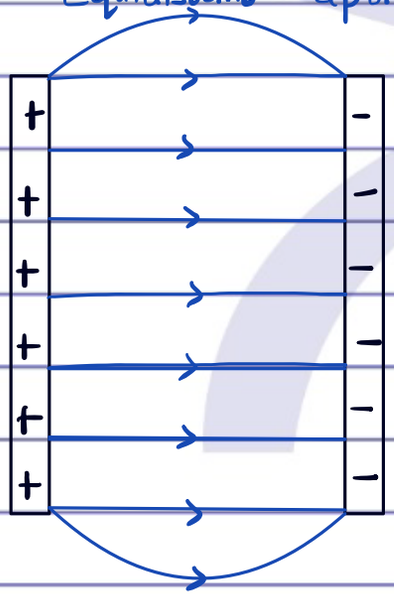
Topic: Electric Field. Date:

Concept of Electric Field.

Electric Field is a region around any charge particle where other point charges if placed will experience either an attractive force or a repulsive force.

Electric field are classified either as uniform or a nonuniform Electric field.

① Uniform Electric field is one in which field lines are parallel and Equidistant apart as shown.



Property: No matter where ever charge is placed it experience the same force.

Direction of field is always from High potential to low potential.

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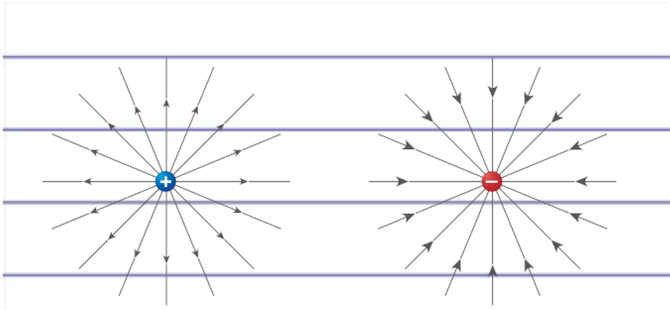
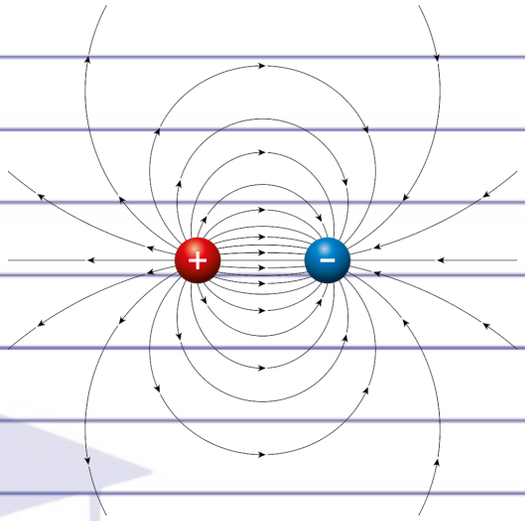
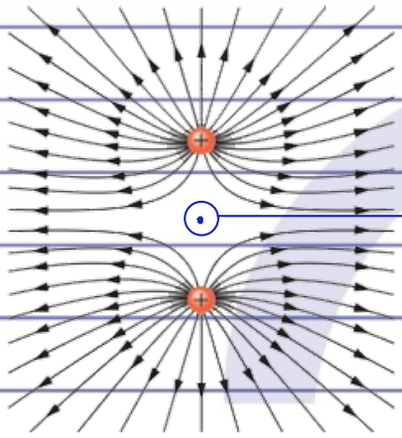
Non Uniform Electric field. are one in which the field lines are neither parallel nor equidistant apart.



The electric field form an isolated positive charge — The electric field from an isolated negative charge

- Field lines must be radial.
- Correct Direction of field lines.



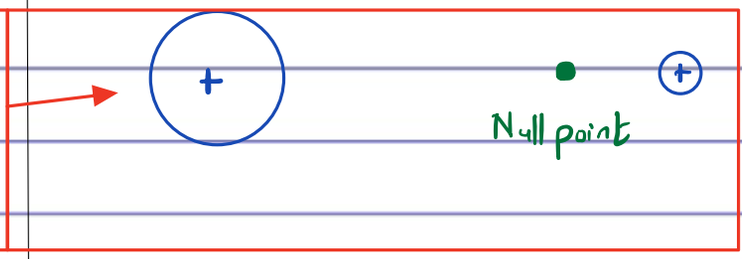


When there are two unlike charges field lines come out of postive and are deposited in the negative.

Null point: A region where there is not electric or magnetic field.

For Identical charges null pt is in the centre

For Non Identical charges nullpoint will always be closer to the smaller charge.



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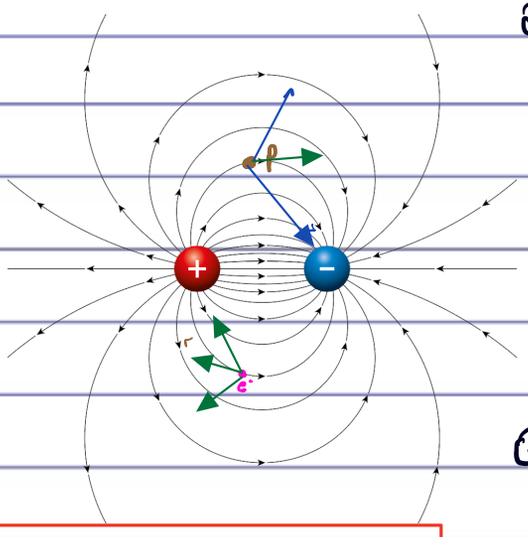
Note



* mass of proton : 1.66×10^{-27} kg
* Charge on proton : $+1.6 \times 10^{-19}$ C (Elementary charge.)
* mass of Electron : 9.11×10^{-31} kg
* Charge on Electron : -1.6×10^{-19} C

Q) In which direction will the proton move?

⇒ Proton will move in the direction of the Electric field by making a tangent with the field lines.

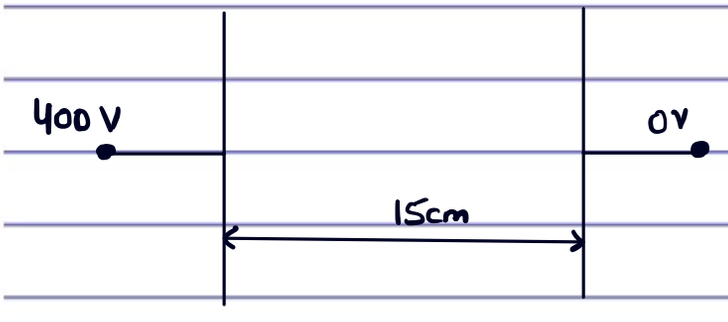
Q) In which direction will the Electron move

Electron moves opposite to the direction of Electric field again by making a tangent with the field lines.

How can we calculate Electric field strength

* Electric field strength is denoted by symbol "$\mathcal{E}$"
* It can be calculated using 2 formulas

First formula is only for uniform Electric field?



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

V = Voltage / PD

d = distance b/w the plates.

$$= \frac{400}{15 \times 10^{-2}}$$

$$= 2670 \text{ V/m}$$

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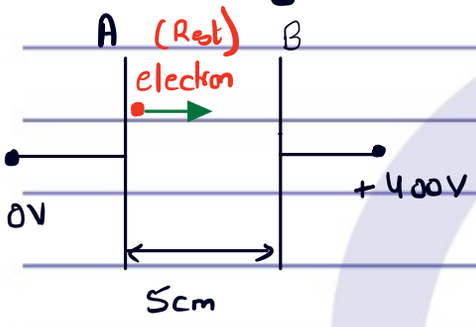
Second Formula is used to define Electric field strength & this is a universal formula ie it can be used for both uniform & Non uniform electric field.

Defination: Electric field strength is defined as force per unit +ve charge.

$$E = \frac{F}{q} \quad \text{or} \quad F = Eq \qquad \text{Units} = NC^{-1}$$

How to apply the formulas.



$M_e = 9.11 \times 10^{-31}\ kg$

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

i) Calculate Electric Field Strength:

$$E = \frac{V}{d} = \frac{400}{5 \times 10^{-2}}$$

$$E = 8000\ Vm^{-1} \text{ or } NC^{-1}$$

ii) Calculate Force Experienced by the electron as it moves in the field

$$E = \frac{F}{q} \Rightarrow F = (8000)(1.6 \times 10^{-19})$$

$$F = 1.28 \times 10^{-15}\ N$$

Topic: _____ Date: _____

Calculate the workdone in moving electron from A to B.

Mechanics.

$W = F \times d$

$W = 1.28 \times 10^{-15} \times 5 \times 10^{-2}$

$\boxed{W = 6.4 \times 10^{-17} \text{ J}}$

Electricity

$V = \frac{WD}{Q}$ Prefred

$400 = \frac{WD}{1.6 \times 10^{-19}}$ $\Rightarrow W = 6.4 \times 10^{-17} \text{ J}$

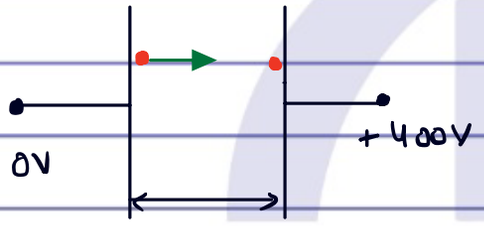
iv) Calculate the acceleration of the Electron

$F = ma$

$1.28 \times 10^{-15} = 9.11 \times 10^{-31}(a)$

$a = 1.4 \times 10^{15} \text{ ms}^{-2}$

v) Calculate final speed of Electron as it reaches B



Mechanics

$v^2 = u^2 + 2as$

$v^2 = 0^2 + 2(1.4 \times 10^{15})(0.05)$

$v = 1.18 \times 10^7 \text{ m/s}$

Electricity.

