

Exercise walk-through

17.1

Electric fields: force and a positive test charge

International Baccalaureate · IB Diploma · Physics · HL

17.1 Electric fields: force and a positive test charge

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS test charge • electric field strength

Objective

Electric fields: force and a positive test charge. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

1 Key knowledge and worked examples

■ What would explain this observation?

- A negatively charged particle moves opposite to the direction of the electric field. Field direction is defined using a positive **test charge** .
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- **Electric field strength** is force per unit positive test charge. Like charges repel and unlike charges attract. Field lines point away from positive charges and toward negative charges. Closely spaced lines represent a stronger field within a consistently drawn diagram.
- electric field strength: Electric force per unit positive test charge; test charge: A small

charge used to probe an electric field.



■ **Choose evidence that can test it**

- In a uniform field between ideal parallel plates, $E = V/d$ away from edge effects. The force is $F = qE$, so its direction reverses for a negative charge. Coulomb force between ideal point charges decreases with separation squared.
- Sketch labelled plate polarities, field arrows and the charge before calculating. Convert separation to metres. In school, use simulations or approved low-voltage electrostatic models rather than exposed high-voltage equipment.

■ **Work from known quantities**

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: plate potential difference is 120 V and separation is 0.020 m. $E = V/d = 6,000 \text{ V/m}$. A $+2.0$ microcoulomb charge experiences $F = qE = 0.012 \text{ N}$ along the field; a -2.0 microcoulomb charge experiences the same magnitude opposite to it.

Example:

Use $E = V/d$. Find E for 100 V across 0.025 m. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ **Check the conclusion and its limits**

- Field strength is a vector. Potential difference is energy per charge and is not the same quantity. A field-line drawing is a model, not a set of physical threads.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

Every charged particle experiences a force along the electric field direction. This claim is false: Field strength is a vector. Potential difference is energy per charge and is not the same quantity. A field-line drawing is a model, not a set of physical threads.

Key:

Electric fields: force and a positive test charge: In a uniform field between ideal parallel plates, $E = V/d$ away from edge effects. The force is $F = qE$, so its direction reverses for a negative charge. Coulomb force between ideal point charges decreases with separation squared.

Exercises 2.1-2.3

2.1 What happens to force direction if the test charge changes sign? Choose one answer.

- **A** It reverses in the same field
- **B** It always stays along the field
- **C** The field ceases to exist

[1]

2.2 Use $E = V/d$. Find E for 100 V across 0.025 m. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: Every charged particle experiences a force along the electric field direction.

[2]

Exercises 2.1-2.3

2.1 What happens to force direction if the test charge changes sign? Choose one answer.

- **A** It reverses in the same field
- **B** It always stays along the field
- **C** The field ceases to exist

[1]

2.1 A In a uniform field between ideal parallel plates, $E = V/d$ away from edge effects. The force is $F = qE$, so its direction reverses for a negative charge. Coulomb force between ideal point charges decreases with separation squared.

2.2 Use $E = V/d$. Find E for 100 V across 0.025 m. Show the relation, substitution and units.

[2]

2.2 $E = V/d = 100/0.025 = 4,000 \text{ V/m}$.

2.3 Decide whether this claim is true and justify: Every charged particle experiences a force along the electric field direction.

[2]

2.3 False. Field strength is a vector. Potential difference is energy per charge and is not the same quantity. A field-line drawing is a model, not a set of physical threads.

Exercises 2.4·3.1

2.4 Electric force per unit positive test charge: write the technical term. [1]

3 Exam-style questions

3.1 Parallel plates have 120 V across 0.030 m. Find field and force on a -2.0 micro-coulomb charge. State directions and the uniform-field boundary. [4]

Exercises 2.4·3.1

2.4 Electric force per unit positive test charge: write the technical term. [1]

3 Exam-style questions

2.4 electric field strength. electric field strength means Electric force per unit positive test charge.

3.1 Parallel plates have 120 V across 0.030 m. Find field and force on a -2.0 micro-coulomb charge. State directions and the uniform-field boundary. [4]

3.1 $E=4,000$ V/m from positive to negative plate. Force magnitude is 0.0080 N opposite the field. The uniform model excludes edge fringing.