Formulas (similar to gravitational ones)

- $F_e = \dfrac{kQq}{r^2}$ $\qquad k = \dfrac{1}{4\pi\varepsilon_0} = 9\times10^9\ \mathrm{N\,m^2\,C^{-2}}$

ε_0: $8.85\times10^{-12}\ \mathrm{C^2\,N^{-1}\,m^{-2}}$

field strength

- $E_e = \dfrac{kQ}{r^2}$

Potential

- $V_e = \dfrac{kQ}{r}$

Potential energy

- $U_e = \dfrac{kQq}{r}$

← AKA, inverse square law of force

- Columbs law, The force between 2 point charges is proportional to product of the charges and inversely proportional to the square of the distance between them.

for point charges

$$F_e = \frac{kQq}{r^2} \qquad P \to \frac{WD}{t}$$

- Electric field strength at a point is as force per unit charge acting on the a small stationary Positive charge placed at that point.

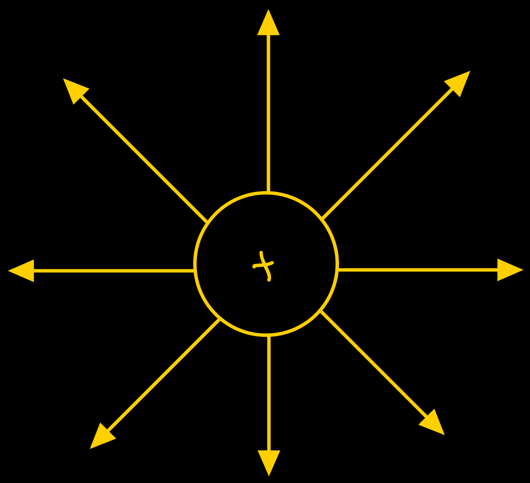
$$E_e = \frac{kQ}{r^2}$$

k can be replaced by $\frac{1}{4\pi\varepsilon_0}$

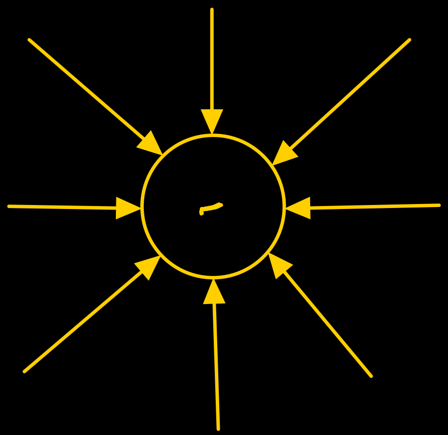
- They charges need to be isolated. keep in mind coz u are asked in 1 mark questions

- Electric field due to a point charge is radial.

- Diagram field lines.



radially out



radially in

- electric potential at a point in a electric field is the work done per unit positive test charge from infinity to the point.

$$V_q = \frac{kQ}{r}$$

Potential

- Electric potential energy is the electric potential multiplied by q

$$U_g = \frac{kQq}{r}$$

Electric fields and gravitational fields

Electric fields and gravitational fields, whilst being different in their natures, do have some features in common. These include

- Both can be represented by field lines.
- Gravitational fields are always attractive, whereas electric fields can be attractive or repulsive.
- For spherical bodies, the charge/mass on the sphere behaves as a point charge/mass at its centre.
- The field strength due to a point charge/mass follows an inverse square law with distance from the charge/mass.
- Gravitational potential is always negative, whereas electric potential can be positive or negative.
- The potential due to a point charge/mass varies inversely with distance from the charge/mass.

- For spheres to be conductive
  - Es inside sphere = 0 ← As charge cant flow inside sphere
  - Ve inside sphere = max

