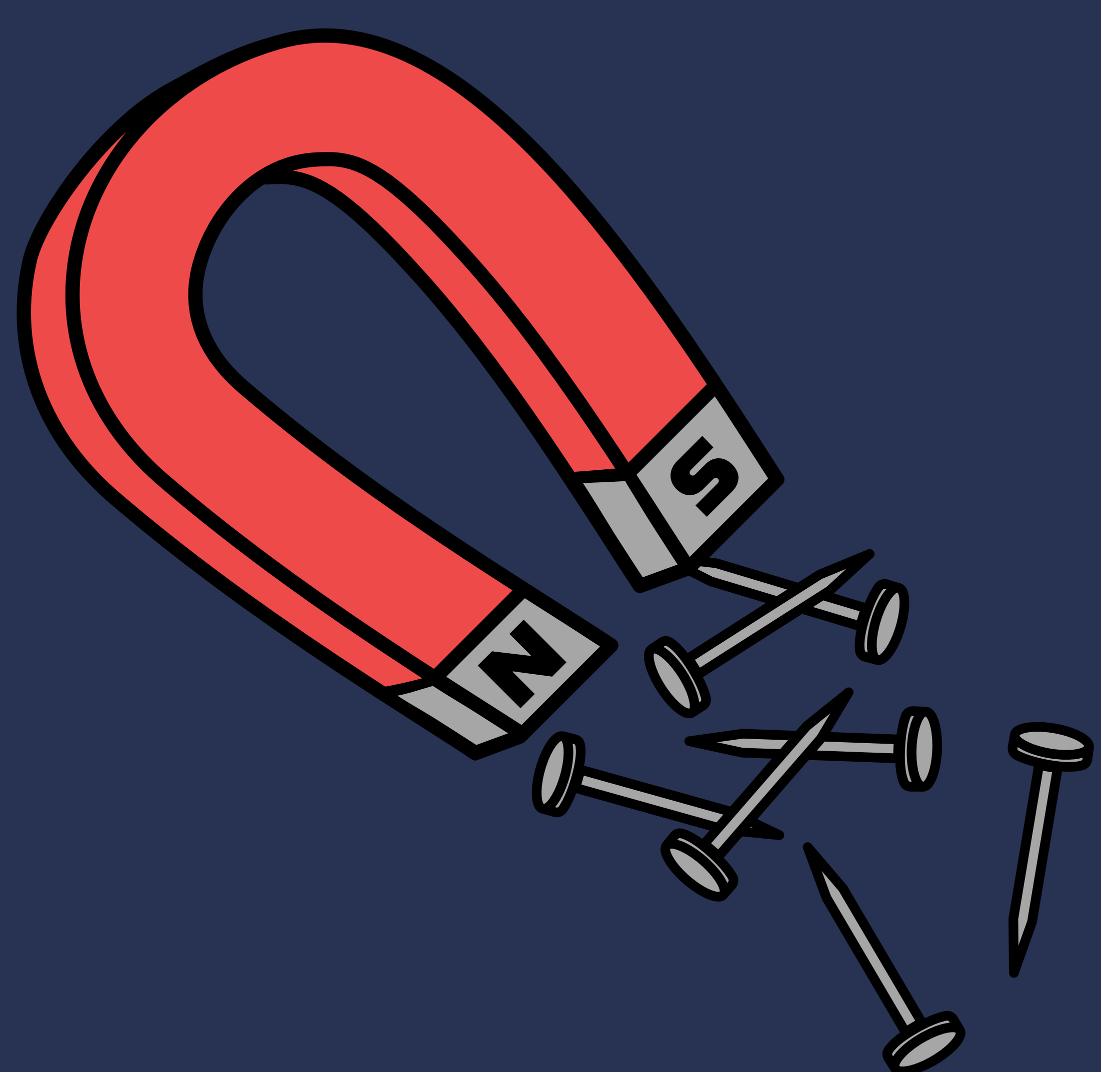
Educate Cloud

GCSE PHYSICS

MAGNETISM + ELECTROMAGNETISM



CHECKLIST

4.7.1 Permanent and Induced Magnetism, Magnetic Forces and Fields				
Topic	**Success Criteria**	**Progress**		
Poles of a Magnet	I can describe where the magnetic forces around a magnet are the strongest.			
	I can describe the attraction and repulsion between unlike and like poles for permanent magnets.			
	I can state whether attraction and repulsion between two magnetic poles are contact or non-contact forces.			
	I can describe the difference between permanent and induced magnets.			
Magnetic Fields	I can name four magnetic materials.			
	I can explain what a magnetic field is.			
	I can describe the type of force between a magnet and a magnetic material.			
	I can explain what affects the strength of a magnetic field.			
	I can describe the direction of the magnetic field at any point.			
	I can describe the direction of a magnetic field line.			
	I can explain how a magnetic compass works.			
	I can describe how to plot the magnetic field pattern of a magnet using a compass.			
	I can draw the magnetic field pattern of a bar magnet showing how strength and direction change from one point to another.			
	I can explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic.			

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4.7.2 The Motor Effect				
Topic	**Success Criteria**	**Progress**		
Electromagnetism	I can describe how a magnetic field is produced around a wire.			
	I can describe what affects the strength of the magnetic field around a wire.			
	I can explain how shaping a wire into a solenoid affects the strength of the magnetic field produced around the wire.			
	I can give two properties of the magnetic field inside a solenoid.			
	I can describe how the magnetic effect of a current can be demonstrated.			
	I can draw the magnetic field pattern for a straight wire carrying a current and for a solenoid (showing the direction of the field).			
	I can interpret diagrams of electromagnetic devices in order to explain how they work.			
Fleming's Left-Hand Rule (HT Only)	I can explain what is meant by the motor effect.			
	I can show that Fleming's left-hand rule represents the relative orientation of the force, the current in the conductor and the magnetic field.			
	I can recall the factors that affect the size of the force on the conductor.			
	I can calculate the force for a conductor at right angles to a magnetic field that is carrying a current by applying the correct equation from the physics equation sheet.			
	I can rearrange the equation linking current, force, length and magnetic flux density to calculate the current, length or magnetic flux density.			
Electric Motors (HT Only)	I can recall the factors that affect the size of the force on the conductor.			
Loudspeakers (HT Only)	I can recall the factors that affect the size of the force on the conductor.			

CHECKLIST

4.7.3 Induced Potential, Transformers and the National Grid (HT Only)				
Topic	**Success Criteria**	**Progress**		
Induced Potential	I can explain what is meant by the generator effect.			
	I can describe how the magnetic field of an induced current opposes the change that induced the current.			
	I can recall the factors that affect the size of the induced potential difference/induced current.			
	I can recall the factors that affect the direction of the induced potential difference/induced current.			
	I can apply the principles of the generator effect in a given context.			
Uses of the Generator Effect	I can explain how the generator effect is used in an alternator to generate ac.			
	I can explain how the generator effect is used in a dynamo to generate dc.			
	I can draw graphs of potential difference generated in the coil against time.			
	I can interpret graphs of potential difference generated in the coil against time.			
Microphones	I can explain how a moving-coil microphone works.			

CHECKLIST

Topic	Success Criteria	Progress		
Transformers	I can describe what a basic transformer consists of.			
	I can explain why iron is used in transformers.			
	I can explain how the ratio of the potential difference across the two coils depends on the ratio of the number of turns on each.			
	I can apply the equation linking the potential differences across the primary and secondary coils and the number of primary and secondary coils from the physics equation sheet.			
	I know how the voltage of the primary coil and secondary coil compare in a step-up transformer.			
	I know how the voltage of the primary coil and secondary coil compare in a step-down transformer.			
	I can state how the electrical power output would compare with the electrical power input if transformers were 100% efficient.			
	I can apply the correct equation from the physics equation sheet to calculate the current drawn from the input supply to provide a particular power output.			
	I can explain how the effect of an alternating current in one coil in inducing a current in another is used in transformers.			
	I can apply the correct equation from the physics equation sheet linking the potential differences and number of turns in the two coils of a transformer to the currents and the power transfer involved and relate these to the advantages of power transmission at high potential differences.			

POLES OF A MAGNET AND LAW OF MAGNETISM

Magnets have two poles called the north pole and south pole. When magnets are brought close together, they exert forces on each other depending on pole arrangement. This is called the law of magnetism

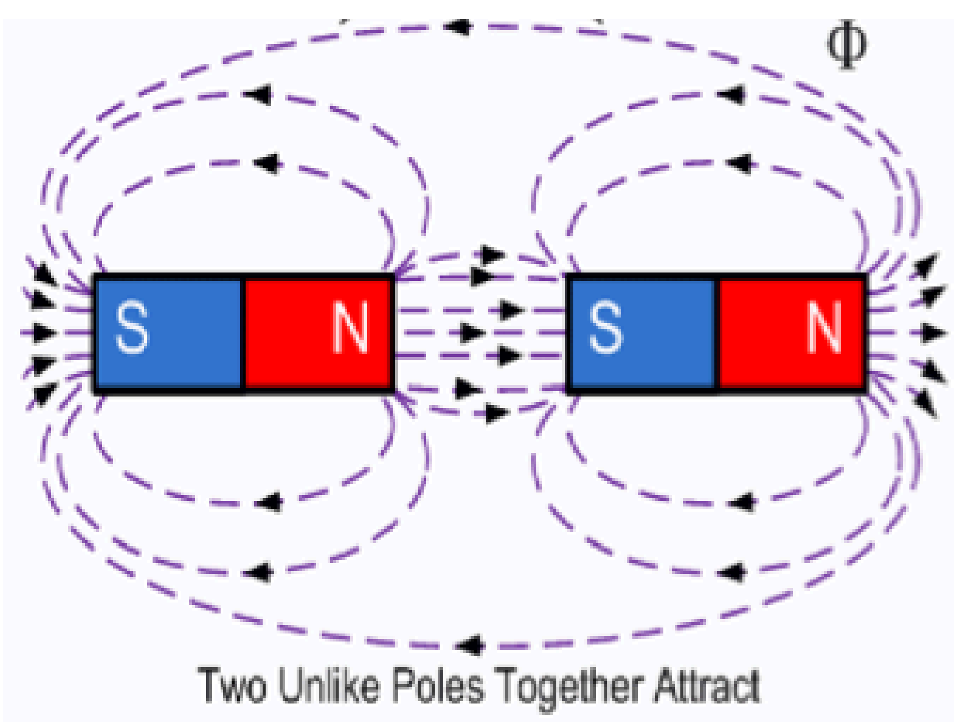
Magnets have two poles: north and south

- Opposite poles attract
- Like poles repel
- Magnetic forces are non-contact forces

