Electric field

Electric field

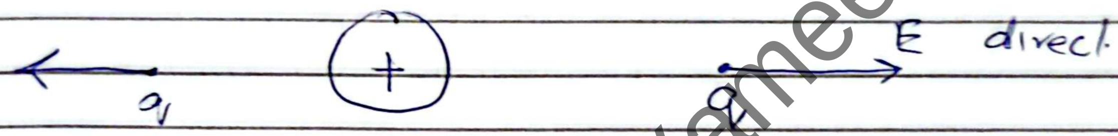
Electric force per unit positive charge

$E = \frac{F}{q}$ $\quad NC^{-1}$

$q = +ive$

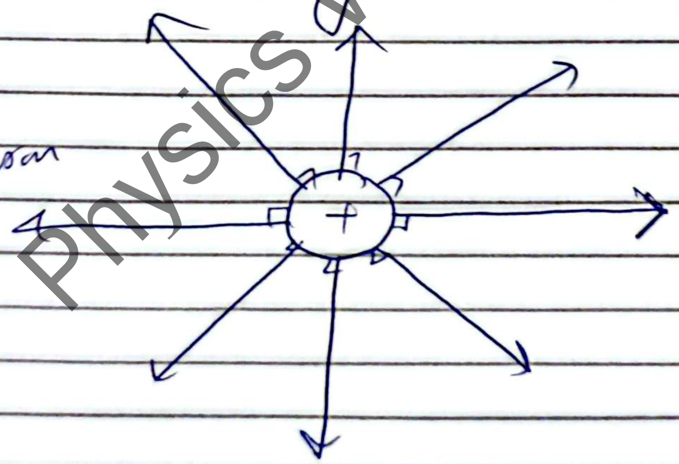
$F = Eq$ $\quad F = mg$

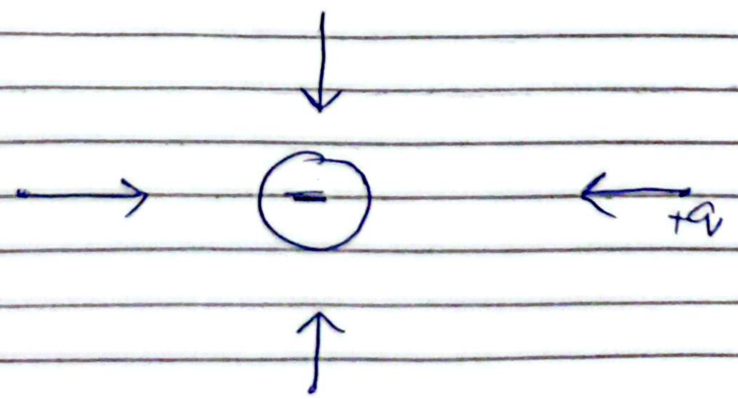
Vector

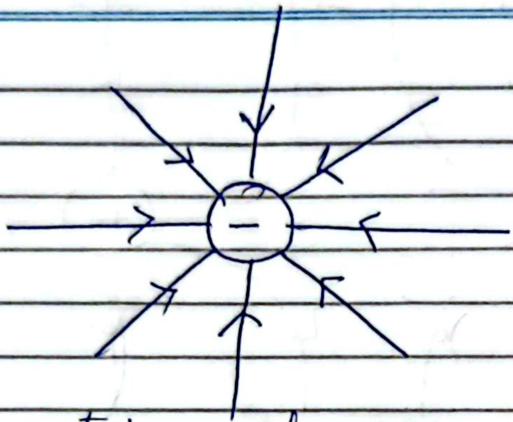


Direction: away from positive charge.

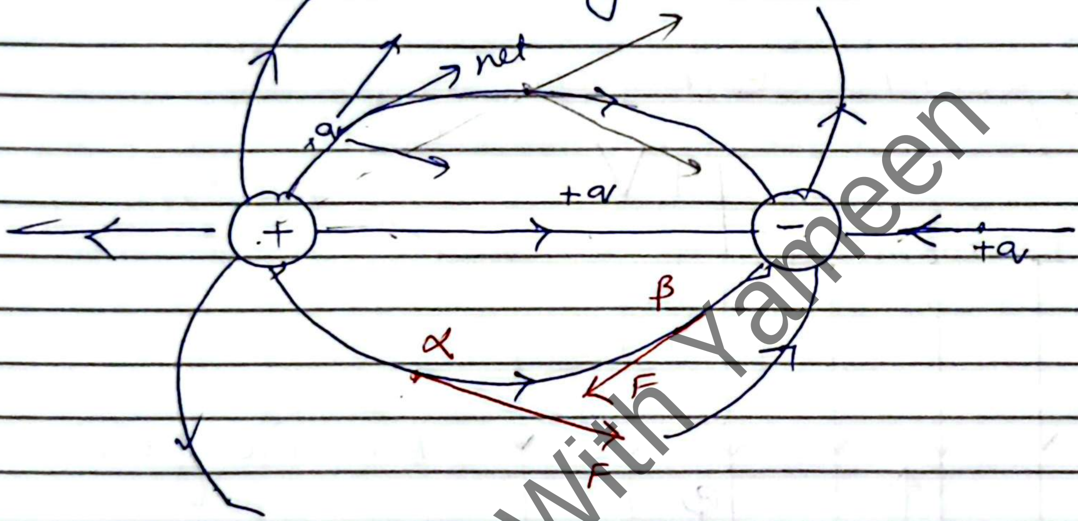
Field is non uniform







Due To two Charges

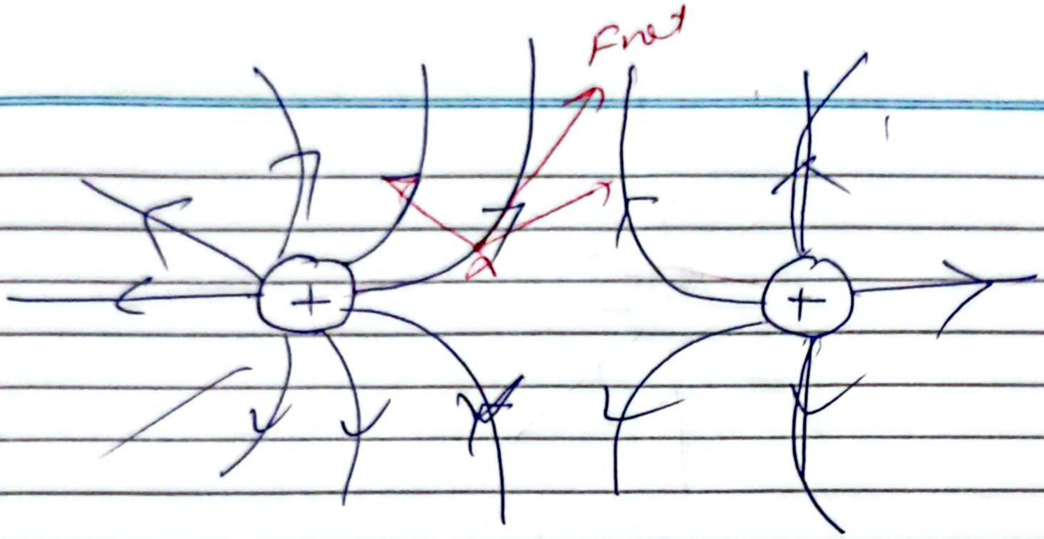


Force on any charge particle gets at tangent to the curve.

