

A Level Physics A

H556/02 Exploring physics

Question Set 29

1 (a) Fig. 22.1 shows two horizontal metal plates in a vacuum.

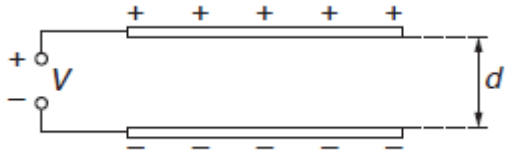


Fig. 22.1

The plates are connected to a power supply. The potential difference V between the plates is constant. The magnitude of the charge on each plate is Q . The separation between the plates is d .

Fig. 22.2 shows the variation with d of the charge Q on the positive plate.

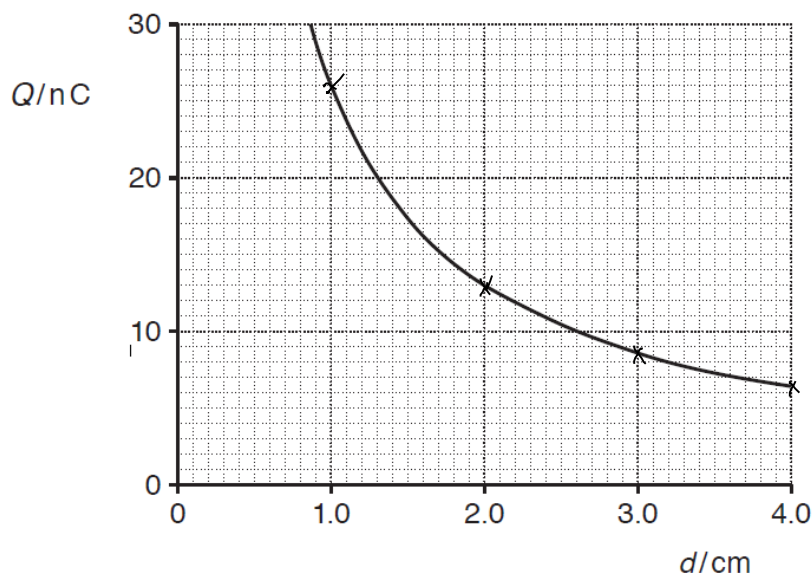


Fig. 22.2

- (i) Use Fig. 22.2 to propose and carry out a test to show that Q is inversely proportional to d .

Test proposed:

If $Q = \frac{k}{d}$ then $Qd = k = \text{constant}$. Therefore, take several points on the line and check that $Qd = \text{constant}$

Working:

Point 1 $\rightarrow 1 \times 26 = 26$
 Point 2 $\rightarrow 2 \times 13 = 26$

Point 3 $\rightarrow 3 \times 8.5 = 26$
 Point 4 $\rightarrow 4 \times 6.5 = 26$

[2]

All constant so inversely proportional ✓

- (ii) Use capacitor equations to show that Q is inversely proportional to d .

$$Q = CV \quad \text{and} \quad C = \frac{\epsilon_0 A}{d} \quad \Rightarrow \quad Q = \frac{\epsilon_0 A V}{d}$$

[2]

- (b) Fig. 22.3 shows a negatively charged oil drop between two oppositely charged horizontal plates in a vacuum.

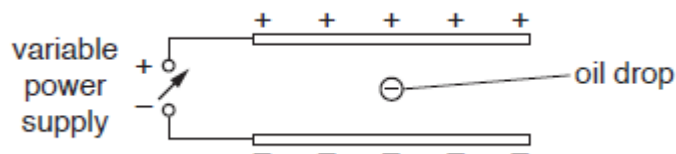


Fig. 22.3

The plates are fixed and connected to a variable power supply. The weight of the oil drop is 1.8×10^{-14} N.

- (i) The power supply is adjusted so that the potential difference between the plates is 200 V when the oil drop becomes **stationary**.

State the magnitude of the vertical electric force F_E acting on the charged oil drop.

$$F_E = \dots\dots\dots 1.8 \times 10^{-14} \dots\dots\dots \text{N [1]}$$

- (ii) The potential difference between the plates is now increased to 600 V. The oil drop accelerates upwards.

Calculate the acceleration a of the oil drop.

$$200 = \frac{F_E}{Q} \Rightarrow Q = \frac{F_E}{200} = \frac{1.8 \times 10^{-14}}{200} a = \dots\dots\dots 20 \dots\dots\dots \text{ms}^{-2} [3]$$

$$= 9 \times 10^{-17} \text{ C}$$

$$600 = \frac{F_E}{Q} \Rightarrow F_E = 600 \times 9 \times 10^{-17}$$

$$= 5.4 \times 10^{-14} \text{ N}$$

$$\text{Resultant force} = 5.4 \times 10^{-14} - 1.8 \times 10^{-14} = 3.6 \times 10^{-14} \text{ N}$$

$$F = ma \Rightarrow a = \frac{F}{m} = \frac{3.6 \times 10^{-14}}{1.8 \times 10^{-14} / 0.8} = 16$$

- (c)* Fig. 22.4 shows an arrangement used by a student to investigate the forces experienced by a small length of charged gold foil placed in a uniform electric field.

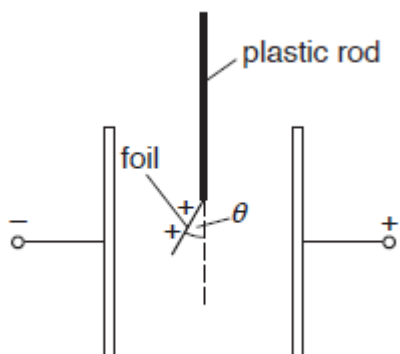


Fig. 22.4

The two vertical metal plates are connected to a high-voltage supply.

The foil is given a positive charge by briefly touching it to the positive plate.

The angle θ made with the vertical by the foil in the electric field is given by the expression

$$\tan \theta = \frac{qE}{W}$$

where q is the charge on the foil, E is the electric field strength between the plates and W is the weight of the foil.

The angle θ can be determined by taking photographs with the camera of a mobile phone.

Describe how the student can safely conduct an experiment to investigate the relationship between θ and E .

Identify any variables that must be controlled.

[6]

Electric field strength E is equal to the potential difference V between the plates. To charge the plates, we need to treat them like a capacitor. The plates will charge like $V = V_0(1 - e^{-\frac{t}{RC}})$ so to get to V_0 we need to let the plates charge for a long time. Vary the voltage of the supply and let charge for a long time to get to different values of E . For each E , record θ using a camera - make sure not to touch the plates when charged. Plot $\tan \theta$ against E : if relationship correct, then should be straight line through origin.

Total Marks for Question Set 29: 14

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