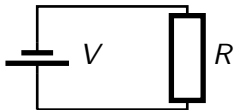


Electric Circuits

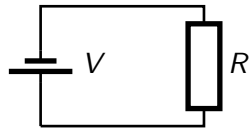
AP Physics 2 ■ Unit 11

AP Physics 2



What we will cover

- 1 Electric current
- 2 Simple circuits and Ohm's law
- 3 Electric power
- 4 Series and parallel resistors
- 5 Kirchhoff's rules
- 6 RC circuits



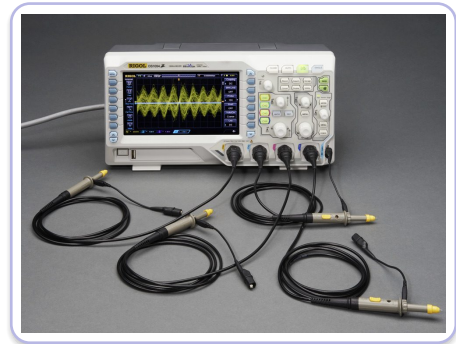
Electric current

Electric current 电流 is the rate charge flows past a point:

Charge per second

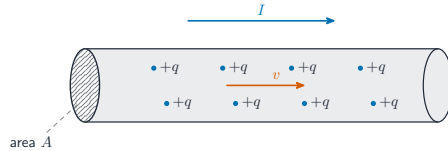
$$I = \frac{\Delta q}{\Delta t} \quad (\text{amperes})$$

Conventional current 常规电流 points the way **positive** charge would flow – opposite to the electron drift.

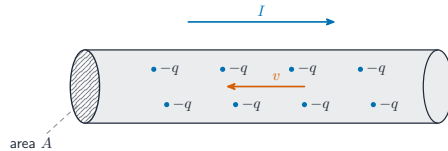


Meters and scopes probe circuit behaviour

Electric current



(a) positive carriers drift with I



(b) electrons drift against I

Simple circuits and Ohm's law

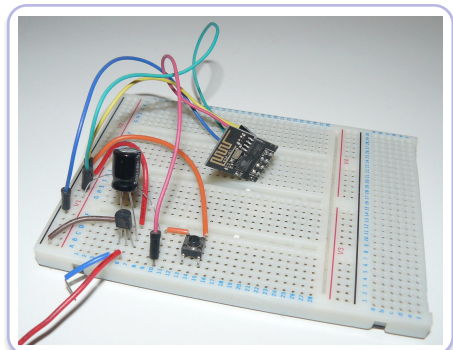
A **battery** 电池 pushes current around a complete loop – break it anywhere and current stops everywhere.

Ohm's law

$$V = IR, \quad R = \frac{\rho \ell}{A}$$

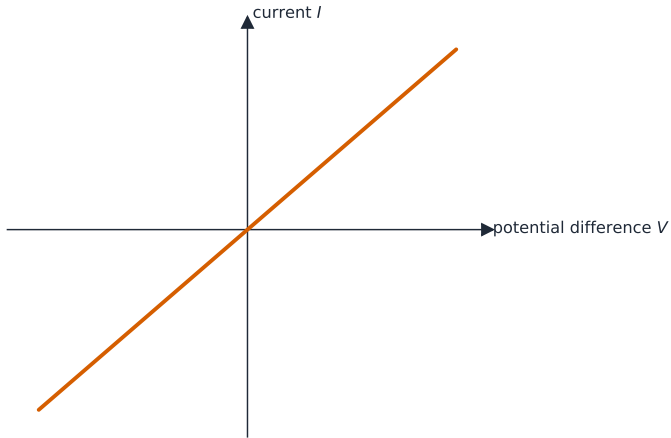
A device is **ohmic** 欧姆性 if its I - V graph is a straight line.

12 V across 4 : $I = 3$ A.



Circuits route charge through components

Simple circuits and Ohm's law



Electric power

A resistor turns electrical energy into heat or light:

Three forms

$$P = IV = I^2 R = \frac{V^2}{R}$$

Energy delivered: $E = Pt$.

Worked example

3 A across 12 V:

$$P = IV = 3 \times 12 = 36 \text{ W}$$

For 10 s: $E = 360 \text{ J}$. $I^2 R$ and V^2/R give the same 36 W.

Series and parallel resistors

Series – one path, adds up

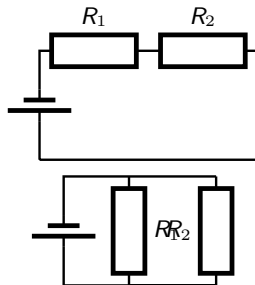
$$R_s = R_1 + R_2 + \dots$$

Same current through each.