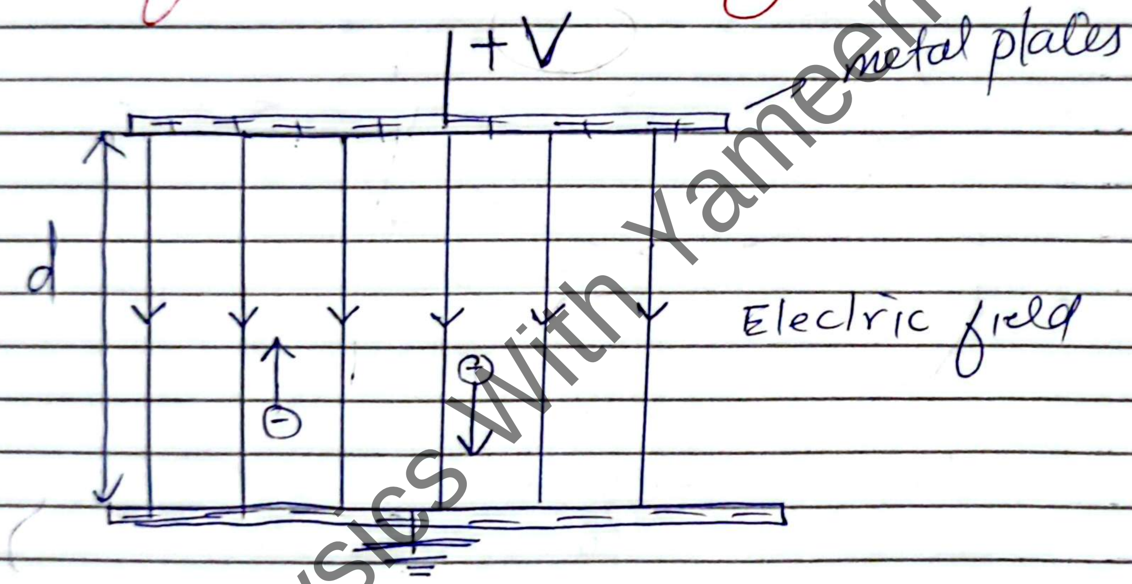
in ~~pos~~ electric field direct- if charge is +ive

in opposite direction if charge is negative

as shown forces on α and β.



uniform electric field



parallel line → uniform Electric field

Field strength: Depends on

i) potential difference

ii) distance b/w plates

field strength

$$\boxed{E = \frac{V}{d}}$$

V: potential difference

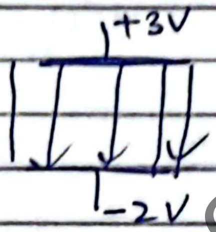
proof is not in this syllabus

$E = \frac{F}{q}$ $\qquad$ $V = \frac{W}{q}$

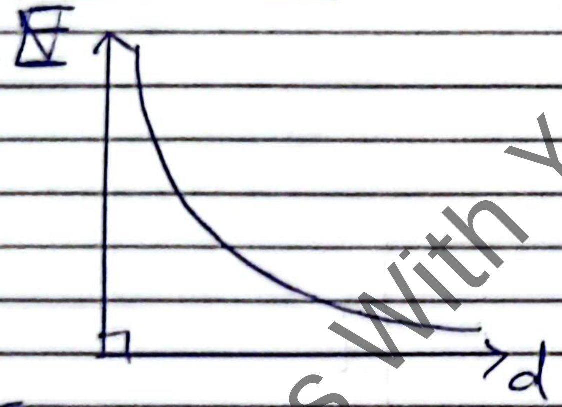
$E = F \times \frac{V}{W}$ $\qquad$ $V = \frac{Fd}{q}$

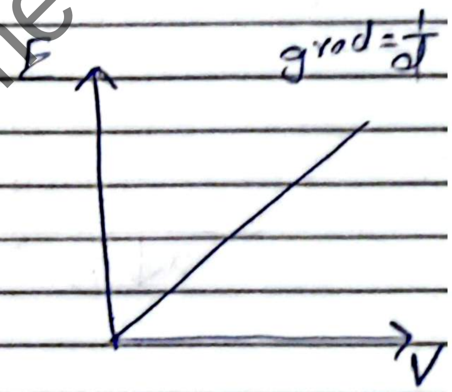
$E = \frac{Vq}{dq}$ $\qquad$ $F = \frac{Vq}{d}$

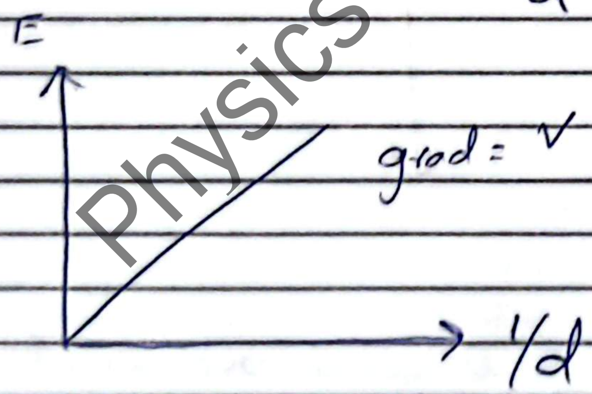
$\boxed{E = \frac{V}{d}}$



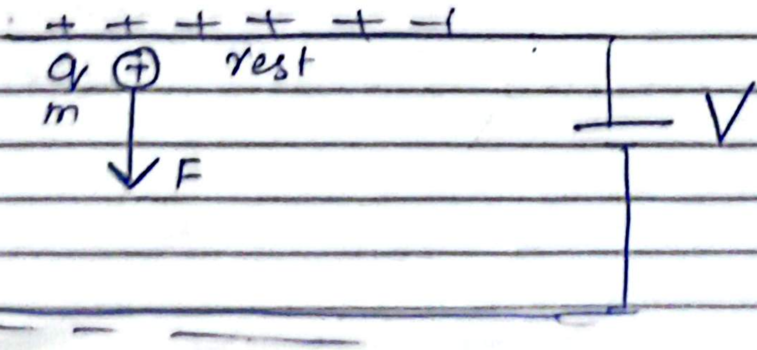
$E = \frac{5}{2 \times 10^{-2}} = 250$







Ignore gravity



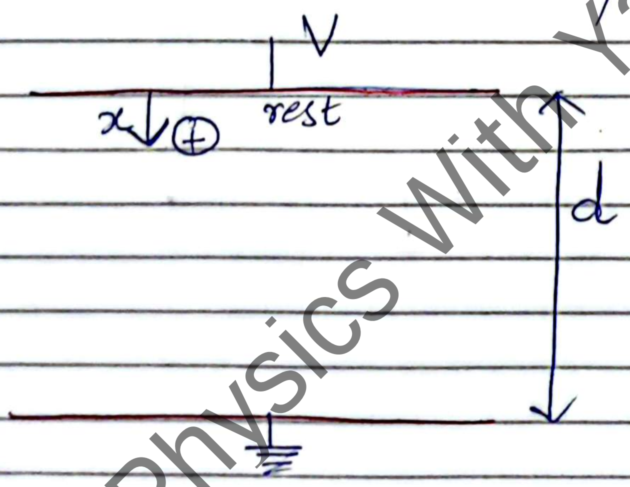
$F = Eq$

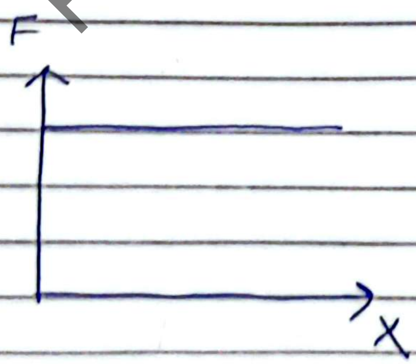
$F = \frac{V}{d} q$

$ma = \frac{Vq}{d}$

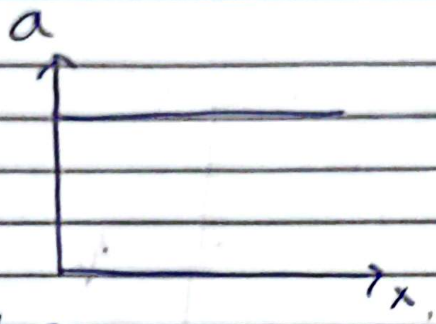
$$\boxed{a = \frac{Vq}{dm}}$$

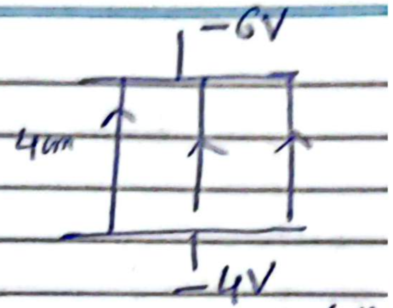
a is constant so equations of motion are applicable.





