$ $C_{\text{side}} = \frac{12C}{7} = 1.7$

Ques>



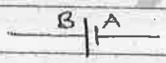
Each side = a

$R_{AB} = ?$

soln = $R_{AB} = \frac{5}{6}R \parallel R$

$\frac{1}{R_{AB}} = \frac{1}{R} + \frac{6}{5R} = \frac{11}{5R}$

⊛ ⇒ Earthing :-

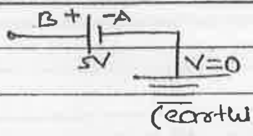


5V = (P.D)

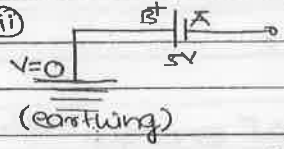
V_B	V_A
+5	0
+8	+3
−5	−10
0	−5

P.D = Higher Poten. − Lower Potent.

→ ①

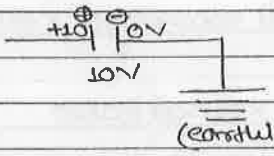


(ii)

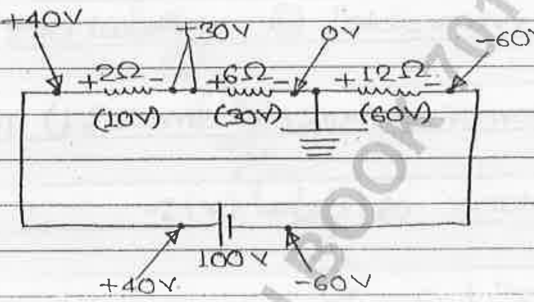


$V_A = 0$ (earthing)　　　　$V_B = 0$ (earthing).

$V_B = +5$　　　　$V_A = -5$



**Ques>



* ⇒ conductor's are Equipotential surface

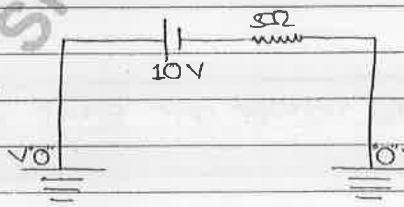
Soln :- $V_2 : V_6 : V_{12} = 1:3:6$

$$V_2 = \frac{1}{10} \times 100 = 10V$$

$$V_6 = \frac{3}{10} \times 100 = 30V$$

$$V_{12} = \frac{6}{10} \times 100 = 60V$$

\#/Ques>



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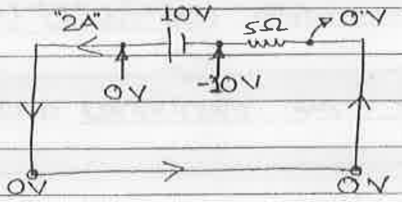


✡ ⇒ CELL :-

① "chemical" Energy $\xrightarrow{\text{CELL}}$ "Electrical" Energy.

(ii) cell → ② types :-

① Primary cell's	② secondary cell's
(i) Not Rechargable	(i) Rechargable
(ii) chemical Rxn's "Irriversible"	(ii) chemical Rxn's "Reversible"
(iii) High (↑↑) Internal Resitance.	(iii) small (↓↓) Internal Resista.

① Internal Resistance of CELL (r) :-

Practically "r" $\neq 0$
Ideal cell "r" $= 0$

② EMF *(E) :-

→ It is "work Done" by cell in Rotating Unit (1) charge in complete "CLOSE LOOP".

→ It is P.D between cell Terminal, when current with cell is "0" (zero).

→ All Mentioned and Printed voltage are E.M.F only.

⑤ Terminal voltage (V) :-

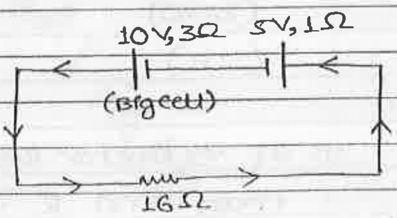
v.imp

It is P.D b/w cell Terminal, when current with cell is "Non-zero".

$V = E - Ir$ ∵ (Discharging ←|‖—) → see ⊕ only

$V = E + Ir$ ∵ (charging →‖|—)

① Ques>



⇒ Find terminal voltage of each cell ?

solutn:- $\textcircled{I} = \frac{10-5}{3+16+1} = \frac{5}{20} = 0.25\,A$

10V cell : $V = E - I\textcircled{r}$
$= 10 - 0.25 \times 3$
$= 9.25$ volt

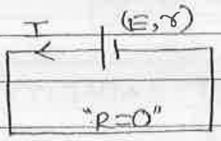
5V cell : $V = E + I\textcircled{r}$
$= 5 + (0.25) \times (1)$
$= 5.25$ volt.

Ques> A cell (E, r) ; Find Terminal voltage (V) If

ⓘ cell is "short" curcuited.

ⓘⓘ cell is "OPEN" curcuited.

Ans> ⓘ cell short ckt.



∵ $I = E/r$

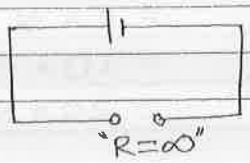
$V = E - Ir \Rightarrow E - \left(\frac{E}{r}\right)r$

$\boxed{V=0}$

ⓘⓘ ∵ $I = 0$

$V = E \textcircled{\pm} \cancel{Ir}$

$\boxed{V=E}$



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***Imp

**⇒ Important Point of Terminal voltage :-

① Terminal voltage of cell may be :- More or Less or Equal to E.M.F. And even it can be zero.

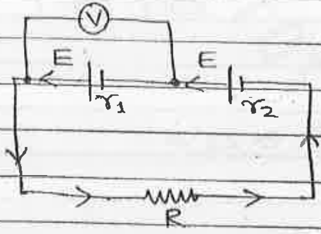
Charging ⇒ Ⓥ= $E+Ir$ $(>E)$

Discharging ⇒ Ⓥ= $E-Ir$ $(<E)$

Short ckt ⇒ Ⓥ= 0 (zero)

Open ckt ⇒ Ⓥ= E $(=E)$

NPMT NEEE Qus> **



⇒ If voltmeter Reading = 0 than Find "R" ?

$$I = \frac{E+E}{R+r_1+r_2} = \frac{2E}{R+r_1+r_2}$$

$$V_1 = E_1 - I_1 r_1.$$

$\because (V_1=0)$ $$0 = E - \left(\frac{2E}{R+r_1+r_2}\right)(r_1)$$

$$\cancel{E} = \frac{2E}{R+r_1+r_2} \cdot r_1$$

$$\boxed{R = r_1 - r_2}$$

④ "CURRENT CAPACITY" of cell (Ah) :-

EX:- 10 Ah = 1A × 10 hours.

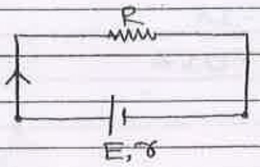
= 2A × 5 hours.

= 5A × 2 hours.

= 10A × 1 hours.

= 20A × $\frac{1}{2}$ hours.

✡ ⇒ cell circuit (ckt) :-



ⓘ $I_{ckt} = \frac{E}{R+r}$

ⓘⓘ $I_{max} = \frac{E}{r}$ (when R=0)

⇒ "I_{max}" = Maxm current A cell can delivered.

(iii) $V = E - Ir.$

(iv) $r = ?$ $\because V = E - Ir$

$$= E - \left(\frac{E}{R+r}\right) r.$$

$$\boxed{r = \left(\frac{E-V}{V}\right) R}$$

(v) $P_{load} = ?$

$$P_{load} = I^2 R$$

$$= \left(\frac{E}{R+r}\right)^2 R$$

(vi) For P_{MAX} at Load :-

$$\frac{dP}{dR} = 0 \Rightarrow \boxed{R = r}$$

$$\boxed{P_{max} = \frac{E^2}{4r}}$$

*Qus> A cell, (E, r)

9f load = 1Ω ⇒ current = 1A

9f load = 3Ω ⇒ current = 0.5A

than; find ① $r = ?$ "A" $E = ?$

Ans> $I = \frac{E}{R+r}$ $\quad 0.5 = \frac{E}{3+r}$ ......(ii)

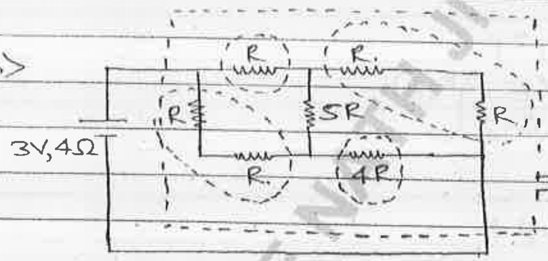
$1 = \frac{E}{1+r}$ ----①

$\left.\begin{array}{l} E = 2 \text{ volt} \\ r = 1\Omega \end{array}\right]$

(ii) Find maxm current the cell's can delivered?

$I_{max} = \frac{E}{r} = \text{"}2A\text{"}$

*Qus>



⇒ For P_{max}; $R = ?$

⇒ Bialance wheat stone Bridg.

$R_{load} = 3R \| 6R = 2R$

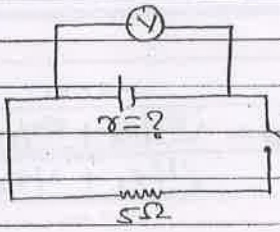
Than for P_{max}:-

$R_{load} = r_{eq}$

$2R = 4$.

$R = 2\Omega$.

Qus>



Given; If Key OFF ⇒ (V) = 2.2 volt.
If Key ON ⇒ (V) = 1.8 volt.
∴ Find $r = ?$

Ans> Key OFF ⇒ V = 2.2 volt ⇒ E = 2.2 volt.
Key ON ⇒ V = 1.8 volt ⇒ V = 1.8 volt.

(i) $r = \left(\frac{E-V}{V}\right)R = \frac{10}{9}\ \Omega.$

(ii) $I_{max} = \frac{E}{r} = \frac{2.2}{10/9} = 1.98\ A.$

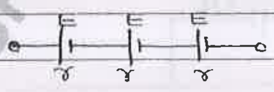
(iii) $R \neq r$ (so; Power at Load is "not Maxm.")

✡ ⇒ GROUPING OF CELL :-

① SERIES :-

$E_{net} = E_1 + E_2 + E_3 + \cdots$
$r_{net} = r_1 + r_2 + r_3 + \cdots$

Imp ** EX :- (i)

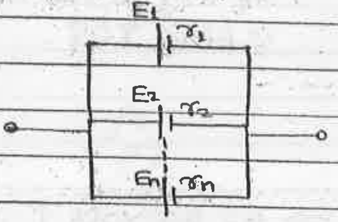


$E_{net} = E + E + E = 3E$
$r_{net} = r + r + r = 3r$

*(ii)

$E_{net} = +E + E - E = E$
$r_{net} = r + r + r = 3r$

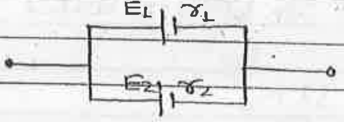
② PARLLEL :-



$$E_{net} = \frac{E_1/r_1 + E_2/r_2 + \dots}{1/r_1 + 1/r_2 + \dots}$$

r_{net} = || Resultant of all r's

EX:-



$$E_{net} = \frac{E_1 r_2 + E_2 r_2}{r_1 + r_2}$$

$$r_{net} = \frac{r_1 r_2}{r_1 + r_2}$$

** Note :- $E_1 < E_{net} < E_2$ always.

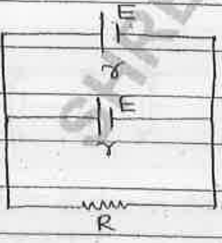
Ques>

$$E_{net} = \frac{(5)(3) \oplus (5)(2)}{3+2}$$

$$= \frac{15+10}{5} = \underline{5V}$$

**⟹ In Parllel grouping of cells having same EMF (E) and of same Polarity than $E_{net} = \textcircled{E}$.

Ques>



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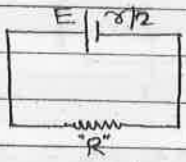
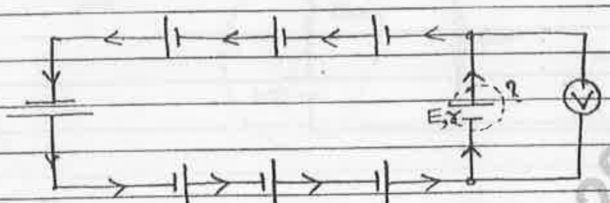


∴ For P_{max} : $R_{eq} = r_{eq}$

$$\boxed{R = \frac{r}{2}}$$

*Ques> ⑧ identical cells (E, r)

Voltmeter Reading=?



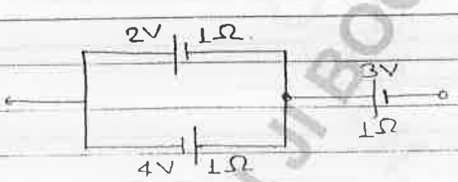
Soln = $I = \frac{8E}{8r} = \frac{E}{r}$

$V = E - Ir$

$= E - \left(\frac{E}{r}\right) r$ → ** of that particular cell, for which we are measuring P.D. or Terminl voltage

$\boxed{V=0}$

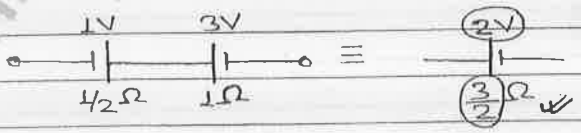
Ques>



⇒ Find Equivalent cell=?

Ans> $E_{net} = \frac{(+2)(1) + (-4)(1)}{1+1} = -1V.$

$r_{net} = 1 || 1 = \frac{1}{2}\,\Omega$



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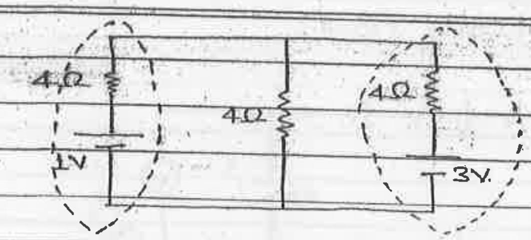
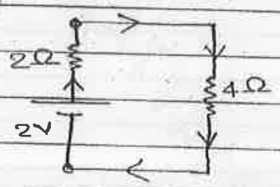
Ques>



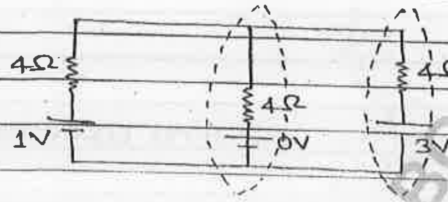
$I_{\text{middle } 4\Omega} = ?$

Ans>



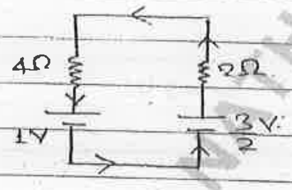
$I = \frac{2}{2+4} = \frac{1}{3}$ "A"

Ques>



$I_{\text{left } 4\Omega} = ?$

Ans>



$I = \frac{3/2 - 1}{4+2} = \frac{1}{12}$ "A"

✡ ⇒ "HEATING" EFFECT OF CURRENT :-

(i) Heat (H) $= I^2Rt = \frac{V^2}{R} \times t = VIt.$ Joule *[always in Joule]

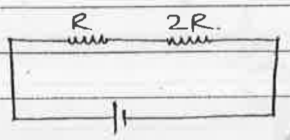
[∵ t = time]

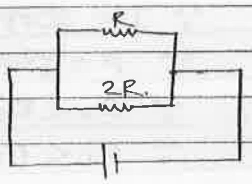
(ii) 1 cal. = 4.2 Joule.

(iii) Electric Power(P) = Ratio of Heat Production.

$$P = I^2R = \frac{V^2}{R} = VI \quad \underset{sec}{\underline{J}} \text{ or watt}$$

Qus>





solutn> ∵ I = same

$P = I^2R \propto R$

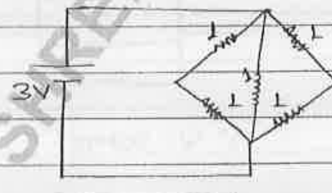
$\frac{P_1}{P_2} = \frac{1}{2}$.

∵ V = same.

$P = \frac{V^2}{R} \propto \frac{1}{R}$

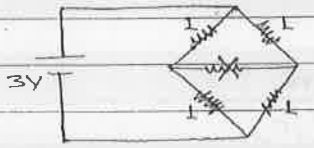
$\frac{P_1}{P_2} = \frac{2}{1}$

Qus>



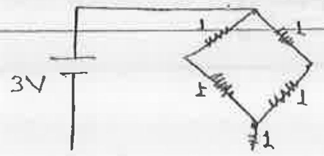
= (ω.s.B)X

$R_1 = \frac{1}{2}\Omega$



= (ω.s.B)✓

$R_2 = 1\Omega$



$R_3 = 2\Omega$

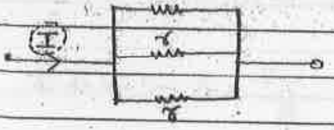
∵ V = same

∵ $P = \frac{V^2}{R} \propto \frac{1}{\boxed{R}}$

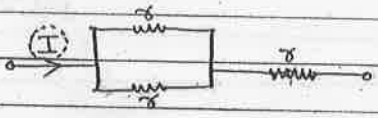
∵ $R_3 > R_2 > R_1$.

∵ $P_3 < P_2 < P_1$

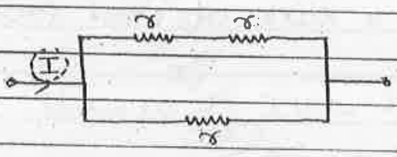
Ques>



$R_1 = \frac{r}{3}$



$R_2 = \frac{r}{2} + r = \frac{3r}{2}$



$R_3 = \frac{2r}{3}$

soln> $\because$ I = same.

$\because P = I^2 R \propto \textcircled{R}$

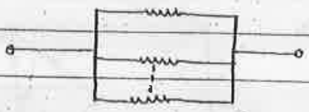
$\because R_1 < R_3 < R_2$

$\because P_1 < P_3 < P_2$

*Ques> n identical resistance 1st connected in series than in
W parllel, If "same supply voltage" is applied than

$\frac{\text{Heat (parllel)}}{\text{Heat (series)}} = ?$

Ans>



$\because$ V = same

$\because$ V = same

$H = \frac{V^2}{R} * t \propto \frac{1}{R}$

$\frac{H(\text{parllel})}{H(\text{series})} = \frac{R(\text{series})}{R(\text{parllel})} = \frac{nR}{R/n}$

$= \boxed{n^2 : 1}$

⇒*Alway keep the Units while solving Question

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⊛ ⇒ Temp. change ⇒ $H = ms\Delta\theta$

Phase change ⇒ $H = mL$

$$S_{water} = 1 \frac{cal}{gm.°C}$$

$$L_{ice} = 80 \frac{cal}{gm.}$$

$$L_{water} = 540 \frac{cal}{gm.}$$

*Ques> A 50Ω of water is inside Ice, If 210 voltage is applied than calculate Mass of Ice Melted in 1 sec.? m gms?

