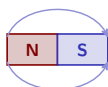


Electricity & Magnetism

IGCSE Physics ▪ Topic 4

IGCSE Physics



Electricity & Magnetism

What we will cover

- 1 Magnetism & static
- 2 Current e.m.f. & resistance
- 3 Power & circuits
- 4 Electrical safety
- 5 Electromagnetic effects
- 6 Recap



1

Magnetism and static

Electricity & Magnetism

↳ Magnetism and static

Magnets and fields

- field lines run N to S outside a magnet and never cross
- closer lines $\Rightarrow$ stronger field
- like poles repel; unlike poles attract

A plotting compass's N pole points along the field. Iron filings line up on the same lines.

Electricity & Magnetism

↳ Magnetism and static

Static electricity

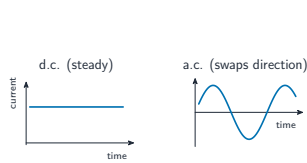
Charge is **electrons** 电子. Rubbing transfers them, so one object goes negative and the other positive.

Only electrons move. Like charges repel; unlike attract. A charged object can attract a **neutral** one by induction.

2

Current and resistance

Electric current



Current 电流 $I = \frac{Q}{t}$ (A). **Conventional current** 常规电流 $\rightarrow$ to $\leftarrow$; electrons the other way.

3.0 A for 20 s
 $Q = It = 60 \text{ C}$

d.c. 直流电 one way; **a.c.** 交流电 swaps direction.

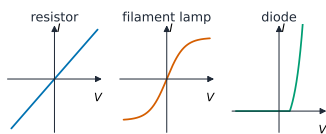
E.m.f., p.d. and resistance

- **e.m.f.** 电动势 & p.d.: $V = \frac{W}{Q}$ (volts)
- **resistance** 电阻 $R = \frac{V}{I}$ (Ω)
- $R \propto l$, $R \propto \frac{1}{A}$

12 V drives 0.50 A
 $R = \frac{12}{0.50} = 24 \Omega$



I-V graphs



- a longer wire has a bigger resistance – resistance is **directly proportional** 成正比 to length, $R \propto l$;
- a thicker wire has a smaller resistance – resistance is **inversely proportional** 成反比 to **cross-sectional area** 横截面积, $R \propto \frac{1}{A}$.

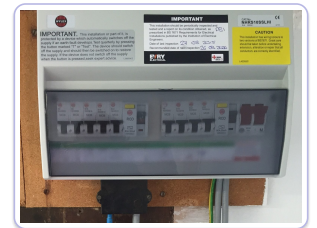
Electrical power and energy

$$P = IV, \quad E = IVt.$$

12 V motor, 2.0 A, 30 s

$P = 24 \text{ W}$, $E = Pt = 720 \text{ J}$

Bills use the **kilowatt-hour** 千瓦时:
 $\text{kWh} = \text{kW} \times \text{h}$.



Electrical energy is metered and distributed safely

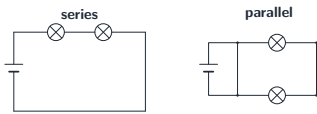
3 Circuits and safety

Circuit components

- cell / battery, lamp, switch, resistor, variable resistor
- **thermistor** 热敏电阻 (temperature) and **LDR** 光敏电阻 (light)
- ammeter in **series**; voltmeter in **parallel**

$I = Q/t$, $V = W/Q$, $R = V/I$.

Series and parallel



- series: same current; $R = R_1 + R_2$
- parallel: same p.d.; $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

6 Ω and 3 Ω in parallel

$$\frac{1}{R} = \frac{1}{6} + \frac{1}{3} = \frac{1}{2} \Rightarrow R = 2 \Omega$$

Potential dividers and safety

A **potential divider** 分压器 shares the voltage:

$$\frac{R_1}{R_2} = \frac{V_1}{V_2}$$

A thermistor/LDR makes the output change with temperature or light.

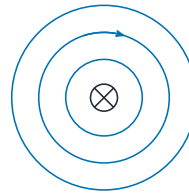
Fuses and circuit breakers protect by cutting the current when it is too large – never rely on the appliance alone.

4 Electromagnetic effects

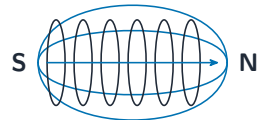
The magnetic effect of a current

A current makes a magnetic field – circles round a wire, bar-magnet-like for a **solenoid** 螺线管. Stronger with more current, more turns, or a soft-iron core.

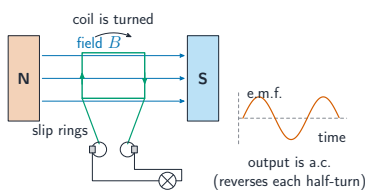
straight wire



solenoid (coil)

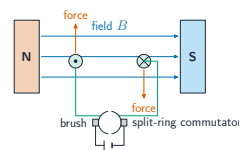


Electromagnetic induction & the generator



Move a wire across a field $\Rightarrow$ an e.m.f. is **induced** 感应. An **a.c. generator** 交流发电机 spins a coil in a field; **slip rings** 滑环 carry the a.c. out. Bigger e.m.f. with a stronger magnet, faster spin, more turns.

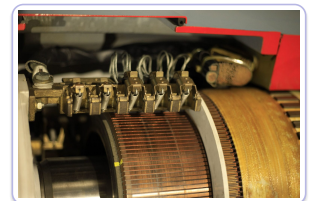
The motor effect and d.c. motor



the two forces form a couple that turns the coil

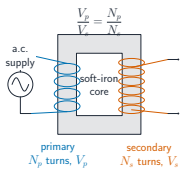
commutator 换向器 keeps it turning

Left-hand rule: thumb = force, first finger = field, second = current.



Motors convert electrical energy into motion

The transformer



$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$N_p = 1200, N_s = 100, V_p = 240 \text{ V}$$

$$V_s = \frac{240}{12} = 20 \text{ V (step-down)}$$

High-voltage transmission



Power lost in cables is $P = I^2 R$.

Step **up** the voltage $\Rightarrow$ lower current
 $\Rightarrow$ far less wasted power. Step down again for homes.

5

Recap

Topic 4 – key takeaways

1 Current

$$I = Q/t; R = V/I; P = IV$$

2 Circuits

series adds R ; parallel lowers it

3 Induction

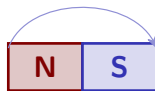
move a wire in a field $\rightarrow$ e.m.f.

4 Transformer

$V_p/V_s = N_p/N_s$; high V for transmission

Check yourself

- 1 Charge through a 2 A lamp in 10 s?
- 2 Two 4Ω resistors in parallel – combined R ?
- 3 Which wire holds the switch and fuse?
- 4 Why send power at high voltage?



Answers 1. $Q = It = 20 \text{ C}$ 2. 2Ω 3. the live wire 4. lower current $\Rightarrow$ less heat lost