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

$V = \frac{KE}{q} \Rightarrow V = \frac{\frac{1}{2}mv^2}{q} \Rightarrow \boxed{v = \sqrt{\frac{2qV}{m}}}$

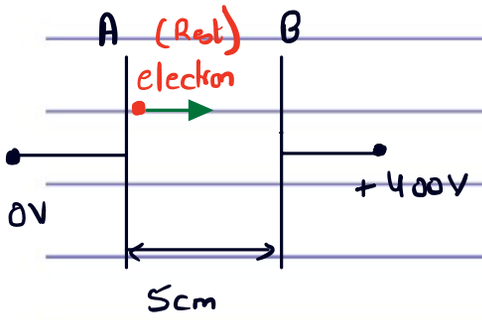
$v = \sqrt{\frac{2(1.6 \times 10^{-19})(400)}{9.11 \times 10^{-31}}}$ $v = 1.18 \times 10^7 \text{ m/s}$

Topic: _____ Date: _____

Formulas:

$E = \frac{V}{d}$ $E = \frac{F}{q}$ $V = \frac{W}{q}$ $v = \sqrt{\frac{2qV}{m}}$

How Else can we use the velocity formula i.e $v = \sqrt{\frac{2qV}{m}}$



i) Calculate the speed when the electron is midway b/w the two plates A and B

Total P.D b/w the two plates = 400V

if electron has travelled midway voltage = 200V

$v = \sqrt{\frac{2qV}{m}}$

$v = \sqrt{\frac{2(1.6\times10^{-19})(200)}{9.11\times10^{-31}}}$

$v = 8.4\times10^{6}$ m/s.

Calculate the speed when electron has travelled three quaters of the total distance.

$v = \sqrt{\frac{2(1.6\times10^{-19})(300)}{9.11\times10^{-31}}}$ $v = 1.02\times10^{7}$ m/s

Topic: _____ Date: _____

iv) Four charges $^{23}_{11}Na^{+}$, $^{40}_{20}Ca^{2+}$, $^{4}_{2}\alpha^{2+}$, $^{0}_{-1}e$ all four charges are released simultaneously; which charge will reach the opposite plate with greatest velocity?

Formula $v = \sqrt{\frac{2qV}{m}}$ → Constant

Velocity will only depend upon $\sqrt{\frac{q}{m}}$ or

{ Velocity will depend on the ratio of q/m }

$v \propto \sqrt{\frac{q}{m}}$

① Sodium $\sqrt{\frac{1}{23}}$ ② Calcium $= \sqrt{\frac{2}{40}}$ ③ Alpha $= \sqrt{\frac{2}{4}}$

④ Electron $\sqrt{\frac{1}{1 \div 1840}}$

answer = electron

iv) for the same charges, calculate which particle will have greatest momentum?

Momentum = mass x Velocity

$m \times \sqrt{\frac{2qV}{m}}$ $\quad m \times \frac{1}{\sqrt{m}} = \sqrt{m}$

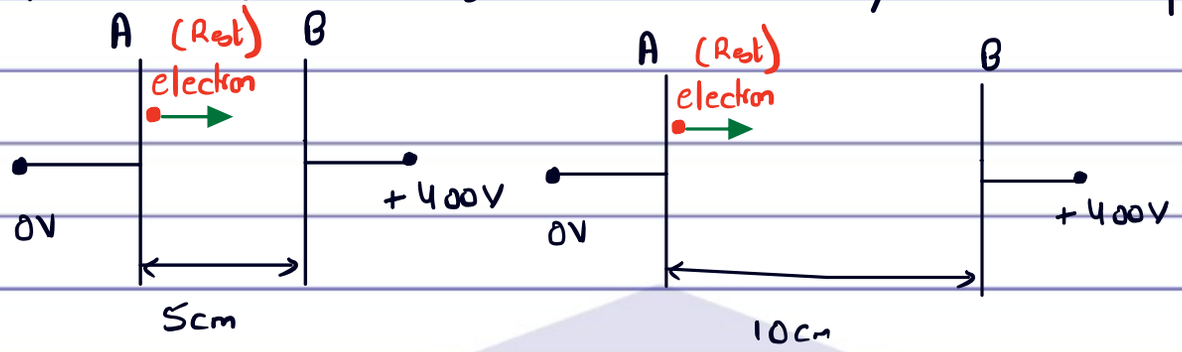
Momentum $= \sqrt{2qmV}$

Since Voltage V = constant ∴ momentum depends upon the product of mass & charge i.e momentum $\propto \sqrt{m \times q}$

Topic: _____ ⇒ Calcium will have greatest momentum Date: _____

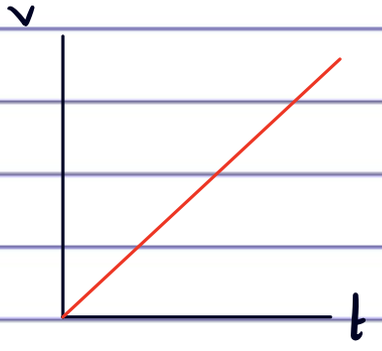
$Na = \sqrt{23 \times 1}$ $Ca = \sqrt{40 \times 2}$ $\propto = \sqrt{4 \times 2}$ $C^- = \sqrt{\frac{1}{1840} \times 1}$

v) The distance b/w the two plates A and B is now doubled ie from 5cm to 10cm suggest what happens to the final velocity of the electron if it now travells b/w the two plates.



$V = \sqrt{\frac{2qV}{m}}$ → Velocity depends upon voltage, q, and mass since it does not depend upon the distance b/w the plates final velocity remains unchanged.

vi) Sketch the following graphs for the electron moving from one plate to the other



gradient = acceleration

$F = Eq$

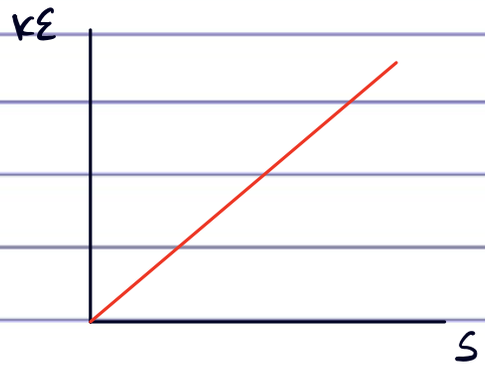
F = constant

$F = ma$

a = constant

(straight line)

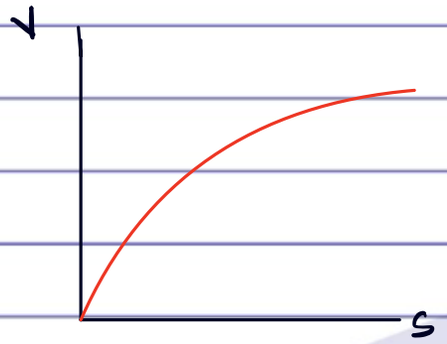
Topic: _____ Date: _____



$KE = WD = F \times s$

If F constant

$KE \propto s$



$v^2 = u^2 + 2as$

Since u is zero

$v^2 = 2as$

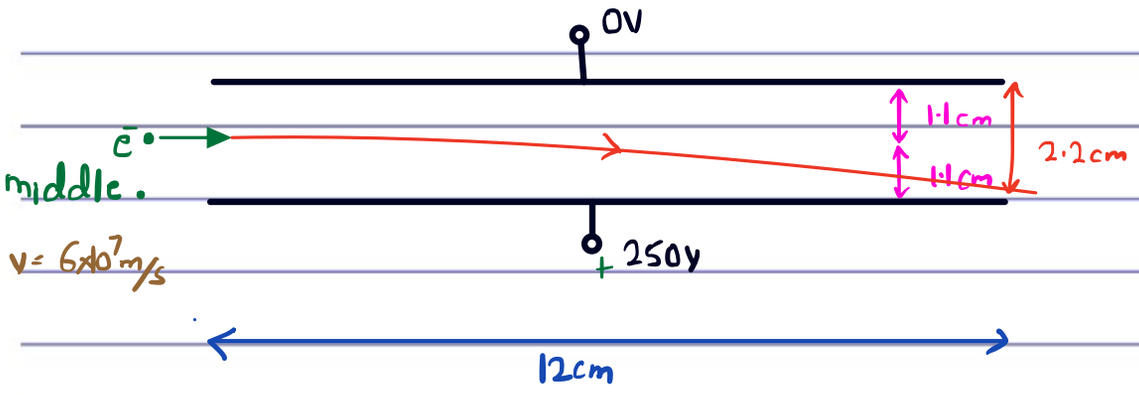
$v^2 \propto s$

{ distance increase at a much faster rate then velocity }

If velocity in doubled s will increase by a factor of 4

Topic: Electric Field Date:

Half projectile motion for a charged particle in an Electric field.



$m_e = 9.11 \times 10^{-31}$ kg

$q_e = -1.6 \times 10^{-19}$

(i) Calculate Electric field strength b/w the plates.

$$E = \frac{V}{d} = \frac{250}{2.2 \times 10^{-2}} = 11000 \text{ Vm}^{-1}$$

(ii) Calculate the force on this Electron

$F = Eq$ $\quad F = 11000 \times 1.6 \times 10^{-19}$

$F = 1.8 \times 10^{-15}$ N

(iii) Calculate the Acceleration of this electron

$F = ma$ $\quad 1.8 \times 10^{-15} = (9.11 \times 10^{-31})(a)$

$a = 2 \times 10^{15}$ m/s²

* Explain why acc due to gravity is not concidered

acc due to gravity is negligible as compare to acceleration of Electric field.

Topic: _____ Date: _____

iv) Calculate the time taken by Electron to travel b/w the plates?

$d = s \times t$

$0.12 = 6 \times 10^{7} (t)$

$t = 2 \times 10^{-9}\ s$

Calculate the vertical distance travelled by the electron as it moves b/w the plates.

