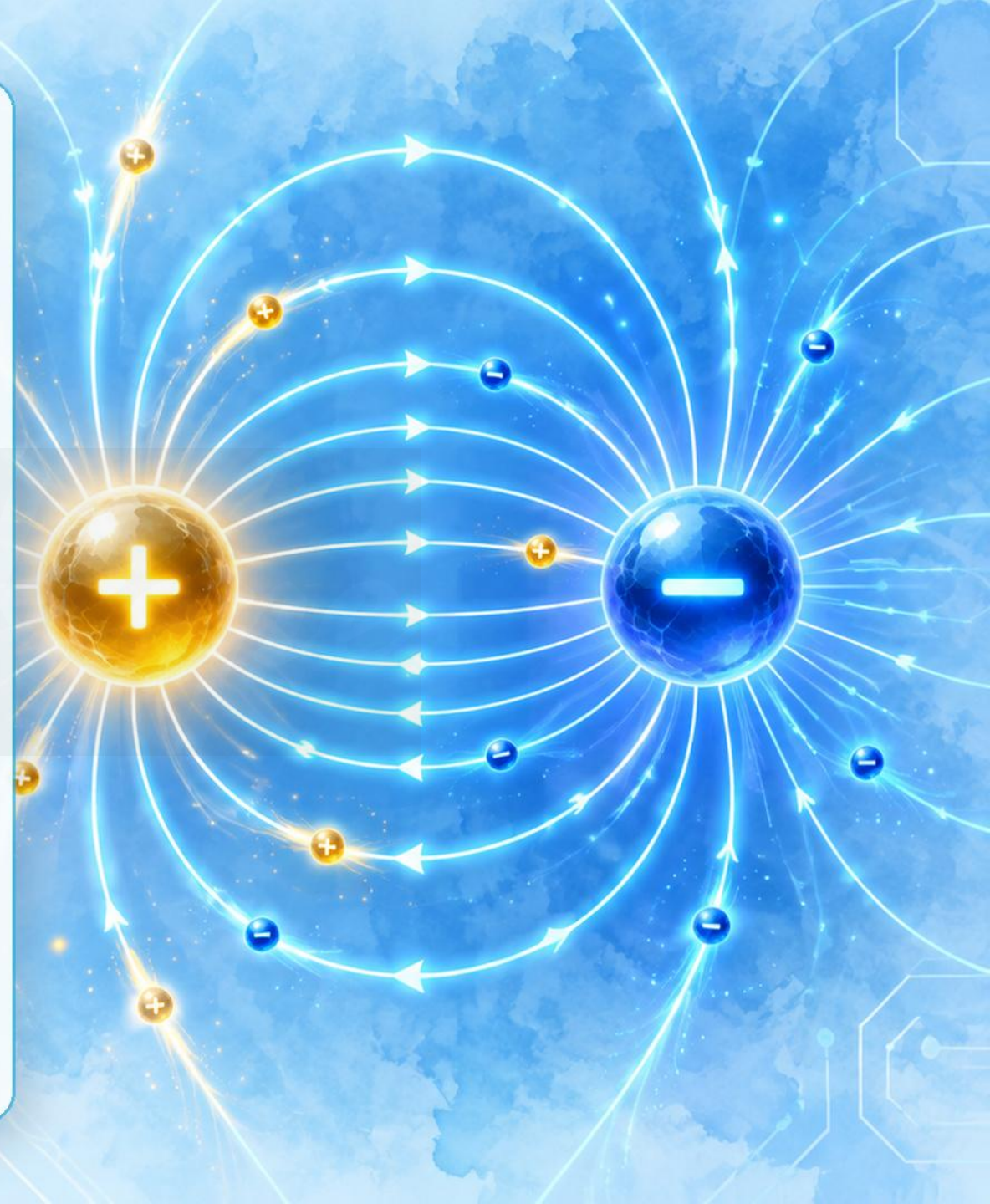


PHYSICS • CLASS 12

CHAPTER 1

Electric Charges and Fields

NCERT SOLUTIONS



COULOMB'S LAW — EXERCISE 1.1

Q. What is the force between two small charged spheres with charges $2 \times 10^{-7} \text{ C}$ and $3 \times 10^{-7} \text{ C}$, placed 30 cm apart in air?

Answer:

Given:

$$q_1 = 2 \times 10^{-7} \text{ C}$$

$$q_2 = 3 \times 10^{-7} \text{ C}$$

$$r = 30 \text{ cm} = 0.30 \text{ m}$$

$$k = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

Coulomb's law:

$$F = k \frac{|q_1 q_2|}{r^2}$$

$$F = \frac{(9 \times 10^9 \times 2 \times 10^{-7} \times 3 \times 10^{-7})}{(0.30)^2}$$

$$= \frac{5.4 \times 10^{-4}}{0.09}$$

$$F = 6.0 \times 10^{-3} \text{ N}$$

Both charges are positive, so the force is repulsive.



