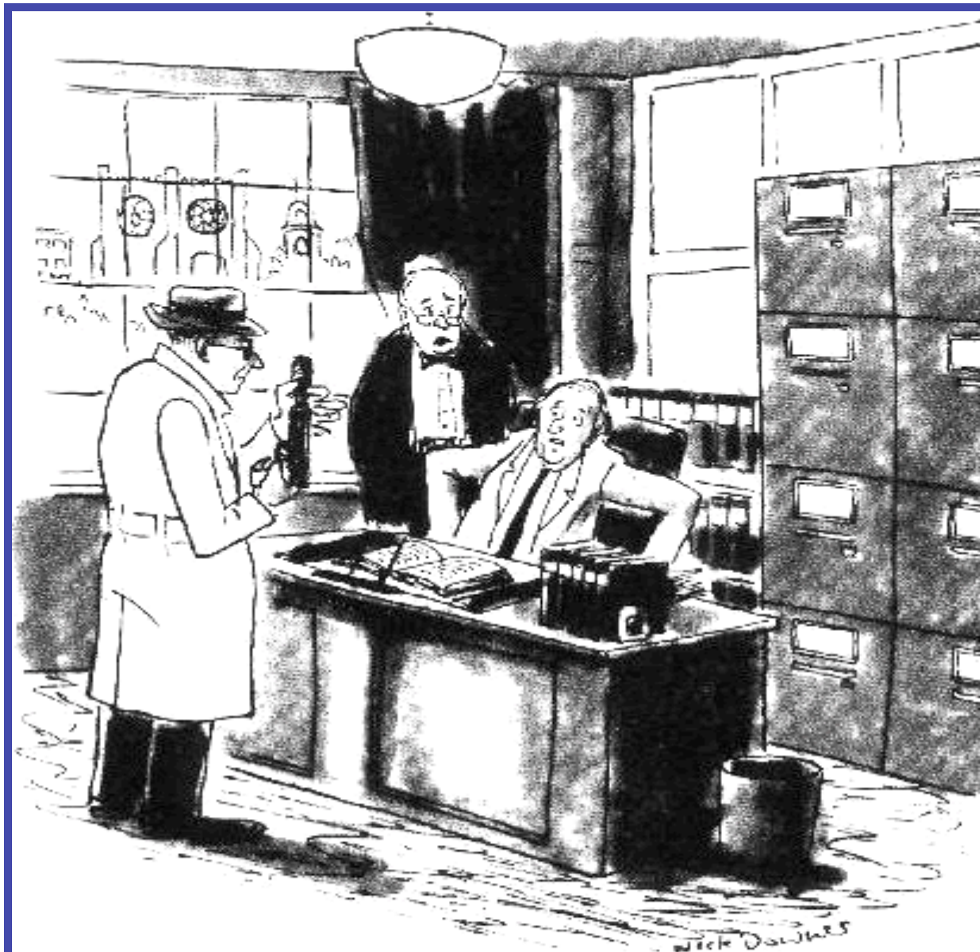
Chapter 28: DC Circuits



"Surely you were aware when you accepted the position, Professor, that it was publish or perish."

EMF & Terminal Voltage

- An electric circuit needs a battery or a generator to produce current – these are called

Sources of "Electromotive Force" or EMF.

- It is important to remember that, despite its misleading name,

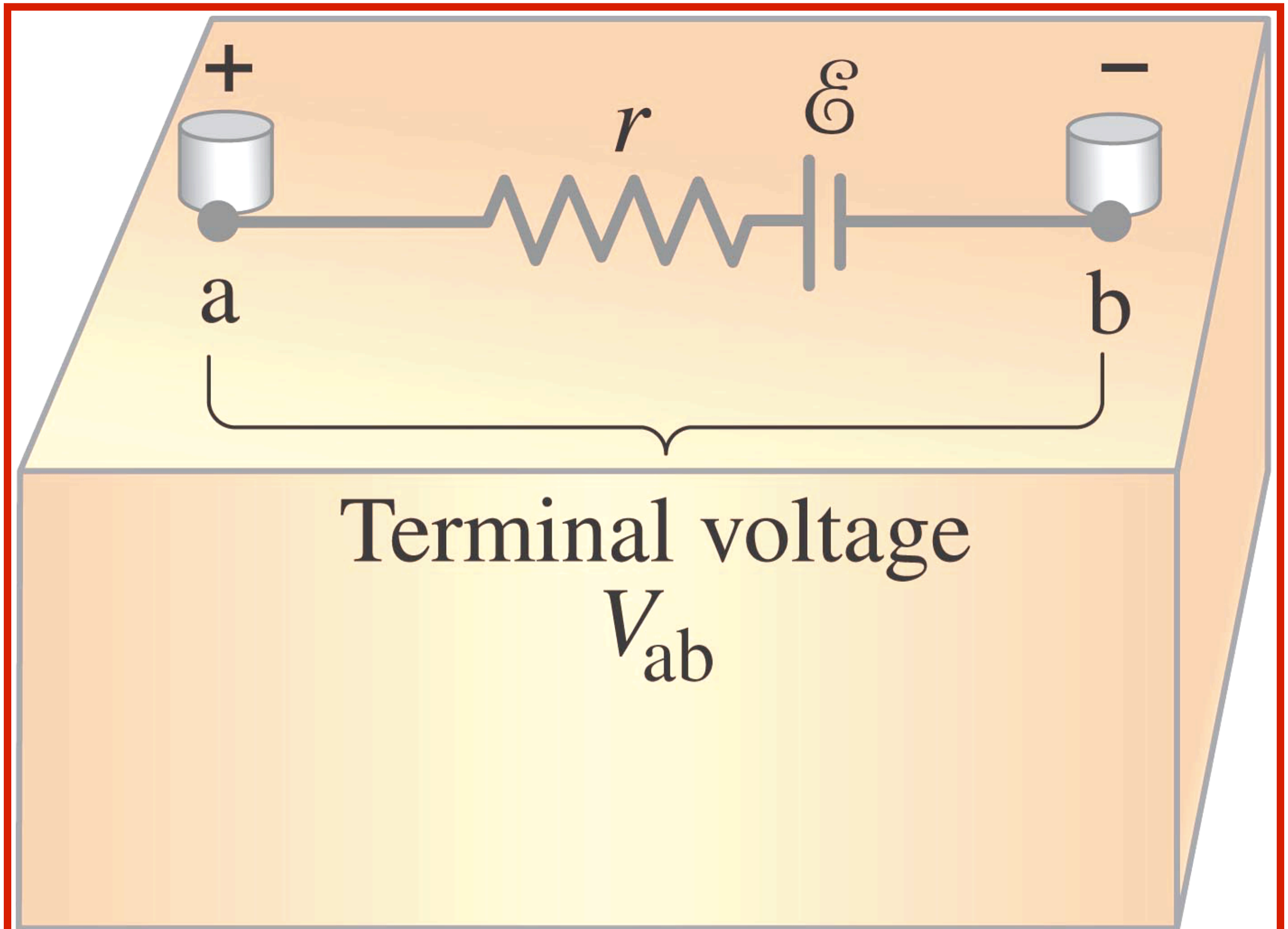
EMF is a VOLTAGE source!

