UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, APRIL 1999

First year - Programs: 01, 02, 03, 04, 06, and 08

ECE 110S - ELECTRICAL FUNDAMENTALS

NAME:_____
(Last) (First)

STUDENT NO.:_____

EXAM TYPE: A

Question	Mark	Maximum
1		25
2		25
3		25
4		25
Total		100

EXAMINERS:
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S. Zukotynski - Coordinator

INSTRUCTIONS:
1. Type A examination: No aids allowed.
2. Only non-programmable calculators allowed (models: as specified in the Faculty Calendar).
3. Answer all parts of all four questions.
4. All four questions are of equal weight.
5. All work is to be done on these pages.
6. Place your final answer in the corresponding box. You may use the back of the proceeding page for rough work.
7. Do not unstaple this exam book.

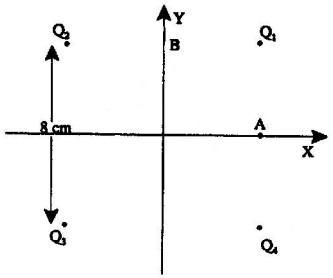
$e=1.6\times10^{-19}$ C, $\epsilon_0 = 8.85 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m

Question 1. Electricity and Magnetism

Part A. Electric field

Four equal charges of 5μC are arranged in a square 8 cm apart, as shown in the figure below.

i) What is the magnitude and direction of the electric field at the centre of the square and at the point B, midway between charges Q_1 and Q_2. Give the direction (a unit vector in the direction of $\vec{E}$) in terms of unit vectors $\hat{i}$ and $\hat{j}$. Use the figure below to illustrate your answer.



At the centre of the square:
|E| =

$\hat{E}$ =

Midway between Q_1 and Q_2:
|E| =

$\hat{E}$ =

ii) What is the work required to move a charge of 3 μC from the point A, midway between Q_1 and Q_4 to the point B, midway between Q_1 and Q_2? Justify your answer.

W =
Justification:

Question 1. Electricity and Magnetism

Part B. Electric current

i) A current of 3 A exists in a 5 Ω resistor for 7 minutes. What is the magnitude of the charge that passes through the resistor? How many electrons does this represent (assume the current is carried by electrons only)?

Q =
Number of electrons =

ii) A wire with a resistance of 10 Ω is drawn out so that the new length is twice the original length. Assume the density and resistivity of the material are not changed. What is the new resistance?

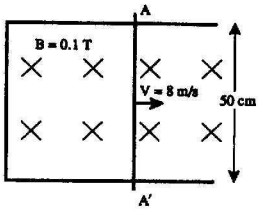
R =

Question 1. Electricity and Magnetism

Part C. Magnetism

A conducting rod AA′ slides from left to right at 8 m/s on conducting rails in a uniform magnetic field B = 0.1T oriented into the page, as shown.

i) What is the induced EMF in the circuit consisting of the rod and rails?



EMF =

ii) Assume the total resistance of the circuit is a constant 20 Ω. What is the current in the circuit? Is the current cw or ccw?

I =
cw ☐, or ccw ☐

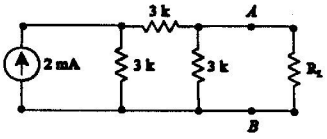
iii) What is the force required to keep the rod in motion?

F =

Question 2. DC Circuit

Part A. Thevenin and Norton equivalent circuits

i) Find and sketch the Norton equivalent circuit for the circuit to the left of terminals A and B.



Norton equivalent circuit:

ii) Use the Norton equivalent circuit from (i) to find the Thevenin equivalent circuit.

Thevenin equivalent circuit:

iii) What value of the load resistor, R_L, produces the maximum power transfer to the load?

R_L=

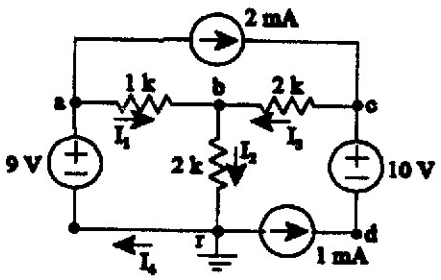
iv) Determine the maximum power transferred to the load, P_{max}.

P_{max}=

Question 2. DC Circuit

Part B. Nodal analysis

For the circuit below:



i) What is the total number of nodes, including the reference node?

Number of nodes=

ii) Write a set of equations required for the nodal voltage analysis.

Set of Equations:

iii) Find the voltages at a, b, c, and d.

V_a=

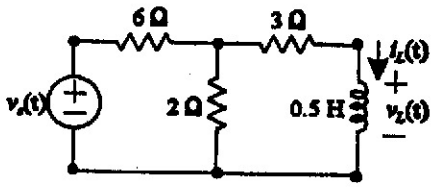
V_b=

V_c=

V_d=

Question 3. Transient Analysis

For the circuit below, assume $v_s(t) = 18$ V for $t < 0$ and $v_s(t) = 0$ for $t \geq 0$.



i) Derive a differential equation for $i_L(t)$, for $t \geq 0$.

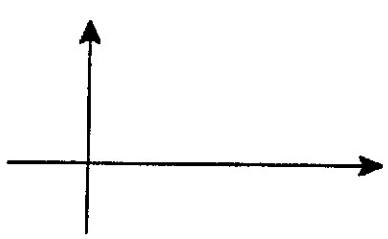
ii) Find $i_L(t)$ for all time.

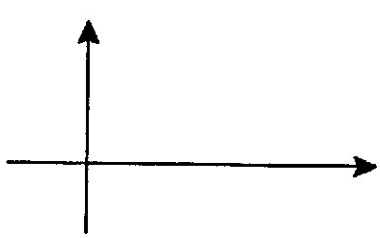
$i_L(t) =$	for $t < 0$
$i_L(t) =$	for $t \geq 0$

iii) Find $v_L(t)$ for all time.

$v_L(t) =$	for $t < 0$
$v_L(t) =$	for $t \geq 0$

iv) Sketch $i_L(t)$ and $v_L(t)$ (label all axis properly).





Question 4. Phasors

The internal resistance of a 60 Hz sinusoidal generator is 50 Ω. The open circuit voltage of the generator is 120 V rms. The generator is connected to a load consisting of a series combination of a 0.16 H inductor and a 100 Ω resistor.

i) Draw the equivalent circuit in the frequency domain (using phasors). Fully label all the circuit elements.

Determine:

ii) The phasor $\underline{I}$ representing the current in the circuit, $i(t)$.

$\underline{I}$ =

iii) The average (real) power absorbed by the load P_{load}.

P_{load} =

iv) The phasor $\underline{V}_{load}$ representing the voltage across the load, $v(t)$.

$\underline{V}_{load}$ =

v) The power factor of the load. Is it a leading or lagging power factor? Explain.

PF =

leading ☐ or lagging ☐

Explanation: