

Magnets, fields and electromagnets

Grade 8 science (Year 9 · Class 8) · Lesson

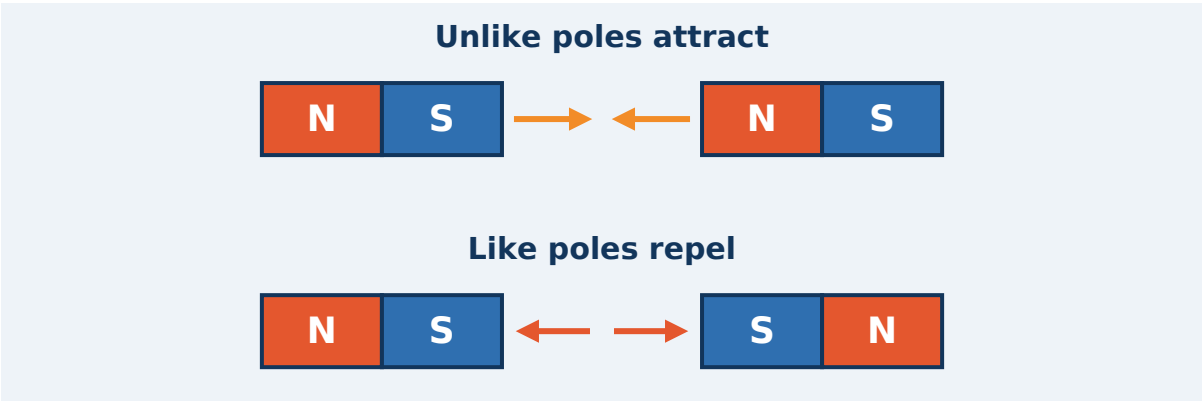
Quick answer: A magnet has a north and a south pole: like poles repel and unlike poles attract. Its magnetic field is drawn as lines running from north to south, closest together where the field is strongest. An electromagnet is a coil carrying current, made stronger with more turns, more current or an iron core.

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What are magnetic poles?

A magnet is an object that attracts some metals and can attract or repel other magnets. The force is strongest at two places near the ends of a bar magnet, called the poles.

Definition
A magnet has two poles: a north pole (N) and a south pole (S). Like poles repel each other, and unlike poles attract each other.



Unlike poles attract each other; like poles repel each other.

Only a few materials are attracted by a magnet. Iron, steel, nickel and cobalt are magnetic materials. Most other metals are not.

Material	Attracted by a magnet?
Iron nail	Yes
Steel paper clip	Yes
Nickel pin	Yes
Aluminium foil	No
Copper wire	No
Plastic ruler	No

If you cut a bar magnet in half, you do not get a lone north pole and a lone south pole. Each piece becomes a smaller magnet with its own N and S.

What is a magnetic field?

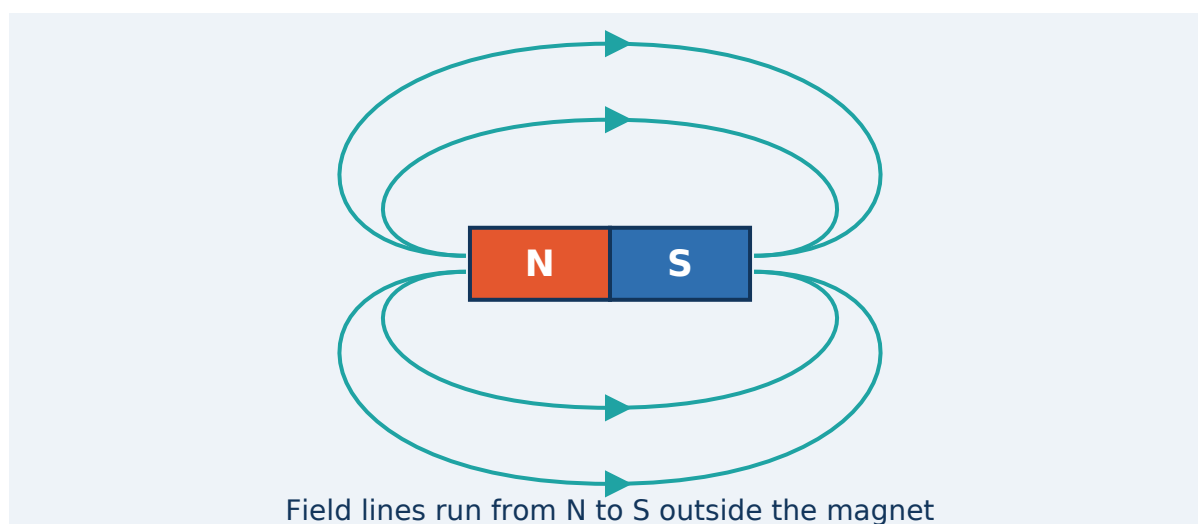
A magnet changes the space around it. Any magnetic material or other magnet placed there feels a force, even without touching.

Definition

A magnetic field is the region around a magnet where another magnet or a magnetic material feels a force.

Key rule

Magnetic field lines leave the north pole, curve round and enter the south pole. Lines never cross. The closer together the lines, the stronger the field.



Magnetic field of a bar magnet. Lines are closest together near the poles, where the field is strongest.

The field is strongest at the poles, where the lines crowd together, and it gets weaker as you move away. That is why a paper clip jumps to the end of a magnet but not to its middle from far away.

