ECE 20001 Spring 2020

Midterm Exam 3

Last Name: Solution **First Name:** _____

Student ID: _____ **Section:**

- ○ 2:30 Mayer
- ○ 12:30 Kildishev
- ○ 12:30 Irazoqui
- ○ 7:30 Cui
- ○ 1:30 Michelusi

I have neither given nor received unauthorized assistance on this exam.

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Instructions:

1. You may show your work by annotating this .pdf document, writing on a hard-copy of this document, or writing on regular paper. If you are writing on regular paper, create your own cover page with your name, Student ID, section, and signature in roughly the same positions that they appear on this page
2. Adhere to the Purdue Honor Pledge. Sign the statement above before submitting your exam.
3. Print your name and Student ID. Indicate your section.
4. This is an open-book, open-note exam. Use of any calculator or general-purpose mathematical software (e.g., MATLAB, Mathematica, Excel, etc.) is allowed. Use of specialized software/websites for solving circuit-related problems is not allowed.
5. For each problem, show work that is clear, concise, and complete. Box or underline final answers for each part.
6. Insert a page(s) if you need extra space for your solution to any problem. Any extra page(s) should have the same portrait orientation as this document
7. All problems (but not individual parts) are equally weighted but are not equally difficult – manage your time wisely.
8. You have 60 minutes to prepare your solution plus 15 minutes to submit it via Gradescope using the same process used for homework.

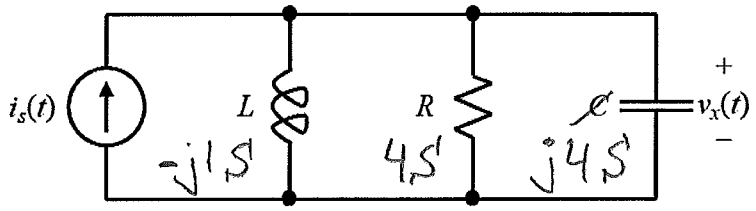
Learning Outcomes

i. An ability to analyze linear resistive circuits.
ii. An ability to analyze first-order linear circuits with sources and/or passive elements. (P1-P4)
iii. An ability to analyze electronic circuits with diodes and transistors.

1. The element parameters are: $L = 0.2$ H, $R = 0.25\ \Omega$, $C = 0.8$ F, and $i_s(t) = 3\cos(\omega t + 30°)$ A where $\omega = 5$ rad/s.

   a. Express $v_x(t)$.

   b. Evaluate $i_s(t)$ at $t = 0.1$ s.



$$Y_{eq} = 4 + j3$$

$$\tilde{V}_x = \frac{3\angle 30°}{4 + j3}$$

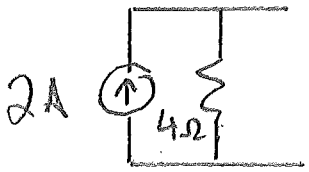
$$= \frac{3\angle 30°}{5\angle 36.87°}$$

$$= 0.6\angle -6.87°\ V$$

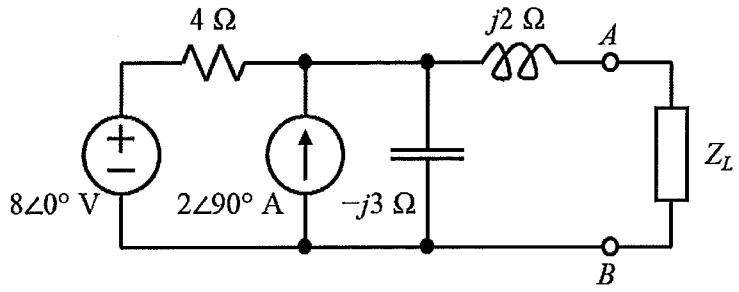
$$v_x(t) = 0.6\cos(5t - 6.87°)\ V$$

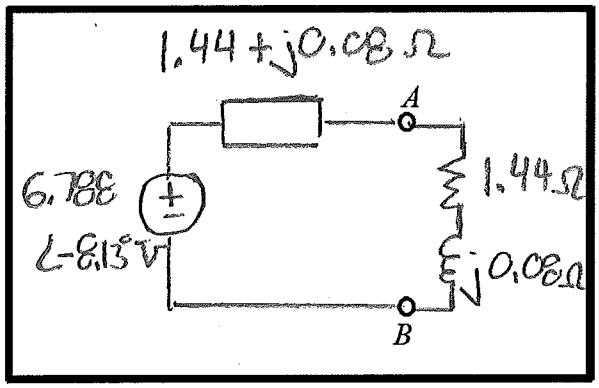
$$i_s(0.1) = 3\cos(0.5 + \pi/6\ \text{rad})$$

$$= 1.561\ A$$



2. Determine the following:
   a. Thevenin equivalent network looking to the left of terminal-pair *A-B*. Draw it in the box.
   b. Load impedance Z_L that absorbs the most average power. Draw it in the box using elements (resistor, capacitor, and/or inductor).
   c. Average power absorbed by Z_L in Part b.





