Cambridge IGCSE · Physics 0625 · Notes

Simple phenomena of magnetism

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Last checked 29 September 2026

What you need to know

This topic is about magnets, the materials they attract, and the magnetic field around them. The parts marked **Extended only** are tested on Papers 2 and 4 only. By the end of it you should be able to:

1. **Describe the forces between magnetic poles, and between magnets and magnetic materials**, using the words north pole (N pole), south pole (S pole), attraction, repulsion, magnetised and unmagnetised.
2. **Describe induced magnetism**: how a magnet turns a nearby piece of magnetic material into a magnet.
3. **State how temporary magnets (made of soft iron) and permanent magnets (made of steel) differ.**
4. **State the difference between magnetic and non-magnetic materials.**
5. **Describe a magnetic field** as a region in which a magnetic pole experiences a force.
6. **Draw the pattern and direction of the magnetic field lines around a bar magnet.**
7. **State that the direction of a magnetic field at a point** is the direction of the force on the N pole of a magnet placed at that point.
8. **Describe how to plot magnetic field lines** with a compass or with iron filings, and how to use a compass to find the direction of the field.
9. **Describe uses of permanent magnets and of electromagnets.**
10. **Extended only:** explain that magnetic forces are caused by magnetic fields interacting.
11. **Extended only:** know that the spacing of the field lines shows how strong the field is: the closer the lines, the stronger the field.

Understand it

Magnets and their poles

A magnet's pull is strongest at its two ends, the **poles**. If you hang a bar magnet from a thread so it can turn freely, it settles pointing north–south. The end that points north is the **north-seeking pole**, or **N pole**; the other end is the **S pole**. Every magnet has both: cut a magnet in half and you get two smaller magnets, each with an N and an S pole.

When two magnets are brought together:

- **like poles repel** (N and N, or S and S push each other apart);

- **unlike poles attract** (N and S pull together).

The forces get weaker quickly as the magnets are moved apart.

Magnetic and non-magnetic materials

A **magnetic material** is attracted by a magnet, and it can be made into a magnet. **Iron, steel, nickel and cobalt** are magnetic. A **non-magnetic material** is not attracted by a magnet and cannot be magnetised: most metals (copper, aluminium, silver, zinc, lead, gold) and all non-metals (plastic, wood, glass, paper) are non-magnetic. Being a metal, or being a good electrical conductor, does **not** make a material magnetic.

A magnetic material can be **magnetised** (it is a magnet, with an N and an S pole) or **unmagnetised** (it is not a magnet, but a magnet still attracts it). An unmagnetised iron bar is attracted by **both** poles of a magnet. It is never repelled.

How to tell whether something is a magnet

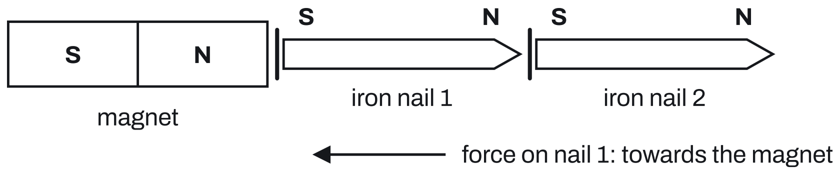
Bring each pole of a known magnet, in turn, up to the same end of the object:

What happens	What the object is
Repelled by one pole, attracted by the other	A **magnet**
Attracted by both poles	An **unmagnetised magnetic material** (such as iron)
No force with either pole	A **non-magnetic material** (such as copper or plastic)

Only repulsion proves that something is a magnet. Attraction alone does not, because a magnet attracts unmagnetised iron too.

Induced magnetism

Put an unmagnetised piece of iron or steel near a magnet, or touching it, and it **becomes a magnet itself** while it is there. This is **induced magnetism**. The end of the iron **nearest** the magnet's pole becomes the **opposite** pole, so the two attract. That is why a magnet attracts unmagnetised iron, whichever pole you use.



Each induced magnet can induce magnetism in the next piece, so a magnet can hold up a chain of nails or paper clips. When the magnet is taken away, what happens depends on the material.

