# Topic 6: Magnetism and electromagnetism

Edexcel International GCSE Physics 4PH1 · Section 6 · statements 6.1–6.20P · sheets 6.1–6.2

# From a moving magnet to the mains

Sheet 6.1: magnets, field patterns, the field of a current.

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Sheet 6.1: the motor effect and the **left-hand rule**.

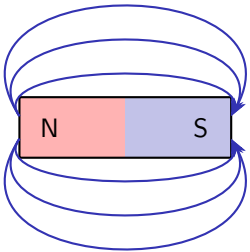
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Sheet 6.2: induction in coils and generators.

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Sheet 6.2 (P): transformers carry energy across a country.

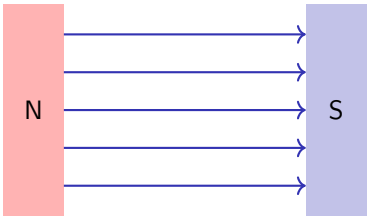
# Magnets, materials and field lines




Hard (steel): keeps its magnetism. Soft (iron): magnetises and demagnetises easily.

- Like poles repel; unlike poles attract.
- Field lines run N to S outside and never cross.

# A uniform field between flat poles




In the central gap the lines are parallel and equally spaced, so the field is uniform.

- Broad, flat unlike poles give parallel, evenly spaced lines.
- Magnetism is induced in a material placed in a field.

# A current makes a magnetic field

## Straight wire

Concentric circles around the wire, closer near it.

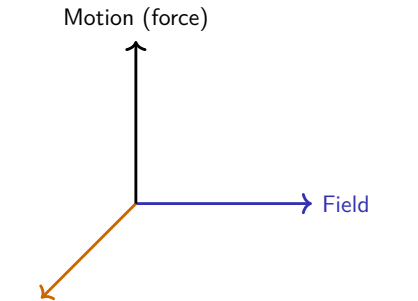
Right-hand grip: thumb along the current, fingers curl the field.

## (P) Solenoid electromagnet

Coil around a soft-iron core; field like a bar magnet.

Switch it off and the field goes; more turns or current, stronger.

# The motor effect and the left-hand rule




Field, current and force are at right angles; reverse either and the force reverses.

- First finger Field, seCond finger Current, thuMb Motion.
- Bigger with stronger field or larger current.

# Worked example: which way is the push?

1. **Field** N pole on the left, S on the right: the field points right.
2. **Current** The current flows into the page.
3. **Rule** First finger right, second finger into the page: the thumb points down.
4. **Changes** Reverse the current: force up. Reverse current and swap poles: down again.

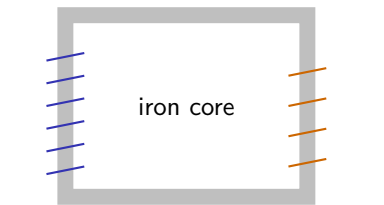
## Decision

Uses: d.c. motors (rotating coil and commutator) and loudspeakers.

# Inducing a voltage

| **Situation** | **Induced voltage?** |
|---|---|
| Magnet pushed into a coil | yes; reverses when pulled out |
| Magnet held still inside a coil | none |
| Wire moved across a field | yes |
| Magnet pushed in twice as fast | yes, bigger |
| Generator spun faster | bigger a.c. at higher frequency |

# (P) Transformers change a.c. voltages




$$\frac{V_p}{V_s} = \frac{N_p}{N_s} \qquad V_p \times I_p = V_s \times I_s$$

power equation: 100% efficient

Step-up: more secondary turns, higher $V_s$. Step-down: fewer turns, lower $V_s$.

- Two coils on an iron core; a.c. only.
- More secondary turns, higher secondary voltage.

# (P) Turns ratio and current

1. **Known** $N_p = 200,\ N_s = 50,\ V_p = 230\ \text{V},\ I_p = 0.5\ \text{A}$.
2. **Voltage** $V_s = V_p \times N_s/N_p = 230 \times 50/200 = 57.5\ \text{V}$: step-down.
3. **Power** $V_p I_p = V_s I_s$, so $I_s = V_p I_p / V_s$.
4. **Current** $I_s = 230\ \text{V} \times 0.5\ \text{A}/57.5\ \text{V} = 2.0\ \text{A}$.

# (P) Why the grid steps up to 400 kV

| **Cables at** | **Current $I = P/V$** | **Heating loss $I^2R$, $R = 2.0\ \Omega$** |
|---|---|---|
| 25 kV | $10^8/25\,000 = 4000$ A | $4000^2 \times 2.0 = 32$ MW |
| 400 kV | $10^8/400\,000 = 250$ A | $250^2 \times 2.0 = 125$ kW |

## Use the evidence

Turns ratio $400/25 = 16$: a 500-turn primary needs an 8000-turn secondary. Current 16 times smaller, loss 256 times smaller.

# Six mistakes that cost marks

| **Mistake** | **Correct idea** |
|---|---|
| Right hand for the motor effect | **Left-hand rule** for force; right-hand grip for the field |
| Biggest force parallel to the field | No force then; biggest at right angles |
| Voltage with nothing moving | Movement or a changing field is needed |
| (P) Transformer on d.c. | Needs a.c. for a changing field |
| (P) Step-up raises power | Voltage up, current down, power at best equal |
| (P) Ratio upside down | More secondary turns, higher $V_s$ |

# Check yourself

## Your turn

Answer without notes, then check.

A. Name a magnetically hard and a magnetically soft material, with a use for each.

B. State the left-hand rule.

C. Give three ways to increase an induced voltage.

D. (P) 100 primary turns, 400 secondary, 12 V primary. Secondary voltage?

E. (P) Why is electricity transmitted at high voltage?