¶ 3.1

PHYS 102 B Lecture 3: Current, Resistance, and Circuits

Welcome to Lecture 3.



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¶ 3.2

Before:
Standing Still



Electric Current

Resistance & Ohm's Law

Electric Power

Series Circuits

Parallel Circuits

The tools behind every battery-powered device you own.



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¶ 3.3

Current (Ampere, A)
- Rate of flow

Charge
(Coulomb, C)

$$I = \frac{Q}{t}$$

Time
(seconds, s)

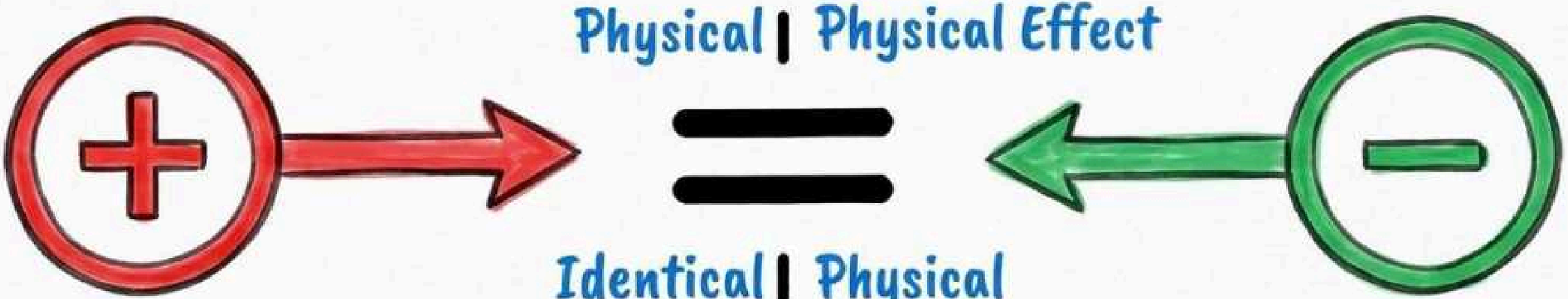
3 Coulombs
÷ 6 Seconds
= 0.5 Amperes

1 Ampere = 1 Coulomb per second

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Identical Physical Effect



Identical Physical Effect

Convention
(Since Benjamin Franklin):
Positive charge
moving right.

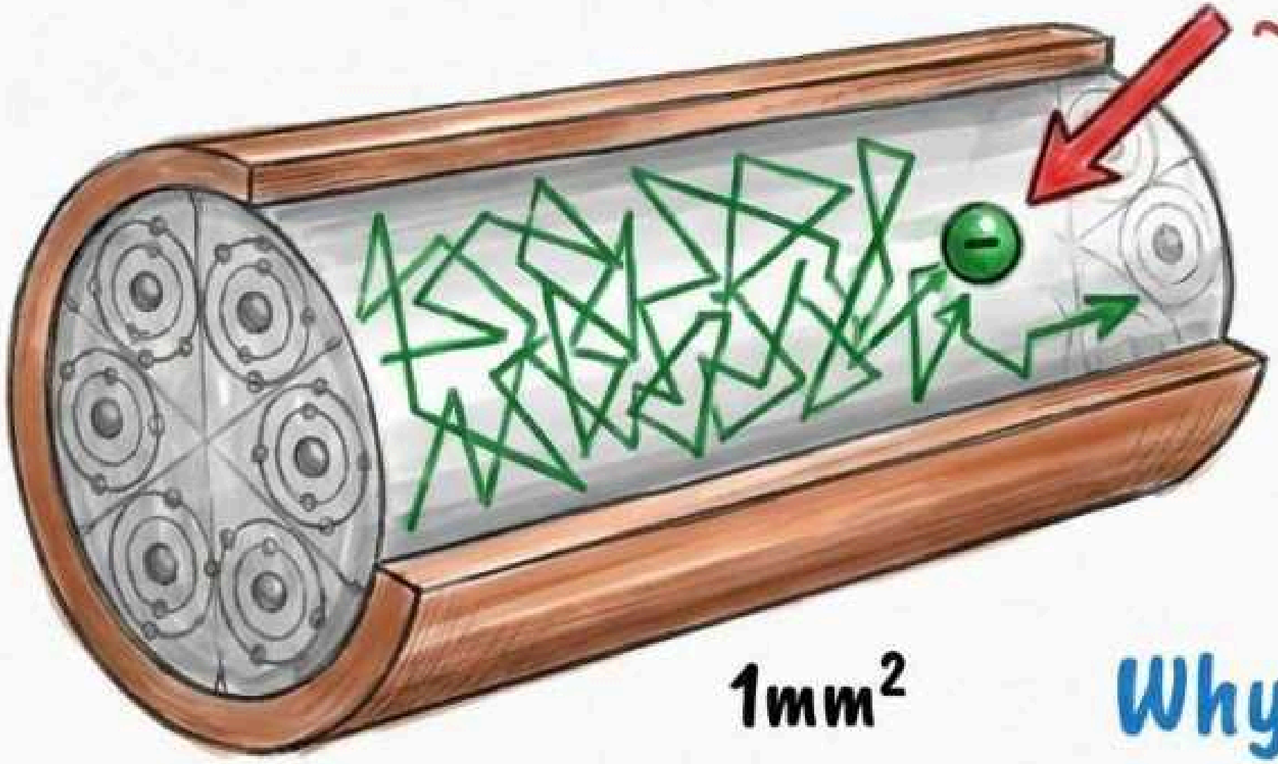
Reality in Metals:
Negative electrons
moving left.

