UNIVERSITY OF OTTAWA
Principles of Physics
PHY1322 Winter 2017
Dr. A. Czajkowski

STUDENT #: ____________________

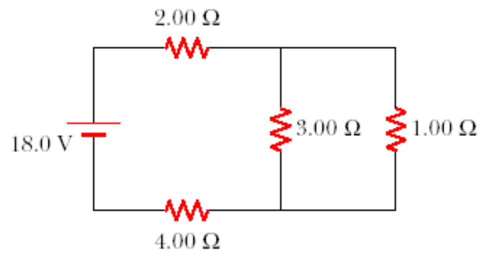
NAME: ________________________

ASSIGNMENT 2:

Electric Circuits

Released: Jan 20 **Due: Jan 27 6PM**

1 Find the Equivalent resistance for this circuit and calculate the power delivered to each resistor in the circuit.



$$R_p = \left(\frac{1}{3.00} + \frac{1}{1.00}\right)^{-1} = 0.750\ \Omega$$

$$R_s = (2.00 + 0.750 + 4.00)\ \Omega = 6.75\ \Omega$$

$$I_{\text{battery}} = \frac{\Delta V}{R_s} = \frac{18.0\ \text{V}}{6.75\ \Omega} = 2.67\ \text{A}$$

$$\text{P} = I^2R : \text{P}_2 = (2.67\ \text{A})^2(2.00\ \Omega) \quad \text{P}_2 = \boxed{14.2\ \text{W}} \text{ in } 2.00\ \Omega$$

$$\text{P}_4 = (2.67\ \text{A})^2(4.00\ \text{A}) = \boxed{28.4\ \text{W}} \text{ in } 4.00\ \Omega$$

$$\Delta V_2 = (2.67\ \text{A})(2.00\ \Omega) = 5.33\ \text{V},$$

$$\Delta V_4 = (2.67\ \text{A})(4.00\ \Omega) = 10.67\ \text{V}$$

$$\Delta V_p = 18.0\ \text{V} - \Delta V_2 - \Delta V_4 = 2.00\ \text{V}(= \Delta V_3 = \Delta V_1)$$

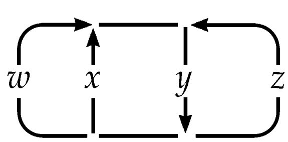
$$\text{P}_3 = \frac{(\Delta V_3)^2}{R_3} = \frac{(2.00\ \text{V})^2}{3.00\ \Omega} = \boxed{1.33\ \text{W}} \text{ in } 3.00\ \Omega$$

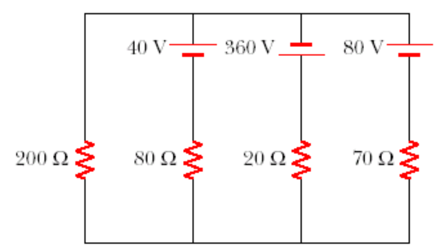
$$\text{P}_1 = \frac{(\Delta V_1)}{R_1} = \frac{(2.00\ \text{V})^2}{1.00\ \Omega} = \boxed{4.00\ \text{W}} \text{ in } 1.00\ \Omega$$

2 Determine the current in each resistor and the voltage across the 200-**Ω** resistor.

Name the currents as shown in the figure to the right.
Then $w + x + z = y$. Loop equations are

$$-200w - 40.0 + 80.0x = 0$$
$$-80.0x + 40.0 + 360 - 20.0y = 0$$
$$+360 - 20.0y - 70.0z + 80.0 = 0$$





Eliminate y by substitution. $\begin{cases} x = 2.50w + 0.500 \\ 400 - 100x - 20.0w - 20.0z = 0 \\ 440 - 20.0w - 20.0x - 90.0z = 0 \end{cases}$

Eliminate x. $\begin{cases} 350 - 270w - 20.0z = 0 \\ 430 - 70.0w - 90.0z = 0 \end{cases}$ Eliminate $z = 17.5 - 13.5w$ to obtain

$$430 - 70.0w - 1\,575 + 1\,215w = 0 \quad w = \frac{70.0}{70.0} = \boxed{1.00\ \text{A upward in } 200\ \Omega}.$$

Now $z = \boxed{4.00\ \text{A upward in } 70.0\ \Omega}$ $x = \boxed{3.00\ \text{A upward in } 80.0\ \Omega}$

$y = \boxed{8.00\ \text{A downward in } 20.0\ \Omega}$

and for the 200 Ω, $\Delta V = IR = (1.00\ \text{A})(200\ \Omega) = \boxed{200\ \text{V}}$.

