

Exercise walk-through

11.3

Resistance, Resistivity, and Ohm's Law

AP Physics C: Electricity and Magnetism

Compound circuits and internal resistance

Reduce series/parallel resistors to one **equivalent resistance**. A real battery is an ideal **emf** plus a small **internal resistance** r .

Terminal voltage

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

Worked example

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

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

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

2 V lost inside the battery.

Power, and how to rank bulb brightness

where it comes from

a charge q falling through ΔV gives up $q\Delta V$ of energy, so the rate is $P = I\Delta V$

three forms

$P = I\Delta V = I^2 R = \frac{(\Delta V)^2}{R}$ – use the one whose two quantities you actually know

in a resistor

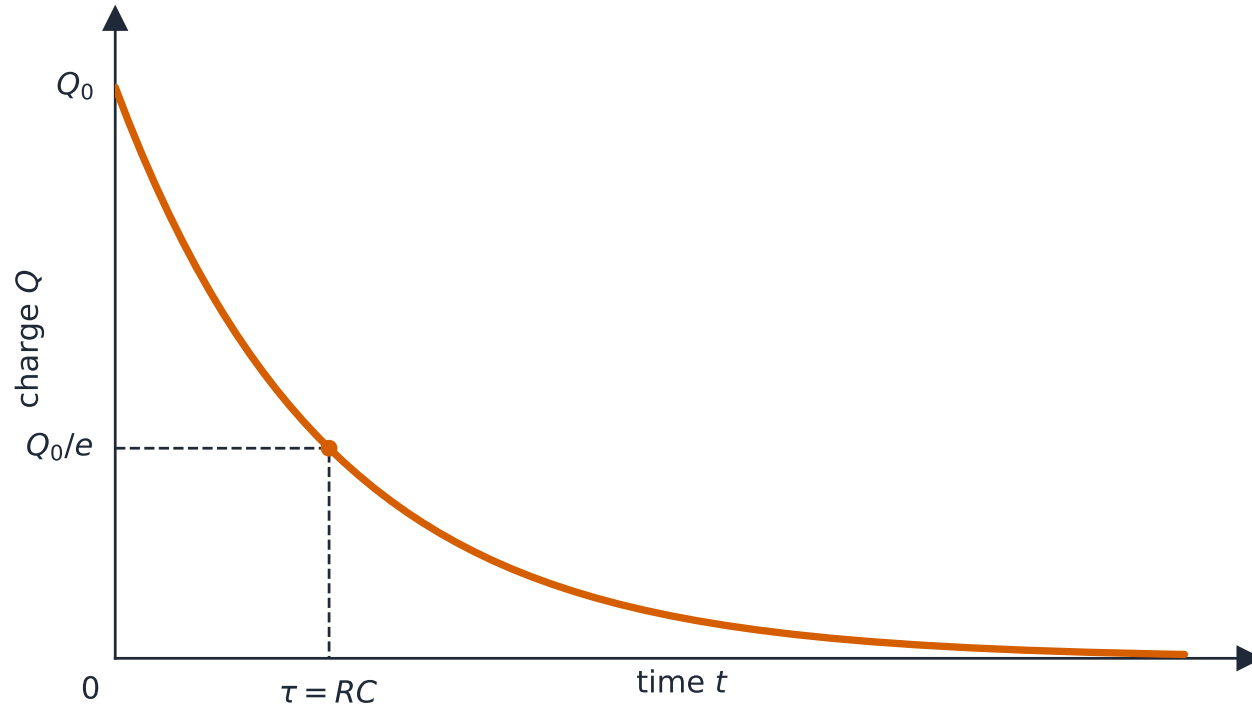
all of it becomes **heat**

brightness

rank bulbs by **power**, never by current or by voltage alone – a bulb can carry more current and still be dimmer