stationary point

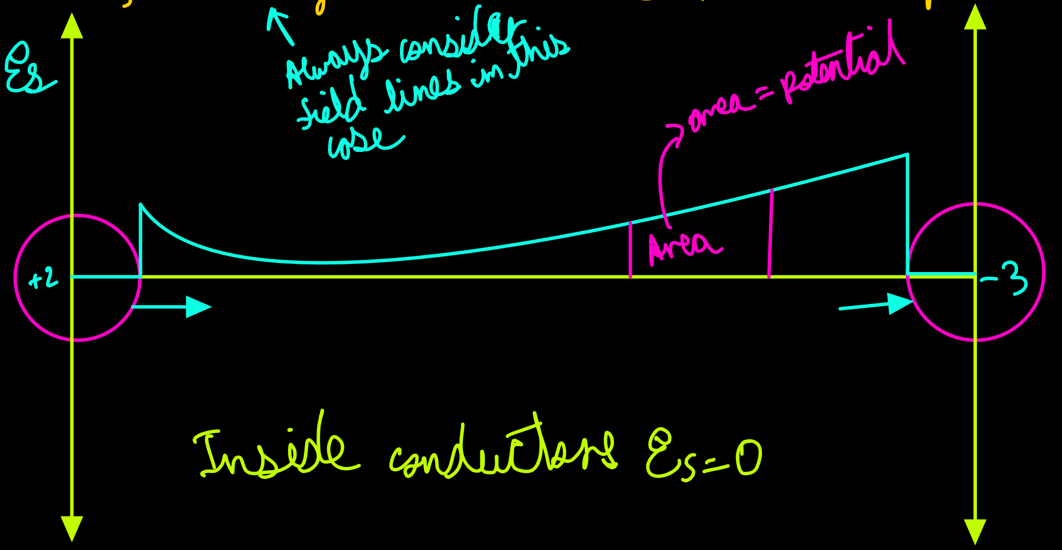
max/min

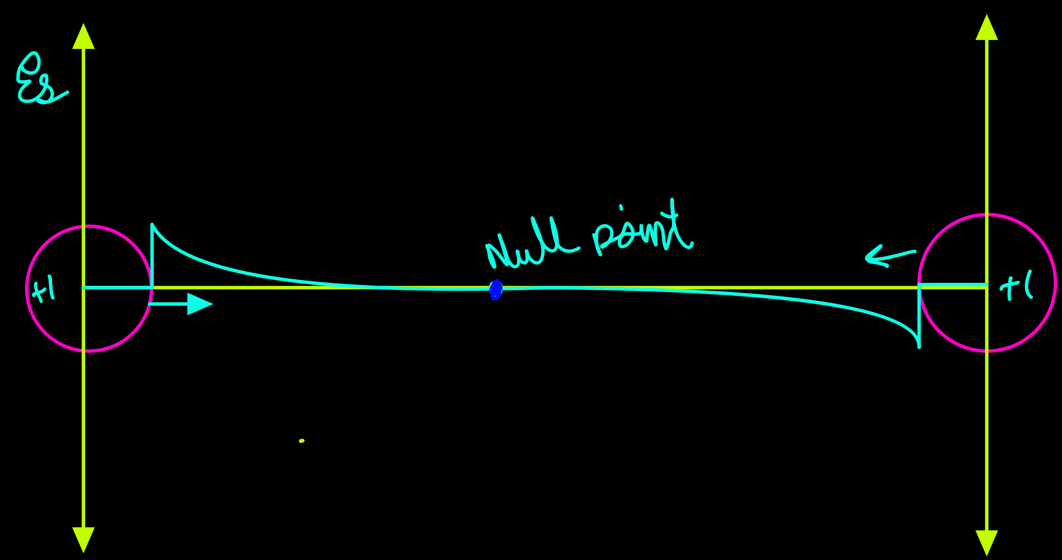
$$E_s = \frac{-dV_e}{dr} = 0 \longrightarrow V = max$$

(explain)

Graphs

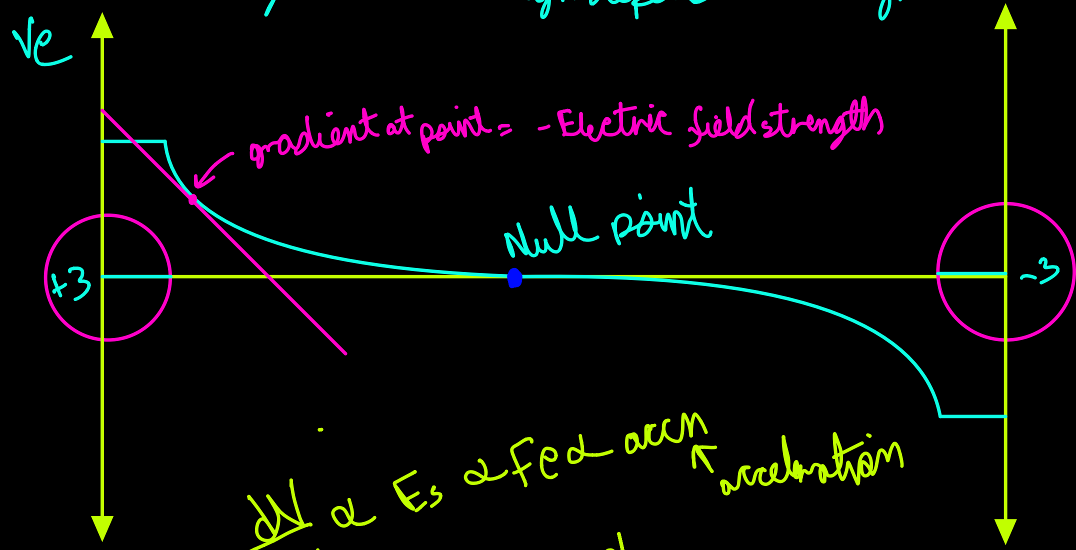
- Electric field strength vs r between 2 spheres