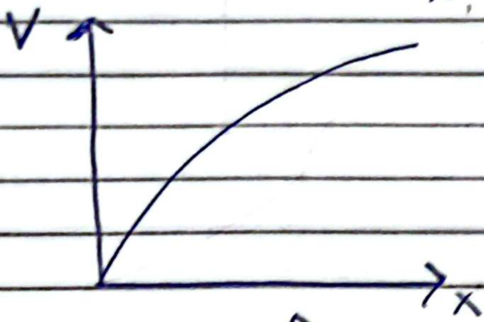
x: distance of charged particle from upper plate





$E = \frac{-4-(-6)}{4\times10^{-2}}$

$E = \frac{2}{4\times10^{-2}}$



$V^2 = u^2 + 2ax$

$u = 0$

$V^2 = 2ax$

$V = \sqrt{2ax}$

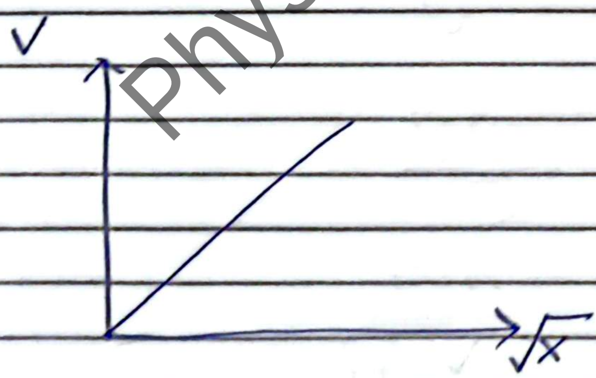
$V = \sqrt{2a}\,\sqrt{x}$

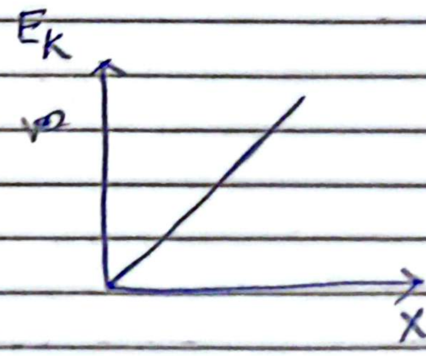
$2as = v^2 - u^2$

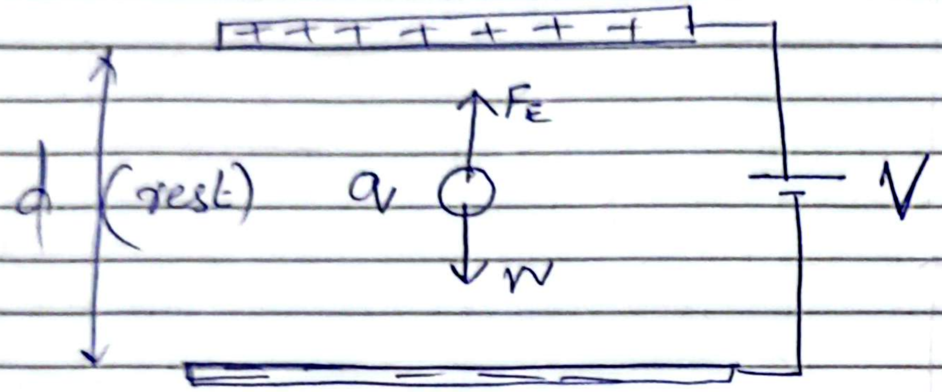
$v = \sqrt{2as}$

$\frac{dv}{dx} = \sqrt{2a} \times \frac{1}{2} x^{-\frac{1}{2}}$

$\frac{dv}{dx} = \frac{\sqrt{2a}}{2\sqrt{x}}$







If charge is negative the

Electric force → up

gravitational " → Down

If at rest

$$F_E = W$$

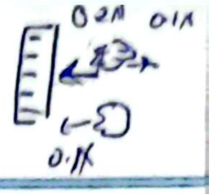
$$Eq = mg$$

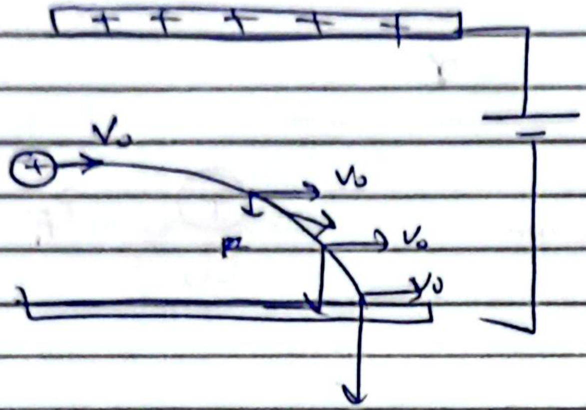
$$q = \frac{mg}{E}$$

$$q = \frac{mg}{V/d}$$

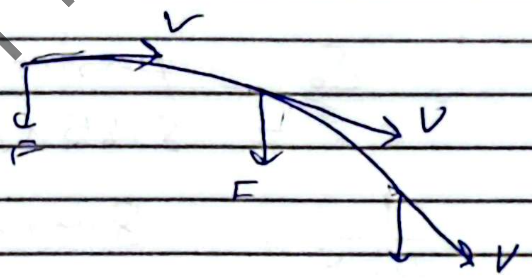
$$q = \frac{mgd}{V}$$

[If V is increased now Charge q will accelerate up]



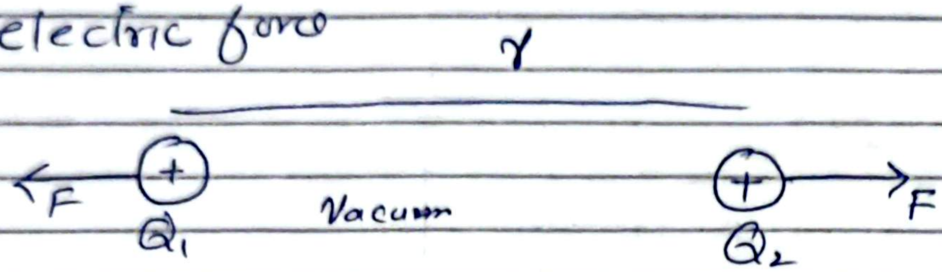


It will follow projectile motion
It is not an arc of circle
because Force is not ⊥ to
Velocity



Coulomb's Law

F: electric force



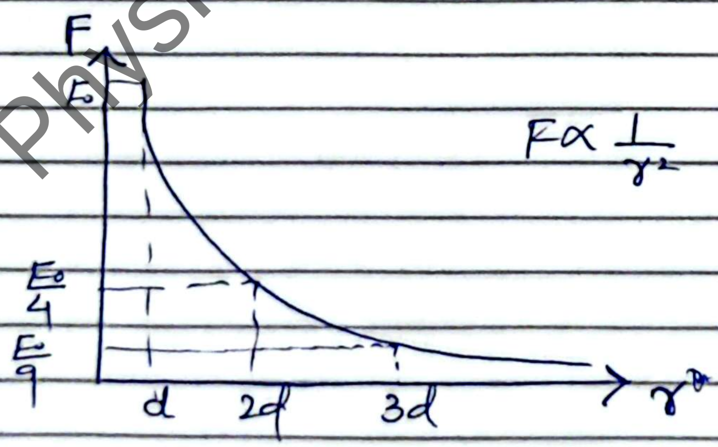
$$F \propto \frac{Q_1 Q_2}{r^2}$$

$$\boxed{F = \frac{1}{4\pi\epsilon_0}\frac{Q_1 Q_2}{r^2}}$$

$Q_1 \rightarrow$ coulomb
$Q_2 \rightarrow$ "
$r \rightarrow m$
$F \rightarrow N$

