ECE 10, Winter 2020, Final Examination – March 20, 2020

Instructions: This exam booklet consists of exam problems, blank sheets for the solutions, reference sheets with mathematical identities, and additional blank sheets. Please follow these instructions while answering your exam:

1. **Write your name and student identification number below.**
2. **You have 3 hours to finish your exam.**
3. **Write your solutions in the provided blank sheets after each problem.**
4. **The sheets marked "Scratch…" will NOT be graded. These sheets are provided for your rough calculations only.**
5. **Write your solutions clearly. You may box in your final answer. Illegible solutions will NOT be graded.**
6. **Be brief.**
7. **Open text, notes, homework and homework solutions.**
8. **Calculators are allowed.**

NAME: ______________________________________

STUDENT ID: _________________________________

TA SECTION: _________________________________

Problem	Score
#1	$/_{5}$
#2	$/_{15}$
#3	$/_{35}$
#4	$/_{20}$
#5	$/_{25}$
Total	$/_{100}$

Problem 1: Refer to Figure 1. Note that Z represents impedance while Y represents admittance. For each of the following statements indicate whether it is true or false. Circle the appropriate response. Give reasons. **Be very brief; no more two sentences for each response.**

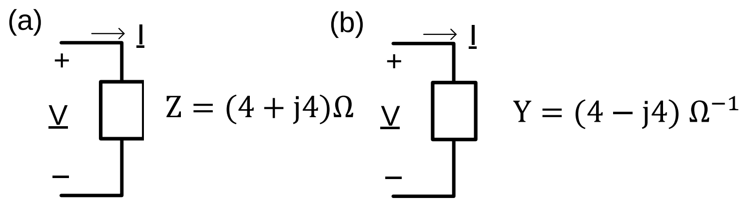

Figure 1

a. In Figure 1(a), the voltage V lags the current, I, by 45 degrees. **True** **False**

b. In Figure 1(b), the voltage V lags the current, I, by 45 degrees. **True** **False**

(2 + 3 = 5 points)

(1 page max allowed)

Solution:

Problem 2: Consider the circuit shown in Figure 2.
(a) What is the impedance looking into 1-1', in sinusoidal steady state, at an angular frequency of 1 rad/s?
(b) Determine the angular frequency, ω, for which the network looking into 1-1' is purely resistive. What is the value of this purely resistive impedance?

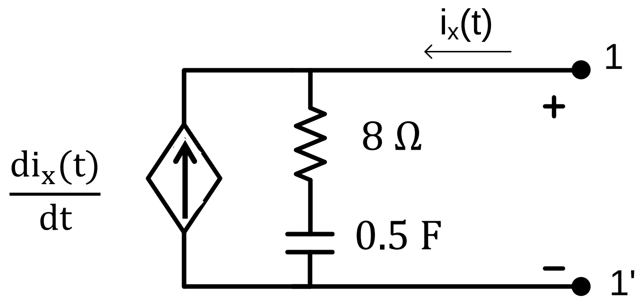

Figure 2

(5 + 10 = 15 points)
(2 pages max allowed)
Solution:

Problem 3: Refer to the circuit schematic shown in Figure 3.
(a) Obtain the phasor domain representation for the circuit shown in the figure.
(b) Solve for the phasors of $i_B(t)$ and $i_L(t)$ i.e. $\underline{I}_B$, and $\underline{I}_L$. Express your numerical phasor answers in polar form (i.e. in $re^{j\theta}$ form). You are free to use any analysis method of your choice.
(c) Draw a complex plane "phasor" diagram showing $\underline{V}_A$, $\underline{I}_L$, $\underline{V}_L$, and $\underline{V}_s$. Indicate the angles and magnitudes of these phasors on the diagram.
(d) Determine the sinusoidal steady state expression for $v_A(t)$. Does it lead or lag $v_S(t)$? By how many degrees?
(e) What is the impedance, Z, seen by the source, $v_s(t)$ i.e. the impedance seen looking into the dashed box in the figure? Is it resistive, inductive, or capacitive?

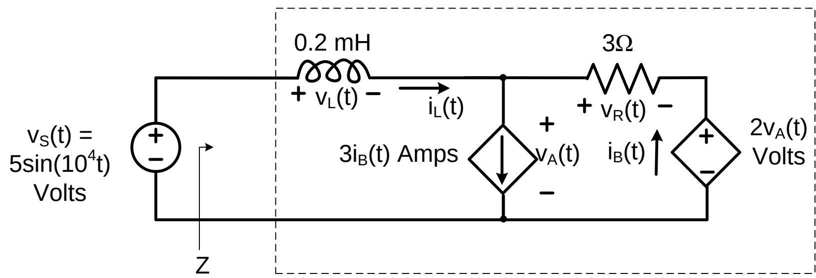

Figure 3

(5 + 8 + 10 + 7 + 5 = 35 points)
(3 pages max allowed)
Solution:

Problem 4: Refer to Figure 4 for this problem. What is the Norton's equivalent circuit for sinusoidal steady state operation?

