University of Toronto
Faculty of Applied Science and Engineering
Department of Electrical and Computer Engineering

ECE110S – Electrical Fundamentals
Term Test 2 – March 28, 2017, 1:30 – 3:00p.m.

($e = 1.6 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m, g = 9.81 N/kg)

ANSWER ALL QUESTIONS ON THESE SHEETS, USING THE BACK SIDE IF NECESSARY.

1. Non-programmable calculators (Casio FX-991MS & Sharp EL-520X) are allowed.
2. For full marks, you must show methods, state UNITS and compute numerical answers when requested.
3. Write in PEN. Otherwise, no remarking request will be accepted.
4. There is one extra blank page at the end for rough work.

Last Name: ______________________

First Name: Solutions

Student Number: ______________________

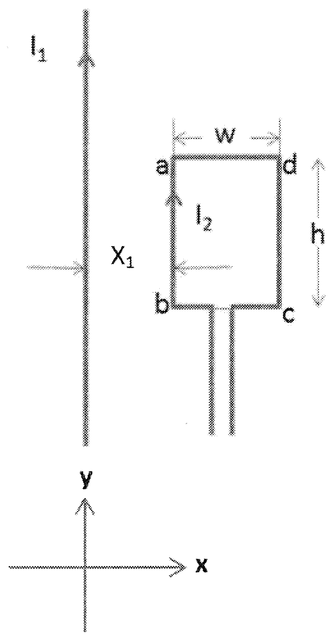
Tutorial Section:
(YOU LOSE ONE MARK FOR NOT MARKING YOUR TUTORIAL SECTION CORRECTLY)

☐	01	GB404	Mon. 3-5 p.m.
☐	02	SF2202	Mon. 3-5 p.m.
☐	03	WB342	Thu. 12-2 p.m.
☐	04	WB342	Thu. 4-6 p.m.
☐	05	GB404	Fri. 4-6 p.m.
☐	06	GB304	Thu. 12-2 p.m.
☐	07	WB341	Tue. 3-5 p.m.
☐	08	SF2202	Wed. 10-12 p.m.
☐	09	GB405	Tue. 10-12 p.m.
☐	10	BA1240	Tue. 3-5 p.m.
☐	11	SF2202	Fri. 9-11 a.m.
☐	12	BA1220	Wed. 4-6 p.m.

Question	Mark
1	
2	
3	
TOTAL	

Q1 [10 marks]

Consider the two-wire construction shown in the figure below, $I_1 = 15$ A, $I_2 = 1$ A, $x_1 = 3$ m, $w = 2$ m, and the height h=4 m.



(a) **[2 marks]** Write down an expression as a function of distance for the magnitude and direction of the magnetic field created by the current I_1. No derivation is required.

$$\vec{B} = \frac{\mu_0 I}{2\pi r} \hat{r}$$

(b) **[3 marks]** Calculate the force on the sides *ab* and *cd* of the rectangular wire loop, taking into account only the magnetic field created by I_1.

$$F_{ab} = -4\times10^{-6} N \hat{x}$$

$$F_{cd} = 2.4\times10^{-6} N \hat{x}$$

(c) **[1 mark]** If the rectangular wire loop is suspended and is free to move; which direction will it move to?

I. Positive x-direction
II. Negative x-direction
III. Positive y-direction
IV. Negative y-direction
V. The loop will not move

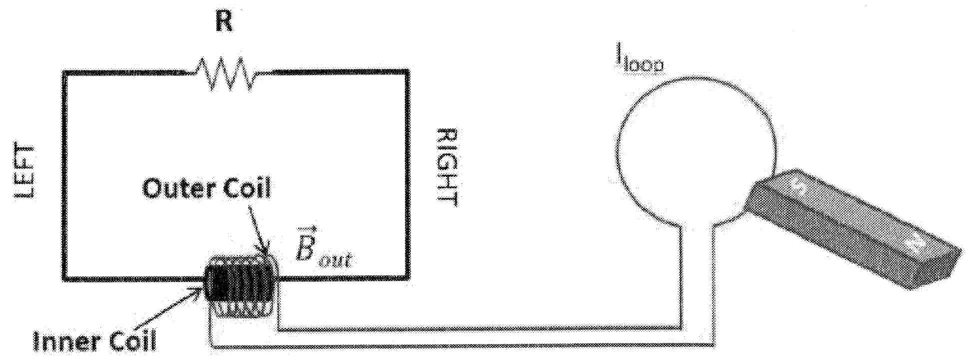
Answer: II

(d) **[4 marks]** Calculate the magnitude of the magnetic flux passing through the rectangular wire loop due to I_1.

