Unit 19 · Electric Charges

HARDER PRACTICE QUESTIONS

Full marks 30

Write your answers on separate paper. Show your working. Take $k = 1/(4\pi\varepsilon_0) = 9.0 \times 10^9$ N m^2/C^2, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N m^2), e = 1.6×10^{-19} C and G = 6.67×10^{-11} N m^2/kg^2.

1 Spot the error [3]

Find the mistake in the working and correct it.

Two charged spheres, each of radius 1.0 cm and with charges of +3.0 μC and +3.0 μC, have their surfaces 4.0 cm apart. Nishant wrote:
"$F = kQ_1Q_2/r^2 = 9.0 \times 10^9 \times (3.0 \times 10^{-6})^2 \div (0.040)^2 = \mathbf{51\ N}$."

2 Work backwards [3]

Two equal point charges, 5.0 cm apart in air, repel each other with a force of 0.90 N.

i. Find the charge on each.

ii. How many electrons would have to be removed from each to give it this charge?

3 Check the readings [3]

Sakshi measured the force between two small charged spheres at different distances (center to center):

r (cm)	2.0	3.0	4.0	5.0	6.0
F (mN)	7.2	3.2	1.4	1.15	0.80

Do the readings follow Coulomb's law? Which reading is most likely wrong, and what should it have been?

4 Predict, then explain [3]

Write your prediction first, then explain it.

A small positive charge q is free to move only along the line joining two fixed charges, +Q at one end and +4Q at the other, 30 cm apart. Predict where between them q can rest. Then explain whether that resting place is stable along the line, and what would happen if q were negative instead.

5 Estimate it [3]

A 3 g copper coin contains about 8×10^{23} electrons. Suppose two such coins, 1 m apart, each lost just one electron in every 10^{12} (a million million).

i. Estimate the charge on each coin and the electric force between them.

ii. Compare it with the gravitational force between the coins.

6 Show that [2]

Show that $k = 1/(4\pi\varepsilon_0)$ is about 9.0×10^9 N m^2/C^2, and that Coulomb's law gives a force in newtons when the charges are in coulombs and the distance in meters.

7 A real setting [3]

At a petrol pump the hose's nozzle is metal, the tanker that fills the station's tank is joined to the ground with a metal cable before its petrol flows, and passengers are warned not to slide in and out of car seats while filling. Explain each in terms of charge.

8 Which explanation fits the evidence? [3]

A rubbed balloon sticks to a wall. Two students explain it:
Aakash: “The wall must have the opposite charge to the balloon.”
Kriti: “The wall is uncharged; the balloon's charge pulls the wall's charges slightly apart, and the near ones are opposite.”
Kriti then shows that the same balloon also sticks to a second, different wall, and to the ceiling, and that bits of paper from a fresh notebook jump up to it. Which explanation does her evidence support? Explain.

9 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Prakriti wrote: “When a glass rod is rubbed with silk, friction creates positive charge on the glass. In induction, some of the rod's charge jumps across to the sphere. The force between two charges is larger in water than in air, because water is denser.”

10 Think [2]

The electric force between a proton and an electron is about 10^{39} times their gravitational force. Why, then, does gravity, and not electricity, hold the Moon in its orbit round the Earth?

11 Make your own [2]

Choose two point charges and a distance of your own so that the force between them is exactly 1.0 N. Show that your choice works and say whether the force attracts or repels.