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¶ 3.5

0.5 A = 3.1×10^{18} electrons crossing every second.

Drift Speed:
~ 0.07 mm/s

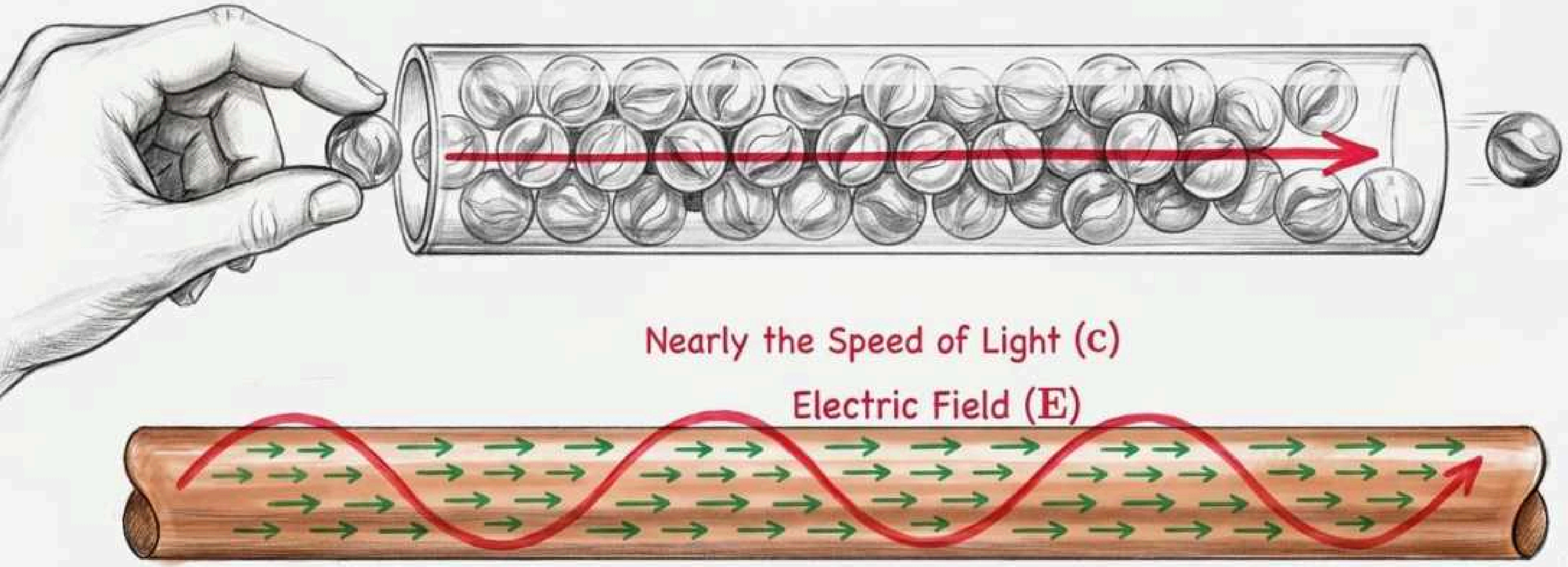




Why, then, does a lamp light INSTANTLY?

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The electric field travels at nearly the speed of light, pushing ALL free electrons at once.

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¶ 3.7

Voltage (Volts)
— The Driver

Resistance (Ohms, Ω)
— The Opposition

$$V = I \times R$$

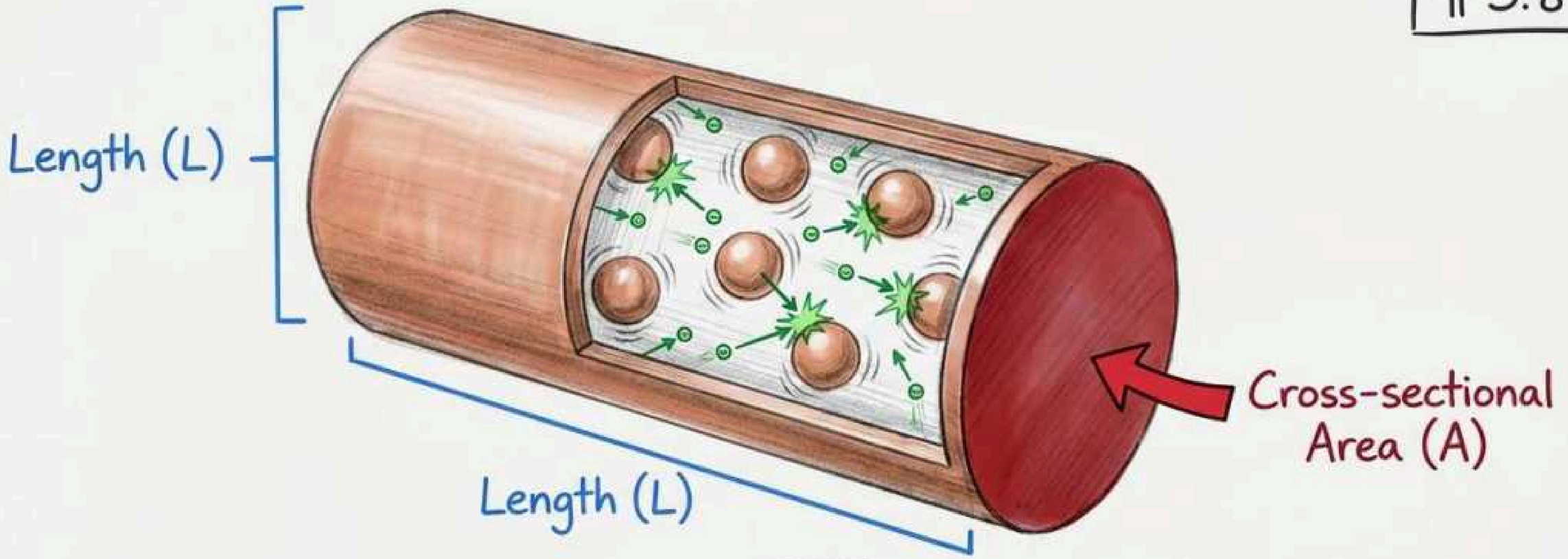
Current (Amps)
— The Flow

$$12V = I \times 4\Omega$$

$$\rightarrow \text{Current } (I) = 3A$$

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$$R = \rho\left(\frac{L}{A}\right)$$

Resistivity of the material

Copper: $\rho = 1.68 \times 10^{-8}\ \Omega \cdot m$

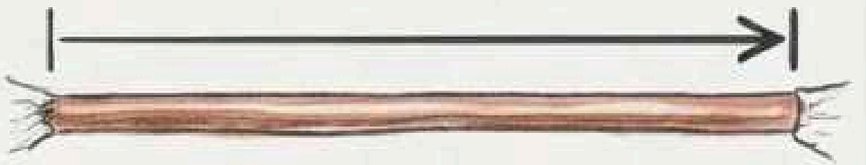
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10m length, 1mm^2 area (10^{-6} m^2)