It is NOT a FORCE!!

- A battery is a nearly constant voltage source, but it does have a small internal resistance **r**, which reduces the actual voltage from the ideal EMF:

$$V_{ab} = \mathcal{E} - Ir.$$

The internal battery resistance **r** behaves as if it were in series with the EMF.



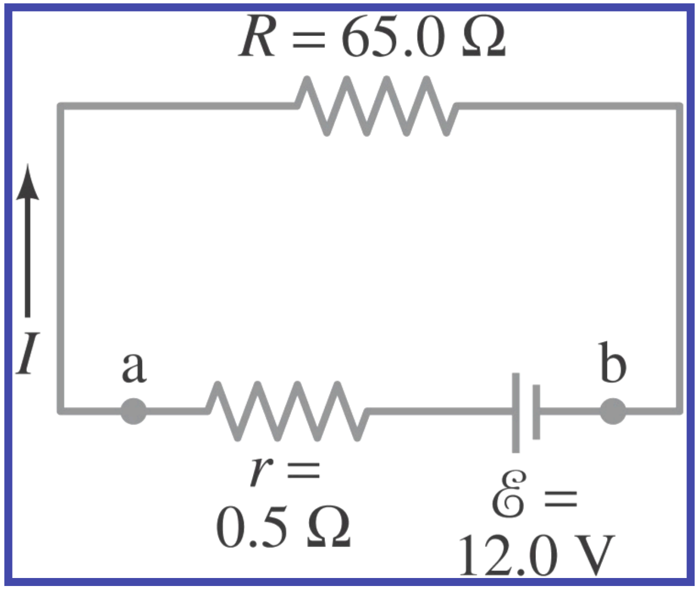
Electromotive Force

- The **electromotive force (emf), e,** of a battery is the ***maximum possible voltage*** that the battery can provide between its terminals.
- The ***emf supplies energy***, it does not apply a force.
- The battery will normally be the source of Energy in the circuit.
- **The positive terminal of the battery is at a higher potential than the negative terminal.**
- We assume that the wires to have no resistance.

Example: Battery with Internal Resistance

- A resistor **R = 65.0-Ω** is connected to the terminals of a battery with emf **E =12.0 V** & internal resistance **r = 0.5 Ω.**

Calculate



(a) the current **I** in the circuit,

(b) the terminal voltage of the battery, V_{ab}, and

(c) the power dissipated in the resistor ***R*** & in the battery's internal resistance **r**.

