UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, APRIL 2009

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, M. Graovac, MO Mojahadi, L. Qian, 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, $g = 9.81$ N/kg

Question	Mark
1	
2	
3	
4	
5	
6	
Total	

Question 1 [10 marks]

(a) A charged oil droplet with a radius of 1 μm and density of $3/(4\pi)$ grams per cm^3 can be held suspended vertically between two parallel, horizonal metal plates when an appropriate electric field is applied between them. The lower and upper plates are negatively and positively charged, respectively. **Compute** the charge (magnitude and sign) on the oil droplet if the magnitude of the electric field required to hold it stationary is $2548.75 N/C$. **Hint:** The volume of a sphere is $(4\pi r^3/3)$ where r is the radius of the sphere. (5 marks)

$q =$

(b) A uniform magnetic field described as function of time by $B(t) = (9t^2 - 20t) \times 10^{-7}$ where B is in tesla and t is in seconds. This magnetic field is perpendicular to a wire loop enclosing an area of $18\,m^2$. **Compute** the magnitude of the induced **emf** in the wire loop at $t = 3\,s$. (5 marks)

emf =

Question 2 [10 marks]

(a) State the Kirchhoff current law (KCL). (1 mark)

(b) State the Kirchhoff voltage law (KVL). (1 mark)

(c) KCL is based on _____ (choose one) (1 mark)

KVL is based on _____ (choose one) (1 mark)

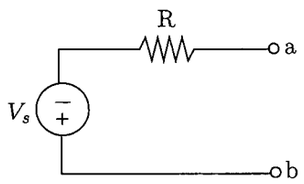
i) Ohm's Law
ii) Coulomb's Law
iii) Superposition principle
iv) Conservation of charge
v) Conservation of energy
vi) Faraday's Law

(d) Is the following statement true or false: The voltage across a capacitor can be a discontinuous function of time? (1 mark)

true	☐
false	☐

Question 2 (cont'd)

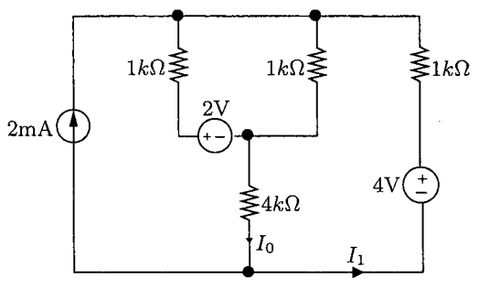
(e) For the circuit shown below draw its equivalent circuit (with respect to terminal a-b) using a current source and a resistor. Give the expression for the current source and its resistor in terms of the original circuit parameters. (1 mark)



(f) For the circuit shown below we observed the following:

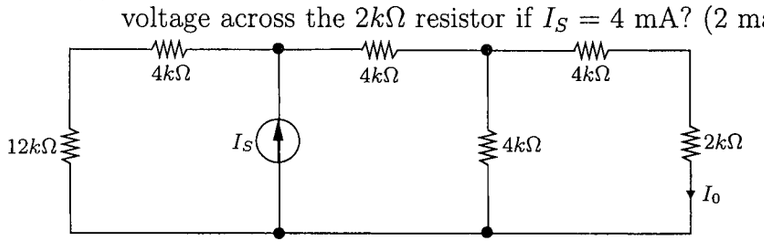
- With current source 2 mA acting alone (all other sources deactivated) I_0 was measured to be 0.364 mA.
- With voltage source 2 V acting alone (all other sources deactivated) I_0 was measured to be -0.182 mA.
- With voltage source 4 V acting alone (all other sources deactivated) I_0 was measured to be 0.727 mA.

What is the value of I_1 when all sources are acting together? (2 marks)



$I_1 =$

(g) For the circuit shown below with $I_S = 3.5$ mA we measured I_0 to be 1 mA. What is the voltage across the $2k\Omega$ resistor if $I_S = 4$ mA? (2 marks)



$V_{2k\Omega} =$

Question 3 [10 marks]

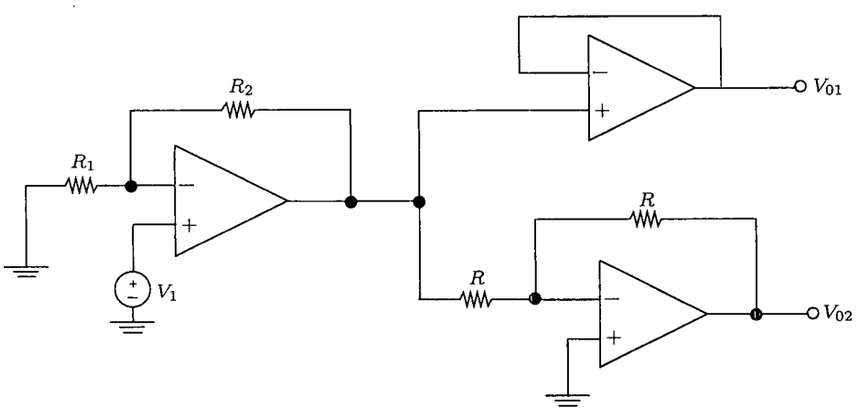
(a) Consider the ideal op-amp circuit shown below, determine the voltage gains

i) $A_{v1} = \dfrac{V_{01}}{V_I}$ (2 marks)

ii) $A_{v2} = \dfrac{V_{02}}{V_I}$ (2 marks)

