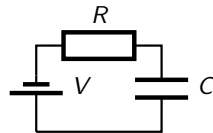


Electric Circuits

AP Physics C: E&M ■ Unit 11

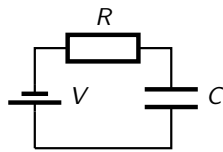
AP Physics C: E&M



Electric Circuits

What we will cover

- 1 Electric current
- 2 Ohm's law and power
- 3 Compound circuits and internal resistance
- 4 Kirchhoff's rules
- 5 RC circuits



1

Current

Electric current and Ohm's law

Rate of charge flow

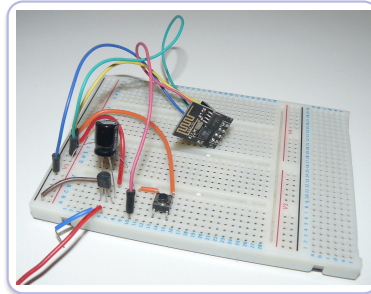
$$I = \frac{dQ}{dt}$$

Conventional current 常规电流 is opposite to the electron **drift** 漂移速度.

Ohm's law

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

Resistivity 电阻率 ρ is a material property; R is the object's.



Breadboard

2 Internal resistance

Compound circuits and internal resistance

Reduce series/parallel resistors to one **equivalent resistance** 等效电阻. A real battery is an ideal **emf** 电动势 plus a small **internal resistance** 内阻 r .

Terminal voltage

$$V_{term} = \varepsilon - Ir$$

Worked example

$\varepsilon = 12 \text{ V}$, $r = 1$, load 5 :

$$I = \frac{12}{6} = 2 \text{ A}$$

$$V_{term} = 12 - 2(1) = 10 \text{ V}$$

2 V lost inside the battery.

3 Kirchhoff

Electric Circuits
↳ Kirchhoff

Kirchhoff's rules

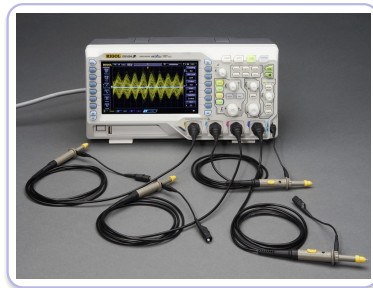
Loop rule (energy)

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

A rise across an emf, a drop $-IR$ across a resistor.

Junction rule (charge)

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



Oscilloscope

4 RC

RC circuits

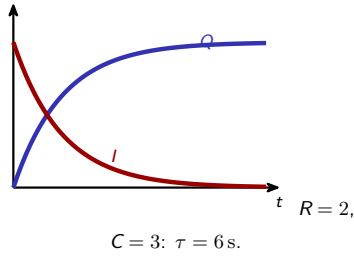
A capacitor charges through a resistor with **time constant** 时间常数 $\tau = RC$:

Charging

$$Q(t) = C\varepsilon (1 - e^{-t/\tau})$$

$$I(t) = \frac{\varepsilon}{R} e^{-t/\tau}$$

Empty capacitor = a wire at first; full = blocks steady current.



5

Recap

Unit 11 – key takeaways

1 Current & Ohm

$$I = dQ/dt; V = IR; P = IV = I^2 R = V^2 / R$$

2 Real battery

$$V_{\text{term}} = \varepsilon - Ir; \text{ small internal resistance}$$

3 Kirchhoff

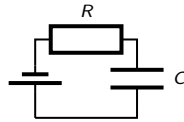
$$\text{loop } \sum \Delta V = 0; \text{ junction } \sum I_{\text{in}} = \sum I_{\text{out}}$$

4 RC

$$\tau = RC; \text{ charge and current decay exponentially}$$

Check yourself

- 1 Write current as a derivative of charge.
- 2 What conservation law is Kirchhoff's loop rule?
- 3 At $t = 0$, how does an empty capacitor behave?
- 4 After a long time, how much current flows through a charged capacitor?



Answers 1. $I = dQ/dt$ 2. conservation of energy 3. like a plain wire 4. zero