Exercise walk-through

Electric Potential ▪ 9.2

eXercise

You must be able to

- define **electric potential 电势** as energy per unit charge, $V = \frac{U}{q}$
- calculate the potential of a point charge, $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$, and use superposition
- relate potential to field through $V = -\int \vec{E} \cdot d\vec{l}$ and $\vec{E} = -\nabla V$
- describe **equipotential surfaces 等势面** as perpendicular to the field

Method — Electric potential

$V = \dfrac{U}{q}$, in volts. For a point charge $V = k\dfrac{q}{r}$ — a **scalar**, so potentials just add (superposition).

Method — Field and potential

$V = -\int \vec{E} \cdot d\vec{l}$, and conversely $\vec{E} = -\nabla V$: the field points **down** the steepest potential drop.

Method — Equipotentials

Surfaces of constant V are always **perpendicular** to the field lines; no work is done moving a charge along one.

Practice 2.1 ▪ 2 marks

Find the potential 0.30 m from a $+6.0$ μC charge ($k = 8.99 \times 10^9$).

Solution 2.1

Worked steps

$$V = k\frac{q}{r} = 8.99 \times 10^{9} \times \frac{6.0 \times 10^{-6}}{0.30} = 1.8 \times 10^{5}\ \text{V}$$ M1 A1.

Practice 2.2 ▪ 1 mark

State the relationship between equipotential surfaces and field lines.

Solution 2.2

Method: Equipotentials

Worked steps

they are perpendicular to each other B1.

Practice 2.3 ▪ 1 mark

State whether electric potential is a scalar or a vector.

Solution 2.3

Method: Electric potential

Worked steps

a scalar B1.

Exam-style 3.1 ▪ 1 mark

The electric potential of a point charge is

A $k\frac{q}{r^2}$

B $k\frac{q}{r}$

C $k\frac{q^2}{r}$

D qE

Solution 3.1

Method: Electric potential

A $k\frac{q}{r^2}$

B $k\frac{q}{r}$ ✓

C $k\frac{q^2}{r}$

D qE

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

Equipotential surfaces are always _____ to the electric field.

A parallel

B perpendicular

C at $45°$

D unrelated

Solution 3.2

Method: Equipotentials

A parallel

B perpendicular ✓

C at 45°

D unrelated

Worked steps

B.

Exam-style 3.3 ▪ 3 marks

Two $+4.0$ μC charges are 0.40 m apart.
(a) Find the potential at the midpoint between them.
(b) State why the two potentials can simply be added.

Solution 3.3

Method: Electric potential

Worked steps

(a) each charge is 0.20 m from the midpoint: $V = 2 \times k\dfrac{q}{r} = 2 \times 8.99 \times 10^{9} \times \dfrac{4.0 \times 10^{-6}}{0.20} = 3.6 \times 10^{5}$ V M1 M1 A1. (b) potential is a scalar, so contributions add directly (no direction) B1.