Temporary and permanent magnets: soft iron and steel

	Soft iron	Steel
Magnetising	Easy to magnetise	Harder to magnetise
When the magnet (or current) is removed	Loses almost all its magnetism: easy to demagnetise	Keeps its magnetism: hard to demagnetise
Makes a	**Temporary magnet**	**Permanent magnet**
Used for	Cores of electromagnets and transformers	Bar magnets, compass needles, fridge magnets, loudspeaker magnets

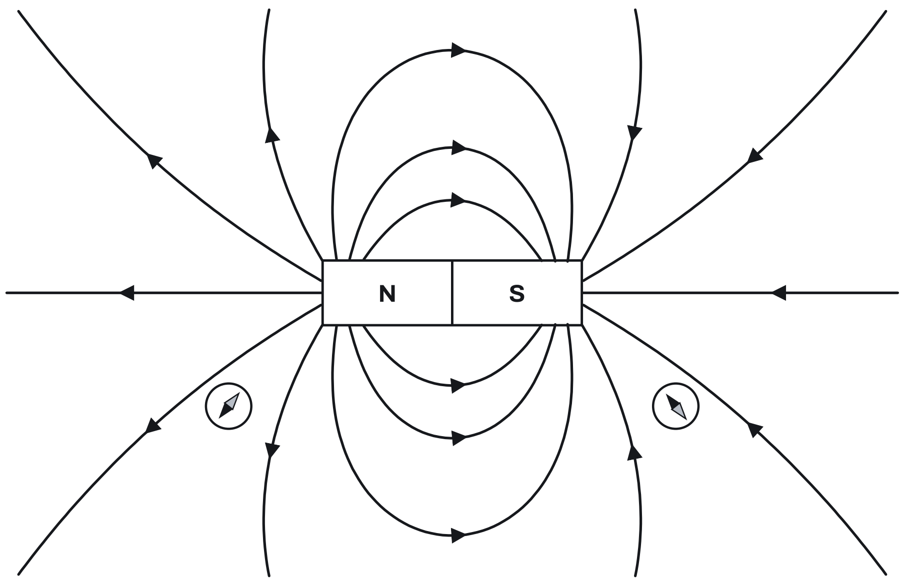
So a chain of **iron** nails falls apart as soon as the magnet is removed, but **steel** nails stay magnetised and keep sticking together. Remember the pairing: **steel stays**; **iron is instant** on and off.

An **electromagnet** is a coil of wire with a soft-iron core. When there is a current in the coil, the core becomes a strong magnet; when the current is switched off, the soft iron loses its magnetism at once. That is exactly what a temporary magnet is for.

Magnetic fields

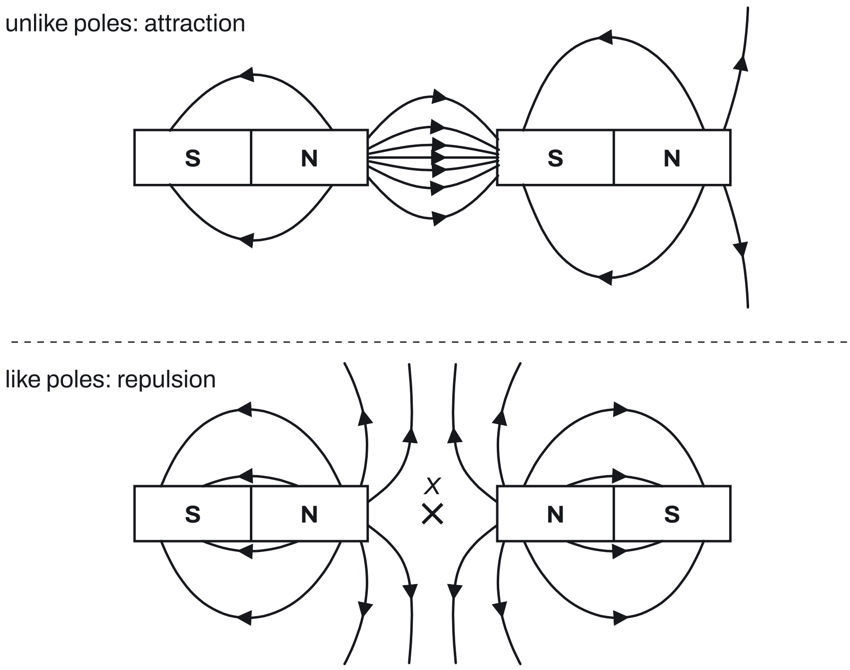
Around every magnet is a **magnetic field**: a **region in which a magnetic pole experiences a force**. (A magnetic material in the field feels a force too.) A field is invisible, so we draw it with **field lines**.

