Basic Electricity 2

ME 120 Lecture Notes

Portland State University
Mechanical and Materials Engineering

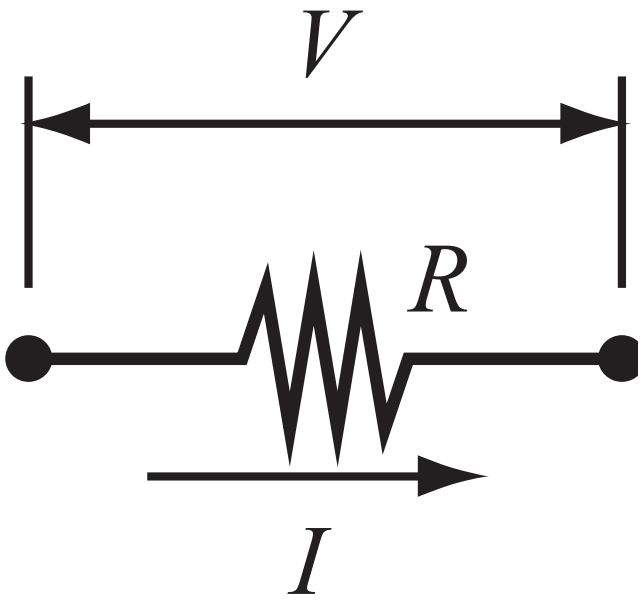
Learning Objectives

Successful completion of this module will enable students to

- Compute power dissipation in simple DC circuits, using Ohm's law
- Combine resistors in series to obtain one equivalent resistor
- Combine resistors in parallel to obtain one equivalent resistor
- Reduce resistor networks to an equivalent resistance

Review

Ohm's law relates voltage, current and resistance for the flow of current through a conductor.



$$V = I \times R$$

in amp (A)

in volts (V)

in ohms (Ω)

Definition

Power:

Power is the rate at which work is done. It is also the rate at which energy is expended.

$$P = \frac{\text{Work}}{\text{time}} = \frac{\text{Energy}}{\text{time}}$$

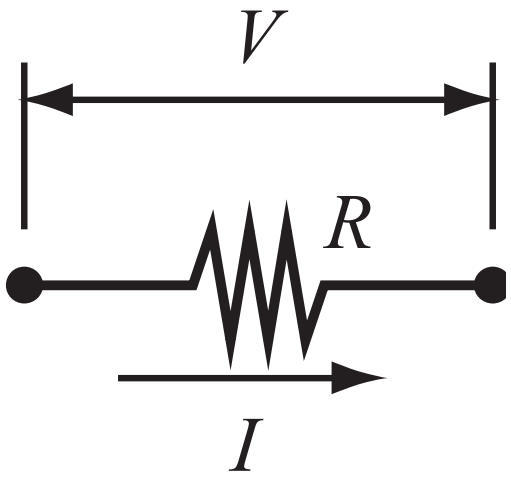
in watts (W)

in joules (J)

in seconds (s)

Power

For electrical current:



$$P = V \times I$$

Using Ohm's Law:

$$P = VxI = (IR)xI = I^2R$$

$$P = VxI = Vx\frac{V}{R} = \frac{V^2}{R}$$

Ohm's Law:

$V = I \times R$

$I = V / R$

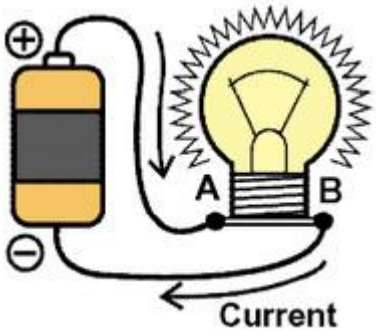
Power Limits

All electrical devices have limits on the power they can handle

Too much power consumption will cause a device to fail or “burn out”

We need to work within the power limits when we design equipment

Characteristics of a light bulb



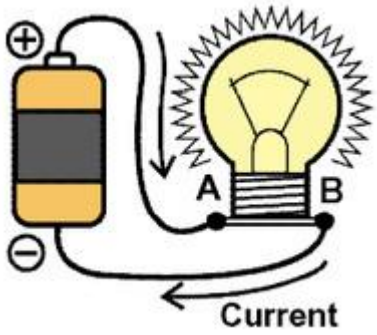
Given:

- Battery voltage: $V_b = 1.5$ V
- Current going through the light bulb is I = 2A

Find:

- What is R, resistance of light bulb
- What is P, power dissipated by the light bulb

Characteristics of a light bulb



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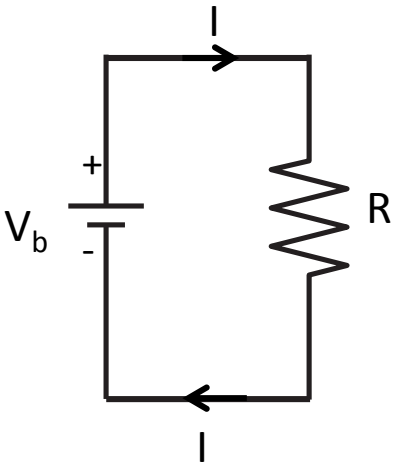
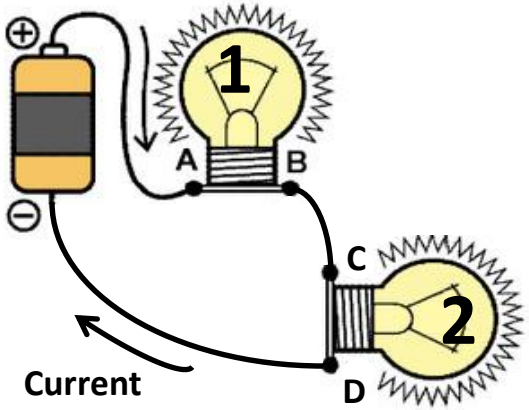


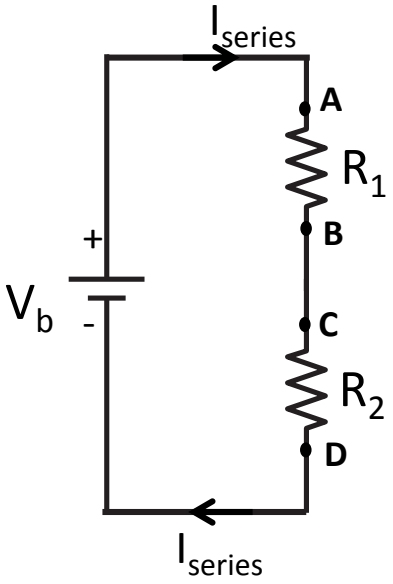
Results:

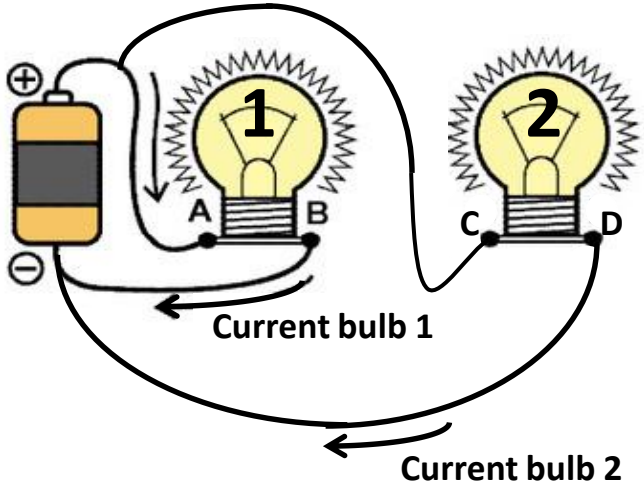
→ Resistance R = V_b /I = 0.75 Ω

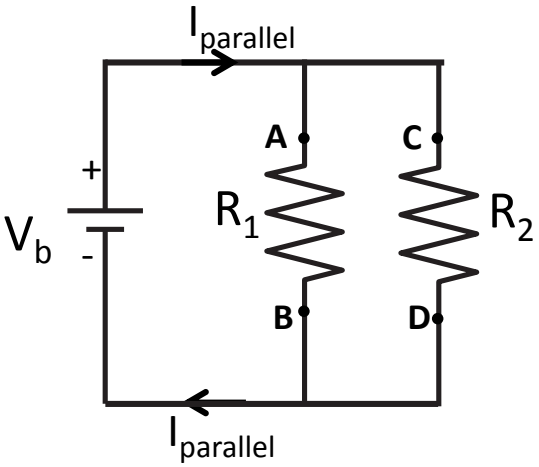
→ Power is P= V_b I= 3W.

