Problem Set 1

Due Date: Sat Sept 19 2015
by 9 PM

Name:______________________________

Lab Section & TF:______________________

Collaborators:_________________________

For Grading Purposes Only:

Q1: _____ / 7
Q2: _____ / 12
Q3: _____ / 16

Total:_____ / 35

Instructions:

Please place your homework in the appropriate Dropbox in the basement of Maxwell Dworkin.

Please staple your homework. If your homework is not stapled, please hand it in with your name written on every page, all the pages numbered front & back, and the total number of pages in the homework written on the first page (so we don't lose any of your work).

Show all your work. If we can't figure out how you reached the answer, you won't get credit. More importantly, if you show your work but messed up the figures, you can get partial credit for your thought process.

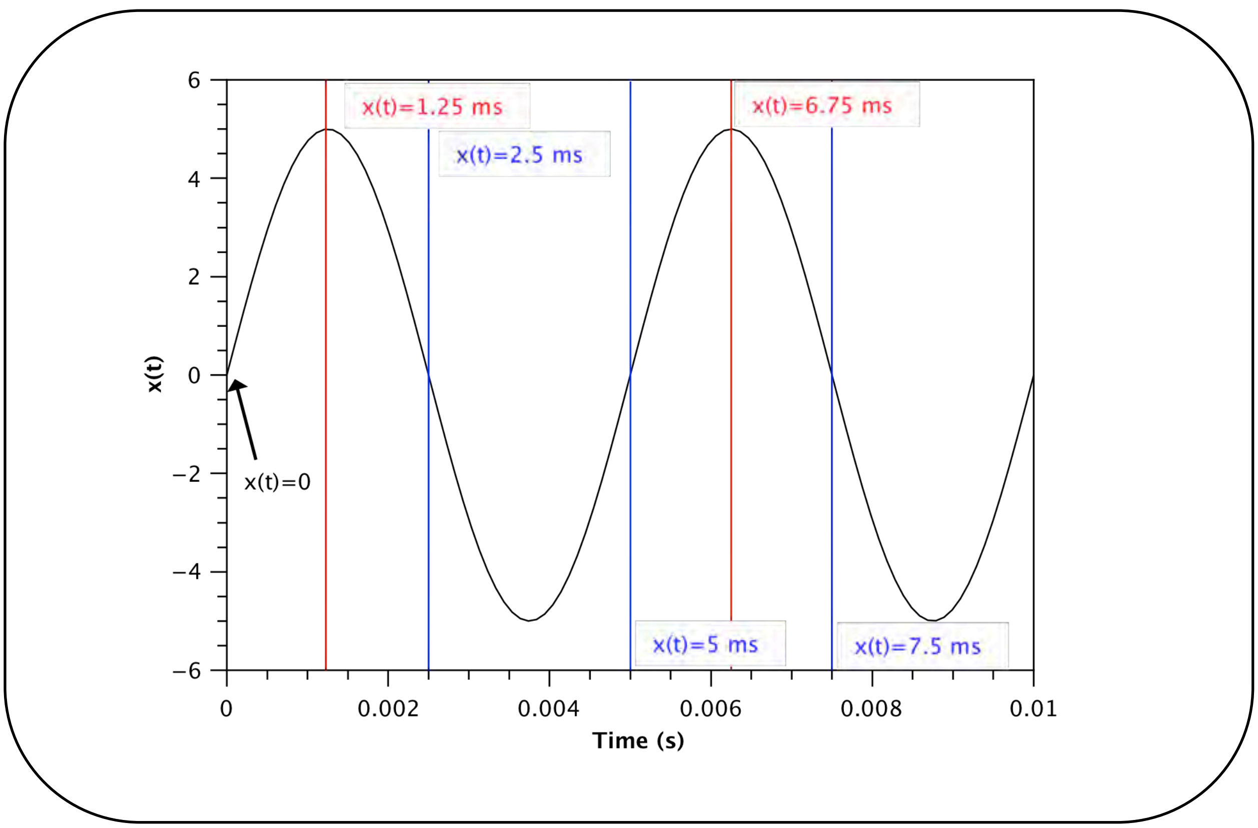
MENTION ALL YOUR COLLABORATORS and which problems you collaborated on. There is no negative marking for collaborating on problems.