$$R = \frac{(1.68 \times 10^{-8}) \times 10}{10^{-6}}$$

Result: 0.168 Ω



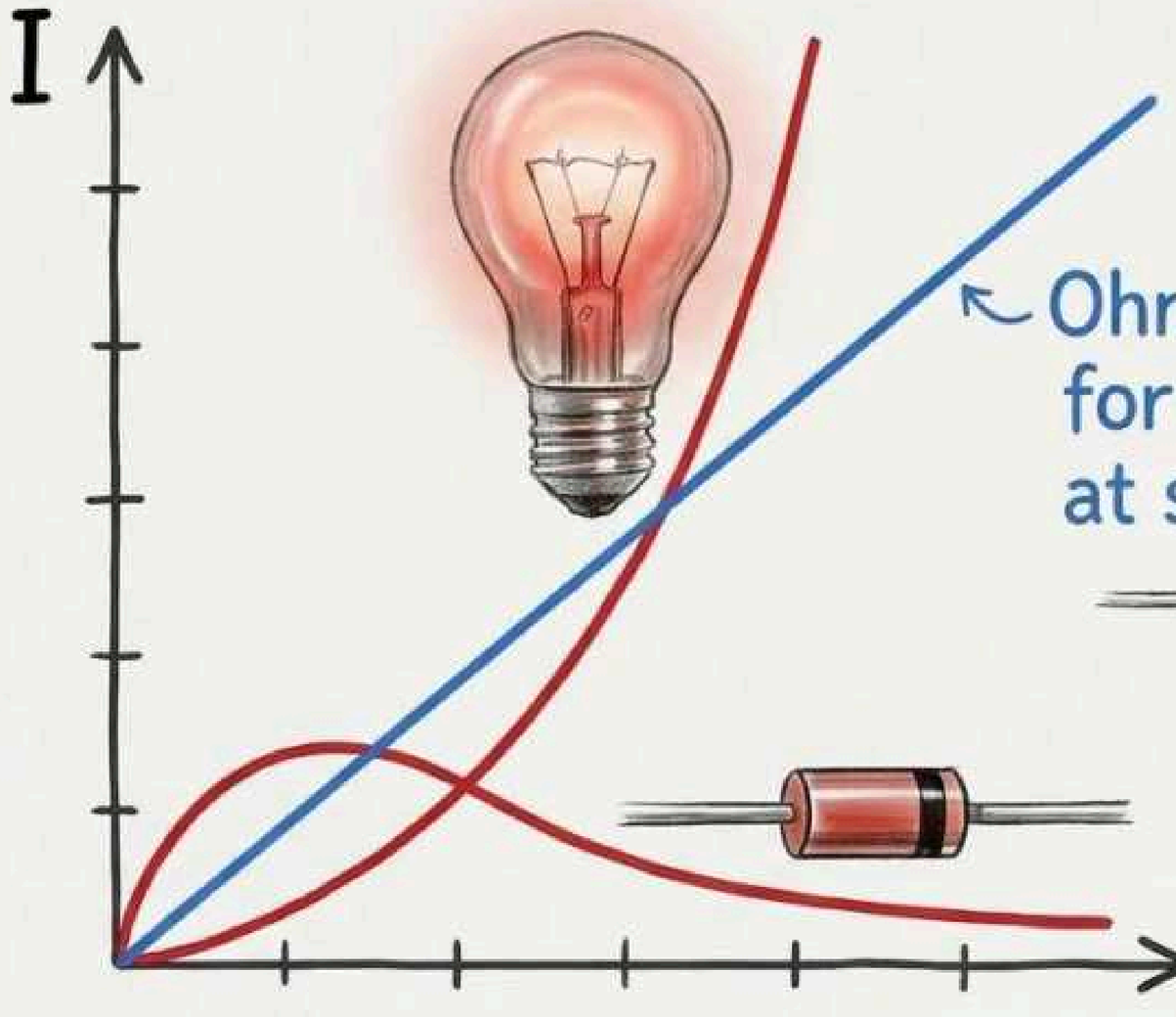
Double the Length
→ Doubles Resistance (2R)



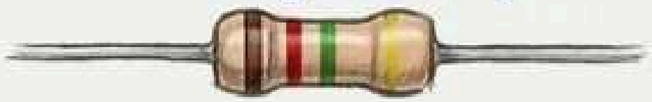
Double the Area
→ Halves Resistance (R/2)

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¶ 3.10



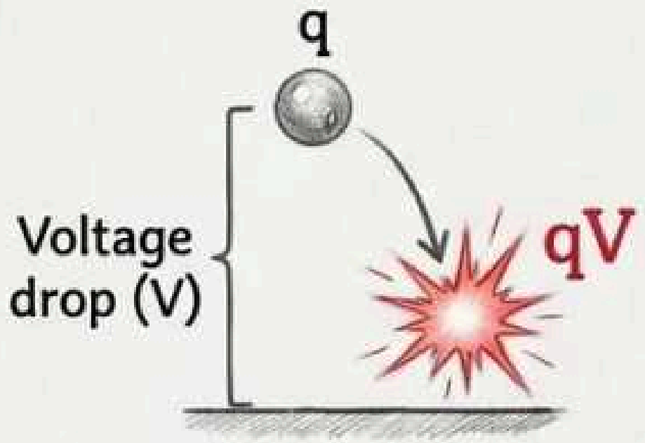
Ohm's Law: Holds for resistors/metals at steady temp.



Not a law of nature, but a rule of thumb.

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¶ 3.11

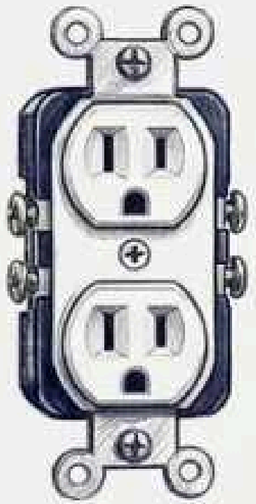


$$\left\{ \begin{array}{l} P = I \times V \\ P = I^2 \times R \\ P = \dfrac{V^2}{R} \end{array} \right\}$$

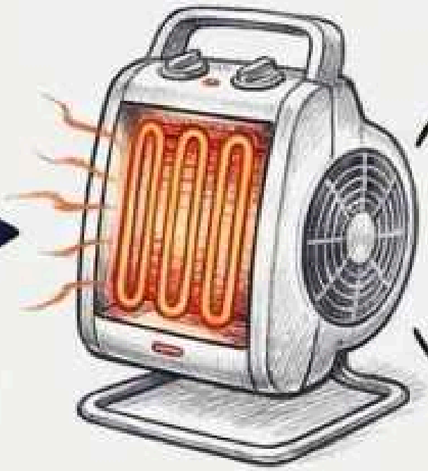
All three forms are useful, depending on what variables you know.

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¶ 3.12



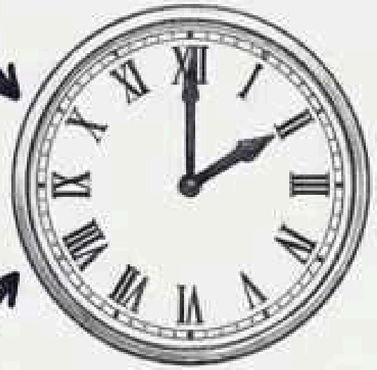
120V Source



1500W Heater

$$I = \frac{1500\text{W}}{120\text{V}} = 12.5\text{A}$$

$$R = \frac{120\text{V}}{12.5\text{A}} = 9.6\,\Omega$$



2 Hours



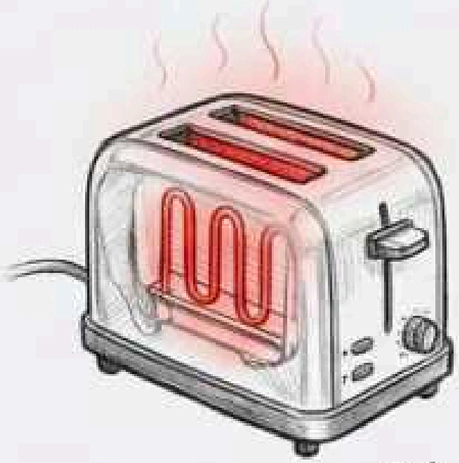
3 kWh

What your meter counts, and what you pay for.