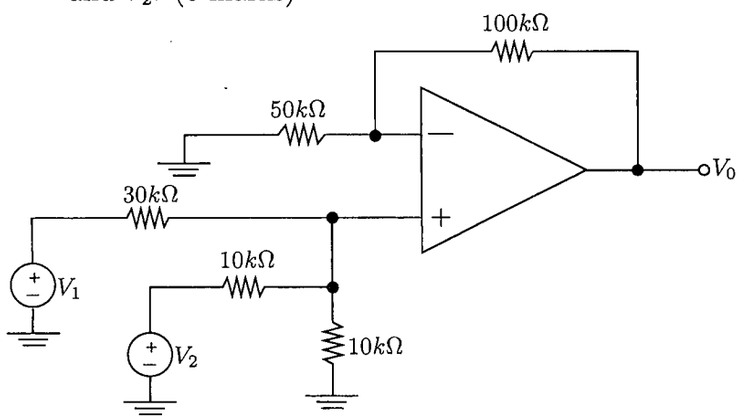
$A_{v1} =$

$A_{v2} =$



Question 3 (cont'd)

(b) For the ideal noninverting op-amp circuit shown below, determine V_0 as a function of V_1 and V_2. (6 marks)



$V_0 =$

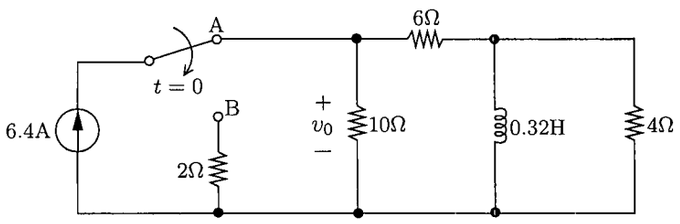
Question 4 [10 marks]

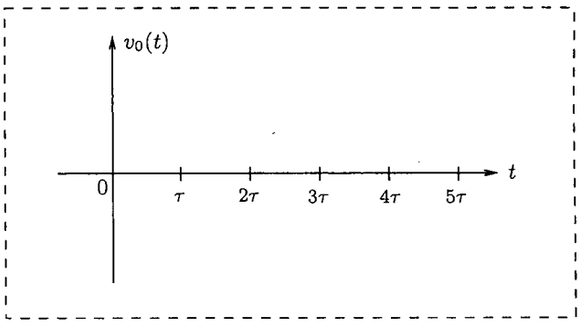
Consider the circuit shown below. The switch had been in position "A" for a long time. At $t = 0$, the switch moves instantaneously from position "A" to "B".

(a) Find $V_0(t)$ for (i) $t < 0$ (steady-state); (ii) $t \geq 0$. (3 marks)

(b) Sketch $V_0(t)$ in the space provided. Indicate on the plot the values for the time constant τ, $v_0(t = 0^-), v_0(t = 0^+)$, and $v_0(t = \infty)$. (4 marks)

(c) What percentage of the initial energy stored in the inductor is eventually dissipated in the 4Ω resistor? (3 marks)





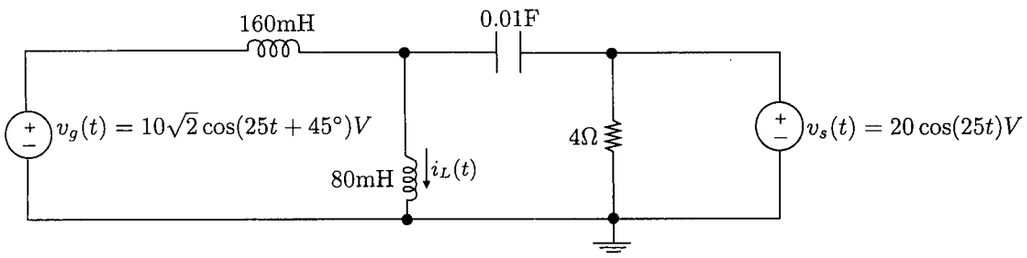
Question 5 [10 marks]

The circuit below is in AC steady state.

(a) Redraw the circuit by transforming the sources into phasors and components into impedances. (3 marks)

(b) Find the phasor current $\mathbf{I_L}$ for $i_L(t)$. (5 marks)

(c) Find $i_L(t)$. (2 marks)

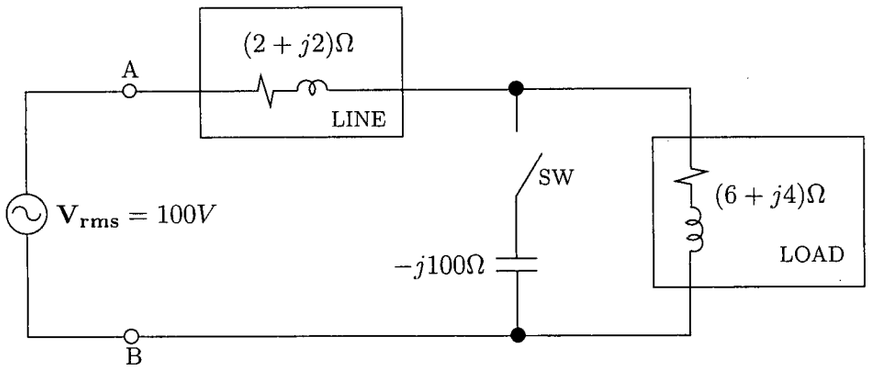


$\mathbf{I_L} =$

$i_L(t) =$

Question 6 [10 marks]

Consider the circuit below, with the switch (SW) open.



(a) Determine the total average power supplied by the source. (3 marks)
(b) Determine the power factor seen by the source at terminal AB. (2 marks)
(c) Determine the average power absorbed by the load. (2 marks)
(d) If the capacitor with impedance $-j100\Omega$ is connected across the load by closing the switch (SW), will the line losses increase or decrease? Explain. (3 marks)

$P_{ave}(\text{source}) =$

$pf =$

$P_{ave}(\text{load}) =$