UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

ECE 110H1 S -- ELECTRICAL FUNDAMENTALS
FINAL EXAMINATION, APRIL 17, 2015, 2 pm

First Year -- Computer, Electrical, Industrial, Mechanical, Materials,
and Track One Engineering Programs.
Examiners – S. Aitchison, B. Bardakjian, A. Helmy, M. Mojahedi, 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, $g = 9.81$ N/kg)

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

STUDENT NUMBER : _____

EXAMINATION TYPE : A
CALCULATORS : Casio FX-991MS & Sharp EL-520X
DURATION : 2.5 hours
INSTRUCTIONS :
- Answer all six questions. Put the answers in the boxes provided.
- All work is to be done on these pages. Show steps, compute numerical results when requested and state units. Write down any assumption made.
- You may use the back of each page.
- Last blank page may be removed for rough work.

Question	Mark
1	
2	
3	
4	
5	
6	
Total	

Q1 [10 marks] Circle the correct answer

1. Which one of the following charge values cannot physically exist in nature? (1 mark)

A) 6.4×10^{-19} C

B) 64×10^{-19} C

C) 0.16×10^{-19} C

D) 112×10^{-19} C

E) 11.2×10^{-19} C

2. Which of the following lines follow the equipotential lines for the charges +Q and –Q shown? (1 mark)

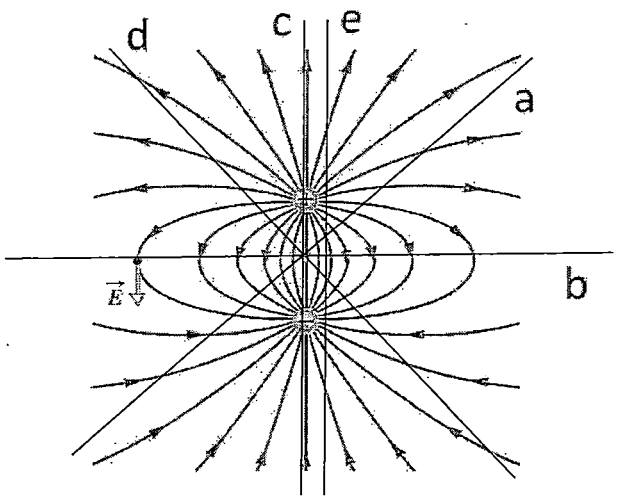
A) Line a

B) Line b

C) Line c

D) Line d

E) Line e



3. What would the mass *m* of the sphere, which has a charge of $(q_1 + q_2)$, be for it to be suspended as balance due to the effect of the forces of charges $+q_1$ and $+q_2$? (2 marks)

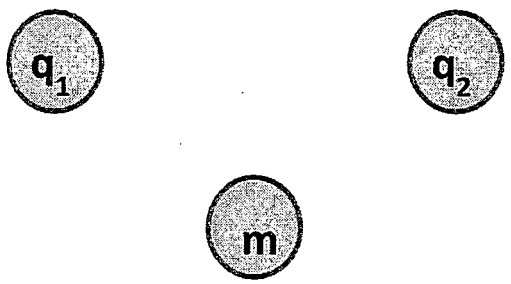
A) $(q_1 + q_2)\, q_1\, q_2 / 4\pi\varepsilon_o r^2$

B) $(q_1 + q_2) / 4\pi\varepsilon_o r^2$

C) $q_1\, q_2 / 4\pi\varepsilon_o r^2$

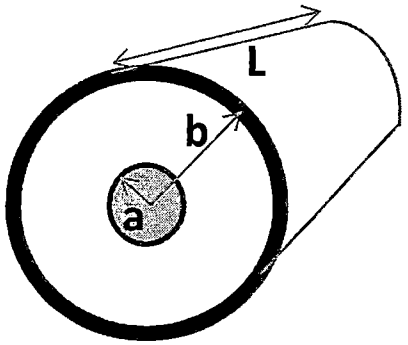
D) Balance will not be possible

E) $q_2 / 4\pi\varepsilon_o r^2$



Q1 continue.