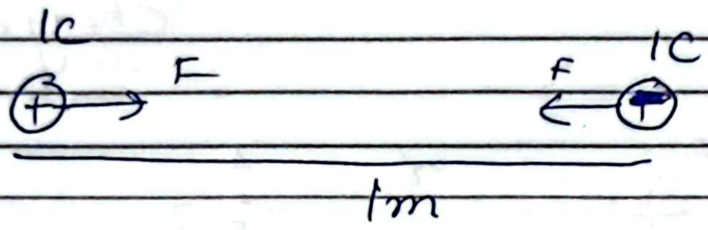
ϵ_0 = permittivity of free space
$= 8.85 \times 10^{-12}$

$$\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \ Nm^2/C^2$$



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

Define: Force b/w two point charges is directly proportional to product of their charges and inversely proportional to square of distance b/w them



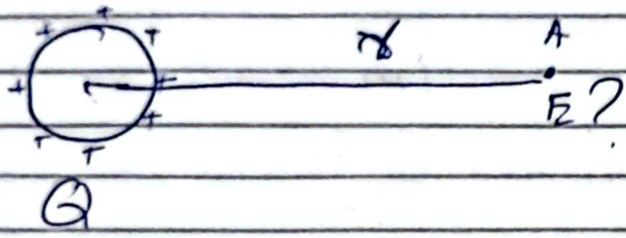
$$F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{r^2}$$

$$F = 8.99\times10^9 \times \frac{1\times1}{1^2}$$

$$\boxed{F = 8.99\times10^9 \, N}$$

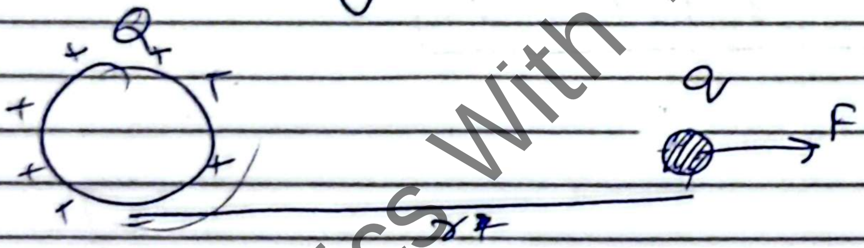
Electric field strength

$E = \frac{F}{q}$ → (1) electric force per unit positive charge



E at point A ?

put charge q at point A



$F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$

use eq (1)

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

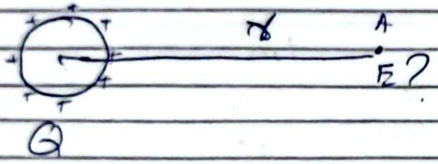
r: distance from centre

$= \frac{1}{4\pi\varepsilon_0}\frac{Q\cancel{q}}{r^2} / \cancel{q}$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}}$$

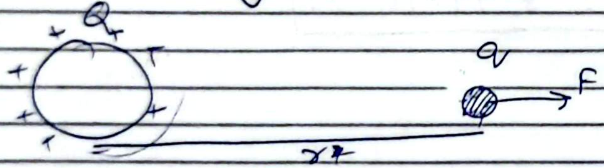
Electric field strength

$E = \frac{F}{q}$ —① electric force per unit positive charge



E at point A ?

put charge q at point A



$F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$

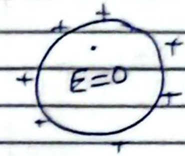
use eq ①

$E = \frac{F}{q}$ r: distance from Centre

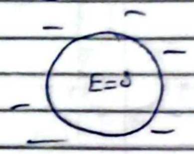
$= \frac{1}{4\pi\varepsilon_0}\frac{Q\cancel{q}}{r^2} / \cancel{q}$

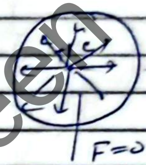
$$\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}}$$

