

## Exercise walk-through

Electric Charge and Electric Force ■ 10.1

eXercise

## You must be able to

- describe **electric charge** 电荷 as a conserved property in positive and negative types
- state that like charges repel and unlike charges attract
- apply **Coulomb's law** 库仑定律  $F = k \frac{q_1 q_2}{r^2}$
- explain **charge quantization** 电荷量子化 — charge in whole multiples of  $e$

## Method — Charge and force

Charge comes in two types; **like repel, unlike attract**, and total charge is conserved.

## Method — Coulomb's law

$F = k \frac{q_1 q_2}{r^2}$  with  $k = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$  — an inverse-square law like gravity.

## Method — Quantization

Charge is always a whole multiple of  $e = 1.6 \times 10^{-19} \text{ C}$ .

## Method — Example

Two  $+2.0 \mu\text{C}$  charges  $0.10 \text{ m}$  apart:  $F = 8.99 \times 10^9 \times \frac{(2.0 \times 10^{-6})^2}{(0.10)^2} = 3.6 \text{ N}$   
(repulsive).

## Practice 2.1 ■ 1 mark

State whether two negative charges attract or repel.

## Solution 2.1

Method: Charge and force

### Worked steps

repel **B1**.

## Practice 2.2 ■ 1 mark

Two point charges are moved twice as far apart. State the factor by which the force between them changes.

## Solution 2.2

Method: Example

### Worked steps

it becomes one quarter as large ( $1/2^2$ ) **B1**.

## Practice 2.3 ■ 2 marks

Find the force between a  $+3.0 \mu\text{C}$  and a  $-3.0 \mu\text{C}$  charge  $0.20 \text{ m}$  apart ( $k = 8.99 \times 10^9$ ).

## Solution 2.3

## Worked steps

$$F = 8.99 \times 10^9 \times \frac{(3.0 \times 10^{-6})^2}{(0.20)^2} = 2.0 \text{ N, attractive } \text{M1} \text{ A1}.$$

## Exam-style 3.1 ■ 1 mark

The Coulomb force between two point charges varies with their separation as

**A**  $1/r$

**B**  $1/r^2$

**C**  $r$

**D**  $r^2$

## Solution 3.1

**A**  $1/r$

**B**  $1/r^2$



**C**  $r$

**D**  $r^2$

## Worked steps

**B.**

## Exam-style 3.2 ■ 1 mark

An object carries a charge of  $-4.8 \times 10^{-19}$  C. The number of excess electrons is

**A** 1

**B** 2

**C** 3

**D** 4

## Solution 3.2

Method: Quantization

A 1

B 2

C 3



D 4

### Worked steps

C —  $4.8 \times 10^{-19} / 1.6 \times 10^{-19} = 3.$

## Exam-style 3.3 ■ 3 marks

Two point charges,  $+5.0 \mu\text{C}$  and  $+2.0 \mu\text{C}$ , are  $0.30 \text{ m}$  apart.

- (a) Find the force between them.
- (b) State whether the force is attractive or repulsive.

## Solution 3.3

Method: Example

**Worked steps**

$$(a) F = 8.99 \times 10^9 \times \frac{(5.0 \times 10^{-6})(2.0 \times 10^{-6})}{(0.30)^2} = 1.0 \text{ N} \quad \text{M1 M1 A1. (b) repulsive}$$

(both charges positive) B1.