PH202-1G
Spring 2014

Worksheet January 27

Current

What is the difference between conventional current and actual current?

Conventional current - movement of positive charges

Actual current - movement of negative charges, i.e. electrons

Define electric current and give its units of measurement in terms of units of measurement you have already studied.

Electric current $I = \frac{\Delta q}{\Delta t}$ Amperes $A = C \cdot s^{-1}$

What causes current? Give an example of a device that could generate an electric current.

Potential difference called electromotive force $\mathcal{E}$. Batteries produce an emf.

Ohm's law

State Ohm's law. Does Ohm's law apply to all materials? If not, give an example of a material that does not obey Ohm's law.

Ohm's law states that the ratio of voltage to current is constant over a range of voltages. Not all materials obey Ohm's law, e.g. superconductors, fluorescent lights, diodes.

Define resistance and give its units of measurement in terms of units of measurement you have already studied.

Resistance $R = \frac{V}{I}$ Ohms $\Omega = V \cdot A^{-1}$

Is resistance constant for a given material? If not, list some parameters that can affect resistance.

Resistance is not constant for a given material but depends on length, cross-sectional area, and temperature.

Resistivity

Define resistivity and give its units of measurement. Is resistivity constant for a given material?

Resistivity $\rho = R\frac{A}{L}$ in $\Omega \cdot m$. Resistivity is not constant, but depends on temperature.

How does resistance relate to resistivity?

Resistance $R = \rho \frac{L}{A}$

How does resistivity relate to temperature? How does resistance relate to temperature?

$\rho = \rho_0[1 + \alpha(T - T_0)]$ $R = R_0[1 + \alpha(T - T_0)]$

Electric power

Define power and give its units of measurement in terms of units of measurement you have already studied.

Power $P = \frac{\Delta E}{\Delta t}$ Watts $W = J \cdot s^{-1}$

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Give an expression for the power consumed by an electric circuit. Use the definition of resistance to rewrite this expression in terms of current and resistance and in terms of voltage and resistance.

$$P = IV = I^2R = \frac{V^2}{R}$$

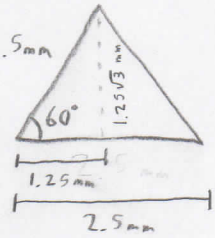
Problems

1. A graduate student is measuring the resistances of conductors with differently-shaped cross-sections. Wire 1 has a circular cross-section with a diameter of 2 mm. Wire 2 has a square cross-section with a width of 2 mm. Wire 3 has a triangular cross-section with equal sides of length 2.5 mm. The wires are all made from the same material. Rank the wires in order from lowest to highest resistance.

Wire 1 - $A = \pi r^2 = \pi\left(\frac{2\text{ mm}}{2}\right)^2 = \pi\ \text{mm}^2$

Wire 2 - $A = d^2 = (2\text{ mm})^2 = 4\ \text{mm}^2$

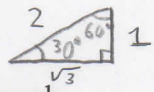
Wire 3 - $A = \frac{1}{2}bh = \frac{1}{2}(2.5\text{ mm})(1.25\cdot\sqrt{3}\text{ mm}) = 2.7\ \text{mm}^2$



Wire 3

$R \propto \frac{1}{A}$ so $R_2 < R_1 < R_3$

Pythagorean theorem or



2. A conducting wire is attached to a 6.00 V battery and an ammeter to monitor the current through the wire. The wire is left out in the sun, and the current changes as the wire heats up (obviously, this experiment is not taking place in Birmingham). Initially, when the temperature is 20.3 °C, the current is measured to be 1.20 A. Later, when the temperature of the wire is 45.7 °C, the current is measured to be 1.07 A. What is the temperature coefficient of resistivity for the wire?

$$R_0 = \frac{6.00\text{ V}}{1.20\text{ A}} = 5.00\ \Omega \qquad R = \frac{6.00\text{ V}}{1.07\text{ A}} = 5.61\ \Omega$$

$$\alpha = \frac{\frac{R}{R_0} - 1}{T - T_0} = \frac{\frac{5.61\ \Omega}{5.00\ \Omega} - 1}{45.7^\circ\text{C} - 20.3^\circ\text{C}} = 4.78\cdot10^{-3}\ ^\circ\text{C}^{-1}$$

3. When Pikachu uses Thunderbolt, it delivers about 3.1 kJ of energy to the opposing Pokémon in a period of 1.7 s. If the resistance between the pouches on Pikachu's cheeks is about 6 Ω, what current does Pikachu generate when it uses Thunderbolt?

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{\Delta E}{R\Delta t}} = \sqrt{\frac{3100\text{ J}}{6\ \Omega\cdot 1.7\text{ s}}} = 17\text{ A}$$