Inside Metal Charged sphere



Charge lies only on surface

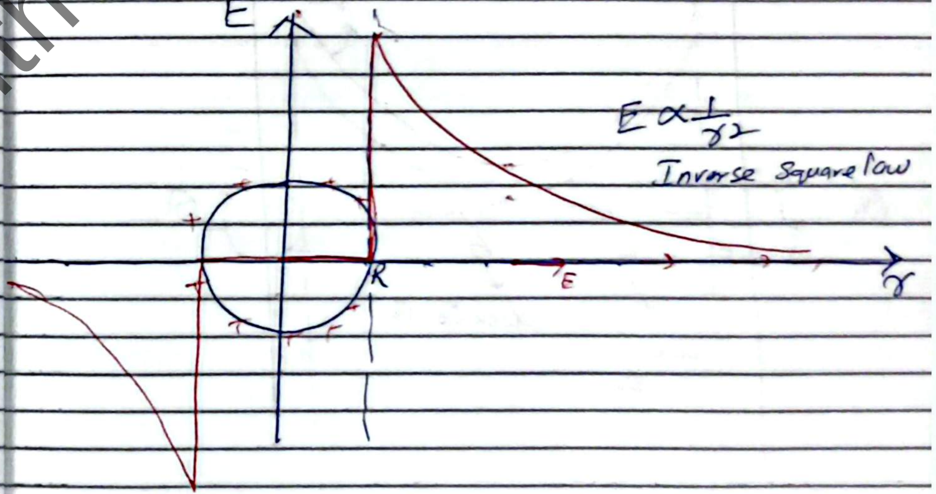




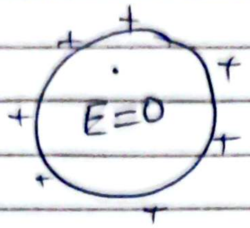
F=0 so E=0

Inside metal charged sphere

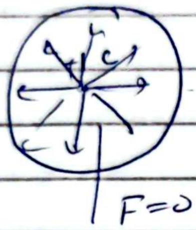
E=0

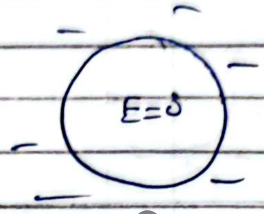


Inside Metal Charged sphere



Charge lies only on surface

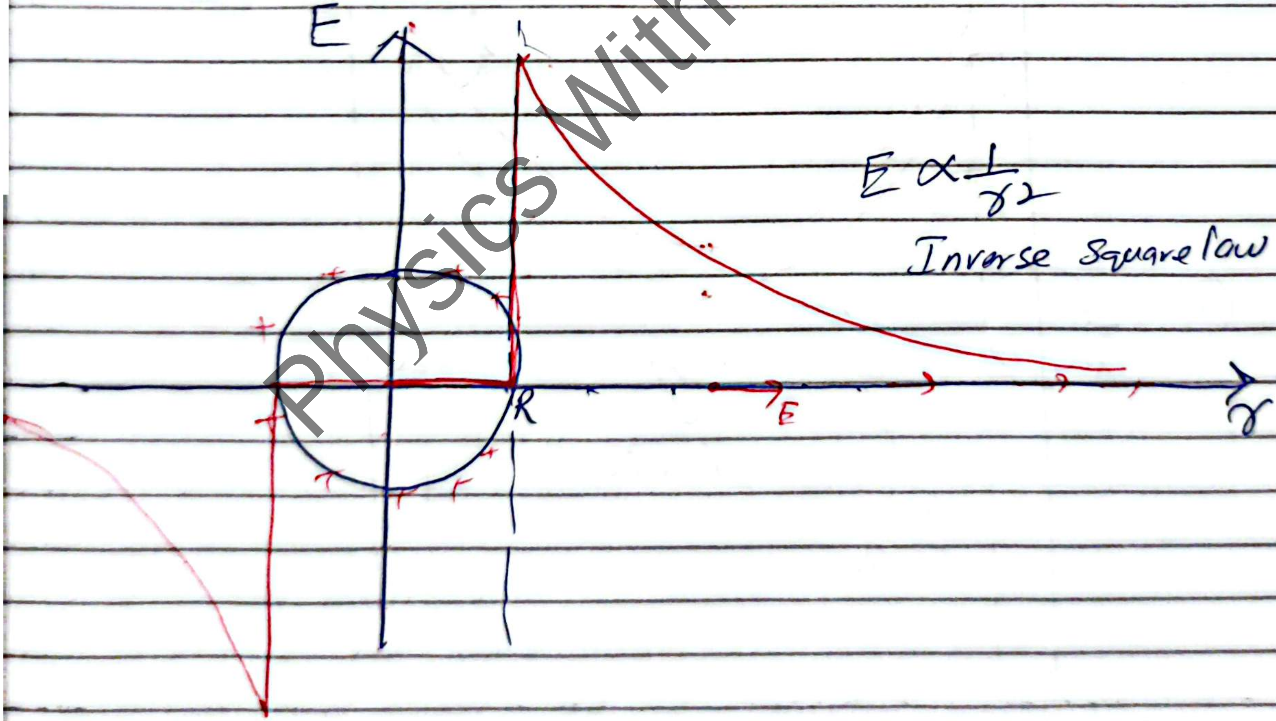


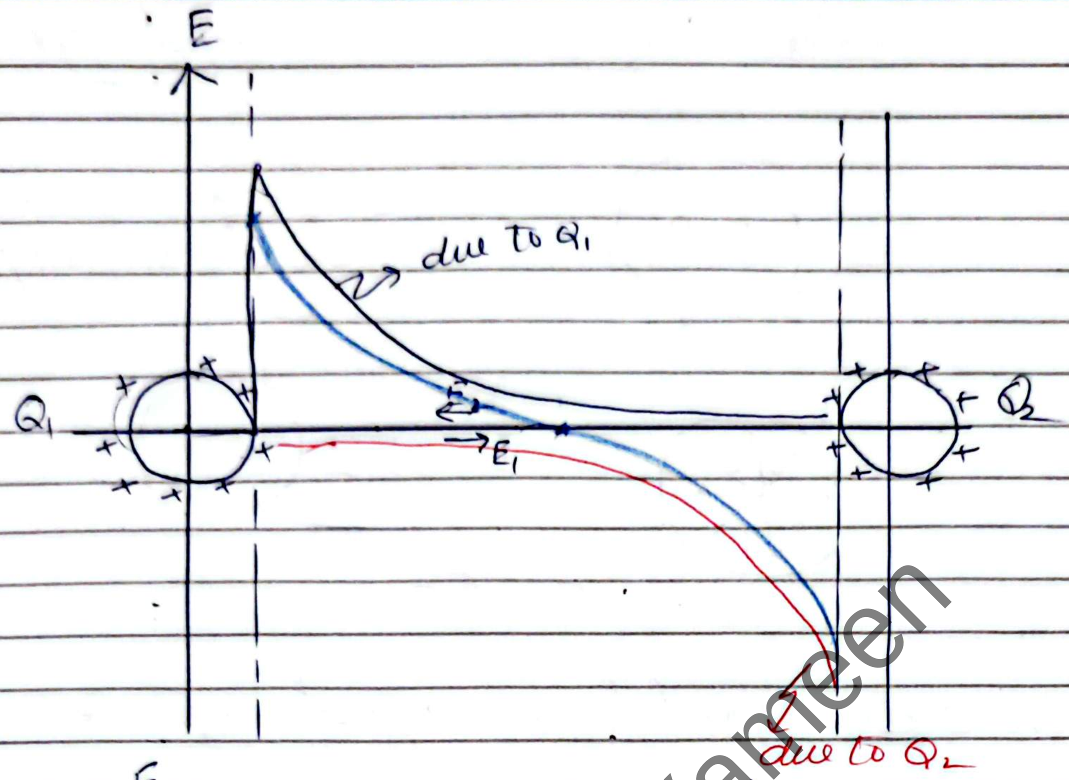


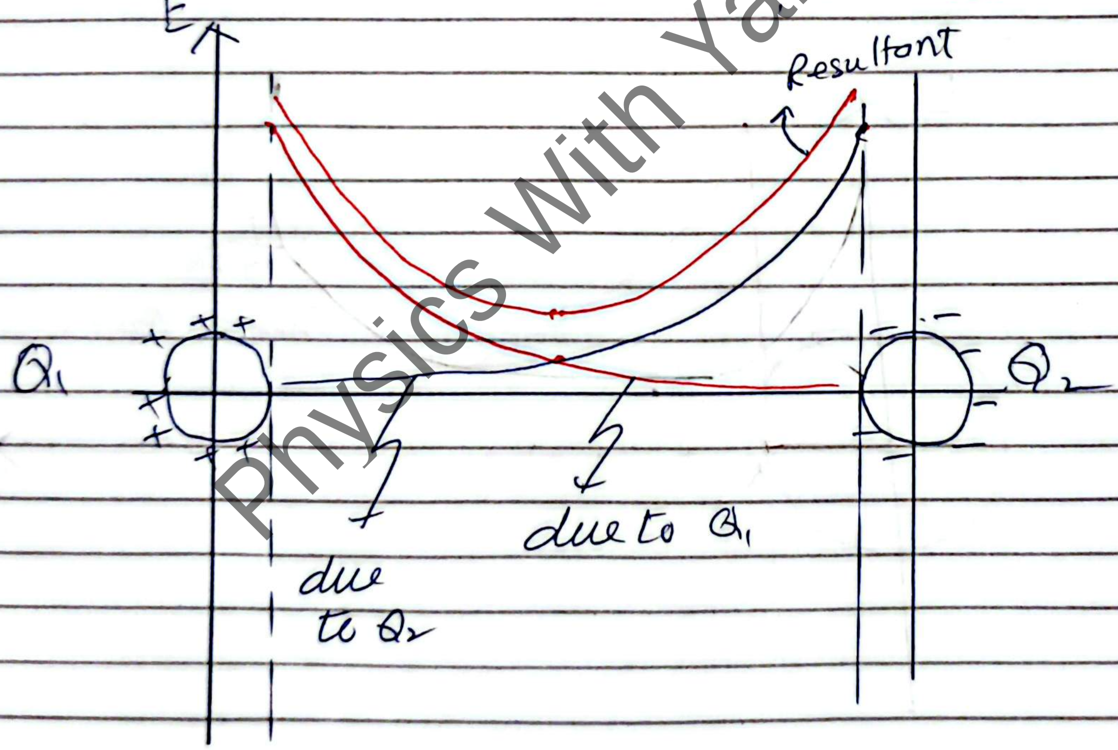
F=0 so E=0

Inside metal charged sphere

E = 0







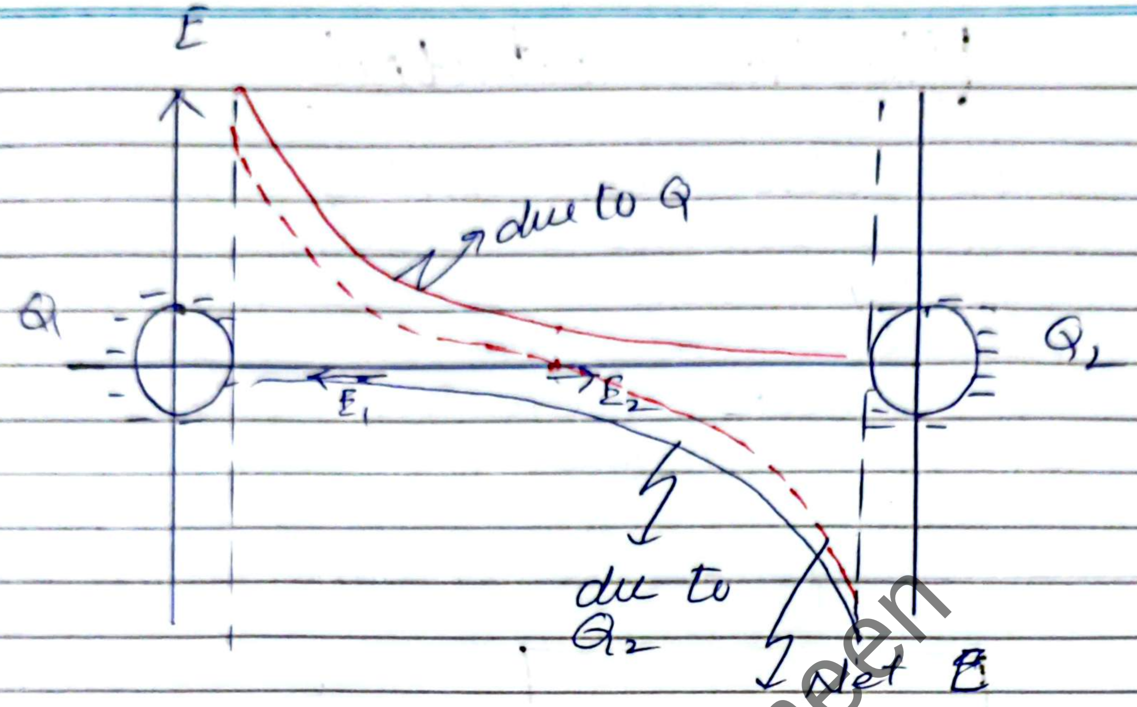
E at any point b/w charges

due to Q_1 $\longrightarrow$ Right

" Q_2 $\longrightarrow$ Right

Same direction

$\oplus$ $\rightarrow \ominus$



Electric potential

Work done to bring a unit positive charge from infinity to a point inside ~~gravitational~~ electric field is called electric potential of that point.