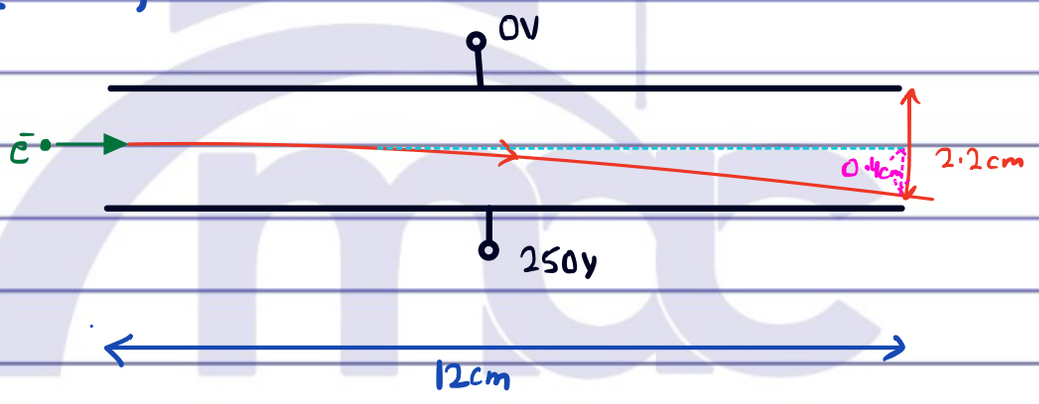
$S = ut + \frac{1}{2} at^2$

$S = \frac{1}{2} (2 \times 10^{15}) (2 \times 10^{-9})^2$

$S = 0.004\ m$

l

$0.4\ cm$



Hence determine with full working weather this particle strikes the bottom plate. or Exists without striking.

1.1 = avalible space

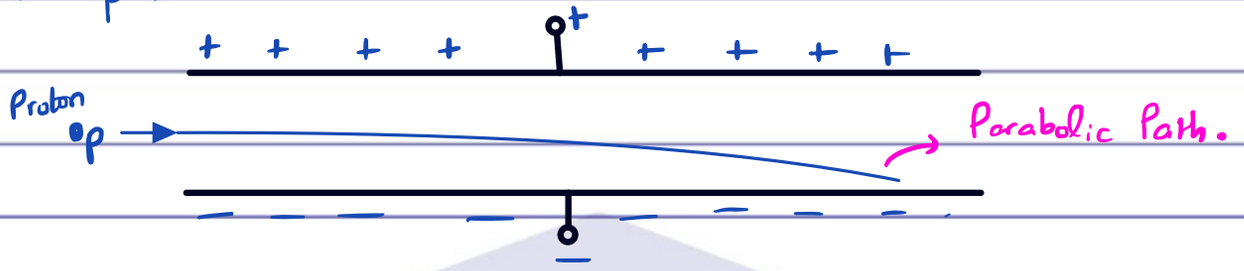
0.4 = vertical distance fallem

* Electron will exit from the other side, as it has 0.7cm remaining.

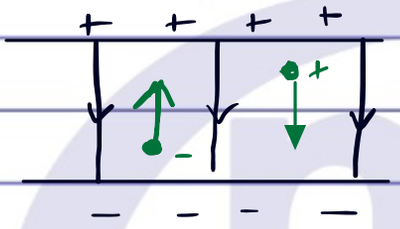
Topic: Properties of Electric Field. Date:

① Electric field is capable of applying force on a stationary charge aswell as on a moving charge.

② A moving charge in an electric field field always forms a parabolic path rather than a circular path.



③ The Force exerted by the electric field is always paralled to the field lines.



Conservation of Energy from one form to another in an Electric Field

Electricity:

Electric potential Energy ⟶ Kinetic Energy or Viseversa.

How to calculate Electric potential Energy:

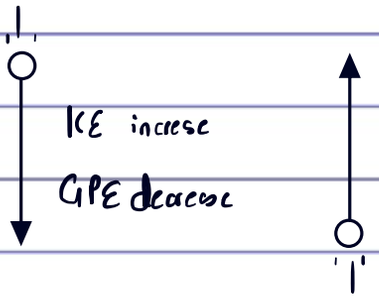
$$EPE = qV$$

$$V = \frac{W \rightarrow EPE}{q} \quad \text{(already)}$$

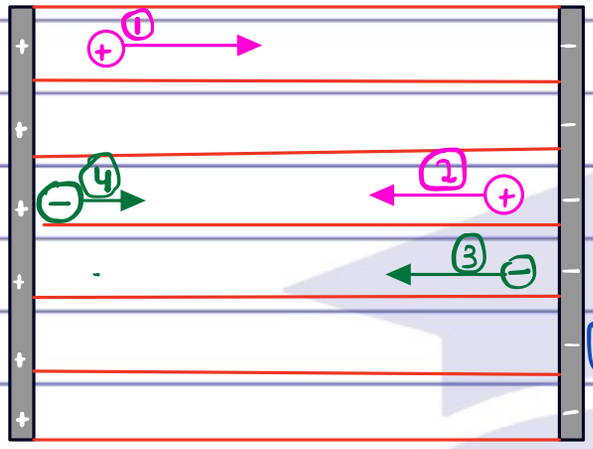
Topic: _____ Date: _____

Comparision:

Mechanics:



Electricity.

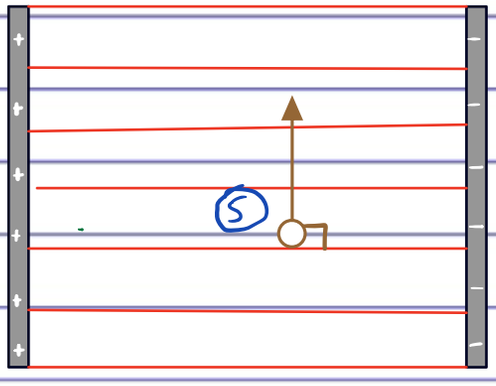


① Speed of +ve increases
KE also increases
Electric Potential Energy decreases.

② Speed of +ve decrease
KE decreases
Electric Potential Energy increases.

③ If -ve charge moves against the field speed increases
KE increases Electric potential Energy decreases.

④ If -ve charge moves in the direction of the field Speed decreases, KE also decreases and Electric potential Energy increases.

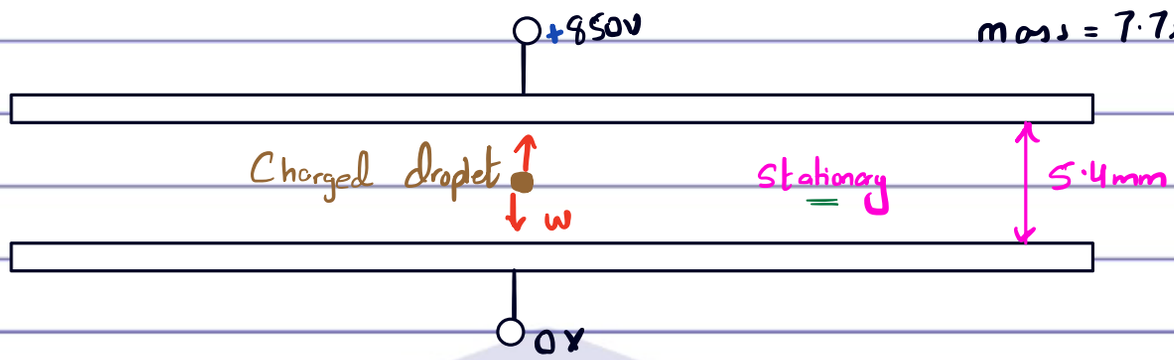


⑤ If charge is moving perpendicular to the field lines then $\Delta EPE / W_{Done} = 0$

Topic: _____ Date: _____

Quantisation of charge:

Example: The diagram below shows a charged particle b/w two metal plates A and B



(a) Suggest & Explain weather the charged particle is +vely charged or -vely charged if we want to maintain its stationary position.

Answer: Weight of the droplet will act downwards so for keeping it stationary Electric force must act upwards hence droplet will be negatively charged.

b) Hence calculate the magnitude of the charge on this droplet?

$W = F_E$

$mg = Eq$

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

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

Charge on electron: 1.6×10^{-19} C

The value of q should be a multiple of 1.6×10^{-19}

For eg = 3.2×10^{-19}, 4.8×10^{-19} ....

* you can only provide electrons in whole numbers.

Topic: _____ Date: _____

$$q = \frac{(7.7\times10^{-15})\left(\frac{5.4}{1000}\right)(9.81)}{850} \Rightarrow q = 4.8\times10^{-19}\,C$$

This idea that charges exist as integer multiples of the elementary charge is known as quantization.

Q) What is the meaning of term "Quantization"?

It means that charges exist as integer multiples of the Elementary charge where the term elementary charge refers to the charge of an electron ie $1.6\times10^{-19}C$

Topic: _____ Date: _____

Coloumb's law of Electrostatics: According to the law, the electrostatic force of attraction or repulsion is known to be directly propotional to the product of these charges and inversly propotiond to the square of distance b/w them.

$$F \propto \frac{Q_1 Q_2}{r^2} \rightarrow \boxed{F = \frac{k Q_1 Q_2}{r^2}} \quad (1) \qquad k = \frac{1}{4\pi \varepsilon_0}$$

ε_0 = Permitivity of free space.

$\varepsilon_0 = 8.85 \times 10^{-12}$ Fm^{-1}

Fm^{-1} = Farad per meter.

Find formula: $\boxed{F = \frac{Q_1 Q_2}{4\pi \varepsilon_0 r^2}}$

This is preffered.

Difference b/w F_G and F_E

F_G = only attractive

F_E = both attractive and repulsive

F_G = Acts on masses

F_E Acts on Charges.

Calculate Electrostatic Force b/w them.

$$F = \frac{Q_1 Q_2}{4\pi \varepsilon_0 r^2} \Rightarrow F = \frac{(8 \times 10^{-6})(6 \times 10^{-6})}{4\pi (8.85 \times 10^{-12})(0.07)^2}$$

Formula is only meant to give us the magnitude of the force not the direction

For direction of the force if like chages force away from each other, If Unlike charges force towards each other.

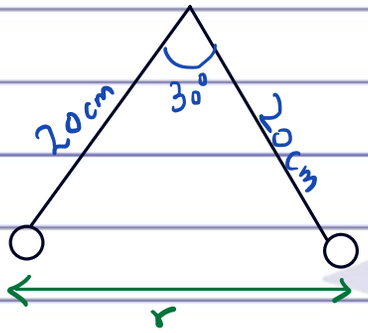
Topic: _____ Date: _____

Important Constants.