- The **direction** of the field at a point is the direction of the force on an **N pole** placed there. So field lines go **out of the N pole and into the S pole**, and arrows on them point from N to S (outside the magnet).
- Field lines never cross, and they never start or stop in empty space: each one runs from an N pole to an S pole.
- A small **plotting compass** is a tiny magnet whose needle can turn freely. Its N end is pushed along the field, so **the compass needle points along the field line, its N end pointing in the direction of the field**. Near a magnet's N pole the compass's N end points away from the pole; near the S pole it points towards it.



Extended only: strength from spacing. The closer together the field lines, the **stronger** the field. Around a bar magnet the lines are crowded together at the **poles**, where the field is strongest, and spread out further away, where it is weaker. A **stronger magnet** is drawn with more lines, closer together; a **weak** one with fewer lines, far apart. Where lines are parallel and equally spaced, the field is the same strength everywhere (a **uniform** field).

Two magnets together



- **Unlike poles facing (attraction)**: the lines go across the gap from N to S, crowded together, so the field in the gap is strong. The closer the two flat pole faces, the more nearly parallel and evenly spaced the lines in the middle of the gap, and the more uniform the field there.
- **Like poles facing (repulsion)**: the lines from each pole turn away from the other. Halfway between is a **neutral point**, where the two fields cancel and there is no field at all.

Extended only: why magnets exert forces

A magnet does not reach out and touch the other magnet. Each magnet sets up a field, and **the force on a magnet is caused by the other magnet's field acting on it**: the two fields interact. The same is true for a magnetic material: the magnet's field induces magnetism in it, and then the field of the magnet and the field of the induced magnet interact, giving attraction.

A freely hanging magnet, or a compass needle, always settles pointing north–south for the same reason: its field interacts with the **Earth's magnetic field**. It is not an electric or gravitational effect.

Plotting a field

With a plotting compass (this gives the pattern **and** the direction):

1. Put the magnet on a sheet of paper and draw round it.
2. Place a small plotting compass near the N pole. Mark a dot on the paper at the N end of the needle.
3. Move the compass so its S end is over that dot, and mark a new dot at its N end.
4. Repeat until you reach the S pole or the edge of the paper. Join the dots with a smooth curve and add an arrow in the direction the compass's N end pointed.
5. Start again from other points around the N pole to draw more lines.

With iron filings (this gives the pattern only): put a sheet of card or paper on top of the magnet, sprinkle iron filings thinly over it and **tap the card gently**. Each filing becomes a tiny induced magnet and lines up along the field, showing the pattern of lines. Iron filings do not show the direction, so place a plotting compass on the pattern to find it.

Uses of magnets

Permanent magnets (steel, or other hard magnetic materials): compass needles, fridge door seals and fridge magnets, magnetic catches on cupboard doors, loudspeakers and microphones, electric motors and generators, magnetic window cleaners, and anywhere a magnet must work without a power supply.

Electromagnets (a coil with a soft-iron core): cranes that lift scrap steel in a scrapyard and drop it when switched off, electric bells, relays, circuit breakers, magnetic door locks, and MRI scanners in hospitals.

Advantages of an **electromagnet** over a permanent magnet: it can be **switched on and off**, and its **strength can be changed** by changing the current (more current, a stronger magnet). Its N and S poles also swap if the current is reversed. How the coil's current produces the field is covered in the topic on electromagnetic effects.

Key facts and formulas

The 0625 papers have no formula sheet. This topic has no equations, but these facts all have to be learned.