Examples

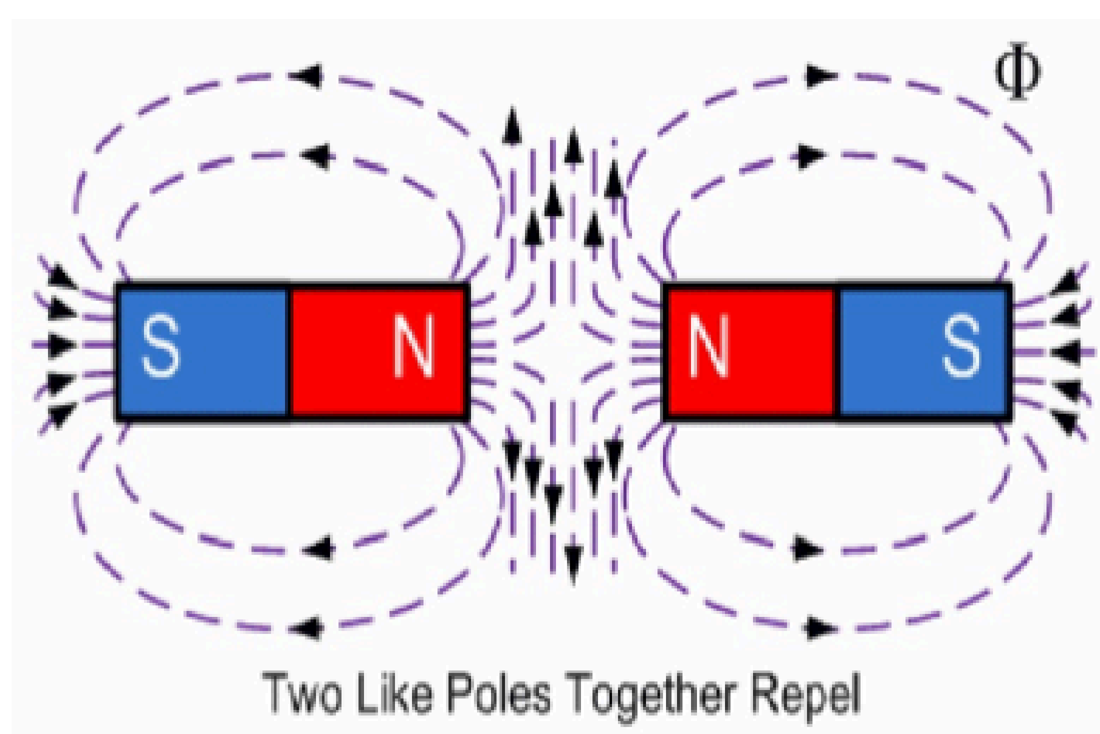
North and south poles attracting

Two north poles repelling



Opposites Attract

- Magnetic poles that are unlike attract each other.



Like Repels

- Magnetic poles that are alike repel each other.

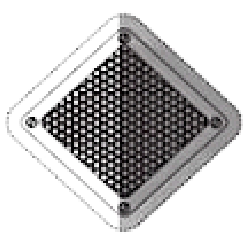
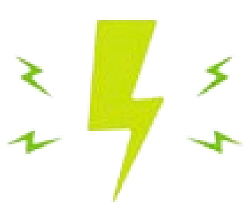
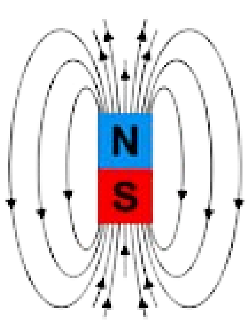
PERMANENT AND INDUCED MAGNETS

Magnetic Materials
Magnetic materials are attracted to magnets. Only certain metals are magnetic, such as iron, cobalt, nickel, and steel. Magnetic materials can be attracted but only magnets can repel

Permanent Magnets
Permanent magnets produce their own magnetic field and do not lose their magnetism. They are made from permanent magnetic materials such as steel.

Induced Magnets
Induced magnetism occurs when a magnetic material is placed in a magnetic field and temporarily becomes a magnet. The induced magnet loses magnetism when removed from the field.
Examples
Iron becoming magnet near magnet

PERMANENT AND INDUCED MAGNETS

	Permanent Magnet	**Electromagnet**
	Permanently Magnetised	Temporarily Magnetised
	Made of Hard Magnetic Materials	Made of Soft Magnetic Materials
	Magnetism doesn't vary in strength	Magnetism can be varied in strength according to needs
	Magnets' poles cannot be altered	Magnets' poles can be modified

MAGNETIC FIELDS

A magnetic field is the region around a magnet where forces act on other magnets or magnetic materials.

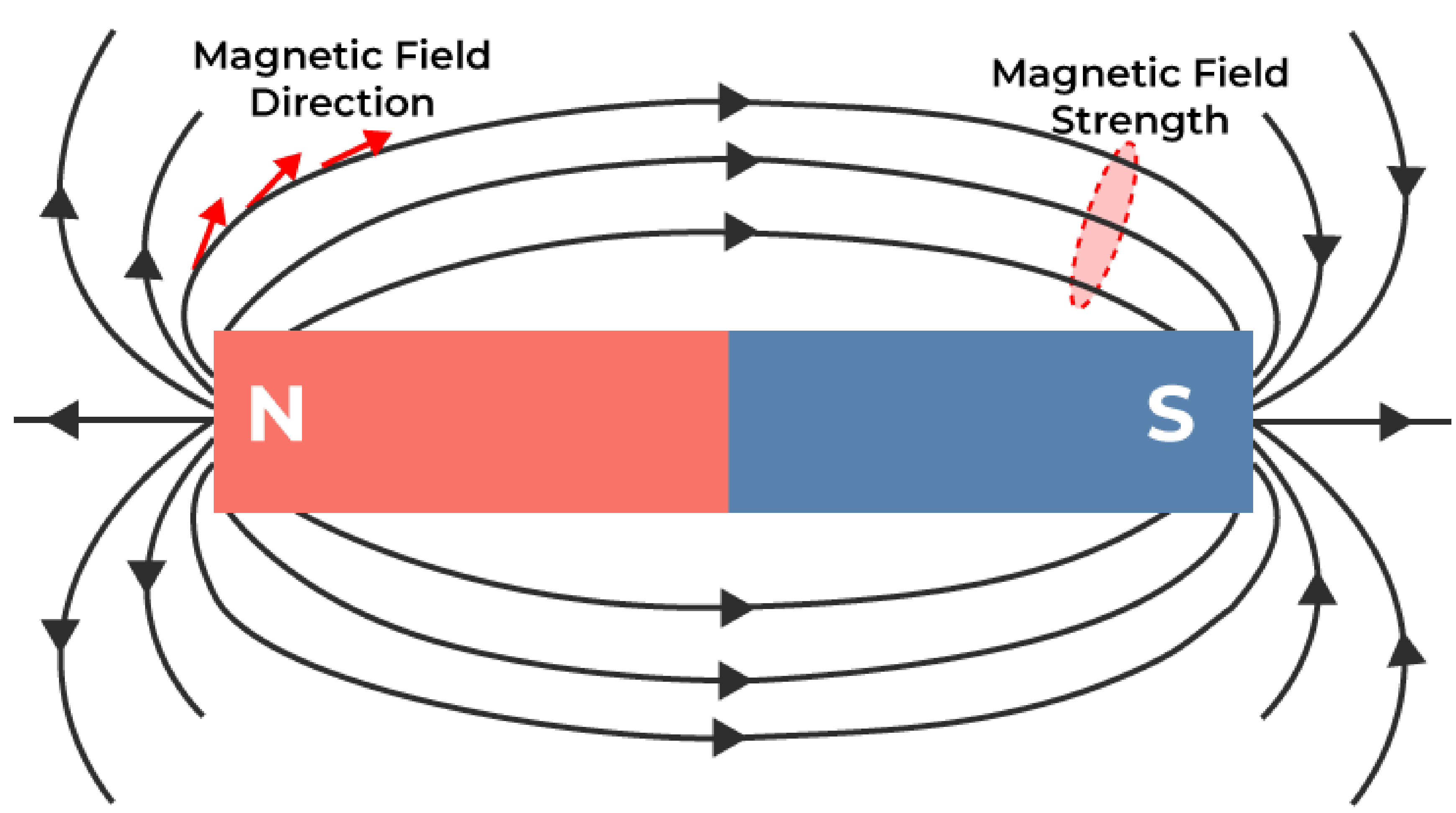
MAGNETIC FIELD LINES

Magnetic field lines show the strength and direction of magnetic fields. The direction is shown by arrows and strength by spacing.

Key Points:

- Field lines go from north pole to south pole
- Field lines never cross
- Closer lines mean stronger field
- Further lines mean weaker field

Magnetic Field Lines



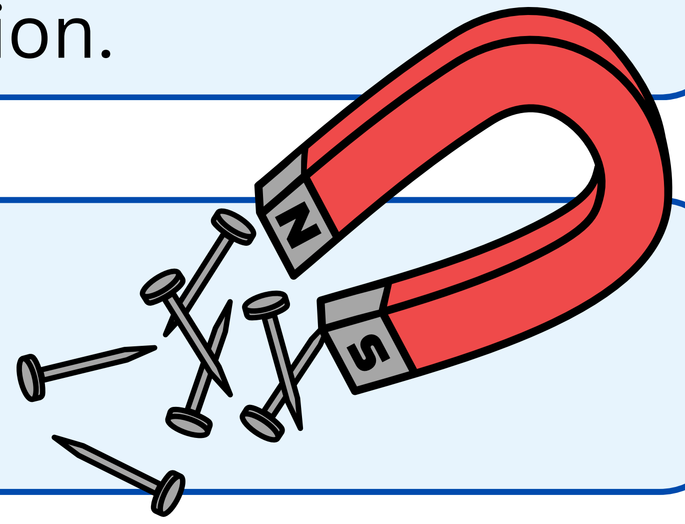
FORCE OF ATTRACTION

Magnetic forces can occur between two magnets or between a magnet and a magnetic material.

Opposite poles attract due to the law of magnetism. When a magnet is placed near a magnetic material, it induces magnetism in the material. This causes the closest end of the material to become the opposite pole, resulting in attraction.