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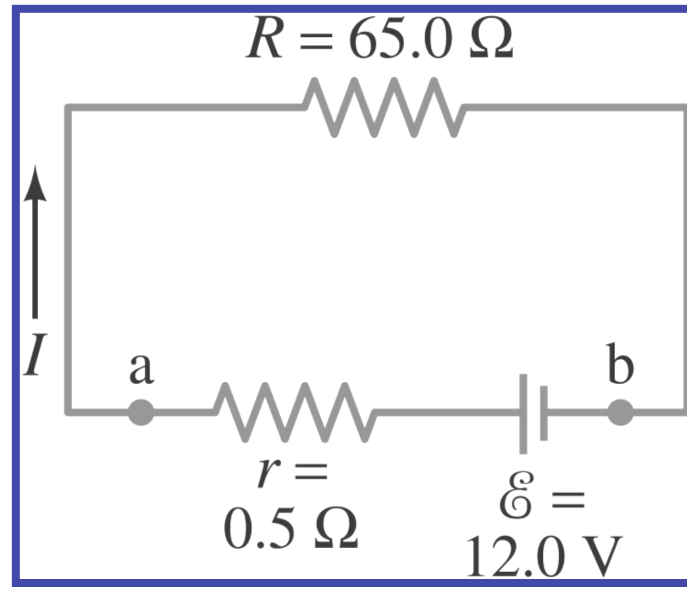
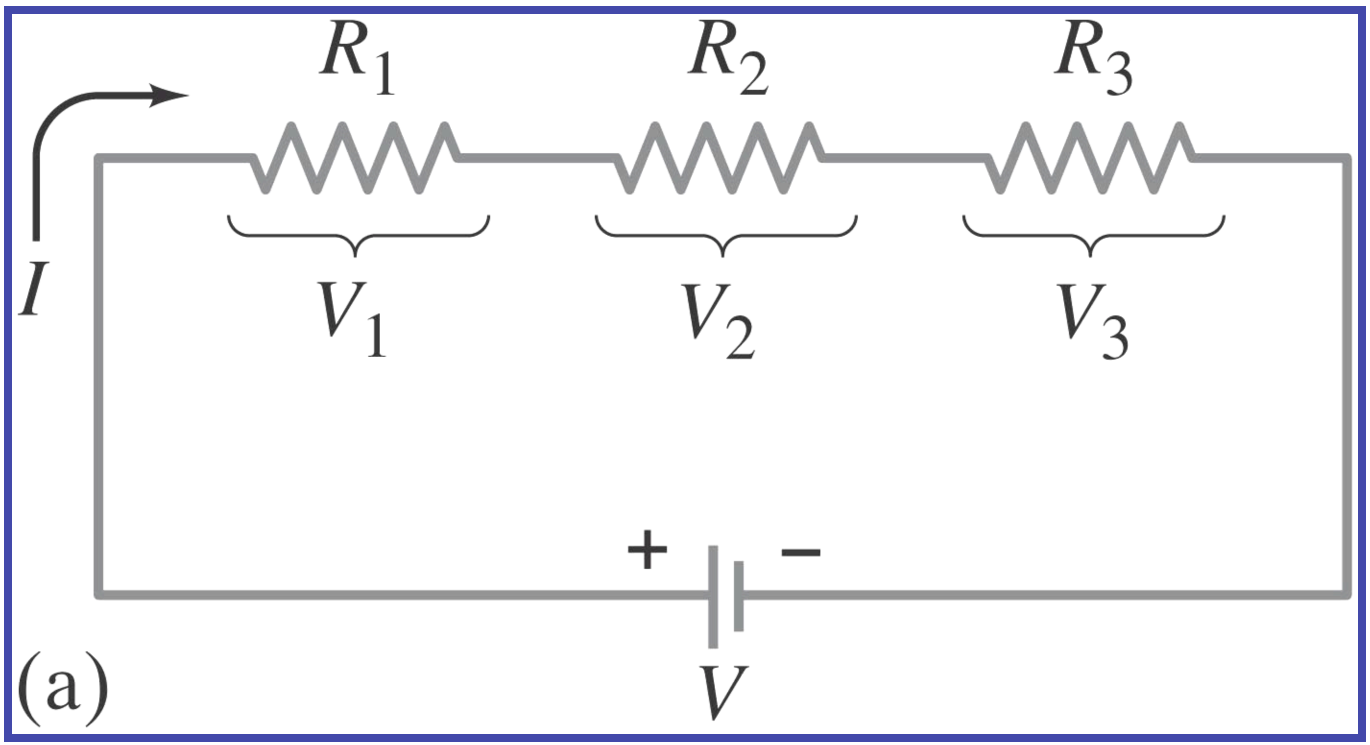


Answers: **(a)** **I = 0.183 A.** **(b)** V_{ab} **= 11.9 V.**
(c) P_R **= 2.18W,** P_r **= 0.02 W**

Resistors in Series & in Parallel

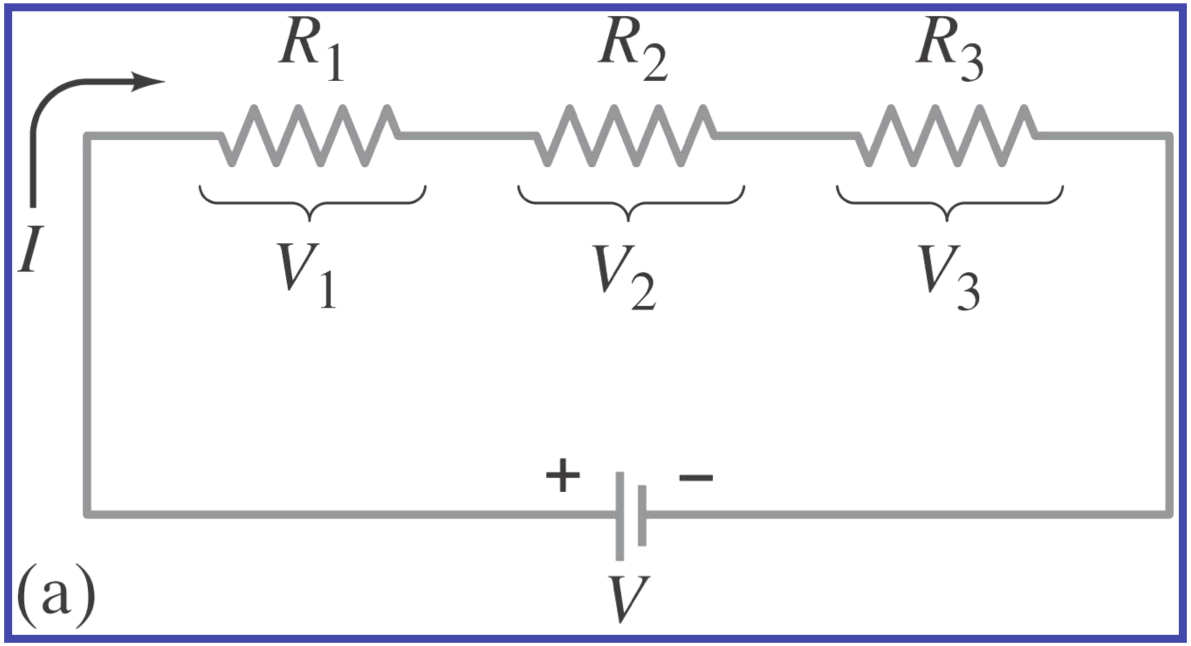
A ***SERIES CONNECTION*** has a single path from the battery, through each circuit element in turn, then back to the battery.



