UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAM

April 24, 2017

2 Hours 30 Minutes

First Year – Engineering Science

ECE 159S - ELECTRIC CIRCUIT FUNDAMENTALS

Exam Type: A

Examiners: K. Phang and N.P. Kherani

NAME: _____
Last First

STUDENT #: _____

INSTRUCTIONS:

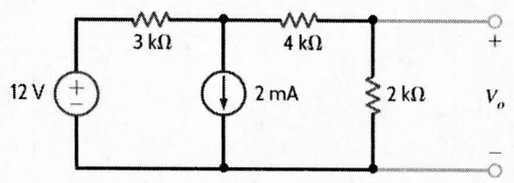
- You may write in pencil.
- This is a Type A examination; no aids are allowed.
- Only non-programmable calculators are allowed.
- The marks for each question are indicated within brackets [ ].
- When answering the questions, include all the steps of your work on these pages. Place your final answers in the boxes where given and include units.
- For additional space, you may use the back of the preceding page and the blank page provided at the end. Do not unstaple this exam booklet.

Q1	/20
Q2	/10
Q3	/5
Q4	/10
Q5	/5
Q6	/10
Q7	/10
Total	**/70**

Name: _____ Student No.: _____

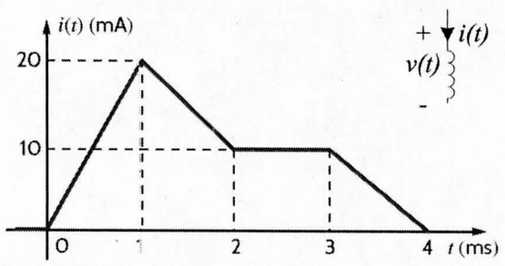
QUESTION 1 [20 marks]
Answer the following short-answer questions.

a) [2 marks] Using superposition, find V_o in the circuit shown below.

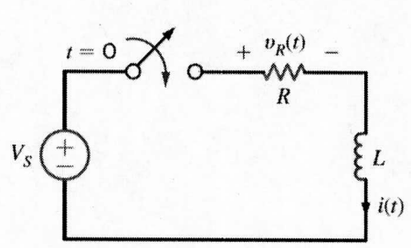


V_o =

b) [2 marks] The current in a 5-mH inductor has the waveform shown below. Compute and plot the waveform for the inductor voltage. Label the axes clearly.



c) [1 mark] Write the differential equation for the following circuit for $t > 0$. Note, the switch is closed at t=0.



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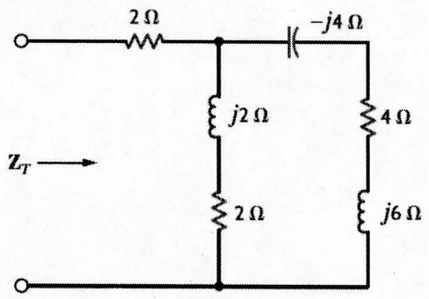
Question 1 (cont.)

d) [2 marks] Compute the impedance $\boldsymbol{Z}_T$ in the network shown below.



$\boldsymbol{Z}_T$ =

e) [4 marks] The complex power delivered to a load $\boldsymbol{Z}$ is $\boldsymbol{S}$ = 100 + j57.7 VA. If the **magnitude** of the load, $|\boldsymbol{Z}|$ = 10Ω, and the angular frequency, ω=377 rad/s, calculate the equivalent series resistance, R, and inductance, L (or capacitance, C) to model the load.

R =

L *or* C =
(circle)

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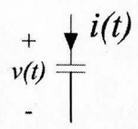
Question 1 (cont.)

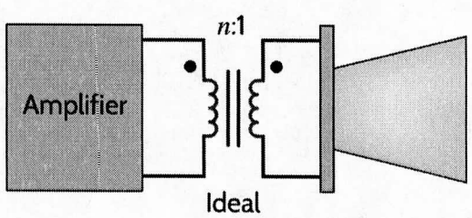
f) [2 marks] The voltage $v(t) = 100 \cos(314t + 15°)$ V is applied to a 100μF capacitor. Find $i(t)$.