Parallel – separate paths, less

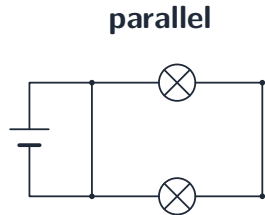
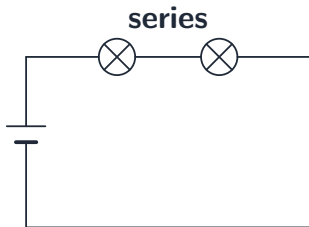
$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

Same voltage across each.



Two 6 : series 12, parallel 3 .

Series and parallel resistors



Kirchhoff's rules

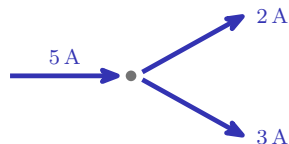
Loop rule (energy)

$$\sum V = 0 \quad \text{around a loop}$$

Batteries raise the potential; resistors drop it – they cancel.

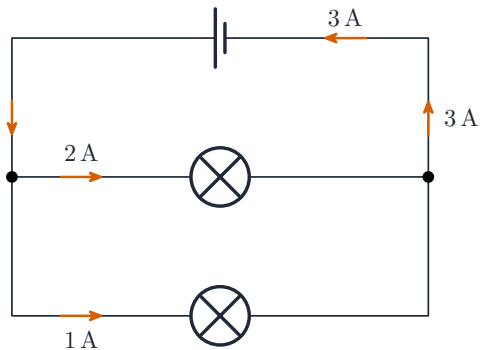
Junction rule (charge)

$$\sum I_{in} = \sum I_{out}$$



$$5 = 2 + 3$$

Kirchhoff's rules



at each junction: $3\text{ A} = 2\text{ A} + 1\text{ A}$

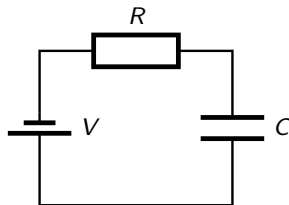
RC circuits

Add a **capacitor** 电容器 in series and the current changes **smoothly** over time:

Time constant

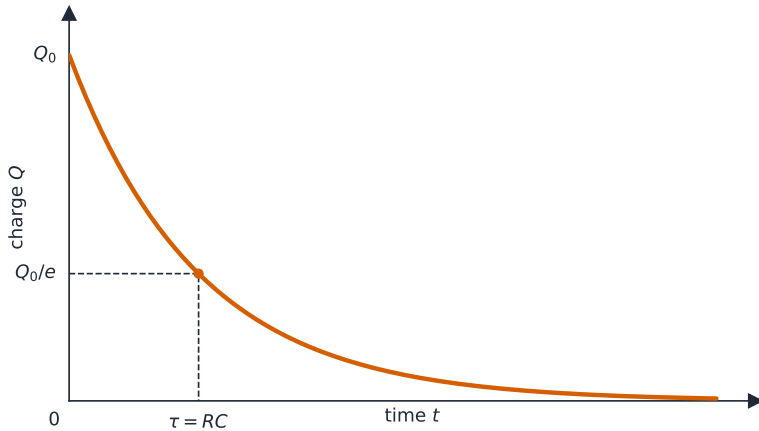
$$\tau = RC$$

- at first: empty capacitor acts like a wire – current largest
- after a long time (**steady state** 稳态): full capacitor blocks current



$$2, 3 \text{ F: } \tau = 6 \text{ s.}$$

RC circuits



Unit 11 – key takeaways

1 Ohm's law

$V = IR$; $R = \rho\ell/A$; ohmic = straight I - V line

2 Power

$P = IV = I^2R = V^2/R$; energy
 $E = Pt$

3 Combinations

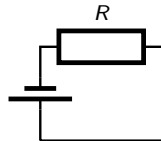
series adds; parallel gives less than any branch

4 Kirchhoff

loop $\sum V = 0$ (energy); junction
 $\sum I_{in} = \sum I_{out}$ (charge)

Check yourself

- 1 12 V across an 8 Ω resistor – find the current.
- 2 Two 4 Ω resistors in parallel – what is R_p ?
- 3 What conservation law is the junction rule?
- 4 A fully charged capacitor in steady state – how much current flows?



Answers 1. 1.5 A 2. 2 3. conservation of charge 4. zero