$m_p = 1.66 \times 10^{-27}\ kg$ $\quad q_p = +1.6 \times 10^{-19} C$

$m_e = 9.11 \times 10^{-31}\ kg$ $\quad q_e = -1.6 \times 10^{-19} C$

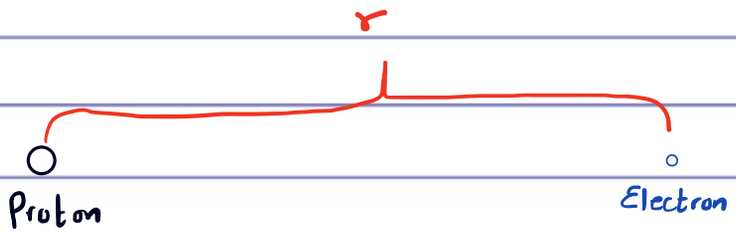
Example of F_E



Two charged sphere of mass = 0.06 kg $g = 10 m/s^2$ are at rest Calculate "Q" charge on one sphere

Topic: _____ Date: _____

Example



Ratio of $F_E : F_G$ based on your answer suggest why F_G may be ignored throughout Electrostatics.

$\frac{F_E}{F_G}$ $\quad F_G = \frac{G m_p m_e}{r^2}$ $\quad F_E = \frac{e^2}{4\pi\varepsilon_0 r^2}$

$\frac{F_E}{F_G} = \frac{e^2}{4\pi\varepsilon_0 G m_p m_e}$

$G = 6.67 \times 10^{-11}$

$\varepsilon_0 = 8.85 \times 10^{-12}$

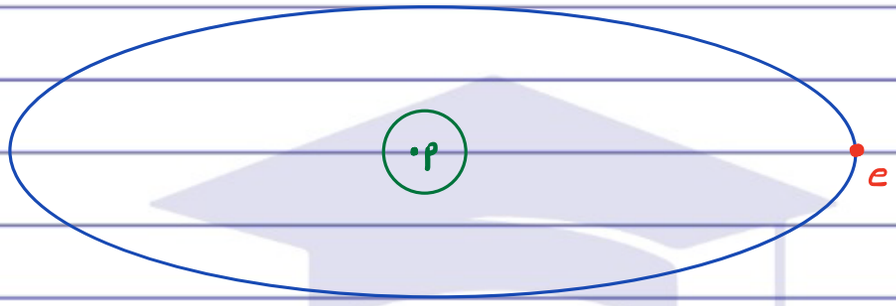
$e = 1.6 \times 10^{-19}$

$\frac{F_E}{F_G} \approx \frac{10^{39}}{1}$ Answer indicates that $F_G \ll\ll\ll\ll\ll\ll F_E$ hence can be ignored throughout Electrostatics.

Topic: _____ Date: _____

Example of How Electrostatic Force can be used in Practical Situations

Q) The diagram shows a model for Hydrogen atom it consist of one proton in the nucleus and one electron orbiting at the distance "r"



i) Calculate linear velocity (v) of the electron in its orbit Based on concept of circular motion:

$$F_E = F_C$$

$$\frac{e^2}{4\pi\varepsilon_0 r^2} = \frac{m_e v^2}{r}$$

$$v = \sqrt{\frac{e^2}{4\pi\varepsilon_0 r m_e}}$$

KE of Electron

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2}m_e v^2$$

$$KE = \frac{1}{2}m_e\left(\frac{e^2}{4\pi\varepsilon_0 r m_e}\right)$$

$$KE = \frac{e^2}{8\pi\varepsilon_0 r}$$

Topic: _____ Date: _____

Calculate angular velocity.

$$F_E = F_C$$

$$\frac{e^2}{4\pi\varepsilon_0 r^2} = m_e r \omega^2$$

$$\omega = \sqrt{\frac{e^2}{4\pi\varepsilon_0 m_e r^3}}$$

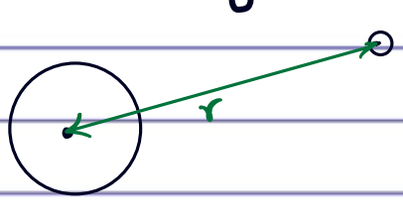
Time period: (for electron in an orbit)

$$T = \frac{2\pi}{\omega} \Rightarrow T = 2\pi\sqrt{\frac{4\pi\varepsilon_0 m_e r^3}{e^2}}$$

Concept of Electric field strength:

- A region where a charge experience an attractive force or repulsive force. (Electric field)
- Denoted by "E"
- measured in Vm^{-1} or NC^{-1}

Electric field at any point can be calculated using the equation.



Source Charge
Q

Calculate Electric field strength

$$E = \frac{k \cdot Q}{r^2}$$

SS

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

limitation

This formula only gives magnitude of the field.

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

Topic: _____ Date: _____

Direction of Electric Field.

- away from the +ve source charge.

- towards the -ve source charge

Q) Calculate Electric field strength at P?

$$E = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{20\times10^{-6}}{4\pi\varepsilon_0 (0.12)^2}$$

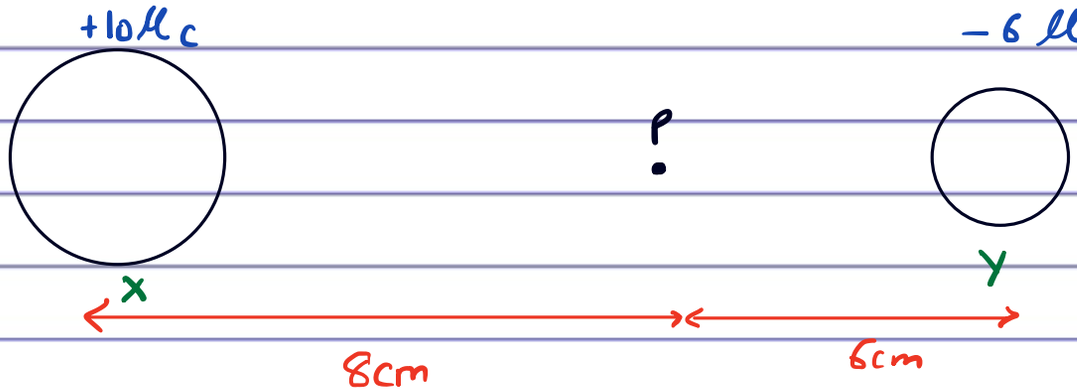
$$= 1.3\times10^{7}\ NC^{-1}$$

magnitude

Direction due east (away from +ve)

Q) Calculate the magnitude & direction of Electric Field strength at "P" due to two source charges placed at x & y

- Calculate E_p due to x



Topic: _____ Date: _____

Calculate E_p due to x

$$E_p = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{10\times10^{-6}}{4\pi(8.85\times10^{-12})(0.01)^2}$$

$$= 1.4\times10^{7}\ NC^{-1} \rightarrow$$

Calculate E_p due to Y

$$E_p = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{6\times10^{-6}}{4\pi(8.85\times10^{-12})(0.06)^2}$$

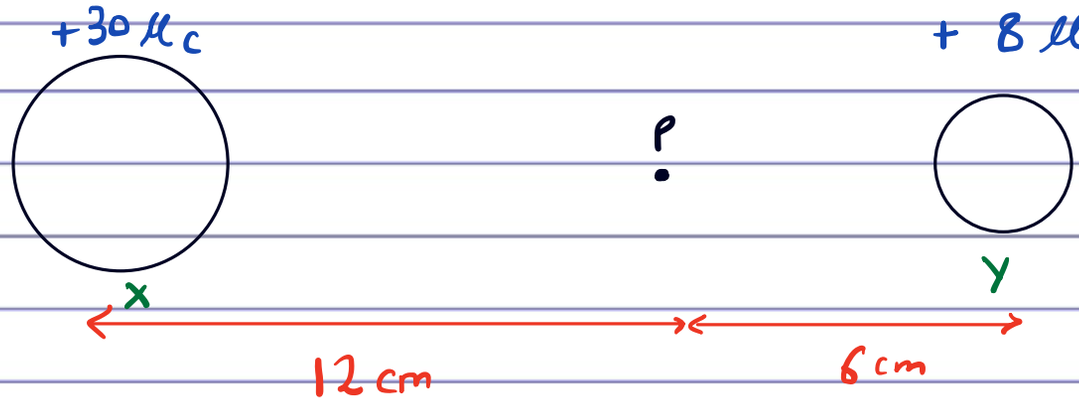
$$= 1.5\times10^{7}\ NC^{-1} \rightarrow$$

At point P the Resultant Electric Field stength due to source charges at X and Y can be obtained by vector addition of the above values.

$$E_p = 1.4\times10^{7} + 1.5\times10^{7} = 2.9\times10^{7}\ NC^{-1}$$

If Arrows are in Same direction then add
If Arrows are in opposite direction then subtract the values.

Topic: _____ Date: _____



E_p due to x

$$E_p = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{30\times10^{-6}}{4\pi\varepsilon_0 (0.12)^2} \qquad E_p = 1.9\times10^7\ NC^{-1} \rightarrow$$

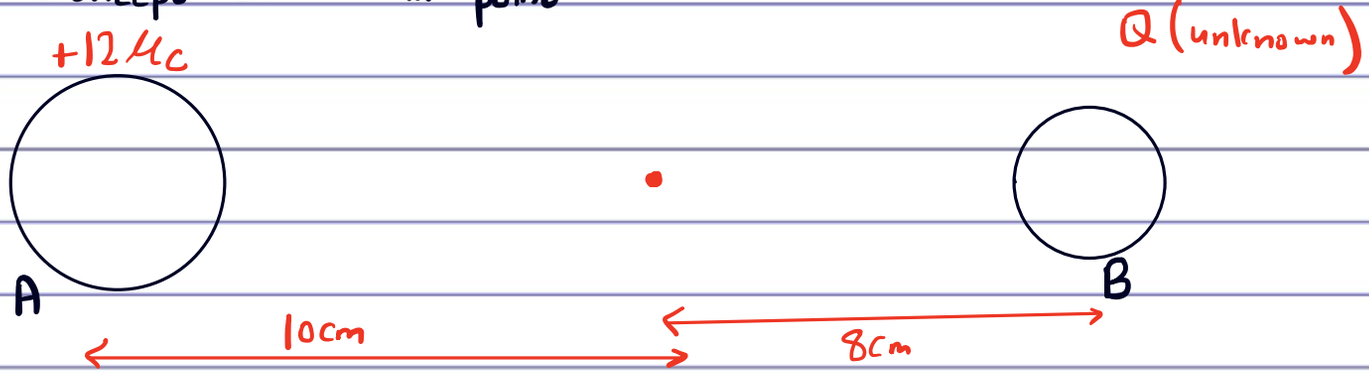
E_p due to Y

$$E_p = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{8\times10^{-6}}{4\pi\varepsilon_0 (0.06)^2} = 2.0\times10^7\ NC^{-1} \leftarrow$$