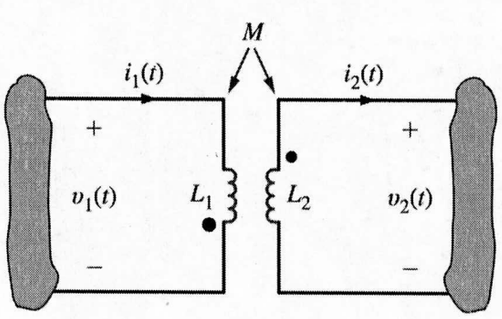
$i(t)$ =

g) [2 marks] For an amplifier with an output resistance of 1.6kΩ, what is the turns ratio, n, of the ideal transformer required to match the amplifier to an 8Ω speaker?

n =



h) [2 marks] Write the equations for voltages $v_1(t)$ and $v_2(t)$ in terms of currents $i_1(t)$ and $i_2(t)$ as shown.



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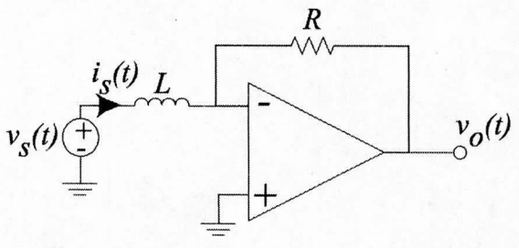
Question 1 (cont.)

i) [1 mark] What is the peak magnitude of a sinusoidal current having an rms value of 15A?

j) [2 marks] For the opamp circuit below, write an expression for the inductor current $i_s(t)$ and output voltage $v_o(t)$ in terms of the input signal, $v_s(t)$, for time t > 0? Assume zero initial conditions.



$i_s(t)$ =

$v_o(t)$ =

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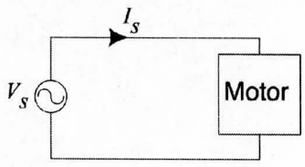
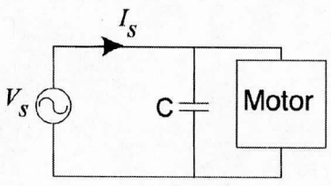
QUESTION 2 [10 marks]
A 500W electric motor is connected to a sinusoidal source of 220V(rms), 50Hz and has a lagging power factor of 0.7.



a) [2 marks] Calculate the current, I_S, drawn from the source.

$I_S =$

b) [2 marks] The power factor is now increased to 0.95 lagging by placing a capacitor in parallel with the motor as shown. Calculate the new current drawn from the source.



$I_S =$

c) [6 marks] Determine the value of the capacitor required to make this power factor correction. Illustrate this power factor correction by drawing the corresponding power triangle.

$C =$

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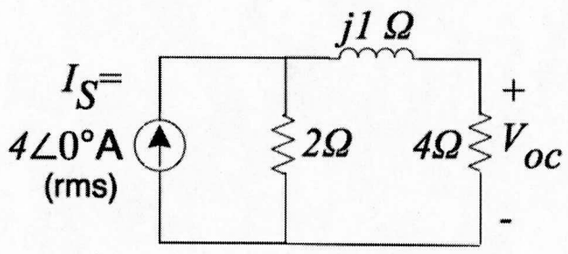
QUESTION 3 [5 marks]
Find the voltage V_{oc} in the circuit shown and the complex power, S_S, supplied by current source I_S. Calculate the average power, $P_{4\Omega}$, dissipated by the 4Ω resistor.



V_{oc} =

S_S =

$P_{4\Omega}$ =

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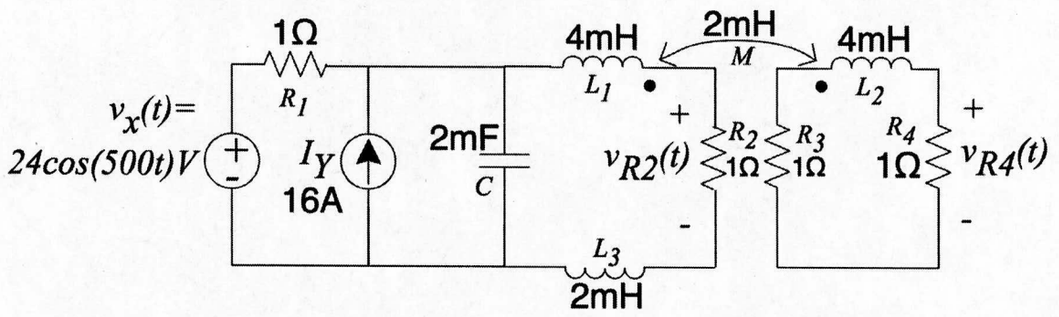
QUESTION 4 [10 marks]
The circuit shown below is at steady-state and has both an AC voltage source, $v_x(t)$, and a DC current source, I_Y. Find expressions for voltages $v_{R2}(t)$ and $v_{R4}(t)$ across R_2 and R_4 respectively.