DISTANCE & FORCE — EXERCISE 1.2

Q. A sphere of charge $+0.4 \mu\text{C}$ experiences a force of 0.2 N due to a second sphere of charge $-0.8 \mu\text{C}$ in air.

(a) Find their separation.

(b) Find the force on the second sphere due to the first.

Answer:

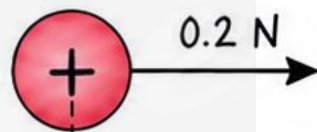
(a) $|q_1| = 0.4 \times 10^{-6} \text{ C}; \quad |q_2| = 0.8 \times 10^{-6} \text{ C}.$

$$F = k \frac{|q_1 q_2|}{r^2} \Rightarrow r = \sqrt{\frac{k |q_1 q_2|}{F}}$$

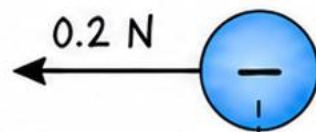
$$r = \sqrt{\frac{(9 \times 10^9)(0.4 \times 10^{-6})(0.8 \times 10^{-6})}{0.2}} = \sqrt{0.0144}$$

$$r = 0.12 \text{ m} = 12 \text{ cm}$$

$$q_1 = +0.4 \mu\text{C}$$



$$q_2 = -0.8 \mu\text{C}$$



12 cm

(b) By Newton's third law, the two forces have equal magnitude and opposite directions. Opposite charges attract.

Force on the second sphere = 0.2 N , towards the first sphere.

FORCE RATIO — EXERCISE 1.3

Q. Show that $\frac{ke^2}{Gm_em_p}$ is dimensionless. Use physical constants to find its value and explain its meaning.

Answer:

Units:

$$[k] = \text{N m}^2 \text{C}^{-2}$$

$$[e^2] = \text{C}^2$$

$$[G] = \text{N m}^2 \text{kg}^{-2}$$

$$[m_em_p] = \text{kg}^2$$

$$[ke^2] = (\text{N m}^2 \text{C}^{-2})(\text{C}^2) = \text{N m}^2$$

$$[Gm_em_p] = (\text{N m}^2 \text{kg}^{-2})(\text{kg}^2) = \text{N m}^2$$

Therefore, $\frac{ke^2}{Gm_em_p}$ has no unit (dimensionless).

Calculation:

$$k \approx 9.0 \times 10^9 \text{ N m}^2 \text{C}^{-2}$$

$$e \approx 1.6 \times 10^{-19} \text{ C}$$

$$G \approx 6.67 \times 10^{-11} \text{ N m}^2 \text{kg}^{-2}$$

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

$$m_p \approx 1.67 \times 10^{-27} \text{ kg}$$

$$R = \frac{ke^2}{Gm_em_p} = \frac{(9.0 \times 10^9)(1.6 \times 10^{-19})^2}{(6.67 \times 10^{-11})(9.11 \times 10^{-31})(1.67 \times 10^{-27})} \\ \approx 2.3 \times 10^{39}.$$

$$\frac{F_e}{F_g} = \frac{(ke^2/r^2)}{Gm_em_p/r^2} = \frac{ke^2}{Gm_em_p} = R.$$

For an electron and proton at the same separation, electric attraction is about 2.3×10^{39} times their gravitational attraction. The separation cancels.

CHARGE QUANTISATION — EXERCISE 1.4

- (a) What does 'electric charge of a body is quantised' mean?
(b) Why can quantisation be ignored for macroscopic charges?

Answer:

- (a) Charge is transferred in discrete amounts, not in any arbitrary fraction of the elementary charge.

$$\boxed{q = ne} \quad , \quad n = 0, \pm 1, \pm 2, \dots ; \quad e = 1.6 \times 10^{-19} \text{ C}.$$

A body gains a negative charge by gaining electrons and a positive charge by losing electrons.

- (b) The elementary charge is extremely small compared with ordinary large-scale charges. A macroscopic charge contains a huge number of elementary charges, so one-electron steps are too small to notice.

$$\text{For } q = 1 \mu\text{C}, \quad n = \frac{q}{e} = \frac{1 \times 10^{-6}}{1.6 \times 10^{-19}} = 6.25 \times 10^{12}.$$

Charge remains quantised, but it can be treated as continuous on a macroscopic scale.

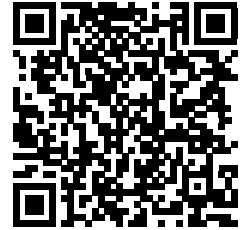


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