Resultant: $2.0\times10^7 - 1.9\times10^7 = 0.1\times10^7\ NC^{-1} \leftarrow$

Topic: _____ Date: _____

Concept of Null point



Calculate Q if P is a null point (Resultant $\mathcal{E} = 0$)

at Null pt $\mathcal{E}$ (due to A) = $\mathcal{E}$ (due to B)

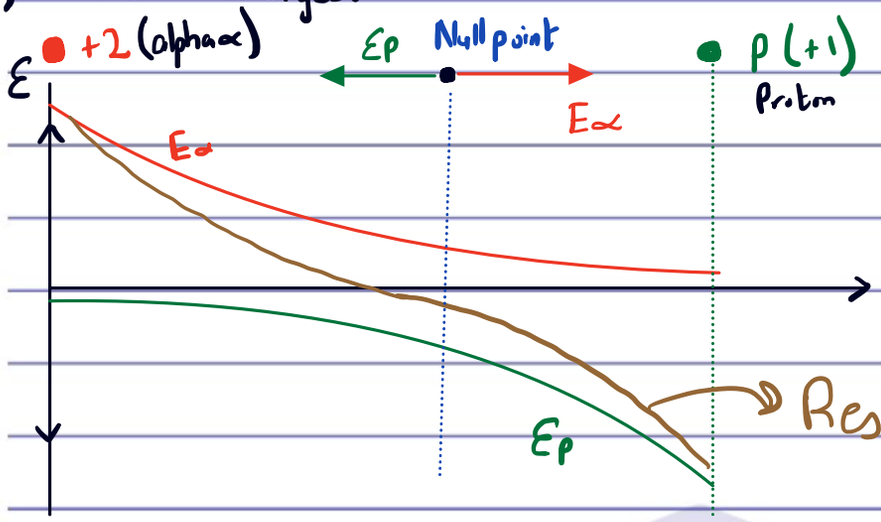
$$\frac{12\,\mu C}{4\pi\varepsilon_0 (0.1)^2} = \frac{Q}{4\pi\varepsilon_0 (0.08)^2}$$

$$Q = 7.7\,\mu C \quad \text{Answer.}$$

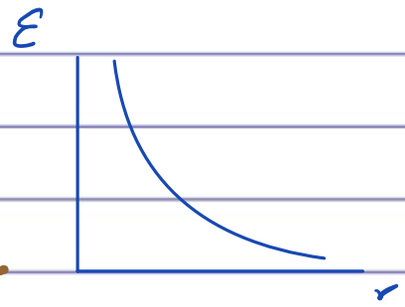
Topic: _____ Date: _____

How can we construct graphs of $\mathcal{E}$ vs r for

i) like Charges.



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



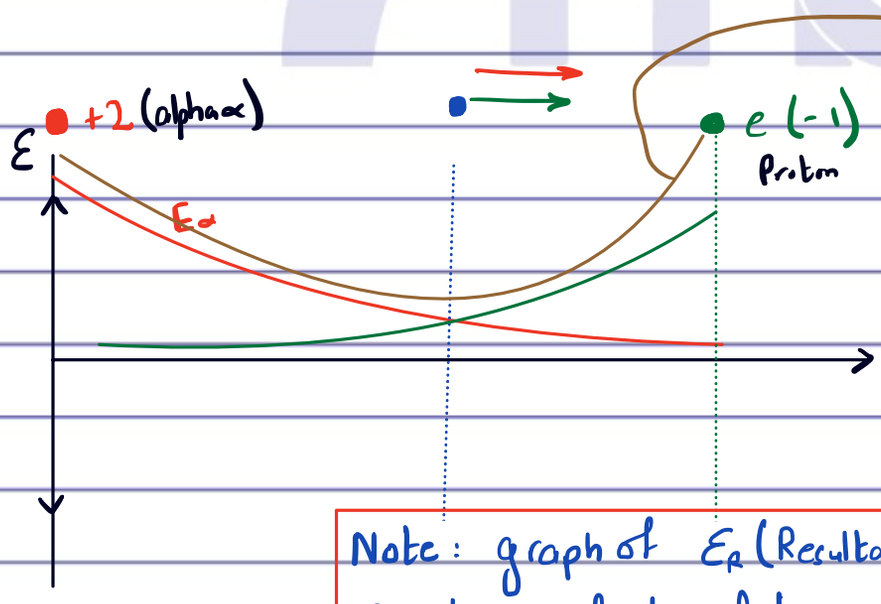
resultant Electric field strength

Note

direction of $\mathcal{E}_\alpha$ (alpha) = right

direction of $\mathcal{E}_p$ (proton) = left

opposite direction of Electric field hence graph have opposite signs.



Direction of $\mathcal{E}_\alpha$ = right

Direction of $\mathcal{E}_c$ = right

Same direction of Electricfield

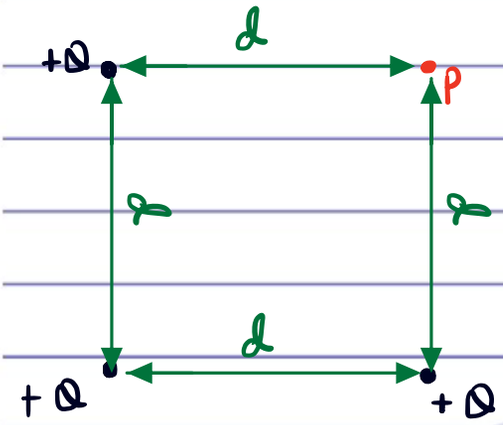
∴ graphs will have same signs.

Note: graph of $\mathcal{E}_R$ (Resultant Electric field strength) can be used to determine weather charges are like or unlike.

Topic: _____ Date: _____

Q) Calculate resultant Electric field Strength at Point P.

Q)

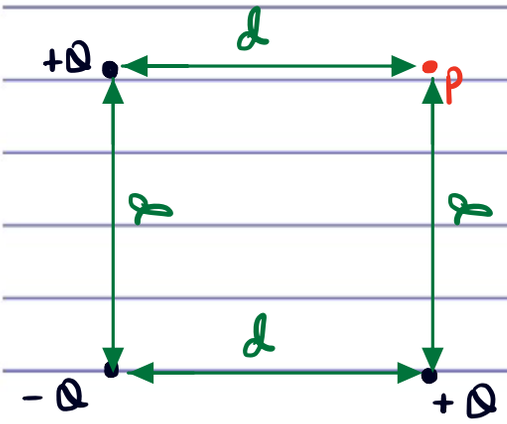


let a be $\frac{Q}{4\pi\varepsilon_0 d^2}$

Topic: _____ Date: _____

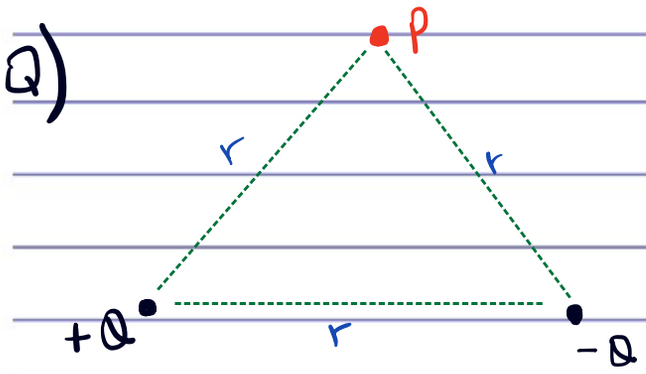
Q) Calculate resultant Electric field Strength at Point P.

Q)

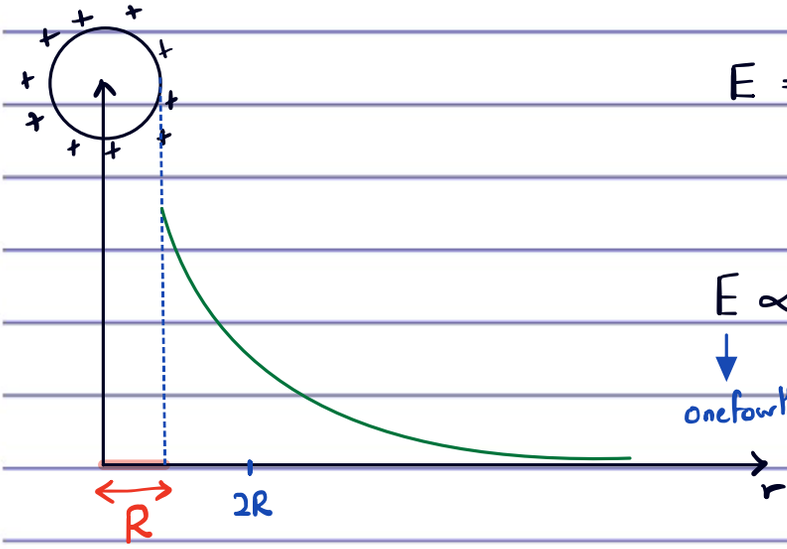


Topic: _____ Date: _____

Q)



Graph of Electric Field Strength ($\mathcal{E}$) varies with distance(r) for a hollow charged sphere.



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

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

onefourth

double

Hollow sphere means no charge inside. no charge means no Electric field hence E = 0

Topic: _____ Date: _____

Concept of Electric Potential.

Symbol = V

Units = JC^{-1}

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

Gravitational Potential.

ϕ

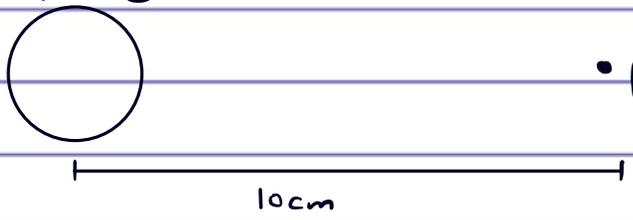
Jkg^{-1}

$$\phi = -\frac{GM}{r}$$

Sign was taken into account

Note: The negative sign in ϕ implies that signs were taken into consideration while calculating gravitational Potential hence, while calculating Electric potential V as well, the sign of source charge will be taken into account.