Formula	Status
Like poles repel; unlike poles attract	Learn it
A magnet attracts unmagnetised magnetic materials with either pole; only repulsion proves a magnet	Learn it
Magnetic materials: iron, steel, nickel, cobalt; copper, aluminium and non-metals are non-magnetic	Learn it
Induced magnetism: the near end becomes the opposite pole, so it is attracted	Learn it
Soft iron: temporary magnet (easily magnetised and demagnetised); steel: permanent magnet	Learn it
Magnetic field: a region in which a magnetic pole experiences a force	Learn it
Field direction: the direction of the force on an N pole; lines go from N to S outside the magnet	Learn it
A compass needle's N end points along the field direction	Learn it
Extended only: closer field lines mean a stronger field; strongest at the poles	Learn it
Extended only: magnetic forces are due to interacting magnetic fields	Learn it
Weight and force: $W = mg$, with $g = 9.8$ N/kg (for balance questions)	Learn it

How to do it

We have tagged 93 questions for this topic across Papers 1–4, 2021–2025; 14 are repeats on other papers, leaving 79 different questions. 28 of the 93 mix two or more types, so the counts add up to more than 93. Parts of mixed questions about other topics (circuits, transformers, induced e.m.f.) are not counted here.

Question type	Questions
Magnetic materials: soft iron, steel, temporary and permanent magnets	31
Field lines: pattern, direction, compasses and poles	28
Attraction and repulsion: identify magnets and materials	21
Induced magnetism	11
Extended: field strength from the spacing of field lines	10

Question type	Questions
Magnetic field: definition and direction	8
Magnetising and demagnetising (2021–2022 only)	8
Plotting field lines with a compass or iron filings	6
Uses of permanent magnets and electromagnets	4

1. Magnetic materials: soft iron, steel, temporary and permanent magnets (31 questions)

1. **Decide what the job needs**: a magnet that stays magnetised (permanent, **steel**), a magnet that switches off (temporary, **soft iron**), or no magnetism at all (**non-magnetic**, such as copper for wires or plastic for a case).
2. **Name the material** and, if asked, give the property that fits the job: "steel, because it keeps its magnetism"; "soft iron, because it loses its magnetism when the current is switched off".

Variations you will meet:

- **Multiple-choice rows**: permanent magnet, steel; temporary magnet or electromagnet core, (soft) iron. Iron is sometimes called a "soft" magnetic material and steel a "hard" one.
- **"Which metal is attracted by a magnet?"** Iron (or steel, nickel, cobalt). Copper, aluminium, silver, zinc and lead are not.
- **"State the difference between magnetic and non-magnetic materials"**: magnetic materials are attracted by a magnet (experience a force in a magnetic field); non-magnetic materials are not.
- **"How can a magnet show that a material is non-magnetic?"**: bring the magnet near it; there is no attraction (no force) with either pole.
- **Table of parts**: compass needle, steel; electromagnet core and transformer core, soft iron; coils and connecting wires, copper.
- **Nails and electromagnets**: when the current is switched off, soft-iron nails drop off, steel nails stay stuck together (they became permanent magnets), and copper nails were never picked up at all.
- **Steel instead of iron in an electromagnet**: it stays magnetised after the current is switched off (and is a little weaker while on). **Copper instead of iron**: copper is non-magnetic, so the magnet is much weaker, as if there were no core.

2. Field lines: pattern, direction, compasses and poles (28 questions)

1. **Lines leave N and enter S.** Arrows point from N to S outside the magnet.
2. **A compass's N end points along the field.** So the compass's N end points **away from** an N pole and **towards** an S pole.
3. **To label poles from a diagram**, look at the arrows (they leave N) or at a compass (its N end points to the magnet's S pole). **To label poles from the pattern alone**: lines crossing the gap mean unlike poles (attraction); lines that bend away from each other with a neutral point between mean like poles (repulsion).

Drawing the field of a bar magnet (worth 2 or 3 marks):

- at least four to six smooth lines, each going from one pole round to the other, symmetrical above and below;
- lines that start and end **at the poles** (the ends), not on the long sides of the magnet;
- lines that **never cross or touch**, closer together near the poles;
- an **arrow on each line** pointing from N to S.