Examples

- Magnet attracting iron nail



UNIFORM MAGNETIC FIELD

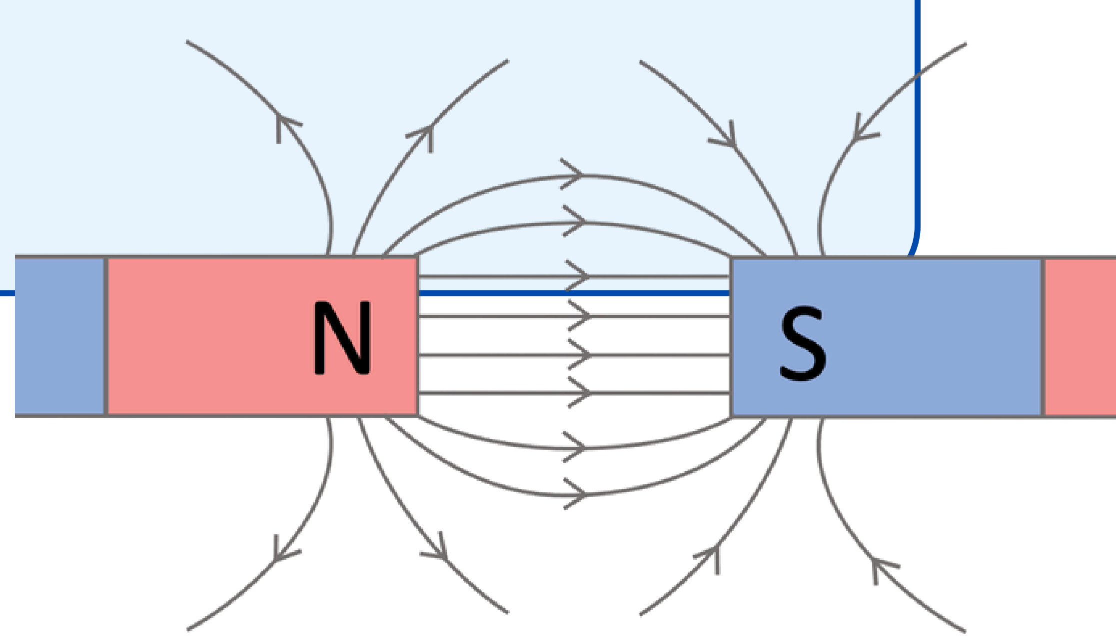
A uniform magnetic field is a magnetic field that has constant strength and constant direction at all points. This type of field is produced between two opposite poles placed close together.

Relationship

Equal spacing of field lines → constant magnetic field strength

Examples

Magnetic field between opposite poles



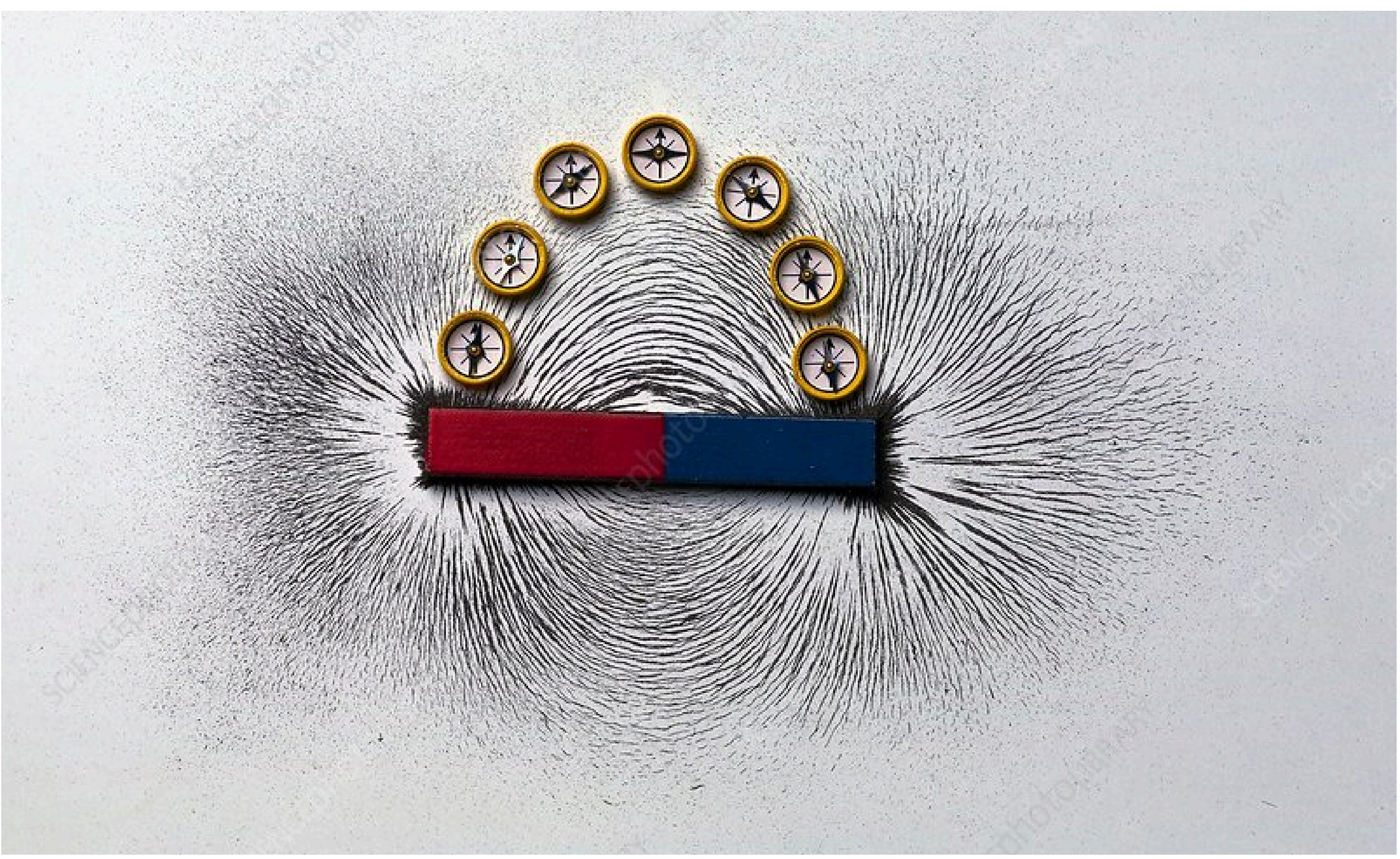
PLOTTING MAGNETIC FIELDS

Magnetic fields can be mapped using plotting compasses. A plotting compass contains a small magnetized needle that aligns with the magnetic field.

The north pole of the compass needle points in the direction of the magnetic field. By placing the compass at different points around the magnet and marking the needle direction, magnetic field lines can be drawn. These lines show the shape and direction of the magnetic field.

Examples

- Compass showing magnetic field around bar magnet



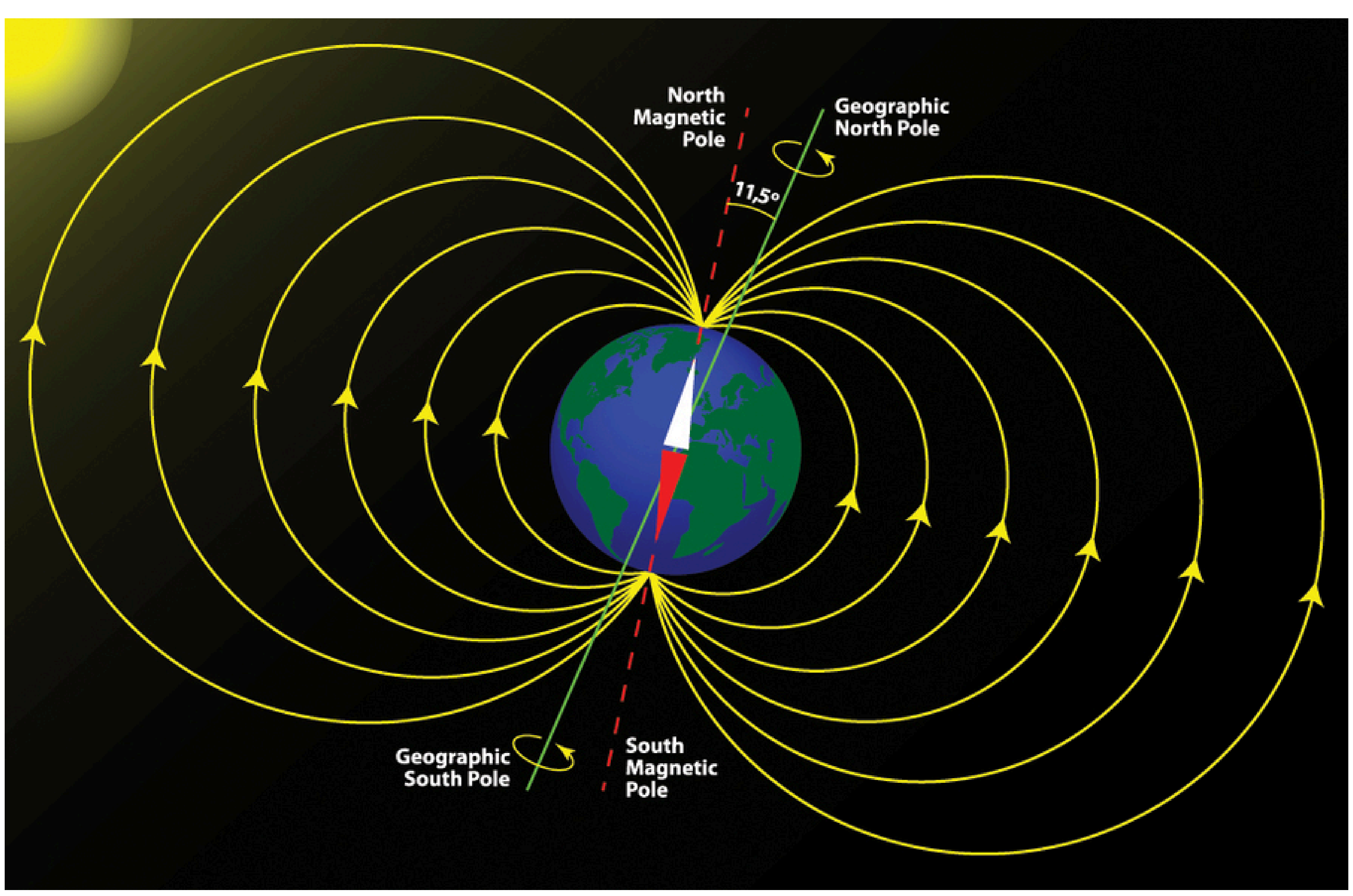
THE EARTH'S MAGNETIC FIELD

The Earth produces its own magnetic field, similar to the magnetic field of a bar magnet. This magnetic field is created by processes occurring inside the Earth's core.