Example 1:



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

$$= \frac{+12\times10^{-6}}{4\pi(8.85\times10^{-12})(0.1)}$$

$$+ 1.1\times10^{6}\ JC^{-1}$$

Topic: _____ Date: _____

Q2)

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

$$V = \frac{-6\times10^{-6}}{4\pi(8.85\times10^{-12})(0.1)}$$

$$V = -5.5\times10^{5}\ JC^{-1}$$

Define Electric Potential. (V)

Amount of workdone in moving a unit (+charge) from infinity to any point within the electric field.

Suggest Why Gravitational potential Ø is always negative

As work is always done by the field in moving the mass towards the source mass.

From the above calculation we have established by Electric Potential (V) Can either be +ve or negative (because sign of charge is always considered)

Positive answer implies work is done against the electric field in moving a unit +ve charge from infinity to any point.

Where as

Negative answer implies work is done by the field itself in moving a unit charge from infinity to any point.

Topic: _____ Date: _____

Similarities and Differences b/w gravitational Potential Ø and electric potential (V)

Similarity

* Both have value of zero at infinity.
* Both involve concept of workdone

Differences.

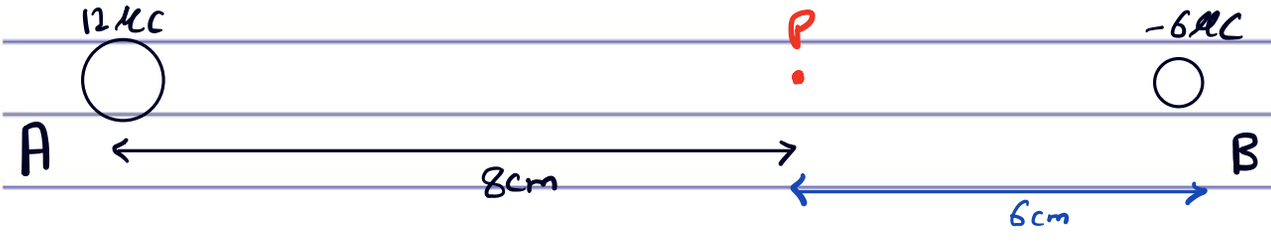
* one involves mass, other involves charge.
* Ø is only attractive and V can be attractive or repulsive.

How to calculate Electric Potential V due to multiple charges.

Step 1 : Calculate Electric Potential due to one charge at a time using

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$ (Taking sign in account)

Step 2 : Finally add all your individual answer to get the resultant.



Topic: _____ Date: _____

$V_A = \frac{+12 \times 10^{-6}}{4\pi\varepsilon_0 (0.08)} = +1.4 \times 10^6 \ JC^{-1}$

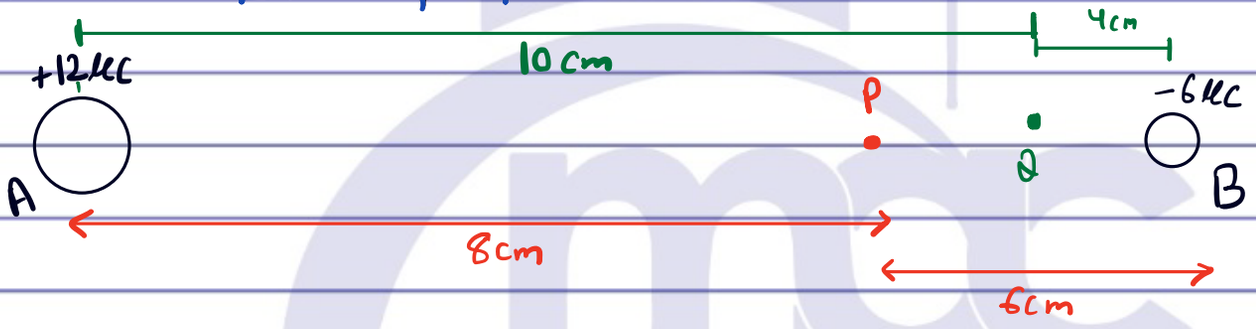
$+$

$V_B = \frac{-6 \times 10^{-6}}{4\pi\varepsilon_0 (0.06)} = -0.9 \times 10^6 \ JC^{-1}$

$0.5 \times 10^6 \ JC^{-1}$

How to calculate change in Electric Potential

* Symbol ΔV
* also called as potential difference.
* Formula = $\Delta V = V_f - V_i$



Calculate the Potential from Q to P

Step 1: Calculate V_P

$V_A = \frac{+12 \mu C}{4\pi\varepsilon_0 (0.08)}$

$+$

$V_B = \frac{-6 \mu C}{4\pi\varepsilon_0 (0.06)}$

5×10^5

Step 2 Calculate V_Q

$V_A = \frac{+12 \mu C}{4\pi\varepsilon_0 (0.1)}$

$+$

$V_B = \frac{-6 \mu C}{4\pi\varepsilon_0 (0.04)}$

$V_Q = -2.7 \times 10^5$

$\Delta V = V_F - V_i$

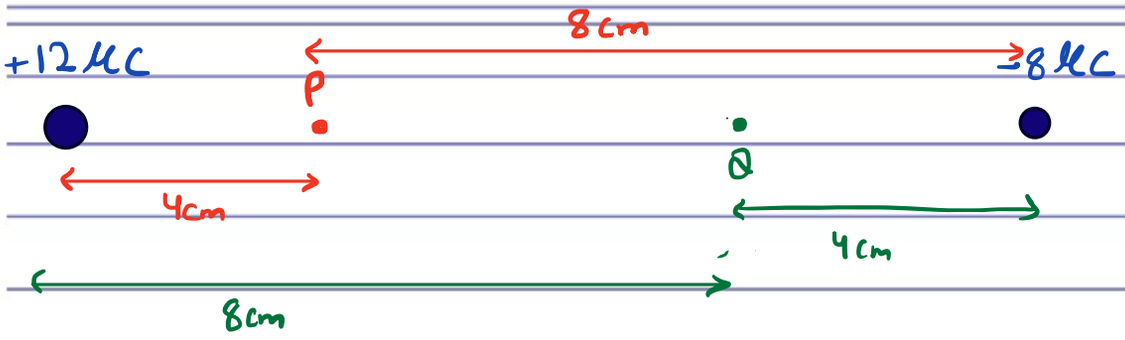
$\Delta V = V_P - V_Q$

$\Delta V = (5 \times 10^5) - (2.7 \times 10^5)$

$\Delta V = +7.7 \times 10^5 \ JC^{-1}$

This the answer implies that if 1 coulomb of charge is made to move from Q to P The work done against the field would be 7.7×10^5 J

Topic: _____ Date: _____



Calculate Potential difference from Q to P

$V_P = \frac{Q}{4\pi\varepsilon_0 r}$	$V_Q = \frac{Q}{4\pi\varepsilon_0 r}$	$\Delta V = V_P - V_Q$
$V_A = +\frac{12\times10^{-6}}{4\pi\varepsilon_0(4\times10^{-2})}$	$V_A = +\frac{12\times10^{-6}}{4\pi\varepsilon_0(8\times10^{-2}}$	$1.8\times10^6 - (-0.45\times10^6)$
$+$		$= 2.25\times10^6$ V
$V_B = -\frac{8\times10^{-6}}{4\pi\varepsilon_0(8\times10^{-2})}$	$V_B = -\frac{8\times10^{-6}}{4\pi\varepsilon_0(4\times10^{-2})}$	
$= 1.8\times10^6$ V	-0.45×10^6 V	

Calculate the amount of workdone in moving a proton from Q to P

$V = \frac{W}{q}$ $\quad W = qV$

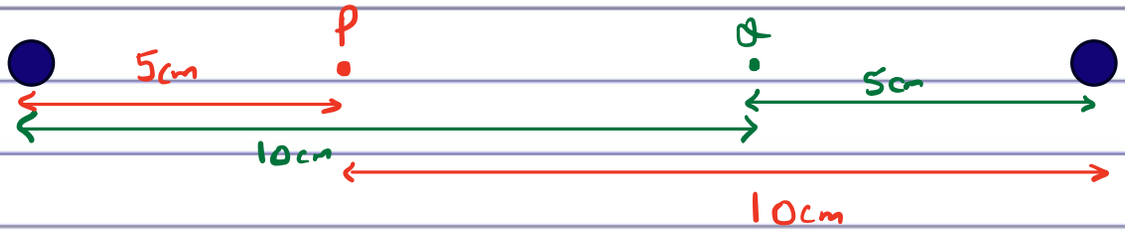
$W = (+1.6\times10^{-19})(2.25\times10^6$

$W = +3.6\times10^{-13}$ J WD is done against the field

Topic: _____ Date: _____

Q) Is it possible for Potential difference (ΔV) to ever be equal to zero

If Yes what will it signify?



Calculat ΔV

$$V_p = \frac{+8\mu C}{4\pi\varepsilon_0(0.05)} + \frac{+8\mu C}{4\pi\varepsilon_0(0.1)} = 2.16\times10^6 V \text{ or } JC^{-1}$$

$$V_a = \frac{+8\mu C}{4\pi\varepsilon_0(0.1)} + \frac{+8\mu C}{4\pi\varepsilon_0(0.05)} = 2.16\times10^6 V \text{ or } JC^{-1}$$

Answer: Yes it is possible.