$$\phi_B = \frac{\mu_0 I_1}{2\pi} h \ln(x) \Big|_{x_1}^{x_1 + w}$$

Q2 [10 marks]

Consider the following system that consists of two independent circuits that are electromagnetically coupled through a pair of coils (one located within the other). All elements of this system lie flat with respect to the paper.



(a) **[3 marks]** The first circuit consists of a single circular loop connected in series with the outer coil. Let's say the south pole of a magnet, which was initially located far away above the paper, is moved towards but not through the conductive loop. Which of the following statements must be true? (I_{loop} = current induced in the loop; B_{out} = magnetic field induced through the outer coil)

I. I_{loop} = clockwise, B_{out} = right-to-left
II. I_{loop} = counter-clockwise, B_{out} = right-to-left
III. I_{loop} = clockwise, B_{out} = left-to-right
IV. I_{loop} = counter-clockwise, B_{out} = left-to-right

Answer: III

Consider the case where the magnet shown in the diagram above, is displaced such that it induces a time dependent current, $I_{loop}(t) = 6.5t$ Amperes, where t = time, through the outer coil (length = 10 cm, 500 turns). This current is electromagnetically coupled to the inner coil (40 turns, cross-sectional area = 2 cm^2), which results in a peak power dissipated at the resistor, R = 2 kΩ.

(b) **[3 marks]** Calculate the magnetic field in the outer coil:

$B = 4.08 \times 10^{-2} t$ T

(c) **[2 marks]** Calculate the induced emf in the inner coil:

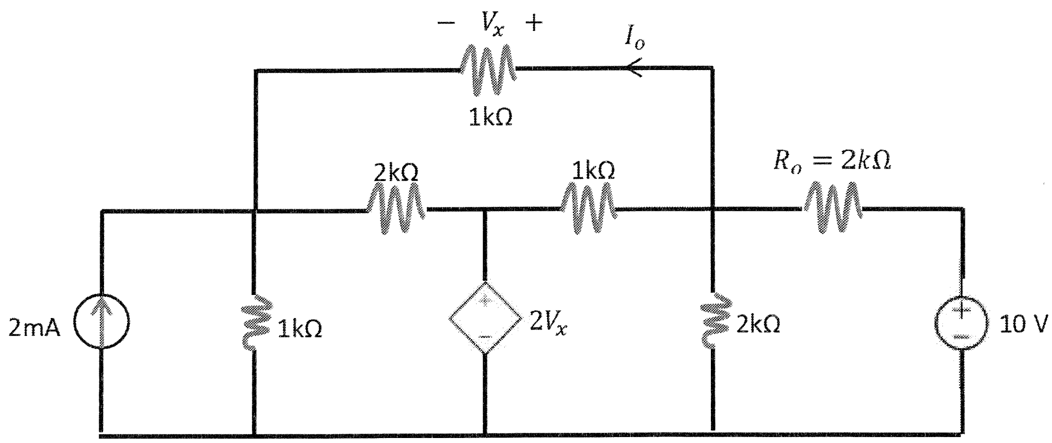
$$\mathcal{E} = -N \frac{d}{dt} \phi_B = -3.28 \times 10^{-4} V$$

(d) **[2 marks]** Calculate the current through the resistor

$$|I| = 0.164 \mu A$$

Q3 [10 marks]

Consider the following circuit:



(a) **[7 marks]** Compute I_o using Nodal Analysis

$V_a = \frac{24}{11}$ V

$V_b = \frac{31}{11}$ V

$I_o = \frac{7}{11}$ mA

(b) **[1 mark]** Compute power in resistor R_o

$P_{R_o} = 25.789 mW$

(c) **[2 marks]** Compute power in the independent sources

$P_{current} = -4.3636 mW$

$P_{voltage} = -35.91 mW$