

# Magnetism

Matthew Williams • Physics • May 20, 2026

## Magnetism

### Magnetic and Non-Magnetic Materials

**Magnetic materials** are attracted to magnets. Common magnetic materials include iron, nickel, cobalt, and alloys containing them.

**Non-magnetic materials** are not attracted to magnets. These include copper, aluminium, wood, glass, and most plastics.

### Permanent and Temporary Magnets

Type	Material	Properties
Permanent magnet	Steel, alnico, magnadur (ceramic ferrite)	Retains magnetism after the magnetising force is removed, "hard" magnetic material
Temporary (soft) magnet	Soft iron, mumetal, permalloy	Magnetised easily by an external field but loses magnetism when the field is removed, "soft" magnetic material

Soft iron is used in electromagnet cores because it becomes strongly magnetised when current flows and loses its magnetism when the current is switched off, essential for relays and electric motors.

Steel is used for permanent magnets (fridge magnets, compass needles, loudspeaker magnets) because it retains magnetism.

### Poles and Forces

Every magnet has a **north pole** (N) and a **south pole** (S). The north pole is defined as the end that points toward geographic north when the magnet is freely suspended.

#### Rule of poles:

- Like poles repel (N-N, S-S).

- Unlike poles attract (N-S).

## Magnetic Fields

A **magnetic field** is a region in which a magnetic material or a moving charge experiences a force. The direction of the field at a point is defined as the direction in which the north pole of a small test compass would point.

### Field Line Conventions

- Field lines emerge from the north pole and enter the south pole.
- Arrows on field lines show the direction a north pole would move (N to S outside the magnet).
- Closely spaced lines indicate a strong field; widely spaced lines indicate a weak field.
- Field lines never cross.

### Field Patterns

**Bar magnet:** Field lines emerge from N, curve around, and re-enter at S. Near the poles, lines are densely packed (strong field).

**Between two unlike poles (N facing S):** Lines run directly from N to S between the poles, approximately uniform in the central region.

**Between two like poles (N facing N):** Lines push away from each other. A neutral point exists midway between the poles where the net field is zero.

### Plotting Magnetic Fields

A small compass is placed at various positions around the magnet. The compass needle aligns with the local field. Mark the direction of the needle tip at each position and join the marks smoothly to draw field lines.

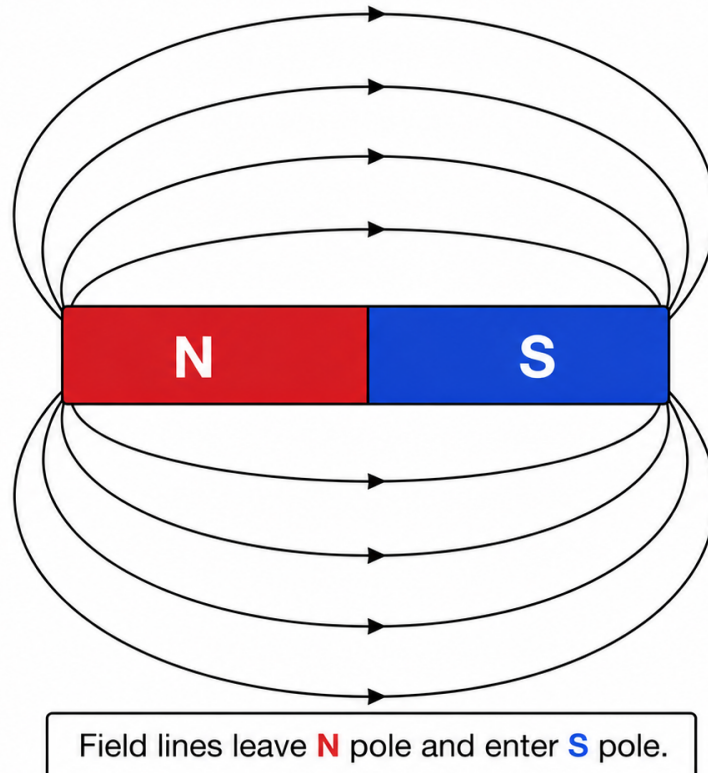


Diagram showing the magnetic field lines around a bar magnet: lines emerge from the north pole, curve around through the surrounding space, and re-enter at the south pole, with closely spaced lines near the poles indicating a stronger field and arrows showing the direction from north to south outside the magnet

## Induced Magnetism

When an unmagnetised magnetic material (e.g. a nail) is placed near or in contact with a magnet, it becomes magnetised by induction. The end nearest the magnet acquires the opposite polarity to the inducing pole (because unlike poles attract). Induced magnetism in soft iron disappears when the magnet is removed.

### Exam Tip

A common question asks which end of an induced magnet faces the original magnet. The answer: the **opposite** pole, because unlike poles attract and hold the material in place.

Permanent magnets use steel or other "hard" magnetic materials. Electromagnet cores use soft iron or mumetal because they respond quickly to changes in the magnetising current.