Exercise walk-through

Uniform electric fields ▪ 18.2

eXercise

You must be able to

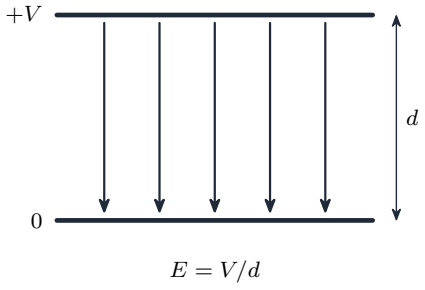
- use $E = V/d$ for the field between parallel plates
- describe the motion of a **charged particle** in a uniform field

Method — Field between plates

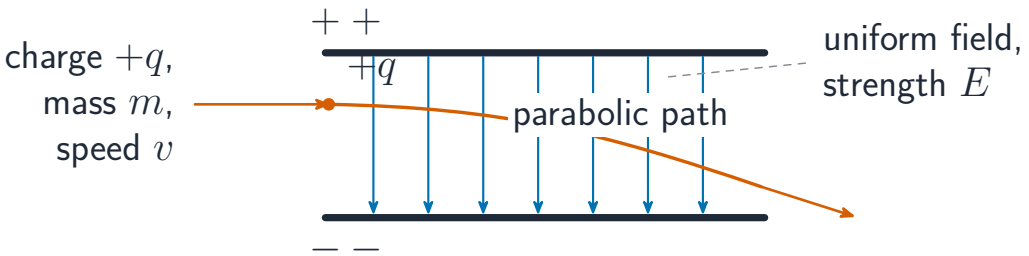
Between parallel plates a distance d apart with p.d. V, the field is **uniform**:

$$E = \frac{V}{d} \quad (\text{V m}^{-1} = \text{N C}^{-1}),$$

pointing from the **higher** to the **lower** potential plate.



Method — Field between plates



A charge follows a parabola in a uniform field

Method — Charged particle in the field

A charge in the field feels a **constant force** $F = qE$, so it has a **constant acceleration** $a = \dfrac{F}{m} = \dfrac{qE}{m}$. A particle entering **perpendicular** to the field follows a **parabolic** path (like a projectile in gravity); a particle released **from rest** accelerates straight along the field, towards the plate of **opposite** sign to its charge.

Worked example. Plates 5.0 mm apart, 200 V: $E = \dfrac{200}{5.0 \times 10^{-3}} = 4.0 \times 10^{4}$ V m^{-1}; force on an electron $= qE = (1.6 \times 10^{-19})(4.0 \times 10^{4}) = 6.4 \times 10^{-15}$ N; acceleration $a = \dfrac{F}{m} = \dfrac{6.4 \times 10^{-15}}{9.1 \times 10^{-31}} = 7.0 \times 10^{15}$ m s^{-2}.

Practice 2.1 ▪ 1 mark

Write the equation for the field strength between **parallel plates**.

Solution 2.1

Method: Field between plates

Worked steps

$E = V/d$ B1.

Practice 2.2 ▪ 2 marks

Two plates 5.0 mm apart have a p.d. of 200 V. Find the **field strength**.

Solution 2.2

Worked steps

$E = V/d = 200/(5.0 \times 10^{-3}) = 4.0 \times 10^{4}$ V m^{-1} M1 A1.

Practice 2.3 ▪ 1 mark

State the **direction** of the field between two charged plates.

Solution 2.3

Method: Field between plates

Worked steps

From the **higher-potential** plate to the **lower-potential** plate B1.

Practice 2.4 ▪ 1 mark

State the unit equal to V m^{-1}.

Solution 2.4

Method: Field between plates

Worked steps

N C^{-1} B1.

Exam-style 3.1 ▪ 1 mark

The electric field between two parallel charged plates is:

A radial

B uniform

C zero

D circular

Solution 3.1

Method: Field between plates

A radial

B uniform ✓

C zero

D circular

Worked steps

B — uniform.

Exam-style 3.2 ▪ 3 marks

Two plates 5.0 mm apart have a p.d. of 200 V. Calculate (a) the field strength, (b) the force on an electron in the gap. ($e = 1.6 \times 10^{-19}$ C.)

Solution 3.2

Method: Charged particle in the field

Worked steps

(a) $E = V/d = 200/(5.0 \times 10^{-3}) = 4.0 \times 10^{4}$ V m^{-1} M1 A1. (b) $F = qE = (1.6 \times 10^{-19})(4.0 \times 10^{4}) = 6.4 \times 10^{-15}$ N A1.

Exam-style 3.3 ▪ 2 marks

Describe the **path** of an electron that enters the uniform field **perpendicular** to the field lines.

Solution 3.3

Method: Charged particle in the field

Worked steps

It follows a **parabolic** path B1 — constant velocity along the plates, constant acceleration across the field (like a projectile) B1.

Exam-style 3.4 ▪ 1 mark

State what happens to the force on a charge if the plate separation is **halved** (same p.d.).

Solution 3.4

Worked steps

The force **doubles** ($E = V/d$, so halving d doubles E and hence $F = qE$) B1.

Exam-style 3.5 ▪ 2 marks

An electron is released from rest at the negative plate of two plates 8.0 mm apart with a p.d. of 250 V. ($e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg.)

(a) Calculate the field strength between the plates.

(b) Calculate the **acceleration** of the electron.

Solution 3.5

Method: Charged particle in the field

Worked steps

(b) $F = qE = (1.6\times10^{-19})(3.1\times10^{4}) = 5.0\times10^{-15}$ N M1; $a = \dfrac{F}{m} = \dfrac{5.0\times10^{-15}}{9.1\times10^{-31}}$ M1 $= 5.5\times10^{15}$ m s^{-2} A1.