$v_{R2}(t)$ =

$v_{R4}(t)$ =

QUESTION 4 (blank page for calculations)

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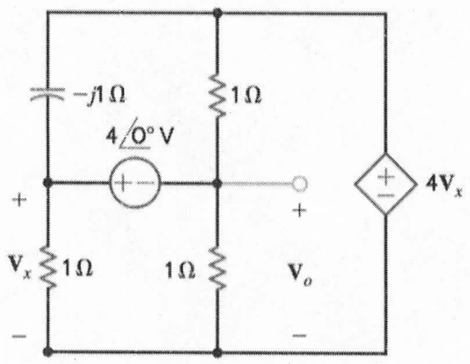
QUESTION 5 [5 marks]
Find V_o using nodal analysis.

V_o =



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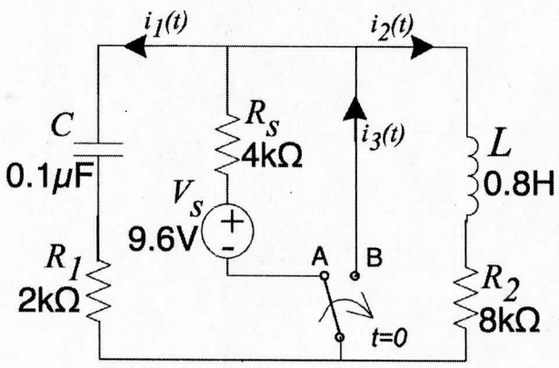
QUESTION 6 [10 marks]

In the circuit shown below, the switch has been in position A for a long time. At time t=0, the switch is moved to position B.

a) [8 marks] Find the expression for $i_1(t)$, $i_2(t)$, and $i_3(t)$ for $t \geq 0$.

b) [2 marks] What is the energy stored in the capacitor, $w_C(0)$, and inductor, $w_L(0)$, at time t=0?



$i_1(t)$ =

$i_2(t)$ =

$i_3(t)$ =

$w_C(0)$ =

$w_L(0)$ =

QUESTION 6 (blank page for calculations)

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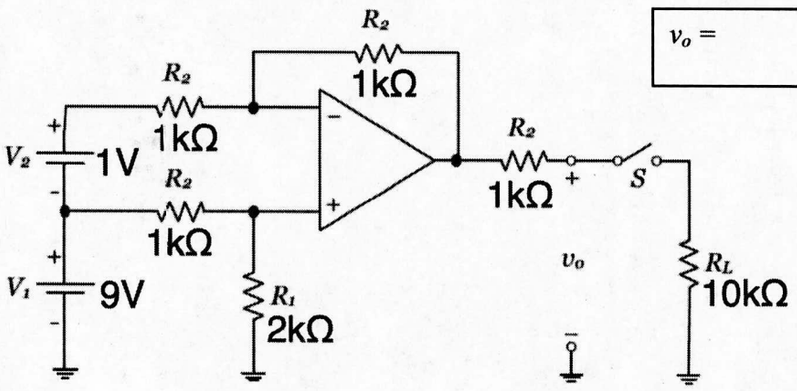
QUESTION 7 [10 marks]

Consider the circuit shown below, assuming the op-amp is ideal.

(a) [6 marks] With the switch S in the open position, find an expression for the output voltage v_o in terms of V_1, V_2, R_1 and R_2.

(b) [4 marks] Find the Thevenin equivalent circuit values, V_{OC} and R_{Th}, seen by the load resistor R_L when the switch S is closed.



v_o =

V_{OC} =

R_{Th} =

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