Two light bulbs







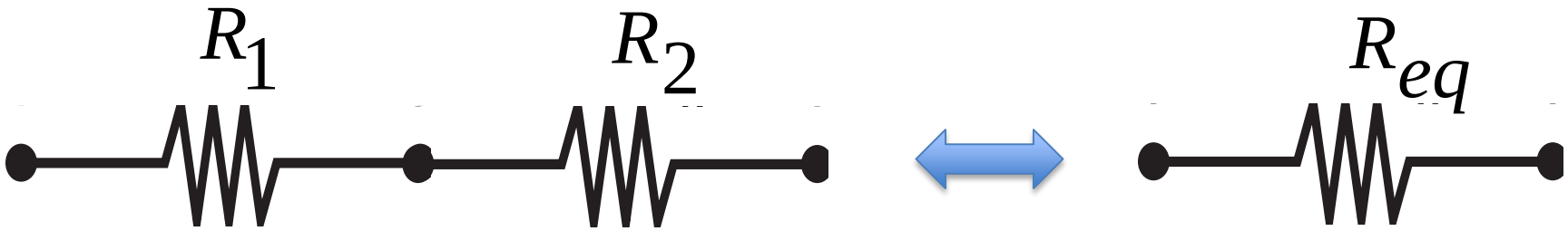


Equivalent Resistance

Most interesting and useful circuits are a combination of individual components

Resistors in Series

Resistors in series are equivalent to a single resistor having a resistance equal to the sum of the individual resistors.

