ECE 110 Final Exam

2024-04-24

Last Name: _____

First Name: _____

Student Number: _____

University of Toronto
Faculty of Applied Science and Engineering
Department of Electrical and Computer Engineering

ECE110H1S – Electrical Fundamentals
Final Examination – April 24, 2024, 2:00 pm

(e = 1.6 $\times 10^{-19}$ C, ε_0 = 8.85 $\times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m, g = 9.81 N/kg)

Examination Type: C (Students may use a single, double sided 8.5" x 11" aid sheet)

Calculators: Type 3 (i.e., Non-programmable calculators are allowed).

Duration: 2.5 hours

Instructions:

Answer all five questions.
For full marks, you must show methods, state UNITS and compute numerical answers (when requested).

There is one extra blank page at the end for rough work.

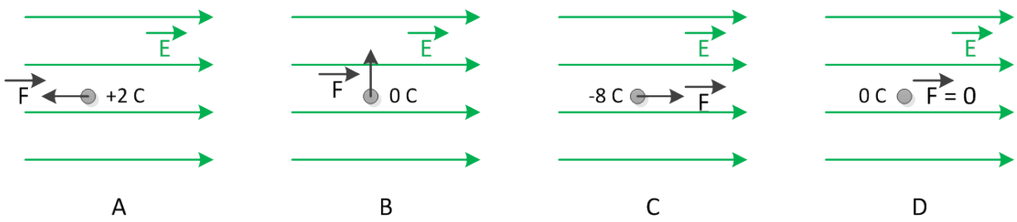
Q1. Multiple Choice Questions. Circle the correct answer.

PART A **(1 mark each)**

1.1 If the electric charge on each of two charged particles is doubled, the electric force between the two charges would be:

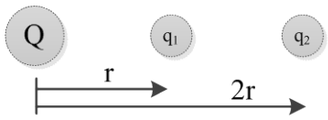
A the same as before
B doubled
C quadrupled
D none of the above

1.2 Which of the following diagrams provides the correct direction for the electric field and electric force vectors?



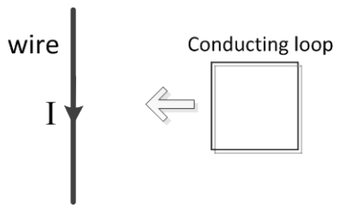
1.3 Charge $q_1 = +q$ and charge $q_2 = +2q$. Which charge has the higher electrostatic potential energy?

A q_1
B both q_1 and q_2 have the same potential energy
C q_2



1.4 A square conducting loop lies in the same plane as a long straight wire carrying a constant current. While the loop is pushed towards the wire, the direction of the induced current in the square loop is

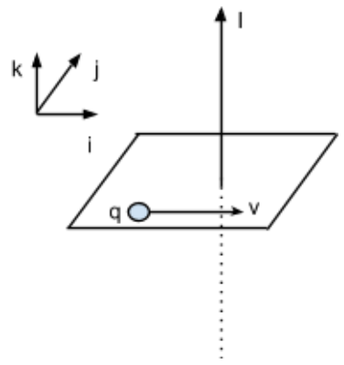
A in the clockwise direction
B in the counter clockwise direction
C hard to tell



Q1. Multiple Choice Questions. Circle the correct answer.

PART B **(2 marks each)**

1.5 A negative particle (q) is moving in the i-direction at speed v when it passes by a wire lying perpendicularly to the i-j plane, and carrying current in the k-direction, as shown below.



The particle will:

A change its path and start moving in the k-direction

B stop completely

C continue in its path along the i-direction

D change its path and start moving towards the wire

1.6 A long straight copper wire lies in the north-south direction and carries a current pointing to north. The wire is immersed in a uniform magnetic field pointing into the sky. The direction of the force exerted on the wire is:

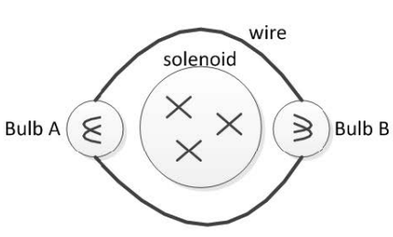
A north

B east

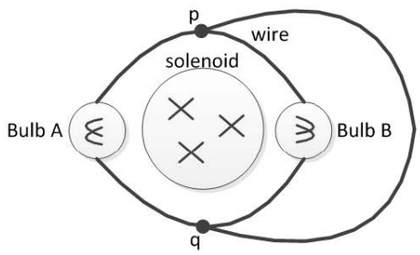
C south

D west

1.7 A magnetic field increasing in strength pointed into the page is produced by a solenoid. An induced emf is established in a conducting wire loop connected to two light bulbs, A and B. Both bulbs light up in figure (i). Points, p and q in figure (ii) are shorted with a wire. Select the correct observation regarding figure (ii).



