UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, APRIL 2008

First Year – Computer, Electrical, Industrial, Mechanical, Materials, and TRACK ONE (General) Engineering Programs.

ECE 110H1 S – ELECTRICAL FUNDAMENTALS

Exam. Type: A

Examiners – B.L. Bardakjian, L. de Windt, P. Herman, L. Qian, C. Sarris, and B. Wang

NAME : (PLEASE PRINT)	FAMILY NAME	GIVEN NAME
STUDENT NUMBER :		

EXAMINATION TYPE : Type A – Paper for which no data are permitted other than the information printed on the examination paper.

CALCULATORS : ONLY Non-programmable scientific type allowed (models as specified in the Faculty Calendar).

DURATION : 2.5 hours

INSTRUCTIONS :
- DO NOT UNSTAPLE THIS EXAM. BOOK.
- Answer all six questions.
- All six questions are of equal weight.
- All work is to be done on these pages. Show methods, compute numerical results when requested and state units.
- Place your final answer in the corresponding box. You may use the back of the preceding page for rough work.

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

Question	Mark
1	
2	
3	
4	
5	
6	
Total	

Question 1 - Electricity and Magnetism

Part A

The device shown in Fig. 1A is called a velocity selector and its operation is as follows: Charges q launched into the chamber from its left aperture with velocity $\vec{v} = v\,\hat{\imath}$, should be able to exit the chamber from its right aperture, moving along a linear trajectory, only if $v = v_0$.

If the electric field in the chamber is $\vec{E} = -E_0\,\hat{\jmath}$, determine the magnetic field (magnitude in terms of E_0, v_0, q and direction) needed for the device to operate as described above. [4 marks]

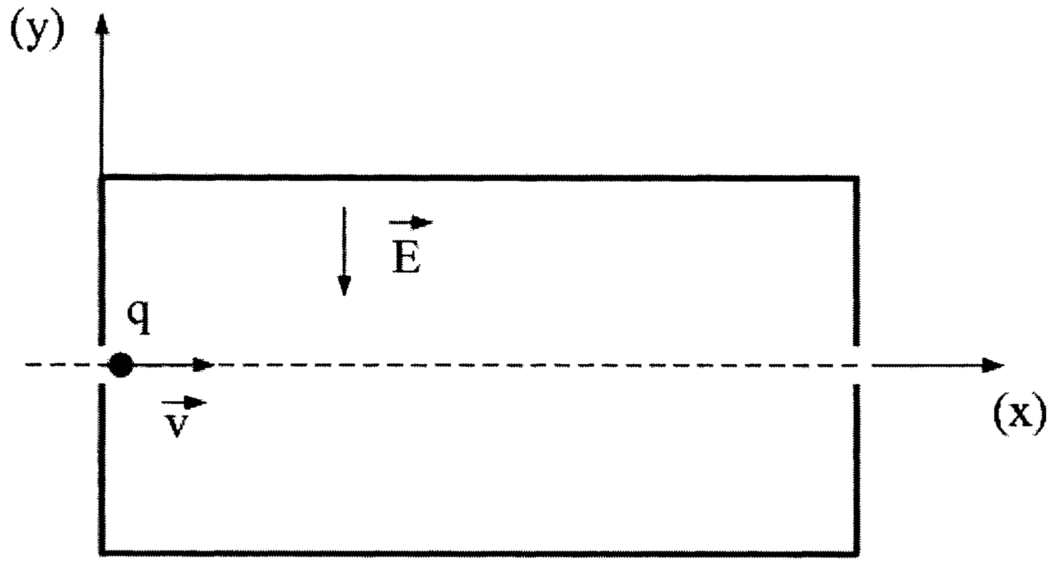

Figure 1A: Velocity selector

$\vec{B} =$

Question 1 - Electricity and Magnetism

Part B

A small conducting loop of area S=2 cm^2 moves near an infinite line current I, and includes a resistor R=5 Ω, as shown in Fig. 1B.