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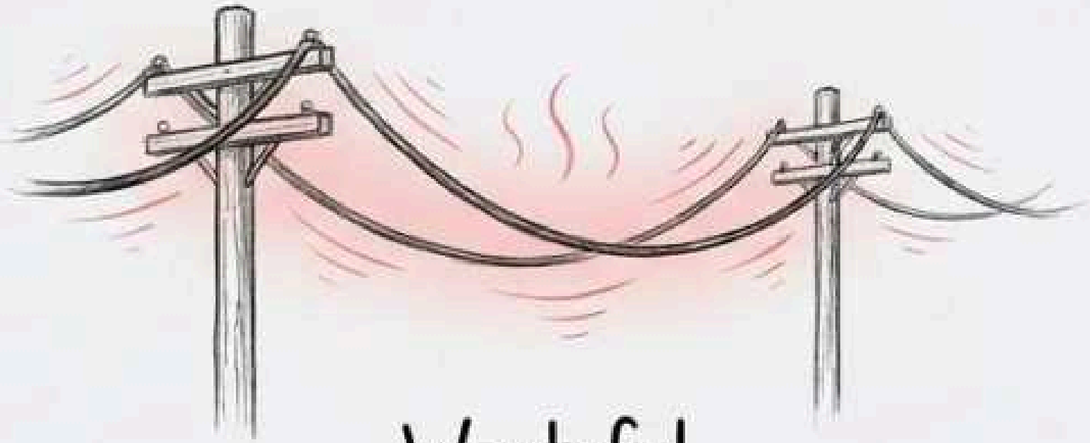
Electrical Energy → Heat