(i)



(ii)

A bulb A goes out while bulb B gets dimmer.

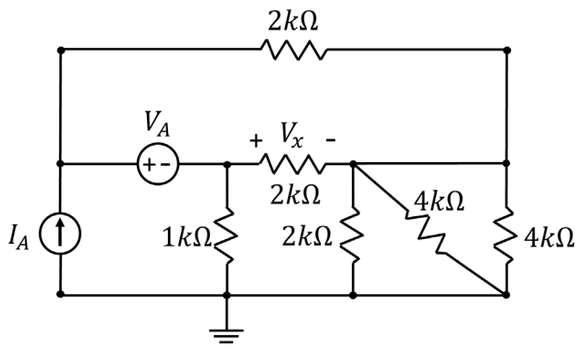
B bulb A goes out while bulb B gets brighter.

C bulb B goes out while bulb A gets dimmer.

D bulb B goes out while bulb A gets brighter.

Q2

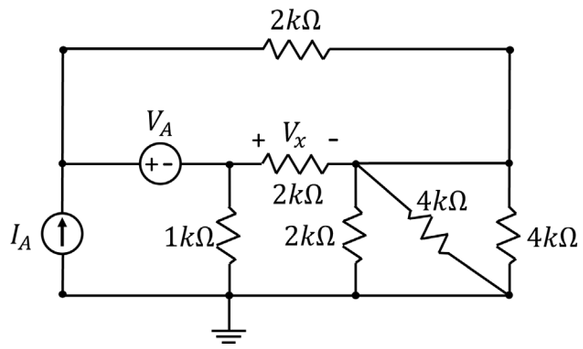
Consider the following circuit.



a) If $I_A = 3\ [mA]$, and $V_A = 0\ [V]$. Determine V_x **[4 marks]**.

$\boldsymbol{V_x =}$

Q2 continued. (Circuit diagram has been duplicated for your convenience)



b) If $I_A = 0\ [mA]$, and $V_A = 6\ [V]$. Determine V_x **[4 marks]**.

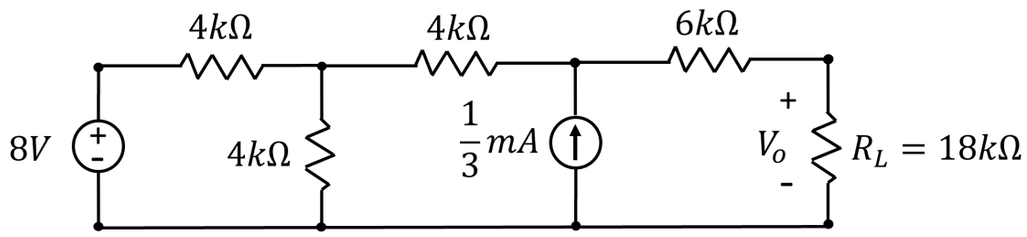
$\boldsymbol{V_x =}$

c) If $I_A = -4\ [mA]$, and $V_A = 8\ [V]$. Determine V_x **[2 marks]**.

$\boldsymbol{V_x =}$

Q3

Consider the following circuit with a load resistor ($R_L = 18k\Omega$) and an output voltage (V_o) measured across this resistor



a) Use the source transformation or superposition method to determine the Thevenin equivalent circuit, excluding the load resistor (R_L) **[3 marks]**.

$\boldsymbol{V_{OC}} =$

$\boldsymbol{R_{th}} =$

b) Calculate the power consumed by R_L **[2 marks]**.

$\boldsymbol{P_{R_L}} =$

Q3 continued.

c) Which of the following R_L values would enable maximum power transfer between the circuit and the load resistor (circle your answer) **[2 marks]**?

