UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAM

April 24, 2019

2 Hours 30 Minutes

ECE 159S - ELECTRIC CIRCUIT FUNDAMENTALS

Exam Type: A

Examiners: K. Phang and H. Timorabadi

NAME: ____
Last   First

STUDENT #: ____

INSTRUCTIONS:

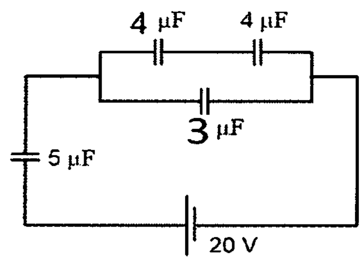
- You may write in pencil.
- **Aids:** Any non-programmable calculator.
- The marks for each question are indicated within brackets [ ].
- Clearly show the work behind your answers. You can use the backside of each page, and an extra blank page is provided at the end.
- Place your final answers in the boxes where given and include units.

Q1	/6
Q2	/10
Q3	/10
Q4	/9
Q5	/8
Q6	/7
Total	**/50**

Student Number: ______________________

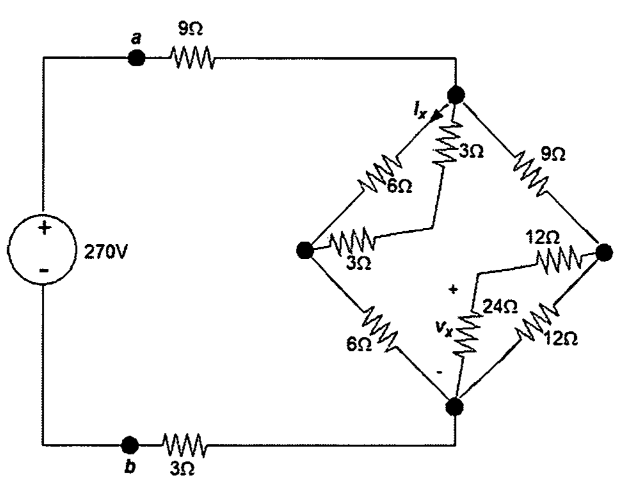
QUESTION 1 [6 marks]

a) [3] In the following circuit find the energy, U_5, stored in the $5\mu F$ capacitor. Assume all capacitors were discharged before the source was added to the circuit.



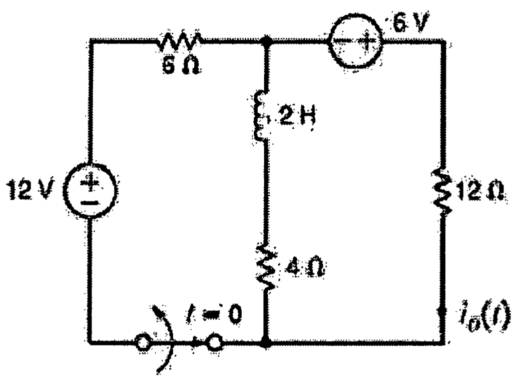
$U_5 =$

b) [3] Find the equivalent resistance, R_{eq}, at terminals *a*-*b*.

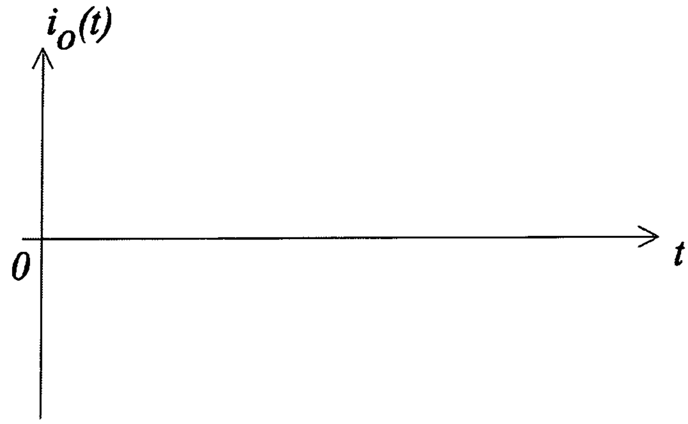


$R_{eq} =$

QUESTION 2 [10 marks]
Find an expression for the current $i_o(t)$ for time t > 0. Sketch the waveform on the graph below, clearly indicating the time scale, the final value, and the initial values, both before and after time t=0, when the switch is opened.