¶ 3.13

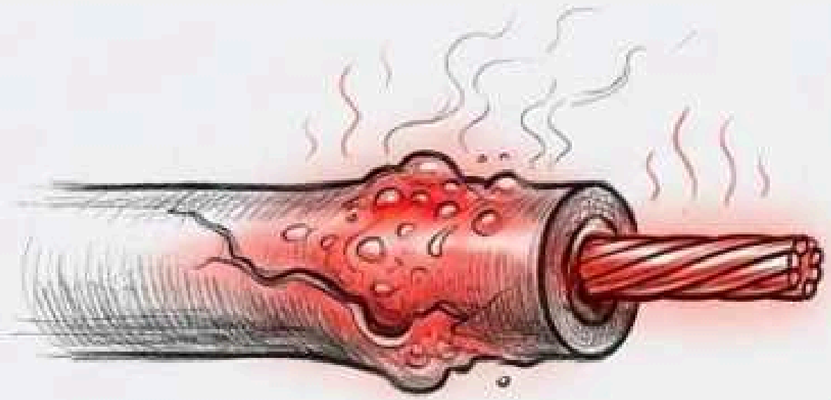




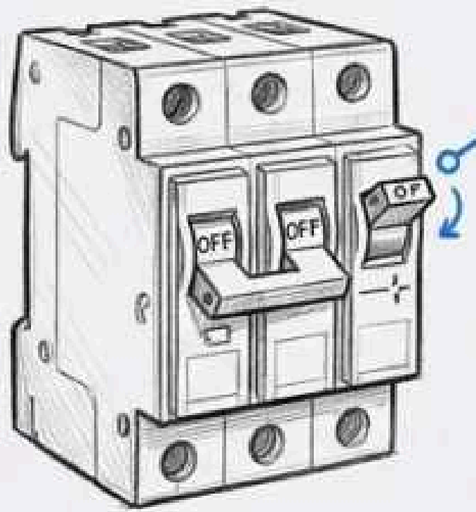
Useful



Wasteful



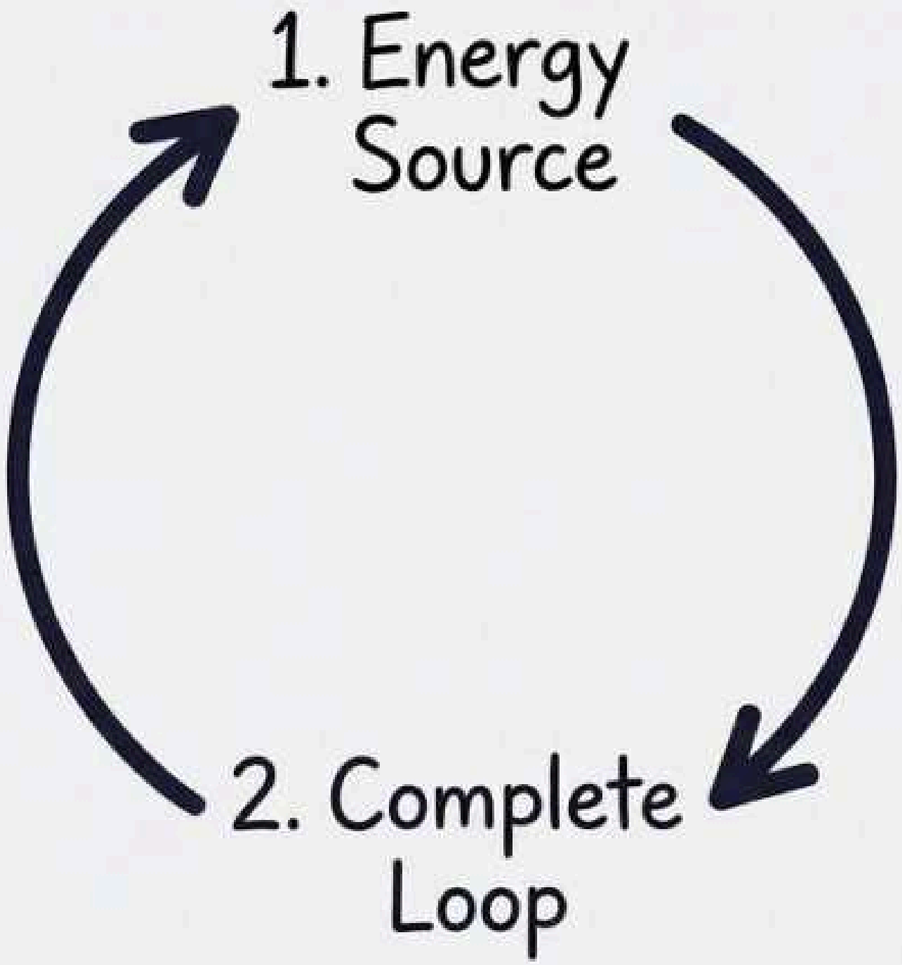
Overload



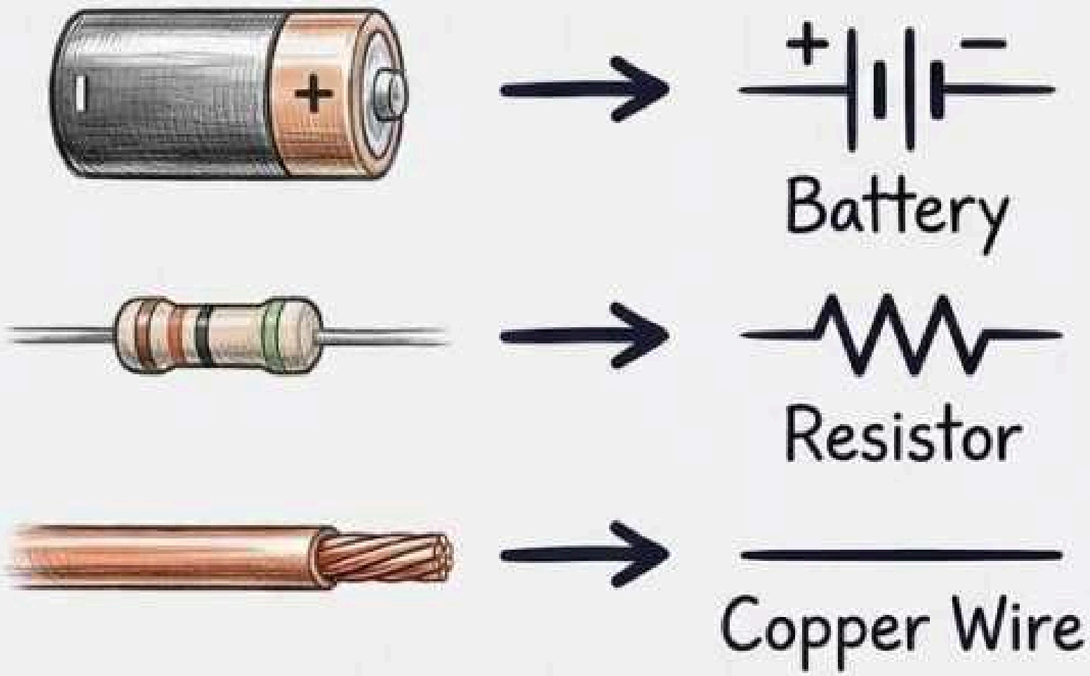
The Deliberate Weak Link — Opens the circuit before insulation burns.

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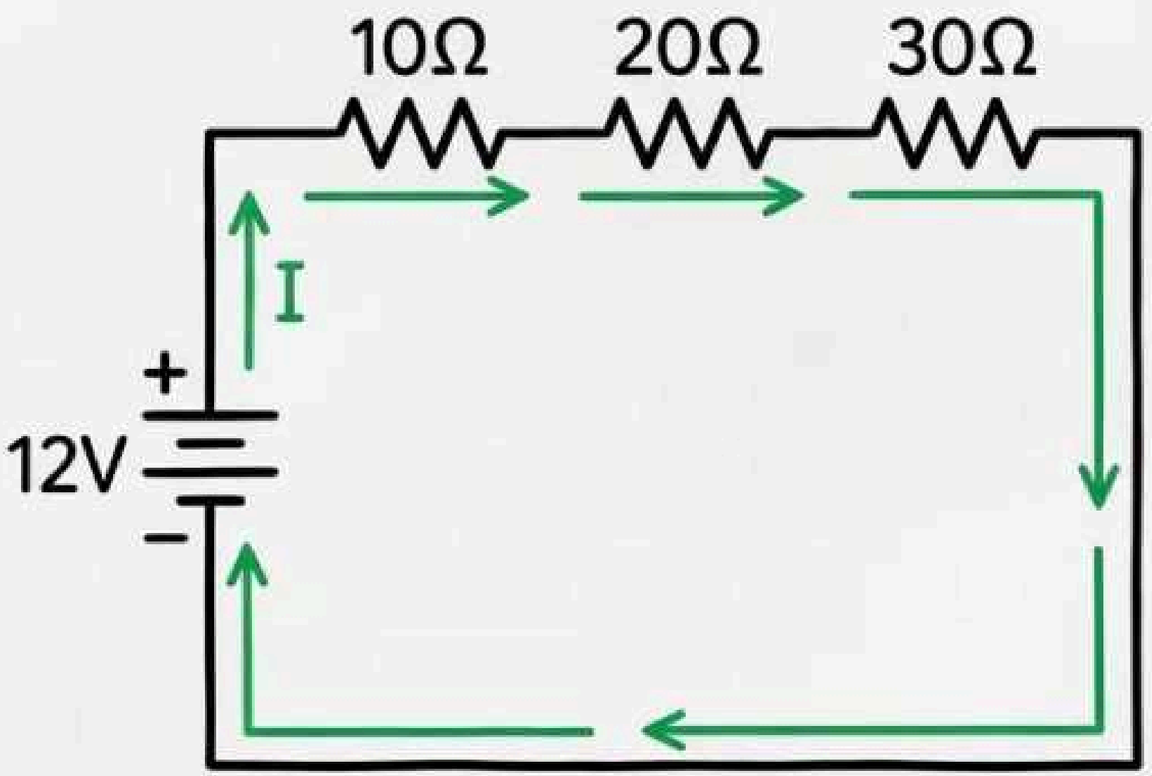
Translation Matrix