A $24k\Omega$

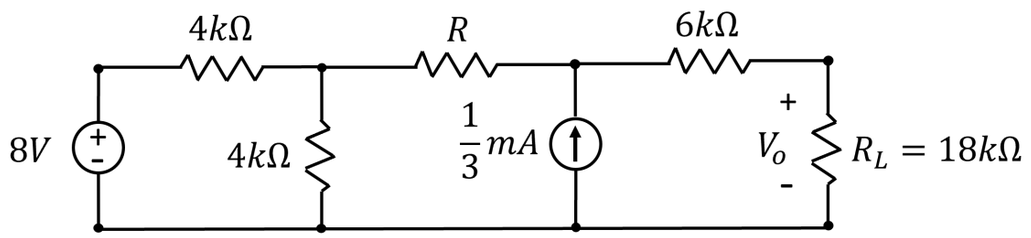
B $18k\Omega$

C $12k\Omega$

D $8k\Omega$

E None of the above would maximize power transfer

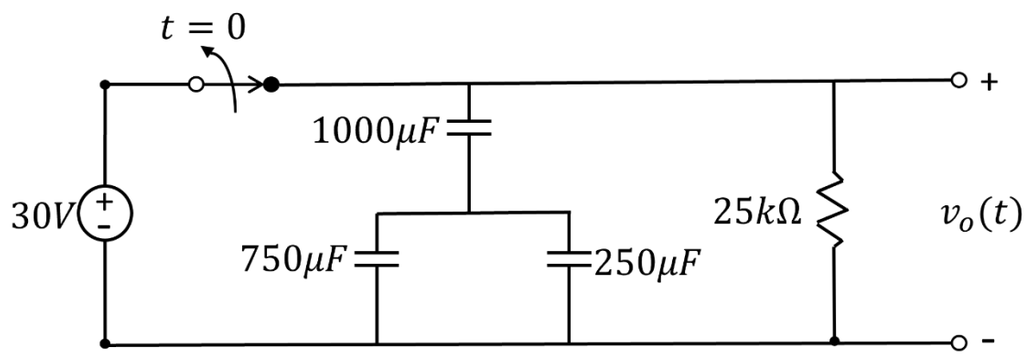
d) Consider the following modified circuit where one of the $4k\Omega$ resistors is replaced with an unknown resistor (R). Determine the value of R that can provide maximum power transfer between the circuit and the load resistor (R_L) **[3 marks]**.



$\boldsymbol{R} =$

Q4

Consider the following circuit.



a) Find $v_o(t)$ for t > 0 **[5 marks]**.

$\boldsymbol{v_o(t) =}$

Q4 continued.

b) Find the total energy stored in the three capacitors for t < 0 **[2 marks]**.

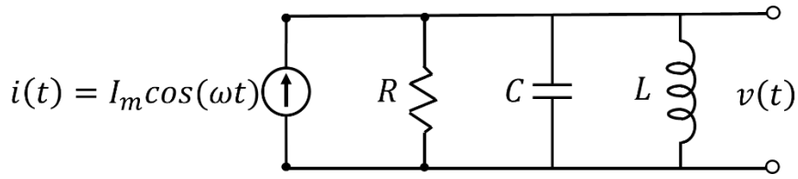
$Energy =$

c) Find the time (t) for the total energy to be reduced to 50 mJ **[3 marks]**.

$t =$

Q5

Consider the following circuit.

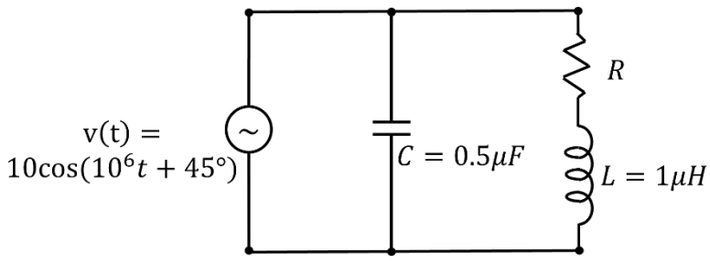


a) Find the expression for angular frequency ($\omega \neq 0$), in terms of the circuit elements, at which $v(t)$ and $i(t)$ are in phase **[5 marks].**

$\boldsymbol{\omega} =$

Q5 continued.

Now consider the circuit below,



b) Find the value of resistor R for which the input impedance as seen by the source is purely real **[5 marks].**

$\boldsymbol{R} =$

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