Ans> $H = \frac{V^2}{R} t = mL$

$$\frac{(210)^2}{50} \times 1\ \text{Joule} = (m \cdot gm)\left(80 \frac{cal}{gm}\right) \times 4.2$$

$$\boxed{m = 2.6\,gm}$$

*Ques> A 60Ω of Rod is insid 42 kg water, If 7A current is Pass than calculate Rise in Temprature of water Per Minute?

Ans> $H = I^2 R t = m s \Delta\theta$

$$7^2 \times 60 \times 60\ \text{Joul.} = (42\,kg)\left(\frac{1000\ cal}{kg \times °C}\right)\overset{\cancel{0°C}}{(\Delta\theta)}\ \overset{Joul}{4.2}$$

$$\boxed{\Delta\theta = 1°C}$$

⊛ ⇒ For "same Heat" By TWO Diffrent Heaters :-

Heater ① Resistance = R_1 time = t_1
Heater ② Resistance = R_2 time = t_2

∵ V = same (bcz in Home = 220V always)
∵ H = same (Given)
∵ $H = \frac{V^2}{R} t$
∴ $\boxed{t \propto R}$

** ⇒ If Booth used Jointly for same Heat :-

(i) $t_{series} = t_1 + t_2$ **

(ii) $t_{parrllel} = \frac{t_1 \cdot t_2}{t_1 + t_2}$ **

** Qus> For Boiling 1 Litre water ; Heater₁ = 3 min.
Heater₂ = 6 min.

Ans> (i) $\boxed{t \propto R}$
$t_2 > t_1$
$R_2 > R_1$
⇒ $R_2 = 2R_1$

(ii) If both used Jointly for same Heater :-

$t_{series} = 3 + 6 = 9$ min.
$t_{parrllel} = \frac{3 \times 6}{3 + 6} = 2$ min.

Imp ** ☆☆ ⇒ BULB :-

→ Based on Heating Effect of current.

① Rated values (P_R & V_R)

EX:- Bulb (100 W, 220V)

$P_R = 100\ W$
$V_R = 220\ V$

(i) If $V_{actual} = 220V \Rightarrow P_{actual} = 100\ W \Rightarrow$ Perfect Glow.

(ii) If $V_{actual} < 220V \Rightarrow P_{actual} < 100\ W \Rightarrow$ Less Glow.

(iii) If $V_{actual} > 220V \Rightarrow P_{actual} > 100\ W \Rightarrow$ **Fused.

② Resistance of Bulb (R_B) :-

(i) $\boxed{R_B = \frac{V_R^2}{P_R}}$

(ii) ∵ V_R = same.

∴ $\boxed{R_B \propto \frac{1}{P_R}}$ ** Always

EX:-① $R_{40W} > R_{60W} > R_{100W}$

② Bulb ① (200W, 220V) $\frac{R_{B1}}{R_{B2}} = ?$
Bulb ② (500W, 220V)

Soln :- $R_B \propto \frac{1}{P_B} \Rightarrow \frac{R_{B1}}{R_{B2}} = \frac{500}{200} = 5:2$

Ques> Bulb (220V, 100 W); Find $R_B = ?$

Ans> $R_B = \frac{V_R^2}{P_R} = \frac{(220)^2}{100} = 22 \times 22 \Rightarrow 484\Omega$

*** ③ Actual Power consumption of Bulb :-

$$P_{Actual} = I_{Actual}^2 R_B = \frac{V_{Actual}^2}{R_B}$$

AIEEE

Ques> Bulb (220 V, 100 W); $V_{actual} = 100$ V

$P_{actual} = ?$

soln> $R_B = \frac{(220)^2}{100} \Omega$

$$P_{actual} = \frac{V_{actual}^2}{R_B} = \frac{(110)^2}{\left[\frac{(220)^2}{100}\right]} = 25 \text{ W}$$

(Less Bright)

** ⇒ $\boxed{\text{Brightness} \propto P_{Actual}}$

✡ ⇒ Bulb in series AND Parllel :-

case :- ① :- Bulb in Series :-

① BRIGHTNESS $\propto P_{Actual} (= I^2 R_B)$ ∵ I = const.

$$\propto R_B$$

$$\propto \frac{1}{P_R}$$

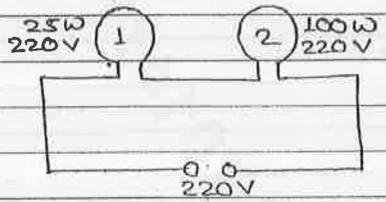
⇒ Bulb of Less Rated Power is more Bright. and vice versa.

② $P_{Total} = ?$

∴ If ** $V_{R1} = V_{R2} = \dots\dots\dots = V_{supply}$

// $\boxed{\frac{1}{P_{Total}} = \frac{1}{P_{R1}} + \frac{1}{P_{R2}} + \dots\dots}$

// EX:-



(i) Brightness ① > Brightness ②

(ii) $P_{Total} = ?$

$$\frac{1}{P_{Total}} = \frac{1}{25} + \frac{1}{100} = \frac{1}{20W}$$

(iii) Resistance of Bulbs:-

$R_{B1} = \frac{(220)^2}{25}$ $\quad R_{B2} = \frac{(220)^2}{100}$

(iv) Ratio of Resistance:-

$R_B \propto \frac{1}{P_R} \Rightarrow R_{B1} : R_{B2} = 4:1$

(v) Voltage Across Each Bulb:-

∵ $V \propto R$

∴ $V_1 : V_2 = 4:1$

$V_1 = \frac{4}{5} \times 220 = 176V$ $\quad V_2 = \frac{1}{5} \times 220 = 44V$

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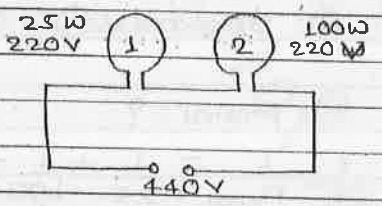
(vi) $P_1 = \frac{V_1^2}{R_{B1}} = \frac{(176)^2}{\left[\frac{(220)^2}{25}\right]} = \boxed{16W}$

$P_2 = \frac{V_2^2}{R_{B2}} = \frac{(44)^2}{\left[\frac{(220)^2}{100}\right]} = \boxed{4W}$

$P_{total} = P_1 + P_2 = (16+4)W = \boxed{20W}$

NEEE Ques>



Ans> $V \propto R$.

$V_1 : V_2 = 4 : 1$

$V_1 = \frac{4}{5} \times 440 = 352V$ ⇒ Get Fused due to over voltage ($V > 220V$)

$V_2 = \frac{1}{5} \times 440 = 88V$ ⇒ It is safe but it will not glow due to open ckt. [BCZ ① Bulb Fuse]

Case:- (II):- Bulb in Parallel:-

① *BRIGHTNESS $\propto P_{ACTUAL} \left(= \frac{V^2}{R_B}\right)$ ∵ $V = \text{const.}$

$\propto \frac{1}{R_B}$

$\propto P_R$

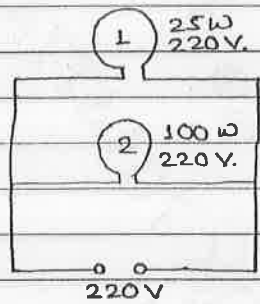
⇒ Bulb of "Less Rated" Power is "Less Bright" and VICE VERSA.

② $P_{Total} = ?$

If $V_{R1} = V_{R2} = \ldots\ldots = V_{supply}$

$$\boxed{P_{Total} = P_{R1} + P_{R2} + \ldots\ldots}$$

Ques>

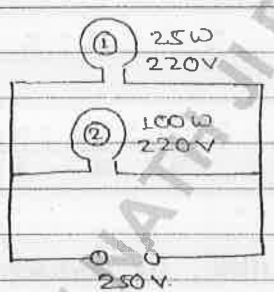


ⓘ Brightness of Bulb; Ⓑ > Ⓐ

ⓘⓘ $P_{Total} = ?$

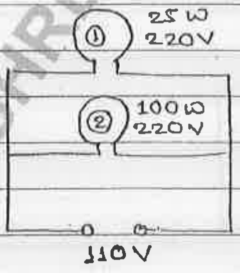
$P_{Total} = 100 + 25 = 125 W$

Ques>



⇒ Both the Bulb get Fused due to excess voltage.

Ques>



ⓘ Brightness of Bulb; ① < ②

ⓘⓘ $P_{Total} = ?$

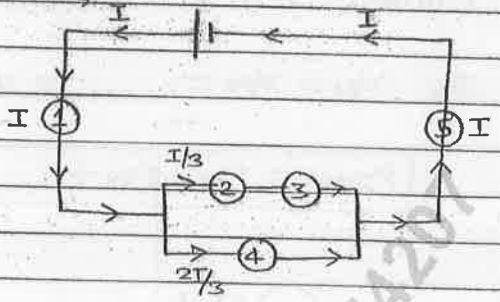
$$P_1 = \frac{(110)^2}{\left[\frac{(220)^2}{25}\right]} = 6.25 W$$

$$P_2 = \frac{(110)^2}{\left[\frac{(220)^2}{100}\right]} = 25 W$$

$$P_{Total} = 25 + 6.25$$
$$= 31.25$$

Ques> ⑤ Identical Bulb's ;

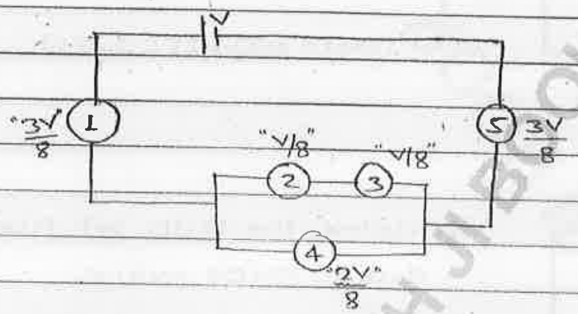
method :- ①



"I" ⇒ ① = ⑤ > ④ > ② = ③

"चमक" ⇒ ① = ⑤ > ④ > ② = ③

Method :- ②



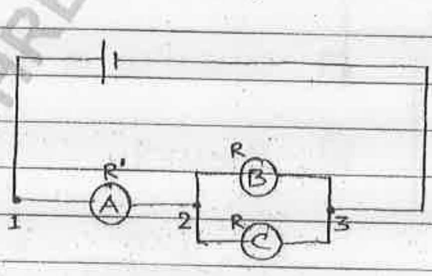
$\because R : \frac{2R}{3} : R$

$\because 3 : 2 : 3$

$\because \frac{3}{8}V : \frac{2}{8}V : \frac{3}{8}V$

Ques> Ⓑ "A" Ⓒ are Identical Bulbs, If suddenly bulb Ⓒ get Fused than Affect of Brightness ~~of~~ on Bulb Ⓐ "A" Bulb Ⓑ will be ?

Ans>



∴ If confused than Do it current Method.

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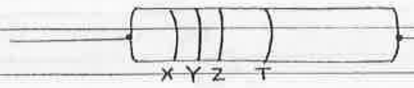
Bulb Ⓒ OK:- $V_{12} : V_{23} = R' : R/2$

Bulb Ⓒ FUSED:- $V_{12} : V_{23} = R' : R$

∴ $V_{23}\uparrow \Rightarrow V_B\uparrow \Rightarrow P_B\uparrow \Rightarrow$ Brightness of Ⓑ ↑

∴ $V_{12}\downarrow \Rightarrow V_A\downarrow \Rightarrow P_A\downarrow \Rightarrow$ Brightness of Ⓐ ↓

✡ ⇒ COLOUR CODING OF CARBON RESISTANCE:-



∵ First 3 colour = (Value) ∵ Fourth colour = (Tolerance)

(Black) = B —— 0
(Brown) = B —— 1
R —— 2
O —— 3
Y —— 4
(Green) = G —— 5
(Blue) = B —— 6
V —— 7
(Gray) = G —— 8
W —— 9

Golden = ± 5%
silver = ± 10%
NO colour = ± 20%

$$\boxed{R = xy \times 10^z \,\Omega \pm T}$$

Ques>	Red	orange	Blue	Golden
	(2)	(3)	(6)	(±5%)

Solⁿ:- $R = 23 \times 10^6 \,\Omega \pm 5\%$

$= 23\ M\Omega \pm 5\%$

Date_______ Page ____

Ques> Brown (1), Black (0), Blue 6

soln :- $R = 10 \times 10^6 \Omega \pm 20\%$

$= 10 \, M\Omega \pm 20\%$

"V.V.Imp" J.M.S.I.M.D

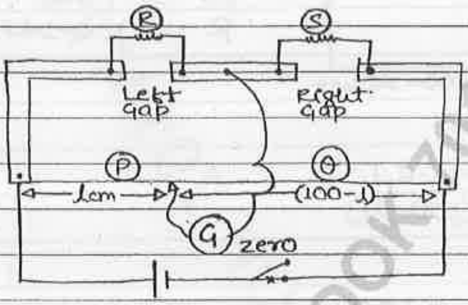
"ELECTRICAL INSTRUMENT"

① METER BRIDGE :-

(i) Based on wheat-stone Bridge.

(ii) Based on zero (0) Deflection method.

(iii) Unknown Resistance is measured by comparing with the known Resistance.



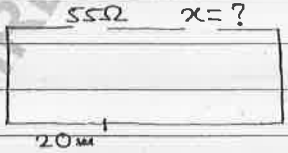
⇒ At "Bialance" :-

$$\boxed{\frac{P}{Q}=\frac{R}{S}}$$

$$\frac{l}{(100-l)}=\frac{R}{S}$$

$$\therefore \boxed{S=\left(\frac{100-l}{l}\right)R}$$ X(Dont Use Formula)

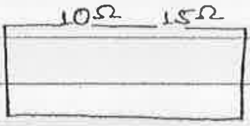
AIEEE Ques>



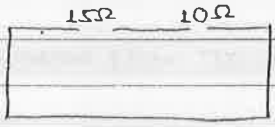
$$\frac{55}{x}=\frac{20}{80}$$

$$x = 220\,\Omega.$$

Qus>



$l_{balancing}$ = 40 cm

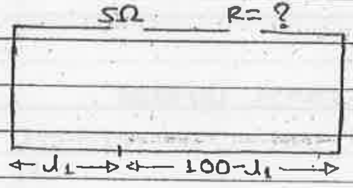


$l'_{balancing}$ = 60 cm

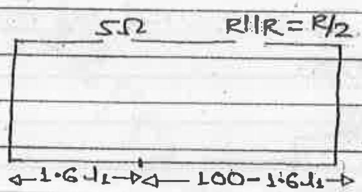
incrosed by 20cm.

Date________Page____

AIPMT 2015 Ques> ##



$$\frac{5}{R} = \frac{l_1}{100-l_1} \quad ----①$$



$$\frac{10}{R} = \frac{1.6l_1}{100-1.6l_1} \quad ---②$$

$\frac{①}{②}$:- $\frac{1}{2} = \frac{100-1.6l_1}{\underset{0.8}{\cancel{1.6}}(100-l_1)}$

$$80-0.8\,l_1 = 100-1.6l_1$$

$$-0.8l_1 = 100-80-1.6l_1$$

$$-0.8l_1 = 20-1.6l_1$$

$$0.8l_1 = 20$$

$$l_1 = \frac{20}{0.8} = 25\,cm.$$

by eqn --①:

$$\frac{5}{R} = \frac{l_1}{100-l_1}$$

$$\frac{5}{R} = \frac{25}{100-25}$$

$$\Rightarrow R = 15\Omega$$

⇒ Draw Back of volt Meter:-

It does "not gives Acqurate" Reading, because It "draw some current" from the ckt.

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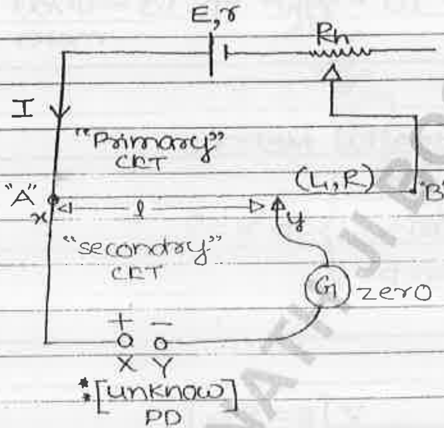
② POTENTIOMETER :-

① Used to Measure Potential Diffrence (P.D)

(ii) Based on zero (0) Deflection Method.

(iii) "Not" Based on wheat-stone Bridge.

(iv) It Does not draw current From ckt under measurm. so, Measurement is Acquerate, so Behave as a Ideal Volt Meter.



① Primary CKT:-

$$I = \frac{E}{R+Rh+r}$$

$V_{AB} = I \times \textcircled{R} \rightarrow$ wire Resistance

$\Rightarrow$ Potential Gradient (x):- PD across "unit length" of wire

$\because L$ ——————— $= V_{AB}$

$\because 1$ ——————— $= \frac{V_{AB}}{L}$

$$\therefore \boxed{x = \frac{V_{AB}}{L}}$$

Date______ Page ___

Ques> Primary CKT of Potentiometer ; Battery = 2volt

∵ wire = 10m, 40Ω

Find $x = ?$ ∵ Extra Resistance = 780 Ω

Ans> $I = \frac{2\text{volt}}{760+40} = \frac{1}{400}$ "A"

$V_{AB} = I \times R = \frac{1}{400} \times 40 = 0.1$ volt.

$x = \frac{V_{AB}}{L} = \frac{0.1}{10m} \Rightarrow 10^{-2}$ V/m $\Rightarrow$ 10 $\frac{\text{Milivolt}}{\text{meter}}$

Ques> In Primary CKT of Potential Meter :-

$$\left.\begin{aligned} \rho &= 1\times10^{-6} \\ A &= 1\text{cm}^2 \\ I &= 1\text{ Amp} \end{aligned}\right\} \Rightarrow x = ?$$

Ans> $x = \frac{V_{AB}}{L} = \frac{I \times R}{L}$ ∵ $\left[R = \frac{\rho \cdot L}{A}\right]$

$= \frac{I}{L}\left(\frac{\rho L}{A}\right)$

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

$= \frac{1\times10^{-6}}{1\times10^{-4}} = 10^{-2}$ V/m

$=$ 10 $\frac{\text{Mili Volt}}{\text{meter}}$

AIPMT 2015 ** Ques> Primary CKT of Potentiometer :- cell = 2 volt
wire (4m, 8Ω)
$x = \frac{1\,mV}{cm}$

Find :- Rh = ?

