UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

ECE 110H1 S -- ELECTRICAL FUNDAMENTALS
FINAL EXAMINATION, APRIL 17, 2014, 9:30 am.

First Year -- Computer, Electrical, Industrial, Mechanical, Materials, and Track One Engineering Programs.

Examiners – S. Aitchison, B. Bardakjian, A. Helmy, L. Qian, B. Wang and P. Yoo

($e = 1.6 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m)

NAME :
(PLEASE PRINT) _____ Family (Last) Name _____ Given (First) Name

STUDENT NUMBER : _____ Answer Key

EXAMINATION TYPE : A

CALCULATORS : Casio FX-991MS & Sharp EL-520X

DURATION : 2.5 hours

INSTRUCTIONS :
- DO NOT UNSTAPLE THIS EXAMINATION BOOK.
- Answer all six questions.
- All work is to be done on these pages. Show steps, compute numerical results when requested and state units.
- You may use the back of each page for rough work.
- Last blank page may be removed for rough work.
- Write down any assumption made in any of the problems.

Question	Mark
1	
2	
3	
4	
5	
6	
Total	

Q1 [**10 marks**]

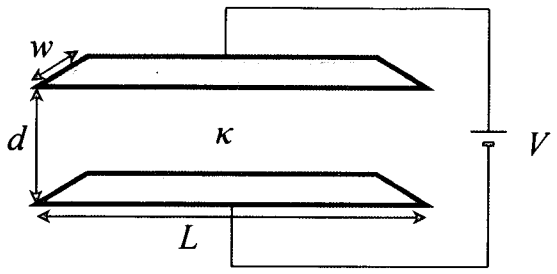


Figure 1

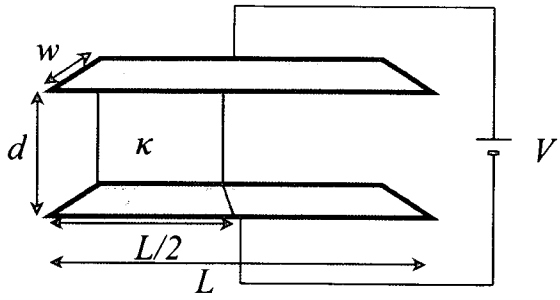


Figure 2

a) For the parallel plate capacitor in Figure 1, write down an expression (no derivation) for the capacitance of this device if it is filled with a material of relative permittivity κ and has the dimensions w, L and d. (1 mark)

$c = \kappa \frac{\varepsilon_0 wL}{d}$

b) Calculate the capacitance for the device shown in Figure 1, for w=5 mm, L=1 cm, d=1 mm and air filling **the gap** between the parallel plates. (1 mark) 4.425×10^{-13} F

c) If the air for the device in part b) is replaced with material κ=10, what is the capacitance of the device now? (1 mark) 4.425×10^{-12} F

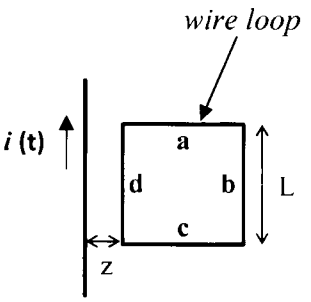
d) What is the capacitance of the device composed of the parallel connection of the two devices described in parts b) and c)? (3 marks) 4.868×10^{-12} F

e) What is the capacitance of the device shown in Figure 2, using the same dimensions as in part b) and κ=10? What is the total energy stored in this device for $V = 3$ V? (4 marks)

2.433×10^{-12} F
1.095×10^{-11} J

Q2 [**10 marks**] A wire loop is placed in close proximity to a semi-infinite wire, as shown in the diagram below. The wire forming the loop has a diameter of 0.5 mm. Each side of the loop has length, L=15 cm and is located at z=1 mm from the wire. The current through the straight wire varies with respect to time as i (t) = 3000sin(2πt) Amperes.

a) What is the direction of the induced *emf* in the wire loop between t = 0.25 s to t = 0.3 s? (2 marks) CW direction



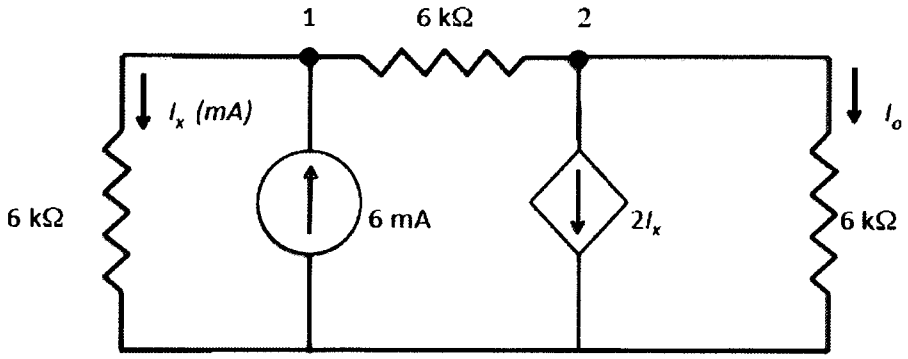
b) If segments **a** and **c** of the loop have resistivity of $2x10^{-4}$ Ωm, and segments **b** and **d** have resistivity of $1x10^{-4}$ Ωm, calculate the resistance of each wire segment. (2 marks)

$R_a = R_c = 150\ \Omega$
$R_b = R_d = 75\ \Omega$

c) What is the magnitude of the induced current in the wire loop at t = 1 s? (4 marks) 3.1 μA

d) What is the peak power dissipated within segment **d**? (2 marks) 7.2×10^{-10} W

