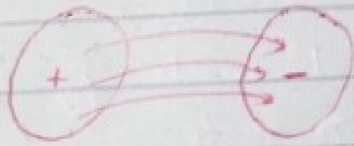
11:

Electrostatics

charges at rest

What is charge?
↳ still unknown
"intrinsic property of matter"
Electron − Positron +

Body
- e loss
  - ↳ +ive
  - ↳ Lighter
- e gain
  - ↳ −ive
  - ↳ Heavier



What is 1C?
→ Quantization of charge

$q = ne$

↳ e = elementary charge
1e = minimum value of charge one e
$1e = 1.6 \times 10^{-19} C$
$1e = 16 \times 10^{-20} C$

$q = 1C, n = ?$

$n = \frac{q}{e} = \frac{1C}{16 \times 10^{-20} C}$

@isamiqamar

$n = 6.25 \times 10^{18}$ es

$1C = 6.25 \times 10^{18}$ es

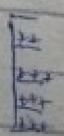
$1C = \frac{6.25}{100} \times 10^{18}$

1C = 625 0000 0000 0000 0000 es
$1C = 6 \times 10^{18} e$

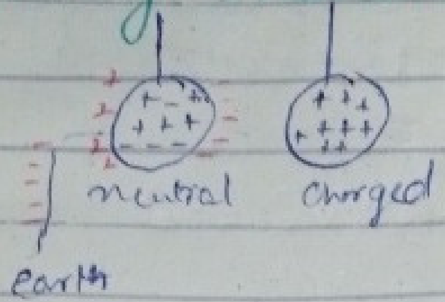
$1C = 625 \times 10^{16}$

Chargin Method:

i: By Friction:
Combing



ii: By Induction:

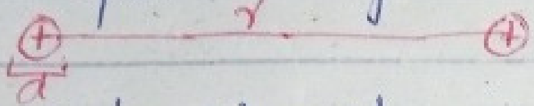


Gold leaf electroscope.

Coulombs Law:

Limitation:

↳ for point charges.



$r >>>> d$

↳ must be at rest

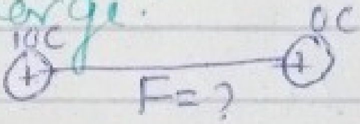
↳ Inside nucleus not applicable

$F \propto q_1 q_2$

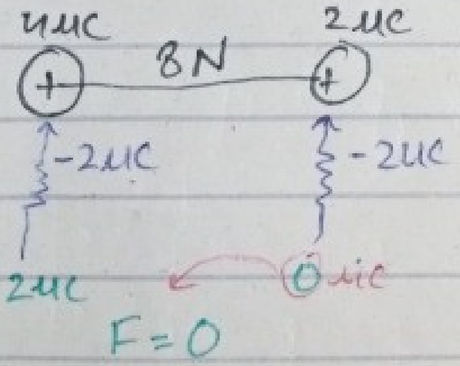
$F \propto \frac{1}{r^2}$

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

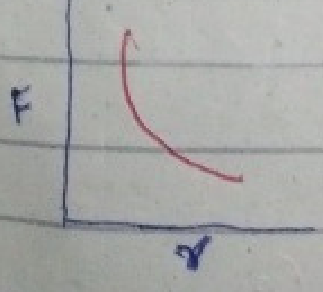
∴ Force depends upon product of charges not on single charge.



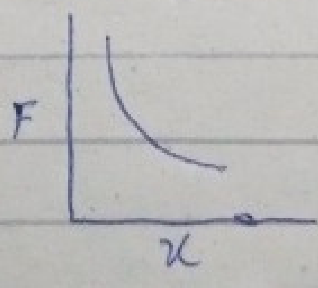
$F = q_1 q_2 = 0$ → If one charge is zero the force will become zero



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



or



Let $K = 1$:

- $q_1 = 2q$, $q_2 = 2q$, r same

$$F' = \frac{K(2q)(2q)}{r^2}$$

$$F' = 4F$$

- $q_1 = 2q$, $q_2 = 2q$, $r = 2r$

$$F' = \frac{(2q)(2q)}{(2r)^2}$$

F' = same

- $q_1 = q_2$ = same, $r = 2r$

$$F = \frac{1}{4}F$$

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

$$F' = 4F$$

mcq: For what value of r Force becomes half.

a: $2r$ b: $\frac{r}{2}$

ⓒ: $\sqrt{2}r$ d: none.

$$F = \frac{Kq_1q_2}{(\sqrt{2}r)^2}$$

$$F = \frac{Kq_1q_2}{2r^2}$$

$$F' = \frac{1}{2}F$$

$$F = \frac{Kq_1q_2}{r^2}$$

K = coulomb's constant.

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

$\therefore \varepsilon = \varepsilon_0\varepsilon_r$

Vacuum

$\varepsilon_r = 1$

$$K_{vac} = \frac{1}{4\pi\varepsilon_0}$$

Medium.