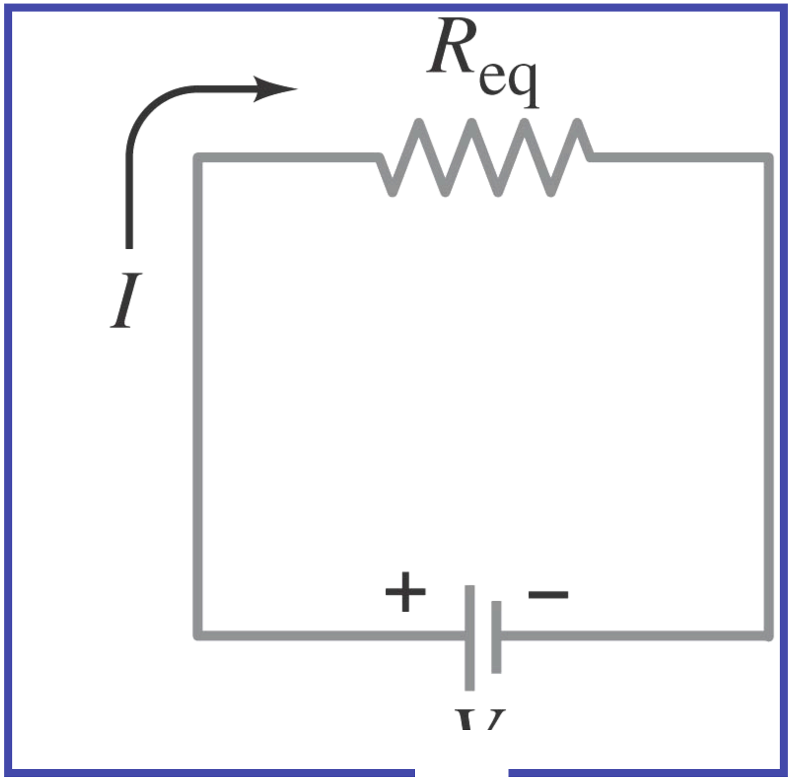
The current through each resistor is the same; the voltage depends on the resistance.

***The sum of the voltage drops across the resistors equals the battery voltage*:**

$$V = V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3.$$



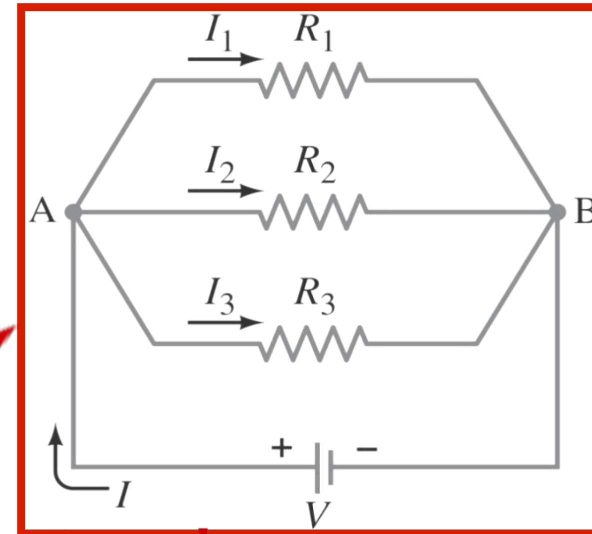
This can be used to obtain the **Equivalent Resistance** $\mathbf{R_{eq}}$ ($\mathbf{R_{eq}}$ **:** The single resistance that gives the same current in the circuit for the same voltage drop.)