A compass works because its needle aligns with the Earth's magnetic field. The north-seeking pole of the compass points toward the Earth's geographic North Pole. However, the geographic North Pole is actually a magnetic south pole. This is why the north pole of a compass is attracted to it.

Relationship:
Geographic North Pole = magnetic south pole
Geographic South Pole = magnetic north pole

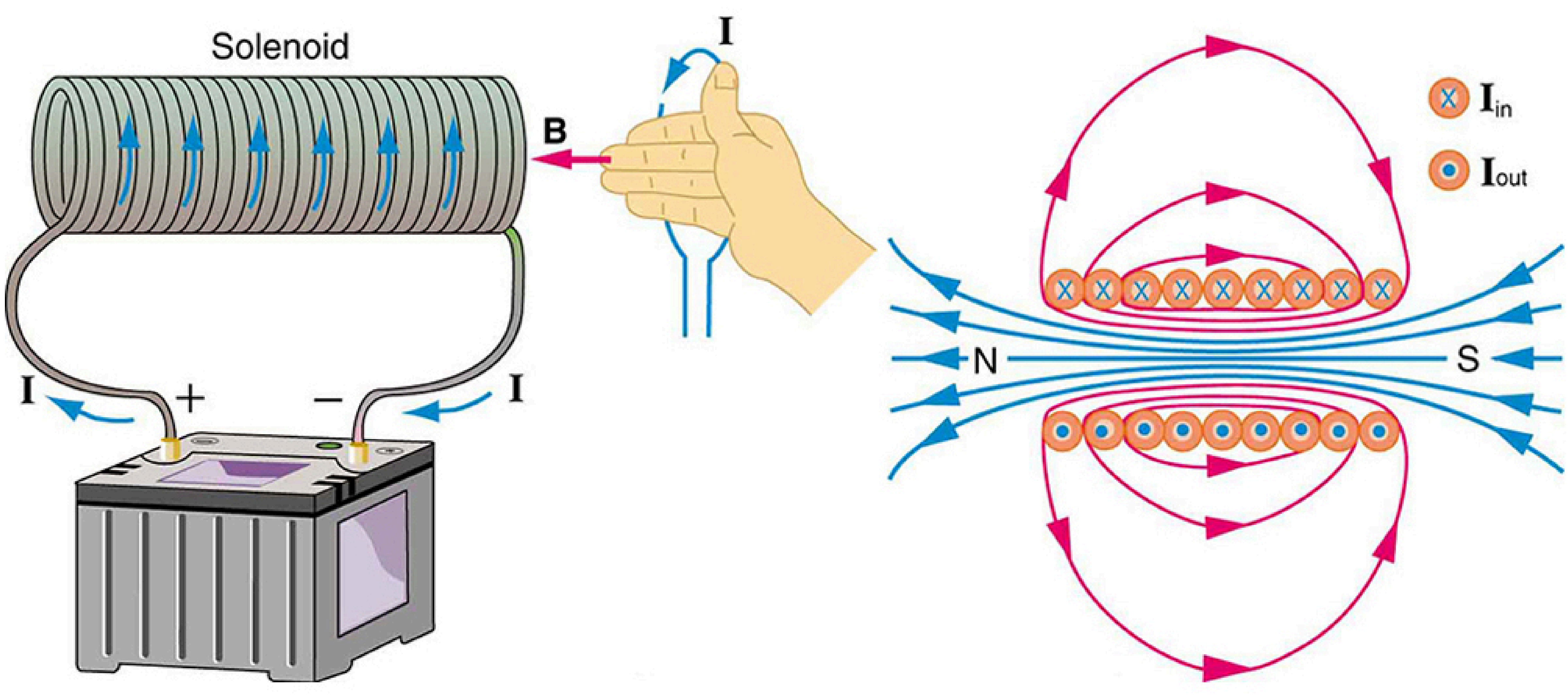
Examples:
Compass pointing north



MAGNETIC FIELDS IN WIRES AND SOLENOIDS

When an electric current flows through a conducting wire, it produces a magnetic field around the wire. This happens because moving electric charges create magnetic effects. If there is no current, there is no magnetic field.

The magnetic field produced around a straight wire forms circular patterns around the wire. These circular field lines are called concentric circles. This circular pattern shows that the magnetic field exists all around the wire and does not originate from poles like a bar magnet.



(a) (b)

MAGNETIC FIELDS IN WIRES AND SOLENOIDS

The direction of the magnetic field can be determined using the right-hand thumb rule. If you point your right thumb in the direction of current, your curled fingers show the direction of the magnetic field. If the direction of current is reversed, the magnetic field direction also reverses.