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¶ 3.15

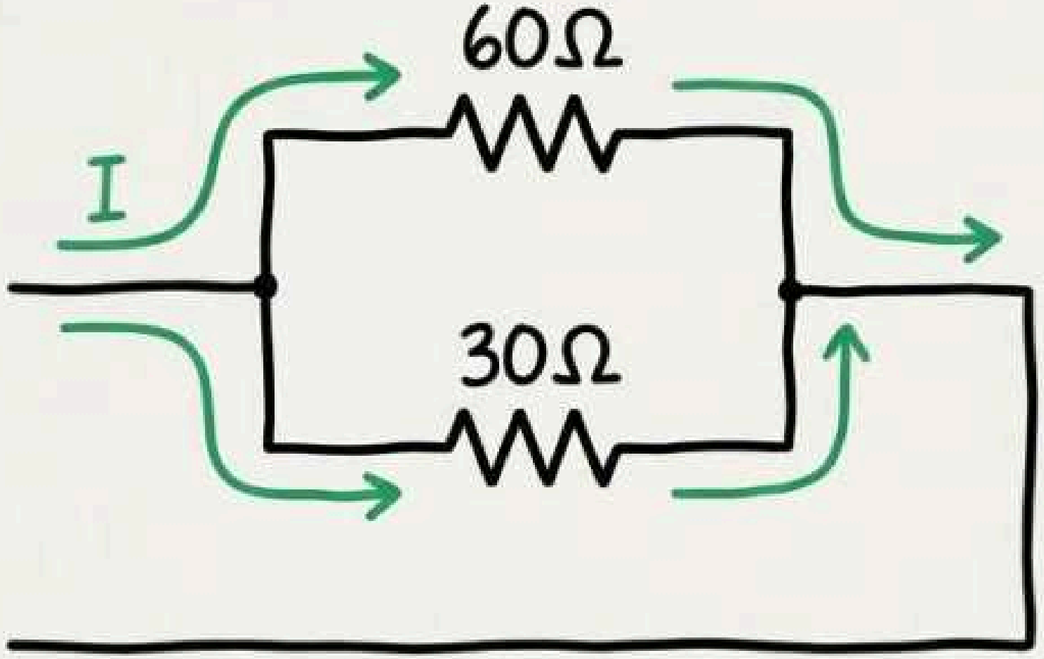


SERIES RULES

- **Path:** Single path.
- **Current:** Same through each (0.2A everywhere).
- **Resistance:** Adds up (10 + 20 + 30 = 60Ω total).
- **Voltage:** Divides proportionally (2V, 4V, and 6V across the three, summing perfectly back to 12V).

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PARALLEL RULES

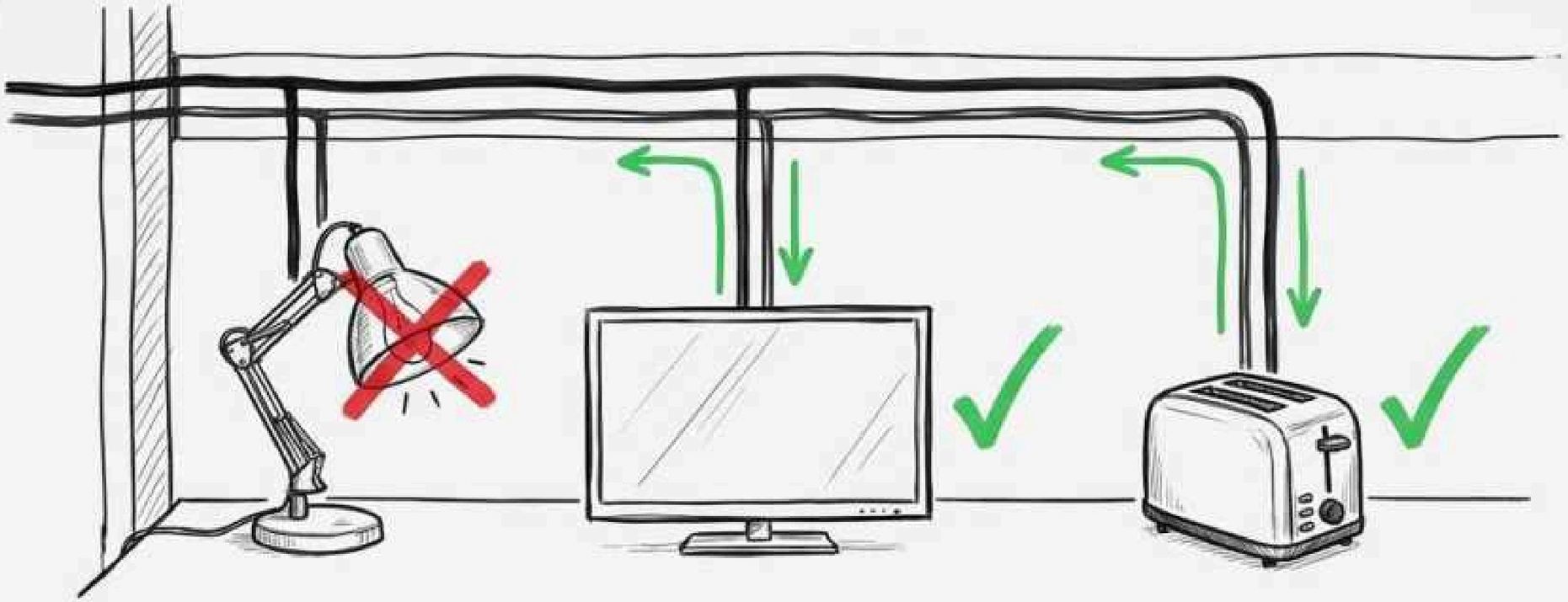
- Path: Multiple branches.
- Voltage: Same across each branch.
- Current: Branch currents add together.
- Resistance: $\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2}$

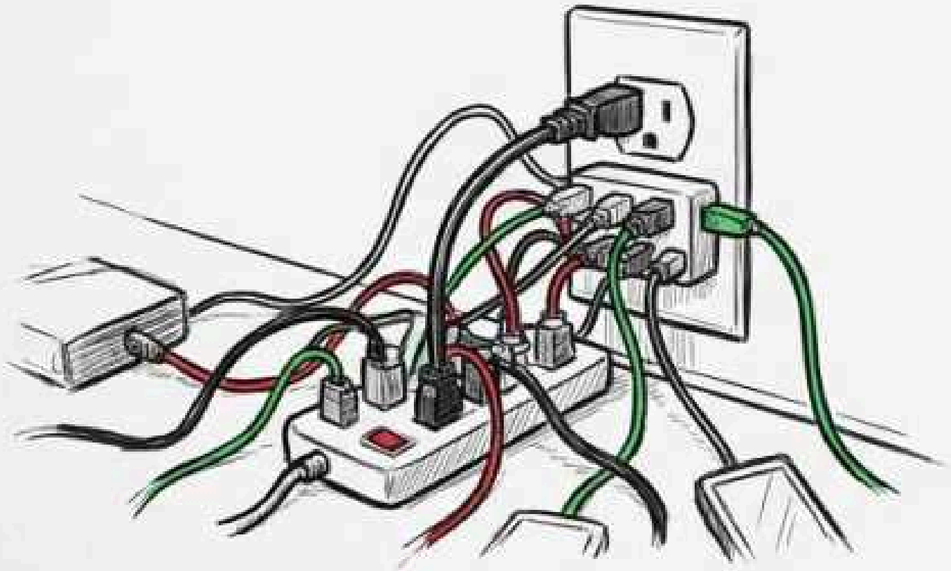
60Ω and 30Ω yield 20Ω total

More paths ALWAYS mean less total resistance.