$\varepsilon_r \neq 1$

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

ε_0 = Permitivity of free space

$= 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$

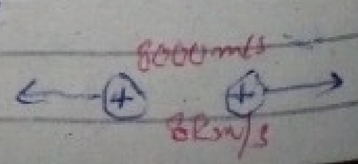
$$K_{vac} = \frac{1}{4(3.14)(8.85\times10^{-12})}$$

$K_{vac} = 9\times10^{9}\ Nm^2C^{-2}$

$$F = \frac{Gm_1m_2}{r^2}, \quad F = \frac{Kq_1q_2}{r^2}$$

$G = 6.67\times10^{-11}$ $K = 9\times10^{9}$

$K > G$



Dependance Of K:

1: Medium:

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

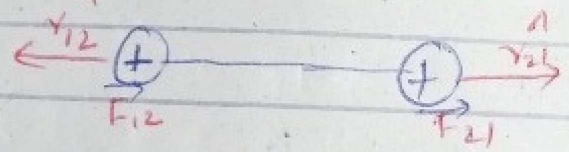
$\varepsilon_r = 2, 4, 80$

2: System of units:

$K = 9 \times 10^{7}$ (SI)

$K = 1$ (C.G.S)

Vector Form Of Columbs law:



$\hat{r}_{12} = -\hat{r}_{21}$

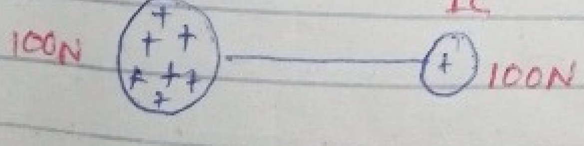
$\vec{F}_{12} = -\vec{F}_{21}$

magnitude:

$F_{12} = F_{21}$

$\frac{F_{12}}{F_{21}} = \frac{1}{1}$ 1:1

* Columbs Force is mutual force.



→ The force will remain same on both charges as it doesnot depend on indivirual charge.

$\frac{F_1}{F_2} = \frac{1}{1}$

Effect Of Medium:

$F_{vac} = K_{vac} \frac{q_1 q_2}{r^2}$

$F_{vac} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$ —— ①

$F_{med} = K_m \frac{q_1 q_2}{r^2}$

$F_m = \frac{1}{4\pi\varepsilon_0\varepsilon_r} \frac{q_1 q_2}{r^2}$ —①

$F_m = \frac{F_{vac}}{\varepsilon_r}$ $\varepsilon_r = ?$ (Relative prmiability

$\varepsilon_r = \frac{F_v}{F_m}$

mcq:

$F_{vac} = 100N$

$\varepsilon_r = 2$

$F_{med} = ?$

$F_{med} = \frac{100}{2}$

$F_m = 50N$

mcq:

$F_m = 10$

$F_v = 5$

$\varepsilon_r = ?$

$\varepsilon_r = \frac{5}{10} = \frac{1}{2}$

$\varepsilon_r = 0.5$

$F_v = 100N$

$F_{water} = ?$

$F_{water} = \frac{100N}{80}$

$= \frac{10}{8} = 1.2$

$\varepsilon_r = 1$
↳ air/ vac/ free space

$\varepsilon_r = 2$
↳ Paraffin paper

$\varepsilon_r = 78.5$
$\varepsilon_r = 80$ } water

$\varepsilon_r = \infty$ → metals

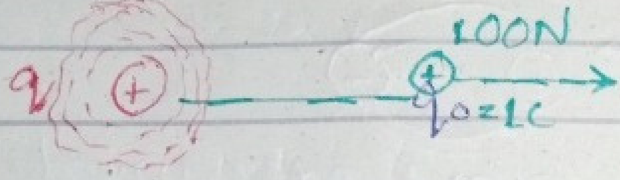
$F_{metal} = \frac{F_v}{\infty} = 0$

Electric Field Intensity:

$$\vec{E} = \frac{\vec{F}}{q_0} \left(\frac{N}{C} = \frac{V}{m} \right)$$

$$E = -\frac{\Delta V}{r} \left(\frac{V}{m} \right)$$

↳ Vector quantity
↳ in direction of $\vec{F}$



Mcq: If $F = 100N$, $q = 1C$
$E = ?$

$$E = \frac{100}{1} = \frac{100N}{1C}$$

Test Charge
↳ Magnitude ≈ 0
↳ Field ignorable
↳ $q_0 = +ve$

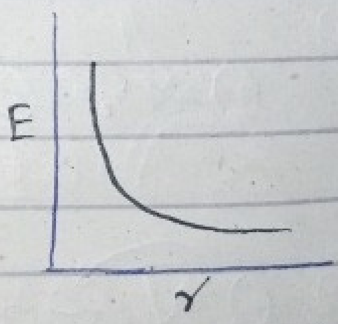
E field Due to Point Charge:

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

$E \propto q$

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

Dependance
↓ K
↓ q
↓ r

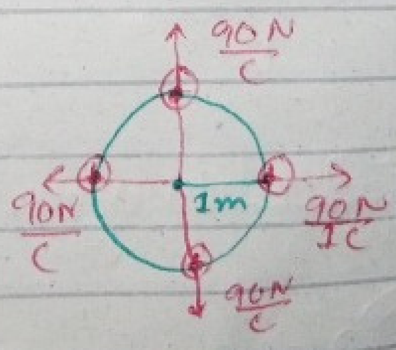


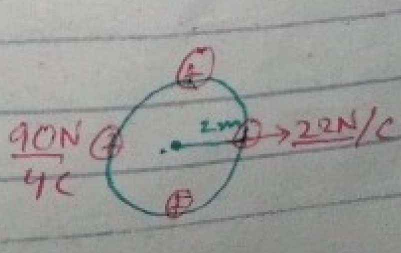
$q = 10nC$
distance $= r$
$E = ?$

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

$$= \frac{9 \times 10^9 \times 10 \times 10^{-9}}{r^2}$$

$$E = \frac{90N}{r^2}$$

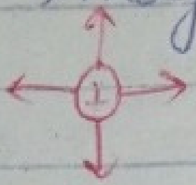


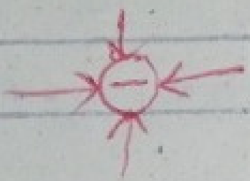


Properties Of E.f.