Ans> $I = \frac{2}{8+Rh}$

$V_{AB} = I \times R \Rightarrow \left(\frac{2}{8+Rh}\right) \times 8$

$x = \frac{V_{AB}}{L} \Rightarrow \frac{\left[\frac{16}{8+Rh}\right]}{4m}$

$\frac{1 \times 10^{-3}}{1 \times 10^{-2}} = \frac{4}{8+Rh}$

$40 = 8 + Rh$

$Rh = 32\,\Omega$

② secondry CKT :-

Unknown P.D is connected in secondory CKT as show in Figure. And Balancing Length is obtained by Jockey on Potentiometer wire.

∴ If Balancing Length = l
∴ Unknown P.D (V) = $\boxed{V = x l}$

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③ Range :-

EX:- $\left.\begin{aligned} V_{AB} &= 10 \text{ volt.} \\ L &= 10 \text{ m.} \end{aligned}\right\} x = 1\frac{V}{m}$

Unknown	Balancing Length(l)	Measured = ($x \cdot l$)
2V	l = 2m.	1×2 = 2 volt.
5·5V	l = 5·5 m.	1×5·5 = 5·5 volt.
10V	l = 10m.	1×10 = 10 volt.
10·1V	l = Not exist.	×

∴ Range = V_{AB}

Range = $x \cdot L$

$\boxed{\text{Range} \propto x}$

④ Sensitivity (S) :-

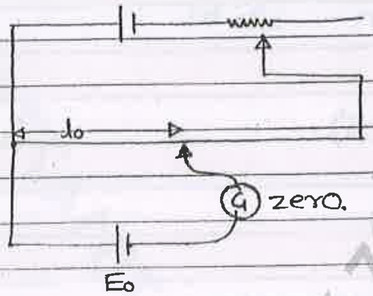
It is Ability to measure "small value" :- $\boxed{S \propto \frac{1}{x}}$

** ⇒ Rh (Rehoustat) is used in Primay ckt to adjust ⓧ; so that; ① $x\uparrow$ = Range ↑.
sensitivity↓.

$x\downarrow$ = Range↓.
sensitivity↑.

⑤ Standaridasition of Potentiometer :-

It is Process to Find "Accurate" ⓧ by Bialancing a "standard cell" on Potentiometer wire.

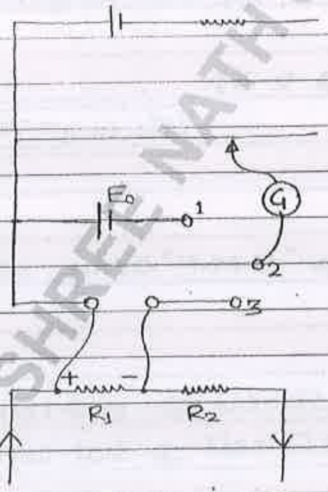


$\therefore x l_o = E_o$

$\therefore \boxed{x = \frac{E_o}{l_o}}$

✡⇒ APPLICATION OF POTENTIOMETER :-

① To Measure P.D across current carrying Resistnce :-



⇒ 1–2 :- $x = \frac{E_o}{l_o}$

⇒ 2–3 :- If Bal. leng. = l

$\boxed{V_{R_1} = x l}$

Ques> A standard cell of 1.2 volt is batalanced at 2.6 m. An unknown P.D is biolanced at 6.5 m, than find its value?

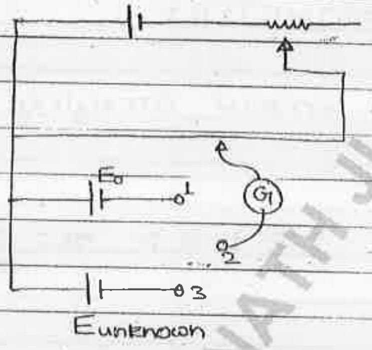
Ans> $x = \frac{E_0}{l_0} = \frac{1.2V}{2.6m} = \frac{6}{13}\frac{V}{m}$.

$V = x \cdot l$.

$= \left(\frac{6}{13}\right)(6.5)$

$= 3$ volt.

② TO Measure E.M.F of cell :-



⊛ 1-2 :- $x = \frac{E_0}{l_0}$

If Blal. Length $= l$

⊛ 2-3 :-

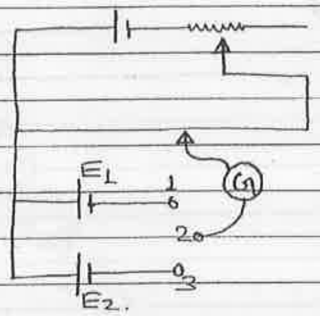
$\boxed{E_{unknown} = x \cdot l}$

** → This Blalancing Length is For "E.M.F" only, so does not Depends on r of cell.

Ex:- In Potentiometer:- ① 5 V, 2Ω cell ⇒ Bal. Len. = 3.2m
② 5 V, 3Ω cell ⇒ Bal. Len. = ?

soln:- ② Balancing Length = 3.2 (does not depends on "r" of cell.)

③ TO compare E·M·F of TWO cell:-



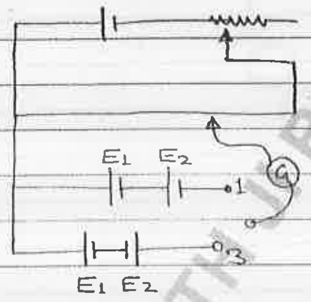
⊛ 1-2:- $E_1 = x l_1$ ---- ①

⊛ 2-3:- $E_2 = x l_2$ ---- ②

$$\boxed{\frac{E_1}{E_2} = \frac{l_1}{l_2}}$$

→ Here; standarisation do not Required.

Ques>



⊛ 1-2:- $E_1 + E_2 = x l_1$

⊛ 2-3:- $E_1 - E_2 = x l_2$

↳ "Always > E_2"

$$\frac{①}{②} = \frac{E_1 + E_2}{E_1 - E_2} = \frac{l_1}{l_2}$$

$$\boxed{\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_1 - l_2}}$$ ⇒ Not use as formula.

EXTRA ⊛ ⇒ componento & Dividendo:-

Ques> series group of two cell is Bialanced at 6m, one cell is Reversed then it is Bialanced at 2m length; than Find $\frac{E_1}{E_2} = ?$

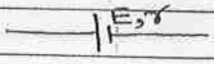
Ans> $E_1+E_2 = x(6)$ ----①

$E_1 - E_2 \quad x(2)$ ----②

$\frac{E_1}{E_2} = 2:1$

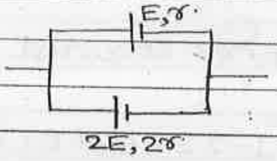
Ques> In Potentiometer:-

9f



∵ Balancing Length = l

⇒



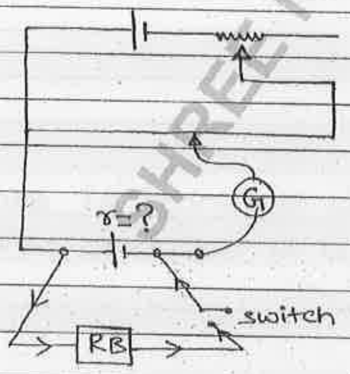
∵ Balancing Length = $(l') = ?$

Soln:- $E = xl$ -----①

$\frac{4E}{3} = xl'$ -----②

$\frac{①}{②} \Rightarrow l' = \frac{4}{3}l$

④ To Measure Interal Resistance (r) of cell :-



(i) switch OFF:- $E = x\cdot\underset{OFF}{(l_1)}$

(ii) switch ONN:- $V = x\cdot\underset{ONN}{(l_2)}$

∵ $r = \left(\frac{E-V}{V}\right)R$

V.IMP $\boxed{r = \left(\frac{l_1-l_2}{l_2}\right)(R.B)}$ ⇒ use as formula.

→ Here; standrisation is not Required.

Ques-44; pg=211.

NPMT Ques> $l_1 = 52cm$ If $R = 4\Omega$ then; $r = ?$
$l_2 = 40cm.$

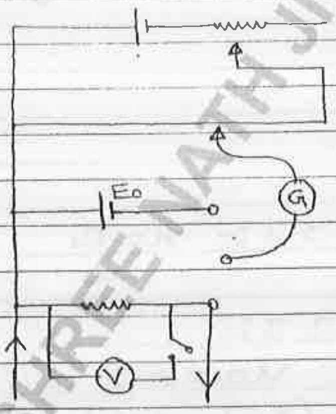
soln :- $r = \left(\frac{l_1 - l_2}{l_2}\right)R \Rightarrow \left(\frac{52-40}{40}\right) \times 4 \Rightarrow 1.2\Omega$

NPMT 2014 Ques> $l_1 = 3m.$ If $R = 9.5\Omega$ than; $r = ?$
$l_2 = 2.85m.$

soln : $r = \frac{\cancel{0.15}^{3}}{2.85} \times \frac{\cancel{9.5}}{\cancel{10}_{2}} = \underline{0.5\Omega}$

⑤ calibration of Ⓥ :-

⇒ It is Used to Find Error in voltmeter.



❀ 1-2 :- $x = \frac{E_0}{l_0}$

❀ 2-3 :- $V = xl$

Let Ⓥ Reading = V'

(i) Error :- = $V' - V$

(ii) Relative error :- = $\frac{V'-V}{V}$

"Error" = असुद्ध ⊖ शुद्ध (always.)

(iii) % Error :- = $\frac{V'-V}{V} \times 100$

Ques> A standard cell of 1.1 volt is bailanced at 4.4m, an unknown P.D is Bialanced at 1.9m, and voltmeter Reading is 0.5V. Than calculate % Error in voltmeter ?

Ans> $x \cancel{V} = \frac{E_0}{l_0} = \frac{1.1V}{4.4m} = \frac{1}{4}\frac{V}{m}$.

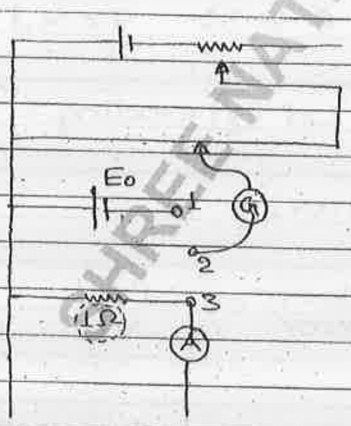
$$V = x.l \Rightarrow \frac{1}{4} \times 1.9 = 0.475 \text{ volt.}$$

Ⓥ reading = 0.5 volt.

$$\% \text{ Error} = \cancel{\frac{0.475-0.5}{0.475}} \times 100$$

$$= \frac{0.5-0.475}{0.475} \times 100 \Rightarrow +5.2\%$$

⑥ calibration of Ⓐ :-



❋ 1-2 :- $x = \frac{E_0}{l_0}$

❋ 2-3 :-

$$V_{1\Omega} = x.l.$$
$$(IR)_{1\Omega} = x.l.$$
$$I(1) = x.l$$
$$I = x.l.$$

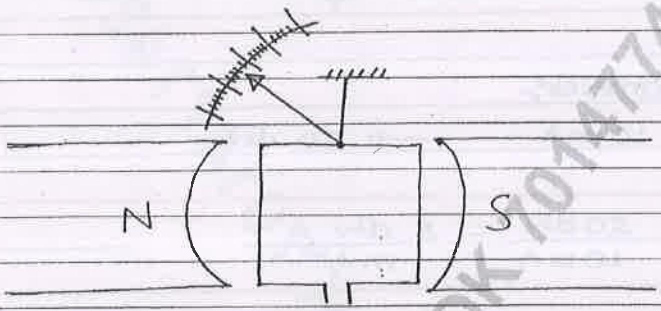
∴ Let Ⓐ reading = I'

$$\% \text{ error} = \frac{I'-I}{I} \times 100$$

③ MOVING COIL GALVANOMETER (M.C.G) :-

*(i) Based on Magnetic Effect of current.

(ii) Used to Measure *small current and used to Detect current in the circuit.



If ϕ

$$\tau_{deflecting} = \tau_{restoring}$$

$$NIAB\sin 90^\circ = K\phi$$

$$\boxed{\phi = \left(\frac{NAB}{K}\right) I \Rightarrow \phi \propto I}$$

Here;

K :- (Torsinal constant) ⇒ Restoring Torque for unit deflection
rad. unit

⊛⇒ CURRENT SENSETNITY :- (CS) :-

∵ I ——— ϕ

1 ——— $\frac{\phi}{I}$

$$\boxed{CS = \frac{\phi}{I} = \frac{NAB}{K}}$$

⊛⇒ VOLTAGE SENSITIVITY (VS):-

$$VS = \frac{\phi}{V}$$

⊛⇒ Figure of Merit:- $= \frac{1}{CS} = \frac{I}{\phi}$

EX:- In galvanometer:-

$$10\,mA \longrightarrow 50\text{ div.}$$

(i) $CS = \frac{\phi}{I} = \frac{50\,div}{10\,mA} = \frac{5\,div}{mA}$

(ii) Figure of Merit $= \frac{I}{\phi} = \frac{10\,mA}{50\,div} = \frac{1\,mA}{5\,div}$

⊛ SYMBOL:-

I_g ⇒ Full Deflection current.
V_g ⇒ Full Deflection voltage.
R_g ⇒ Resistance of Galvanometer.

⇒ $\because V_g = I_g \cdot R_g$

*⇒ It Behaves like Ameter of "I_g" Range And; Voltmeter of "V_g" Range

Date______ Page ___

Ques> MOVING COIL Ⓖ has 100 Divs^n and $CS = 5 \frac{div}{mA}$ and $VS = 10 \frac{div}{mA}$, than Find Rg ?

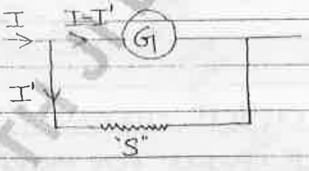
Ans> $CS = 5 \frac{div}{mA} \Rightarrow I_g = 20\,mA$

$V_s = \frac{10 div}{mA} \Rightarrow V_g = 10\,mA$.

$\therefore R_g = \frac{V_g}{I_g} = \frac{10\,mA}{20\,mA} = 0.5\,\Omega$.

④ SHUNTING:-

"shunting" is apply "small" Resistance in "Parallel" to galvanometer



Due to shunting some part of current is Diverted through shunt ; so deflection & sensitivity (Cs) Both Decreases.

$$\boxed{S = \frac{\phi_2 R_g}{\phi_1 - \phi_2}}$$

$\therefore \phi_1$ = Diflecth before shunting

$\therefore \phi_2$ = Diflecth after shunting.

Ques> $R_g = 50\,\Omega$, calculate shunt for changing Diflect^n 80 div. to 20 divs^n ?

Ans> $S = \frac{\phi_2 R_g}{\phi_1 - \phi_2} \Rightarrow \frac{20 \times 5}{80-20} = \frac{100}{6} \Rightarrow \frac{50}{3}\,\Omega$

(S) AMMETER :-

(i) Used to measure current.

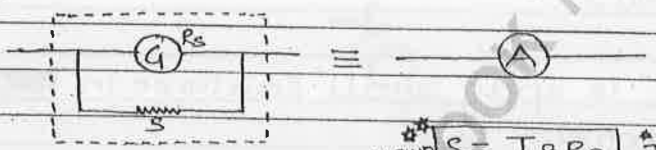
(ii) "Always" connected in series.

(iii) It's Resistance is small.

(iv) Resistance of Ideal Ammeter is zero (0).

⇒ $(G) \xrightarrow{\text{CONVERSION}} (A)$ "or" $(A) \xrightarrow{\text{UPGRADATN}} (A)$ "or" $(V) \xrightarrow{\text{CONVERSN}} (A)$:-

→ "Small" shunt is connected across Galvanometer



V.IMP $\boxed{S = \frac{I_g R_g}{I - I_g}}$ * I = Required Range of Ammeter.

Ques> $R_g = 13\Omega$, Full Diflectn current $(I_g) = 100$ Amp, calculate Required shunt for Making Ammeter of 750A.

Ans> $S = \frac{\cancel{1\times}100\times13}{750-100} = \frac{1300}{650} = 2\Omega$

AIEEE Ques> Range of Ammeter is 1A, and its Resistance is 90Ω, calculate shunt for Making it Range 10A?

soln :- $S = \frac{1\times90}{10-1} = 10\Omega$

⊛ It $S\downarrow$ ⇒ Range of (A)↑ [From Formula]

⊛ $R_A = S \| R_g$ ⇒ $\boxed{R_A = \frac{S \cdot R_g}{S+R_g}} < R_g$

(smaller than smallest)

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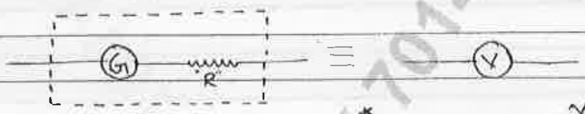
⑥ VOLTMETER :-

(i) Alway's connected in ~~series~~ Parallel. to a ckt.

(ii) 9ts Resistance is High (Idealy = ∞).

✻ ⟹ Ⓖ $\xrightarrow{\text{CONVERS}^{N}}$ Ⓥ "or" Ⓥ $\xrightarrow{\text{UPGRADAT}^{N}}$ Ⓥ "or" Ⓐ $\xrightarrow{\text{CONVERS}^{N}}$ Ⓥ :-

"[redacted]" Resistance is connected in series of Galvanometer.



Here;
* V = Require Range
OF voltmeter.

* $\boxed{R = \frac{V}{I_g} - R_g}$ V.Imp For Exam.

Qus> $R_g = 10\Omega$, Find deflecat^{n} current (I_g) = 1 mA, than calculate series Resistance for making voltmeter of 1V Range?

Soln :- $R = \frac{1}{1\times10^{-3}} - 10 = 990\Omega$.

✻ $R_{series}\uparrow$ = Range of Ⓥ ↑

✻ $R_{Ⓥ} = R_g + R$

∴ * $R_{Ⓥ} > R_{ⓖ} > R_{Ⓐ}$

Date________ Page ____

J.M.S J.M.D

"CADACITANCE"

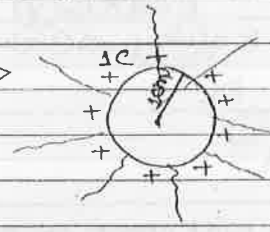
✡ ⇒ DI-electric strength of Medium :-

→ It is Maximum Electric Field after which insulation of DI-electric medium get's punchured.