Problem 1: Easy Signals (7 points)

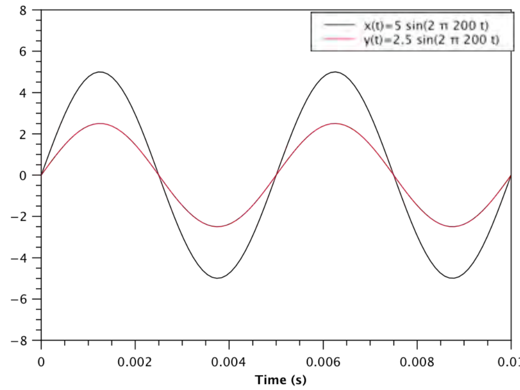
Consider the voltage signal:

$$x(t) = A\, sin(2\pi f_0 t) \text{ where } A = 5\ V \text{ and } f_0 = 200\ Hz$$

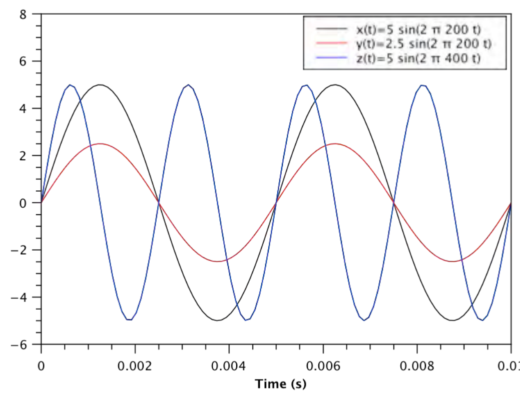
a. Sketch the signal as a function of time. Make sure that you clearly indicate the time points at which $x(t) = 0$, as well as those where $x(t)$ reaches maximum. (1 point)



b. Now consider the signal $y(t)$ with HALF the amplitude and same frequency and phase. Write down the equation for this signal, and sketch it on the same plot as signal $x(t)$. (2 points)



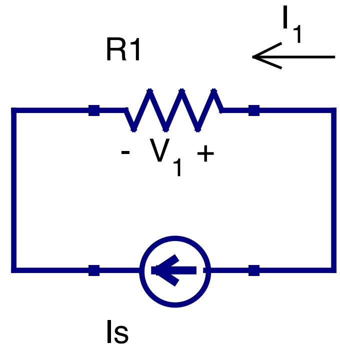
c. Next, consider the signal $z(t)$ that has TWICE the frequency of $x(t)$, and other parameters (amplitude & phase) the same. Write down the equation for this signal, and sketch it on the same plot as $x(t)$ and $y(t)$. (2 points)



d. If you are to play signals $x(t)$, $y(t)$ and $z(t)$ on the speaker, what differences would you hear? (2 points)

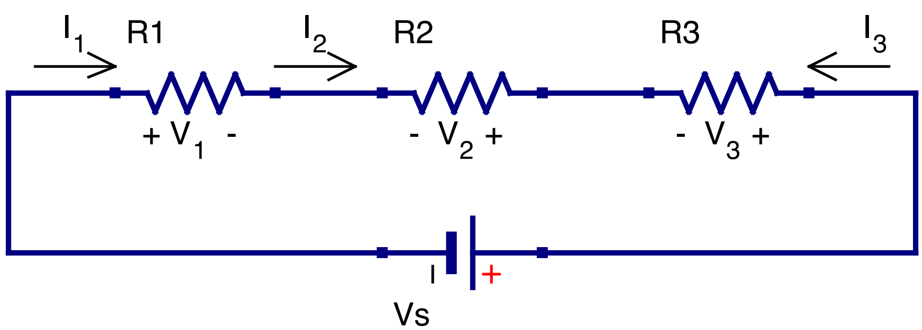
$x(t)$ would be 200 Hz audio signal
$y(t)$ would be the same frequency but half as loud as $x(t)$
$z(t)$ would be higher pitch than $x(t)$ and $y(t)$ and the same volume as $x(t)$

Problem 2: Easy Circuits (12 points)



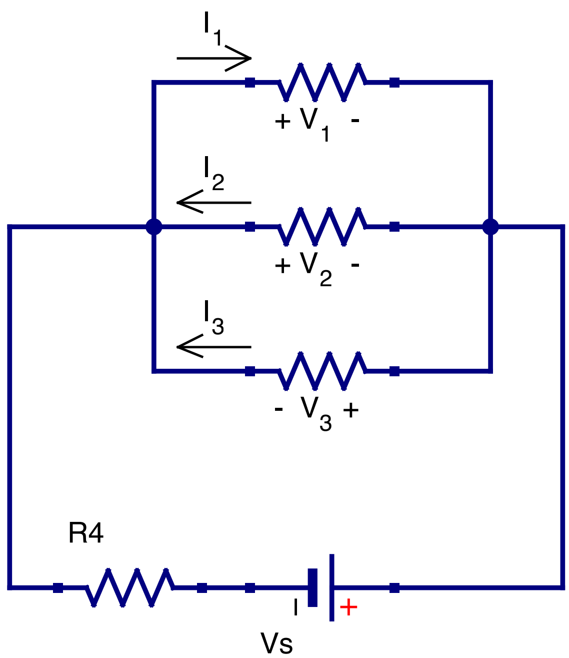
a. For the circuit shown above, find I_1 and V_1 with respect to the indicated reference directions. $I_s = 2\ A$ and $R_1 = 2\ \Omega$. (2 points)