Q3 **[10 marks]** Consider the DC circuit shown below



a) Calculate the nodal voltages at node 1 and node 2. (6 marks)

14.4 V
-7.2 V

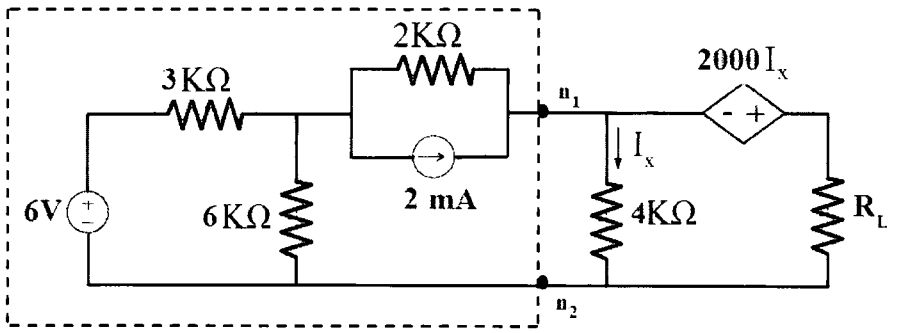
b) Calculate the current I_o. (1 mark) -1.2 mA

c) What is the power dissipated in the 6 kΩ resistor between nodes 1 and 2. (2 marks) 77.8 mW

d) Is the dependent current source supplying or absorbing power? (1 mark)

Supplying [x] Absorbing [ ]

Q4 **[10 marks]**



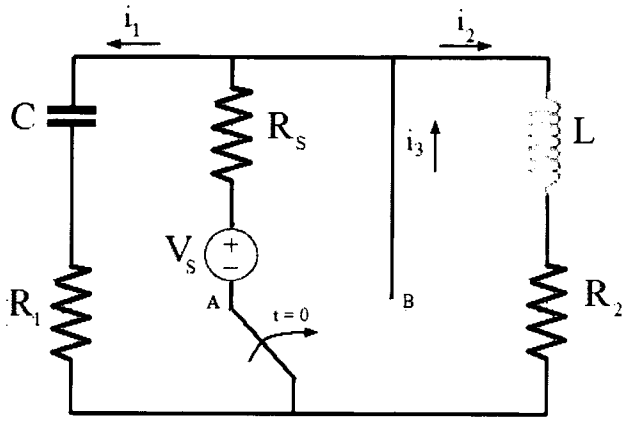
a) Find the Thevenin equivalent of the circuit inside the box between nodes n_1 and n_2 as shown. (4 marks)

$V_{th} = 8$ V
$R_{th} = 4$ kΩ

b) Consider the case of maximum power that can be transferred to the load. Using the obtained Thevenin equivalent circuit in part a) above, calculate R_L and the maximum power. (6 marks)

3 kΩ
3 mW

Q5 [**10 marks**] Consider the DC circuit shown in the figure below, where the switch has been at position A for a long time. At t = 0, the switch is moved to position B.



$V_s = 9.6$ V
$R_s = 4$ kΩ
$R_1 = 2$ kΩ
$R_2 = 8$ kΩ
$L = 0.8$ H
$C = 0.1$ μF

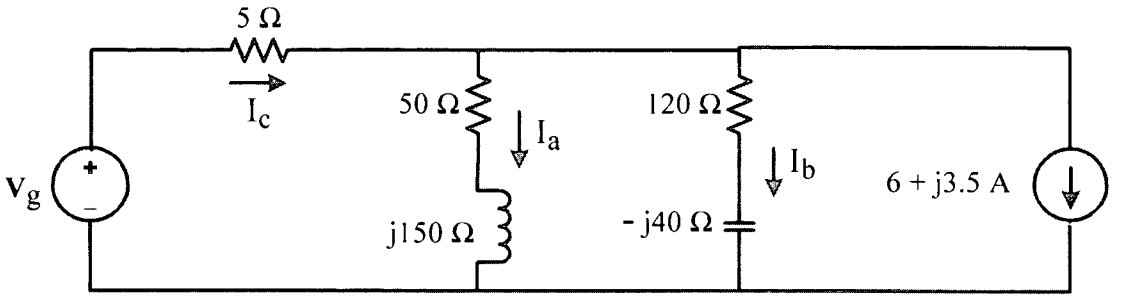
a) Find the expressions $i_1(t)$, $i_2(t)$ and $i_3(t)$ for $t \geq 0$. (8 marks)

$i_1(t) = -3.2e^{-5000t}$ mA
$i_2(t) = 0.8e^{-10000t}$ A
$i_3(t) = -3.2\text{x}10^{-3}e^{-5000t} + 0.8e^{-10000t}$ A

b) What are the energies stored in the capacitor and the inductor at t = 0? (1 mark) 2.05 μJ 0.256 J

c) What are the energies stored in the capacitor and the inductor at t = ∞? (1 mark) 0, 0

Q6 [**10 marks**] The phasor current $\mathbf{I_a}$ in the circuit shown is **2 / 0°** A.



a) Find the phasor currents $\mathbf{I_b}$ and $\mathbf{I_c}$, and the phasor voltage $\mathbf{V_g}$. (7 marks)

j2.5 A
8+j6 A
140+j330 V

b) If $f = 60$ Hz, write the expression for $v_g(t)$, and find the inductance and the capacitance. (3 marks)

358.5 cos (377t+67°) V
L = 0.4 H C = 66 μF