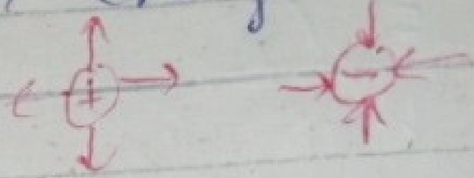
→ Michael Faraday

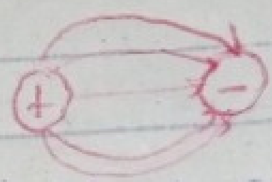
→ Imaginary lines

→  originate

→  Terminate.

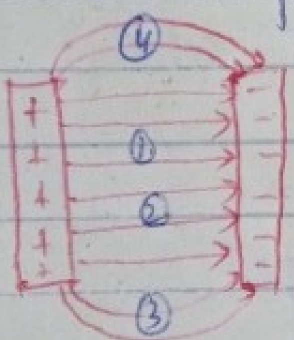
→ Charge Isolation …



→ 

↳ lines are curved

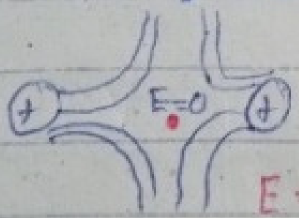
→ Parallel plate.



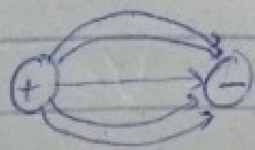
$E_1 = E_2 =$ uniform stronger

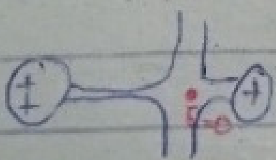
$E_3, E_4 =$ non-uniform weaker.

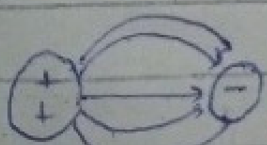
Zero Field Location:

①: 

E=0, lies at mid

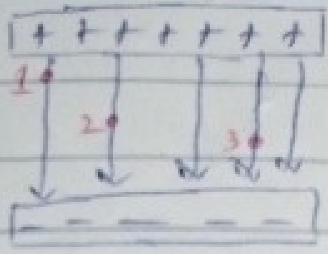
②  E=0, doesn't exist

③:  E=0, lies near smaller charge

④  E=0, lies outside smaller charge

→ E·F is long range.

MCQs:

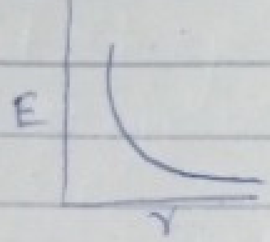


✗ $E_1 > E_2 > E_3$

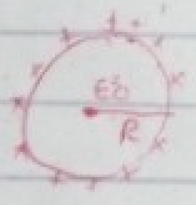
✓ $E_1 = E_2 = E_3$ → u/c uniform field

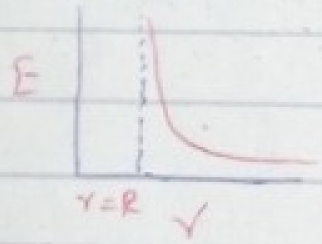
E due to point charge:

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



E to Hollow Charge Sphere.

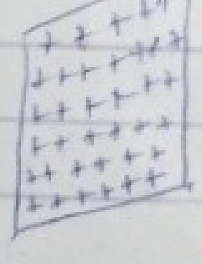


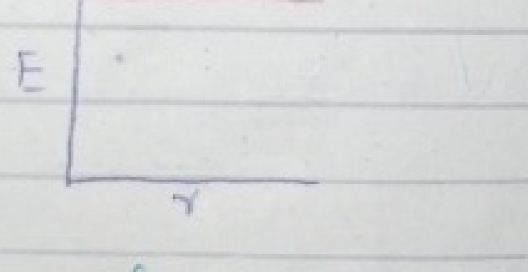


E due to infinite sheet of charge:

↳ so that fringing field should not produce.

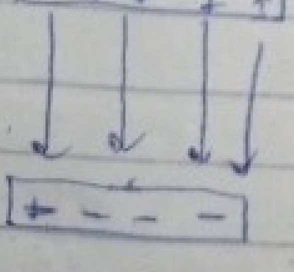
$$E = \frac{\sigma}{2\varepsilon_0}$$

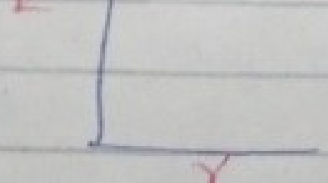




E due to oppositely charged plate.

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



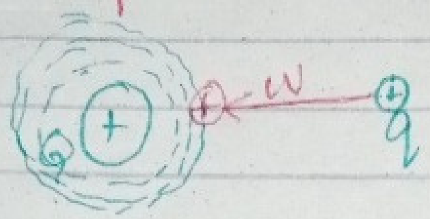


Electric Potential:

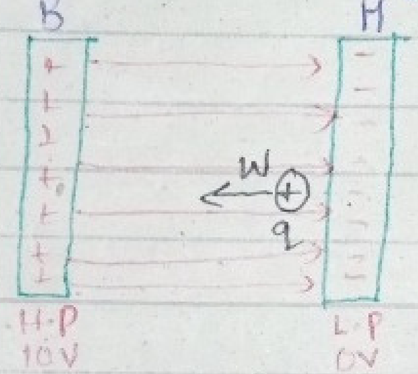
$$V = \frac{W}{q} \left(\frac{J}{C} = JC^{-1} = \text{Volt} \right)$$

Nm/C

↳ Work per unit charge



Potential Difference:



Work per unit charge to move it from L.P to H.P.

$$\Delta V = \frac{W_{B \to A}}{q}$$

∴ W = P.E = mgh

W = E.P.E = U

$W_{B \to A} = \Delta U$

$$\Delta V = \frac{\Delta U}{q}$$

mcq: W = 10 J, q = 0.1C

ΔV = ?

$$\Delta V = \frac{U_A - U_B}{q}$$

$$\Delta V = \frac{10}{\frac{0.1}{10}} = 100V$$

Change of E.P.E per unit charge called p.d

In general:

$$\Delta V = \frac{W}{q}$$

ΔV = 10, q = 0.1, W = ?