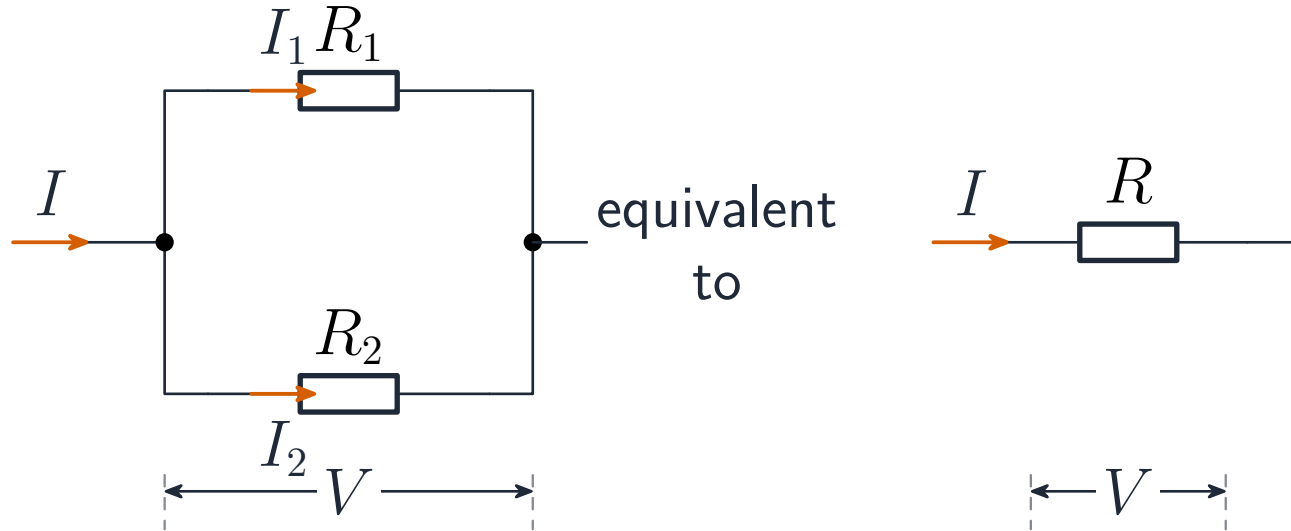
In **series** the current is shared, so $P = I^2 R$ ranks them: bigger R is brighter. In **parallel** the voltage is shared, so $P = (\Delta V)^2 / R$ ranks them: smaller R is brighter. The ranking reverses.

Resistor-Capacitor (RC) Circuits



The charge on a capacitor decays exponentially as it discharges

Compound Direct Current Circuits



Resistors in parallel combine to a smaller equivalent resistance

Where each meter goes, and why

ammeter

in series at the point whose current you want – ideal $R = 0$, so it changes nothing

voltmeter

in parallel across the element – ideal $R = \infty$, so it draws no current

get it backwards

an ammeter in parallel is a short circuit; a voltmeter in series stops the current

circuit diagram

redraw before you calculate – series and parallel are far easier to see in a tidy diagram than in the given one

The ideal resistances are chosen so the meter does not disturb what it measures. Every real meter fails that a little, which is what internal-resistance questions probe.

Exercises 2.1-2.3

2.1 A 12 V supply drives 3.0 A through a resistor. Find its resistance. [2]

2.2 State how doubling a wire's length changes its resistance (same material and area). [1]

2.3 State the difference between resistivity and resistance. [2]

Exercises 2.1-2.3

2.1 A 12 V supply drives 3.0 A through a resistor. Find its resistance. [2]

2.1

- $R = \frac{V}{I} = \frac{12}{3.0} = 4.0 \, \Omega$

2.2 State how doubling a wire's length changes its resistance (same material and area). [1]

2.2

- it doubles ($R \propto L$)

2.3 State the difference between resistivity and resistance. [2]

2.3

- resistivity is a property of the material alone; resistance also depends on the object's length and cross-sectional area

Exercise 3.1

3.1 Resistance relates to geometry by

[1]

☐

A $\frac{\rho A}{L}$

B $\frac{\rho L}{A}$

C $\frac{L}{\rho A}$

D ρLA

Exercise 3.1

3.1 Resistance relates to geometry by

[1]

- ☐ A $\frac{\rho A}{L}$
- ☐ B $\frac{\rho L}{A}$
- ☐ C $\frac{L}{\rho A}$
- ☐ D ρLA

3.1 B

• $\frac{\rho L}{A}$.

Exercise 3.2

3.2 Resistivity is a property of the

[1]

☐

A object's shape

B material

C current

D voltage

Exercise 3.2

3.2 Resistivity is a property of the

[1]

☐

A object's shape

B material

C current

D voltage

3.2 B

- material.

Exercise 3.3 (a)

3.3 A wire has resistivity $1.7 \times 10^{-8} \, \Omega \text{ m}$, length 2.0 m, and area $1.0 \times 10^{-6} \text{ m}^2$.

(a) Find its resistance.

[2]

Exercise 3.3 (a)

3.3 A wire has resistivity $1.7 \times 10^{-8} \, \Omega \text{ m}$, length 2.0 m , and area $1.0 \times 10^{-6} \text{ m}^2$.

(a) Find its resistance.

[2]

(a)

- $$R = \frac{\rho L}{A} = \frac{(1.7 \times 10^{-8})(2.0)}{1.0 \times 10^{-6}} = 0.034 \, \Omega$$

Exercise 3.3 (b)

3.3 A wire has resistivity $1.7 \times 10^{-8} \, \Omega \text{ m}$, length 2.0 m, and area $1.0 \times 10^{-6} \text{ m}^2$.

(b) The wire is stretched to twice its length (its volume unchanged, so its area halves). Find the new resistance. [2]

Exercise 3.3 (b)

3.3 A wire has resistivity $1.7 \times 10^{-8} \, \Omega \text{ m}$, length 2.0 m, and area $1.0 \times 10^{-6} \text{ m}^2$.

(b) The wire is stretched to twice its length (its volume unchanged, so its area halves). Find the new resistance. [2]

(b)

- length $\times 2$ and area $\div 2$ give $R \times 4 = 0.136 \, \Omega$