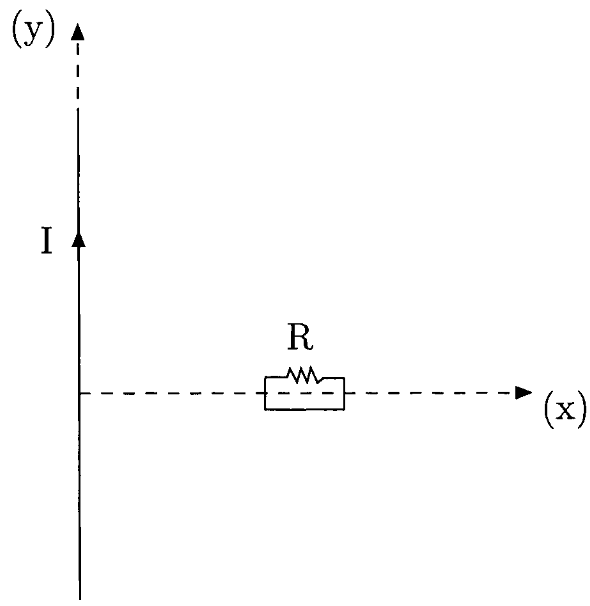

Figure 1B: Small loop and infinite line current.

i) Determine whether there is an induced current in the loop and show the direction of that current, if the loop moves with a constant velocity in the:

- $+x$ direction;
- $+y$ direction. [2 marks]

ii) Assume that the magnetic field produced by the wire is almost constant throughout the loop area and equal to its value at the center of the loop. Find the current I of the vertical wire if the loop current is I_{loop}=1 μA at (x=0.25 m, y=0), when the loop moves with a constant velocity $\vec{v}$= 10 m/sec $\hat{\imath}$. [4 marks]

You may need: $\frac{d}{dt}\left(\frac{1}{x}\right) = -\frac{1}{x^2}\frac{dx}{dt}$.

I =

Question 2 – DC Circuits

Consider the circuit shown in Fig. 2.1.

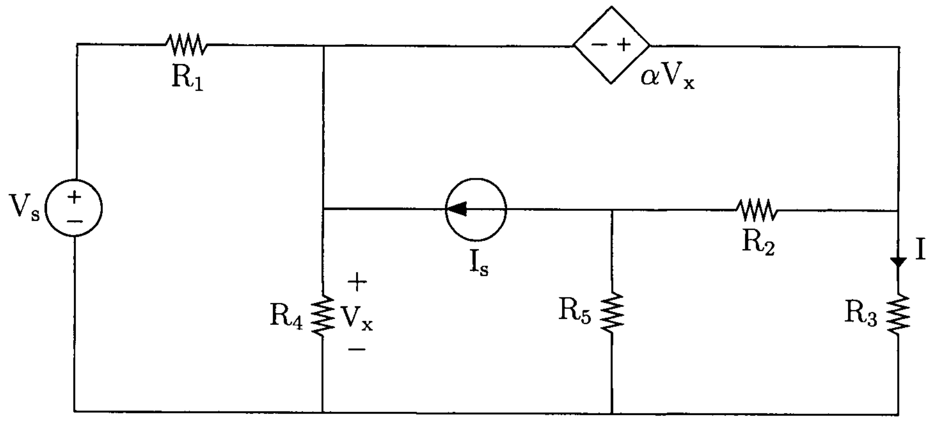

Fig. 2.1

$V_s = 3\text{V},\ I_s = 10\text{mA},\ \alpha = 2,$

$R_1 = 4\text{k}\Omega,\ R_2 = 3\text{k}\Omega,\ R_3 = 1\text{k}\Omega,\ R_4 = 2\text{k}\Omega,\ R_5 = 6\text{k}\Omega$

(a) Use LOOP or NODAL analysis to find I. [7 marks]

(b) If the values of V_s and I_s are doubled (i.e., V_s is replaced by $V_s' = 6\text{V}$ and I_s is replaced by $I_s' = 20\text{mA}$), find the new current I' passing through R_3. [3 marks]