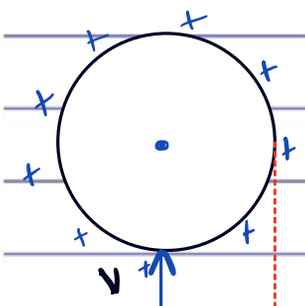
If potential at P (V_p) is equal to the potential at Q (V_Q) ie potential at Q (V_Q) i.e potential diff $\Delta V = 0$

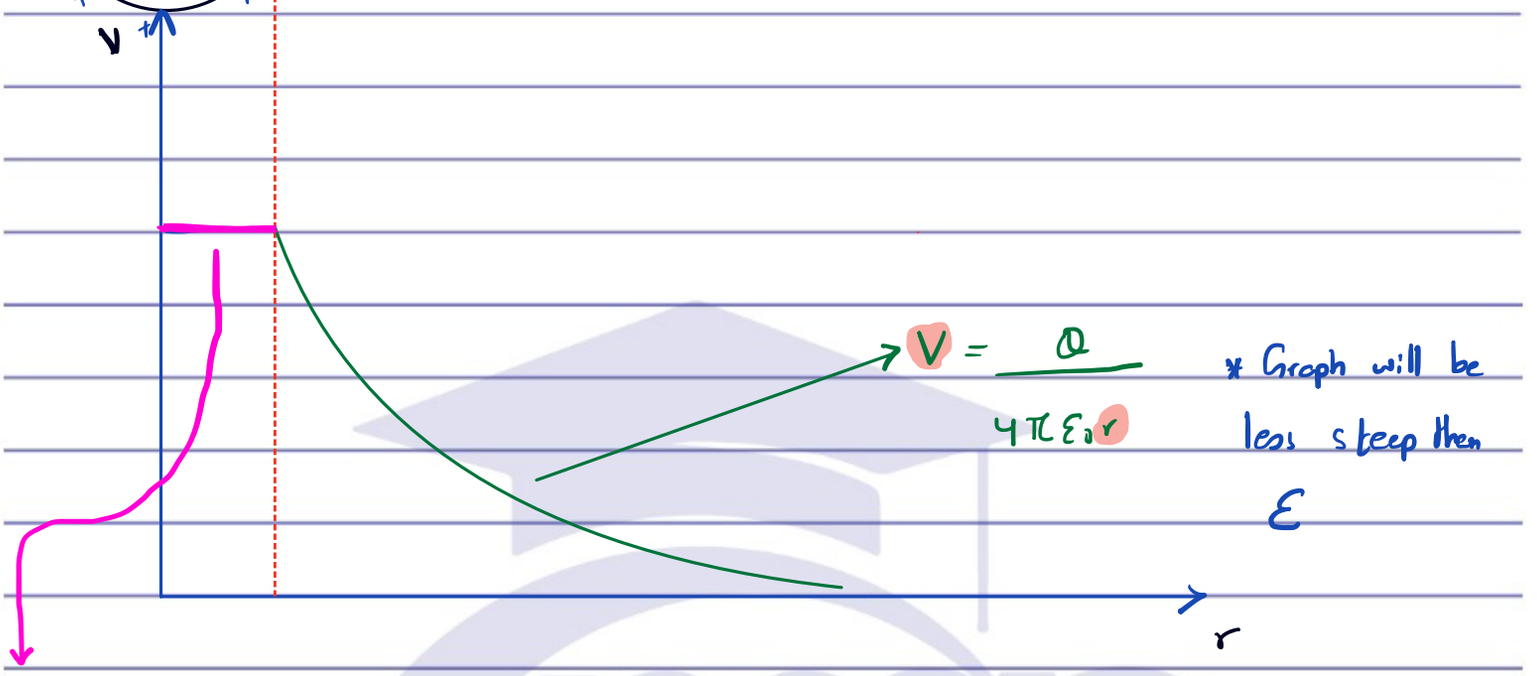
(Such points are called Equipotential points)

It signifies that no work is done in moving a unit charge b/w these points.

Topic: _____ Date: _____

Sketch the graph of Electric Potential (V) against r





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

* Graph will be less steep than E

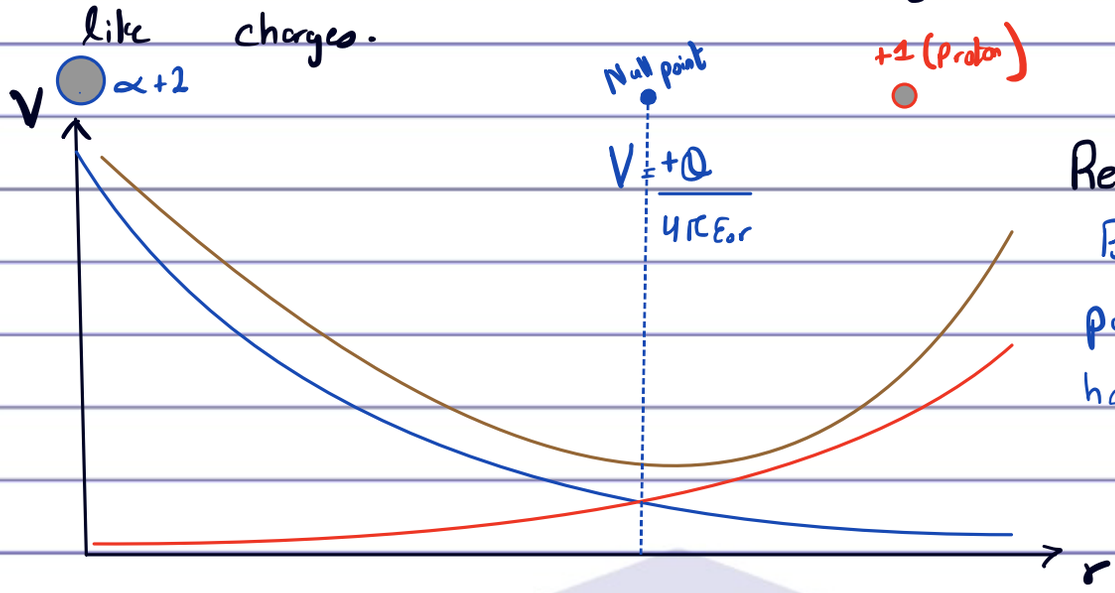
Explain:

- Hollow: ∴ Charge on the inside is zero
- No charge ∴ No field
- No field ∴ No workdone by the field & if W = 0 then all points inside the sphere can be classified to be at Equipotentials ∴ horizontal line (3 Marks)

Topic: _____ Date: _____

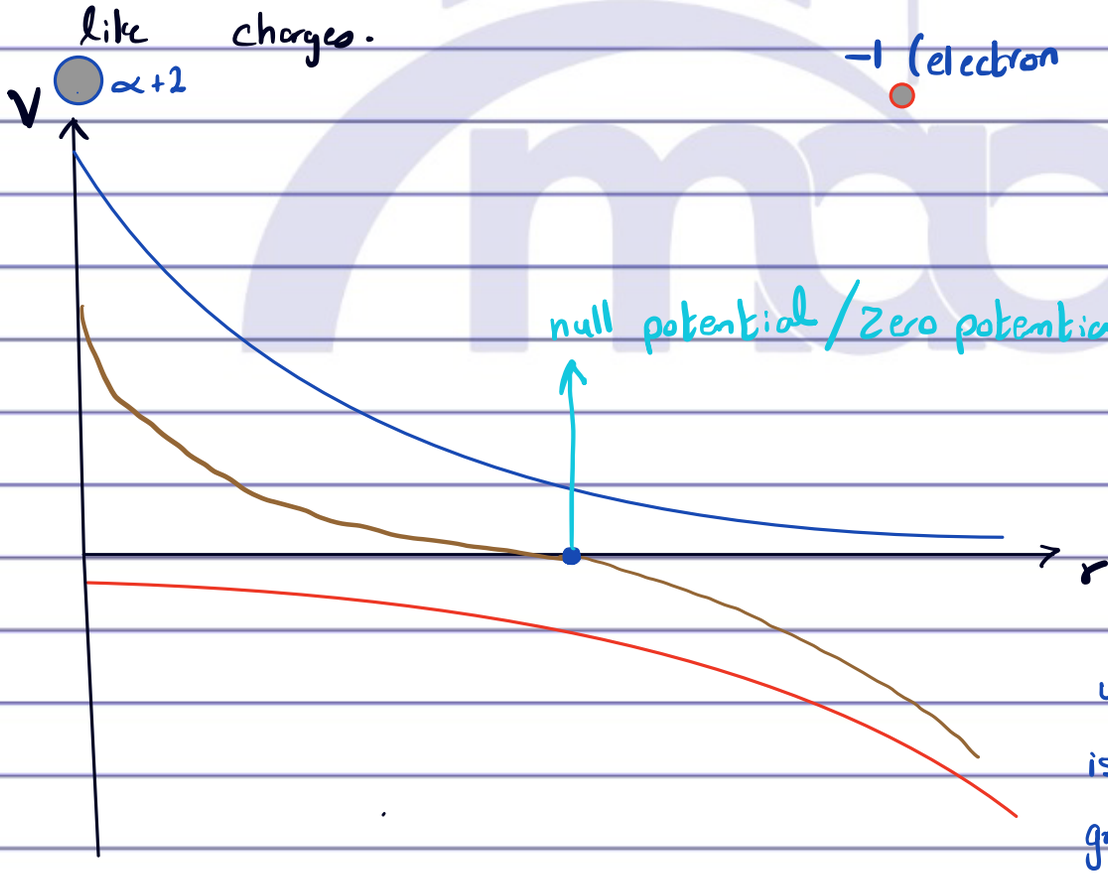
Graphs of Electric Potential (V) against distance (r) For

like charges.



Reason:
Both Potential are positive ∴ graphs have same signs.

