cdli the Centre for Distance Learning & Innovation | Newfoundland Labrador

Physics 3204 - Unit 2 WS # 11 - Introduction to Current Electricity - 2007 - 08

Name: ______________________ School: ______________________

1. a) What is meant by electric current? Be as descriptive as possible and use an equation to formalize the definition.

Electric current refers to the movement of charged particles along a conducting path. Current, I, is also used to refer to the rate that the particles move. The rate of movement is measured in amperes and indicates the number of coulombs that moves past any point in the circuit in 1 second. $I = q/t$

b) How is electron current different from conventional current?

Electron current and conventional differ in the direction that current is envisioned to travel. For electron current we regard charge to move from the negative side of a cell to the positive in the circuit. Conventional, from + to − !

c) A light bulb draws a current of 0.78 A. How long does it have to be on for 40.0 C of charge to flow through it.

$I = 0.78\ A$ $\quad I = q/t \Rightarrow It = q \Rightarrow t = q/I$

$q = 40.0\ C$ $\quad t = q/I = \frac{40.0C}{.78 C/s} = 51 s$ $\quad$ $t = 51s$

$t = ?$

d) How many electrons flow through the light bulb in the previous question, c), in a one-minute period?

$I = 0.78 A$ $\quad q = I \cdot t = (.78)(60) = 46.8 C$ $\quad N = q/e = \frac{46.8C}{1.6 \times 10^{-19}} = 2.9 \times 10^{20}$ $\quad$ $N = 2.9 \times 10^{20}$

$t = 1 min = 60 s$

$N = ?$

e) Two 1.5-V (AAA) cells connected in series run a portable MP3 player that draws 6.3×10^{-3} A of current for twelve hours before it runs out. How much energy does the battery transfer?

$V = 2 @ 1.5 = 3.0 V$ $\quad E = VIt$

$I = 6.3 \times 10^{-3} A$ $\quad = (3.0)(6.3 \times 10^{-3} A)(12 hrs)$

$t = 12 hrs$ $\quad = (1.89 \times 10^{-3} W)(12 hrs)$

$= 2.3 \times 10^{-2} W \cdot hr.$

$= 2.3 \times 10^{-5} kW \cdot hr.$

$E = 2.3 \times 10^{-5} kW \cdot h$

2. a) How much work is done when 40.0 C of charge is moved through a potential difference of 240.0 V?

$q = 40.0\,C$

$V = 240.0\,V$

$E = ?$

$V = E/q \Rightarrow E = V \cdot q$

$= (240)(40)$

$= 9600\,J$

9600 J of work are done.

b) A potential difference of 13.6 V exists across the terminals of a car battery. When operating a starting motor, it delivers a constant current of 112.5 A for 1.81 seconds. How much work is done on the charge by the battery? HINT: rather than relying on advanced formulas, think about Work and Voltage and about Time and Current. Notice that both pairs have TIME in common.

$V = 13.6\,V$

$I = 112.5\,A$

$t = 1.81\,s$

$E = VIt$

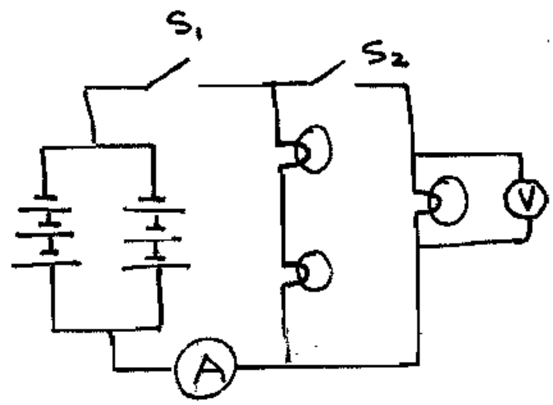
$= (13.6\,J/C)(112.5\,C/s)(1.81\,s)$

$= 2770\,J.$

The battery does 2770 J of work.

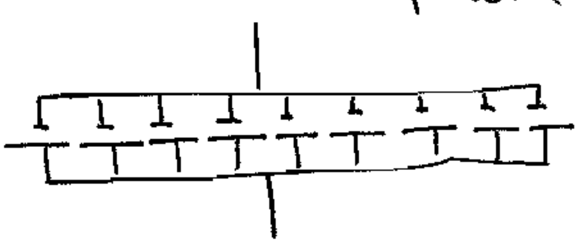
3. Draw a schematic diagram of the following circuit:

- The circuit has, for its energy source, a battery composed of 6 1.5-V dry cells. The battery is made from two equal banks of cells and is configured in such a manner that the total voltage is 4.5 V.
- There are three light bulbs in the circuit and the circuit has two separate (parallel) branches. One branch has two bulbs in series and the remaining bulb is in the other branch.
- Switch S1 can shut down the entire circuit and switch S2 shuts down only the lone bulb in the branch by itself.
- Include meters to measure current in the circuit and the voltage across the "single" bulb.