Formula

$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}}$$

$V = \frac{W}{Q}$

unit: J/C

Scaler

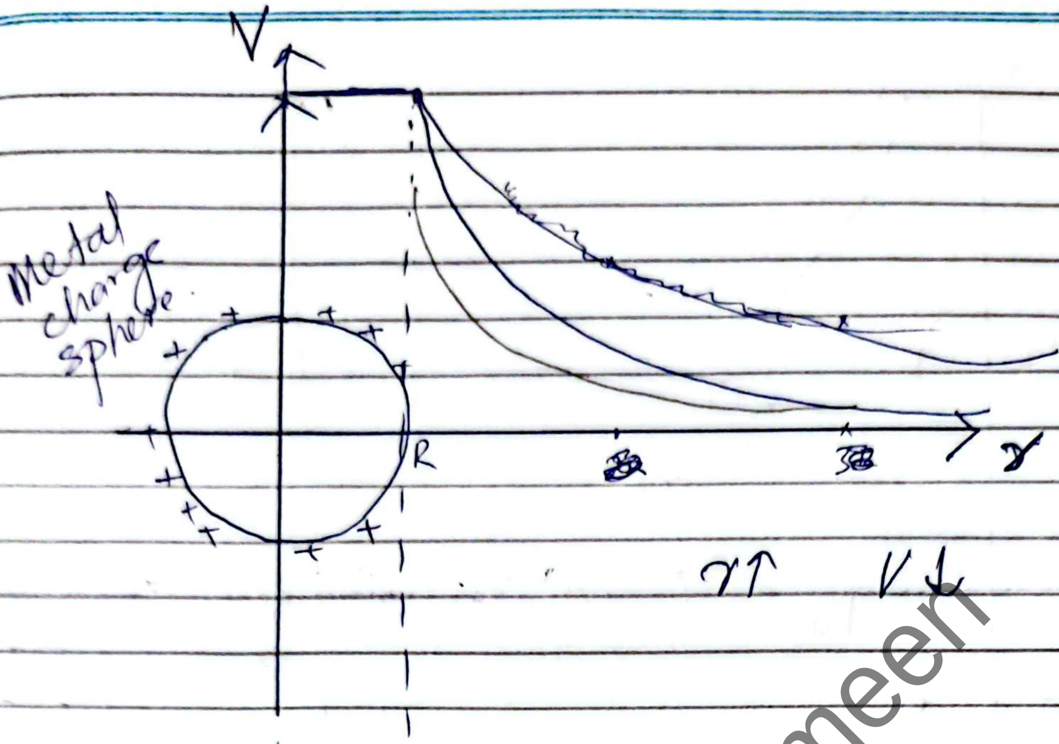
Electric potential can be negative and positive.

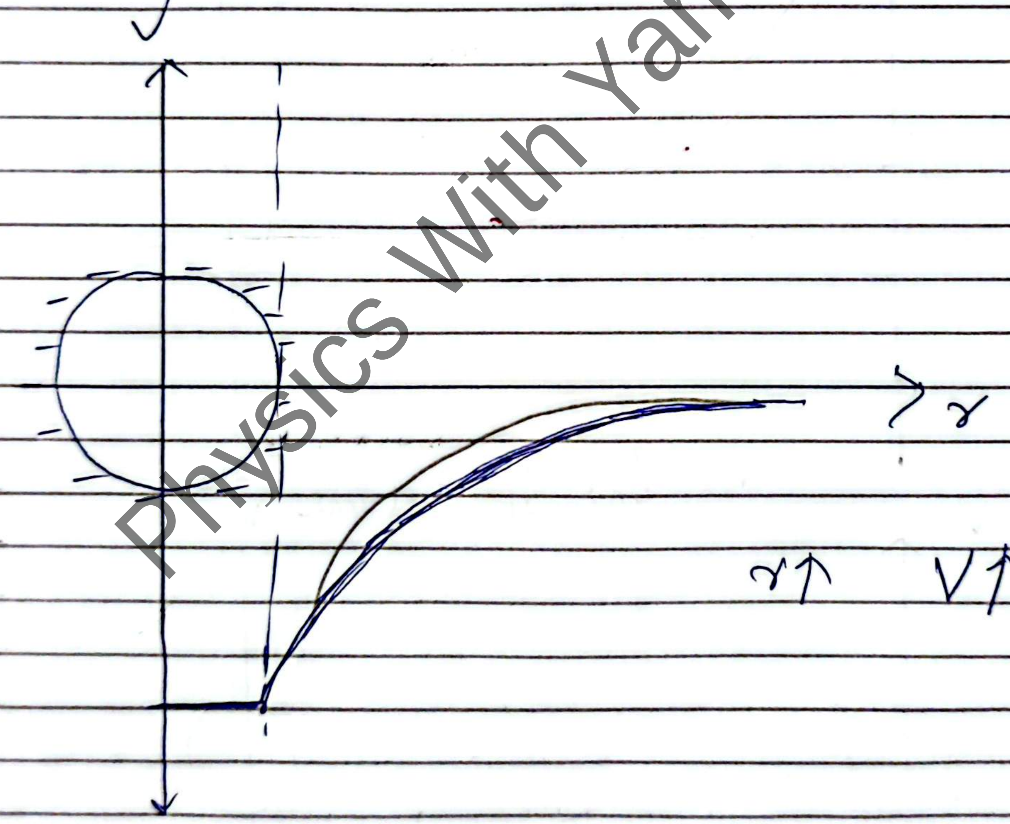
* If Q is positive then V is positive

* If Q is negative then V is negative

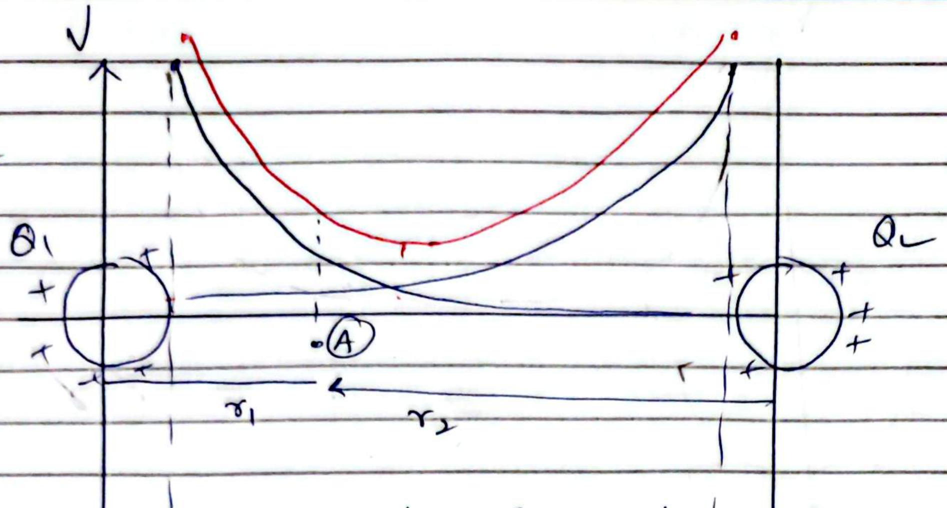
* V is zero at infinity.

