First name (please write as legibly as possible within the boxes)

Last name

Student ID number

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

ECE110H1S – Electrical Fundamentals
Final Examination – April 24, 2023, 6:30 pm

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

**Examination Type: C** (Students may use a single, double-sided 8.5" x 11" aid sheet, handwritten or printed)

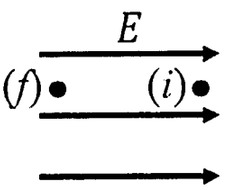
**Calculators:** Non-programmable calculators (Casio FX-991MS & Sharp EL-520X) are allowed.

**Duration:** 2.5 hours

**Instructions:**

Answer all five questions.
For full marks, you must show methods, state UNITS and compute numerical answers (when requested).
There is two extra blank pages at the end for rough work.

Q1.1) The figure shows a uniform electric field. An electron has moved from position (*i*) to position (*f*). Let $\Delta V$ be the change in electrostatic potential of the electron and $\Delta U$ be the change in potential energy of the electron. Circle the correct answer: [2 marks]



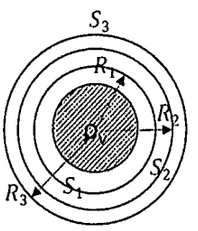

a) In moving from (i) to (f): $\Delta V < 0$ and $\Delta U < 0$

b) In moving from (i) to (f): $\Delta V > 0$ and $\Delta U > 0$

c) In moving from (i) to (f): $\Delta V < 0$ and $\Delta U > 0$

d) In moving from (i) to (f): $\Delta V > 0$ and $\Delta U < 0$

1.2) The figure shows a positive volume charge density $\rho_v$ (hatched region) completely enclosed by three spherical Gaussian surfaces $S_1$, $S_2$, and $S_3$ with radii $R_1$, $R_2$, and $R_3$. Let $\Phi_1$, $\Phi_2$ and $\Phi_3$ be the electric fluxes through $S_1$, $S_2$, and $S_3$ , respectively. Circle the correct answer. [2 marks]



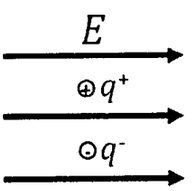

a) $\Phi_1 < \Phi_2 < \Phi_3$

b) $\Phi_1 > \Phi_2 > \Phi_3$

c) $\Phi_1 > \Phi_2 < \Phi_3$

d) $\Phi_1 = \Phi_2 = \Phi_3$

1.3) The figure shows a uniform electric field and positive charge $q^+$ and negative charge $q^-$. What are the directions of the current densities associated with positive ($\vec{J}^+$) and negative charges $\vec{J}^-$)? Circle the correct statement below: [2 marks]




a) Both point from left to right

b) Both point from right to left

c) $\vec{J}^+$ points from left to right and $\vec{J}^-$ points from right to left

d) $\vec{J}^+$ points from right to left and $\vec{J}^-$ points from left to right

1.4) In step 1, a capacitor was charged by connecting it to a battery. The battery was then removed. In step 2, a dielectric was inserted between the two plates of the same capacitor.
If the total electric field between the two plates of the capacitor in step-1 was $\vec{E}_1$ and the total electric field between the two plates of the capacitor in step-2 was $\vec{E}_2$, circle the correct statement below. [2 marks]