For; Air (Dielectric const.) = 3×10^6.

Qus> Is it possible to Hold 1C charge on Metal sphere of 1cm Radius ?

Ans>



$$E_{surface} = \frac{KQ}{r^2} = \frac{9\times10^9\times1}{(1\times10^{-2})^2} = 9\times10^{13}$$

→ Breakdown of surrounding air takes Place due to this High Electric Field, so charge leakage takes Place.

✡ ⇒ CAPACITANCE OF CONDUCTOR :- (C) :-

(i) It Represent charge Holding capacity of CONDUCTOR.

(ii) In CONDUCTOR; $Q\uparrow = V\uparrow$

$Q \propto V$

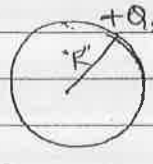
⇒ Scalar Quantity.

$$\boxed{\begin{matrix} Q = CV \\ C = \dfrac{Q}{V} \end{matrix}}$$

Unit
- MKS :- $\frac{\text{coulumb}}{\text{volt}}$, Farad (F)
- CGS :- St. F

1F = 9×10^{11} st. F

① capacitance of spherical conductor:-



If +Q is given:-

$V = \frac{KQ}{R} \Rightarrow \therefore V = \frac{Q}{4\pi\epsilon_0 R}$

$\frac{Q}{V} = 4\pi\epsilon_0 R \Rightarrow \boxed{C_{sphere} = 4\pi\epsilon_0\epsilon_r R}$ $\boxed{C_{sph.} \propto R}$

$\therefore C_{Big} = n^{1/3} C_{small}$

"C" does not Depends on:-
(i) Q (ii) V

"C" depends on:-
① size
② surrounding Medm. (ϵ_r)

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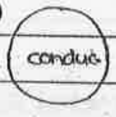
② capacitance of Earth:-

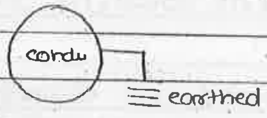
① Theoritically:- By considering a earth, a conducting sphere of R = 6400 km. ∵ $C_{earth} = 4\pi\epsilon_0 (6400\ km) \Rightarrow$ * $\boxed{C_{earth} = 711 \mu F}$

(ii) Practically:- Earth can except unlimited charge; $\boxed{C_{earth} = \infty}$

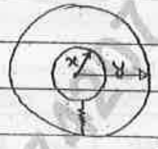
EX:- ①



(ii)



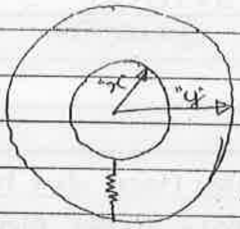
(iii)



Capacitance = C   capacitance = ∞* (V=0) $C = 4\pi\epsilon_0 (y)$

*Note:- capacitance of any earthed conductor is alway ∞ (infinite).

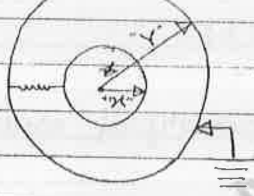
*Ques>



$C = 4\pi\epsilon_0 Y$.

∵ All charge will come on outer surface (∵conductor)

*Ques>



$\boxed{C = \infty}$

∵ Earthed

✡ ⇒ POTENTIAL ENERGY OF CHARGED CONDUCTOR (U):-

It is External work Done During charging of conductor which is "stored" in the form of Potential Energy.

** $\boxed{U = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{Q^2}{2C}}$

⊛ Energy spent by Battery :-

$\because$ E.M.F = V

Unit charge ——— work = V

'Q' charge ——— work = QV

⊛ $W_{battery} = \Delta U + \text{Heat}$

$$\boxed{QV} = \left(\frac{1}{2}QV - 0\right) + \text{Heat}$$

$\boxed{\text{Heat} = \frac{1}{2}QV}$ ⇒ only while charging of conduct

Ques> For a conductor:-

If charge = Q ⇒ P.E = U

If charge = $\frac{Q}{2}$ ⇒ P.E = ?

Soln :- $\because$ C = constant.

$U = \frac{Q^2}{2C} \propto Q^2$

$U' = U/4$

AIPMT

Ques> For charging a conductor, from "5V" to "10V", work done is "W", then calculate work done to increasing its potential "5V" Further ?

Soln :- 5V ⟶ 10V ; W = W

10V ⟶ 15V ; W' = ?

5V :- $U_5 = \frac{1}{2}C(5)^2$ 15V :- $U_{15} = \frac{1}{2}C(15)^2$

10V :- $U_{10} = \frac{1}{2}C(10)^2$

$\because$ $W_{ext} = \Delta U$

$W = U_{10} - U_5$

$W = \frac{1}{2}C(10)^2 - \frac{1}{2}C(5)^2$

$\boxed{W} = \frac{75}{2}C$ ------①

$W' = U_{15} - U_{10}$

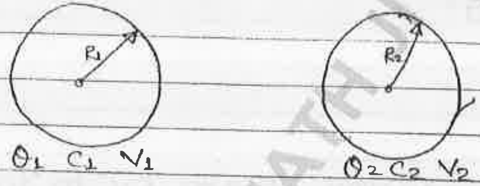
$= \frac{1}{2}C(15)^2 - \frac{1}{2}C(10)^2$

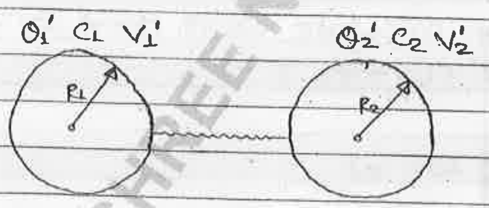
$\boxed{W'} = \frac{125C}{2}$ ------②

$\frac{①}{②}$:- $W' = \frac{5}{3}W$

✡ ⇒ RE-DISTRIBUTION OF CHARGES:-

→





① $C_{SYSTEM} = C_1 + C_2$

② Charge Distributn ⇒ $Q = CV$ $\because$ V = same after conductn

$\because$ $Q \propto C \propto R$

③ common Potential :-

$$Q_1 + Q_2 = Q_1' + Q_2'$$

$$C_1V_1 + C_2V_2 = C_1V + C_2V$$

$$\boxed{V_{common} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}}$$

$$\boxed{V_{common} = \frac{Q_1 + Q_2}{C_1 + C_2}} \qquad \boxed{V_{common} = \frac{Q_{SYSTEM}}{C_{SYSTEM}}}$$

④ Energy loss (ΔU) :-

$$U_{before} = \frac{1}{2} C_1V_1^2 + \frac{1}{2} C_2V_2^2$$

$$U_{After} = \frac{1}{2} C_1V^2 + \frac{1}{2} C_2V^2$$

$\because U_{before} > U_{After}$

→ ** some Energy is lost in the form of "Heat", so

$\because U_{Before} > U_{After}$

$$\Delta U = U_{Before} - U_{After}$$

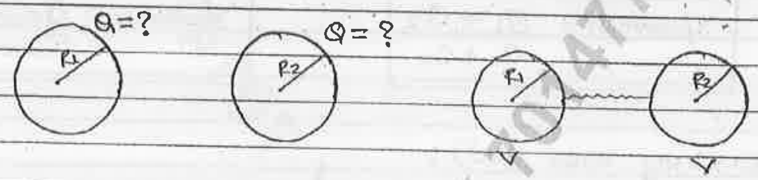
$$\boxed{\Delta U = \frac{C_1C_2}{2(C_1+C_2)} (V_1 - V_2)^2}$$

IIT Qus> Two conductor of each capacitance "C", one is charged upto 'V' and another is Neutral. If both are connected; find charge loss ?

soln :- $\Delta U = \frac{C \times C}{2(C+C)} (V-0)^2 \Rightarrow \frac{1}{4} CV^2$

 # Ques> A.I.EEE V.IMP — Two Metal sphere of Radius R_1 & R_2 have same charges, and if theses are connected with each other than common potentital become "V", Find initial charge at each sphere?

soln :-



Ist Method :- EASY

$$V_{common} = \frac{Q_1+Q_2}{C_1+C_2}$$

$$V = \frac{Q+Q}{4\pi\epsilon_0 R_1 + 4\pi\epsilon_0 R_2}$$

$$V = \frac{2Q}{4\pi\epsilon_0(R_1+R_2)}$$

$$V = \frac{2KQ}{R_1+R_2}$$

$$Q = \frac{V(R_1+R_2)}{2K}$$

IInd Methd :- COMPLEX

$$Q_{Total} = Q+Q = 2Q$$

$$Q_1' : Q_2' = R_1 : R_2$$

$$Q_1' = \frac{R_1}{R_1+R_2} \cdot 2Q$$

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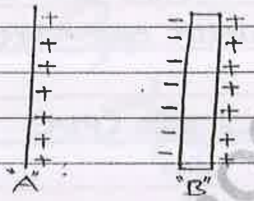
$$V_1' = \frac{KQ_1'}{R_1} = \frac{K\left(\frac{R_1}{R_1+R_2}\cdot 2Q\right)}{R_1} = V$$

$$\because Q = \frac{V(R_1+R_2)}{2K}$$

⇒ CAPACITOR :-

✡ ⇒ CONCEPT OF CAPACITOR :-

case :- I ⇒



Potential of Plate A :-

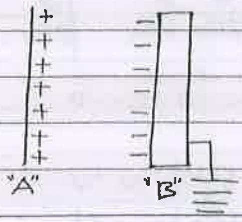
$\because V_A' = V_A - V_{B^-} + V_{B^+}$

$\because |V_{B^-}| > |V_{B^+}|$ ∵ Bcz Distance of ⊖ve is less than Distance of ⊕ve.

$\because V_A' < V_A$

$$\because C = \frac{\overset{(same)}{Q\leftrightarrow}}{V\downarrow} \Rightarrow C\uparrow$$

case :- II ⇒



$V_A'' = V_A - V_{B^-}$

$\because V_A'' \ll V_A$

$$\because C = \frac{\overset{(const)}{Q\leftrightarrow}}{V\downarrow\downarrow}$$

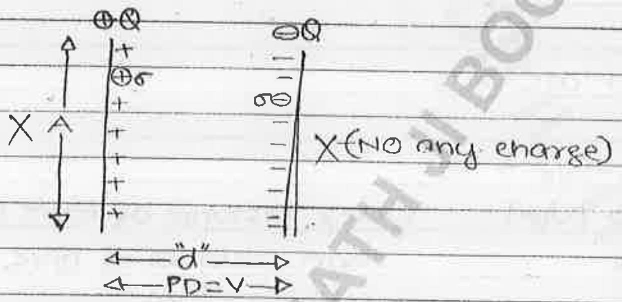
$\Rightarrow C\uparrow\uparrow$

⇒ wheather "Neutral" ore "oppositely" charge conductor is place at already charged conductor, than; its charge remains constant and Potential increases significantly (ज्यादा)

✡ ⇒ CAPACITOR :-

⇒ It is combination of two or more electricaly seperacted "conductor" having "same" Magnitude and "opposite Nature charges at Facing layer and Potential of conductor are Diffrent.

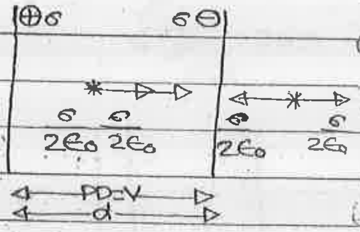
(A) PARLLEL PLATE CAPACITOR (PPC) :-



① Electric Field (E) :-

"$E_{outside} = 0$"

"$E_{inside} = \frac{\sigma}{\epsilon_0 \epsilon_r} = \frac{V}{d}$"



$$\because E = \left|\frac{dV}{dr}\right| = \frac{V}{d}"$$

② Potential Energy (U) :-

$$\boxed{U = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{Q^2}{2C}}$$

** → This Energy is stored in the Form of "Electric Field" b/wn the Plates.

V.Imp ③ Energy Density (u) "or" Electrostatic Pressure :-

→ Energy stored in unit volume.

$$*u = \frac{\text{Energy}}{\text{Volume}} = \frac{\frac{1}{2}CV^2}{A.d}$$

V.Imp

$$*\boxed{u = \frac{1}{2}\epsilon_0 E^2 = \frac{\sigma^2}{2\epsilon_0}} \qquad \because E = \frac{\sigma}{\epsilon_0}$$

AIPMT Ques> Dimension of $\frac{1}{2}\epsilon_0 E^2 = ?$

soln :-

$$= \frac{\text{Energy}}{\text{Volume}} = \frac{ML^2T^{-2}}{L^3} \Rightarrow M^1L^{-1}T^{-2}$$

AIPMT Ques> Total stored Energy :-

soln :-

$$= u \times \text{volme}.$$
$$= \left(\frac{1}{2}\epsilon_0 E^2\right) A.d$$

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V.IMP. ④ Force b/w^{n} Plates :-

∵ $u = \frac{\text{Energy}}{\text{Volume}} = \frac{\text{Force} \times \text{Distance}}{\text{Area} \times \text{Distance}}$

= Electrostatic Pressure.

∵ Force on each point :-

$= \boxed{u \times \text{Area}}$

$= \left(\frac{\sigma^2}{2\epsilon_0}\right) \times \text{Area}$

AIPMT 2015 Ques>

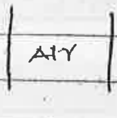
Force = u × Area.

$= \left(\frac{\frac{1}{2}CV^2}{Ad}\right) \times \text{Area}$

$= \frac{CV^2}{2d}$

⑤ capacitonce (C)

(i)



$C_{air} = \frac{\epsilon_0 A}{d}$

(ii)

$C_{med} = \frac{\epsilon_0 \epsilon_r A}{d}$

$\boxed{C_{med.} = \epsilon_r C_{air}}$

∵ $\epsilon_r > 1$ (alway)

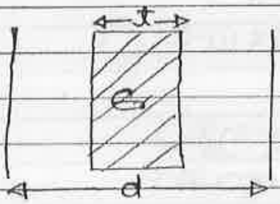
$\boxed{C_{med.} > C_{air}}$

(iii) If $C_{air} = C_{med}$

$$\frac{\epsilon_0 A}{d_{air}} = \frac{\epsilon_0 \epsilon_r A}{d_{med}}$$

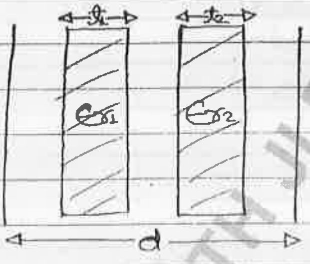
$$\therefore \boxed{d_{air} = \frac{d_{med}}{\epsilon_r}}$$

(iv)



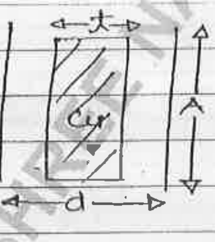
$$\boxed{C = \frac{\epsilon_0 A}{(d-t) + t/\epsilon_r}}$$

(v)



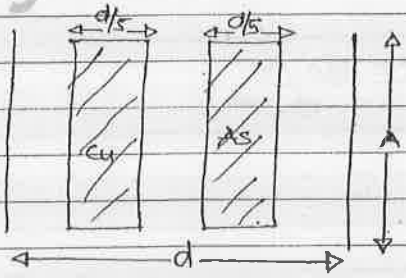
$$\boxed{C = \frac{\epsilon_0 A}{(d-t_1-t_2 \dots) + \left(\frac{t_1}{\epsilon_{r_1}} + \frac{t_2}{\epsilon_{r_2}} \dots\right)}}$$

Qus>



$$C = \frac{\epsilon_0 A}{(d-t) + \frac{t}{\infty}} = \frac{\epsilon_0 A}{(d-t)}$$

Qus>



$$C = \frac{\epsilon_0 A}{\left(d - \frac{d}{5} - \frac{d}{5}\right) + \left(\frac{d/5}{\infty} + \frac{d/5}{\infty}\right)}$$

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*Ques> capacitance of ppc (diameter of plate = 6cm) is equal to capacitance of metel sphere (dia = 200 cm) Find seperation b/wn plates?

soln :- $C_{ppc} = C_{sphere}$.

$$\frac{\cancel{\epsilon_0}(\cancel{\pi} r^2)}{d} = \cancel{\epsilon_0}\, 4\cancel{\pi} R$$

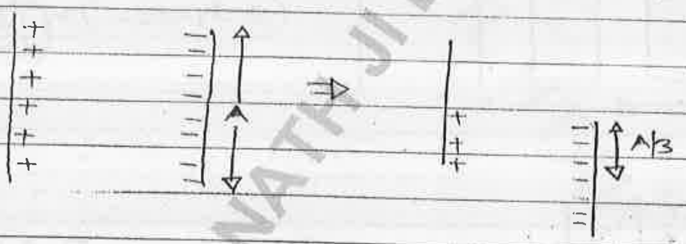
$$d = \frac{r^2}{4R} = \frac{3\overset{9}{\cancel{6}}\times\cancel{10}^{-4}}{\cancel{4}\times\cancel{200}\times10^{-2}}$$

$$= 0.45$$

$$= \frac{(3\times10^{-2})^2}{4\times100\times10^{-2}}$$

$$= 2.25\times10^{-4}$$

*Ques> A ⇒ common Area of plates.



capa. = $C = \frac{\epsilon_0 (A)}{d}$

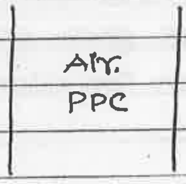
Capa. = $C' = \frac{\epsilon_0 \left(A/3\right)}{d}$

$= C/3$

Ques>

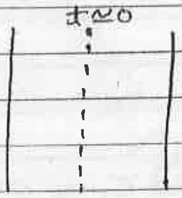
$C' = \frac{\epsilon_0 A_1}{d.}$

Ques>



Given:- $C = \frac{\epsilon_0 A}{d}$

AIEEE ① If a "thin" Metal Foil is placed inside ppc as shown

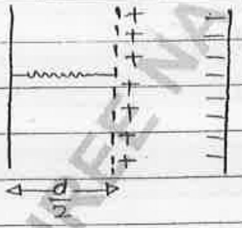


$$C' = \frac{\epsilon_0 A}{(d-0)+\frac{0}{\infty}}$$

$$C' = \frac{\epsilon_0 A}{d} = C$$

$\boxed{\begin{array}{l} C' = C \checkmark \\ C' \Rightarrow \text{"slightly more" than } C \checkmark\checkmark \end{array}}$

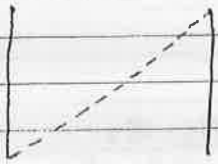
(ii) If Foil is placed at mid and connected with one plate :-



$d' = d/2$

$C' = 2C$ ✓✓

*(iii) If Foil touches both the plates :-

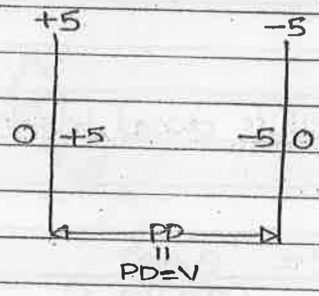


∴ P.D (V) = 0 ∵ [conductors are equipotential surface]

∴ $C = \frac{Q}{V} = \infty$ ✓✓

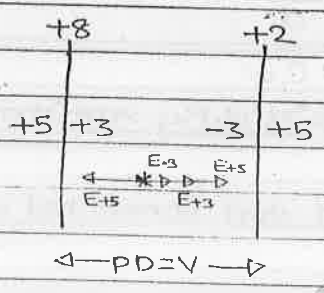
Ques> Two Metal Placed Parllel, are given charges +5 and −5 C. If P.D = V, than Capacitance = ?

soln :-



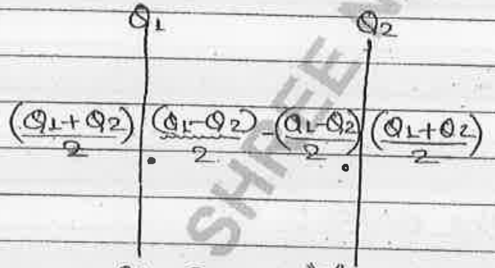
$C = \frac{Q}{V} = \frac{5}{V}$ ✓

Ques> 2 Metal plates; charges +8C "A" +2 'C'. If P.D=V, than capacitance = ?