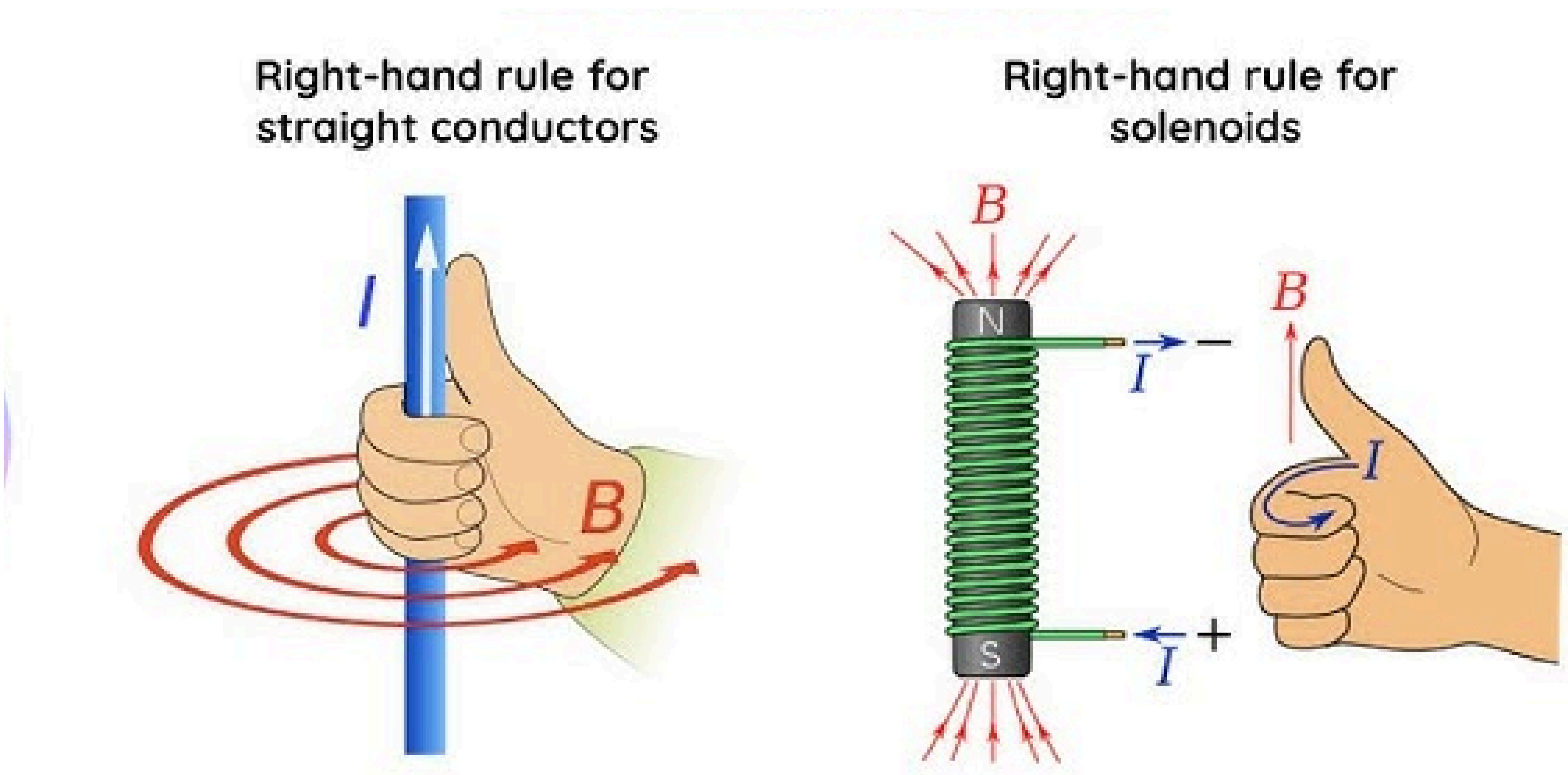
Relationship

Current ↑ → Magnetic field strength ↑

Distance from wire ↑ → Magnetic field strength ↓

Examples

Magnetic field around current-carrying wire

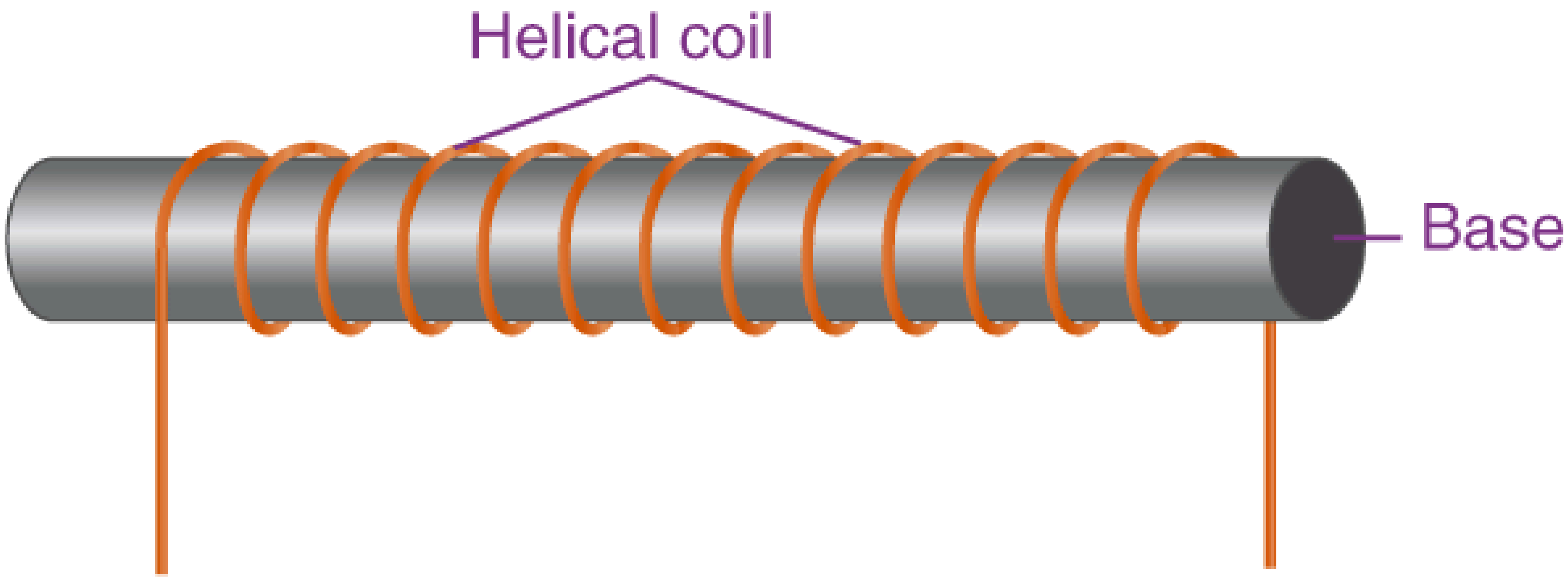


MAGNETIC FIELD AROUND A SOLENOID

A solenoid is a coil of wire formed by looping the wire into many circular turns. When current flows through a solenoid, each loop produces a magnetic field, and these fields combine to create a strong overall magnetic field.

The magnetic field inside the solenoid is strong and uniform. This means the field strength is constant throughout the inside of the solenoid. Outside the solenoid, the field is weaker and spreads out.

A solenoid behaves like a bar magnet. One end acts as a north pole and the other acts as a south pole. The direction of the poles depends on the direction of the current. If the current direction is reversed, the north and south poles switch places.

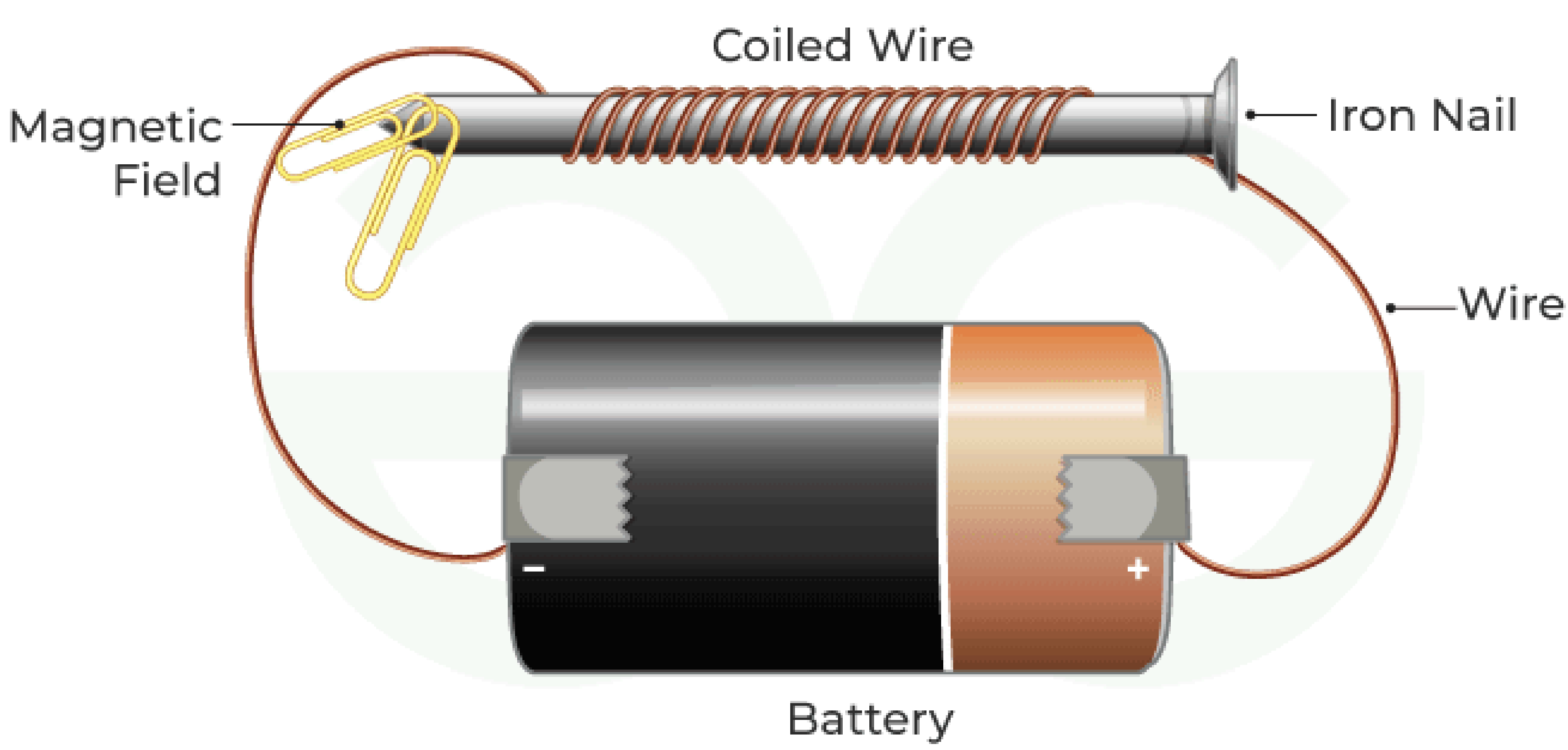


ELECTROMAGNETS

An electromagnet is a solenoid with an iron core placed inside it. The iron core becomes magnetized due to induced magnetism and increases the strength of the magnetic field.

Electromagnets are different from permanent magnets because they can be switched on and off. When current flows through the solenoid, the electromagnet produces a magnetic field. When the current is switched off, the magnetic field disappears.

The strength of an electromagnet can be increased by increasing the current, increasing the number of turns, or adding an iron core.



THE MOTOR EFFECT

The motor effect occurs when a current-carrying wire is placed inside a magnetic field and experiences a force. This happens because the magnetic field around the wire interacts with the external magnetic field.

The interaction between these two magnetic fields creates a force on the wire. This force causes the wire to move. The direction of this force depends on the direction of current and the direction of the magnetic field.

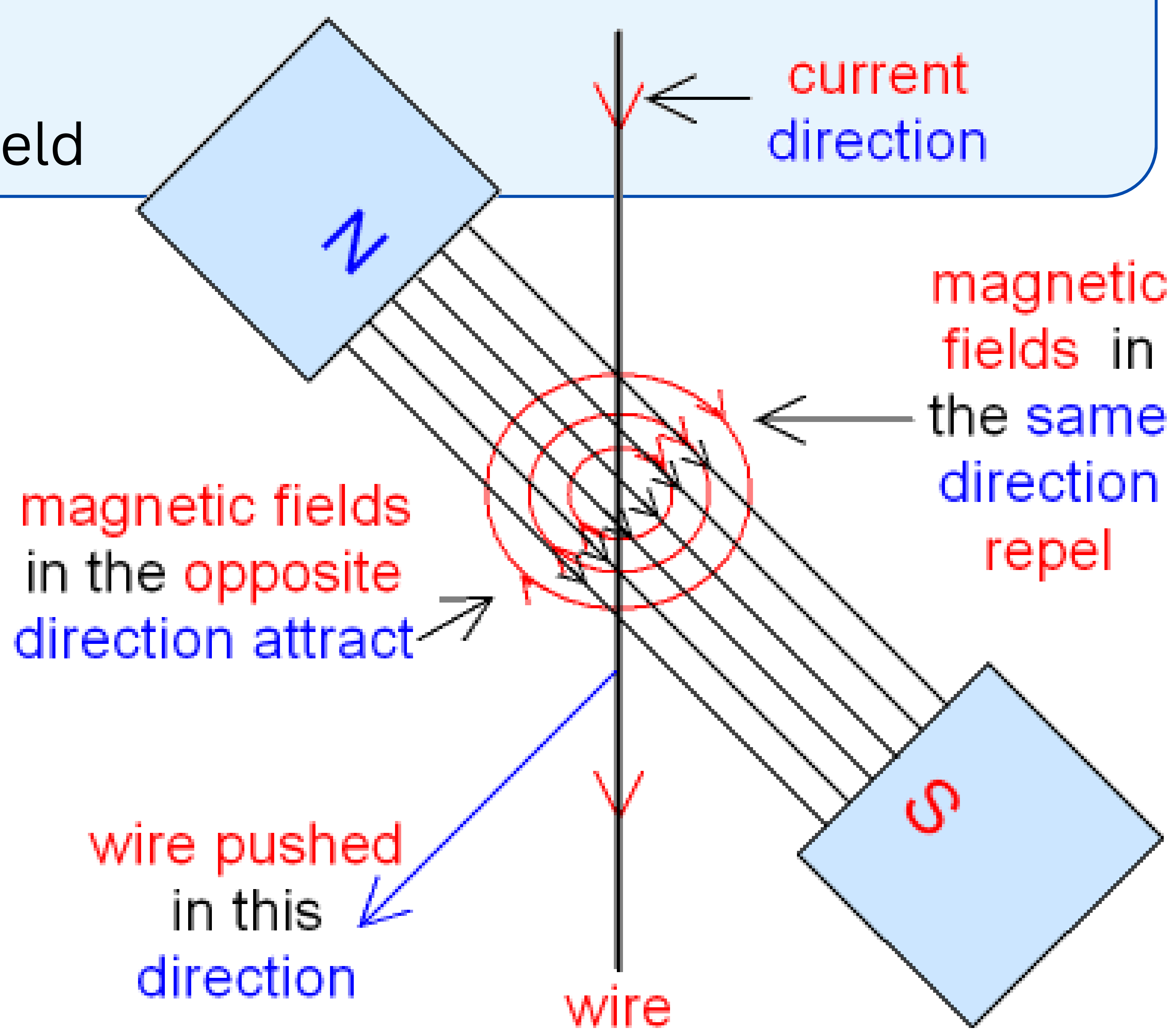
Relationship

Current ↑ → Force ↑

Magnetic field strength ↑ → Force ↑

Examples

Wire moving in magnetic field



FLEMING'S LEFT-HAND RULE

Fleming's left-hand rule is used to determine the direction of force on a current-carrying wire in a magnetic field.