$i_o(t)$ =



QUESTION 2 (blank page for calculations)

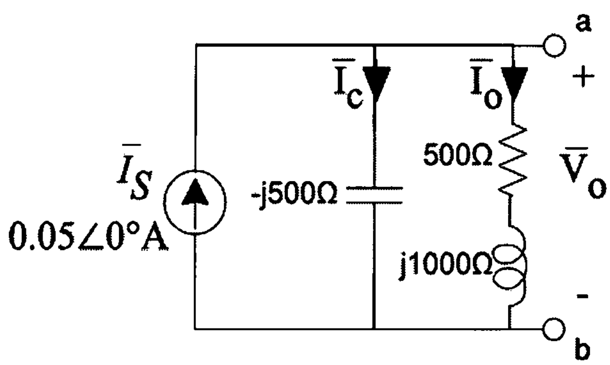
QUESTION 3 [10 marks]

For the phasor circuit shown below, assume the phasors represent peak amplitudes.

a) [3] Find the voltage phasor, $\overline{V_O}$.

b) [5] Draw a phasor diagram showing phasors $\overline{I_S}$, $\overline{V_o}$, $\overline{I_C}$, and $\overline{I_O}$ on the complex plane below.

c) [2] We now introduce a load impedance, Z_L, that is added across terminals a-b. Determine both the value of Z_L for maximum power transfer and the maximum power, P_{max}.



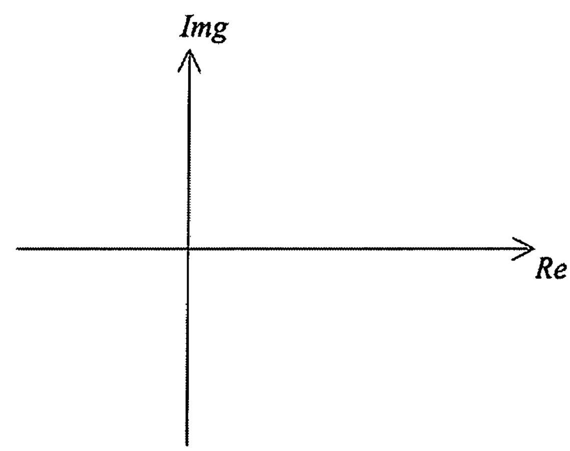
a) $\overline{V_O}$ =

b) (below)

c) Z_L =

P_{max} =

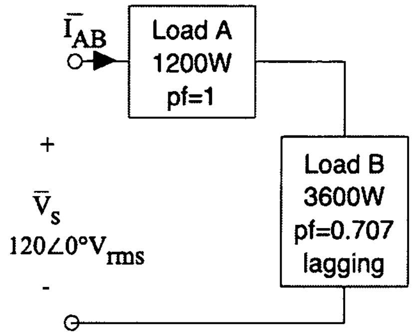
b)



QUESTION 3 (blank page for calculations)

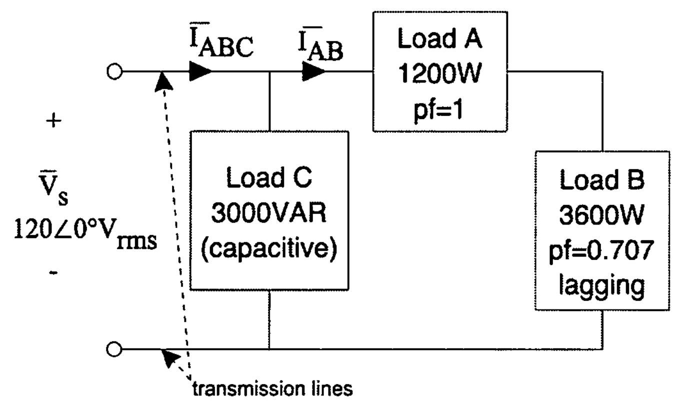
QUESTION 4 [9 marks]

a) [4] Find the power factor, pf, of loads A and B combined and the current, $\overline{I_{AB}}$.