$C = \frac{Q}{V} = \frac{3}{V}$ ✓

IIT ☆// Ques> ✓ Two Metal Plates; charge = Q_1 "A" Q_2



If cap. = "C" ⇒ P.D = ?

soln :- $Q = CV$

$$PD(V) = \frac{Q}{C} = \left(\frac{\frac{Q_1-Q_2}{2}}{C}\right) = \frac{Q_1-Q_2}{2C}$$ ✓

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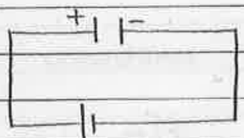
IMP ** ✡ ⇒ VARIATION IN CHARGED PPC :-



$\boxed{V_c = \text{const.}}$ $\boxed{Q_c = \text{const.}}$

① case:- Ⓘ :- If Battery is connected [$V_c = \text{const.}$]

VARIATN	$C = \frac{\epsilon_0 \epsilon_r A}{d}$	$V_c = \text{const.}$	$Q = CV$ $Q \propto C$	$E = \frac{V}{d}$	$U = \frac{1}{2}CV^2$ $U \propto C$
① ϵ_r ↑	↑	↔ cons	↑	↔	↑
(ii) A ↑	↑	↔	↑	↔	↑
(iii) d ↑	↓	↔	↓	↓	↓

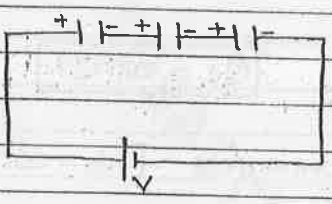
(ii) case:- II :- If Battery is Disconnected [$Q_c = \text{const.}$]

VARIATN	$C = \frac{\epsilon_0 \epsilon_r A}{d}$	$Q_c = \text{const}$	$V = \frac{Q}{C} \therefore V \propto \frac{1}{C}$	*** $E = \frac{Q}{A \epsilon_0 \epsilon_r}$	$U = \frac{Q^2}{2C} \therefore U\propto$
(i) ϵ_r ↑	↑	↔ cons.	↓	↓	↓
(ii) A ↑	↑	↔	↓	↓	↓
(iii) d ↑	↓	↔	↑	↔	↑

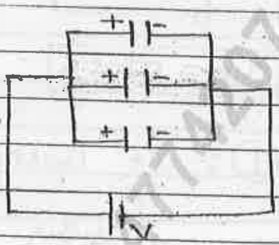
** Note:- If Nothing is Given than consider Battery is Dissconnected.

✡ ⇒ GROUPING OF CAPACITOR :-

SERIES



PARLLEL



*① ∵ Q = same

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

② $C_{eq} = \frac{C_1 \cdot C_2}{C_1 + C_2}$

voltage density :-

$Q = CV$

③ ∴ $\boxed{V \propto \frac{1}{C}}$

*① ∵ V = same.

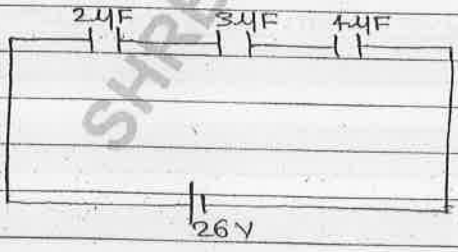
② $C_{eq} = C_1 + C_2 + C_3$

charge density :-

$Q = CV$

③ ∴ $\boxed{Q \propto C}$

Ques>



Find :-

① Voltage in each "C".

② $Q_{3\mu F} = ?$

③ $U_{2\mu F} = ?$

④ $E_{4\mu F} = ?$ (d = 3mm)

Ans> ① ∵ $V \propto \frac{1}{C}$

$$V_2 : V_3 : V_4 = \left(\frac{1}{2} : \frac{1}{3} : \frac{1}{4}\right) \times 12 = 6:4:3$$

$$V_2 = \frac{6}{13} \times 26 = 12\,V$$

$$V_3 = \frac{4}{13} \times 26 = 8\,V$$

$$V_4 = \frac{3}{13} \times 26 = 6\,V$$

(ii) $Q_{3\mu F} = ?$

$$Q = CV$$
$$= (3 \times 10^{-6})(8)$$
$$= 24\,\mu C$$

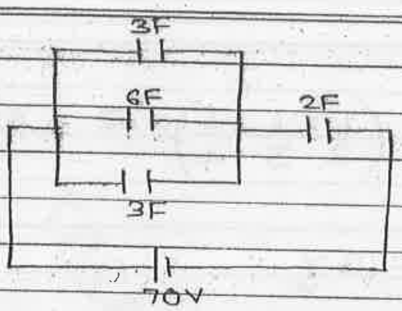
(iii) $U_{2\mu F} = ?$

$$U = \frac{1}{2} CV^2$$
$$= \frac{1}{2}(2 \times 10^{-6})(12)^2$$

(iv) $E_{4\mu F} = ?$ If $d = 3mm$.

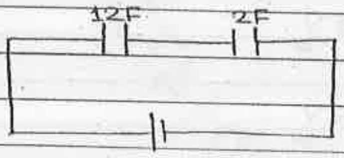
$$E = \frac{V}{d} = \frac{6}{3 \times 10^{-3}} = 2 \times 10^3 = 2\frac{KV}{m}$$

Ques>



∴ Voltage across each capacitor?

soln :-



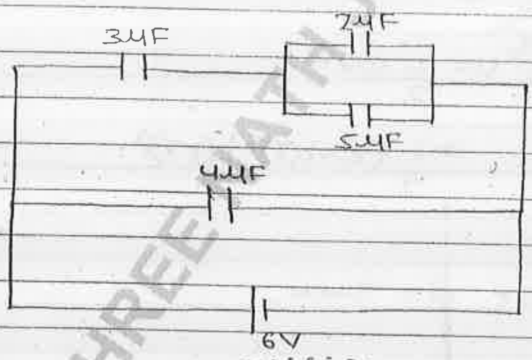
$$V_{12} : V_2 = \left(\frac{1}{12} : \frac{1}{2}\right) \times 12$$

$$= 1 : 6$$

$$V_{12} = \frac{1}{7} \times 70 = 10\,V$$

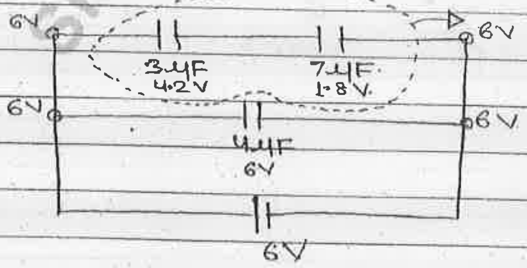
$$V_2 = \frac{6}{7} \times 70 = 60\,V.$$

Ques>



∴ voltage across each capacitor?

soln:



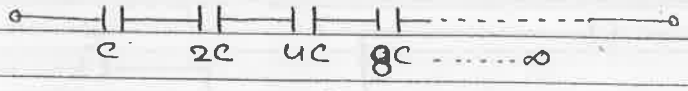
$$V_3 : V_7 = \left(\frac{1}{3} : \frac{1}{7}\right) \times 21$$

$$= 7 : 3$$

$$V_3 = \frac{7}{10} \times 6 = 4.2\,V$$

$$V_7 = \frac{3}{10} \times 6 = 1.8\,V$$

****Qus>**



calculate. $C_{eq} = ?$

soln :- $\frac{1}{C_{eq}} = \frac{1}{C} + \frac{1}{2C} + \frac{1}{4C} + \frac{1}{8C} \,-----\infty$

$= \frac{1}{C}\left(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} -----\infty\right)$

$\frac{1}{C_{eq}} = \frac{1}{C}\left[\frac{1}{1-\frac{1}{2}}\right]$

$= \frac{2}{C}$

$\boxed{C_{eq} = C/2}$

****Qus>**

calculate C_{eq}?

soln :- $\frac{1}{C_{eq}} = \left[\frac{1}{C} + \frac{2}{C} + \frac{4}{C} + \frac{8}{C} \,-----\infty\right]$

$= \frac{1}{C}(1+2+4+8 -----\infty)$

$= \frac{\infty}{C} = \infty$

$\because S_p = \frac{a}{1}$

$\boxed{C_{eq} = \frac{1}{\infty} = 0}$

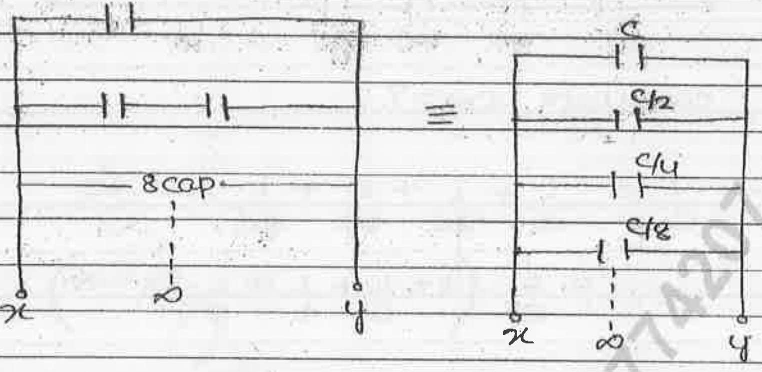
$\because S_\infty = \frac{a}{1-r}$ } Extra point.

$r \because [S_\infty = \infty \,;\, \text{if } (r \geq 1).$

↓ should must less than one. $(\because < 1)$

∵ charge 's' current Move from High Potential to Low Potential,

Qus>



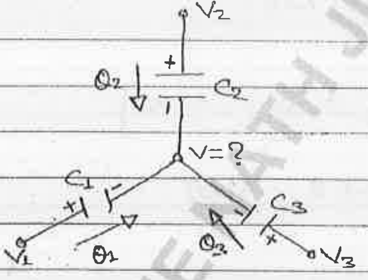
Soln :- $C_{XY} = ?$

$$C_{xy} = C + \frac{C}{2} + \frac{C}{4} + \frac{C}{8} + \dots \infty$$

$$= \frac{C}{1-1/2}$$

$$C_{XY} = 2C$$

Qus>



∵ Find Potential of common Point.?

Soln :- KCL; $\Sigma Q = 0$

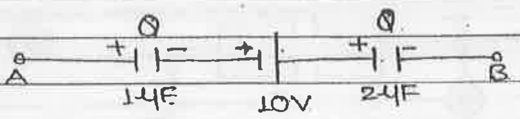
$$-Q_1 - Q_2 - Q_3 = 0$$

$$Q_1 + Q_2 + Q_3 = 0$$

$$C_1(V_1 - V) + C_2(V_2 - V) + C_3(V_3 - V) = 0$$

$$V = \frac{C_1V_1 + C_2V_2 + C_3V_3}{C_1 + C_2 + C_3}$$

Qus>



Given:- $V_A - V_B = 5V$

$\Rightarrow V_{1\mu F} = ?$

Soln:- By KVL:-

Ist method:-

$$V_A - \frac{Q}{1\times10^{-6}} + 10 - \frac{Q}{2\times10^{-6}} = V_B$$

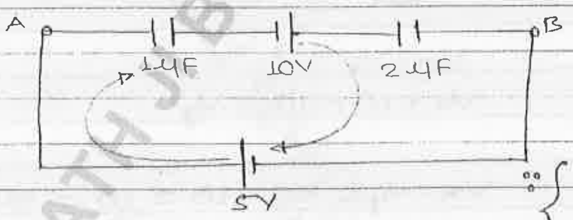
$$(V_A - V_B) + 10 = \frac{3Q}{2} \times 10^{+6}$$

$$5 + 10 = \frac{3Q \times 10^6}{2}$$

$$Q = 10\,\mu F$$

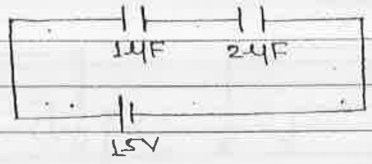
IInd Method:

इक्वी.



∴ { If clockwise:- Add it
If Anticlockwise:- High(V) − Low(V)

|||

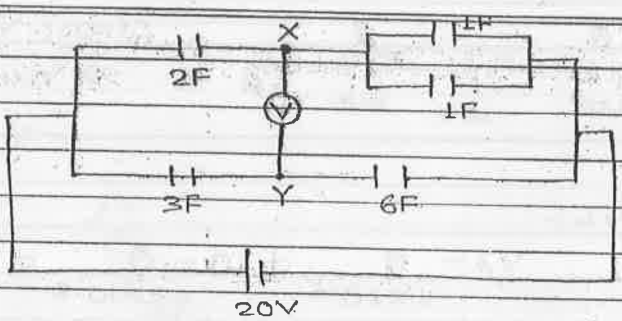


$V_1 : V_2 = 2 : 1$

$\therefore V_1 = \frac{2}{3} \times 15 = 10V$

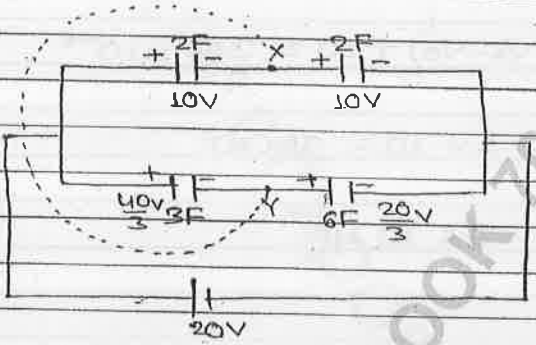
$\therefore V_2 = \frac{1}{3} \times 15 = 5V$

Qus>



(V) Reading = ?

soln :-

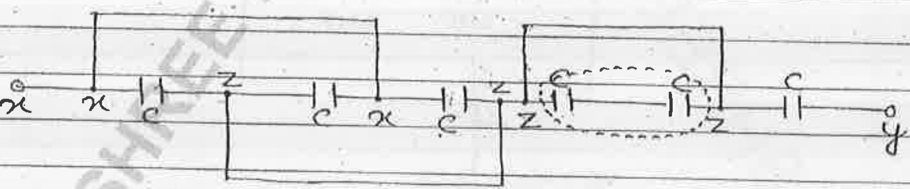


$V_x - V_y = ?$

$V_x + 10 - \frac{40}{3} = V_y$

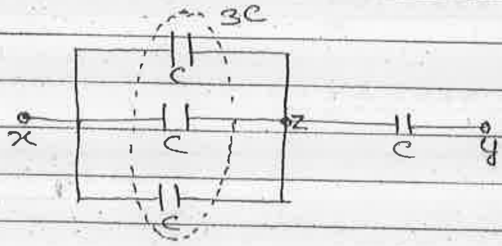
$V_x - V_y = \frac{40}{3} - 10 = \frac{10}{3} = 3.33V$

Qus>



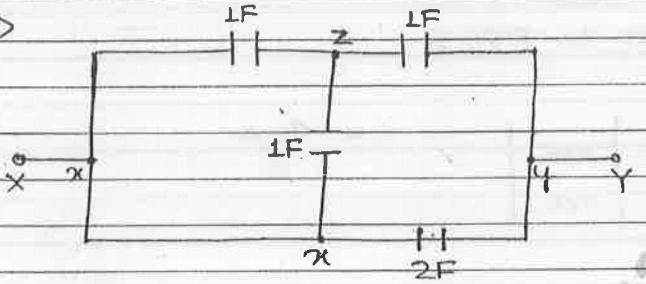
Cxy = ?

soln :-



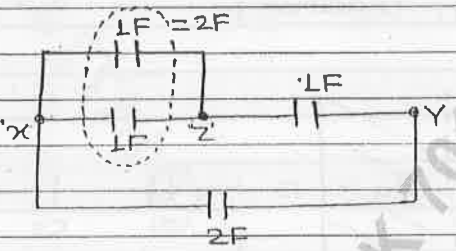
$C_{xy} = \frac{3C}{4}$

Qus>



$C_{XY} = ?$

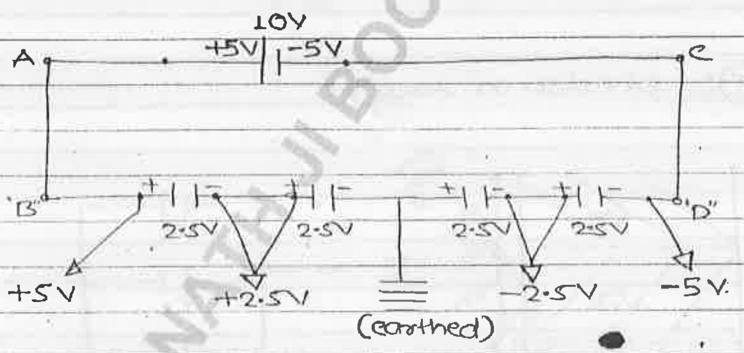
soln.