In this rule:

- First finger → direction of magnetic field (North to South)
- Second finger → direction of current
- Thumb → direction of force (motion)

These three directions are always perpendicular to each other.

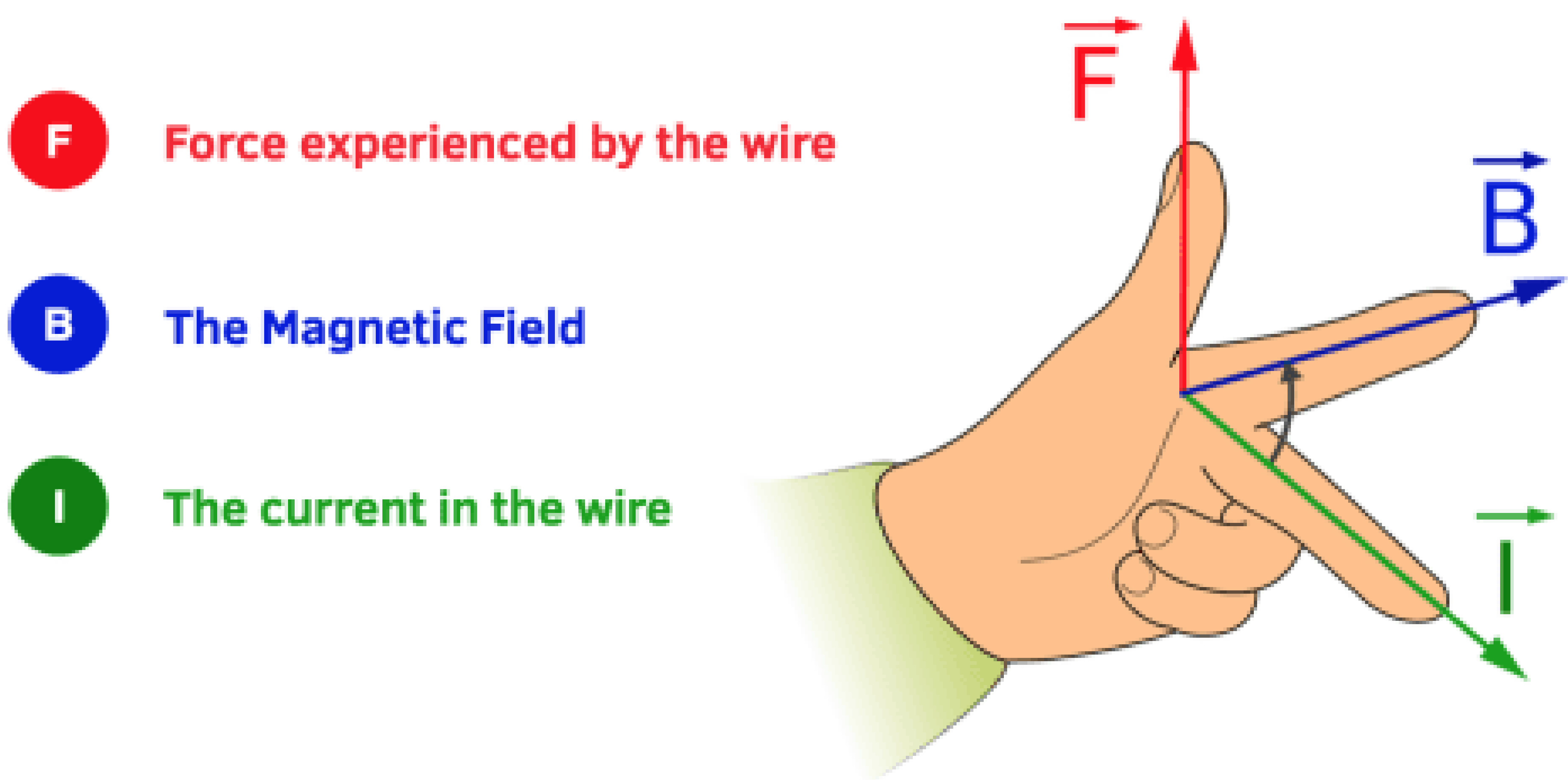


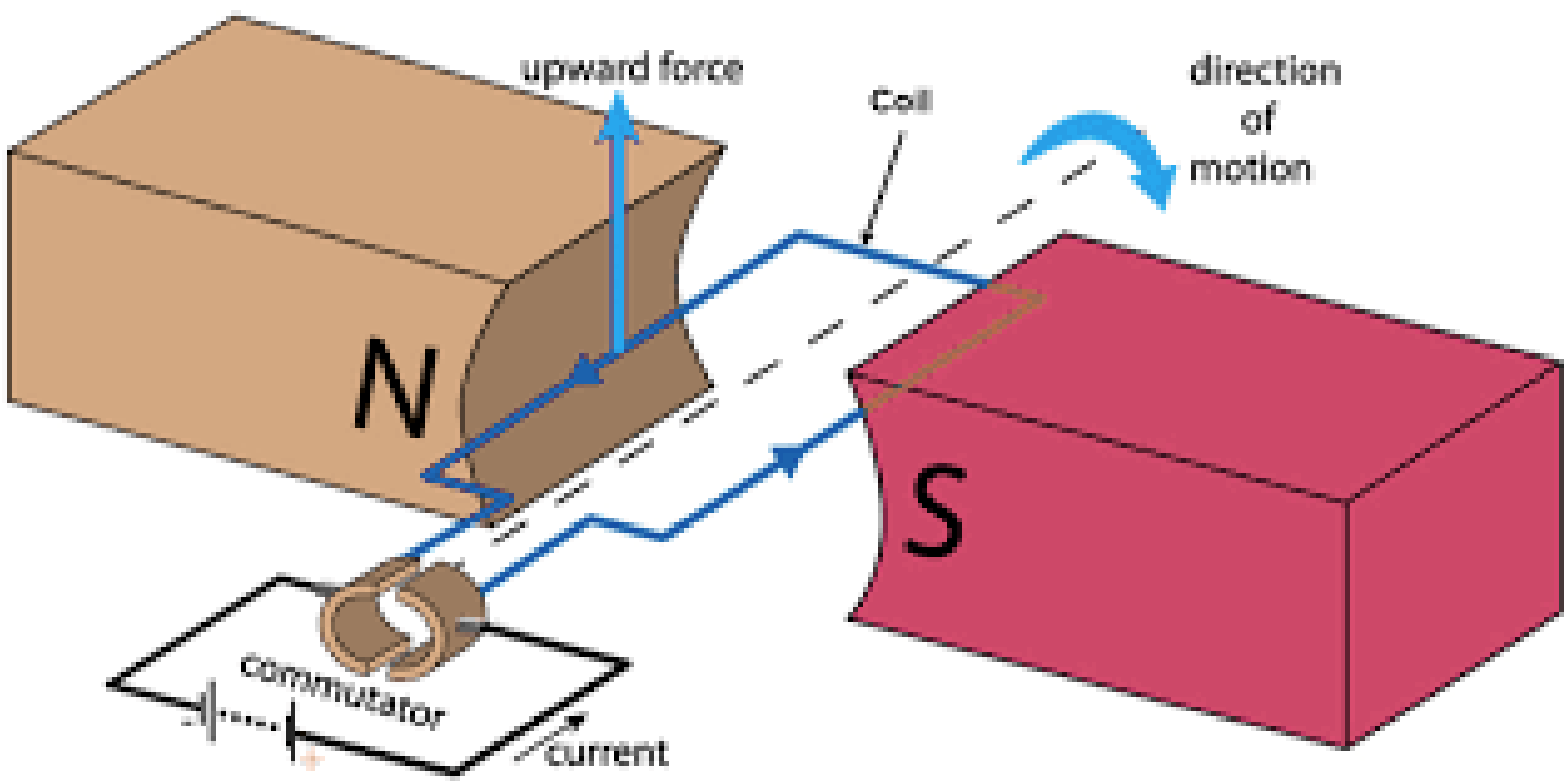
Fig 1. Fleming's Left Hand Rule.

ELECTRIC MOTORS

Electric motors use the motor effect to produce rotation. A coil of wire is placed inside a magnetic field. When current flows through the coil, forces act on opposite sides of the coil in opposite directions.

These opposite forces cause the coil to rotate. A split-ring commutator ensures that the current direction changes at the right time so the coil continues rotating in the same direction.

This continuous rotation converts electrical energy into mechanical energy.



LOUDSPEAKERS AND HEADPHONES

Loudspeakers use the motor effect to convert electrical energy into sound energy.

When alternating current flows through the coil, the magnetic field constantly changes direction. This causes the coil to move back and forth.

The coil is attached to a speaker cone. When the coil moves, the cone also moves. This movement causes air particles to vibrate, producing sound waves.