Variations you will meet:

- **Two magnets end to end**: unlike poles, draw several straight, evenly spaced lines across the gap from N to S, at right angles to the pole faces; like poles, draw the lines bending away with no line across the gap.
- **Which way does a compass point at point X?** Follow the nearest field line in the direction of its arrow: the needle lies along the line, its N end pointing the way the arrow points. Directly beside the middle of a bar magnet the field runs parallel to the magnet, from the N end towards the S end.
- **A chain of reasoning**: a compass's N end points at pole X, so X is an S pole and the other end of that magnet is N. If that N end repels pole P of another magnet, P is an N pole too.
- **Which diagram is correct?** Reject any with lines crossing, arrows going from S to N outside the magnet, or arrows that change direction along one line.

3. Attraction and repulsion: identify magnets and materials (21 questions)

1. **Like poles repel, unlike poles attract.**
2. **A magnet attracts an unmagnetised magnetic material with either pole.**
3. **Repulsion is the only proof of a magnet.** Use the table in "Understand it".

Variations you will meet:

- **Pairs of bars**: N facing S, attraction; N facing N or S facing S, repulsion; a pole facing unmagnetised steel or iron, attraction; a pole facing copper or aluminium, no force.
- **"Which of three steel bars is unmagnetised?"** Bring the end of one bar up to each end of another and look for repulsion; repeat with the other pairs. The two bars that repel each other at some ends are the magnets; the bar that only ever attracts (never repels) is the unmagnetised one.
- **Balance questions**: an object sits on a top-pan balance and a magnet is held above it. If the reading **goes up**, the object is being **pushed down**: **repulsion**, so it must be a magnet. If the reading **goes down**, it is being **pulled up**: attraction (a magnet with an unlike pole facing, or a magnetic material). The size of the magnetic force is the change in mass (in kg) × 9.8 N/kg.
- **"Which statement is always true?"** A magnet attracts a magnetic material; two magnetic materials attract only if at least one of them is magnetised. Non-magnetic materials do not affect each other magnetically.
- **Labelling poles on two magnets** that are said to attract (or repel): mark the facing ends as unlike (or like) poles, and remember each magnet needs both an N and an S.

4. Induced magnetism (11 questions)

1. The magnetic material near (or touching) the magnet **becomes a magnet**.
2. The end **nearest the magnet's pole** becomes the **opposite pole**; the far end becomes the same pole as the magnet's.
3. So the material is **attracted towards the magnet**, whichever pole is used.

Variations you will meet:

- **"Describe what is meant by induced magnetism"**: a magnetic material becomes magnetised (a magnet) when it is placed in a magnetic field, or near or touching a magnet.
- **Chains of nails or bolts**: each nail's top end is opposite to the pole it touches, so the poles alternate down the chain: under the magnet's N pole, each nail is S at the top and N at the bottom.
- **Direction of the force** on the soft iron: always **towards** the magnet. Don't confuse it with the field direction, which points away from an N pole.
- **A soft-iron wire or rod lying beside a magnet**: it is magnetised by induction and pulled towards the magnet.
- **Field lines through an iron rod**: field lines crowd into a nearby iron rod (it becomes a magnet), but pass through copper unchanged.

5. Extended only: field strength from the spacing of field lines (10 questions)

1. **Closer lines, stronger field; further apart, weaker.**
2. The field of a bar magnet is **strongest at the poles** and weakens with distance.

Variations you will meet:

- **"Where is the force on a pole strongest?"** Where the lines are closest together.
- **Along a path past a bar magnet** from one pole round to the other: strong near the first pole, weakest opposite the middle, strong again near the other pole.
- **Order three points** by field strength: rank them by how close the lines are around each point.
- **Two magnets**: a neutral point between like poles is the weakest place (no field at all); the gap between close unlike poles is strong.
- **A weaker magnet or a smaller current in an electromagnet**: draw fewer lines, further apart. "The resistance increases" means the current decreases, so the field is weaker and the lines spread out.
- **Describe the field of a weak magnet**: from N to S, with lines far apart.

6. Magnetic field: definition and direction (8 questions)

1. **Magnetic field**: a region (space) in which a **magnetic pole** (or a magnetic material) experiences a force.
2. **Direction** of the field at a point: the direction of the force on an **N pole** at that point.

Variations you will meet:

- **Multiple-choice wrong options**: "all objects", "all metals" or "an electric charge" feeling a force. Those describe the wrong kind of field. A stationary charge feels no force in a magnetic field; the force on a charge defines an **electric** field.
- **Direction defined by an S pole?** Wrong: the definition uses the force on an **N pole**.
- **Extended only: explain a force between magnets**, or why a freely hanging magnet always settles north–south: the magnetic fields interact (the magnet's field with the other magnet's field, or with the Earth's magnetic field).
- **Extended only: why a compass needle comes to rest along a field line**: its N pole is pushed in the field direction and its S pole the opposite way, so it turns until it lies along the field.

7. Magnetising and demagnetising (8 questions, 2021–2022 only)

These questions come from the syllabus used before 2023. **Magnetising and demagnetising methods are not in the 2026–2028 syllabus**, so you will not be asked to describe them. If you practise those older papers, the one idea you need from this topic is that **steel keeps its magnetism and soft iron does not**, so a permanent magnet is made from steel and it is steel that must be treated to lose its magnetism.

8. Plotting field lines with a compass or iron filings (6 questions)

1. **Name the equipment**: a plotting compass (for pattern and direction) or iron filings on a card (pattern only).
2. **Describe the compass method** in steps: mark the N end of the needle, move the compass on so its S end is at the mark, repeat, join the dots, add an arrow.
3. **If you use iron filings, add a compass** to find the direction.

Variations you will meet:

- **"State a piece of equipment that shows the direction of a field"**: a (plotting) compass.
- **The field between two magnets**: the same methods, with both magnets on the card.
- **"You may draw on the diagram"**: sketch a compass on a field line with its N end marked, and a line of dots.

9. Uses of permanent magnets and electromagnets (4 questions)

1. **Permanent magnet uses**: compasses, loudspeakers, motors and generators, fridge doors, magnetic catches, window cleaners.
2. **Electromagnet uses**: scrapyard cranes, electric bells, relays, circuit breakers, door locks, MRI scanners.
3. **Advantage of an electromagnet**: it can be switched on and off; its strength can be changed (by changing the current).

Variations you will meet:

- **An electric bell**: closing the switch makes a current in the coil, so the soft-iron core becomes a magnet and attracts the springy iron strip; the hammer on the strip hits the gong. That movement breaks the contact, so the current stops and the soft iron loses its magnetism at once; the spring pulls the strip back, the contact closes again, and the cycle repeats.

- **"Name this type of magnet"** (a coil round an iron rod): an electromagnet.
- **Strongest electromagnet** from lists: the most turns, an iron core, the largest current.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

At a recycling centre, a large magnet above a conveyor belt lifts steel cans out of a mixture of steel cans and aluminium cans.

(a) Explain why the magnet lifts the steel cans but not the aluminium cans. **[2]**

(b) A worker thinks one of the steel cans may have become a permanent magnet. She has a labelled bar magnet. Describe a test she could do, and state what she would see if the can **is** a magnet and what she would see if it is **not**. **[3]**

(c) The can is stood on a top-pan balance, which reads 64.0 g. The bar magnet is held just above the top of the can, and the reading changes to 67.5 g. State whether the force between the magnet and the can is attraction or repulsion, and calculate its size. State what this shows about the can. Take $g = 9.8$ N/kg. **[4]**

(a) Steel is a magnetic material: the magnet induces magnetism in the steel cans, so they are attracted **B1**. Aluminium is non-magnetic, so there is no force on the aluminium cans **B1**.

(b) Bring the N pole, then the S pole, of the bar magnet up to the same end of the can **B1**. If the can is a magnet, one pole will **repel** it **B1**. If it is unmagnetised, **both** poles attract it (it is never repelled) **B1**.

(c) The reading went up, so the can is being pushed down: **repulsion B1**. Change in reading $= 67.5 - 64.0 = 3.5$ g $= 0.0035$ kg. Force $= mg = 0.0035 \times 9.8$ **C1** $= 0.034$ N **A1**. Only a magnet is repelled, so the can has become magnetised **B1**.

Example 2

A bar magnet lies on a sheet of paper. Its poles are not labelled. A plotting compass placed just to the left of the left-hand end of the magnet comes to rest with the N end of its needle pointing towards the magnet.

