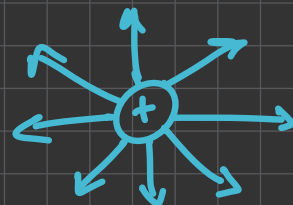


Electric fields

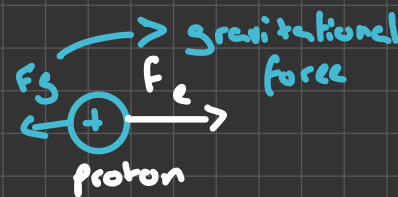
- are due to charges

- You can model a charged sphere as a point charge at its centre



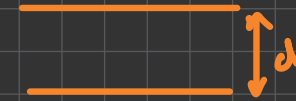
Electric fields vs Gravitational fields

electrical force



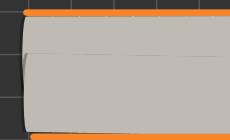
Parallel Plate Capacitors

no insulator



$$C = \frac{\epsilon_0 A}{d}$$

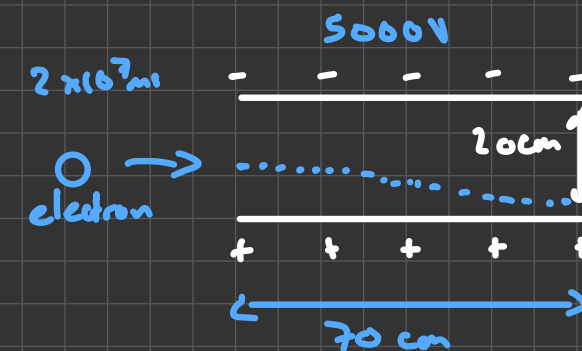
insulator of relative permittivity ϵ_r



$$C = \frac{\epsilon_r \epsilon_0 A}{d} = \frac{\epsilon A}{d}$$

$$\epsilon = \epsilon_r \times \epsilon_0$$

In the vertical direction:
The electron will experience an acceleration as soon as it enters the field



$$F = EQ$$

In the horizontal direction: $ma = EQ$

The electron will keep travelling at a constant velocity

$$ma = \frac{v}{d} Q \quad a = \frac{5000 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31} \times 0.2}$$

$$a = \frac{v Q}{md} \quad a = 4.4 \times 10^{15} \text{ ms}^{-2}$$

Calculate the speed of the electron as it leaves the plate

$$L = v_H \times t \quad t = \frac{L}{v_H} = \frac{0.70}{2.0 \times 10^7} = 3.5 \times 10^{-8} \text{ s}$$

$$v_y = \frac{1}{2} a t^2 = 4.4 \times 10^{15} \times 3.5 \times 10^{-8} = 1.5 \times 10^8 \text{ ms}^{-1}$$

Pythagoras:

$$v = \sqrt{v_y^2 + v_x^2} = \sqrt{(2 \times 10^7)^2 + (1.5 \times 10^8)^2} = 1.51 \times 10^8 \text{ ms}^{-1}$$

Electric Fields Chapter 22

Electric Fields

- can be attractive or repulsive

- Field strength:
 $E = F/d = Q/4\pi\epsilon_0 r^2$

- Force:

$$F = \frac{Qq}{4\pi\epsilon_0 r^2}$$

Gravitational Fields

- always attractive

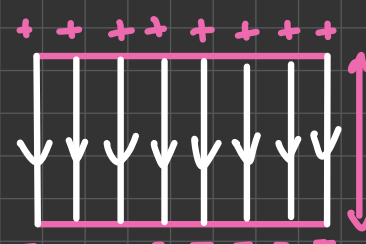
- Field strength:
 $g = F/M = -GM/r^2$

- Force:

$$F = -\frac{GMm}{r^2}$$

Both inversely proportional to r^2

Electric field between 2 parallel plates



$d \rightarrow$ distance between plates

$$E = \frac{F}{Q} = E = \frac{VQ/d}{Q}$$

$$W = Fd$$

$$W = VQ$$

$$Fd = VQ \rightarrow F = \frac{VQ}{d}$$

Only applies for uniform fields

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

Field lines leave and enter surfaces perpendicularly

Field direction: positive to negative

2 like charges do not result in an electric field

the charges will repel each other

The electric field is the amount of force per unit positive charge

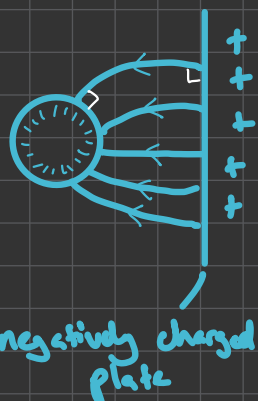
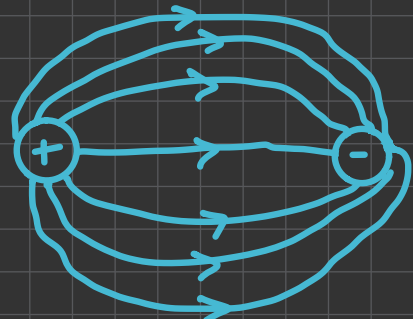
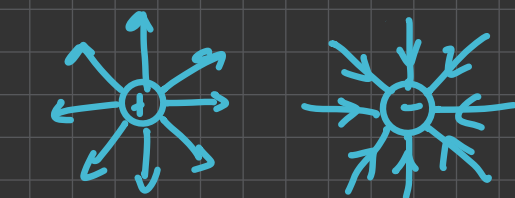
$$E = \frac{F}{Q} \rightarrow \frac{N}{C} = \text{NC}^{-1}$$

$$E = \frac{ms}{It} \rightarrow \frac{\text{kg ms}^{-2}}{\text{As}} = \text{kg ms}^{-3} \text{A}^{-1}$$

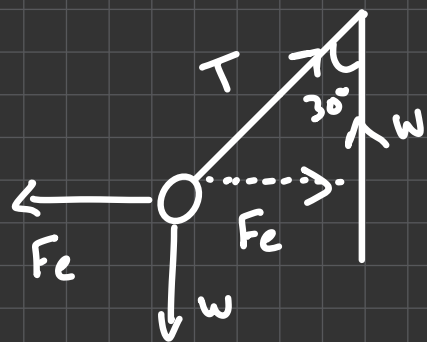
$$F = EQ$$

$$\epsilon_0 = 8.85 \times 10^{-12}$$

$$F = \frac{Qq}{4\pi\epsilon_0 r^2} \quad \text{as } E = \frac{F}{Q} \rightarrow E = \frac{Q}{4\pi\epsilon_0 r^2} \times \frac{1}{q} \rightarrow E = \frac{Q}{4\pi\epsilon_0 r^2}$$



Charged Sphere on a String



A charged ball is balanced on a piece of string and a charged wall

If the angle is 30° and the weight of the ball is 5N , find the electrostatic force between the ball and the wall

F_e = electrostatic force

$$\tan 30 = \frac{0}{1} = \frac{F_e}{W}$$

$$\tan 30 = \frac{F_e}{W} \quad F_e = W \times \tan 30$$

$$= 5 \times \tan 30$$

$$= 2.9\text{N}$$

Electric Potential and Potential Energy

$$F = \frac{Qq}{4\pi\epsilon_0 r^2} \rightarrow \text{inversely proportional to } r^2$$

$$\text{Energy} = \frac{Qq}{4\pi\epsilon_0 r} \rightarrow \text{inversely proportional to } r$$

Electric Potential is the work done in bringing a unit positive charge from infinity to a point

$$V = \frac{\text{Energy}}{q} \quad V = \frac{Q}{4\pi\epsilon_0 r}$$

The electric potential is 0 at infinity

Capacitance of a sphere

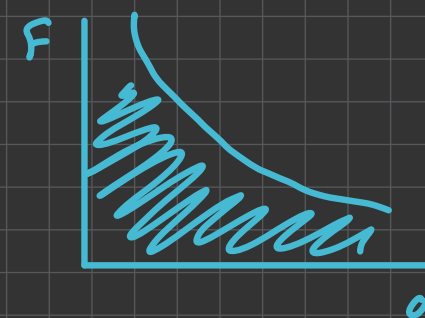
$$\text{⊖} \quad Q = CV \quad C = \frac{Q}{V} = Q \cdot \frac{1}{V}$$

$$V = \frac{Q}{4\pi\epsilon_0 r} \quad \text{so } \frac{Q}{\frac{Q}{4\pi\epsilon_0 r}}$$

$$C = \frac{4\pi\epsilon_0 r}{1}$$

$$C = 4\pi\epsilon_0 r$$

Force Distance graph



work done = ΔE

which is area under the graph