• 

• 

consider charge sign

- Electric Potential (when specifying) vs r between 2 spheres
  ↳ Starting position sign depends on sign



$\frac{dV}{dr} \propto E_s \propto F_e \propto$ accn ← acceleration

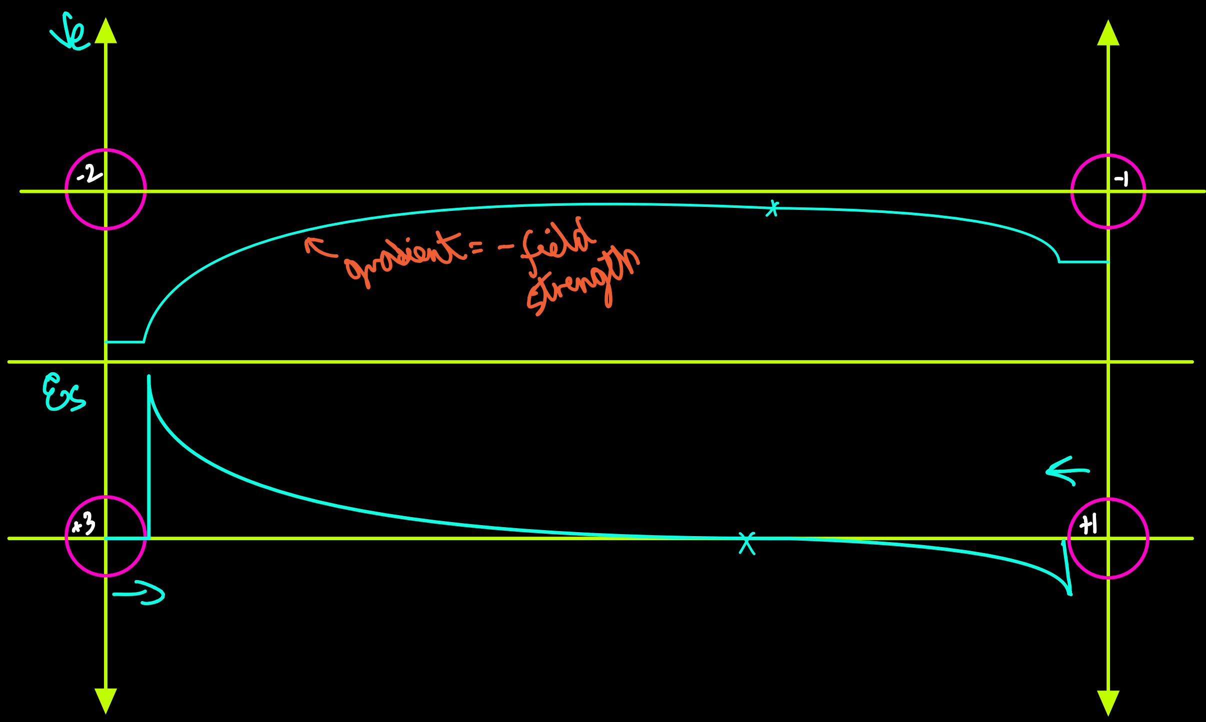
↑ gradient of potential graph

- Electric field strength inside sphere is 0
- Electric potential inside sphere is max
- Use $\Delta V \times q$ not $V \times q$ when equating it with K_e $\left(\frac{1}{2}mv^2\right)$

* Electric field strength inside a conductor is 0 because the net force on the charges inside the metal sphere is 0 and so they do not move

* Electric potential inside the conductors is maximum because $E = -\frac{dV}{dr}$ so when $\frac{dV}{dr} = 0$ (ie. inside the sphere) V is maximum.

- 1 example



Two point charges A and B each have a charge of $+6.4 \times 10^{-19}$ C. They are separated in a vacuum by a distance of 12.0 μm, as shown in Fig. 4.1.

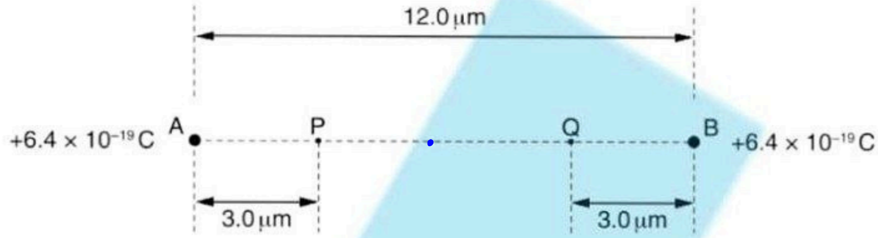


Fig. 4.1

Points P and Q are situated on the line AB. Point P is 3.0 μm from charge A and point Q is 3.0 μm from charge B.