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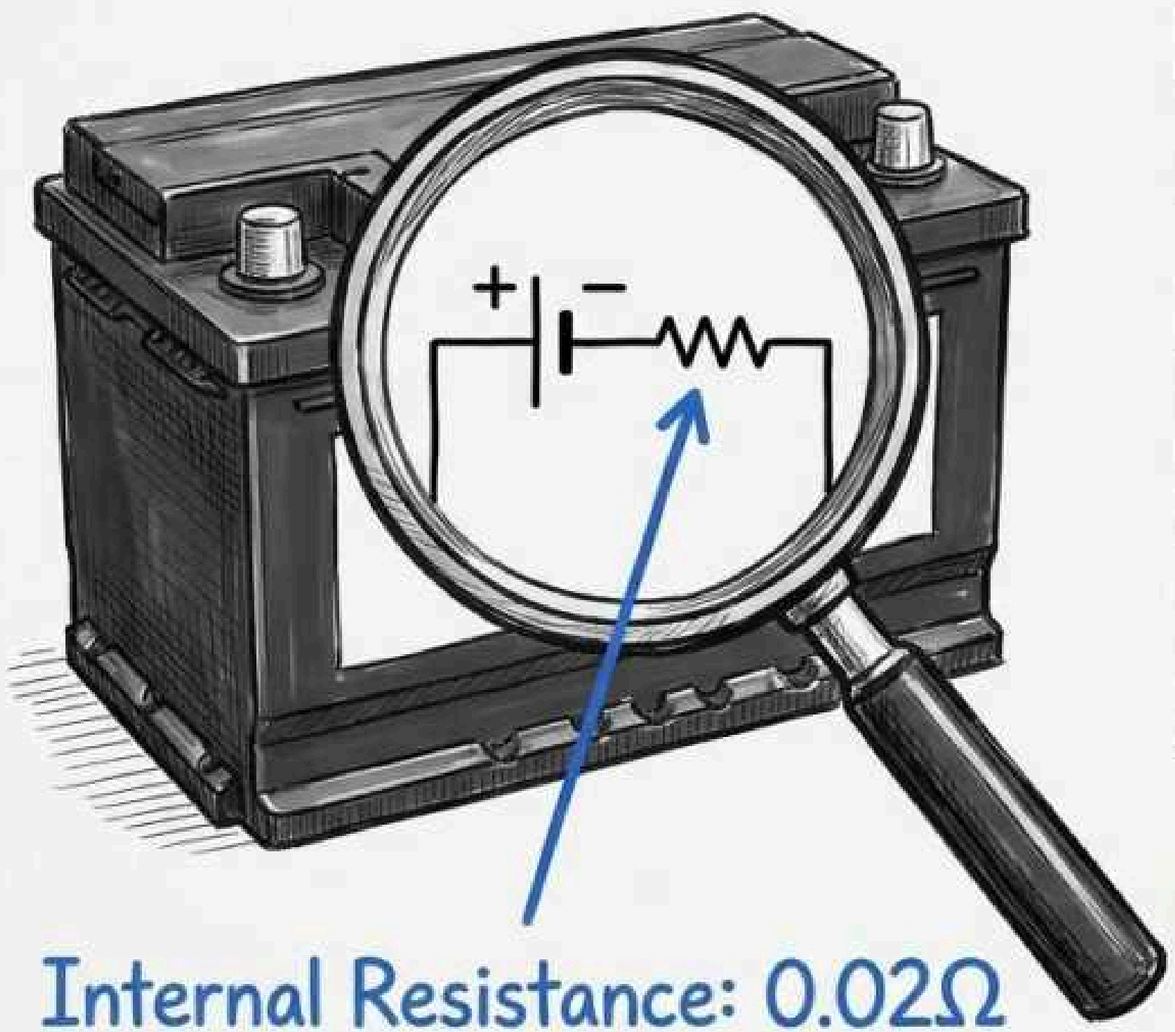




Plugging in too many appliances adds branches → Draws more current → Trips the breaker when safe safe wire limits are exceeded.

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¶ 3.18



Internal Resistance: 0.02Ω

Starter motor demands 150 Amperes.

Internal Voltage Drop: 150A × 0.02Ω
= 3V dropped inside the battery.

Output at terminals:

$$12V - 3V = 9V$$

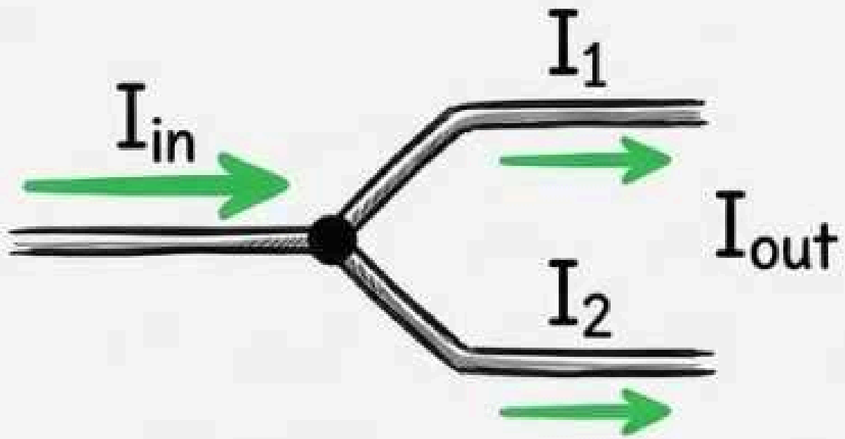


Why headlights dim as the engine cranks.

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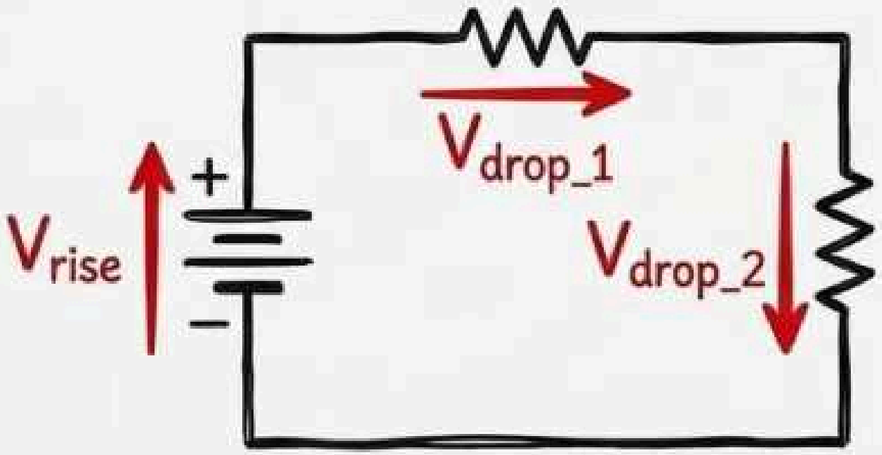
The Junction Rule



$$I_{in} = I_{out}$$

Because CHARGE is conserved.

