Magnetism and electromagnetism

Pearson Edexcel · International GCSE · Physics

Magnetism to mains

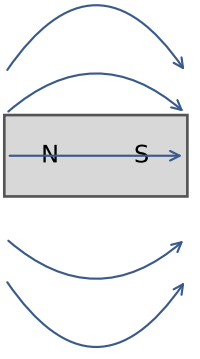
A magnet moves, and current appears in a wire kilometres away. This section builds that chain: permanent magnets and field patterns, the magnetic effect of a current, the motor force with its left-hand rule, induction in coils and generators, and (P) the transformers that move electrical energy across a country.

Edexcel International GCSE Physics 4PH1, Section 6 (statements 6.1–6.20P). P-suffixed statements are the Physics-only extension.

Magnetism

Magnets repel like poles and attract unlike ones, and attract **magnetic materials** (iron, steel, nickel, cobalt). **Magnetically hard** materials (steel) keep their magnetism – permanent magnets; **soft** materials (iron) magnetise and demagnetise easily – electromagnet cores. **Field lines** point from N to S outside a magnet (never cross); magnetism is **induced** in a magnetic material placed in a field. Two **unlike** poles facing each other give a **uniform field** between them.

field lines point from N to S outside the magnet

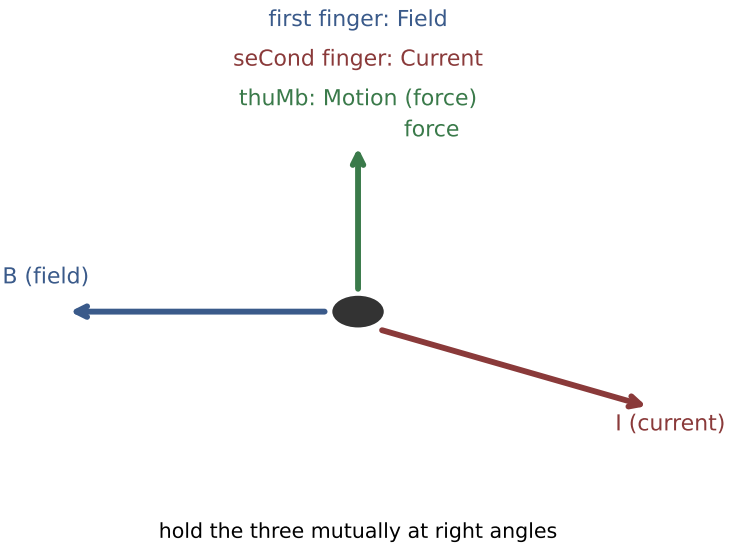


Electromagnetism and the motor effect

A **current in a conductor creates a magnetic field around it** – concentric circles, right-hand grip rule. (P) Electromagnets: a coil (solenoid) around a soft-iron core, switchable and adjustable. (P) Field patterns for a straight wire, flat coil and solenoid.

A wire carrying current **across** a magnetic field feels a force – the **motor effect**, used in d.c. motors (rotating coil + commutator) and loudspeakers. Predict the direction

with the **left-hand rule** : first finger Field, seCond finger Current, thuMb Motion. The force grows with stronger field and larger current, and reverses if either reverses.

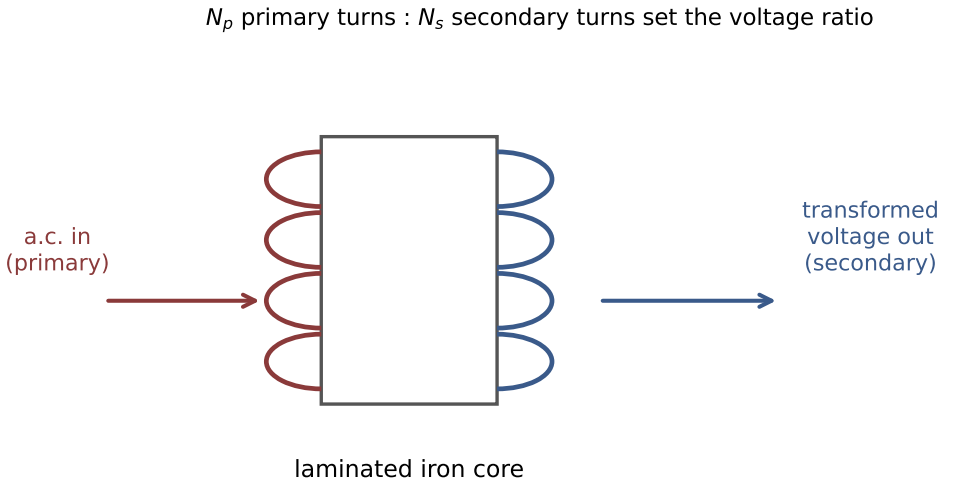


Electromagnetic induction

A voltage is **induced** in a conductor or coil when it **moves through** a magnetic field or when the **field through it changes**. The induced voltage is larger with faster movement, a stronger field, more turns and (for generators) faster rotation. **Generators** rotate a magnet inside a coil (or a coil inside a magnet) – the size and frequency of the induced a.c. follow the rotation.

(P) **Transformers** change an alternating voltage using two coils on an iron core:

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} \qquad V_p I_p = V_s I_s \text{ (100\% efficient)}$$



Step-up transformers raise the voltage (and cut the current) for transmission – high voltage means low current, so far less energy lost as heat in the cables; **step-down** transformers bring it back to safe levels for use.

Worked check. A transformer has 200 primary turns and 50 secondary turns; the primary is 230 V. $V_s = 230 \times 50/200 = 57.5$ V – a step-down. If the primary current is 0.5 A: $I_s = 230 \times 0.5/57.5 = 2.0$ A.

Check yourself

1. State two differences between magnetically hard and soft materials.
2. In which direction do field lines point outside a magnet?
3. Describe how to produce a uniform magnetic field with two bar magnets.
4. What does a current in a wire create around it?
5. State the left-hand rule's three fingers.
6. Name two factors that increase the force on a current-carrying wire in a field.
7. State two ways to induce a voltage in a coil.
8. Name two factors that increase the size of an induced voltage.
9. (P) A step-down transformer has 1000 primary and 100 secondary turns; input 230 V. Calculate the output.
10. (P) Why is electricity transmitted at high voltage?

Answers: 1 hard keeps its magnetism (permanent magnets, steel); soft loses it easily (temporary, iron – electromagnet cores); 2 from N to S; 3 place N and S poles facing each other with a gap – the parallel field lines between them are uniform; 4 a magnetic field of concentric circles (grip rule); 5 first finger Field, second finger Current, thumb Motion; 6 stronger field; larger current.

Answers continued: 7 move the coil or magnet so the coil cuts field lines, or change the field through a stationary coil; 8 faster movement; stronger magnet; more turns; 9 (P) $V_s = 230 \times 100/1000 = 23$ V; 10 (P) high voltage gives low current for the same power; cable heating is I^2R, so losses fall sharply over long distances.