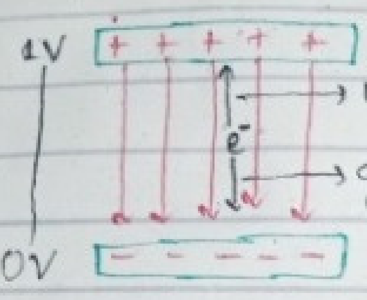
$W = q\,\Delta V$

$= \frac{0.1}{10} \times 10$

$= 1J$

Electron Volt:

→ Energy gain or lost by an electron as it move in P.d of 1V (smaller unit of energy)



$W = q\Delta V$

$W = \Delta P.E$ → $\boxed{\Delta P.E = q\Delta V}$ → gain

$W = \Delta K.E$ → $\boxed{\Delta K.E = q\Delta V}$ → loss

$\Delta K.E = q\Delta V$

$\because q = 1e,\ \Delta V = 1V$

$\Delta K.E = (1e)(1V)$

$\Delta K.E = 1eV = 1.6\times10^{-19}J$

$\boxed{1eV = 16\times10^{-20}J}$

MCQ:

$K.E = W = 4eV$

$q = 2\mu C$

$\Delta V = ?$

$\Delta V = \frac{W}{q} = \frac{4\times16\times10^{-20}}{2\times10^{-6}} = 2\times16\times10^{-14}$

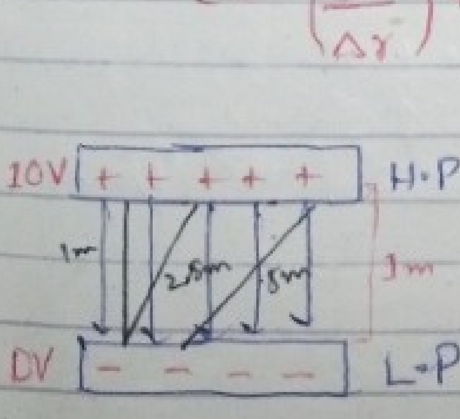
$= 32\times10^{-14}$

$\boxed{\Delta V = 3.2\times10^{-13}}$

Potential Gradient:

The maximum value of rate of change of potential w.r.t displacement

$E = -\left(\frac{\Delta V}{\Delta r}\right)_{max}$ -ive sign, direction of electric field is towards decreasing potential.



$\Delta V = 10V$

$\Delta r = 1m$

$E = -\left(\frac{10}{1}\right)\frac{V}{m}$

$$E = -\frac{10}{2.5}$$

$$E = -4\ \frac{V}{m}$$

$$E = -\frac{10}{5}$$

$$\boxed{E = -2\ Vm^{-1}}$$

Equipotential Surface:

- $V = \text{constant}$
- $\Delta V = 0$
- $E = -\frac{\Delta V}{\Delta r}$
- $\boxed{E = 0}$
  - ~~Work done~~ E.F inside the surface is 0.

- $V = \text{Constant}$
- $\Delta V = 0$
- $\Delta V = \frac{W}{q}$
- $0 = \frac{W}{q}$
- $W = 0$
  - Work done on equipotential surface is 0.

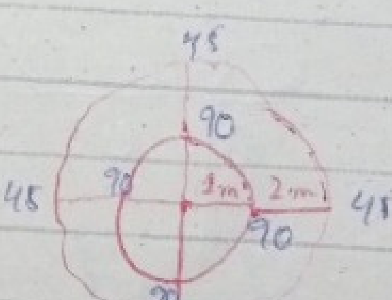
MCQ:

$q = 10nC$

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

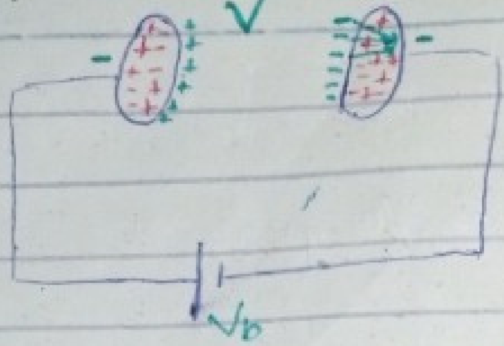
$$V = \frac{9 \times 10^{9} \times 10 \times 10^{-9}}{r}$$

$$V = \frac{90}{r}$$



Capacitor:

- Device used to store charge.
- capacitor stores energy in form of electric field.



$q \propto V$

$q = CV$

C: capacitance

C → independent to q & V

MCQ: If charge on capacitor plates becomes double. It 'C' = ?

a: decrease b: increase

[c:] same d: None

$C = \frac{q}{V} = \frac{2q}{2V} = \frac{q}{V}$ ← same.

MCQ: Which unit is ~~largest~~ suitable for largest capacitance?