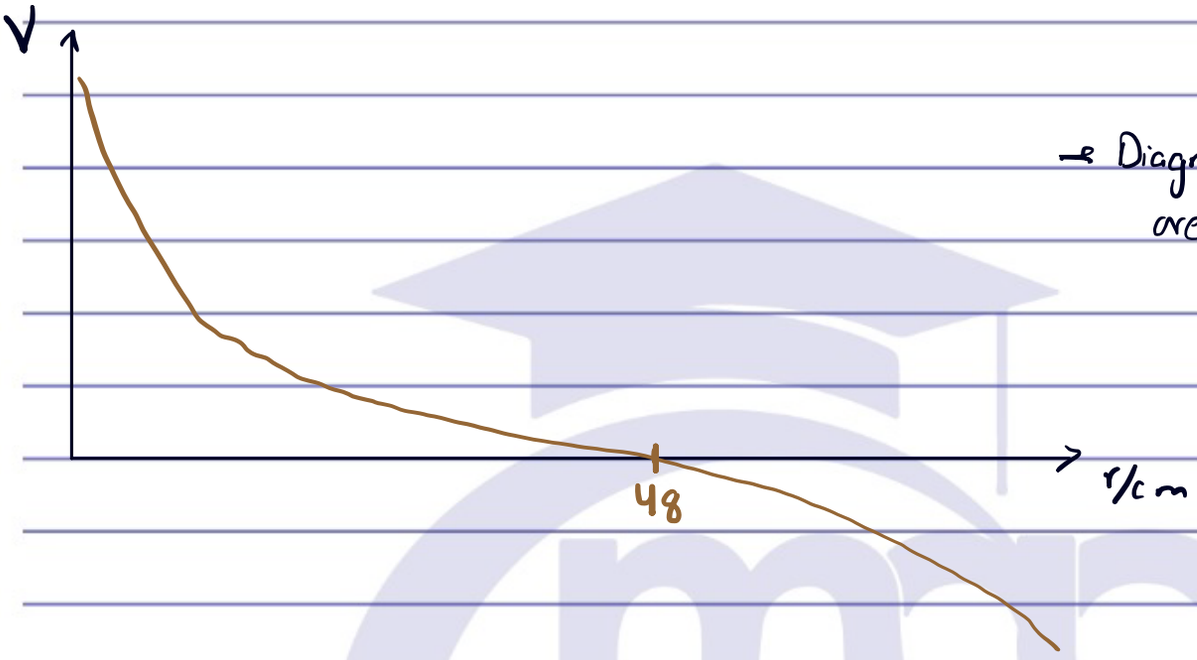
Unlike Charges



Reason:
One potential is positive while the other is negative graphs have opposite signs.

Topic: _____ Date: _____

Example of How concept of Null potential (V=0) can be used



→ Diagram and graph are both provided.

Find value of unknown charge Q

For pt x we can conclude V = 0 . This pt is 48 cm from one charge & 60 − 48 = 12 cm from the other charge. using this formula $\frac{Q}{4\pi\varepsilon_0 r}$ we can find Q as shown

$$\left(\frac{+20\,\mu C}{4\pi\varepsilon_0(0.48)}\right) + \left(\frac{Q}{4\pi\varepsilon_0(0.12)}\right) = 0$$

$$\frac{20}{0.48} = \frac{-Q}{0.12}$$

$$\boxed{Q = -5\,\mu C}$$

Topic: _____ Date: _____

Relationship b/w Electric Field Strength and Electric Potential.

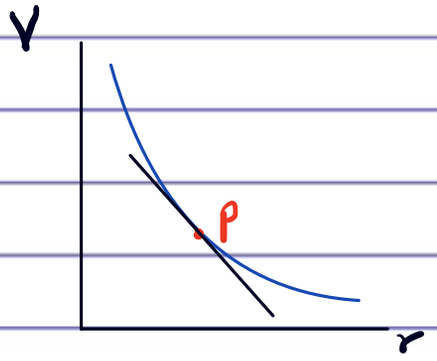
$$E = \frac{Q}{4\pi\varepsilon_0 r^2} \qquad V = \frac{Q}{4\pi\varepsilon_0 r}$$

Using differentiation we can established the following relationship.

$$V = \frac{Q}{4\pi\varepsilon_0 r} \qquad \frac{dV}{dr} = -\frac{Q}{4\pi\varepsilon_0 r^2}$$

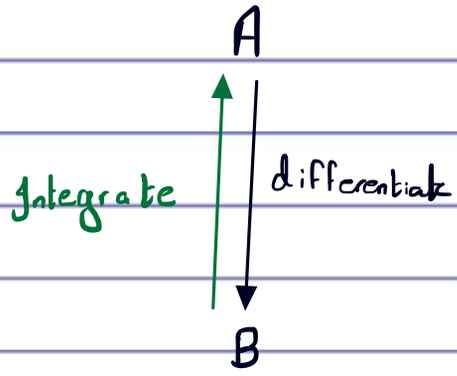
$$\boxed{\frac{dV}{dr} = -E} \qquad \boxed{E = -\frac{dV}{dr}}$$ ← gradient.

Conclusion ① Since $\frac{dV}{dr}$ refers to gradient we can say that "the negative gradient of the graph of V vs r at any point gives the value of E at that point."



Calculate E at P?

(−)grad = E.



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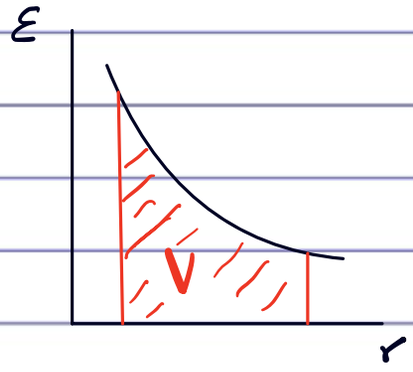
② Reverse conclusion: Using reverse principle we can conclude that "Area under the graph of $\mathcal{E}$ vs r gives the value of V



V vs r
– gradient = $\mathcal{E}$

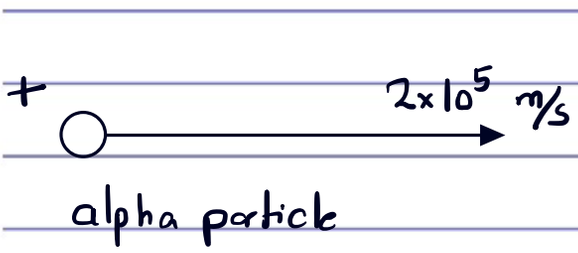
$\mathcal{E}$ vs r
Area = V

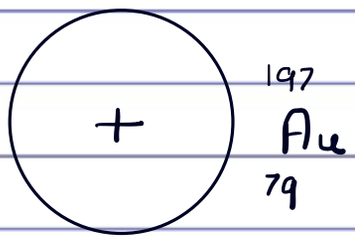
- Concept of Electric Potential Energy

Gravitational Potential Energy	Electric Potential Energy.
Symbol: U	Symbol: U
Units: J	Units: J
Formula $U = \phi \cdot m$	Formula $U = V \cdot q$
$U = \frac{-GM}{r} \cdot m$	$U = \frac{1}{4\pi\varepsilon_0 r} q \Rightarrow \frac{Qq}{4\pi\varepsilon_0 r}$
$U = \frac{-GM_m}{r}$	Signs of Charge must be considered.

Topic: _____ Date: _____

Application of Above Formula.





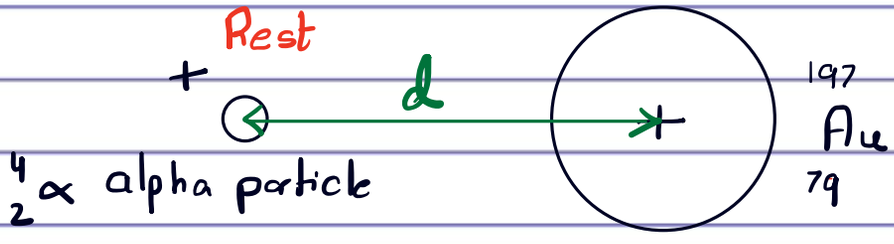
Stationary gold nucleus.

$^4_2\alpha$

As α moves towards gold nucleus Force of repulsion b/w like charges will decrease the speed of α particle ie there will be a loss in its KE. Based on Electrostatics we can say

> Loss in KE = Gain in Electric Potential Energy. (U)

At one pt its KE will become zero; hence the α particle will stop at that point and then be repelled. backward as shown.



$^4_2\alpha$ alpha particle

KE = 0

KE → EPE

Stationary gold nucleus.

d: distance of closest approach.

Topic: _____ Date: _____

Calculate value of d ?

$$1u = 1.66 \times 10^{-27}$$
$$1e = 1.67 \times 10^{-19} C$$
$$\varepsilon_0 = 8.85 \times 10^{-12}$$

Loss in KE = Gain in EPE

$$\frac{1}{2} m_\alpha v_\alpha^2 = \frac{Q q}{4\pi\varepsilon_0 d}$$

$$\frac{1}{2} \times 4u \times (2 \times 10^5)^2 = \frac{(+79e)(+2e)}{4\pi\varepsilon_0 d}$$

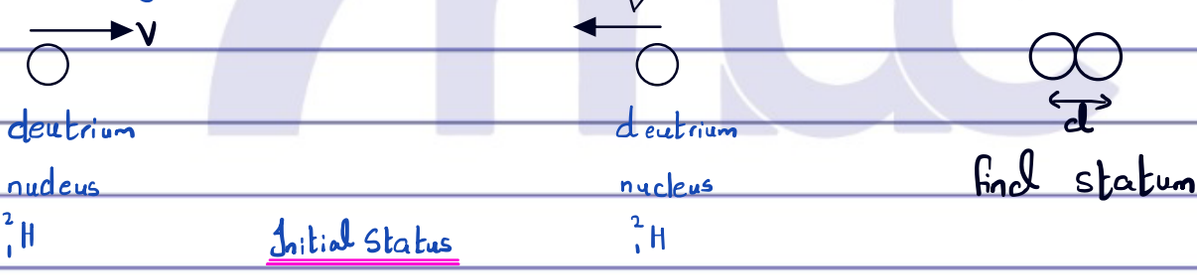
Simplify to get d.

$$d = 2.7 \times 10^{-10} m$$

What if the initial speed of alpha particle was higher than the above stated value, what would have happened?

The value of d will decrease until a point when 2 nuclic will fuse togeather i.e Nuclear fusion will take place.

Q2)



find the minimum speed v required for them to fuse togeather given that radius of dutrium is $1.9 \times 10^{-14} m$

Loss in KE = Gain in EPE

Topic: _____ Date: _____

$$2\left(\frac{1}{2}mv^2\right) = \frac{Q \times Q}{4\pi\varepsilon_0 r}$$

$$(2u)(v^2) = \frac{(+1e)(+1e)}{4\pi\varepsilon_0 (2\times 1.9\times 10^{-14})}$$

$$\boxed{v = 1.35\times 10^6 \text{ m/s}}$$

Assuming that deutrium behaves as ideal gas molecule, calculate the Temperature needed for fusion to occur?

$$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$$

$$\frac{1}{2}(2u)(1.35\times 10^6)^2 = \frac{3}{2}(1.38\times 10^{-23})T$$

$$\boxed{T = 1.5\times 10^8 \text{ K.}}$$

Topic: _____ Date: _____

Example no3

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