AP Phys 2 Unit 3.C.2 Notes - Resistance & Resistor Circuits

3.C.2 Resistance and Resistor Circuits

Resistance: Units = Ohms (Ω)

Resistance: opposition to current.

Unit analysis (from Ohm's Law):

Resistance is Futile!

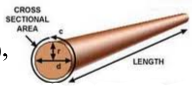
$$R = \frac{V}{I} = \frac{\frac{J}{C}}{\frac{C}{s}} = \frac{J \bullet s}{C^2} = \frac{\frac{kg \bullet m^2}{s^2} s}{C^2} = \frac{\frac{kg \bullet m^2}{s}}{C^2} = \boxed{\frac{kg \bullet m^2}{C^2 \bullet s}}$$

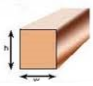
Resistance Factors

Type of material (resistivity),

length (proportional: longer = greater resistance),

area (inversely proportional: larger area = lower resistance),





temperature (proportional).

$R = \frac{\rho \ell}{A}$ AP Equation	ρ = resistivity of material (Ω m) (Resources P. 5) l = length of material (m) A = cross sectional area (m^2)

Thermal Effects

As materials heat up, their resistivity (and therefore resistance) increases. (Remember the light bulb lab?)

Calculate the new resistivity of your substance using:

$\rho = \rho_0 (1 + \alpha \Delta T)$	ρ_0 = resistivity at 20 °C α = coefficient of resistivity (P. 5) T = temperature difference (°C)

Because resistivity and resistance are directly related:

$R = R_0 (1 + \alpha \Delta T)$	R_0 = resistance at 20 °C α = coefficient of resistivity (P. 5) T = temperature difference (°C)

1. Resistivity Example

What is the resistance of a tungsten filament at 1500 °C if its resistance is 9.5 Ω at 20°C?

$$R = R_0 (1 + \alpha \Delta T)$$
$$= 9.5\Omega (1 + 4.5E - 3 / °C \bullet (1500°C - 20°C))$$
$$= 73\Omega$$

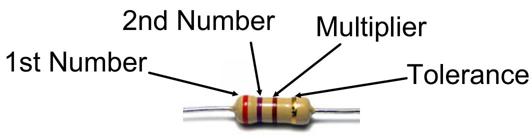
Resistor Codes

Resistors have a printed resistance that at-a-glance tells what its resistance value is (see Resources 5).

The first and second bands (read from closest band end of resistor) are two numbers.

The third band is a multiplier.

The fourth is a +/- tolerance band.



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2. Resistor Code Example

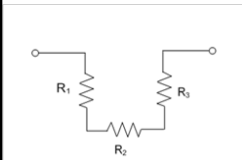
What are the values of the following resistors?

A.  10 megaohms +/- 500 kohms

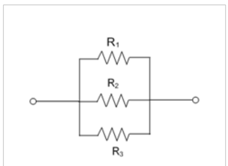
B.  360 ohms +/- 18 ohms

Resistor Circuits

Resistors can be arranged in series or parallel:



Series: current has only one path

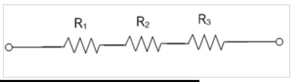


Parallel: current has multiple possible paths

Calculating Series Resistance

Series resistance (R_s) calculation:

$$R_s = R_1 + R_2 + R_3 \ldots$$



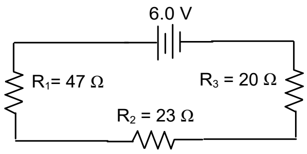
AP Equation	
$R_s = \sum_i R_i$	R = Resistance i = individual

Resistance is additive - current travels through more obstacles (like little football players).

Analogous to parallel capacitor circuit.

3. Series Example

What is the resistance?



$$R_S = R_1 + R_2 + R_3 + \ldots$$

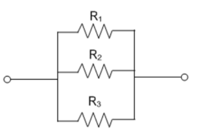
$$R_S = 47\Omega + 23\Omega + 20\Omega = 90\Omega$$

Calculating Parallel Resistance

Parallel resistance (R_p):

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Or: $R_p = \left(R_1^{-1} + R_2^{-1} + R_3^{-1} \ldots\right)^{-1}$



AP Equation	
$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$	R = Resistance i = individual

There are more paths for current to follow, so R_p is always less than the lowest resistor.

Analogous to serial capacitors.

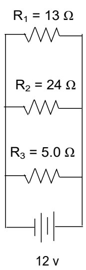
4. Parallel Example

Calculate the resistance:

$$R_p = \left(R_1^{-1} + R_2^{-1} + R_3^{-1} \ldots\right)^{-1}$$

$$= \left(13\Omega^{-1} + 24\Omega^{-1} + 5.0\Omega^{-1}\right)^{-1}$$

$$= 3.14\Omega$$



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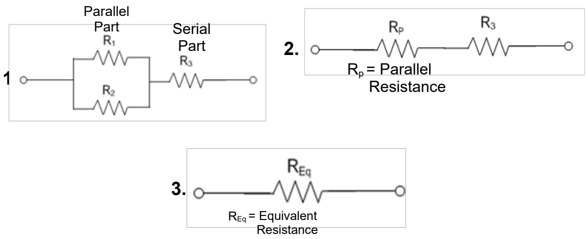
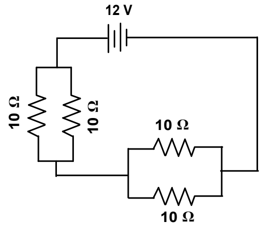
Mixed Circuits: Series & Parallel

Sequentially reduce series/parallel sections until total resistance reduces to one equivalent resistance (R_{eq}).



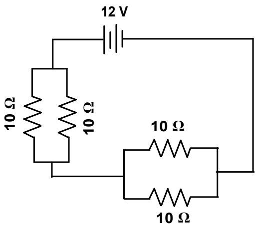
5. Mixed Example

What is the equivalent resistance?



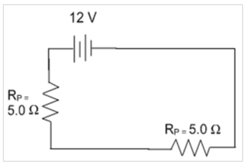
5. Mixed Example

First, solve the two parallel portions of the circuit.



$$R_p = \left(R_1^{-1} + R_2^{-1} + R_3^{-1} ...\right)^{-1}$$

$$= \left(10\Omega^{-1} + 10\Omega^{-1}\right)^{-1} = 5.0\Omega$$

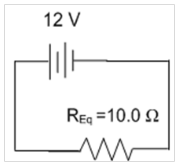


First Reduction

5. Mixed Example

Finally, compute equivalent resistance (it is now effectively a series circuit).

$$R_{Eq} = 5.0\Omega + 5.0\Omega = 10.0\Omega$$

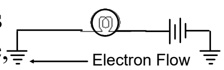


A Note On Grounding

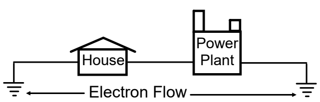
Some circuits use a ground to save on wiring.
Symbol: 

When an object is grounded, it has an electrical path available that has extremely low resistance.

Vehicles: a chassis ground allows current to flow through the frame, and return to the battery.



Homes: an earth ground allows current to flow between a home and the power plant.



Homework

3.C.2 Problems.
Due: Next Class.