[a:] 1F b: 8F

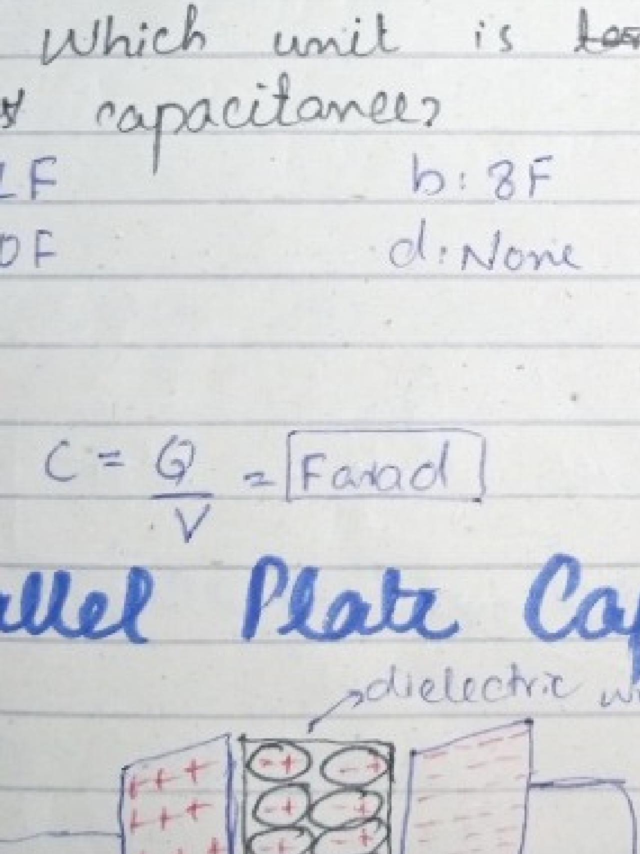
c: 10F d: None

Largest in world.
50,000 μF
[0.05 F]

Unit:

$C = \frac{Q}{V}$ = [Farad]

Parallel Plate Capacitor:



On inserting dielectric b/w plates, its capacitance increases by factor ε_r.

$C_{med} = \frac{A \varepsilon_0 \varepsilon_r}{d}$

$C_{vac} = \frac{A \varepsilon_0}{d}$

[if C_{vac} = 10F]

$C_{med} = C_{vac} \varepsilon_r$

for water

C_{water} = 10F × 80

[= 800F]

Energy stored in Capacitor in form of Electric field:

$$U = \frac{1}{2} \varepsilon_0 \varepsilon_r E^2 A d$$

$U \propto E^2$ → By putting dielectric b/w plates the E will decrease hence energy will decrease

↳ By increasing capacitance the energy will decrease

Energy Density: (J/m^3)

$$U' = \frac{U}{\text{Volume}} = \frac{\frac{1}{2} \varepsilon_0 \varepsilon_r E^2 A d}{A d}$$

$$U' = \frac{1}{2} \varepsilon_0 \varepsilon_r E^2$$

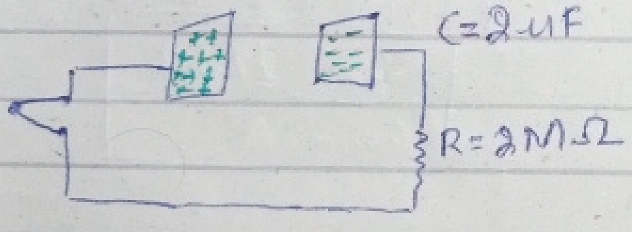
mcq: Unit of Equation $\frac{1}{2} \varepsilon_0 \varepsilon_r E^2 A d$

(a) J c: Jm.

b: Jm^3 d none.

& Energy will always be joule.

Charging of Capacitor:



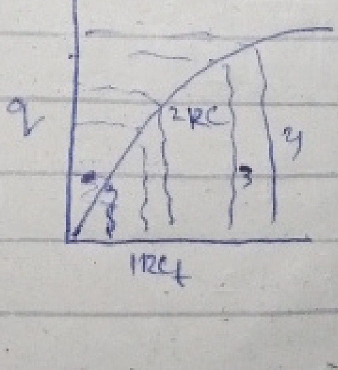
Time constant:

$$t = RC$$

$$s = \Omega F$$

$$t = 2 \times 10^6 \times 2 \times 10^{-6}$$

$$t = 4s$$



1RC ⟶ 63%

↓ 22%

2RC ⟶ 86%

↓ 8%

3RC ⟶ 94% ∴ A capacitor can't charge 100%

↓ 4%

4RC ⟶ 98%

↓ 1%

5RC ⟶ 99

$\varepsilon_r = \frac{C_{med}}{C_{vac}}$

(1) $E\downarrow \rightarrow$ As insulator is placed b/w plates

(2) $\downarrow E = \frac{\downarrow S}{\varepsilon_0}$

(3) $\downarrow E = \frac{\downarrow V}{d}$ → separation b/w plates will remain same

(4): q = constant

$\underset{\text{constant}}{q} = CV$

$\uparrow C \propto \frac{1}{\downarrow V}$

$\varepsilon_r = \frac{F_{vac}}{F_{med}} = \frac{V_{vac}}{V_{med}} = \frac{C_{med}}{C_{vac}} = \frac{Q_{med}}{Q_{vac}}$

Energy Stored in Capacitor:

$E = \frac{1}{2} qV$

$q = CV$ $\qquad$ $V = \frac{q}{C}$

$E = \frac{1}{2} CV^2$ $\qquad$ $E = \frac{1}{2} \frac{q^2}{C}$

$E = \frac{1}{2} qV = \frac{1}{2} CV^2 = \frac{1}{2} \frac{q^2}{C}$

Q) $E = \frac{1}{2} qV$, and charge on capacitor "q = 2q" E = ?

a: double

(b) 4-times

c: half

d: $\frac{1}{4}$ times

$\therefore q \propto V$ As charge increases V will increase

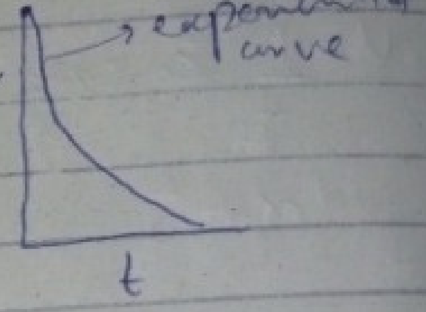
$E' = \frac{1}{2}(2q)(2V)$

$E' = 4\left(\frac{1}{2} qV\right)$

$E' = 4E$

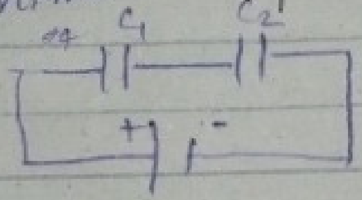
Discharging Of Capacitor:

1 RC ⟶ 37 %
2 RC ⟶ 15 %
3 RC ⟶ 5 %
4 RC ⟶ 1.5 %
5 RC ⟶ 0.05 %



Combinations Of Capacitors:

1: Series Combination
~~Maximum~~ or Minimum Capacitance:



$$C_{eq} = \frac{1}{C_1} + \frac{1}{C_2}$$

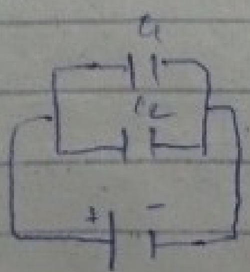
$$C_{eq} = \frac{C}{n}$$

Eg: Ratio of $\frac{C_{max}}{C_{min}} = ?$

$$\frac{C_{max}}{C_{min}} = \frac{nC}{\frac{C}{n}}$$

$$\boxed{\frac{C_{max}}{C_{min}} = n^2}$$

2: Parallel Combination:
~~Minimum~~ or Maximum Capacitance:



$$C_{eq} = C_1 + C_2$$

$$C_{eq} = nC$$

Current Electricity.

↳ Study of charges in motion.

Rate of flow of charges called current.

$$I = \frac{q}{t} \left(\frac{C}{s} = A \to SI \right)$$

$\therefore q = ne$ $\frac{1}{t} = f$

$I = \frac{ne}{t}$ $I = qf$ $n = \frac{It}{e}$ $\frac{I}{e} = \frac{n}{t}$

C.G.S unit of current (stat-A)

$1A = 3 \times 10^9$ stat-A

Current

- (classic) Conventional: $\oplus \longrightarrow \ominus$ ✓
- Electronics: $\ominus \longrightarrow \oplus$ ✗

1750 – 1900

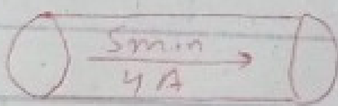
volta

H ⟶ L

motion

MCQ: $I = 4A$, $t = 5min$

$n = ?$



$n = \frac{It}{e}$

$n = \frac{4 \times 300}{4 \cdot 16 \times 10^{-20}} =$

$n = \frac{300 \times 10^{20}}{41}$

$n = 7 \times 10^{21}$ es

Charge Carriers:

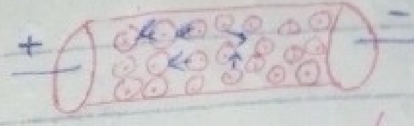
1: Conductors ⟶ only free ēs
2: Semi Conductors ⟶ holes + ēs
3: Gas ⟶ ions + ēs
4: Electrolytes ⟶ ions only

Drift Velocity:

The maximum constant velocity attain by an electron as it moves

$1\,cm^3 = 10^{23}$ free $\bar{e}s$

in presence of electric field.



$V_e = 10^6/10^7$

$t = 1s$

$d = 1mm$

$V_d = \frac{d}{t} = 1mm/s$

$\boxed{V_d = 10^{-3} m/s}$ $V_d = 10^{-3} m/s$

$V_d = \frac{I}{neA}$; n: electron density ; $n = \frac{electron}{volume}$

$V_d = \frac{V}{neR\pi r^2}$; $A = \pi r^2$; $r = \frac{d}{2}$

$V_d = \frac{V}{neR\pi \frac{d^2}{4}}$

$V_d \propto \frac{1}{A} \propto \frac{1}{r^2} \propto \frac{1}{d^2}$

Resistance:

↳ Opposition offered by atoms to the flow of charges.

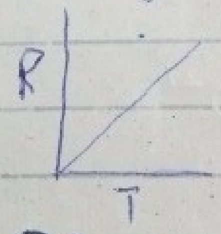
Resistance & Temp

For Conductors

$R \propto T$

→ free $\bar{e}s$ 10^{23}

by giving $100\bar{e}s$ → no effect

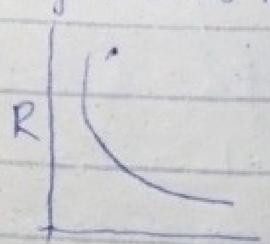


For Semiconductors

$\downarrow R \propto \frac{1}{T\uparrow}$ # 2023

→ free $\bar{e}s$ 20 – 30

adding $\bar{e}s$ will have effect



Ohms Law:

The current is directly proportional to voltage if temperature of conductor remains same.

$I \propto V$

$I = (constant) V$

$V \propto I$ ✗

$I = \left(\frac{1}{R}\right) V$ R = resistance.