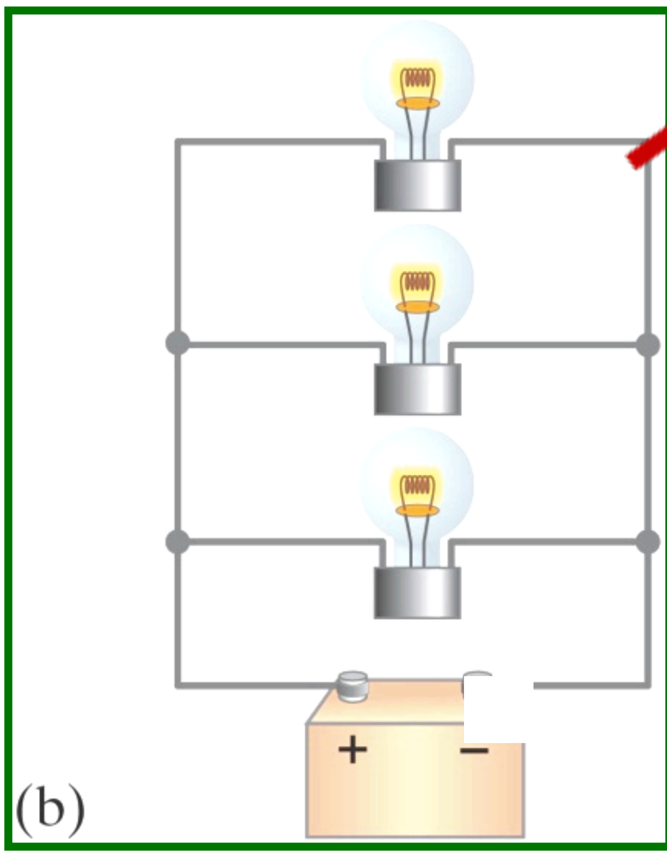


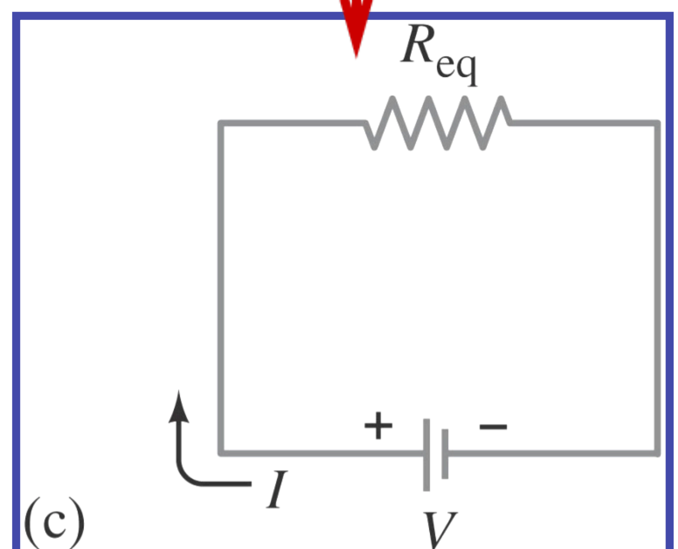
$$\mathbf{V = IR_{eq}}$$

$$R_{eq} = R_1 + R_2 + R_3.$$

A ***PARALLEL CONNECTION*** splits the current; the voltage across each resistor is the same:







The total current **I** is the sum of currents across each resistor:

$$I = I_1 + I_2 + I_3,$$

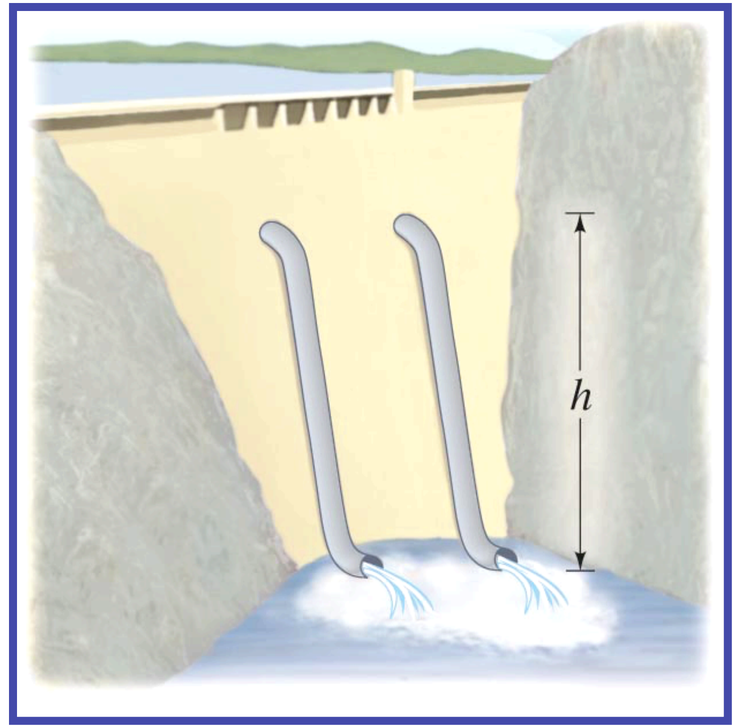
$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}.$$