4. What is the capacitance of the system of cylindrical conductors shown in the figure? (1 mark)



A) $2\pi\varepsilon_o L / (1 + \ln (b/a))$

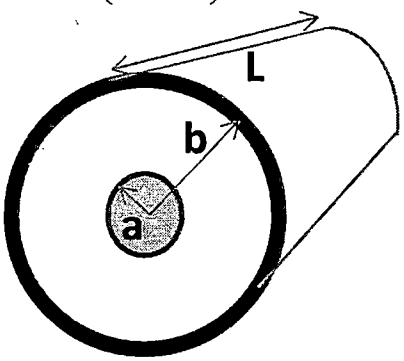
B) $\ln (b/a)$

C) $4\pi\varepsilon_o L / (b - a)$

D) $2\pi\varepsilon_o L / \ln (b/a)$

E) $1 - a/b$

5. If the capacitor shown in the figure is changed in length where $L_2 = 7$ L. What would the new dimensions of the cylinder be to maintain the capacitance of this system of conductors? (2 marks)



A) $b_2/a_2 = 7 + (b/a)$

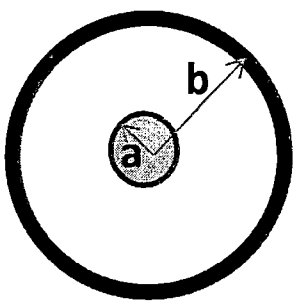
B) $b_2/a_2 = 7\ (b/a)$

C) $b_2/a_2 = \ln (7b/a)$

D) $b_2/a_2 = 1.9\ (b/a)$

E) $b_2/a_2 = (b/a)^7$

6. What is the capacitance of the system of spherical conductors shown in the figure? (1 mark)



A) $a / (1- a/b)$

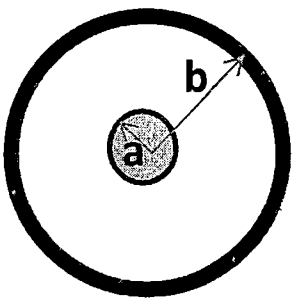
B) $4\pi\varepsilon_o ab / (b - a)$

C) $1- a/b$

D) $4\pi\varepsilon_o ab / (1- a/b)$

E) $4\pi\varepsilon_o (1- a/b)$

7. For the spherical system of conductors shown, what is the ratio of the energy stored in this system U compared to the energy stored, U_∞ of the same system when $b \to \infty$ (i.e. U / U_∞)? (2 marks)



A) $1 - a/b$

B) $4\pi\varepsilon_o (1 - a/b)$

C) $b / (1 - a/b)$

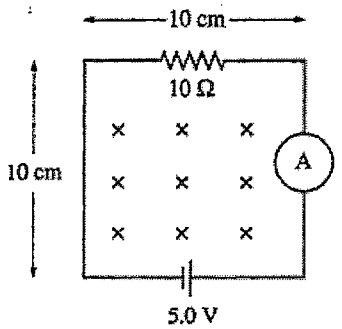
D) $4\pi\varepsilon_o / (1 - a/b)$

E) ∞

Q2 [10 marks] Circle the correct answer

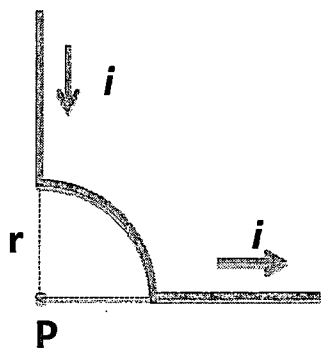
1. The circuit, shown below, is in a uniform magnetic field that is directed into the page and is decreasing in magnitude at a rate of 1.5 x 10^2 T/second. What is the reading on the ammeter? (2 marks)

A) 0.15 A
B) 0.35 A
C) 0.50 A
D) 0.65 A
E) 0.80 A



2. The wire shown below carries a current *i* and contains a circular section with a radius r, and angle π/2. What is the magnitude of the magnetic field at point P? (2 marks)

A) $B = \frac{\mu_0 i}{r}$
B) $B = \frac{\mu_0 i}{2r}$
C) $B = \frac{\mu_0 i}{4r}$
D) $B = \frac{\mu_0 i}{8r}$
E) $B = \frac{\mu_0 i}{r^2}$



3. A positively charged particle is initially at rest when a magnetic field is suddenly turned on. The magnetic field points along the z-axis. What is the direction of the net force acting on the charged particle? (2 marks)

A) Along the x-direction
B) Along the y-direction
C) Along the z-direction
D) In an arc in the xy-plane
E) There is no net force acting on the charged particle

Q2 continue.

