UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAM

April 24, 2018

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:

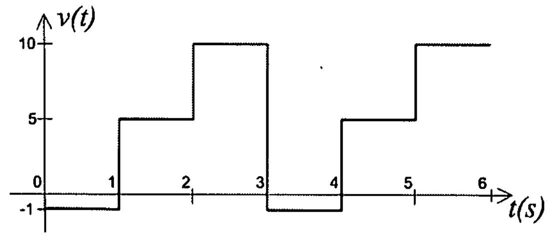
- You may write in pencil.
- This is a Type A examination; no aids are allowed.
- Only non-programmable calculators are allowed.
- The marks for each question are indicated within brackets [ ].
- When answering the questions, include all the steps of your work on these pages. Place your final answers 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	/10
Q2	/8
Q3	/8
Q4	/10
Q5	/8
Q6	/8
Q7	/8
Total	**/60**

Name: ______________________ Student No.: ______________

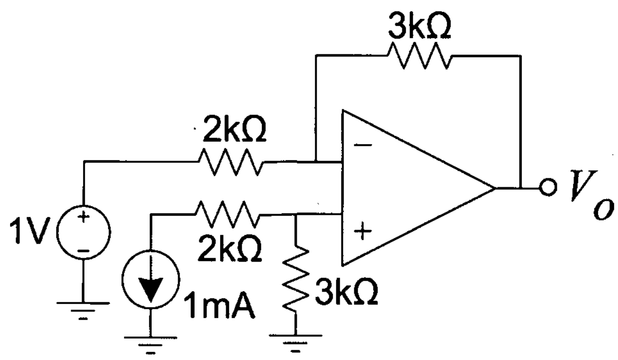
QUESTION 1 [10 marks]

a) [2 marks] Compute the rms value, V_{rms}, of the periodic signal below.



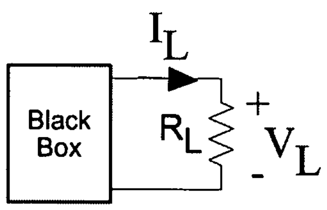
$V_{rms} =$

b) [3 marks] Determine the output voltage, V_o.



$V_o =$

c) [3 marks] For the linear circuit below, the following DC voltages and currents were obtained for two different values of load resistor, R_L. Determine the maximum power, P_{max}, that can be delivered by the black box, and the required value of the load resistor, $R_{L\,(max)}$, to obtain that maximum power.

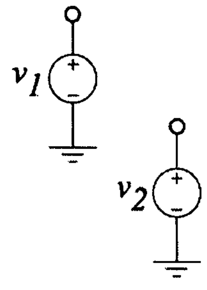


R_L	V_L	I_L
0 Ω	0 V	4 mA
1 kΩ	3 V	3 mA

$P_{max} =$

$R_{L\,(max)} =$

d) [2 marks] Design an opamp circuit that performs the operation $v_{out} = -(2v_1 + 3v_2)$. You are only allowed a single operational amplifier but can use any number of 1kΩ resistors. A BONUS MARK if you manage to use the fewest number of 1kΩ resistors!



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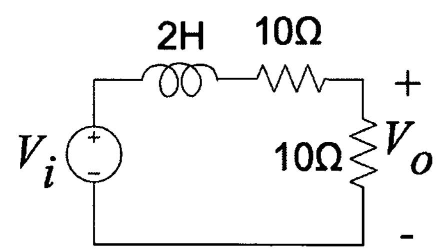
QUESTION 2 [8 marks]
For the circuit shown,



(a) [1 mark] What type of a filter is this (circle one)?