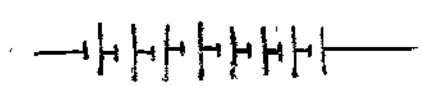
4. Suppose you have 8, 1.5 V-dry cells. Draw diagrams to show how the cells can be combined to produce the minimum and maximum voltage. Determine the voltage of each battery.

minimum voltage - In parallel



$V_T = V_1 = 1.5\,V$

maximum voltage - in series



$V_T = \Sigma V_i = 8(1.5) = 12\,V$

5. a) What is the potential difference across a power supply with a resistance of 35 Ω if it draws a current of 2.3 A?

$R = 35\,\Omega$ $V = IR$

$I = 2.3\,A$ $= (2.3)(35\,\Omega)$

$V = ?$ $= 80\,V$

The potential difference is 80 V.

b) A small radio operates on a 9.0 V battery. If the receiver draws 150 mA of current, what is its resistance?

$V = 9.0\,V$ $R = V/I = 9.0/.150 = 60\,\Omega$

$I = 150\,mA = .150\,A$

$R = ?$

The resistance is 60 Ω.

c) A drill, designed for safe use at 120 V and 6.0 A, is connected to a source of 240 V. Calculate the current the drill will draw, and state what will happen to the drill.

$V_D = 120\,V$ $R = V_D/I_D = \frac{120\,V}{6.0\,A} = 20\,\Omega$

$I_D = 6.0\,A$

$V_A = 240\,V$ $I_A = V_A/R = \frac{240\,V}{20\,\Omega} = 12\,A$

$I_A = ?$

More power is delivered than design! Burn out!

The drill will draw twice the designed current

6. A piece of wire with diameter 0.20 mm and length 20.0 cm is found to have a resistance of 40.0 Ω Find the resistance of each piece of wire that is made from the same material.

$R \propto \frac{L}{A} = \frac{L}{d^2}$

a) diameter = 0.20 mm, length = 80.0 cm

L factor $= \frac{L_N}{L_O} = \frac{80}{20} = 4\times$; $R \propto L = 4\times$

$R_N = \text{factor} \times R_o = 4 \times 40.^\circ\,\Omega = \underline{160\,\Omega}$

b) diameter = 0.050 mm, length = 20.0 cm

$\varnothing = \frac{.050}{.20} = \frac{1}{4}$ $R \propto 1/d^2 = 1/(\frac{1}{4})^2 = 16$

$L = \frac{20}{20} = 1$ $R_N = 16 \times R_{OLD} = 16\,(40\,\Omega) = \underline{640\,\Omega}.$

c) diameter = 0.60 mm, length = 100.0 cm

$\varnothing = \frac{.60}{.20} = 3\times$ $R \propto \frac{L}{d^2} = \frac{5}{(3)^2} = 5/9$

$L = \frac{100}{20} = 5\times$ $R_N = 5/9\,R_o = 5/9 \times 40\,\Omega = \underline{22\,\Omega}.$

7. a) A 350 mA current flows through a copper wire 5.6 m long and 1.4 mm in diameter. Copper has a resistivity of $1.72 \times 10^{-8}\ \Omega \cdot m$. Find the potential difference of the circuit's source.

$I = 350\,mA = .350\,A$ $R = \rho\frac{L}{A} = \frac{(1.72\times10^{-8})(5.6)}{\pi\,(7\times10^{-4})^2}$

$L = 5.6\,m$

$d = 1.4\,mm \Rightarrow r = .7\,mm = 7\times10^{-4}\,m$ $= .063\,\Omega$

$\rho = 1.72\times10^{-8}\,\Omega m$ $V = IR = (.35)(.063) = \underline{.022\,V}$

b) A 1.0 m piece of wire with a cross-sectional radius of 3.0 mm has a resistance of $9.0 \times 10^{-4}\,\Omega$. If the wire is stretched until its cross-sectional radius is reduced to 1.0 mm, what would be the resistance of a 2.0 m long piece of the thinner wire?

$r_0 = 3.0\text{ mm} = 3.0 \times 10^{-3}\text{ m}$

$R = 9.0 \times 10^{-4}\,\Omega$

$r_N = 1.0\text{ mm}$

$R \propto \frac{L}{r^2}$; $L = \frac{2}{1} = 2$

$r = \frac{1}{3}$

$R \propto \frac{L}{R^2} = \frac{2}{(\frac{1}{3})^2} = 18\times$

$R_N = 18 \times R_0 = 18(9.0 \times 10^{-4}\,\Omega) = \underline{1.62 \times 10^{-2}\,\Omega}$

c) Suppose we have two pieces of copper wire of different lengths and cross-section areas, but both have the same resistance. Once piece is 350.0 m long and the other is 140.0 m long. The shorter wire has a cross-sectional radius of 1.80 mm. What is the cross sectional radius of the longer wire?

$R_1 = R_2$

$L_1 = 350.0\text{ m}$

$L_2 = 140.0\text{ m}$

$r_2 = 1.80\text{ mm}$

$r_1 = ?$

$R_1 = R_2$

$\rho \frac{L_1}{\pi r_1^2} = \rho \frac{L_2}{\pi r_2^2}$

$r_1^2 L_2 = r_2^2 L_1$

$r_1 = \sqrt{\frac{r_2^2 L_1}{L_2}}$

$= r_2 \sqrt{\frac{L_1}{L_2}}$

$= (1.80\text{ mm}) \sqrt{\frac{350}{140}}$

$= 2.85\text{ mm}$

The longer wire has radius of 2.85 mm