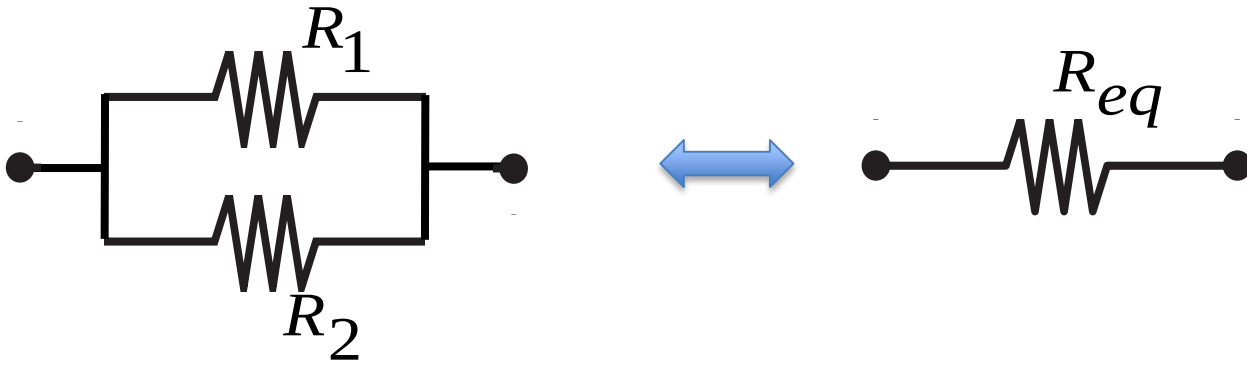


$$R_{eq\_series} = R_1 + R_2$$

Equivalent Resistance

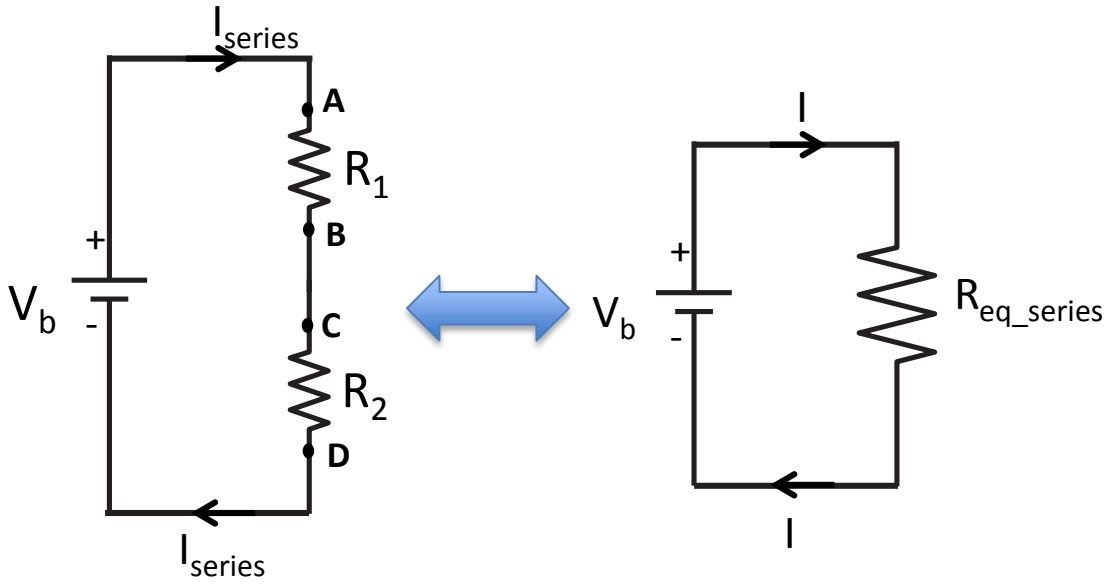
Resistors in Parallel

Resistors in parallel are equivalent to a single resistor having a value obtained by summing the inverse of the individual resistors.

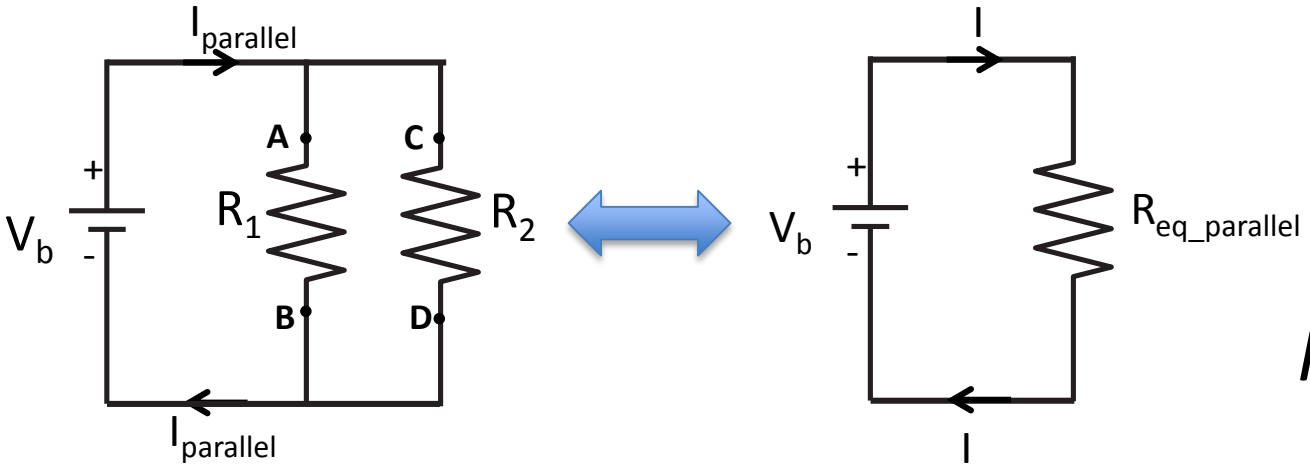


$$\frac{1}{R_{eq\_parallel}} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{or} \quad R_{eq\_parallel} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

Two light bulbs



$$P_{series} = \frac{V_b^{\,2}}{2R_1}$$



$$P_{parallel} = \frac{2V_b^{\,2}}{R_1}$$

The end ☺

Thank you!