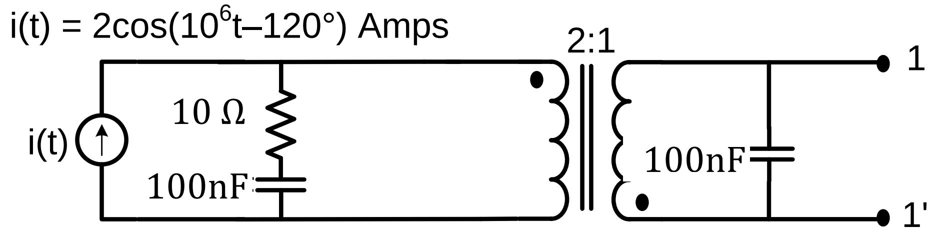

Figure 4

(10 + 10 = 20 points)
(3 pages max allowed)
Solution:

Problem 5: Refer to Figure 5 for this problem. Both switches changed from position 1 to position 2 at time t = 0, after the circuits having achieving steady state. Use V_B = 4V, R = 200Ω, R_L = 400Ω, C_1 = 2mF, C_2 = 4mF, and $V_S(t)$ = 4cos(2.5t) Volts unless stated otherwise.

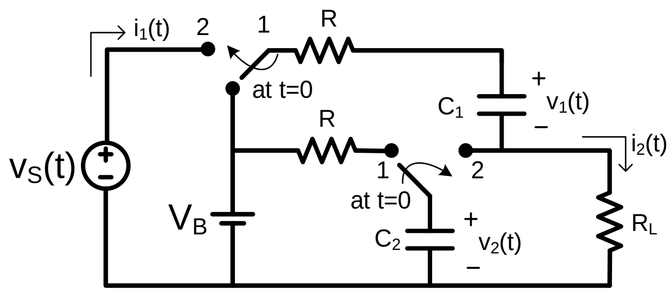

Figure 5

a. Determine the values of $v_1(t)$ and $v_2(t)$ just before t = 0.
b. Determine the values of $i_1(t)$ and $i_2(t)$ just after t = 0.
c. Using $i_1(t)$ and $i_2(t)$ as your unknowns, write down the time-domain mesh current equations for this circuit for t ≥ 0.
d. Determine the values of $\left.\frac{dv_2}{dt}\right|_{t=0+}$, $\left.\frac{di_2}{dt}\right|_{t=0+}$, and $\left.\frac{d^2 i_2}{dt^2}\right|_{t=0+}$.

(4 + 6 + 6 + 9 = 25 points)
(3 pages max allowed)
Solution:

Reference Sheet #1

Trigonometric Identities:

$$\sin A = \cos\left(A - 90^0\right) = \cos\left(A - \pi/2\right)$$

$$\cos A = \sin\left(A + 90^0\right) = \sin\left(A + \pi/2\right)$$

$$\cos\left(A \pm B\right) = \cos A \cos B \mp \sin A \sin B$$

$$\sin\left(A \pm B\right) = \cos A \cos B \pm \sin A \sin B$$

$$\cos A + \cos B = 2\cos\left(\left(A+B\right)/2\right)\cos\left(\left(A-B\right)/2\right)$$

$$\cos A - \cos B = -2\sin\left(\left(A+B\right)/2\right)\sin\left(\left(A-B\right)/2\right)$$

$$\sin A + \sin B = 2\sin\left(\left(A+B\right)/2\right)\sin\left(\left(A-B\right)/2\right)$$

$$\sin A - \sin B = 2\cos\left(\left(A+B\right)/2\right)\sin\left(\left(A-B\right)/2\right)$$

$$\cos 2A = 2\cos^2 A - 1 = \cos^2 A - \sin^2 A = 1 - 2\sin^2 A$$

$$\sin 2A = 2\sin A \cos A$$

$$\cos 3A = 4\cos^3 A - 3\cos A$$

$$\sin 3A = 3\sin A - 4\sin^3 A$$

$$a\cos A + b\sin A = \sqrt{a^2 + b^2}\cos\left(A - \tan^{-1}\left(b/a\right)\right)$$

Complex Arithmetic:

$$\mathrm{Re}\left\{z_1 \pm z_1\right\} = \mathrm{Re}\left\{z_1\right\} \pm \mathrm{Re}\left\{z_2\right\}$$

$$\mathrm{Im}\left\{z_1 \pm z_1\right\} = \mathrm{Im}\left\{z_1\right\} \pm \mathrm{Im}\left\{z_2\right\}$$

$$\mathrm{Re}\left\{z_1 z_2\right\} = \mathrm{Re}\left\{z_1\right\}\mathrm{Re}\left\{z_2\right\} - \mathrm{Im}\left\{z_1\right\}\mathrm{Im}\left\{z_2\right\}$$

$$\mathrm{Im}\left\{z_1 z_2\right\} = \mathrm{Re}\left\{z_1\right\}\mathrm{Im}\left\{z_2\right\} + \mathrm{Im}\left\{z_1\right\}\mathrm{Re}\left\{z_2\right\}$$

$$e^{j\theta} = \cos\theta + j\sin\theta$$

$$x + jy = re^{j\theta} \text{ where } r = \sqrt{x^2 + y^2}, \theta = \tan^{-1}\left(y/x\right)$$

$$re^{j\theta} = x + jy \text{ where } x = r\cos\theta, y = r\sin\theta$$

$$\left|z_1 z_2\right| = \left|z_1\right|\left|z_2\right|, \quad angle\left(z_1 z_2\right) = angle\left(z_1\right) + angle\left(z_2\right)$$

$$\left|1/z\right| = 1/\left|z\right|, \qquad angle\left(1/z\right) = -angle\left(z\right)$$

$$\left(x + jy\right)^* = x - jy, \qquad angle\left(z^*\right) = -angle\left(z\right)$$

Quadratic Equations:

The roots of $ax^2 + bx + c = 0$ are $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

SCRATCH (Will NOT Be Graded)

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