The Loop Rule

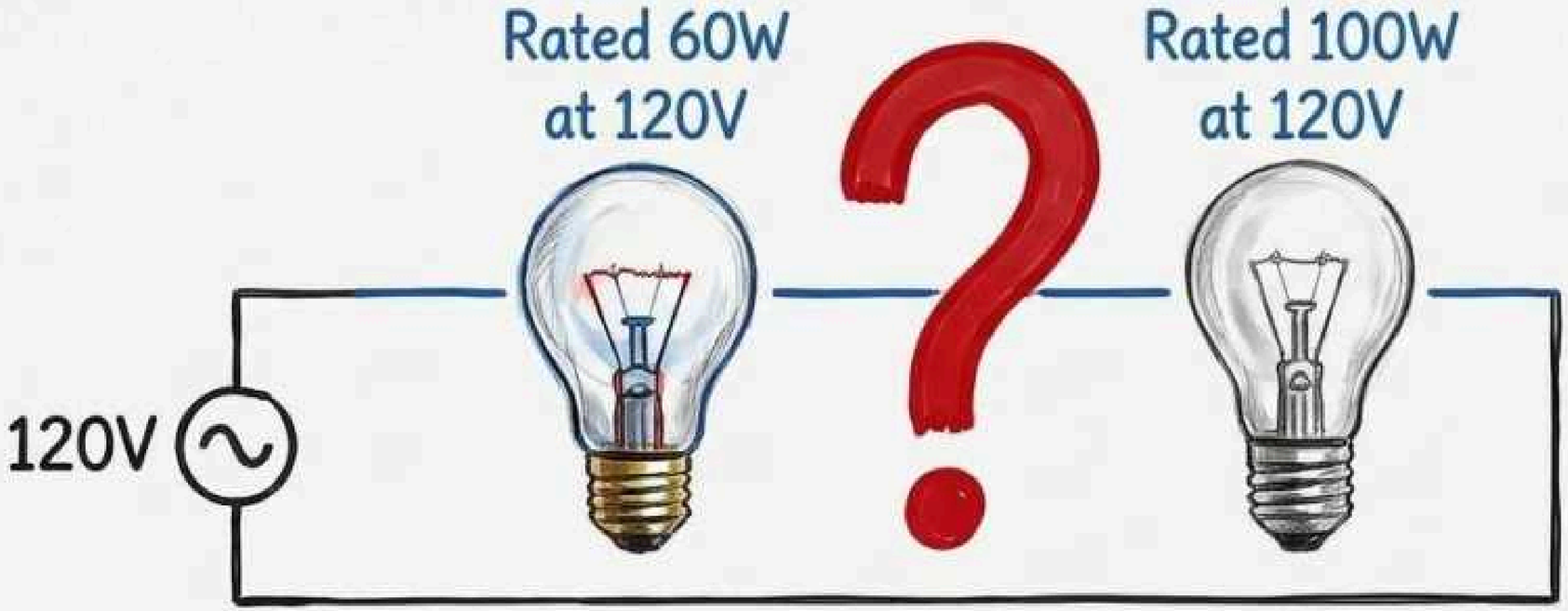


$$\sum V_{closed_loop} = 0$$

Because ENERGY is conserved.

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¶ 3.20



WHICH GLOWS BRIGHTER?

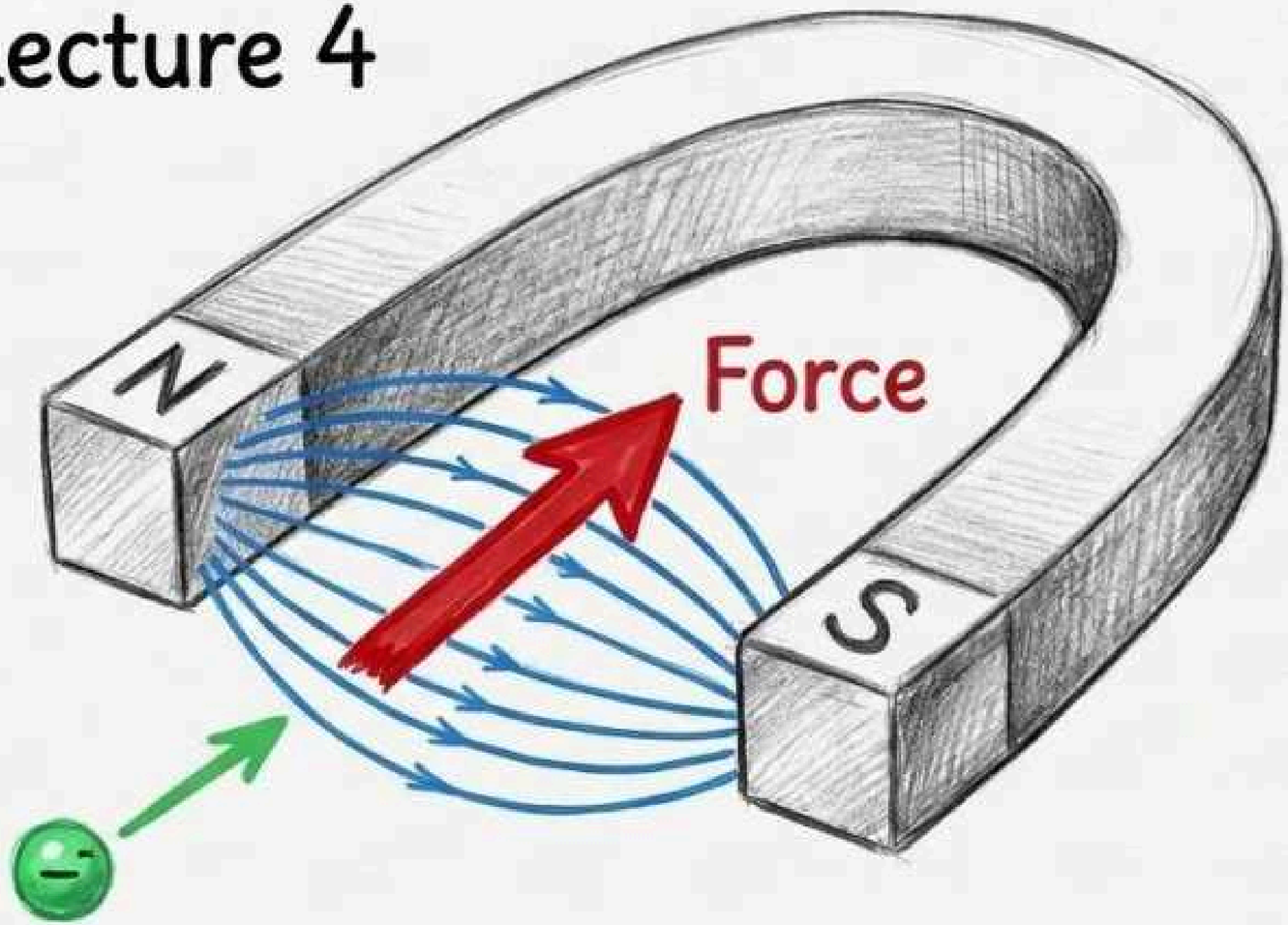
1. Work out each bulb's actual resistance.
2. Calculate the shared series current.
3. Calculate the actual power (I^2R) dissipated by each.

The answer surprises many people...

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Next Time: Lecture 4

¶ 3.21



The second half of the story: Magnetism,
and the hidden forces that act on moving charges.

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