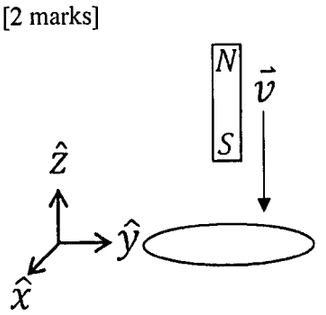
a) $|\vec{E}_1| > |\vec{E}_2|$

b) $|\vec{E}_1| < |\vec{E}_2|$

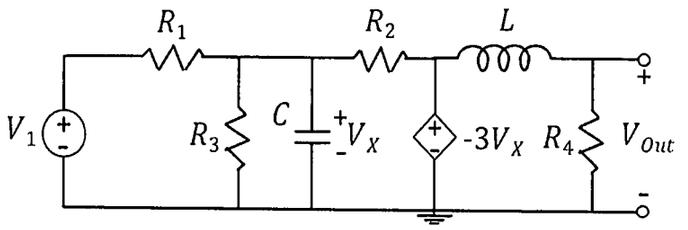
c) $|\vec{E}_1| = |\vec{E}_2|$

d) $|\vec{E}_1| = |\vec{E}_2| = 0$

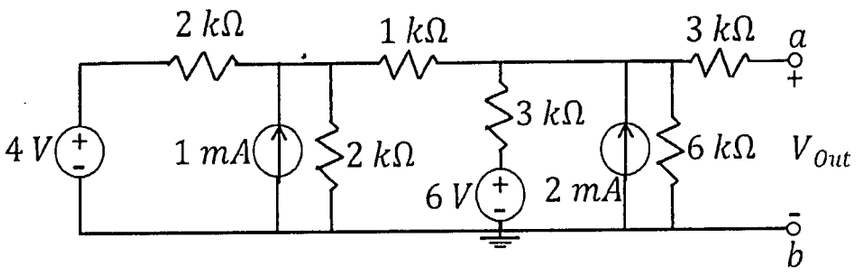
1.5) The figure shows a bar magnet moving in the negative z-direction, toward a metallic ring placed in the x-y plane. On the figure, clearly indicate the direction of induced current. [2 marks]



Q2. Consider the following circuit where: $R_1 = 100\ \Omega$, $R_3 = 100\ \Omega$, $R_4 = 150\ \Omega$. C = 100nF, L = 5mH. $V_1$ produces a DC voltage. Determine the value of $R_2$ that makes $V_{out}/V_1 = -1.2$.
[10 marks]



Q3. A) Given the circuit below, find $V_{out}$ using source transformation [7 marks].



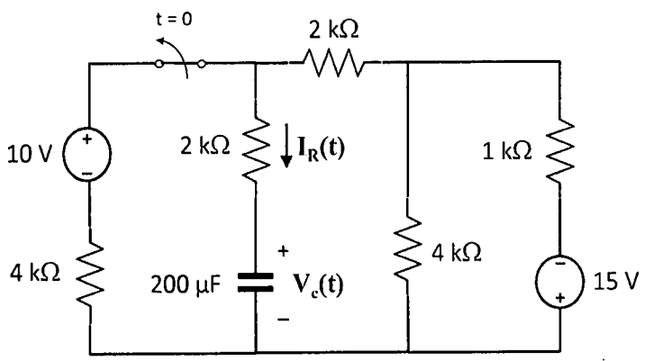
Q3. B) If a load with resistance $R_L$ is connected between the output terminals "a" and "b", determine [3 marks]:

(i) $R_L$ for maximum power transfer

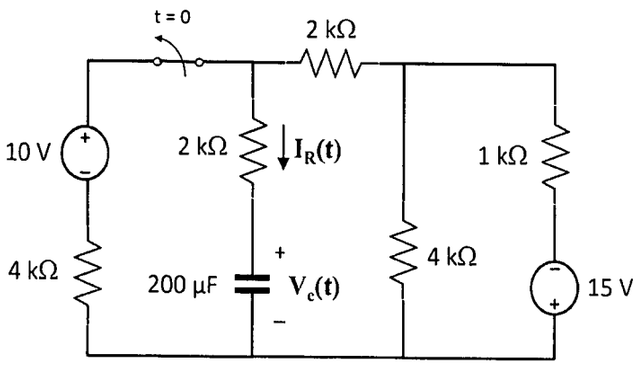
(ii) The maximum power transferred.

Q4. The switch of the following circuit will open at t = 0 seconds.

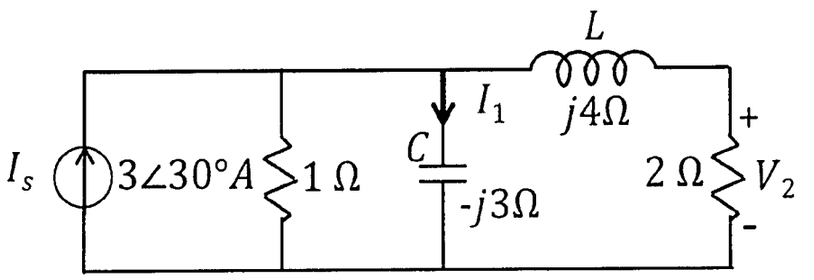
A) Determine the expression for the voltage across the 200 μF capacitor. Hint: use the step-by-step method [7 marks].



B) Plot the current through the 2 kΩ resistor [$I_R(t)$]. The circuit is reprinted for your convenience. [3 marks].



Q5. The current source $I_s$ in the circuit is a 60 Hz sinusoidal waveform.




A) Determine the current phasor, $\mathbf{I}_1$ and the voltage phasor, $\mathbf{V}_2$. [4 marks]

B) What is the voltage across the 2 Ω resistor, expressed as a function of time? Sketch the waveform. [2 marks]

C) Find the inductance, L, and the capacitance, C, in the circuit. [2 marks]

D) Suppose the frequency of the current source is doubled. Redraw the circuit and clearly indicate the impedance of each element. [2 marks]