

18.3 Electric force between point charges

Name: _____ Class: _____ Date: _____

Total: 11 marks

Objective

Build the skills to answer exam questions on **Coulomb's law** —the force between two point charges.

You must be able to:

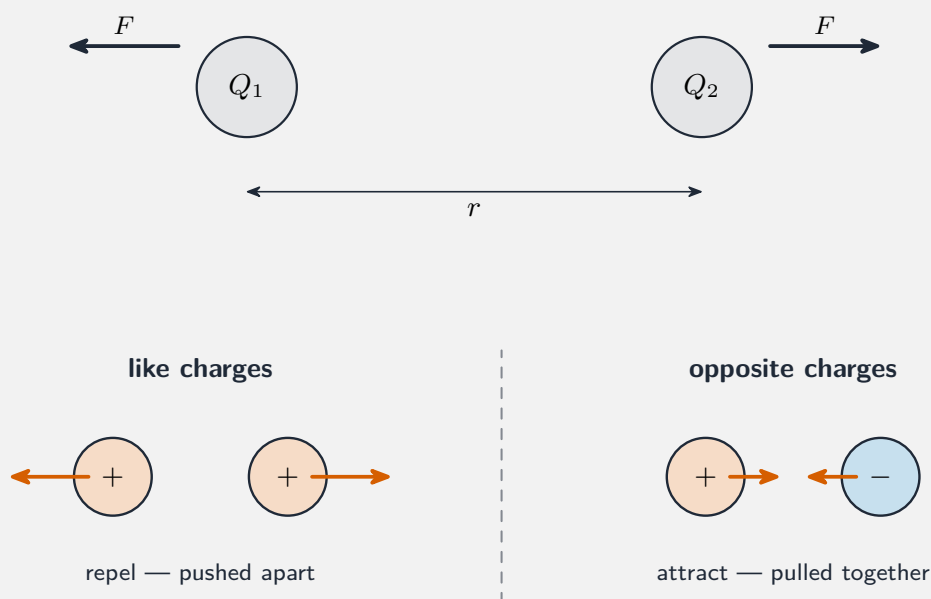
- use Coulomb's law $F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$
- treat a charged sphere as a **point charge** at its centre

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Coulomb's law

Two point charges a distance r apart exert **equal, opposite** forces along the line joining them:



Coulomb force between point charges

$$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}, \quad \frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ N m}^2 \text{ C}^{-2}.$$

Like charges repel; **opposite** charges attract. A charged sphere acts as a **point charge at its centre**.

Worked example. +2.0 nC and +3.0 nC, 4.0 cm apart:

$$F = \frac{(9.0 \times 10^9)(2.0 \times 10^{-9})(3.0 \times 10^{-9})}{(0.040)^2} = 3.4 \times 10^{-5} \text{ N (repulsive)}.$$

2 Practice

Now apply the methods above.

2.1 State **Coulomb's law**. [2]

2.2 State the value of $\frac{1}{4\pi\epsilon_0}$. [1]

2.3 State whether **like** charges attract or repel. [1]

3 Exam-style questions

3.1 If the distance between two charges is **doubled**, the Coulomb force becomes: [1]

- **A** twice as large
- **B** half as large
- **C** one quarter as large
- **D** four times as large

3.2 Calculate the force between point charges of +2.0 nC and +3.0 nC placed 4.0 cm

apart.

[3]

3.3 Two charges of $+5.0\text{ nC}$ are 2.0 cm apart. Calculate the force between them, and state whether it is attractive or repulsive. [3]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **18.3 Electric force between point charges** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/41 J25 —Q2 (Coulomb's law, structured)
- 9702/43 J25 —Q2 (force between point charges)

Solutions

2.1 The force between two **point charges** is **proportional to the product of the charges** and **inversely proportional to the square of their separation**.

2.2 $\frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ N m}^2 \text{ C}^{-2}.$

2.3 They **repel**.

3.1 **C** —one quarter.

3.2 $F = \frac{(9.0 \times 10^9)(2.0 \times 10^{-9})(3.0 \times 10^{-9})}{(0.040)^2} = 3.4 \times 10^{-5} \text{ N}.$

3.3 $F = \frac{(9.0 \times 10^9)(5.0 \times 10^{-9})^2}{(0.020)^2} = 5.6 \times 10^{-4} \text{ N};$ **repulsive** (like charges).