4. Calculate the potential difference induced between the wing tips of an airplane with a wingspan of 64.67 m when it is in level flight at a speed of 913 km/h. Assume that the magnitude of the Earth's magnetic field is 5.0×10^{-4} T, pointing downwards, towards the surface of the Earth. (2 marks)

A) 8.2 V

B) 29.5 V

C) 104 V

D) 301 V

E) 0.75 V

5. A sphere of radius R is placed near a long, straight wire that carries a steady state current, *I*. The magnitude of the magnetic field generated by the current is B. The total magnetic flux passing through the sphere is: (2 marks)

A) $\mu_0 I$

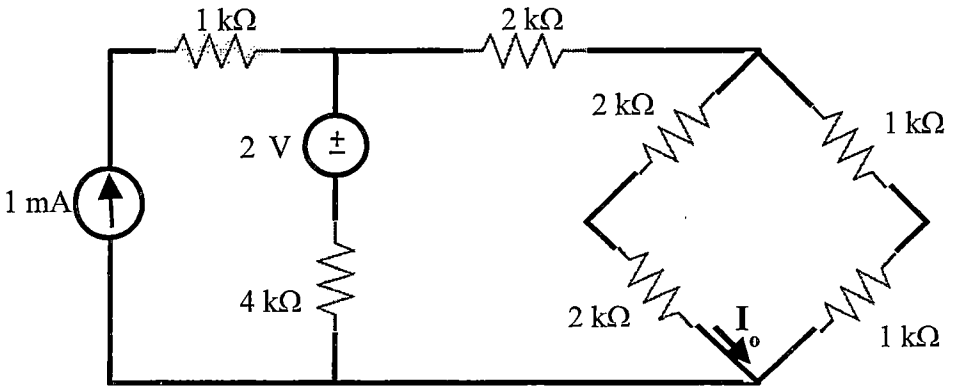
B) $\frac{\mu_0 I}{4\pi R^2}$

C) $4\pi R^2 \mu_0 I$

D) zero

E) Need more information

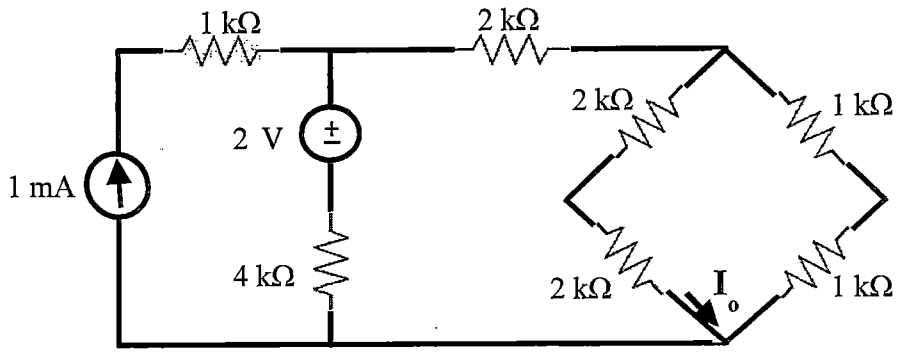
Q3 [10 marks] For the given circuit diagram below,



a) Use mesh analysis to compute $\mathbf{I_o}$. (5 marks)

$I_o =$

Q3 continue. (Circuit diagram has been duplicated for your convenience)

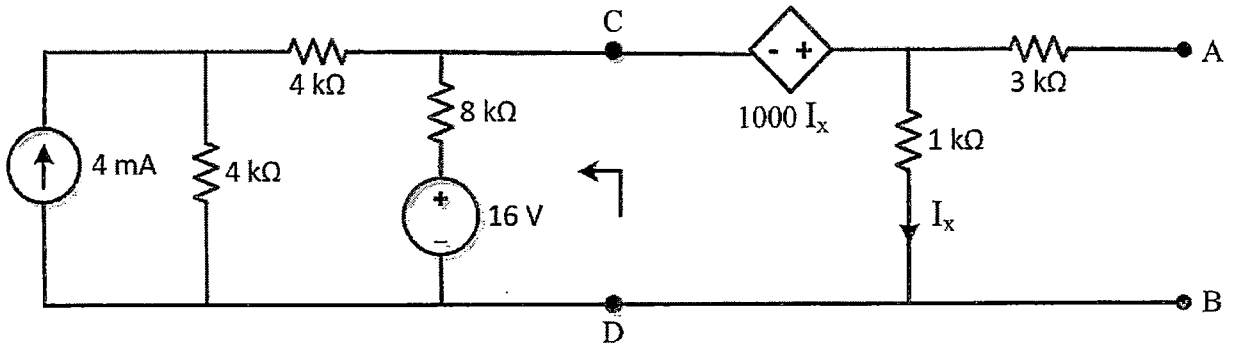


b) Use superposition to find the current in the 4 kΩ resistor. Calculate the power absorbed by the resistor. (5 marks)

$I_{4k\Omega}$ =

$P_{4k\Omega}$ =

Q4 [10 marks] For the circuit shown



a) Find the Norton equivalent circuit to the left of nodes **C** and **D**. (3 marks)

Norton Equivalent Circuit:

Q4 continue.