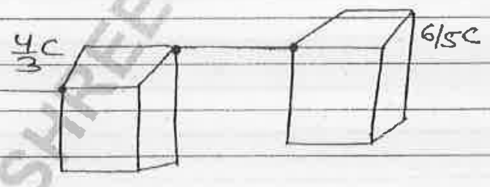
$C_{XY} = \frac{2}{3} + 2$

$= \frac{8}{3}$

Qus>



Qus> $\frac{4C}{3}$

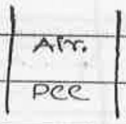


soln :- $\frac{1}{C_{eq}} = \frac{3}{4C} + \frac{5}{6C} = \frac{9+10}{12C}$

$C_{eq} = \frac{12C}{19}$

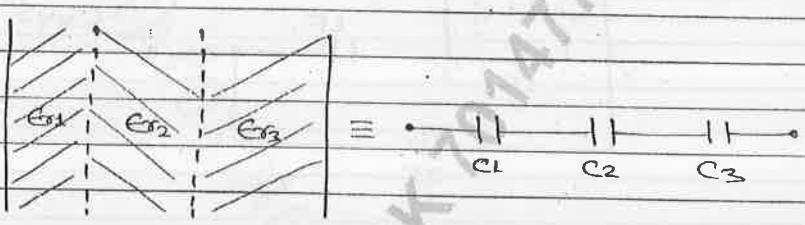
✡ ⇒ Partition in PPC :-

Given :-

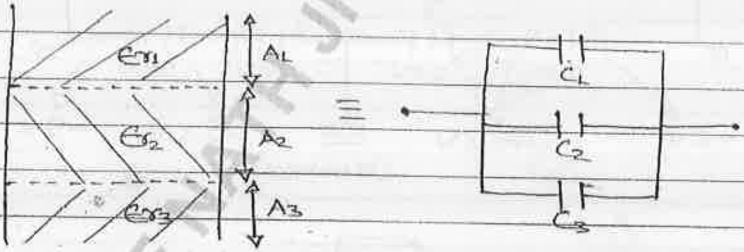


$C = \frac{\varepsilon_0 A}{d}$

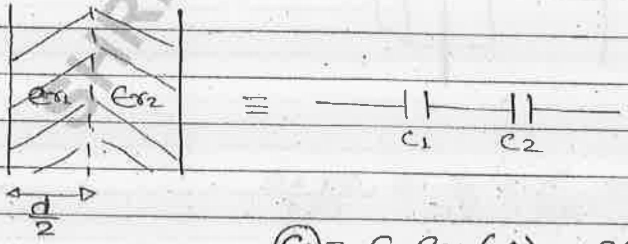
① case:- Ⓘ :- Divsn in Distance. :-



② case: Ⓘⓘ :- Division in Area :-



Qus>



Ceq = ?

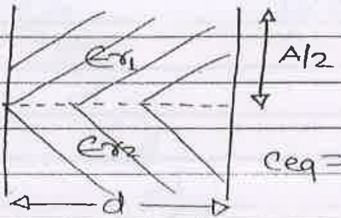
$\boxed{C_1} = \frac{\varepsilon_0 \varepsilon_{r_1}(A)}{d/2} = 2\varepsilon_{r_1}\left(\frac{\varepsilon_0 A}{d}\right) = 2\varepsilon_{r_1}C$

$\boxed{C_2} = \frac{\varepsilon_0 \varepsilon_{r_2}(A)}{d/2} = 2\varepsilon_{r_2}C$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \left(\frac{2\,\epsilon_{r1}\cdot\epsilon_{r2}}{\epsilon_{r1}+\epsilon_{r2}}\right)\times C$$

$$(\epsilon_r)_{eq} = \frac{2\,\epsilon_{r1} * \epsilon_{r2}}{\epsilon_{r1}+\epsilon_{r2}}$$ ∵ (Harmonic Mean of ϵ_{r1} & ϵ_{r2})

Ques>



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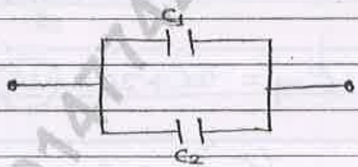


$C_{eq} = ?$

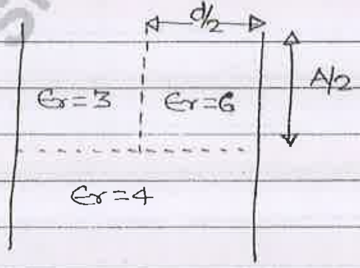
soln :-
$$C_1 = \frac{\epsilon_0 \epsilon_{r1}(A/2)}{d} \Rightarrow \frac{\epsilon_{r1}}{2}C$$

$$C_2 = \frac{\epsilon_0 \epsilon_{r2}(A/2)}{d} \Rightarrow \frac{\epsilon_{r2}}{2}C$$

$$C_{eq} = C_1 + C_2 = \left(\frac{\epsilon_{r1}+\epsilon_{r2}}{2}\right)\times C$$

$$\boxed{(\epsilon_r)_{eq.} = \frac{\epsilon_{r1}+\epsilon_{r2}}{2}}$$ ∵ Arithmatic Mean of ϵ_{r1} "&" ϵ_{r2}

Ques>



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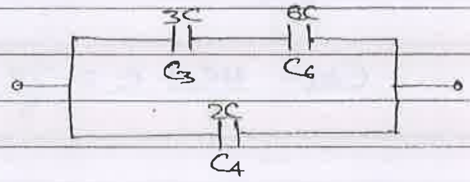


$C_{eq} = ?$

sol^n: $C_3 = \frac{\epsilon_0 (3)(A/2)}{d/2} = 3C$.

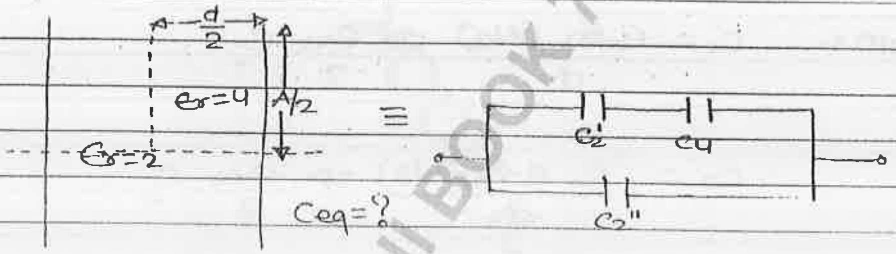
$C_6 = \frac{\epsilon_0 (6)(A/2)}{d/2} = 6C$.

$C_4 = \frac{\epsilon_0 (4)(A/2)}{d} = 2C$

$C_{eq} = 2C + 2C = \textcircled{4C}$

$(\epsilon_r)_{eq} = 4$

IIT 2015 Ques.



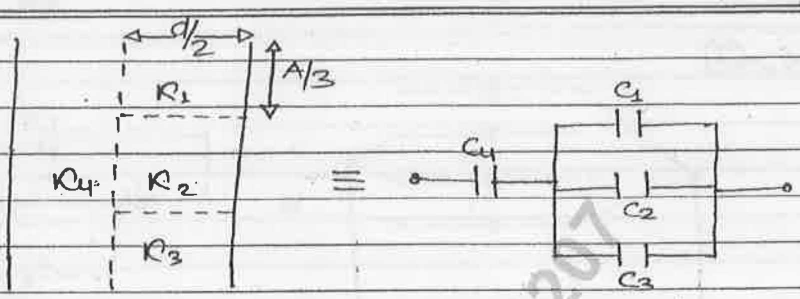
sol^n: $C_4 = \frac{\epsilon_0 (4)(A/2)}{d/2} = 4C$

$C_2' = \frac{\epsilon_0 (2)(A/2)}{d/2} = 2C$

$C_2'' = \frac{\epsilon_0 (2)(A/2)}{d} = C$.

$C_{eq} = \frac{4C}{3} + C = \frac{7C}{3}$

NEET 2016 Ques>



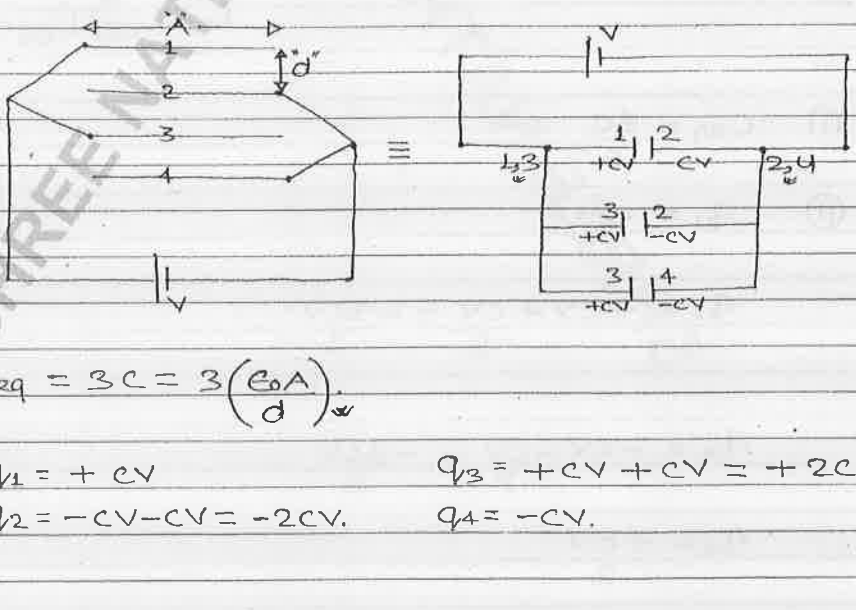
✡ ⇒ MULTIPLATE CAPACITOR :-

→ Given Plate Arrangment is converted into CKT. Using *Point Potential Method.

Step:-① "Nomering" of Plates is Done. conductor's connected with each other consider as single conductor.

Step:-② For Making capacitor; Plates should be consicutiv and their potential should be diffrent.

EX:-①

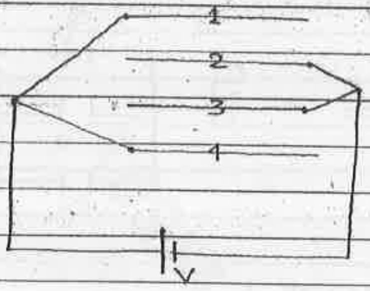


(i) $C_{eq} = 3C = 3\left(\frac{\epsilon_0 A}{d}\right)$.

(ii) $q_1 = +cV$ $\quad$ $q_3 = +cV + cV = +2cV$.

$q_2 = -cV - cV = -2cV$. $\quad$ $q_4 = -cV$.

E.X:- ②



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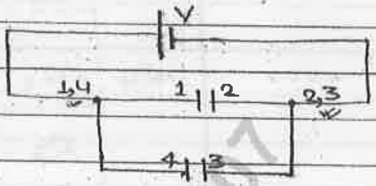
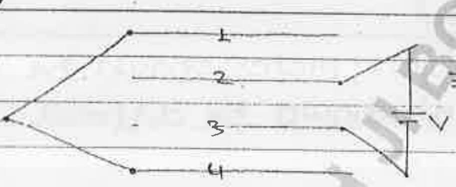


(i) $C_{eq} = 2C$

(ii) $q_1 = +CV \quad q_2 = -CV$

$q_3 = -CV \quad q_4 = +CV$

EX:- ③



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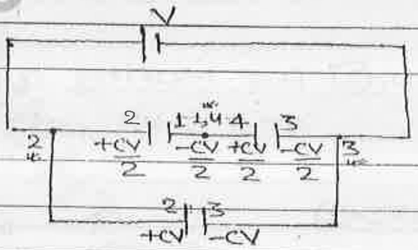


(i) $C_{eq} = \frac{3C}{2}$

(ii) $q_1 = \frac{-CV}{2}$

$q_2 = +CV + \frac{CV}{2} = +\frac{3CV}{2}$

$q_3 = -CV - \frac{CV}{2} = -\frac{3CV}{2}$

$q_4 = +\frac{CV}{2}$

***⇒ Terminal Point सब से दूर बनाओगें |

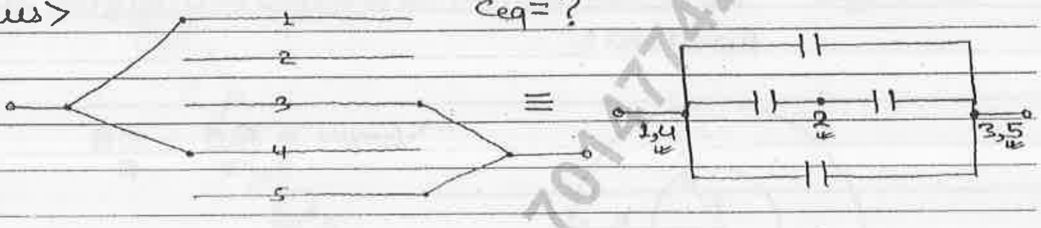
**⇒ If "Alternate Plates" are connected, than Max^m capacitor's "n-1" are formed in "Parllel Grouplugs."

so;

AIEEE

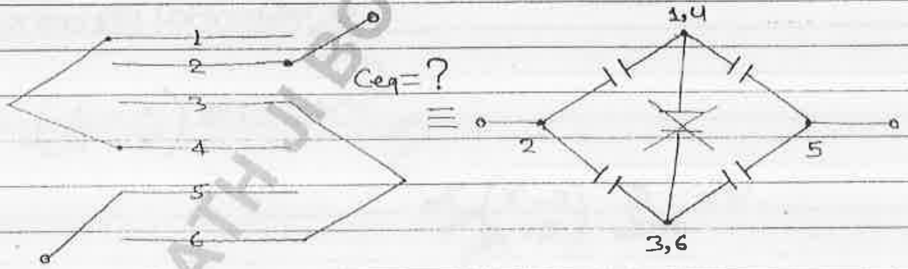
$$\boxed{C_{Max} = (n-1)C}$$

Ques>



soln :- $C_{eq} = 2.5$

Ques>



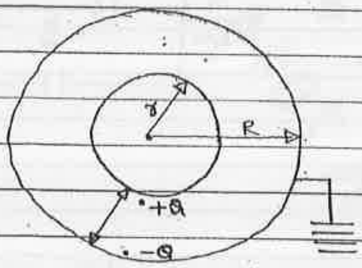
⇒ Bilanced wheat stone Brid.

soln :- $C_{eq} = C$

✡ ⟹ SPHERICAL CAPACITOR :-

It has TWO(2) concentric metalic shell, where one is charged and another is earthed.

case:- Ⓘ :- If "small" sphere is charged and "Big" one is Earthed :-



$$V_{small} = \frac{KQ}{r} - \frac{KQ}{R}$$

$$V_{Big} = \text{zero}\ (0)$$

∴ Potential Difference (P.D) :-

$$V = KQ\left(\frac{1}{r} - \frac{1}{R}\right)$$

$$V = \frac{Q}{4\pi\epsilon_0}\left(\frac{R-r}{Rr}\right)$$

$$\frac{Q}{V} = \frac{4\pi\epsilon_0 Rr}{R-r}$$

**IMPO.

$$\boxed{C_I = \frac{4\pi\epsilon_0\epsilon_r Rr}{R-r}}$$

Qus> If; r = fix And R↑ ⟹ C = ?

soln :- $C = \dfrac{4\pi\epsilon_0\epsilon_r r}{1-\dfrac{r}{R}}$ ∵ [by diving by Ⓡ] ⟹ C↓

Ques> If; r = fix; And $R\downarrow \Rightarrow C = ?$

soln :- $C \Rightarrow \uparrow$.

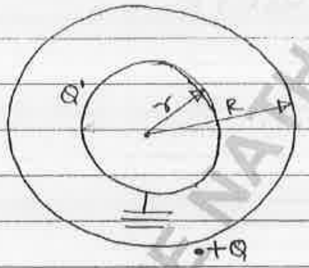
**Ques> If; r = fix; And $R = \infty \Rightarrow C' =$

soln :- $C' = \frac{4\pi\epsilon_0\epsilon_r r}{1 - r/\infty}$

$C' = 4\pi\epsilon_0\epsilon_r \cdot r$

** ⇒ "SINGLE CONDUCTOR" is also a capicator, considering that its Another conductor is at "Infinity."

Case :- (II) :- If "BIG SPHERE" is charged & small sphere is Earthed :-



⇒ As small sphere is Earthed, some chare "Q'" is transfered to small sphere from Earth, for making its Potential zero

∵ $V_{small} = 0$

$\frac{KQ'}{r} + \frac{KQ}{R} = 0$

$\boxed{Q' = -\frac{r}{R}Q}$ ⇓

∵ $V_{small} = 0$

$V_{BIG} = \frac{KQ}{R} + \frac{KQ'}{R}$

∵ PD :-

$V = \frac{KQ}{R} + \frac{KQ'}{R}$

PTO...

$$\because V = \frac{KQ}{R} + \frac{KQ'}{R}$$

$$= \frac{KQ}{R} + \frac{K}{R}\left(\frac{-r\,Q}{R}\right)$$

$$= \frac{KQ}{R}\left(1 - \frac{r}{R}\right)$$

$$V = \frac{Q}{4\pi\epsilon_0 R}\left(\frac{R-r}{R}\right)$$

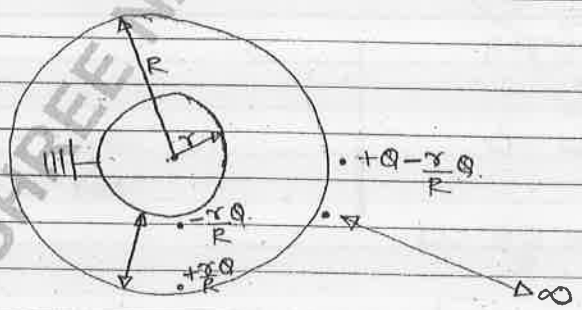
$$\frac{Q}{V} = \frac{4\pi\epsilon_0 R^2}{R-r}$$

IMP

$$\boxed{C_{II} = \frac{4\pi\epsilon_0\epsilon_r R^2}{R-r}}$$

$$C_{II} = \frac{4\pi\epsilon_0\epsilon_r Rr}{R-r} + 4\pi\epsilon_0\epsilon_r R$$

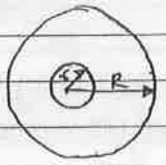
$$C_{II} = C_I + 4\pi\epsilon_0\epsilon_r R$$



Ques> spherical conductor of Radius "r"; capacitance = C i.e.: $4\pi\epsilon_0\epsilon_r R$.

If it is surrounded by metal sphere of Radius "R"; where $\frac{R}{r} = \frac{n}{n-1}$; than capacitance?