How does a compass work?

A compass needle is a tiny magnet that can spin freely. It lines up with whatever magnetic field is around it. If you bring a bar magnet close, the needle turns to follow the field lines of the bar magnet, and its S end points to the magnet's N pole because unlike poles attract.

Far from other magnets, the needle follows the Earth's own field. The Earth behaves as if a huge bar magnet lay inside it, so the end of the needle marked N swings round to point towards the north.

Worked example 1

A plotting compass is placed near the S pole of a bar magnet. Which end of the needle

points at the magnet?

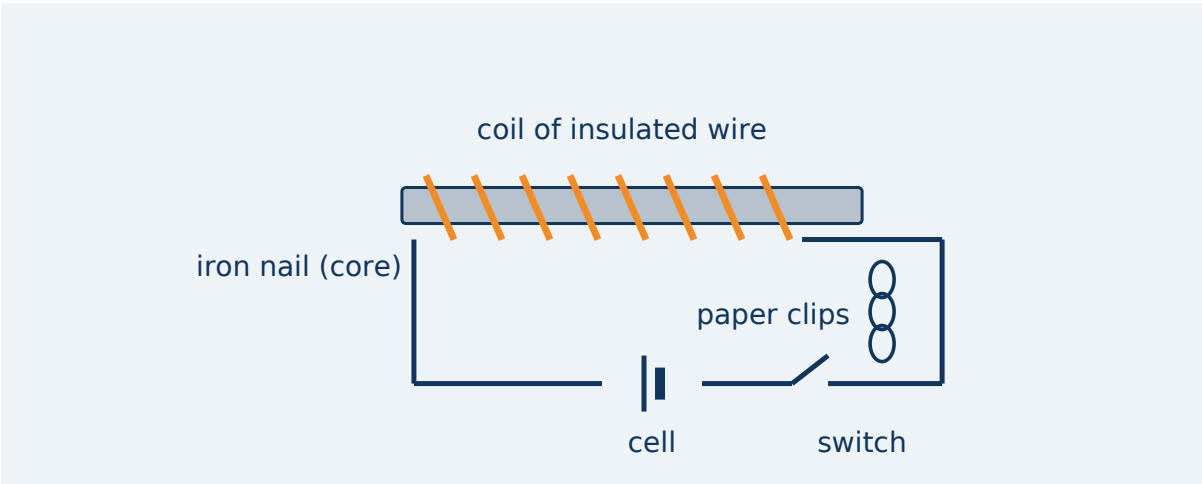
Unlike poles attract, so the N end of the needle is pulled towards the S pole. The answer is the **N end of the needle**.

What is an electromagnet and how can you make it stronger?

When an electric current flows in a wire, it makes a magnetic field around the wire. Coiling the wire makes the field much stronger, and an iron core makes it stronger still.

Definition

An electromagnet is a coil of wire, usually wound on an iron core, that behaves as a magnet only while a current flows.



A simple electromagnet. The current in the coil makes the iron nail a magnet.

An electromagnet has three big advantages over a permanent magnet. It can be switched on and off, its strength can be changed, and its poles swap if the current is reversed.

To make an electromagnet stronger	Reason
Add more turns of wire	More turns add their fields together
Increase the current (more cells)	A bigger current gives a bigger field
Use a soft iron core	The core becomes magnetised and adds to the field

Worked example 2

An electromagnet with 25 turns lifts 5 paper clips. Assume the clips lifted are proportional to the number of turns. How many clips will 60 turns lift?

Clips per turn = $5 \div 25 = 0.2$.

With 60 turns: $0.2 \times 60 = \mathbf{12 \text{ clips}}$.

Worked example 3

Raising the supply from 3 V to 6 V increases the clips lifted from 5 to 11. Find the

percentage increase.

Increase = $11 - 5 = 6$. Percentage = $6 \div 5 \times 100 = \mathbf{120\%}$.

Common mistake

A magnet does not attract every metal. Aluminium and copper are not attracted. Another error is drawing field lines that cross: lines never cross, because the field has only one direction at each point.

Lina's tip

Outside a magnet, draw field-line arrows from N to S. To remember how electromagnets work, think of three levers: turns, current and core.

Key points to remember

- Like poles repel; unlike poles attract
- Iron, steel, nickel and cobalt are magnetic materials
- Field lines run from N to S outside a magnet and never cross
- Compass needle: a small magnet that lines up with the field
- Electromagnet strength rises with more turns, more current and an iron core

Magnets, fields and electromagnets: frequently asked questions

Why do magnets have two poles?

Every part of a magnet is a tiny magnet with a north and a south end. Cutting a magnet in half gives two smaller magnets, so a single pole can never be isolated.

What do magnetic field lines show?

They show the direction of the force on a north pole and the strength of the field. Lines leave the north pole, enter the south pole and are closest together where the field is strongest.

How does a compass work?

A compass needle is a small magnet free to turn. It lines up with the magnetic field around it, which far from other magnets is the Earth's field, so the N end points north.

How can you make an electromagnet stronger?

Add more turns of wire, increase the current by using more cells, or wind the coil on a soft iron core. Each change makes the magnetic field bigger.

Why is an electromagnet useful?

It can be switched on and off, its strength can be changed, and its poles can be reversed. This makes it ideal for cranes, bells and relays.