This gives the reciprocal of the equivalent resistance $\mathbf{R_{eq}}$

$$\mathbf{I = (V/R_{eq})}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

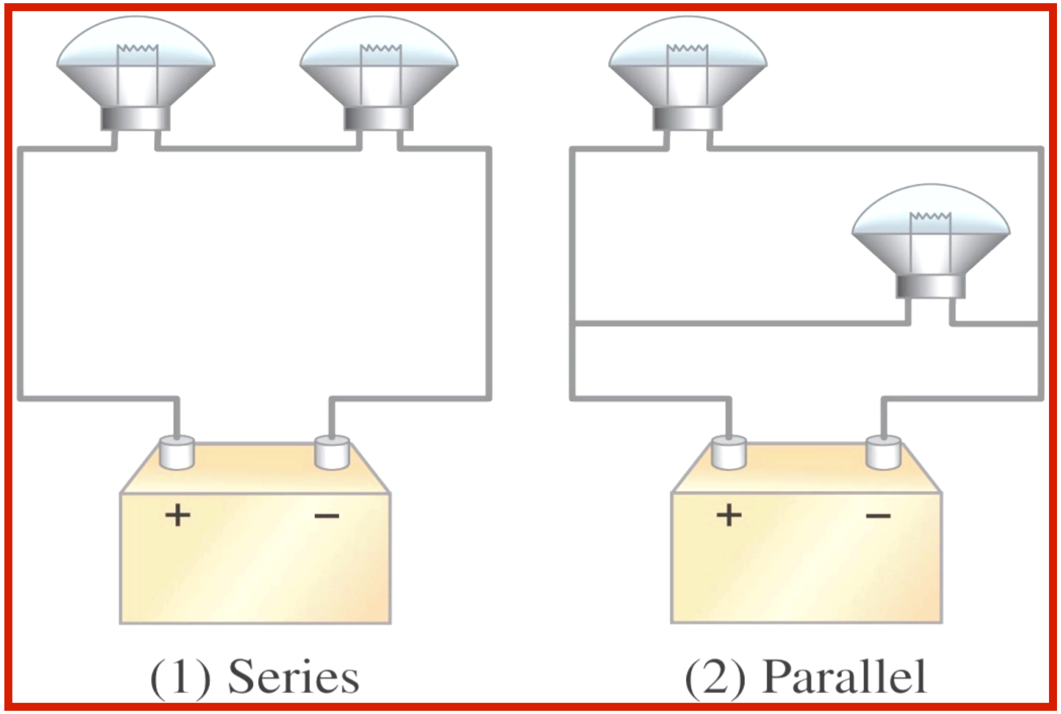
An analogy using water may be helpful in visualizing parallel circuits. The water (current) splits into two streams; each falls the same height, and the total current is the sum of the two currents. With two pipes open, the resistance to water flow is half what it is with one pipe open.



Conceptual Example: Series or parallel?

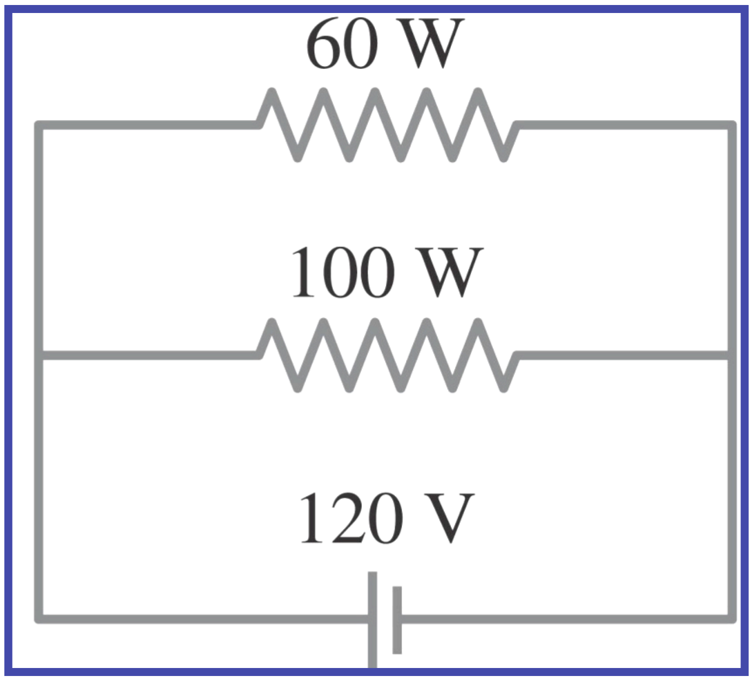
(a) The light bulbs in the figure are identical. Which configuration produces more light?

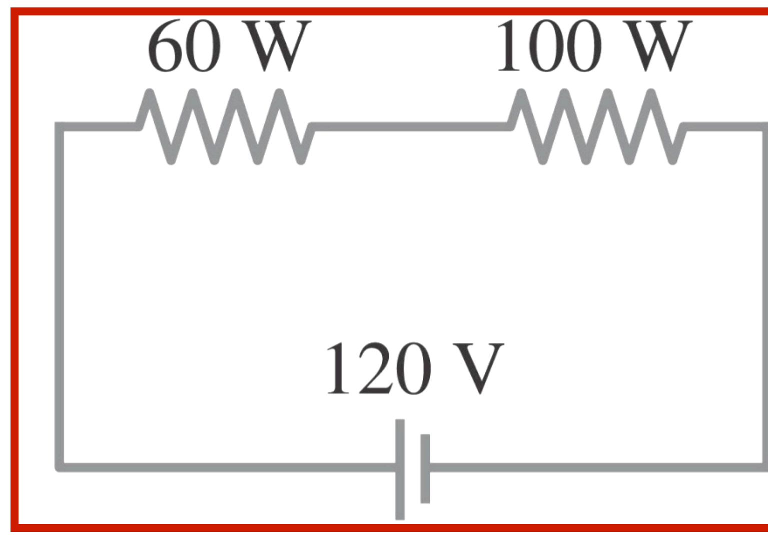
(b) Which way do you think the headlights of a car are wired? Ignore change of filament resistance **R** with current.



Conceptual Example:

A **100-W, 120-V** lightbulb and a **60-W, 120-V** lightbulb are connected in two different ways as shown. In each case, which bulb glows more brightly? Ignore change of filament resistance with current (and temperature).