(a) Calculate the force of repulsion between the charges A and B.

$F_E = \dfrac{KQq}{r^2} = \dfrac{9\times10^{9} \times (6.4\times10^{-19})^2}{(12\times10^{-6})^2} \quad 2.56\times10^{-17}$

force = 2.6×10^{-17} N [3]

(b) Explain why, without any calculation, when a small test charge is moved from point P to point Q, the net work done is zero.

Because WD Moving from P to Midpoint is same in magnitude but opposite in sign compared to when moving from midpoint to Q [2]

(c) Calculate the work done by an electron in moving from the midpoint of line AB to point P.

WD = WD by A + WD by B

WD by A = $\dfrac{KQq}{r} = 9\times10^{9} \times 6.4\times10^{-19} \times -1.6\times10^{-19} \times \left(\dfrac{1}{3\times10^{-6}} - \dfrac{1}{6\times10^{-6}}\right)$

$= -1.536\times10^{-22}$ J

" " B = $9\times10^{9}\times = 9\times10^{9} \times 6.4\times10^{-19} \times -1.6\times10^{-19} \times \left(\dfrac{1}{9\times10^{-6}} - \dfrac{1}{6\times10^{-6}}\right)$

$= 5.12\times10^{-23}$

$\therefore = -1.024\times10^{-22}$

work done = -1.0×10^{-22} J [4]

Two small charged metal spheres A and B are situated in a vacuum. The distance between the centres of the spheres is 12.0 cm, as shown in Fig. 4.1.

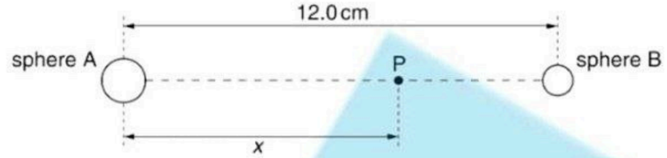


Fig. 4.1 (not to scale)

The charge on each sphere may be assumed to be a point charge at the centre of the sphere.
Point P is a movable point that lies on the line joining the centres of the spheres and is distance x from the centre of sphere A.
The variation with distance x of the electric field strength E at point P is shown in Fig. 4.2.

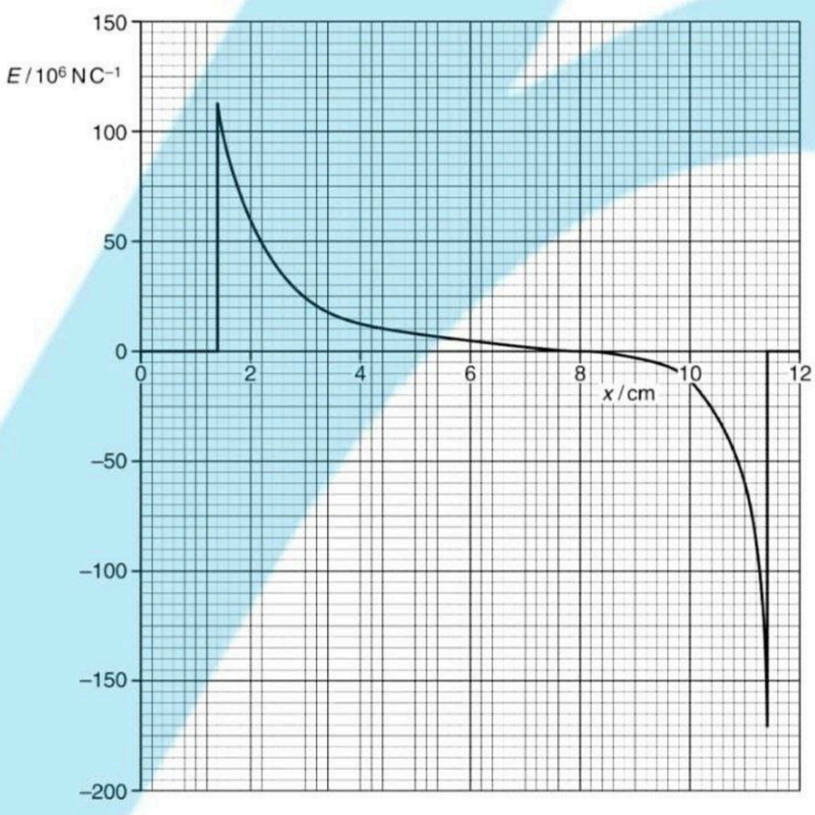


Fig. 4.2