$$4 \| -j3 = \frac{(4)(-j3)}{4-j3} \cdot \frac{4+j3}{4+j3}$$

$$= \frac{36 - j48}{25}$$

$$\tilde{V}_{oc} = \left(\frac{36 - j48}{25}\right)(2 + j2)$$

$$= 6.788 \angle -8.13^\circ \text{ V}$$

$$Z_{th} = \frac{36}{25} - j\frac{48}{25} + j2$$

$$= \frac{36}{25} + j\frac{2}{25} = 1.44 + j0.08 \ \Omega$$

$$Z_L = Z_{th}^*$$

$$= 1.44 + j0.08 \ \Omega$$

2. (cont.)

$$P_{max} = \frac{1}{8} \frac{|V_{oc}|^2}{R_L}$$

$$= \frac{1}{8} \frac{(6.788)^2}{1.44}$$

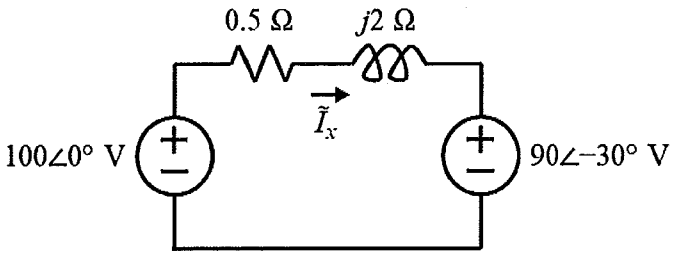
$$= \underline{4 \text{ W}}$$

3. Determine the following:

   a. Current $\tilde{I}_x$.

   b. Average power <u>supplied</u> by the source on the left P_1.

   c. Average power <u>absorbed</u> by the source on the right P_2.



a. $\tilde{I}_x = \dfrac{100 - 90\angle -30^\circ}{0.5 + j2}$

$= 24.31\angle -12.08^\circ$ A

b. $P_1 = \frac{1}{2}(100)(24.31)\cos(0 - -12.08^\circ)$

$= 1188$ W

c $P_2 = \frac{1}{2}(90)(24.31)\cos(-30^\circ - -12.08^\circ)$

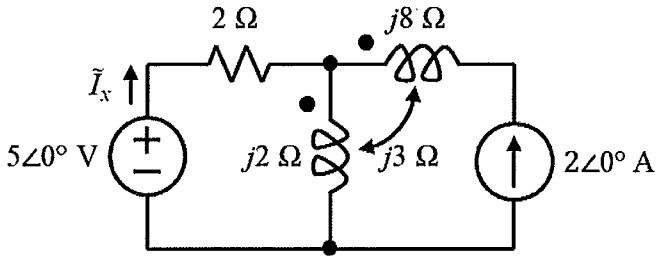
$= 1040$ W

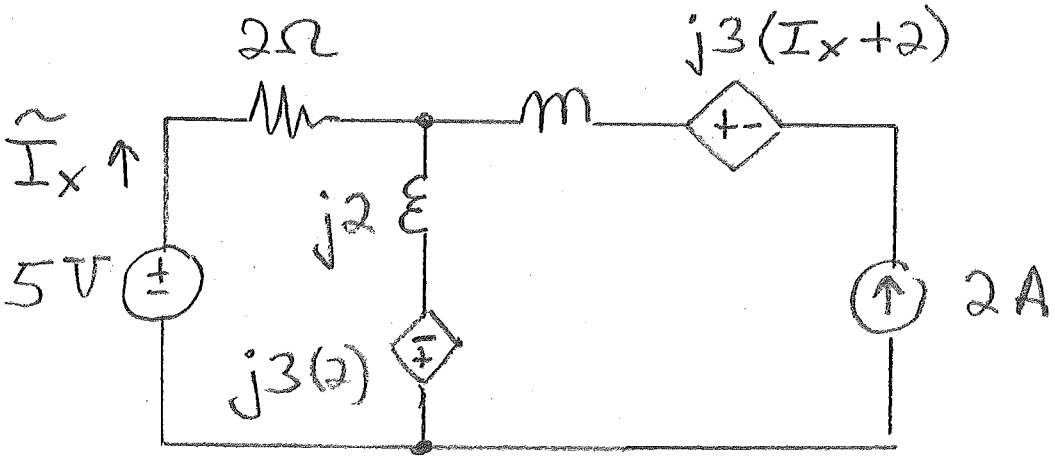
4. Do the following:

   a. Draw an equivalent circuit using dependent sources or three inductors.

   b. Determine current $\tilde{I}_x$.

   c. Express $i_x(t)$ if $\omega = 50$ rad/s.





$$2\tilde{I}_x + j2(\tilde{I}_x + 2) - j6 - 5 = 0$$

$$(2 + j2)\tilde{I}_x = 5 + j2$$

$$\tilde{I}_x = \frac{5 + j2}{2 + j2}$$

$$= 1.75 - j0.75$$

$$= 1.904\angle -23.20^\circ \text{ A}$$

$$i_x(t) = 1.904\cos(50t - 23.20^\circ) \text{ A}$$