Exercise walk-through

Electric Fields ▪ 8.3

eXercise

You must be able to

- define the **electric field 电场** as force per unit charge, $\vec{E} = \dfrac{\vec{F}}{q}$
- calculate the field of a **point charge**, $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r^2}$
- use **superposition** for several point charges
- find the force $\vec{F} = q\vec{E}$ on a charge in a field

Method — The electric field

$\vec{E} = \dfrac{\vec{F}}{q}$ — the force per unit **positive** test charge, in N C^{-1}.

Method — Point charge

$E = k\frac{q}{r^2}$, pointing away from a positive charge and toward a negative one; add fields as vectors (superposition).

Method — Force on a charge

$\vec{F} = q\vec{E}$. A positive charge feels a force **along** $\vec{E}$; a negative charge feels one **opposite** to $\vec{E}$.

Practice 2.1 ▪ 2 marks

Find the electric field 0.20 m from a $+5.0$ μC charge ($k = 8.99 \times 10^9$).

Solution 2.1

Method: The electric field

Worked steps

$$E = k\frac{q}{r^2} = 8.99 \times 10^9 \times \frac{5.0 \times 10^{-6}}{(0.20)^2} = 1.1 \times 10^6 \text{ N C}^{-1}$$ M1 A1.

Practice 2.2 ▪ 2 marks

A $+2.0\ \mu$C charge sits in a field of 3000 N C^{-1}. Find the force on it.

Solution 2.2

Method: The electric field

Worked steps

$F = qE = (2.0 \times 10^{-6})(3000) = 6.0 \times 10^{-3}$ N M1 A1.

Practice 2.3 ▪ 1 mark

State the direction of the field around a negative point charge.

Solution 2.3

Method: Point charge

Worked steps

radially inward, toward the charge B1.

Exam-style 3.1 ▪ 1 mark

The electric field is defined as

A qF

B F/q

C q/F

D qr^2

Solution 3.1

Method: The electric field

A qF

B F/q ✓

C q/F

D qr^2

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

The force on a charge q in a field E is

A q/E

B qE

C E/q

D qE^2

Solution 3.2

Method: The electric field

A q/E

B qE ✓

C E/q

D qE^2

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A $+4.0\ \mu$C charge is at the origin.
(a) Find the electric field 0.30 m from it.
(b) Find the force on a $-1.0\ \mu$C charge placed there, with direction.

Solution 3.3

Method: The electric field

Worked steps

(a) $E = 8.99 \times 10^9 \times \dfrac{4.0 \times 10^{-6}}{(0.30)^2} = 4.0 \times 10^5$ N C^{-1} M1 A1. (b) $F = qE = (1.0 \times 10^{-6})(4.0 \times 10^5) = 0.40$ N, directed toward the $+4.0\ \mu$C charge (attractive) M1 A1.