I =
I′ =

Question 3

Part A

Consider the case of maximum power that can be transferred to the load R_L in the circuit shown in Figure 3A. Determine:

i) The load R_L. [2 marks]

ii) The maximum power. [3 marks]

i) $R_L =$
ii) $P_{max} =$

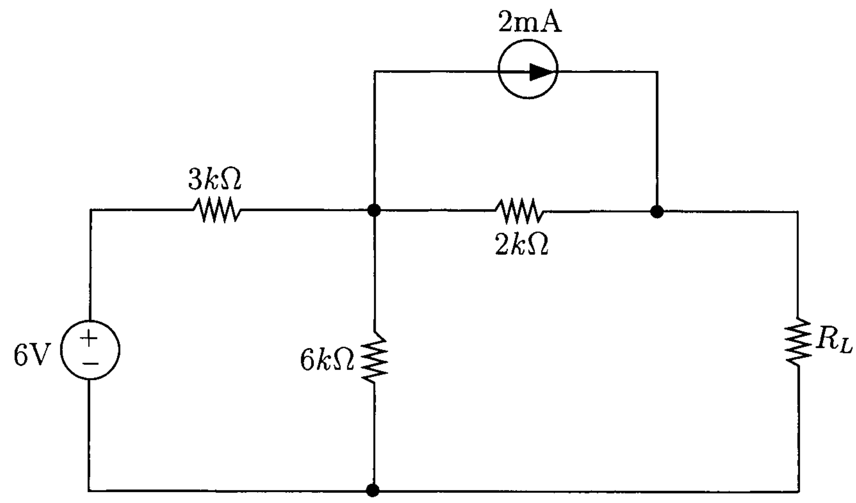

Figure 3A

Question 3

Part B

Consider the circuit shown in Figure 3B. Determine:

i) The Thèvenin equivalent source. [1 mark]

ii) The Thèvenin equivalent resistance. [3 marks]

iii) The Norton equivalent source. [1 mark]

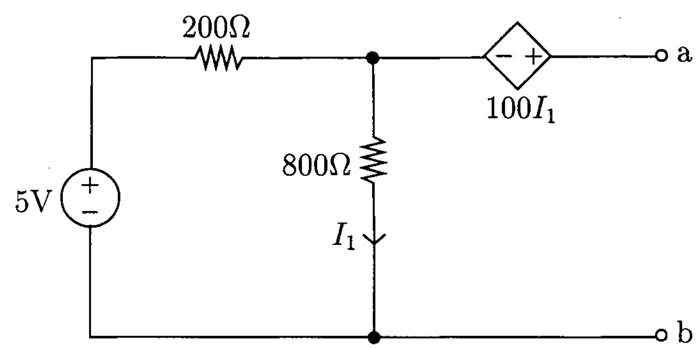

Figure 3B

i) V_{th} =
ii) R_{th} =
iii) I_N =

Question 4

For the circuit shown in Figure 4, the operational amplifiers are ideal and operating in their linear region. Determine in terms of v_i:

i) The voltage v_a [2 marks]

ii) The voltage v_b [2 marks]

iii) The voltage v_O [2 marks]

iv) The current i_a [2 marks]

v) The current i_b [2 marks]