ELECTROMAGNETIC INDUCTION

THE GENERATOR EFFECT

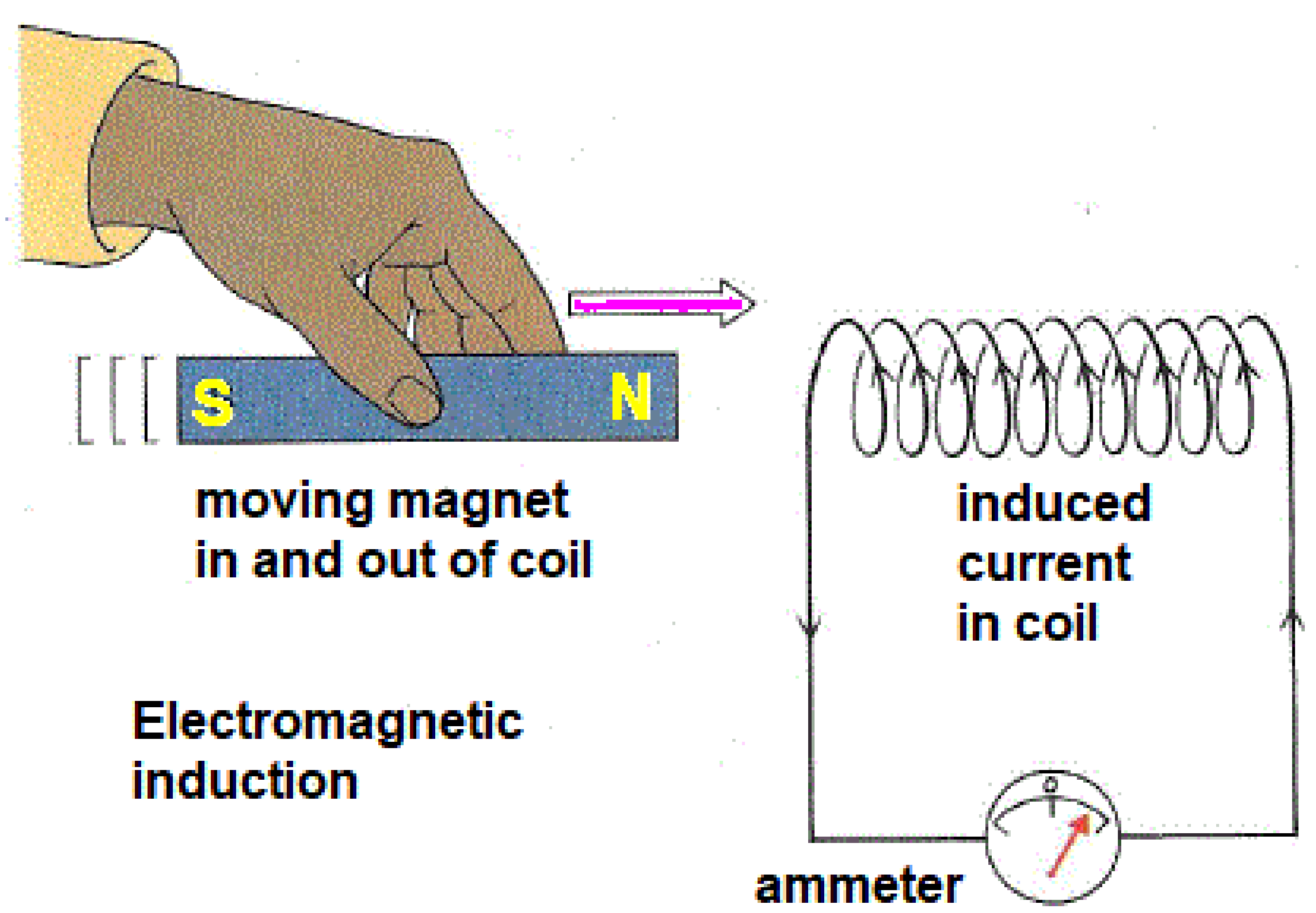
The generator effect is the process by which motion is used to produce electricity. It is the opposite of the motor effect. In the motor effect, electricity causes motion, but in the generator effect, motion causes electricity.

The generator effect occurs when a conductor moves through a magnetic field, or when the magnetic field moves relative to the conductor. When this happens, the conductor cuts through magnetic field lines. This causes a potential difference (voltage) to be induced across the ends of the conductor.

If the conductor is connected in a complete circuit, this induced potential difference causes a current to flow. The faster the conductor cuts through the magnetic field lines, the greater the induced potential difference.

Examples

- Moving wire through magnetic field
- Moving magnet through coil

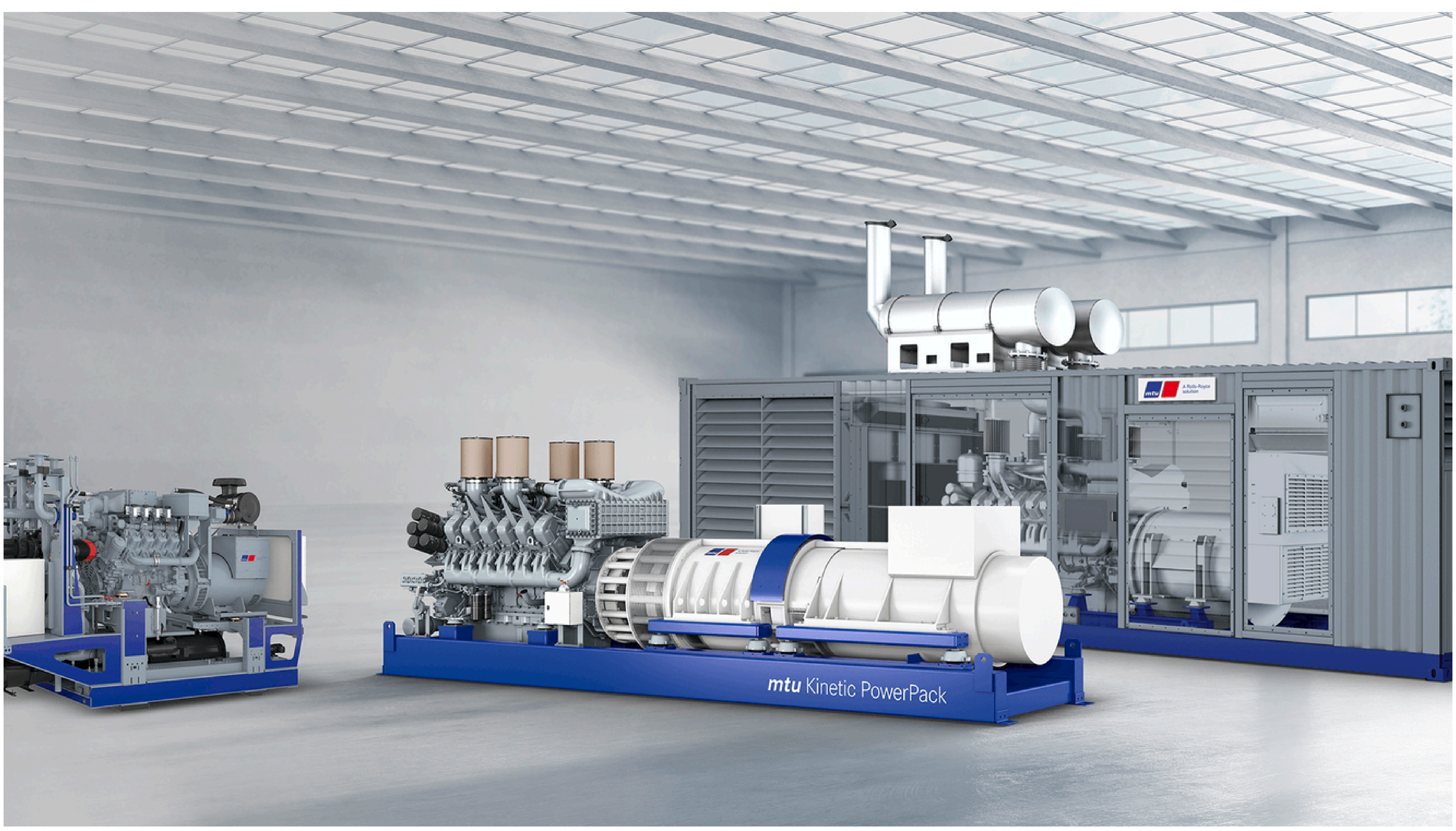


APPLICATIONS OF THE GENERATOR EFFECT

Alternators (AC Generators)
An alternator converts mechanical energy into electrical energy in the form of alternating current (AC). It works using the generator effect, where a coil rotates inside a magnetic field and cuts magnetic field lines, inducing a potential difference.

- Rotating coil cuts magnetic field lines
- Induces potential difference in coil
- Direction of voltage changes continuously
- Produces alternating current (AC)
- Slip rings allow continuous electrical connection

Examples:
- Power station generators

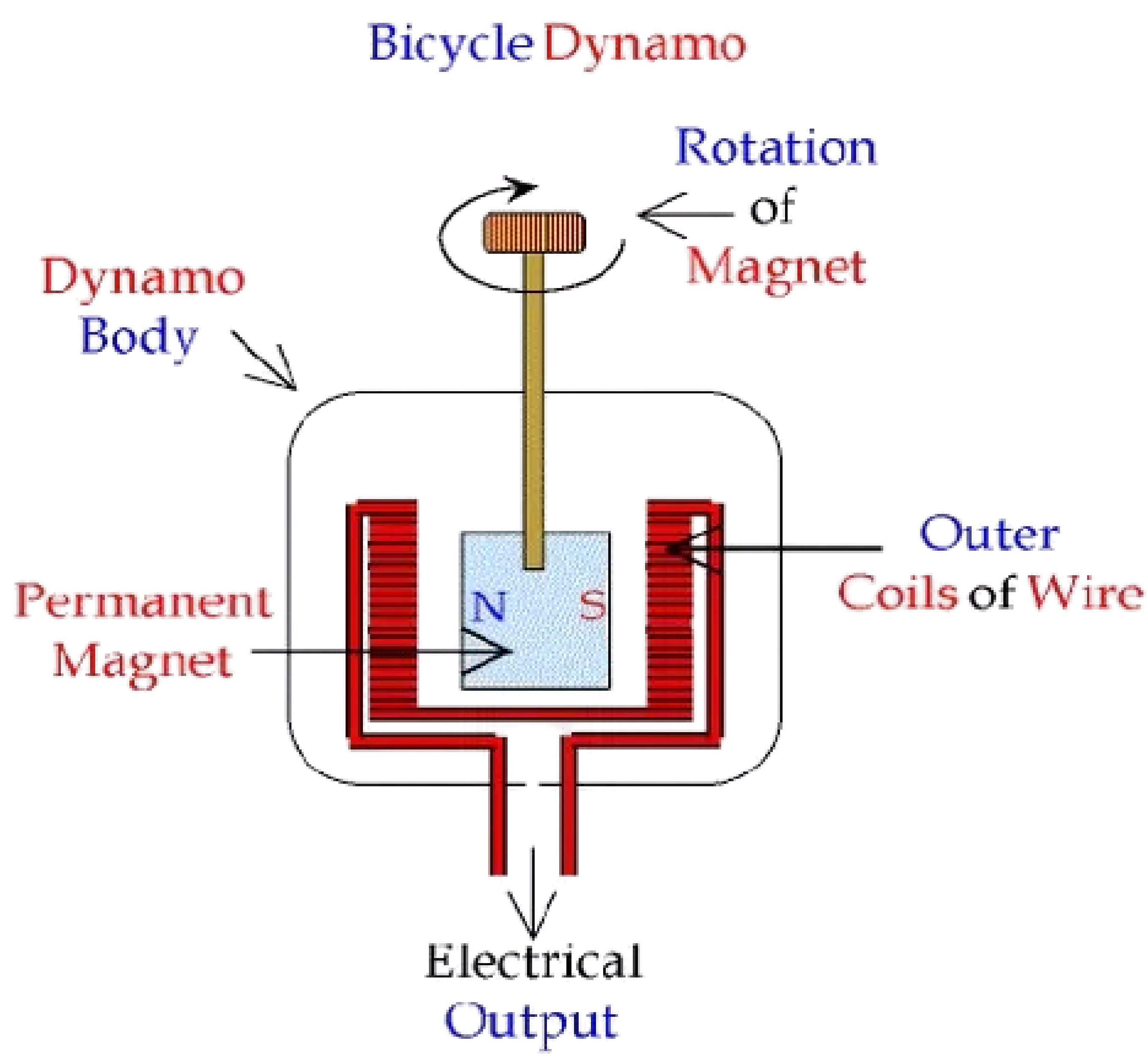


APPLICATIONS OF THE GENERATOR EFFECT

Dynamos (DC Generators)

- A dynamo converts mechanical energy into direct current (DC). It also works using a rotating coil in a magnetic field, which induces a potential difference.
- However, instead of slip rings, a dynamo uses a split-ring commutator. The split ring reverses the connections every half turn, ensuring the current flows in only one direction. This produces direct current, which does not change direction.

