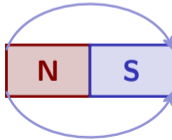


Electricity & Magnetism

IGCSE Physics ■ Topic 4

IGCSE Physics

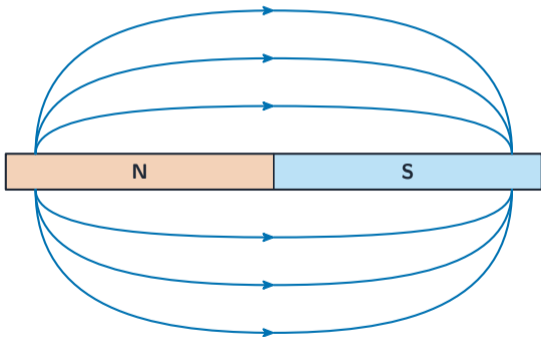


What we will cover

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



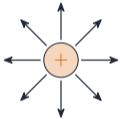
Magnets and fields



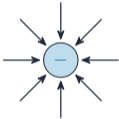
Like **poles** 磁极 repel; unlike poles attract.

Field lines 磁场线 go out of N, into S; close lines = strong field. Soft iron = temporary; steel = permanent.

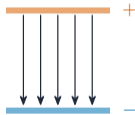
Static electricity



positive charge



negative charge

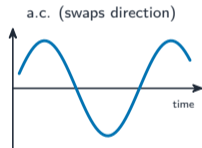
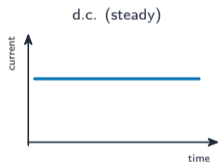


parallel plates

Two charges: + and - (like repel, unlike attract).

- **charging by friction** 摩擦起电 - only **electrons** 电子 move
- **conductor** 导体 lets charge flow; **insulator** 绝缘体 does not

Electric current



Current 电流 $I = \frac{Q}{t}$ (A). **Conventional current** 常规电流 + to -; 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

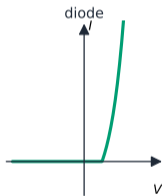
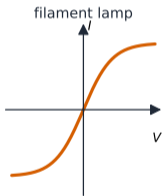
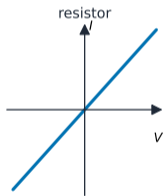
- **e.m.f.** 电动势 & p.d.: $V = \frac{W}{Q}$ (volts)
- **resistance** 电阻 $R = \frac{V}{I}$ (Ω)
- $R \propto l, R \propto \frac{1}{A}$

12 V drives 0.50 A

$$R = \frac{12}{0.50} = 24 \Omega$$



I - V graphs



- resistor – straight ($I \propto V$)
- **filament lamp** 灯丝灯泡 – curves as it heats
- **diode** 二极管 – one way only

Electrical power and energy

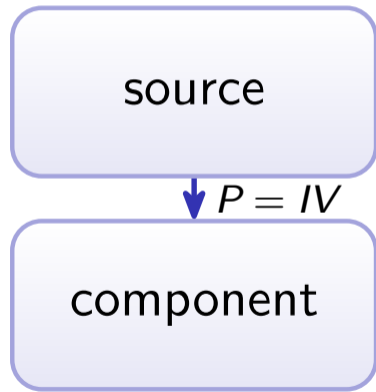
$$P = IV, \quad E = IVt.$$

12 V motor, 2.0 A, 30 s

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

Bills use the **kilowatt-hour** 千瓦时:

$$\text{kWh} = \text{kW} \times \text{h}.$$



Circuit components



cell



battery



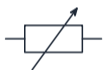
switch



lamp



resistor

variable
resistor

fuse



ammeter



voltmeter



diode



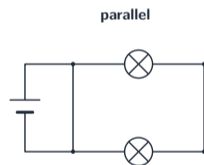
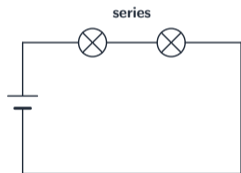
thermistor



LDR

Ammeter 电流表 in series;
voltmeter 电压表 in parallel. **Ther-**
mistor 热敏电阻/**LDR** 光敏电阻: R
 falls with heat/light. A **fuse** 保险丝
 melts on too much current.

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:

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

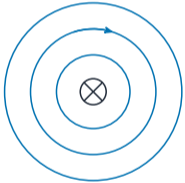
A thermistor/LDR makes the output change with temperature or light.

Mains: **live** 火线, **neutral** 零线, **earth** 地线. The switch & fuse go in the **live** wire.

Earthing 接地 or double insulation makes the casing safe.

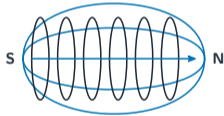
The magnetic effect of a current

straight wire



current into page;
field is circles round it

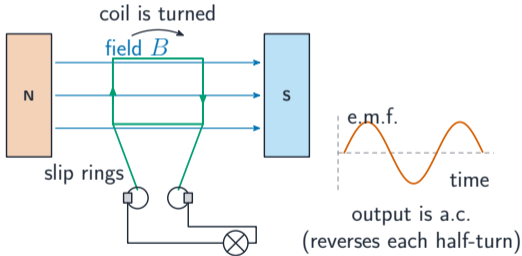
solenoid (coil)



field like a bar magnet

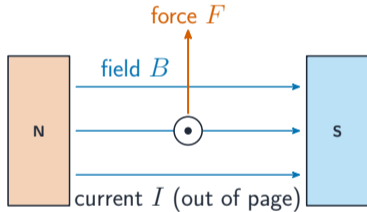
A current makes a magnetic field – circles round a wire, bar-magnet-like for a **solenoid** 螺线管. Stronger with more current, more turns, or a soft-iron core.

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.

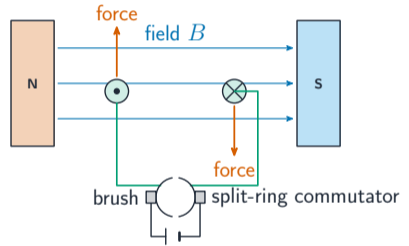
The motor effect and d.c. motor



F , B and I are all at 90° (Fleming's left-hand rule)

force \perp field & current

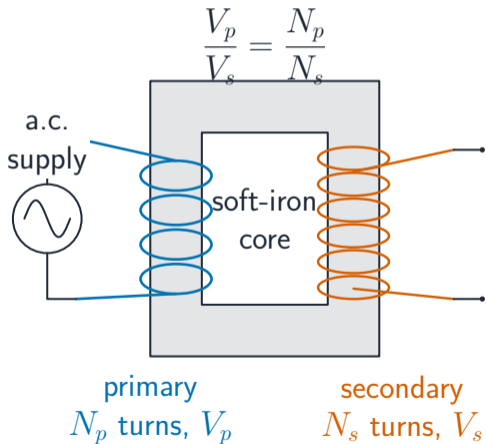
Left-hand rule: thumb = force, first finger = field, second finger = current.



the two forces form a couple that turns the coil

commutator 换向器 *keeps it turning*

The transformer



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

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

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

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

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.

Topic 4 – key takeaways

1 Current

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

2 Circuits

series adds R ; parallel lowers it

3 Induction

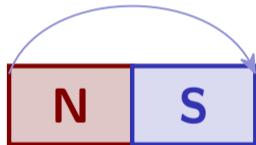
move a wire in a field \rightarrow e.m.f.

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 $4\ \Omega$ 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. $2\ \Omega$ 3. the live wire 4. lower current \Rightarrow less heat lost