pf =
$\overline{I_{AB}}$ =

b) [2] Load C is now added and is purely capacitive (i.e., pf=0, leading). Extending your calculations from part a), find the new power factor, pf_{new}, of loads A, B, and C combined and the current, $\overline{I_{ABC}}$.



pf_{new} =
$\overline{I_{ABC}}$ =

c) [2] By adding load C, the power factor is increased, and the current through the transmission lines is reduced. This reduces the power dissipated in the transmission lines. Assuming we can model the resistance of the transmission lines by a *single* 0.1Ω resistor, how much power is saved by adding load C?

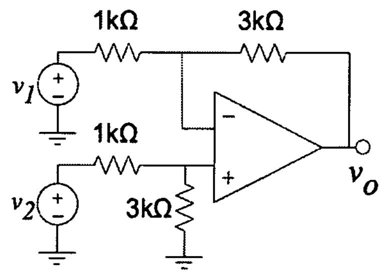
Power saved =

d) [1] What is the term commonly used to describe this process of increasing the power factor?

QUESTION 4 (blank page for calculations)

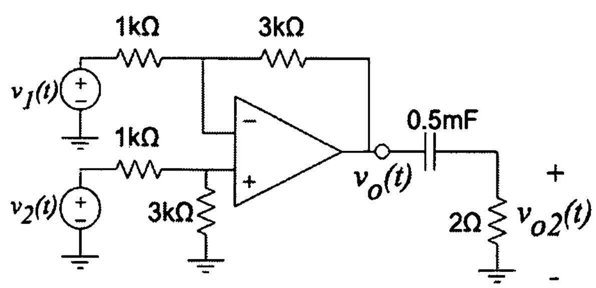
QUESTION 5 [8 marks]

a) [1] Express the output voltage, v_o, in terms of v_1 and v_2.



$v_o =$

b) [6] Similar to Lab 4, the output of the circuit is now used as the input signal to a first-order filter. Given $v_1(t) = 2\cos(200t)$ V, and $v_2(t) = 2\cos(2000t)$ V, find an expression for the new output, $v_{o2}(t)$ (Hint: you can apply both superposition and phasors, but be careful – the two input signals are at *different* frequencies).



$v_{o2}(t) =$

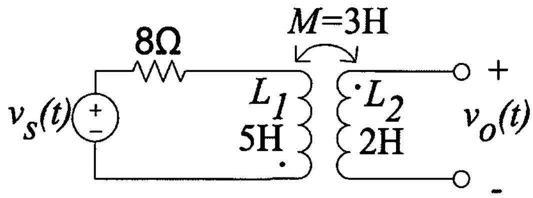
c) [1] What type of first-order filter is this (circle one)?

Low-pass High-pass

QUESTION 5 (blank page for calculations)

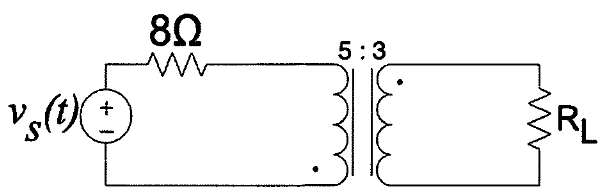
QUESTION 6 [7 marks]
For the circuit below, assume $v_s(t)$ = 4cos(5t) V.
a) [5] Find an expression for the output voltage $v_o(t)$.

$v_o(t)$ =



b) [2] We now model the mutual inductance as an ideal transformer with a turns ratio N_1:N_2 = 5:3 as shown (or equivalently, n=N_2/N_1 = 0.6). A load resistance, R_L, is connected to the secondary coil as shown. Determine the value of R_L required to maximize the power to the load.

R_L =



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