(a) State which pole is at the left-hand end of the magnet. Explain your answer. **[2]**

(b) Describe how the student can use the plotting compass to draw one field line of the magnet, with its direction. **[4]**

(c) **Extended only.** Point A is 1 cm from one pole of the magnet and point B is 10 cm from the middle of the magnet. State at which point the field is stronger, and how the field lines show this. **[2]**

(a) An S pole **B1**. The compass's N end is pushed in the direction of the field, and field lines go into an S pole, so the N end points towards an S pole (unlike poles attract) **B1**.

(b) Any four of: place the compass near one pole (the N pole, at the right-hand end) **B1**; mark a dot at the N end of the needle **B1**; move the compass so that its S end is over the dot and mark the new position of the N end **B1**; repeat until the compass reaches the other pole, then join the dots with a smooth line **B1**; draw an arrow on the line in the direction the needle's N end points (from N to S) **B1**.

(c) At A **B1**: the field lines are closer together near the poles **B1**.

Example 3

A scrapyard crane uses an electromagnet to lift pieces of steel and put them down somewhere else.

(a) State a suitable material for the core of the electromagnet, and explain why this material is chosen. **[2]**

(b) While the electromagnet is on, a small steel bolt hangs from the bottom of a steel sheet that the crane is holding. The bolt does not touch the electromagnet. Describe what is meant by induced magnetism, and use it to explain why the bolt is held. **[2]**

(c) After the steel has been dropped, the steel bolt picks up a few small iron pins, but an iron nail that was held in the same way picks up nothing. Explain the difference. **[2]**

(d) State one advantage of an electromagnet over a permanent magnet for this job. **[1]**

(e) **Extended only.** Explain, in terms of magnetic fields, why the steel sheet is attracted to the electromagnet. **[2]**

(a) Soft iron **B1**. It is a temporary magnet: it loses its magnetism as soon as the current is switched off, so the steel is released **B1**.

(b) Induced magnetism: a magnetic material becomes a magnet when it is in a magnetic field, near a magnet **B1**. The steel sheet is magnetised by the electromagnet, and it in turn magnetises the bolt, with the bolt's top end the opposite pole to the sheet's bottom, so they attract **B1**.

(c) Steel is a permanent magnet material: the bolt stayed magnetised after the field was removed **B1**. Iron is a temporary magnet material: the nail lost its magnetism **B1**.

(d) It can be switched off to drop the load (or its strength can be changed) **B1**.

(e) The electromagnet's field induces magnetism in the steel, so the steel has its own field **B1**; the two fields interact, giving a force of attraction **B1**.

Common mistakes

- **Iron for a permanent magnet.** Examiners report every year that many candidates choose iron or soft iron for a permanent magnet "because it is easy to magnetise". A permanent magnet is **steel**, because steel keeps its magnetism. Soft iron is for temporary magnets and cores.
- **Swapping the properties of iron and steel.** Soft iron: easy to magnetise, loses it. Steel: keeps it.
- **Saying copper is magnetic.** Being a metal or a conductor does not make a material magnetic. Copper, aluminium and silver are not; iron, steel, nickel and cobalt are.
- **Confusing magnetic materials with magnets.** A magnetic material is attracted by a magnet; it is not necessarily a magnet itself. Magnetism has nothing to do with "free electrons".
- **Using attraction to prove a magnet.** An unmagnetised iron bar is attracted by both poles. Only repulsion proves a magnet.
- **Iron filings with no compass.** Filings show the pattern only. A description that doesn't use a compass for the direction loses marks, and describing the pattern in the diagram instead of the method earns nothing.
- **Arrows the wrong way, or no arrows.** Field lines go from N to S. When you draw a compass, mark which end of its needle is N.
- **Careless field lines**: lines drawn from the sides of the magnet, crossing lines, or lines that stop in mid-air. Start and end lines at the poles, and keep them apart.
- **Vague definitions.** "The area around a magnet" or "a region where an object feels a force" are not enough: say "a **region** where a **magnetic pole** (or magnetic material) experiences a **force**". Don't mix it up with an electric field (a force on a **charge**).
- **Getting the force on induced iron backwards.** The iron is always pulled **towards** the magnet, even when the field arrow at the pole points away from it.
- **Weak electromagnet advantages.** "It can be magnetised" or "it is stronger" earn nothing; "it can be switched on and off" does.