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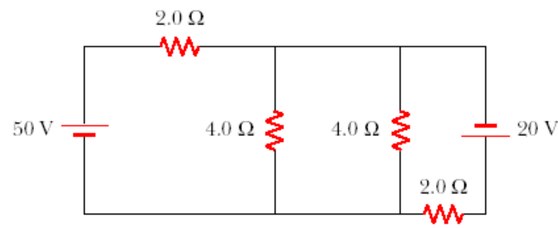
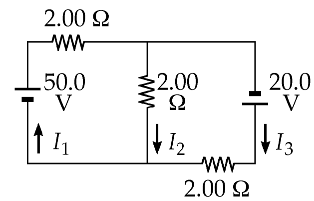
ASSIGNMENT 2:
Electric Circuits
Released: Jan 23 **Due: Jan 30 6PM**



3. Calculate the power delivered to each resistor shown on the right

We apply Kirchhoff's rules to the second diagram.



$$50.0 - 2.00I_1 - 2.00I_2 = 0 \quad (1)$$
$$20.0 - 2.00I_3 + 2.00I_2 = 0 \quad (2)$$
$$I_1 = I_2 + I_3 \quad (3)$$

Substitute (3) into (1), and solve for I_1, I_2, and I_3 $I_1 = 20.0\text{ A}$; $I_2 = 5.00\text{ A}$; $I_3 = 15.0\text{ A}$.

Then apply $\mathsf{P} = I^2R$ to each resistor:

$(2.00\ \Omega)_1$: $\mathsf{P} = I_1^2(2.00\ \Omega) = (20.0\text{ A})^2(2.00\ \Omega) = \boxed{800\text{ W}}$

$(4.00\ \Omega)$: $\mathsf{P} = \left(\frac{5.00}{2}\text{ A}\right)^2(4.00\ \Omega) = \boxed{25.0\text{ W}}$

(Half of I_2 goes through each)

$(2.00\ \Omega)_3$: $\mathsf{P} = I_3^2(2.00\ \Omega) = (15.0\text{ A})^2(2.00\ \Omega) = \boxed{450\text{ W}}$.

5 For given electric potential function, calculate the electrci field vector.

a) $V(x,y,z) = \frac{1}{4\pi\varepsilon_0} r$ $\quad \vec{E} = -grad(V) = -\frac{1}{4\pi\varepsilon_0}\left(\frac{1}{2}r^{-1}\right)(2x,2y,2z) = -\frac{1}{4\pi\varepsilon_0}\frac{\vec{r}}{r}$

b) $V(x,y,z) = \frac{1}{4\pi\varepsilon_0} r^2$ $\quad \vec{E} = -grad(V) = -\frac{1}{4\pi\varepsilon_0}(2x,2y,2z) = -\frac{1}{2\pi\varepsilon_0}\vec{r}$

c) b) $V(x,y,z) = \frac{1}{4\pi\varepsilon_0}\frac{1}{r}$ $\quad \vec{E} = -grad(V) = -\frac{1}{4\pi\varepsilon_0}\left(-\frac{1}{2}r^{-3}\right)(2x,2y,2z) = \frac{1}{4\pi\varepsilon_0}\frac{\vec{r}}{r^3}$

d) $V(x,y,z) = \frac{1}{4\pi\varepsilon_0}$ $\quad \vec{E} = -grad(V) = (0,0,0)$

$$I(t) = -I_0 e^{-t/RC}$$

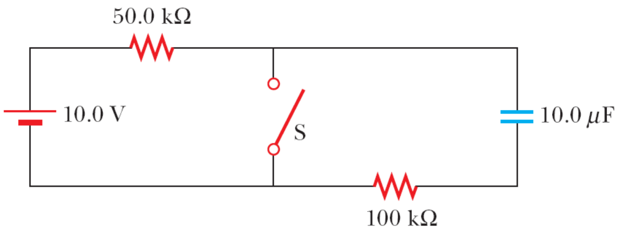
$$I_0 = \frac{Q}{RC} = \frac{5.10\times10^{-6}\text{ C}}{(1\,300\ \Omega)(2.00\times10^{-9}\text{ F})} = 1.96\text{ A}$$

$$I(t) = -(1.96\text{ A})\exp\left[\frac{-9.00\times10^{-6}\text{ s}}{(1\,300\ \Omega)(2.00\times10^{-9}\text{ F})}\right] = \boxed{-61.6\text{ mA}}$$

(b) $q(t) = Qe^{-t/RC} = (5.10\text{ mC})\exp\left[\frac{-8.00\times10^{-6}\text{ s}}{(1\,300\ \Omega)(2.00\times10^{-9}\text{ F})}\right] = \boxed{0.235\text{ mC}}$

(c) The magnitude of the maximum current is $I_0 = \boxed{1.96\text{ A}}$.

6 In the circuit below, the switch S has been open for a long time. It is then suddenly closed. Determine the time constant (a) before the switch is closed and (b) after the switch is closed. (c) Let the switch be closed at $t = 0$. Determine the current in the switch as a function of time.



(a) $t = RC = (1.50 \times 10^5\ \Omega)(10.0 \times 10^{-6}\ \text{F}) = \boxed{1.50\ \text{s}}$

(b) $t = (1.00 \times 10^5\ \Omega)(10.0 \times 10^{-6}\ \text{F}) = \boxed{1.00\ \text{s}}$

(c) The battery carries current $\dfrac{10.0\ \text{V}}{50.0 \times 10^3\ \Omega} = 200\ m\text{A}$.

The $100\ \text{k}\Omega$ carries current of magnitude

$$I = I_0 e^{-t/RC} = \left(\frac{10.0\ \text{V}}{100 \times 10^3\ \Omega}\right) e^{-t/1.00\ \text{s}}.$$

So the switch carries downward current $\boxed{200\ m\text{A} + (100\ m\text{A})e^{-t/1.00\ \text{s}}}$.