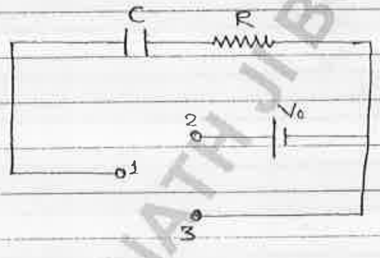
soln.



$$C' = \frac{4\pi\epsilon_0\epsilon_r r}{\left(1-\frac{r}{R}\right)} = \frac{C}{1-\underset{\sim}{\frac{n-1}{n}}}$$

$$= \frac{C}{\frac{n-n+1}{n}} \Rightarrow \underset{\ll}{nC}$$

** ✡ ⇒ "CHARGING" AND "DISCHARGING" OF CAPACITOR :-



① case:-Ⓘ:- "CHARGING" (1–2)

At; $t=0$	$t\uparrow$	$t=\infty$ {full charge}	
$V_c = 0$	$V_c = \uparrow$	$V_c = V_0$	Max^m
$Q_c = 0$	$Q_c = \uparrow$	$Q_c = CV_0$	
$U_c = 0$	$U_c = \uparrow$	$U_c = \frac{1}{2}CV_0^2$	
$^*I_{ckt} = \frac{V_0}{R}$ (Max.)	$I_{ckt} = \downarrow$	$I_{ckt} = 0$ (Minm.)	

→ KVL :-

$$V_c = V_0 \left(\underset{\sim}{1-e}^{-t/RC}\right) \quad \because$$

$$I_{ckt} = I_{max}\, \underset{\sim}{e}^{-t/RC} \text{ (Decay)} \because$$

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⊛=▷ Point's to Remember :-

$e^0 = 1$

$e = 2.73$

$\frac{1}{e} = 0.37$

$\log_{10} 2 = 0.3010$

$\log_{10} 3 = 0.477$

$\log_{10} 5 = 0.699$

$\log_x x = 1$

$e^{\infty} = \infty$

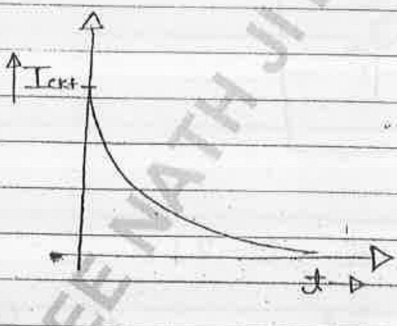
$e^{-\infty} = 0$

$\log_e x = 2.303 \log_{10} x$

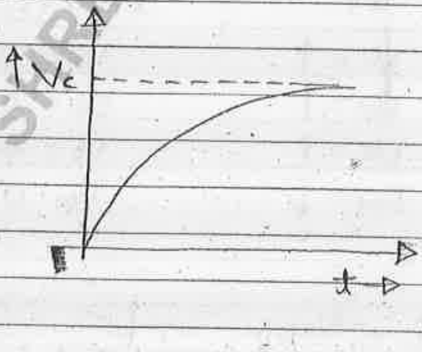
$$\log_e 2 = 2.303 \log_{10} 2$$
$$= 2.303 \times 0.3010$$
$$= 0.693$$

=▷ GRAPH :-

(i) Ickt V/s t :-



(ii) Vc V/s t :-



⊛⇒ Time constant (τ):-

$\boxed{\tau = RC}$ ∵ [63% charging]

** V.Imp →

$t = \tau$	63%
$t = 3\tau$	95%
$t = 5\tau$	99.9%

→ R ↑ ⇒ timing ↑.
R ↓ ⇒ timing ↓.

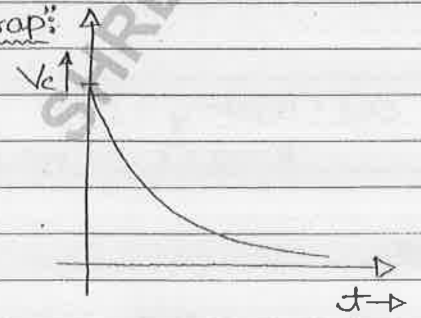
② case:- (II) :- "DISCHARGING" (1-3):-

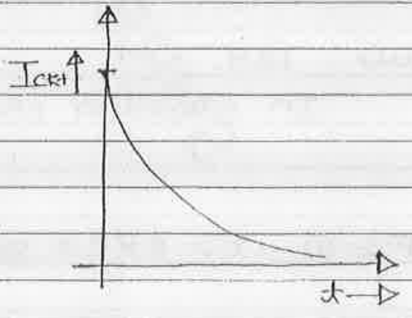
At; $t=0$	$t\uparrow$	$t=\infty$ [Fully Discharge]
$V_c = V_0$	$V_c \downarrow$	$V_c = 0$
$Q_c = CV_0$	$Q_c \downarrow$	$Q_c = 0$
$U_c = \frac{1}{2}CV_0^2$	$U_c \downarrow$	$U_c = 0$
* $I_{ckt} = \frac{V_0}{R}$	$I_{ckt}\downarrow$	$I_{ckt} = 0$

→ $V_c = V_0 e^{-t/RC}$

$I_{ckt} = I_{max} e^{-t/RC}$

→ "Graph":





⊛⇒ Time constant (τ):-

$\boxed{\tau = RC}$:(63% Discharge)

$t = \tau$ 63 %

$t = 3\tau$ 95 %

$t = 5\tau$ 99.3%

⊛⇒ R↑ = Timing↑

⊛⇒* "Total stored Energy" of capacitor is conserved converted into Heat of Resistance.

SO Heat;

$$\boxed{Heat = \frac{1}{2} C V_0^2}$$

**Heat is Indipendent of Resistance.

**Imp ⊛⇒ $t = 0$; Uncharged capacitor = short ckt.
*($I = Max$)

$t = \infty$; Fully charged capac. = open. ckt.
*($I = 0$)

Ques> 12V.

In capacitor charging ckt ; Battery = 12V
$R = 2\,\Omega$ $C = 100\,\mu F$.

solⁿ:- ① $\tau = R \times C = 200\,\mu$ sec.

(ii) $I_{max} = \frac{V_0}{R} = \frac{12}{2} = 6A$.

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(iii) I_{ckt} at $t = 400\ \mu sec$.

$$I_{ckt} = \frac{V_0}{R} e^{-t/RC}$$

$$= \frac{12}{2} e^{-\frac{400\times10^{-6}}{200\times10^{-6}}}$$

$$= 6 e^{-2}$$

$$= \frac{6}{e^2}$$

(iv) 99% charging :-

$$V_c = V_0 \left(1-e^{-t/RC}\right)$$

$$0.99\cancel{V_0} = \cancel{V_0}\left(1-e^{-t/RC}\right)$$

$$0.99-1 = -e^{-t/RC}$$

$$-0.01 = -e^{-t/RC}$$

$$\frac{1}{100} = e^{-t/RC}$$

$$100 = e^{t/RC}$$

$$\log_e 100 = \frac{t}{RC}$$

$$t = RC \log_e 100$$

$$t = 2RC \log_e 10$$

$$= 2\times2\times100\times10^{-6}\left(2.303\times\log_{10}10\right)$$

$$= 921.2\ \mu sec.$$

**Note :- 63% charg. = τ = time ∴ $\boxed{\tau = RC}$.
95% chargng. = 3τ = time
99.3% charging = 5τ = time.
SO; FOR 99% charging Time will be slightly less than "5τ".

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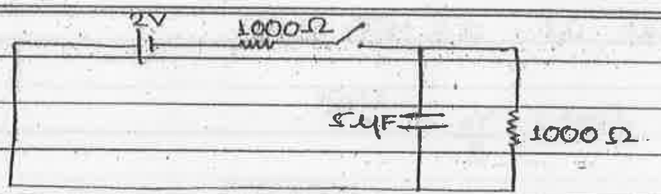
*Qus>

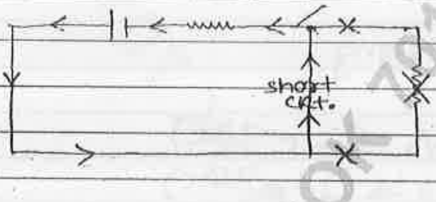


Find capacitor current at:-

① $t=0$

(ii) $t=\infty$

soln:- ① $t=0$;



$I = \frac{2}{1000} = 2mA.$

(ii) $t=\infty$;

$I' = \frac{2}{1000+1000}$

$= 1mA.$

Qus> After Full charging; capacitor is, Discharge than;

If; $R = 10\ M\Omega$ $C = 0.1\ \mu F$

soln:- ① $\tau = R.C$

$= (10\times10^{6})(0.1\times10^{-6})$

$= 1$ second. ∴ [In ① second; 63% Discharge]

(ii) $V_c = V_0 e^{-t/RC}$

$\frac{V_0}{2} = \cancel{V_0} e^{-t/RC}$

$2 = e^{t/RC}$

$\log_e 2 = t/RC$

$t = RC \log_e 2$

$= (10\times10^{6})(0.1\times10^{-6})(0.693)$

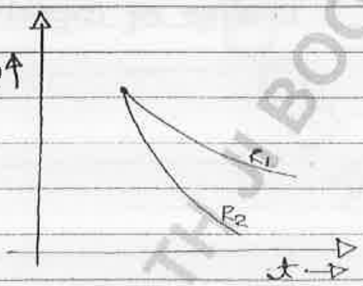
$= 0.693$ sec.

(iii) Time taken for 80% Discharge:-

$V_c = V_0 e^{-t/RC}$

$0.2V_0 = V_0 e^{-t/RC}$

Ques>



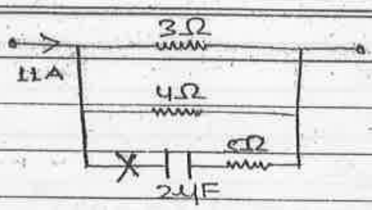
∴ time ② < time ①

∵ $R_2 < R_1$

✡ ⇒ R–C CURCUIT (CRT) :-

In "stable condition" or "steady state condition", capacitor's are fully charged, so current in the capacative Branches is "Zero".

EX:-

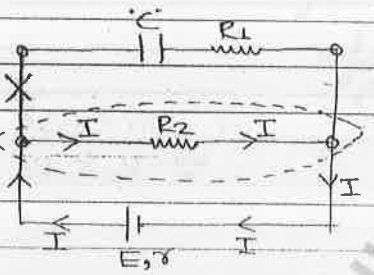


soln:- $\underline{I_{5\Omega}} = 0$

$\underline{I_3 : I_4} = 4:3$

$\underline{I_3} = \frac{4}{7} \times 11 = \frac{44}{7} A$ $\underline{I_4} = \frac{3}{7} \times 11 = \frac{33}{7} A$

Ques>



In stable condition, Find charge of capacitor ?

soln:- $I = \frac{E}{R_2 + r}$

$V_{R2} = I \times R_2$

$= \frac{R_2}{R_2 + r} E$

∵ $V_{R2} = V_c + \cancel{V_{R1}}$

∵ $V_{R1} = \overset{\text{current}}{\text{constant}} \times R_1$

$= 0 \times R_1$

$= 0$

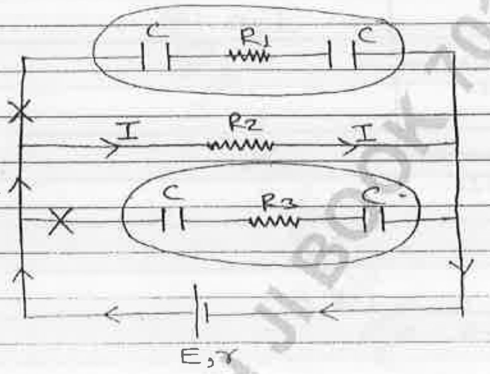
$\because \quad V_C = V_{R2}$

$$V_C = \frac{R_2}{R_2+r} E$$

$$\boxed{Q = CV_C = \frac{R_2}{R_2+r} CE}$$

$$= \frac{CE}{1+\frac{r}{R_2}}$$

Ques>



soln :- $\because I = \frac{E}{R_2+r}$

$$\because V_{R2} = I \times R_2$$
$$= \frac{R_2}{R_2+r} E$$

$\because V_{R2} = V_C + V_{R1} + V_C$

$\because V_{R2} = V_C + V_{R3} + V_C$

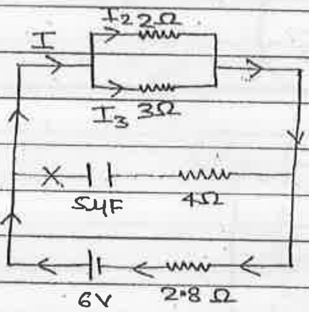
$\because V_{R1} = V_{R3} = 0 \quad (\because \text{current} = 0)$

∵ $V_{R3} = V_C + V_{R1}$

Each $V_C = \frac{V_{R2}}{2} = \frac{R_2}{R_2+r}\,\frac{E}{2}$

∴ $Q = CV_C = \frac{R_2}{R_2+r}\cdot\frac{CE}{2}$

AIEEE
Qus>



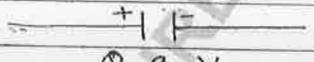
$I_{2\Omega} = ?$

soln :- $I = \frac{6}{1.2+2.8} = 1.5$ A.

$I_2 : I_3 = 3 : 2.$

$I_2 = \frac{3}{5} \times 1.5 = 0.9$ A

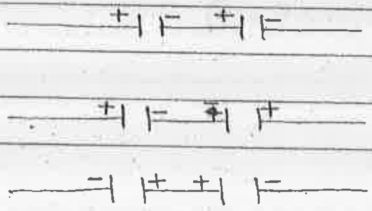
✡ ⇒ TO CONNECT CHARGED PPC'S :-



Q_1, C_1, V_1

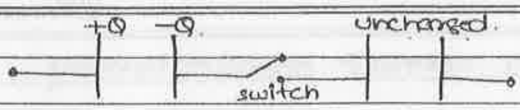
Q_2, C_2, V_2

① series :



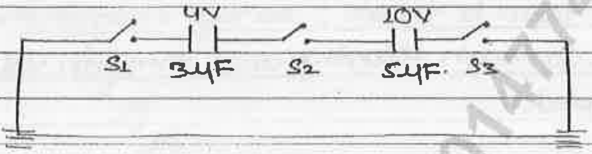
⇒ "NO close loop", so NO charge flow ; so NO any change in Detail of PPC.

IIT Ques>



soln:- If switched is Made ONN than; NO close loop SO; NO charge flow; so uncharged capacitor will Remains Uncharged.

IIT Ques>



soln :- If Any "one" or "TWO" switches are Made ONN, than NO close loop, SO NO charge flow SO; NO change in Detail of Pcc.

② Parllel :-

① case :- (I) :- TO connect same polarity ends :-

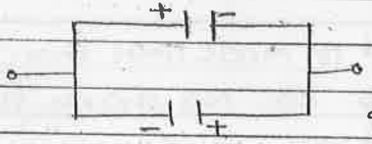
close loop is there; so Due to Potential Diffrence
**charge sharing Takes Place to Make common voltage.

$$V_c = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

$$\Delta U = \frac{C_1C_2}{2(C_1+C_2)}(V_1 \ominus V_2)^2$$

→ If "Nothing is given", than consider it of "same Polarity."

② case :- (II) :- To connect opposite Polarity



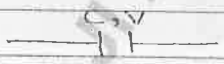
$\because V_2 \longrightarrow -V_2$

A close loop is there ; so by charge sharing Finally common Polarity and common voltage are Devloped.

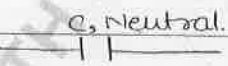
$$V_{common} = \frac{C_1V_1 - C_2V_2}{C_1+C_2}$$

$$\Delta U = \frac{C_1C_2}{2(C_1 \oplus C_2)}(V_1 \oplus V_2)^2$$

Ques capacitor;



capacitor;



If these are connected in Parllel than :-

soln :- (i) $V_{common} = \frac{CV + C(0)}{C+C} = \boxed{\frac{V}{2}}$

(ii) charge of each capacitor :-

$$\boxed{Q_1} = C_1V_1 = C \times \left(\frac{V}{2}\right) = \frac{CV}{2}$$

$$\boxed{Q_2} = C_2V_2 = C \times \left(\frac{V}{2}\right) = \frac{CV}{2}$$

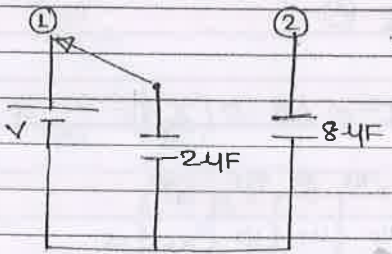
Date_______ Page ___

(iii) $\Delta U = \frac{C_1 C_2}{2(C_1+C_2)} (V_1 - V_2)^2$ ∵(same polarity)

$= \frac{C \cdot C}{2(C+C)} (V-0)^2$

$= \frac{1}{4} CV^2$

\# NEET \# 2016 Ques>



⇒ If Liver is shifted to Posn ② than % loss in stored energy ?