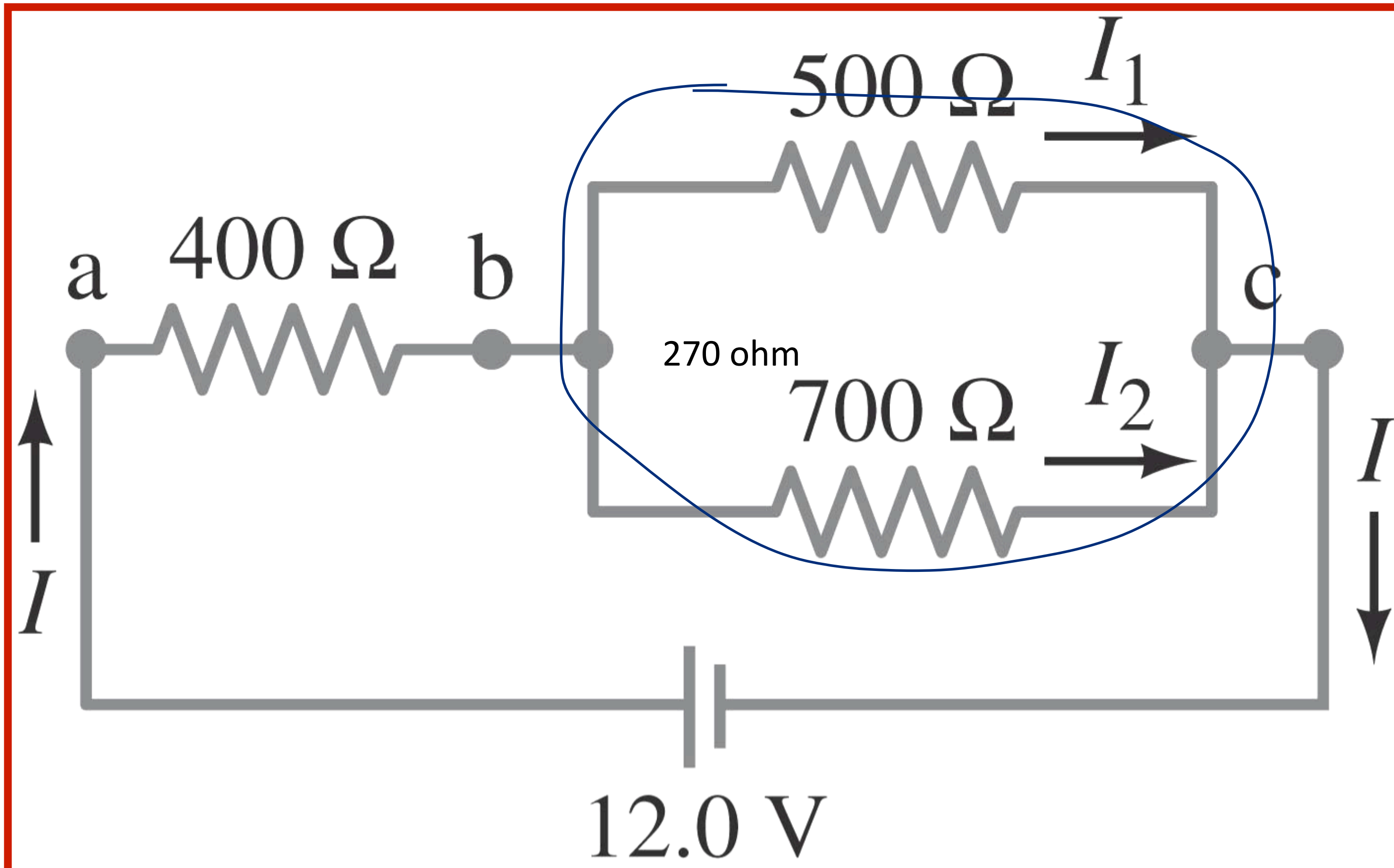


Example:

Circuit with series and parallel resistors.

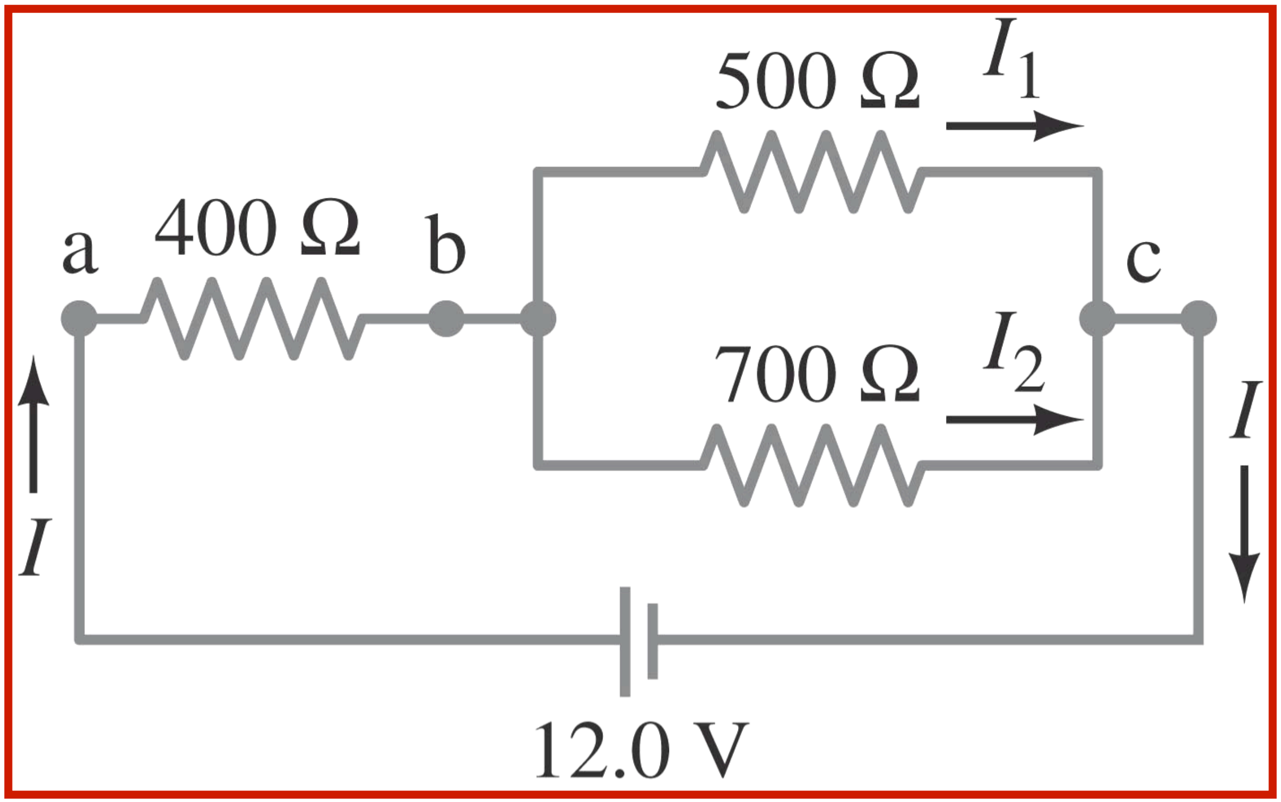
Calculate the current that is drawn from the battery shown.