$IR = V$ $\qquad$ $I = GV$ $\quad \because \frac{1}{R} = G$

MCQ:

In ohms law the proportionality constant is:

a: R $\quad$ b: $\frac{1}{R}$ $\quad$ c: G $\quad$ (d:) b, c

$G = \frac{1}{R} \Rightarrow \boxed{GR = 1}$ $\qquad$ $f = \frac{1}{T} \Rightarrow \boxed{fT = 1}$

* → R is independent of (I) & (V):

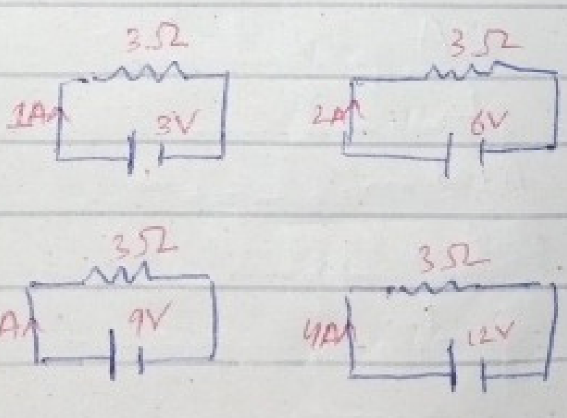
MCQ:

If $I = 2I$, $R = ?$

$R = \frac{V}{I} \Rightarrow R = \frac{2V}{2I} \quad \because I \propto V \quad R = \frac{V}{I}$

Ohms law

V	I	R
3V	1A	3Ω
6V	2A	3Ω
9V	3A	3Ω
12V	4A	3Ω



Limitations:

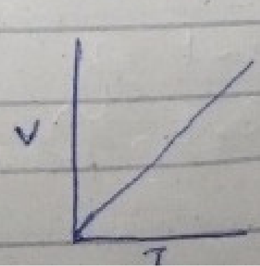
i: Temp = constant

ii: Resistance = constant

→ Ohms law is not applicable for transformer.

T ≠ constant

Area = IV = Power

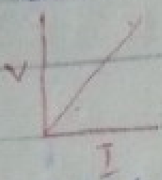


slope = $\frac{V}{I}$

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

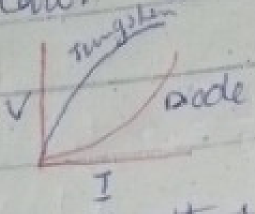
Ohmic Non Ohmic:

Ohmic
→ obeys ohms law



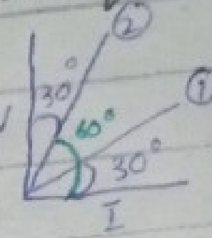
metals

Non Ohmic
↳ not obey ohms law.



all others

mcq: $R_1 : R_2 = ?$ (1 : 3)



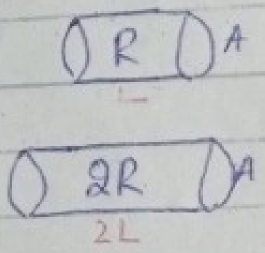
∴ $\tan\theta$ is w.r.t x-axis.

$$\frac{R_1}{R_2} = \frac{\tan 30^\circ}{\tan 60^\circ} = \frac{\frac{1}{\sqrt{3}}}{\sqrt{3}}$$

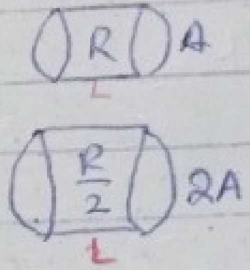
$$\frac{R_1}{R_2} = \frac{1}{(\sqrt{3})^2} = \frac{1}{3}$$

Resistance & Resistivity:

$R \propto L$



$R \propto \frac{1}{A}$

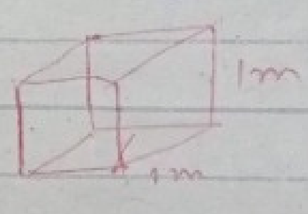


$R = \rho \frac{L}{A}$ ∴ ρ specific resistance or Resistivity $(R = \rho)$
↳ Resistance of 1m wire.

$\rho = \frac{RA}{L} \left(\frac{\Omega m^2}{m}\right)$

If $A = 1m^2$, $L = 1m$

$\rho = \frac{R \times 1m^{2}}{1m}$



$\rho = R \ (\Omega m)$

If wire is cut into two parts. $\rho = ?$, $R = ?$
ρ = same, R = half

$\rho = \frac{\frac{R}{2} A}{\frac{L}{2}}$

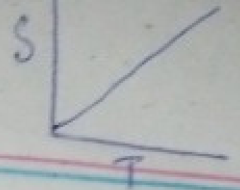
$\rho = \frac{RA}{L}$

Dependance:

↳ Nature
↳ Temp
↳ Independant of dimensions (R, L, A)

Streching:

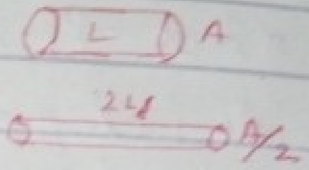
$\rho \propto T$



If the length of wire becomes double by streching. If R = ?

a: double b: Half

(c) 4 times d: same



$$R = \frac{\rho L}{A} \rightarrow R = \frac{\rho(2L)}{A/2}, \quad R' = 4R$$

Short cut:

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

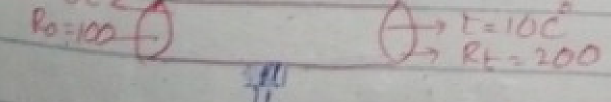
$$R = \rho \frac{L}{A} \times \frac{L}{L} \qquad\qquad R = \rho \frac{L}{A} \times \frac{A}{A}$$

$$R = \frac{\rho L^2}{AL} \qquad\qquad R = \frac{\rho L A}{A^2} \qquad \because AL = V$$

$$\boxed{R \propto L^2} \qquad\qquad \boxed{R \propto \frac{1}{A^2}}$$

Coefficient Of Resistance:

↳ The fractional change in resistance per kelvin temperature



$$\alpha = \frac{R_t - R_0}{R_0 \Delta t} \quad \text{(} \Delta t \rightarrow \text{change in temperature)} \qquad \alpha = \frac{200 - 100}{100(10-0)}$$

$$\alpha = \frac{R_t - R_0}{R_0(t - t_0)} \qquad \alpha = \frac{100}{100(10)} = \frac{1}{10} = 0.1 K^{-1} \text{ or } C^{-1}$$

$$\alpha = \frac{1}{\Delta t}$$

$\alpha \to C^{-1}$ or K^{-1}

α'
- $\alpha = +ve$ — Conductors
- $\alpha = -ve$ — semiconductor
- $\alpha = 0$ — alloy