Soln: Initial :

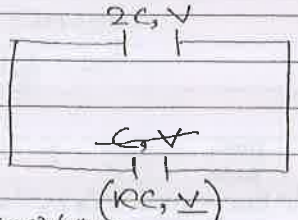
$U = \frac{1}{2} CV^2 = \frac{1}{2} 2(V)^2 = V^2$

$\Delta U = \frac{\cancel{2} \times 8}{\cancel{2}(2+8)} (V-0)^2 = \frac{8}{10} V^2$

∴ $\% \text{ Loss} = \frac{\Delta U}{U} \times 100$

$= \frac{(8/10 V^2)}{V^2} \times 100 = 80\%$

** EX:1 Q;81>



∵ $Q = CV$

$V \propto \frac{1}{C}$

$\left(KC, \frac{V}{K}\right)$

soluth :-

$V_{com} = \frac{(2C)(V) + (KC)(V/K)}{2C + KC}$

$= \frac{3V}{K+2}$

"CURRENT EXERCISE":-

✡ EX:- ①:-

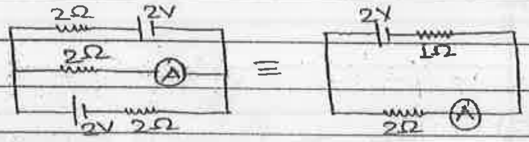
(27)


$R/3 + R \parallel R$

$= \frac{4R}{3} \parallel R \Rightarrow \frac{4R}{7} = 4 \Rightarrow \underline{R = 7}$

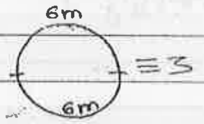
(36) $r/n = x \Rightarrow$ ~~x~~ $\Rightarrow r = n \cdot x.$

$R_{series} = nr \Rightarrow R_{series} = n(n \cdot x) = n^2 x.$

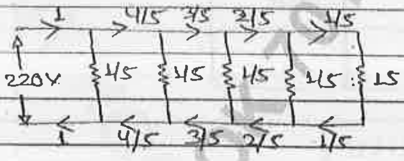
(47)


✡ ⇒ EX:- ② :-

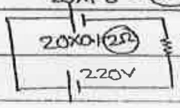
② $H = I^2Rt = ms\,\Delta\theta \Rightarrow I^2 \propto \Delta\theta \Rightarrow \left(\frac{I}{2I}\right)^2 = \frac{3°C}{\Delta\theta} \Rightarrow \Delta\theta = 12°C$

(14)


$= 3$

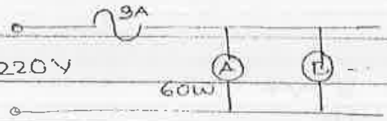
(18)


(28)
20 cell
$20 \times 1.8 = \text{(36V)}$



$\Rightarrow I = \frac{220-36}{2+R} = 15$

$\Rightarrow R = 10.27\Omega.$

(31)


----"n" bulb

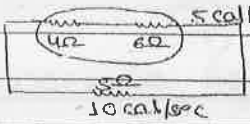
For ① Bulb: $P = V \cdot I$

$60 = 220I$

$① = 3/11\,A$

$n\left(\frac{3}{11}\right) = 9 \Rightarrow n = 33$

(32) $P = \frac{V^2}{R_{eq}} \Rightarrow 48 = \frac{(6)^2}{R/2}$

(47)


① $P = \frac{V^2}{R} \propto \frac{1}{R}$

$\underline{2^{nd}}$:- $H = I^2R$

$H \propto R$

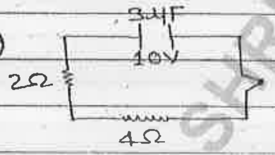
$H_4 : H_6 = 2 : 3$

(46) $H_{40} = H_{100}$

$\left(\frac{E}{40+r}\right)^2 40 \cdot t = \left(\frac{E}{100+r}\right)^2 100 \cdot t$

(51) $I = q \cdot f \Rightarrow 2 \times 10^{-2} \times (F)$

$= 0.6A$

(48)


$Heat = \frac{1}{2} CV_0^2 \Rightarrow \because H = I^2Rt \propto R$

$H_2 : H_4 = 2 : 4 \Rightarrow 1 : 2$

$H_2 = \frac{1}{3}\left(\frac{1}{2}CV_0^2\right)$

*(55) $R_0 C' = ?$ $R_0 Al = ?$

$R_0 C + R_0 Al = 30$ ----①

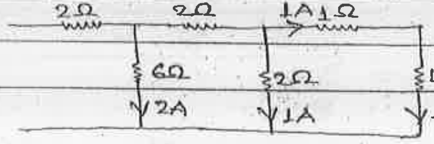
$R_1\alpha_1 + R_2\alpha_2 = 0 \Rightarrow$

$\frac{R_0 C}{R_0 Al} = \frac{\alpha_0 Al}{\alpha_0 C} = 8$ -----(II)

$\because \underbrace{R_0 C' = 80/3 \quad R_0 Al = 10/3}$

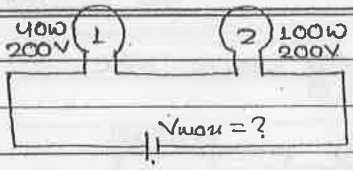
(58) $15°C \quad R = \frac{100}{10} = 20\Omega$

$t°C \quad R' = \frac{200}{5} = 40\Omega$

*(61)


$\because I \propto \frac{1}{R}$

(81)



$V_1 : V_2 = 5:2$

$V_1 = \left(\frac{5}{7}\right) V_{max} = 200 \Rightarrow V_{max} = \underline{280V}$ } ans

$V_2 = \left(\frac{2}{7}\right) V_{max} = 200 \Rightarrow V_{max} = 700V$ }

(87) $V_d = \frac{I}{neA}$ $\quad 1\,cm^3 \equiv 9\,gm \equiv \frac{N_A}{63} \times 9$

$\Rightarrow \boxed{1\,m^3 = N_A/63 \times 9 \times 10^6}$ ans

(89) $V = E - Ir$

✡ ⇒ EX:- 3(A) :-

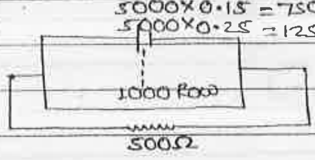
(6) $x = V_{AB}/L_1 = \frac{IS}{A}$.

(14) electrostat ⇒ $\Delta K + \Delta U = 0 \Rightarrow \Delta K = -\Delta U$

(19)

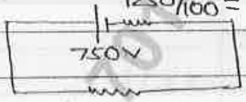
$5000 \times 0.15 = 750V$

$5000 \times 0.25 = 1250V$



≡

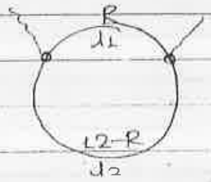
$1250/100 = 12.5$



$I = \frac{750}{500 + 12.5} = \underline{1.5A}$

(15) $\%\eta = \frac{(V \times I \times t)_{output}}{(V \times I \times t)_{Input}} \times 100 \Rightarrow \frac{15 \times 14 \times 5}{15 \times 8 \times 10} \times 100 = \underline{87.5}\%$

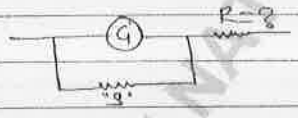
(34)



$\frac{R(12-R)}{R + (12-R)} = \frac{8}{3}$ $\quad \therefore R \xrightarrow{} 4\Omega,\ 8\Omega$

$\therefore \frac{R_1}{R_2} = \frac{1}{2} = \frac{l_1}{l_2}$ ans

(33)



≡

$\boxed{\frac{GS}{G+S} + R = G} \Rightarrow R = \frac{G^2}{G+S}$ ans

(39) $V = IR$

$V = \left(\frac{E}{R+r}\right) R$

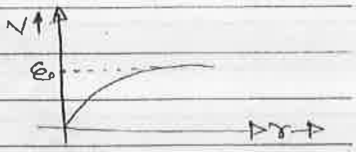
$V = \frac{E}{1 + \frac{r}{R}}$

1st; $R = 0 \Rightarrow V = 0$

2nd; $R = \uparrow \Rightarrow V = \uparrow$

3rd; $R = \infty \Rightarrow V = E$

≡



(45)

$0.2\%\ of\ I = \frac{0.2}{100} \times I = 0.002I \Rightarrow \therefore S = \frac{I_g R_g}{I - I_g} \Rightarrow \frac{0.002I}{I - 0.002I} = \frac{G}{499}$

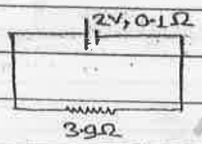
$\Rightarrow R_A = G/499 \parallel G = \boxed{G/500}$ ans

EX:- 3'B':

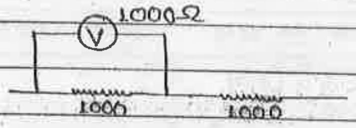
⑥ $\frac{E_1}{E_2}=\frac{l_1}{l_2} \Rightarrow \frac{E_1}{E_2}=\frac{l_1}{l_2}$ $\frac{4.8}{V}=\frac{40}{60} \Rightarrow V=7.2$

⑭ Use Potut Potential method.

㉕



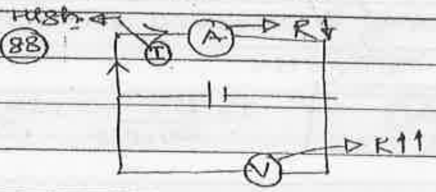
(46)



(47) $R=\frac{\rho l^2}{\text{Vol.}} \propto \frac{1}{\text{Vol.}} \Rightarrow R=1:2$ ∴ V×d×g ⇒ Bouoncy

$V=2:1$

(88)



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CAPACITOR QUES HINTS

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EX:- ①:

(29) (31) $E = \frac{V}{D} = \frac{300^{V}}{1\times10^{-3}} = 3\times10^{5}$ N/C

(33)

(36) $Q = CV. \Rightarrow \frac{1\times10^{-6}}{3\times10^{2}} = C$

$C = \frac{1}{3}\times10^{-8} \Rightarrow$

work done by Batter$_2$ $= 2\left(\frac{1}{2}CV^2\right)$

$W = \left(\frac{1}{3}\right)\times10^{-8}\times9\times10^{4} = 3\times10^{-4}$

(37) $\frac{\text{work by Battery}}{\text{Energy stored}} = \frac{\frac{1}{2}CV^2 + \frac{1}{2}CV^2}{\frac{1}{2}CV^2}$ Heat

$\Rightarrow 2:1$

(53) हर हमेशा एक E.N.D से CAPACITOR BRANCH छोटा करते जाओ।

(70) Capacitor is divided by Area (1/2):

$5\mu F = \frac{\epsilon_0 A}{2d} + \frac{K\epsilon_0 A}{2d} \Rightarrow 10\mu F = 2.5\mu F + K\times2.5\mu F$

$K = 3.0$

"or"

Air | A/2 ⇒ C/2 ⇒ 1.25

K | A/2 ⇒ KC/2 = 1.25 ϵ_r

$\Rightarrow 1.25 + 1.25\epsilon_r = 5$

$\epsilon_r = 3$

(71) $C = \frac{4\pi\epsilon_0 Rr}{R-r}$ (R−r) = 1 mm (Given)

$1\times10^{-6} = \frac{1}{9\times10^{9}}\,\frac{R(R-1\text{mm})}{1\times10^{-3}} \Rightarrow R(R-1\text{mm}) = 9$ ∵ (Neglect 1mm)

$R^2 = 9 \Rightarrow R = \boxed{3m}$

(77) $Q = CV \Rightarrow \frac{dQ}{dt} = C\frac{dV}{dt} \Rightarrow 100\times10^{-6} = 500\times10^{-6}\left(\frac{10}{dt}\right) \Rightarrow dt = 50s$

EX:- ②:

③ $U = \frac{1}{2}CV^2 \Rightarrow U \propto C \Rightarrow$ C ⟶ U_0(U) If KC(Cap) than; $U = KU_0$

∵ (V = const)

(10) $250 = \frac{C_1(300) + C_2(100)}{C_1 + C_2}$

(10)

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(28) $U = \frac{1}{2}\left(\frac{\epsilon_0 A}{d}\right)V_0^2 \Rightarrow Q = \text{const.}$

$d' = 3d \Rightarrow C' = \frac{C}{3}$

$U' = 3U$

$= \frac{3}{2}\left(\frac{\epsilon_0 A}{d}\right)V_0^2$

(29) $U_{before} = \frac{1}{2} C_1 V_0^2$ $\quad U_{after} = \frac{1}{2} C_1 (V_{com.})^2 + \frac{1}{2} C_2 (V_{com})^2$

$V_{common} = \frac{C_1 V_0}{(C_1+C_2)} \Rightarrow$ $= \frac{1}{2}(V_{com.})^2 (C_1+C_2)$

$\Rightarrow \frac{1}{2} \times \frac{(C_1V_0)^2}{(C_1+C_2)^{\cancel{2}}} \cancel{(C_1+C_2)}$

$U_{before} = \frac{\cancel{1/2\, C_1 V_0^2}}{1/2\, \frac{C_1^2 V_0^2}{(C_1+C_2)}} \Rightarrow \frac{(C_1+C_2)}{C_1^2} \Rightarrow \frac{(C_1+C_2)}{C_1}$

(31) 1sec :- 50V ⟶ 40V
2sec :- 50V ⟶ V_c

(ii) $V_c = V_0\, e^{-t/RC}$

$40 = 50\, e^{-1/RC}$ ---- ①

(i) 1sec:- $V_c = \frac{40}{50} = \left(\frac{4}{5}\right)$ part

$V_c = 50\, e^{-2/RC}$ ---- ②

$= 50\left(\frac{4}{5}\right) = 32$ volt from ①

$U = \frac{1}{\cancel{2}} \cancel{C} \left(V^2\right) \Rightarrow \frac{16}{25}$

1, 2 both Ans. correct

(39) $\frac{KQ}{r} = (V) \Rightarrow$ same $\Rightarrow C_1 = \frac{\epsilon_0 A}{d}$ $\quad C_2 = \frac{\epsilon_0 A}{(d-\frac{d}{2})+\frac{d}{2\epsilon_r}} = \frac{2\epsilon_0 A}{d\left(1+\frac{1}{\epsilon_r}\right)}$

$C_3 = \frac{2\epsilon_0 A}{d}$ $(\epsilon_r = \infty)$ $\quad C_1 < C_2 < C_3$

(41) 3A:-13

capacitor = 1μF ; $V_{max} = 500$V

Design 3μF ; $V_{max} = 2000$ V

$$n\left[\frac{1}{2}(1)(500)^2\right] = \frac{1}{2}(3)(2000)^2$$

$n = 48$

EX:- 3 B :

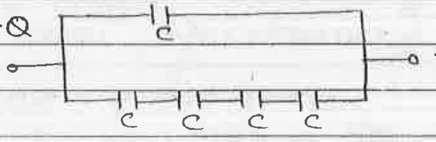
(18) $P = I^2R \Rightarrow IV \left(I = \frac{dq}{dt}\right) \Rightarrow P = \frac{Q}{t} \times V = \frac{12\times10^{-2}\times3000}{2\times10^{-3}}$

$\because Q = 40\times10^{-6}\times3\times10^{3} \Rightarrow 12\times10^{-2}$ $\Rightarrow P = 18\times10^{4} = \underline{180\,kW}$

(19) 1st P—R :-

$\equiv \frac{5C}{6}$

P—Q



$\equiv \frac{5C}{4}$ $\therefore \frac{P-R}{P-Q} = \frac{5C/6}{5C/4} = \frac{4}{6} = \boxed{\frac{2}{3}}$

(23) see copy of Electrostat.

(11) $C = \frac{\epsilon_0 A}{d} \Rightarrow A = \frac{3\times5\times10^{-3}}{8.8\times10^{-12}}$

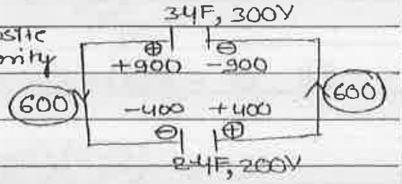
EX:- 3"B":-

(10) $\frac{2KC\times2C}{2KC+2C} = \frac{2C\,C\,K}{2C\,(K+1)}$

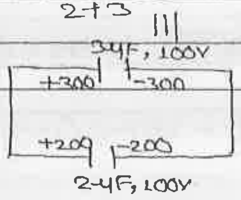
(17) $C = \frac{4\pi\epsilon_0\epsilon_r Rr}{(R-r)} \Rightarrow C = \frac{1}{K}\frac{\epsilon_r Rr}{(R-r)}$

$C \Rightarrow \frac{1}{9}\times10^{-9}\times\frac{6\times3}{1} \Rightarrow 2\times10^{-9}F$

(29) opposite pollority



$V_{common} = \frac{900-400}{2+3} = 100V$



(30) $C = \frac{\epsilon_0\epsilon_r(w\times l)}{d} = ?$

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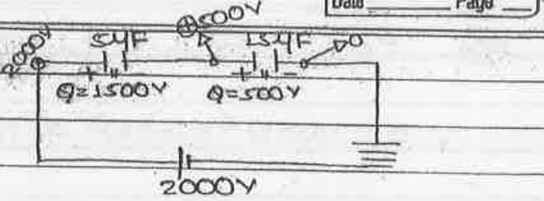
(31) पिछे, से छोटा करा



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(50) $\frac{U}{U} = \frac{1/2 kx^2}{\frac{1}{2} CV^2}$ $\because (F = kx)$ $\Rightarrow \frac{\frac{1}{2} \times 5000 \times 0.2}{\frac{1}{2} \times 10 \times 10^{-6} \times 10^{8}} = \frac{1000}{1000} = 1$

(61) Energy (U) :- $\frac{1}{2} \epsilon_0 E^2 = \frac{\sigma^2}{2\epsilon_0}$ $\Rightarrow \left(\frac{q}{A}\right)^2 \frac{1}{2\epsilon_0} \Rightarrow \frac{q^2}{2\epsilon_0 A^2}$

$\sigma \rightarrow$ charge Density $= q/A$

(66)/(74) $\left(\frac{1}{2} C \underbrace{V^2}_{\text{const.}}\right) \times 2 \Rightarrow \because C' = \frac{C}{2}$ [d → doubled] $\Rightarrow \frac{1}{2}\left(\frac{C \times V^2}{2}\right) \times 2$

∵ V=const; Because work is done by Battery (V=const)

Sir;- Appropritue $d' = 2d \Rightarrow C' = \frac{C}{2} \Rightarrow U = \frac{Q^2}{2C} \propto \frac{1}{C}$ (Batter Discon)

$\left[U_1' = \frac{1}{2} CV^2\right] = U_2' = 2U_1 \Rightarrow 2\left(\frac{1}{2} CV^2\right)$

$W = \Delta U \Rightarrow U_2 - U_1 \Rightarrow \frac{1}{C} V^2$

(79)

K	A/3
Air	2A/3

$C_1 = \frac{\epsilon_0 K (A/3)}{d} \Rightarrow \frac{K}{3} \frac{\epsilon_0 A}{D}$

$C_2 = \frac{\epsilon_0 (1)(2A/3)}{d} = \frac{2}{3}\left(\frac{\epsilon_0 A}{d}\right)$

$E = \frac{V}{d} = E_1 = E_2$

$C = C_1 + C_2 \Rightarrow C = \left(\frac{K+2}{3}\right)\left(\frac{\epsilon_0 A}{d}\right)$

(iii) $Q = C V \propto C \Rightarrow \frac{Q_1}{Q_2} = \frac{C_1}{C_2} = \frac{K}{2}$

(80) $E = \frac{\sigma}{\epsilon_0 \epsilon_r}$

$\frac{C}{C_1} = \frac{\left(\frac{K+2}{3}\right)\left(\frac{\epsilon_0 A}{d}\right)}{K/3 \left(\frac{\epsilon_0 A}{d}\right)} \Rightarrow \frac{K+2}{K}$

(81) $\frac{C}{C+3} = E$ $Q_2 = C_2 V_2' = 2\left(\frac{CE}{C+3}\right) \Rightarrow Q_2 = \frac{2E}{1+\frac{3}{C}} \Rightarrow C\uparrow \Rightarrow Q_2\uparrow$

$\frac{dQ^2}{dC} = 2E(-1)\left(1+\frac{3}{C}\right)^{-2} \times \frac{-3}{C^2} \Rightarrow \frac{6E}{C^2\left(1+\frac{3}{C}\right)^2} \Rightarrow$ solpe $= \frac{6E}{(C+3)^2} \Rightarrow C\uparrow =$ slope$\downarrow$

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