i) $v_a =$
ii) $v_b =$
iii) $v_O =$
iv) $i_a =$
v) $i_b =$

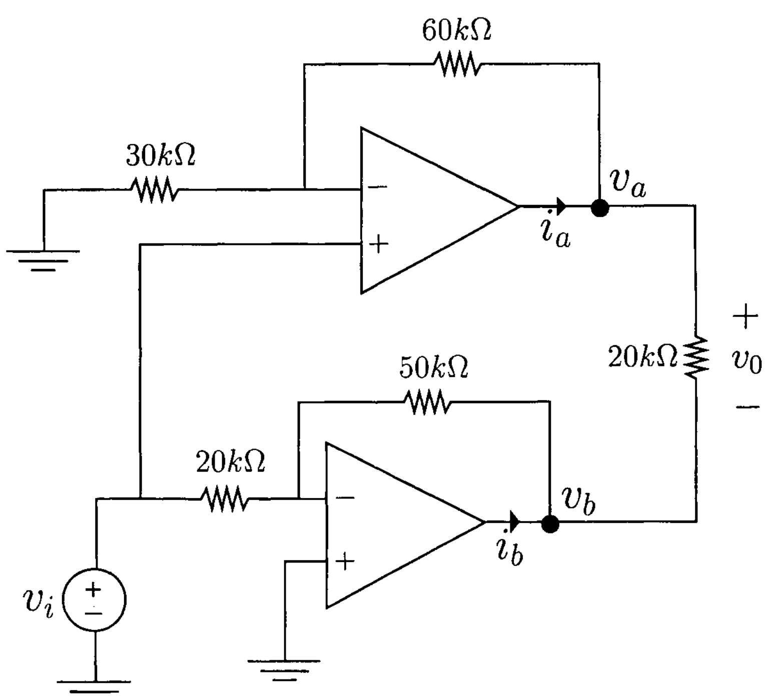

Figure 4

Question 5

For the circuit shown in Figure 5, the switch has been closed for a long time and it opens at $t = 0$.

i) Find the voltage, $V_C(0^-)$ and the current, $i_L(0^-)$; [2 marks]

ii) Find the voltage, $V_1(0^+)$ and the current, $i_L(0^+)$; [2 marks]

iii) Find the voltage, $V_1(\infty)$ and the current, $i_L(\infty)$; [2 marks]

iv) Find the time constants associated with the capacitor, τ_C and that of the inductor, τ_L; [2 marks]

v) Sketch the transient responses, $V_1(t)$ and $i_L(t)$ for $t > 0$. [2 marks]

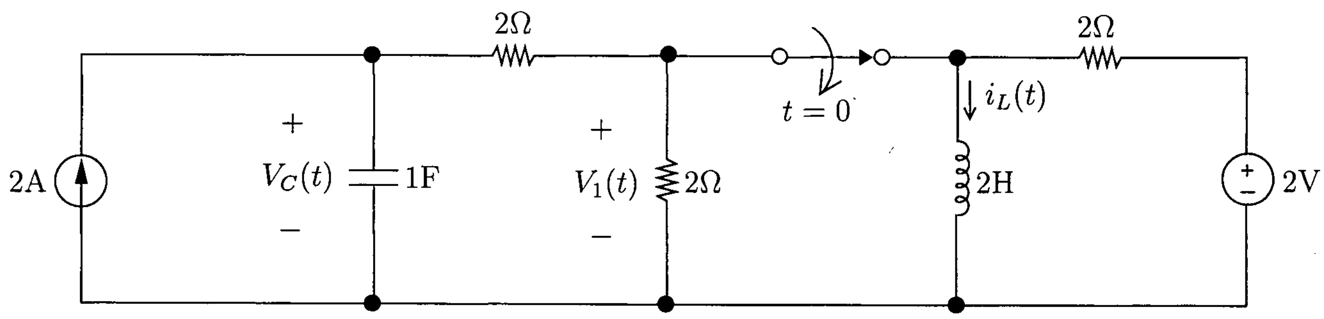

Figure 5

$V_C(0^-) =$	$i_L(0^-) =$
$V_1(0^+) =$	$i_L(0^+) =$
$V_1(\infty) =$	$i_L(\infty) =$
$\tau_C =$	$\tau_L =$

Question 6 – AC Circuit

The circuit below is in a sinusoidal steady state operating at a frequency of 400 Hz.

i) State the values of the capacitor and inductor. [2 marks]

ii) Find the phasor voltage V_{ab} [4 marks]

iii) Determine the average power absorbed by the circuit. [4 marks]

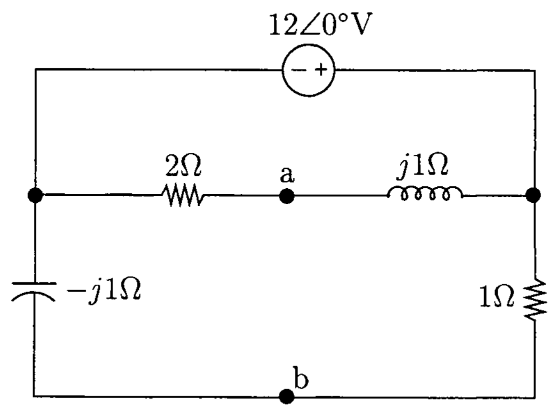

Figure 6

i) $C =$

$L =$

ii) $V_{\mathrm{ab}} =$

iii) $P_{\mathrm{A}} =$