High-pass   Low-pass

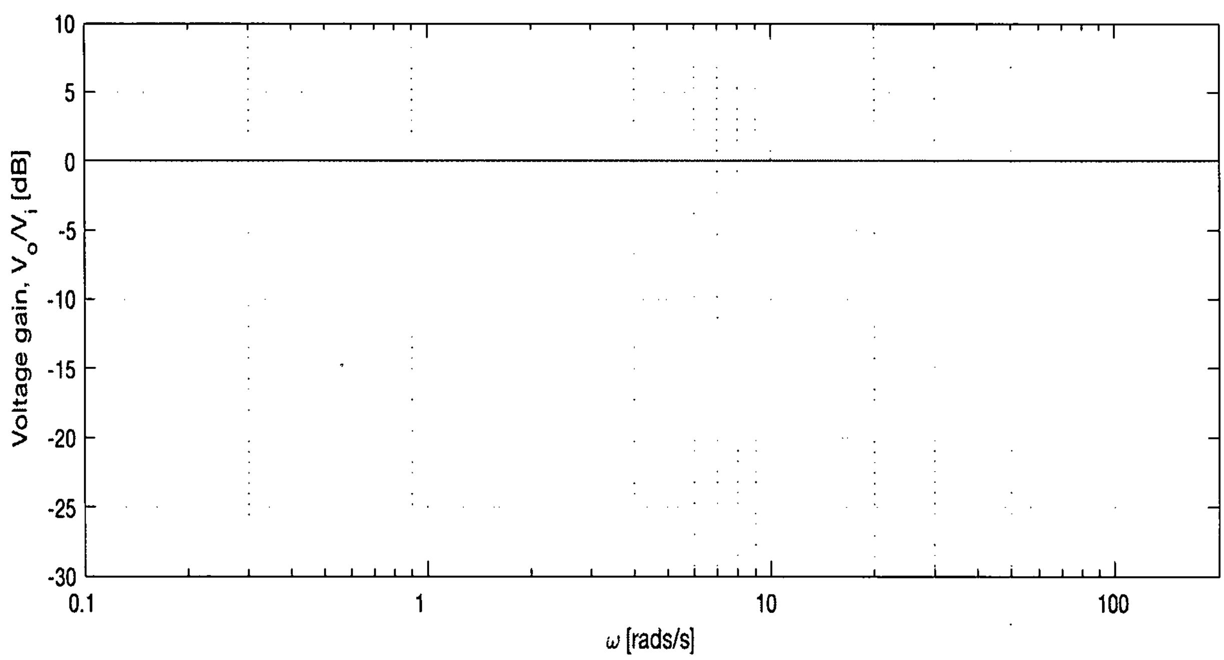
(b) [3 marks] Assuming that this is an ac circuit and that V_i and V_o are phasors representing sinusoids, find a *complex* expression for the voltage gain, $\frac{V_o}{V_i}$, as a function of frequency, ω.

$$\frac{V_o}{V_i}(\omega) =$$

(c) [4 marks] Using your expression in part b), calculate the *magnitude* of the voltage gain, $\left|\frac{V_o}{V_i}\right|$, for the specified frequencies and complete the table below. As in Lab 4, convert the gain into units of decibels (dB) and plot your results (i.e., the gain in dB) on the graph below.

Notes:
1. Since DC(ω=0) cannot be represented on a semi-log graph, plot your value for the DC gain at a frequency of ω=0.1 rad/s.
2. Connect all four data points on your graph to form a continuous curve.

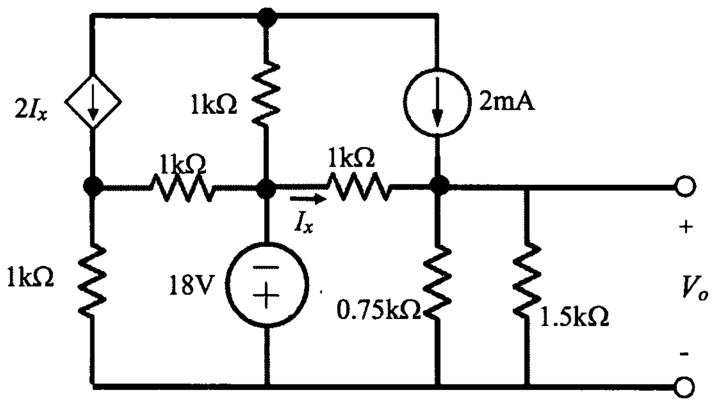
Frequency, ω (rad/s)	Voltage Gain, $A_v = \left\|\frac{V_o}{V_i}\right\|$	A_v (dB) = $20\log_{10}\left\|\frac{V_o}{V_i}\right\|$
0 (DC)		
1		
10		
100		



QUESTION 2 (blank page for calculations)

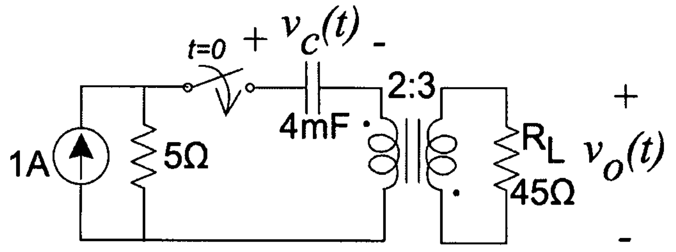
QUESTION 3 [8 marks]

