University of Ottawa
PHY1322 Winter 2017
Principles of Physics II
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STUDENT's ID: ______________________

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The methods used to solve each problem are outlined below. The number solutions may vary.

Assignment 1: Electric Current Resistance and Circuits

Assigned: Jan 13th **Due: Jan 20th 6:00PM**

1 2 m long copper wire of 1mm diameter is stretched permanently to 3 m length. What is its new resistance ?

$$R_1 = \rho\frac{l_1}{A_1} \quad R_2 = \rho\frac{l_2}{A_2} \quad V_1 = V_1 \Rightarrow l_1 A_1 = l_2 A_2$$

$$R_1 = \rho\frac{l_1}{A_1} \quad R_2 = \rho\frac{1.5 l_1}{A_1 / 1.5} = (1.5)^2 \rho\frac{l_1}{A_1} = 2.25 R_1$$

2. A toaster is rated at 720 W when connected to a 120-V source. What current does the toaster carry, and what is its resistance?

$$I = \frac{P}{\Delta V} = \frac{600\text{ W}}{120\text{ V}} = \boxed{5.00\text{ A}} \quad \text{and } R = \frac{\Delta V}{I} = \frac{120\text{ V}}{5.00\text{ A}} = \boxed{24.0\ \Omega}.$$

3 A toy battery has an emf of 15.0 V. The terminal voltage of the battery is 12.6 V when it is delivering 20.0 W of power to an external load resistor *R*. (a) What is the value of *R*? (b) What is the internal resistance of the battery?

$$\Delta V_{term} = \Delta V_{load} \Rightarrow P_R = I\Delta V_{term} \Rightarrow 20W = I(11.6V) \Rightarrow I = \frac{20}{11.6}(A)$$

$$\Delta V_{load} = IR \Rightarrow R = \frac{\Delta V_{load}}{I} = \frac{(11.6)^2}{20}$$

$$rI = \varepsilon - \Delta V_{term} \Rightarrow r = \frac{\varepsilon - \Delta V_{term}}{I} = \frac{3.4}{20/11.6} = \frac{(3.4)(11.6)}{20}$$

4 How much energy is dissipated as heat during a two-minute time interval by a 0.5-kΩ resistor which has a constant 20-V potential difference across its leads?

$$P_R = \frac{(\Delta V_{load})^2}{R} \quad ; \quad E = P_R \Delta t = \frac{(\Delta V_{load})^2}{R}\Delta t = \frac{20^2}{1500}120 = \frac{480}{15} = 32J$$

5 An air-filled capacitor consists of two parallel plates, each with an area of 6.70 cm^2, separated by a distance of 1.50 mm. A 30.0-V potential difference is applied to these plates. Calculate (b) the energy stored in the capacitor, (b) the capacitance, and (c) the charge on each plate.

(a) $C = \frac{\epsilon_0 A}{d} = \frac{\left(8.85\times10^{-12}\ \mathrm{C^2/N\cdot m^2}\right)\left(7.60\ \mathrm{cm^2}\right)\left(1.00\ \mathrm{m}/100\ \mathrm{cm}\right)^2}{1.80\times10^{-3}\ \mathrm{m}} = \boxed{3.74\ \mathrm{pF}}$

(b) U=

(d) $\Delta V = \frac{Q}{C}$ $Q = (20.0\ \mathrm{V})\left(3.74\times10^{-12}\ \mathrm{F}\right) = \boxed{74.7\ \mathrm{pC}}$

6 A 30.0-m length of coaxial cable has an inner conductor that has a diameter of 2.58 mm and carries a charge of 8.10 μC. The surrounding conductor has an inner diameter of 7.27 mm and a charge of –8.10 μC. (a) What is the capacitance of this cable? (b) What is the potential difference between the two conductors? Assume that the region between the conductors is air.

(a) $C = \frac{\ell}{2k_e \ln\left(\frac{b}{a}\right)} = \frac{50.0}{2\left(8.99\times10^9\right)\ln\left(\frac{7.27}{2.58}\right)} = \boxed{2.68\ \mathrm{nF}}$

(b) Method 1: $\Delta V = 2k_e\lambda \ln\left(\frac{b}{a}\right)$

$\lambda = \frac{q}{\ell} = \frac{8.10\times10^{-6}\ \mathrm{C}}{50.0\ \mathrm{m}} = 1.62\times10^{-7}\ \mathrm{C/m}$

$\Delta V = 2\left(8.99\times10^9\right)\left(1.62\times10^{-7}\right)\ln\left(\frac{7.27}{2.58}\right) = \boxed{3.02\ \mathrm{kV}}$

Method 2: $\Delta V = \frac{Q}{C} = \frac{8.10\times10^{-6}}{2.68\times10^{-9}} = \boxed{3.02\ \mathrm{kV}}$

7 A) An aluminum rod has a resistance of 2.234 Ω at 20.0°. C.alculate the resistance of the rod at 120°C by accounting for the changes in both the resistivity and the dimensions of the rod. (check the textbook for the relevant constants)
B) The rod is cooled down to 20 C. And at that temperature it is stretched to twice its length at 20C. Find the new value of the resistance of the rod.

For aluminum, Resistance coeff. $\alpha_E = 3.90\times10^{-3}\ {}^\circ\mathrm{C}^{-1}$

Length coeff $\alpha = 24.0\times10^{-6}\ {}^\circ\mathrm{C}^{-1}$

A) $R = \frac{\rho\ell}{A} = \frac{\rho_0(1+\alpha_E\Delta T)\ell(1+\alpha\Delta T)}{A(1+\alpha\Delta T)^2} = R_0\frac{(1+\alpha_E\Delta T)}{(1+\alpha\Delta T)} = (1.234\ \Omega)\left(\frac{1.39}{1.002\ 4}\right) = \boxed{1.71\ \Omega}$

B) $R_1 = \frac{\rho l_1}{A_1}\ R_2 = \frac{\rho l_2}{A_2} = \frac{(\rho(2l_1)}{(\frac{1}{2}A_1)} = 4R_1 = \boxed{4.936\Omega}$