How to get the marks

- **"State the difference"** (magnetic and non-magnetic, iron and steel): give **both sides**, for example "iron loses its magnetism easily; steel keeps it".
- **"Suggest a material … Explain"**: the material earns one mark, and the reason must fit the job: "steel, because it stays magnetised" for a permanent magnet.
- **"Describe an experiment"** to plot a field: numbered steps someone could follow, naming the equipment (plotting compass, paper, pencil), what you mark, how you move the compass, and how you find the direction.
- **"Draw the field"**: several lines from pole to pole, symmetrical, not crossing, with arrows from N to S. Neatness matters: careless lines lose the pattern mark.
- **Labelling poles**: label **every** pole asked for, with N and S (not other letters); each magnet has one of each.
- **"State and explain what you can deduce"**: the deduction ("the bar is a magnet") **and** the evidence ("it is repelled, and only a magnet is repelled").

- **Multiple choice with two or three columns** (material and use, pole and force): check every column of the row you choose.
- **Extended only: "Explain" a force between magnets**: mention that the **magnetic fields interact**. For field strength, say the lines are **closer together** (or further apart).
- **Balance questions**: say whether the reading goes up or down and link it to the direction of the force (up means pushed down, repulsion).

Quick check

1. Two toy train carriages are joined by small bar magnets fixed at their ends. Carriage A has an N pole at its back. Carriage B has a magnet whose S pole is at its front and N pole at its back. (a) What happens when B's front is pushed towards A's back? (b) B is turned round, so that its back faces A's back. What happens now? (c) Carriage C has a plain soft-iron bar at each end. What happens when either end of C is pushed towards A's back?
2. Name a suitable material for: (a) a compass needle; (b) the core of an electric bell's electromagnet; (c) the wire of the bell's coil.
3. An iron block rests on a top-pan balance, which reads 120.0 g. A magnet held just above it, S pole downwards, changes the reading to 116.2 g. State whether the force on the block is attraction or repulsion and calculate its size ($g = 9.8$ N/kg). What would the reading be if the magnet were turned over so that its N pole faced the block, at the same distance?
4. A bar magnet lies with its N pole on the left and its S pole on the right. A plotting compass is placed just to the right of the S pole, on the magnet's axis. In which direction does the N end of the needle point?
5. **Extended only.** Two bar magnets lie end to end with their N poles facing, a few centimetres apart. Describe the field lines between them and state where the field is weakest.

Answers

1. (a) They attract: S faces N, unlike poles. (b) They repel: B's N pole now faces A's N pole. (c) C is attracted, whichever end: the iron is magnetised by induction, with an S pole at the end nearest A's N pole.
2. (a) Steel (a permanent magnet); (b) soft iron (a temporary magnet, so the bell can switch off); (c) copper (a good conductor and non-magnetic).
3. The reading went down, so the block is pulled upwards: **attraction**. Change $= 120.0 - 116.2 = 3.8$ g $=$ 0.0038 kg, so force $= 0.0038 \times 9.8 = 0.037$ N. With the N pole facing, the reading is still 116.2 g: unmagnetised iron is attracted equally by either pole, because the near end always becomes the opposite pole.
4. To the left, towards the magnet: field lines go into an S pole, and the needle's N end points along the field.
5. The lines from each N pole curve away from the other magnet and bend sideways, back round towards each magnet's own S pole; no line crosses the gap. The field is weakest at the neutral point halfway between the two N poles, where there is no field at all.

Past questions to try

- **0625/31/M/J/23 Q8**: labelling the poles of two repelling magnets and describing how to plot a field (Core).
- **0625/31/O/N/22 Q7**: deducing that a bar is a magnet from attraction and repulsion, and showing a field pattern (Core).
- **0625/21/M/J/23 Q23**: the polarity of an induced pole and the direction of the force on soft iron.
- **0625/42/O/N/22 Q7**: drawing field patterns and justifying the force between two N poles (Extended).