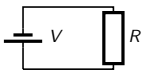
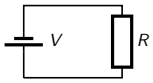
Electric Circuits

AP Physics 2 ▪ Unit 11

AP Physics 2



What we will cover



1 Current

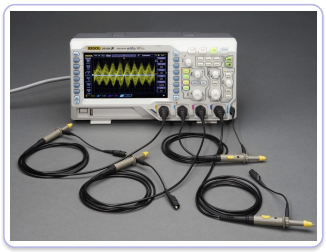
Electric current

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

2 Ohm's law

Simple circuits and Ohm's law

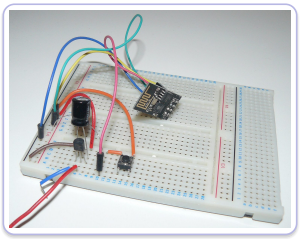
A **battery** 电池 pushes current around a complete loop – break it anywhere and current stops everywhere.

Ohm's law

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

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

$12\,\mathrm{V}$ across $4\,\Omega$: $I = 3\,\mathrm{A}$.



Circuits route charge through components

3 Power

Electric power

A resistor turns electrical energy into heat or light:

Three forms

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

Energy delivered: $E = Pt$.

Worked example

$3\,\mathrm{A}$ across $12\,\mathrm{V}$:

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

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

4 Series & parallel

Series and parallel resistors

Series – one path, adds up

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

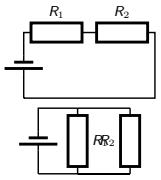
Same current through each.

Parallel – separate paths, less

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

Same voltage across each.

Two $6\,\Omega$: series $12\,\Omega$, parallel $3\,\Omega$.



5 Kirchhoff

Kirchhoff's rules

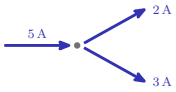
Loop rule (energy)

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

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

Junction rule (charge)

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



$5 = 2 + 3$

6 RC

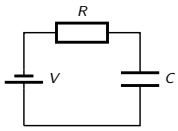
RC circuits

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



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

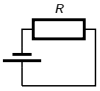
7 Recap

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. $12\,\mathrm{V}$ across an $8\ \ $ resistor – find the current.
2. Two $4\ \ $ 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.** $1.5\,\mathrm{A}$ **2.** $2\ \ $ **3.** conservation of charge **4.** zero