$$I_1 = -I_s = -2\ A$$
$$V_1 = I_1 R_1 = -2\ A(2\ \Omega) = -4\ V$$



b. In the circuit shown above, $I_1 = -5\ A$, $R_1 = 2\ \Omega$, $R_2 = 4\ \Omega$ and $R_3 = 6\ \Omega$. First find I_2 and I_3 with respect to reference directions indicated by the arrows. Then, using these current values and Ohm's Law find voltages V_1, V_2 and V_3 with respect to indicated reference directions. (5 points)

$$I_2 = I_1 = -5\ A$$
$$I_3 = -I_1 = 5\ A$$
$$V_1 = I_1 R_1 = -5\ A(2\ \Omega) = -10\ V$$
$$V_2 = -I_2 R_2 = -(-5\ A)(4\ \Omega) = 20\ V$$
$$V_3 = I_3 R_3 = 5\ A(6\ \Omega) = 30\ V$$



c. In the circuit shown above, the value of voltage V_1 is $V_1 = 10\,V$. What are the values of voltages V_2 and V_3, with respect to indicated reference directions? Once you find these values, use Ohm's Law to find currents I_1, I_2 and I_3, with respect to indicated reference direction, assuming that that the resistance of each resistor is $2\,\Omega$. (5 points)

$$V_2 = V_1 = 10\,V$$

$$V_3 = -V_1 = -10\,V$$

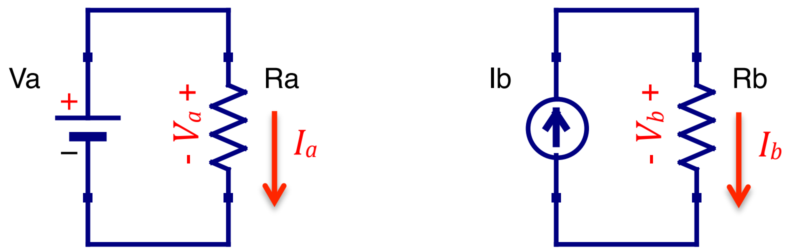
$$I_1 = \frac{V_1}{R} = \frac{10\,V}{2\,\Omega} = 5\,A$$

$$I_2 = \frac{-V_2}{R} = \frac{-10\,V}{2\,\Omega} = -5\,A$$

$$I_3 = \frac{V_3}{R} = \frac{-10\,V}{2\,\Omega} = -5\,A$$

Problem 3: More Easy Circuits (16 points)

For both of the two circuits shown below:



a. Indicate the *direction of* the voltage across the resistor (V_R) and the *direction of* the current in the circuit (I_R). (2 points)

b. Find V_R and I_R using the reference direction that you chose in part a. (4 points)

$$V_{R_a} = V_a$$

$$I_{R_a} = \frac{V_a}{R_a}$$

$$I_{R_b} = I_b$$

$$V_{R_b} = I_{R_b}R_b = I_bR_b$$

c. What is the power (P_R) dissipated on the resistor in each circuit? (2 points)

$$P_{R_a} = V_{R_a}I_{R_a} = V_a\frac{V_a}{R_a} = \frac{{V_a}^2}{R_a}$$

$$P_{R_b} = V_{R_b}I_{R_b} = I_bR_b(I_b) = {I_b}^2R_b$$

d. To get more power dissipated on the resistor, would you pick $R = 10\ \Omega$ or $R = 1\ k\Omega$ resistor in each case? You can assume $V_a = 10\ V$ and $I_b = 2\ A$. (4 points)

$P_{R_a} \propto \frac{1}{R_a}$ so a smaller resistance dissipates more power. In this case, if $R_a = 10\ \Omega$ then $P_{R_a} = \frac{{V_a}^2}{R_a} = \frac{(10\ V)^2}{10\ \Omega} = 10\ W$.

$P_{R_b} \propto R_b$ so a larger resistance dissipates more power. In this case, if $R_b = 1\ k\Omega$ then $P_{R_b} = {I_b}^2 R_b = (2\ A)^2(1\ k\Omega) = 4\ kW$.

e. For each circuit, how big are the values for P_R, I_R, and V_R if the resistance R goes to zero? (2 points)

$$V_{R_a} = V_a$$
$$I_{R_a} = \frac{V_a}{R_a} = \frac{V_a}{0} \to \infty$$
$$P_{R_a} = V_{R_a} I_{R_a} = V_a * \infty \to \infty$$
$$V_{R_b} = I_{R_b} R_b = I_b * 0 = 0$$
$$I_{R_b} = I_b$$
$$P_{R_b} = V_{R_b} I_{R_b} = 0 * I_b = 0$$

f. For each circuit, how big are the values for P_R, I_R, and V_R if the resistance R becomes infinitely large? (2 points)

$$V_{R_a} = V_a$$
$$I_{R_a} = \frac{V_a}{R_a} = \frac{V_a}{\infty} \to 0$$
$$P_{R_a} = V_{R_a} I_{R_a} = V_a * 0 = 0$$
$$V_{R_b} = I_{R_b} R_b = I_b * \infty \to \infty$$
$$I_{R_b} = I_b$$
$$P_{R_b} = V_{R_b} I_{R_b} = \infty * I_b \to \infty$$