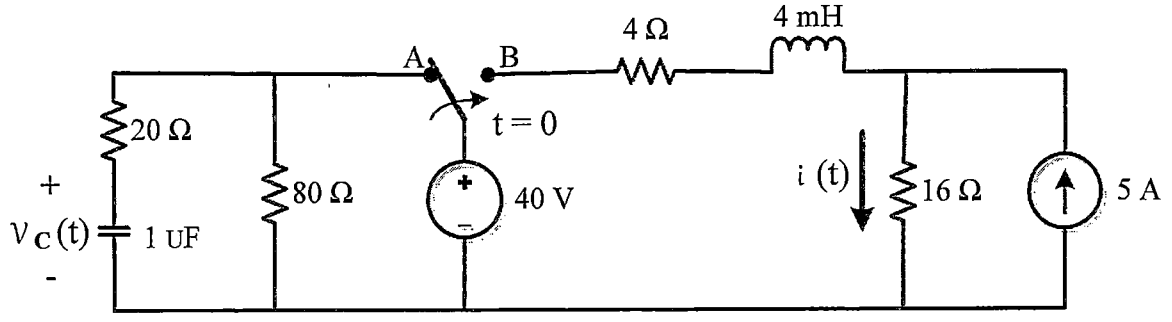
b) Find the Thevenin equivalent circuit between nodes **A** and **B**. ***Hint:*** use the results from a) (5 marks)

Thevenin Equivalent Circuit:

c) If a resistive load is connected between nodes **A** and **B**, what is the maximum power that can be transferred from this circuit. (2 marks)

$P_{max} =$

Q5 [10 marks] The switch in the circuit is in position A for a long time before moving to position B at t = 0.



a) Determine the voltage across the capacitor at $\mathbf{t = 0^+}$. (1 mark)

$v_C(0^+) =$

b) Find the expression for $v_C(t)$ for $\mathbf{t > 0}$. (3 marks)

$v_C(t) =$

Q5 continue.

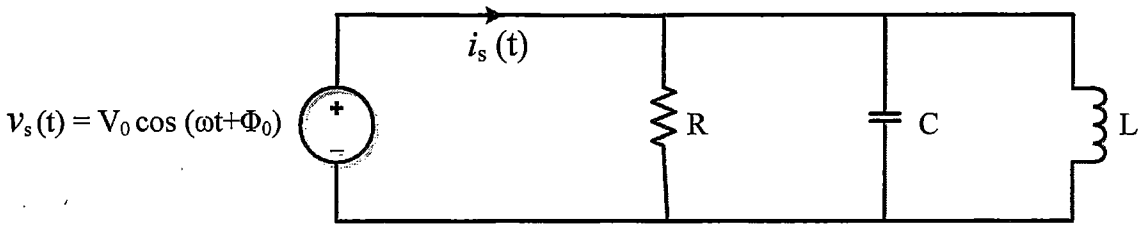
c) Determine the current in the inductor at $\mathbf{t = 0^+}$. (1 mark)

$i_L(0^+) =$

d) Find the expression for $i(t)$ for $\mathbf{t > 0}$. (5 marks)

$i(t) =$

Q6 [10 marks]



a) Redraw the circuit in frequency domain, clearly indicate the phasors, $\mathbf{V_s}$ and $\mathbf{I_s}$ and impedances for R, C and L. (2 marks)

b) Let $\mathbf{Z} = \mathbf{V_s} / \mathbf{I_s}$, show that the frequency for which **Z** is purely real, the so called resonance frequency, is given by $\omega_0 = \frac{1}{\sqrt{A}}$. Determine A. (5 marks)

A =

Q6 continue.

c) Show that at the resonance frequency (ω_0) the currents in the capacitor and the inductor are equal in magnitude but 180° out of phase from each other. (3 marks)