- Rotating coil cuts magnetic field lines
- Induces potential difference
- Split-ring commutator keeps current in one direction
- Produces direct current (DC)



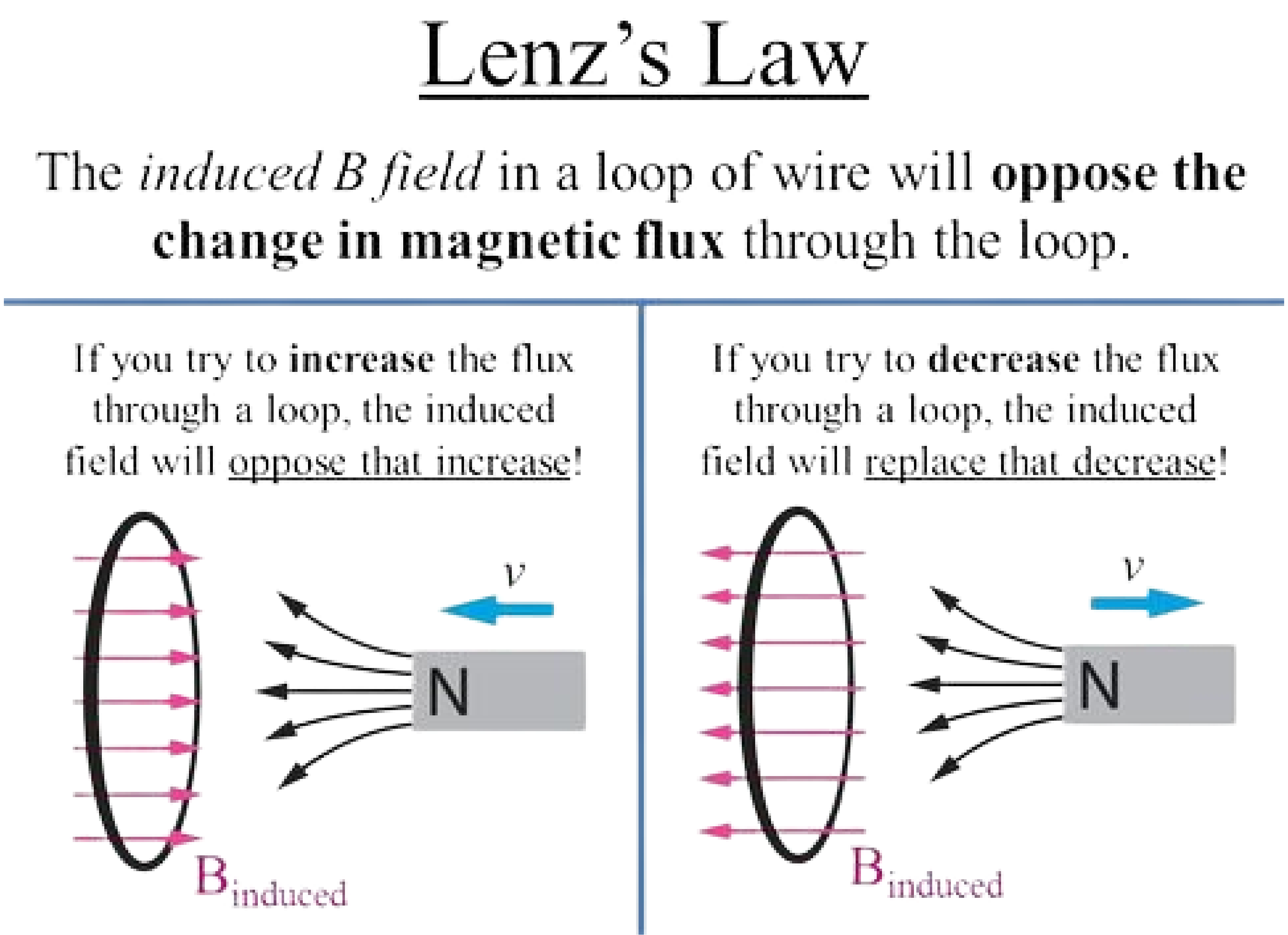
LENZ’S LAW

Lenz’s law states that the direction of the induced potential difference always opposes the change that produced it. This means the induced current creates a magnetic field that tries to stop the motion causing it.

If a magnet is pushed into a coil, the coil produces a magnetic field that repels the magnet. If the magnet is pulled away, the coil produces a magnetic field that attracts the magnet. This opposition ensures conservation of energy.

Examples:

- Coil repelling approaching magnet
- Coil attracting leaving magnet



TRANSFORMERS

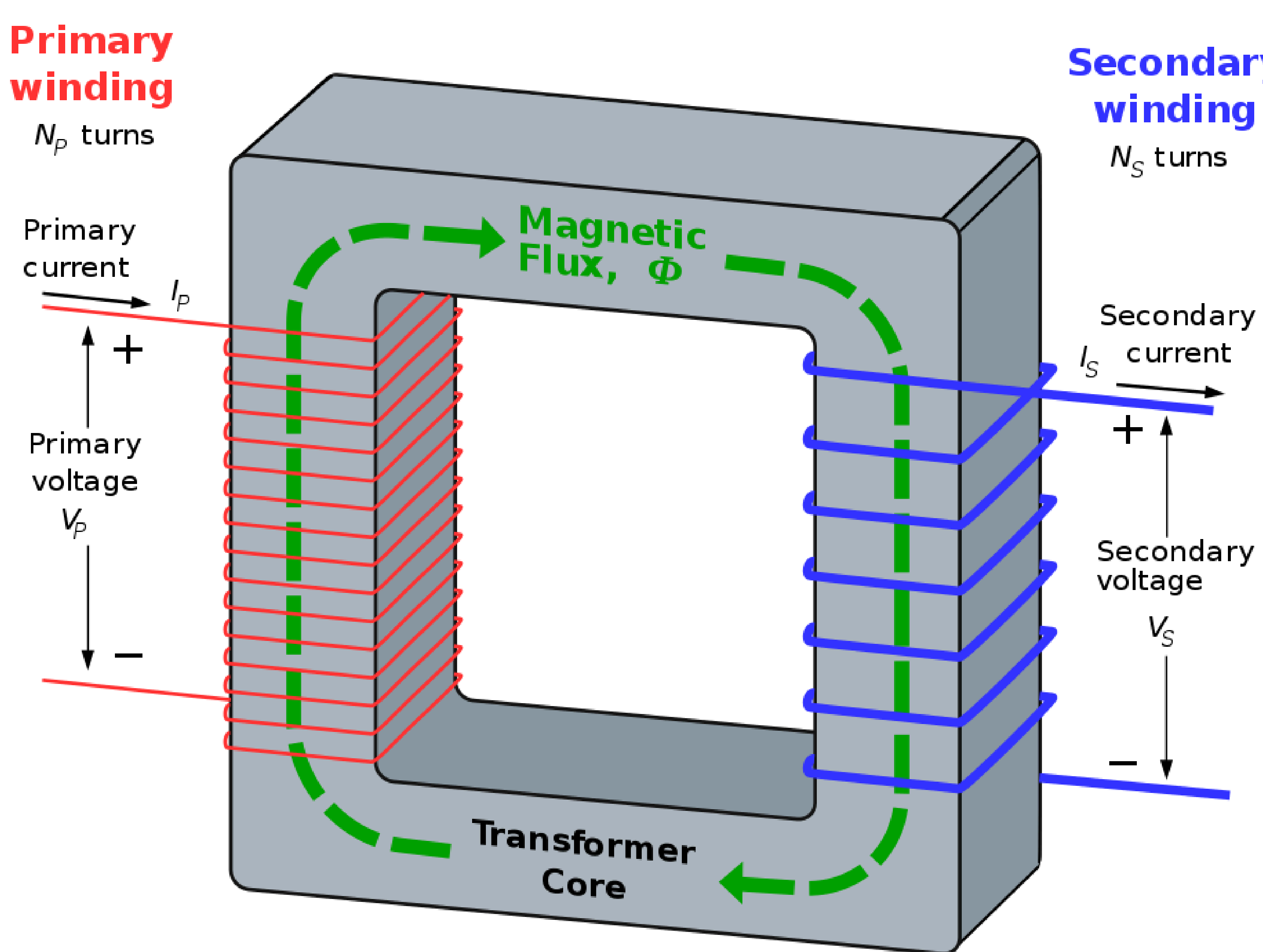
A transformer is a device used to change the potential difference (voltage) of alternating current. It works using electromagnetic induction.

It consists of:

- Primary coil
- Secondary coil
- Iron core

Key Points:

- The iron core allows magnetic fields to pass efficiently between coils.
- Alternating current produces changing magnetic field
- Changing magnetic field induces voltage in secondary coil



TRANSFORMER

TRANSFORMER EQUATION

Formula

$$Vp / Vs = Np / Ns$$

Where

- Vp = primary voltage (V)
- Vs = secondary voltage (V)
- Np = number of turns in primary coil
- Ns = number of turns in secondary coil

Relationship

- More turns in secondary → Higher voltage (step-up transformer)
- Fewer turns in secondary → Lower voltage (step-down transformer)

POWER EQUATION

Formula

$$P = V \times I$$

Where

P = power (watts, W)

V = voltage (volts, V)

I = current (amps, A)