I = 18 mA



Example: Current in one branch.

Calculate the current I_1 through the **500-Ω** resistor. This is the same circuit as in the previous problem.) The total current **I** in the circuit was found to be **I = 17 mA**.



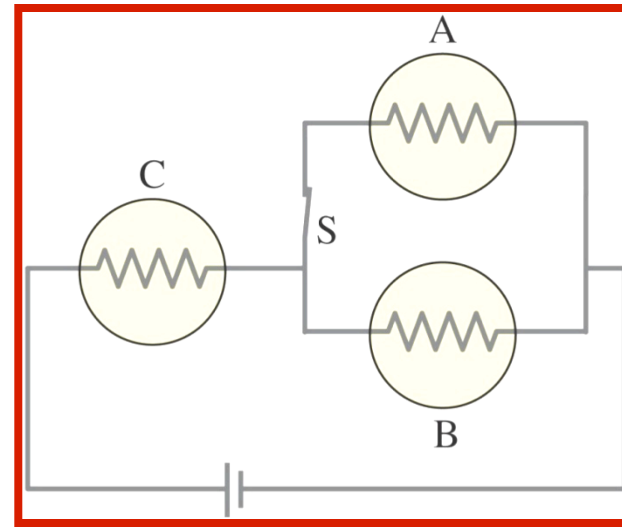
Conceptual Example

Bulb Brightness in a Circuit.

- The circuit shown has 3 identical light bulbs, each of resistance **R**.

(a) When switch **S** is closed, how will the brightness of bulbs **A** & **B** compare with that of **C**?

(b) What happens when switch **S** is opened?



Use a minimum of mathematics to obtain your answer!!!

Example: Two-speed Fan.

- One way a multiple-speed ventilation fan for a car can be designed is to put resistors in series with the fan motor. The resistors reduce the current through the motor and make it run more slowly.
- Suppose the current in the motor is **5.0 A** when it is connected directly across a **12-V** battery.

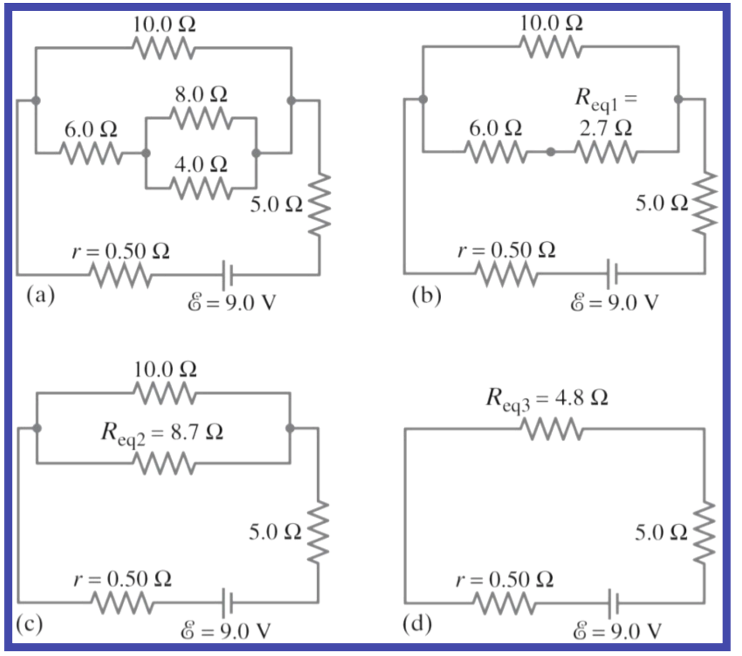
(a) What series resistor should be used to reduce the current to **2.0 A** for low-speed operation?

(b) What power rating should the resistor have?

Example: Analyzing a Circuit

- A **9.0-V** battery with internal resistance **r = 0.50 Ω** is connected in the circuit shown.

  (a) How much current is drawn from the battery?



(b) What is the battery terminal voltage?

(c) What is the current in the **6.0-Ω** resistor?