*

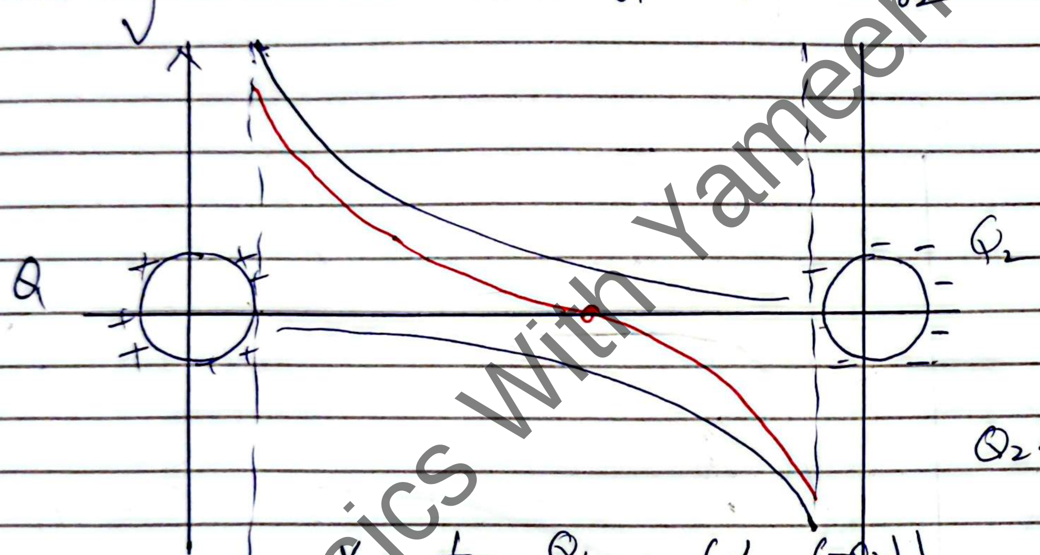

V
Metal charge sphere
R
r
r↑ V↓


V
r
r↑ V↑

$Q_1 = Q_2$

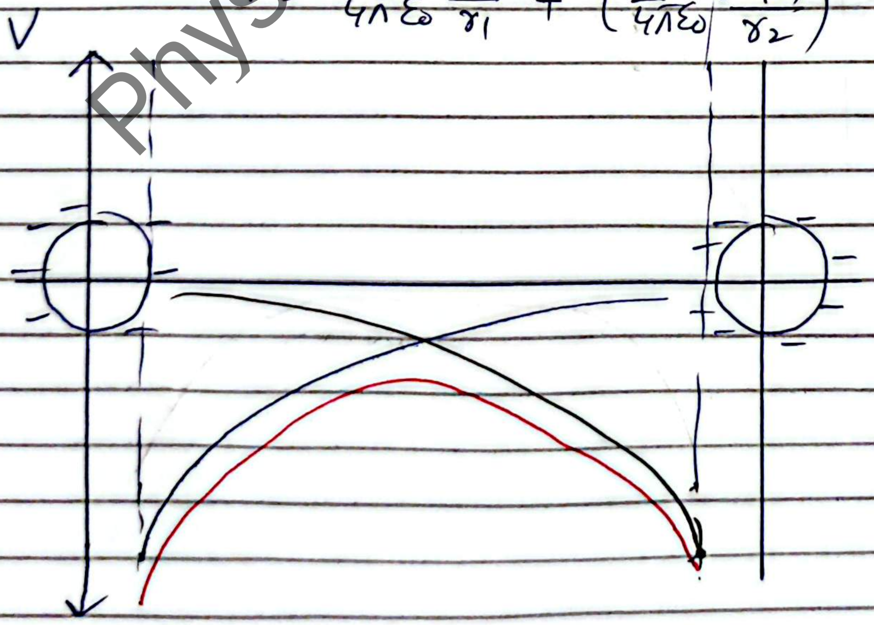


$$V_A = \frac{1}{4\pi\varepsilon_0}\frac{Q_1}{r_1} + \frac{1}{4\pi\varepsilon_0}\frac{Q_2}{r_2}$$



$Q_2 < Q_1$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q_1}{r_1} + \left(\frac{1}{4\pi\varepsilon_0}\frac{(-Q_2)}{r_2}\right)$$



Relation between electric potential and electric field strength.

$$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2} \rightarrow (1)$$ electric field strength

[This proof is not in the syllabus.]

$$V = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r} \rightarrow (2)$$

$$\frac{1}{4\pi\varepsilon_0} Q r^{-1}$$

$$\frac{dV}{dr} = \frac{1}{4\pi\varepsilon_0} Q (-1) r^{-2}$$

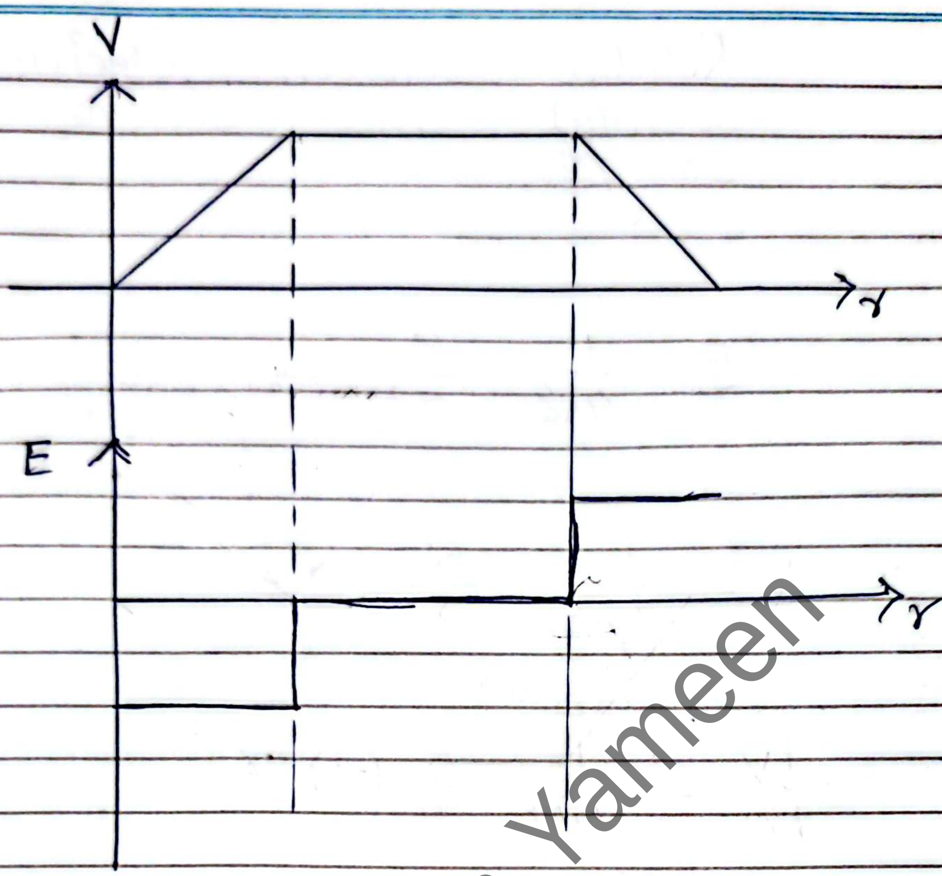
$$grad(V) = -\frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}$$

$$grad(V) = -E$$

$$\boxed{E = -grad(V)}$$

E is negative gradient of electric potential.

This is very important relationship you should known this.