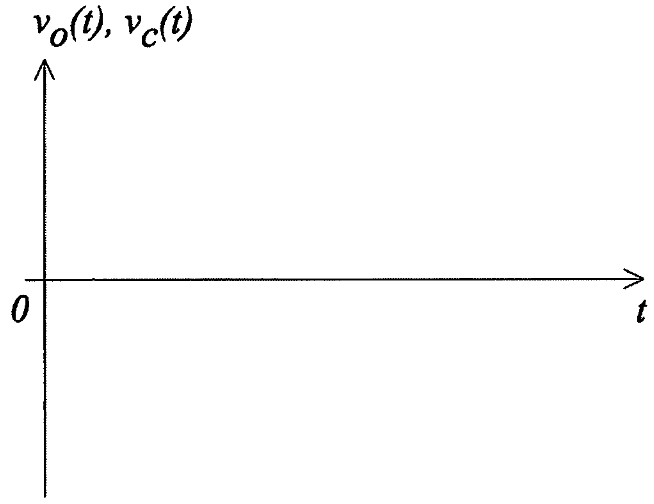
Find the output DC voltage, *Vo*, for the circuit shown using nodal or mesh analysis.



QUESTION 4 [10 marks]
For the circuit below, find the capacitor voltage, $v_c(t)$, and output voltage, $v_o(t)$, and plot both waveforms on the graph below. Clearly mark the scale on the x- and y-axes and indicate the initial and final values (including time t<0).

Assume that the capacitor is initially charged to 2V (i.e., $v_C(0)$=2V, polarity as indicated).
TIP: Consider how techniques such as source transformation and reflected impedance can be used to simplify the analysis.





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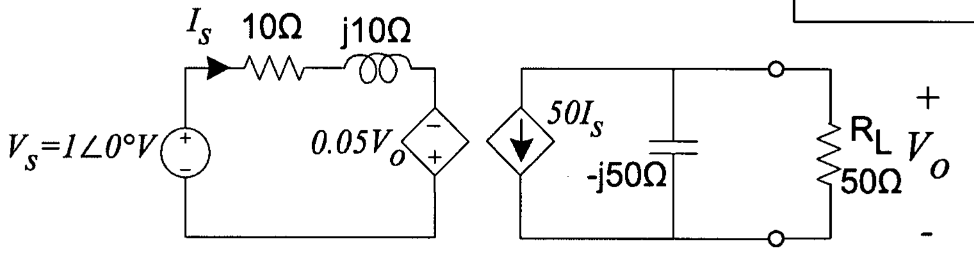
QUESTION 5 [8 marks]
For the circuit below, find phasors $\boldsymbol{I_S}$ and $\boldsymbol{V_o}$.

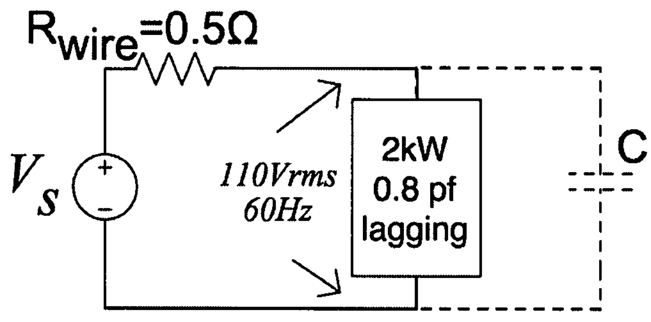
$I_S =$
$V_o =$



QUESTION 6 [8 marks]
For the circuit below, assume the ac source voltage, *Vs*, is adjusted so that 110V (rms) appears at the load as indicated.
a)[4 marks] Find the capacitor, C, required to raise the power factor of the 2kW load to unity.

C =

b)[4 marks] Determine the amount of power, ΔP, saved through power factor correction by calculating the power lossed to the wire resistance, R_{wire}, with and without the capacitor.



ΔP =

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QUESTION 7 [8 marks]

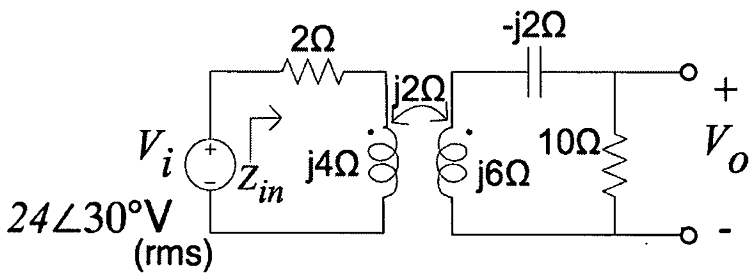
For the circuit shown, find

(a) [6 marks] The output voltage phasor, $\mathbf{V_o}$.

$\mathbf{V_O}$ =

(b) [2 marks] The equivalent impedance, Z_{in}, seen by input voltage source, $\mathbf{V}_i$.

Z_{in} =



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