Exercise walk-through

Concept of a magnetic field ▪ 20.1

eXercise

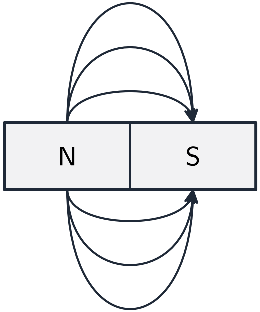
You must be able to

- state what produces a magnetic field
- represent a magnetic field with **field lines**

Method — Magnetic fields

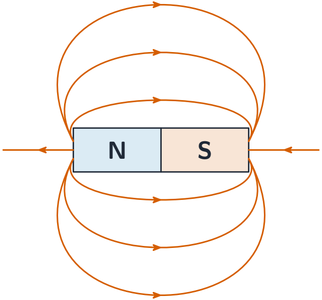
A **magnetic field** is a region where a moving charge or current feels a force. It is produced by **moving charges (currents)** or **permanent magnets**.

- field lines run **N to S** outside a magnet (closed loops);
- they **never cross**; **closer lines → stronger field**.



Method — Magnetic fields

field lines run from **N** to **S** outside the magnet



The field of a bar magnet

Practice 2.1 ▪ 1 mark

State **two** things that can produce a magnetic field.

Solution 2.1

Method: Magnetic fields

Worked steps

Moving charges (currents) and **permanent magnets** B1.

Practice 2.2 ▪ 1 mark

State the direction of the field lines **outside** a bar magnet.

Solution 2.2

Method: Magnetic fields

Worked steps

From **N to S** **B1**.

Practice 2.3 ▪ 1 mark

State what **closer** field lines indicate.

Solution 2.3

Method: Magnetic fields

Worked steps

A **stronger** magnetic field B1.

Exam-style 3.1 ▪ 1 mark

Magnetic field lines **outside** a bar magnet point from:

A S to N

B N to S

C N to N

D nowhere

Solution 3.1

Method: Magnetic fields

A S to N

B N to S ✓

C N to N

D nowhere

Worked steps

B — N to S.

Exam-style 3.2 ▪ 2 marks

Sketch the magnetic field lines around a bar magnet.

Solution 3.2

Method: Magnetic fields

Worked steps

Curved lines from **N to S** outside the magnet B1; closer together near the **poles** B1.

Exam-style 3.3 ▪ 2 marks

State **two** ways a magnetic field can be produced.

Solution 3.3

Method: Magnetic fields

Worked steps

A **current** (moving charges) in a wire; a **permanent magnet** B1 B1.

Exam-style 3.4 ▪ 2 marks

A long, straight vertical wire carries a current of 5.0 A **into** the page. A second parallel wire, 0.040 m away, carries 3.0 A in the **same** direction. The flux density produced by the first wire at the position of the second is 2.5×10^{-5} T.

(a) **State** what is meant by a **magnetic field**.

(b) In the space below, **draw** four field lines to represent the magnetic field around the first wire, and **mark** the direction of the field.

(c) **Calculate** the magnetic force per unit length exerted on the second wire.

(d) **State**, with a reason, the direction of that force.

(e) The flux density produced by the **second** wire at the position of the first is 1.5×10^{-5} T. **Determine** the force per unit length on the first wire, and **explain** your reasoning.

Solution 3.4

Method: Magnetic fields

Worked steps

(a) A region in which a **force** is experienced by a moving charge, a current-carrying conductor or a magnetic pole B1 B1.
(b) Four **concentric circles** centred on the wire B1, drawn with the spacing **increasing** with distance, because the field weakens as $1/r$ B1; arrows **clockwise**, from the right-hand grip rule with the current into the page B1.
(c) $\dfrac{F}{L} = BI = 2.5 \times 10^{-5} \times 3.0$ M1 $= 7.5 \times 10^{-5}$ N m^{-1} A1.
(d) The force is **towards** the first wire, i.e. the two wires **attract** B1. Currents in the same direction attract; applying the left-hand rule with the field of one wire and the

Solution 3.4

current in the other gives a force pointing along the line joining them **B1**.
(e) By **Newton's third law** the forces on the two wires are equal in magnitude and opposite in direction **B1**, so the force per unit length on the first wire is also 7.5×10^{-5} N m^{-1} **B1**. The check confirms it:
$BI = 1.5 \times 10^{-5} \times 5.0 = 7.5 \times 10^{-5}$ N m^{-1} — a smaller field acting on a larger current gives the same product **B1**.