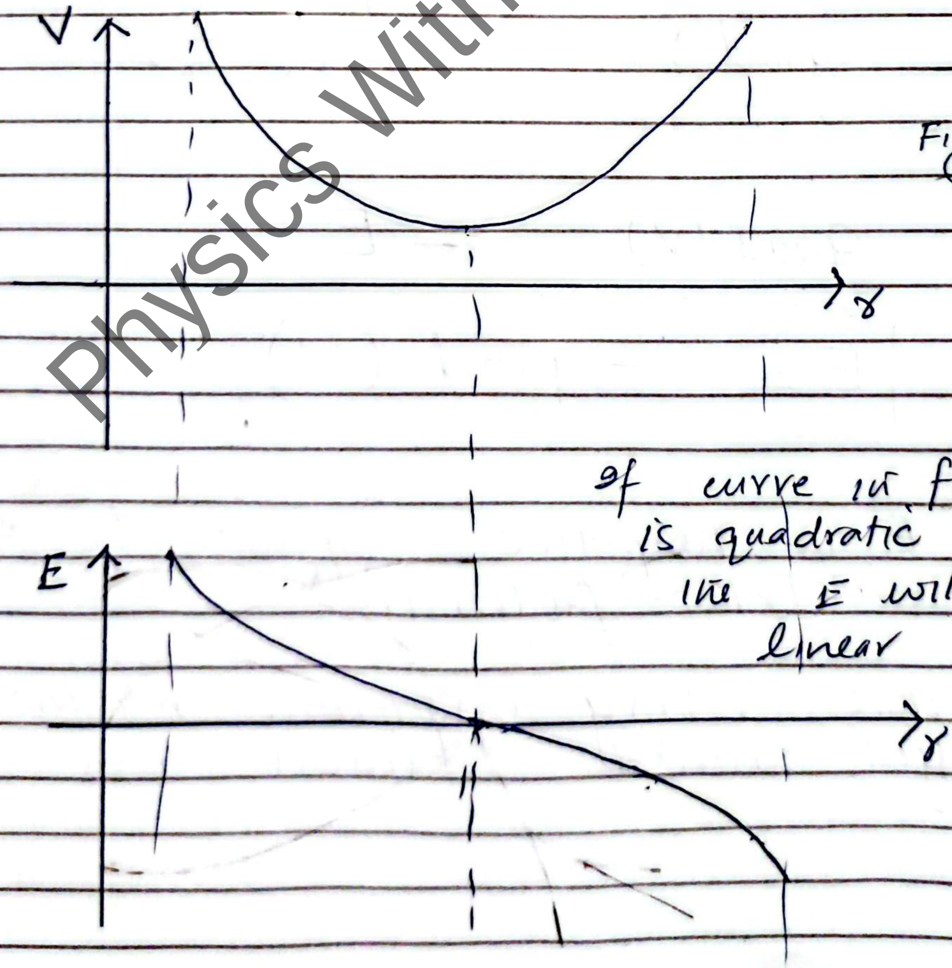
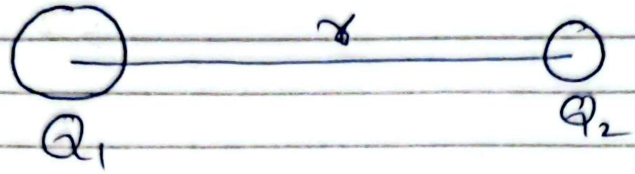


Fig (1)

If curve in fig (1) is quadratic the E will be linear

Electric potential energy.



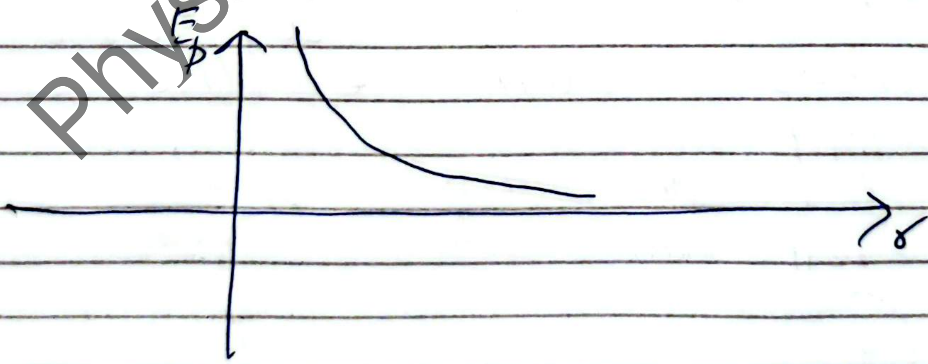
Electric potential energy

$$E_p = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r}$$

* If both charges like (same sign)

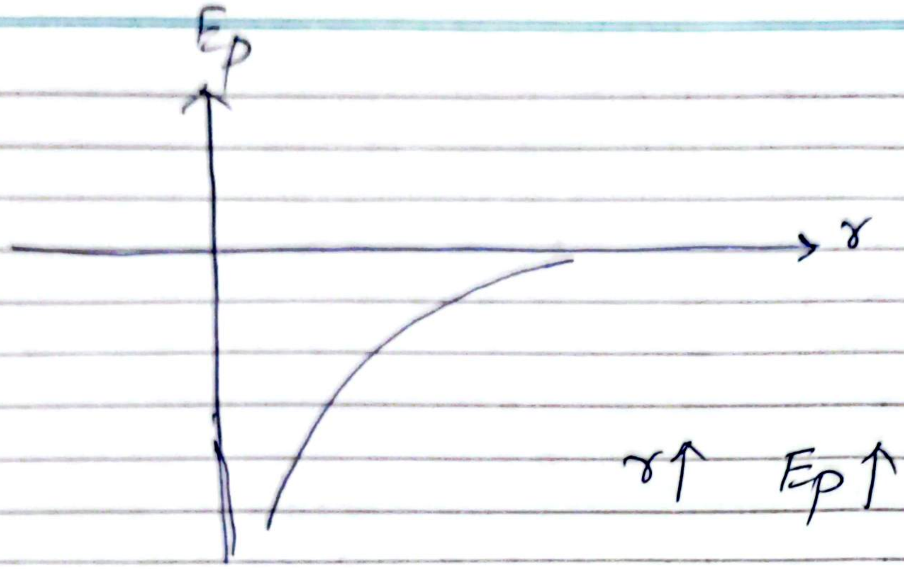
E_p: will be positive

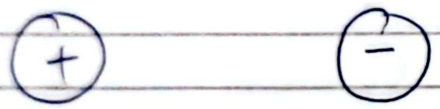
E_p will decrease as r is increased.



If both charges are opposite

E_p : negative





If two opposite charges are moved in opposite direction Then work must be done you need force. Your work done will be used to increase their electric potential energy.

If two opposite charges rest are released from rest

If their speed is increasing that means Ep should decr

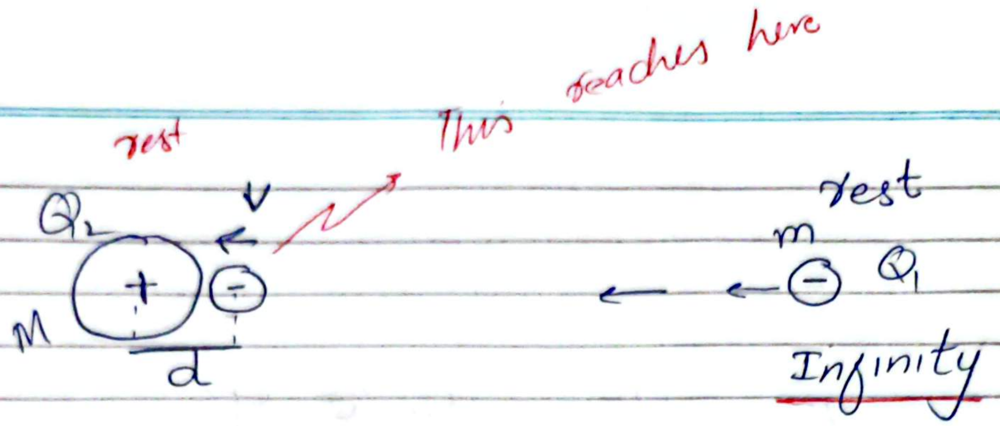
Relation between potential energy and electric potential

$$E_p = \frac{1}{4\pi\varepsilon_0}\frac{Q_1}{r}q$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

$$E_p = Vq$$

$$\boxed{\Delta E_p = \Delta V q}$$



Charge Q_1 is released from rest from infinity find its speed when it touches Q_2.

d: distance between their centers when they touch.

total energy of the system before and after is same.

Before = After

$$E_p + E_K = E_p + E_K$$

$$0 + 0 = -\frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{d} + \frac{1}{2}mv^2$$

$$\frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{d} = \frac{1}{2}mV^2$$