AP Phys 1 Unit 11.3 Notes - Resistance & Ohm's Law

11.3 Resistance and Ohm's Law

Resistance

Resistance: the opposition to motion of charge through a conductor. Water analogue: rocks in a river slow down the current.

Units of resistance = Ohms (Ω)

Unit analysis (kinda weird):

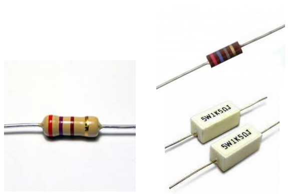
$$R = \frac{V}{I} = \frac{\frac{J}{C}}{\frac{C}{s}} = \frac{J \bullet s}{C^2} = \frac{\frac{kg \bullet m^2}{s^2} \bullet s}{C^2} = \frac{kg \bullet m^2}{C^2 \bullet s}$$

Circuit Components & Symbols 3

Resistors - block current flow.

Symbol: 

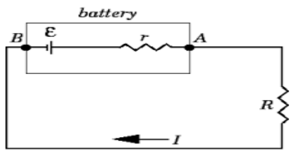
Demo resistor types.



Terminal Voltage & Internal Resistance

Batteries aren't perfect conductors: some power is lost within the battery due to internal resistance (ever felt a hot battery?)

This gives rise to terminal voltage: the voltage measured at the terminals of a battery (duh);
BUT, when internal resistance is accounted for, maximum optimal voltage is larger (but not usable).



Ohm's Law

Voltage, current, and resistance are unified through Ohm's Law, named after Georg Simon Ohm, a German physicist and mathematician, who discovered this relation in the early 1800's.

Mathematically (Resource P. 7)

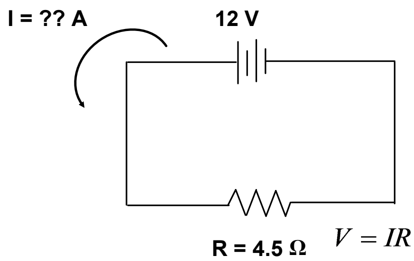
$V = IR$	V = Volts (V) I = Current (A) R = Ohms (Ω)

$$I = \frac{\Delta V}{R}$$

AP Equation

1. Current Example

Calculate the current in the following circuit:



$V = IR$

$$I = \frac{V}{R} = \frac{12V}{4.5\Omega} = 2.7\,A$$

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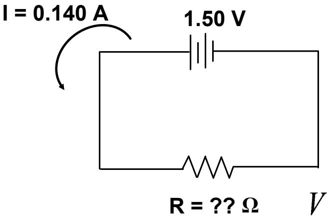
2. Resistance Example

Calculate the resistance in the following circuit:

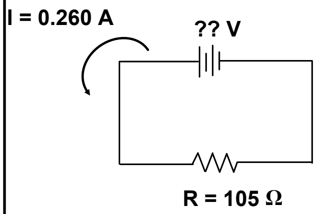


$V = IR$

$$R = \frac{V}{I} = \frac{1.50\,V}{0.140\,A} = 10.7\,\Omega$$

3. Voltage Example

Calculate the voltage in the following circuit:

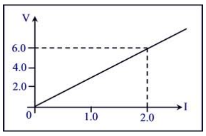


$$V = IR$$
$$= 0.260\,A \bullet 105\,\Omega$$
$$= 27.3\,V$$

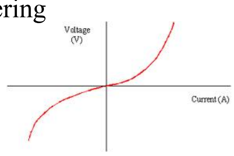
Material Properties

Substances in this class will be considered 'ohmic' – having the same resistance over a large range of voltages.

A plot of voltage vs. current produces a straight line for ohmic materials.



Nonohmic substances have differing resistances as voltage changes.



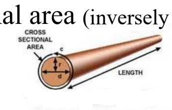
Resistance Factors

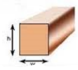
Many things affect resistance of conductors:

Type of material,

length (proportional: longer = greater resistance),

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





temperature (proportional).

Resistivity

Atomic properties of a material influence the resistance of a component also.
For any material, resistance is calculated using:

$R = \dfrac{\rho \ell}{A}$ AP Equation	ρ = resistivity of material (Ω m) (Resources P. 7) l = length of material (m) A = cross sectional area (m^2)

Thermal Effects

As materials heat, resistivity (therefore resistance) increases.
Demo: Resistance of Hot Light Bulb!
Calculate the new resistivity of your substance using:

$\rho = \rho_0 \left(1 + \alpha \Delta T\right)$	ρ_0 = resistivity at 20 °C α = coefficient of resistivity (R. 7) T = temperature difference (°C)

Light Bulb!

Thermal Effects

Resistivity and resistance are directly related:

$R = R_0\left(1+\alpha\Delta T\right)$	R_0 = resistance at 20 °C α = coefficient of resistivity (R. 7) T = temperature difference (°C)

4. Resistivity Example

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

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

Superconductivity

As materials cool, resistivity decreases.

Some materials obtain a resistance of zero at low temperatures (called critical temperature).

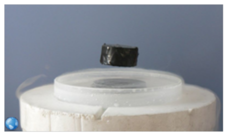
Applications for this are in super computers, where electric lines lose power in the form of heat.

Is this YOUR future place of employment?

Is this the future YOU?

Superconductivity

Meissner Effect – Current in superconductors makes magnets levitate.



High-speed trains use this effect for smooth transport

Some new materials have a critical temperature as high as 138 K (-222 °F). $YBa_2Cu_3O_7$ is the formula.

Homework

11.3 Problems
Due: Next Class