#

$\alpha R_0 \Delta t = R_t - R_0$

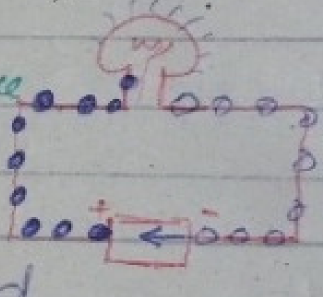
$R_t = R_0 + \alpha R_0 \Delta t$

$R_t = R_0(1 + \alpha \Delta t)$

Electromotive Force:

↳ The energy supplied by a unit +ive charge to move it from -ive to +ive terminal inside.

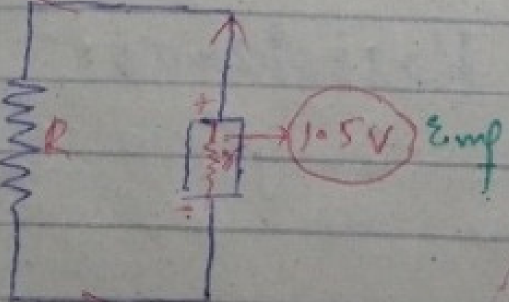
* Battery is not source of charges it just push or pull charges.



$$\text{Emf} = \frac{\text{Energy supplied}}{\text{charge}}$$

$$\text{Emf} = \frac{W}{q} \left(\frac{J}{C} = \text{volt} \right)$$

↳ unit of emf.



$V = IR_{eq}$

ε $V = I(R + r)$

$\varepsilon = IR + Ir$

$$I = \frac{\varepsilon}{R + r}$$

$$\frac{\varepsilon}{I} = R + r$$

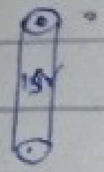
$\mathcal{E} = V_t + Ir$

$V_t = \mathcal{E} - Ir$

Open circuit

$I = 0$

$V_t = \mathcal{E}$



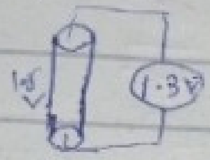
$\mathcal{E} = V_t$

Close circuit

$I \neq 0$

$V_t = \mathcal{E} - IR$

$\mathcal{E} > V_t$



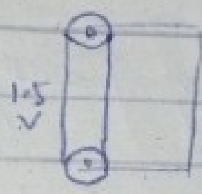
Short circuit

$I = max$

$\boxed{\mathcal{E} = Ir}$

$V_t = \mathcal{E} - \mathcal{E}$

$\boxed{V_t = 0}$



When battery is being charg

$I = -I$

$V_t = \mathcal{E} - (-Ir$

$V_t = \mathcal{E} + Ir$

$V_t > \mathcal{E}$

Power:

$P = \frac{Energy}{t}$

$P = \frac{W}{t}$ $\quad \therefore V = \frac{W}{q}$

$P = \frac{Vq}{t}$ $\quad \therefore \frac{q}{t} = I$

$\boxed{P = IV}$

mcq: $I = 10\,uA$, $V = 90$

$P = ?$

$P = 10 \times 10^{-6} \times 90$

$P = 9 \times 10^{-4}$

$P = IV$

Series

$\frac{1}{P_{eq}} = \frac{1}{P_1} + \frac{1}{P_2}$

$\boxed{P = I^2R}$

Child toys

Parallel

$P_{eq} = P_1 + P_2$

$\boxed{P = \frac{V^2}{R}}$

Housing wire.

Heat.

$P = \frac{E}{t} = \frac{H}{t}$

$\frac{H}{t} = I^2R \Rightarrow \boxed{H = I^2Rt}$

$P_{rat} = 100$ watt
$V_{rat} = 220V$

Rated:

If 100 watt, 220V bulb is connected by a battery of 110V then power consume will be,

$P = \frac{V^2}{R}$

$P_{rated} \propto V_{rated}^2$

$P_{consume} \propto V_{supply}^2$

$P_{rat} = 100$ watt
$V_{rat} = 220V$
$V_s = 110V$
$P_c = ?$

$\frac{P_c}{P_r} = \frac{V_s^2}{V_r^2}$

$P_c = \frac{V_s^2 \times P_r}{V_r^2} \Rightarrow \frac{(110)^2}{(220)^2} \times 100$

$P_c = \frac{110 \times 110}{220 \times 220} \times 100 = \frac{100}{4} \Rightarrow \boxed{25 \text{ watt}}$

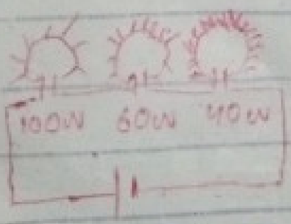
Brightness:

$P_{rated} \propto \frac{1}{R}$ $\quad R \propto \frac{1}{P_{rated}}$

$\boxed{B \to P}$

Series

$P = I^2R$
$B = I^2R$
I = constant
$B \propto R \propto \frac{1}{P_{rat}}$



$B \propto \frac{1}{P_{rat}}$

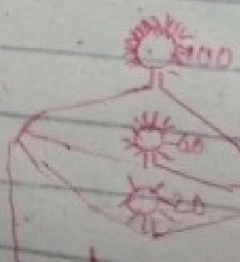
Parallel

$P = \frac{V^2}{R}$

$B = \frac{V^2}{R}$

V = constant

$B \propto \frac{1}{R} \propto P_{rated}$



$B \propto P_{rat}$