UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

Q1	/25
Q2	/25
Q3	/25
Q4	/25
Total	/100

FINAL EXAMINATION

APRIL 2000
EXAM TYPE: A
First Year Programs: 01, 02, 03, 04, 06, 08

ECE 110S: ELECTRICAL FUNDAMENTALS

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NAME: _____
Last First

STUDENT NO.: _____

INSTRUCTIONS:

- This is a Type A examination; no aids are allowed.
- Only non-programmable calculators are allowed (the allowed models are specified in the Faculty Calendar).
- Answer all parts of all four questions.
- All four questions are of equal weight.
- The weight of each of the individual parts of each question is stated in the margins.
- All work is to be done on these pages.
- Place your final answers in the provided boxes unless instructed otherwise.
- When answering the questions include all the steps of your work on these pages. For additional space, you may use the back of the preceding page.
- Do not unstaple this exam.

CONSTANTS:

$e = 1.6 \times 10^{-19}$C $\qquad \varepsilon_o = 8.85 \times 10^{-12}$F/m $\qquad \mu_o = 4\pi \times 10^{-7}$H/m

Question 1: Electricity and Magnetism

PART A: General

Complete the following sentences:

[1] (i) Electrostatics is a study of _____ .

[1] (ii) Electrical and Magnetic phenomena stem from a property of matter known as _____ .

[1] (iii) Materials in which charges cannot move are known as _____ or _____ .

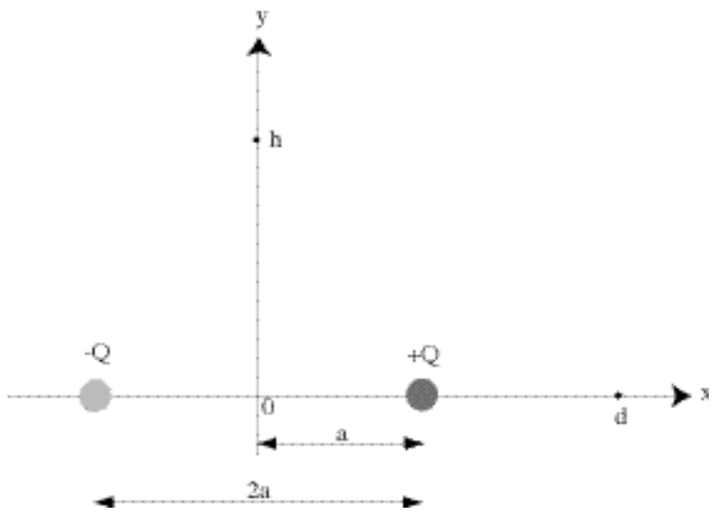
[1] (iv) The work W done by a charge Q as it (the charge) lowers its potential by V is mathematically expressed as _____ .

[1] (v) A solenoid in its simplest form is _____ .

Question 1: Electricity and Magnetism

PART B: Electric Field and Electric Potential

Consider the electric dipole shown in the figure below.



[4] (i) Determine the electric field, including its direction, at $x = d$, where $d > a$, due to the given electric dipole.

E =

[2] (ii) A positive point charge q is placed at $x = d$. Determine the electric force, including its direction, experienced by the test charge due to the given dipole.

F =

[1] (iii) Draw several electric field lines for the given dipole on the above figure.

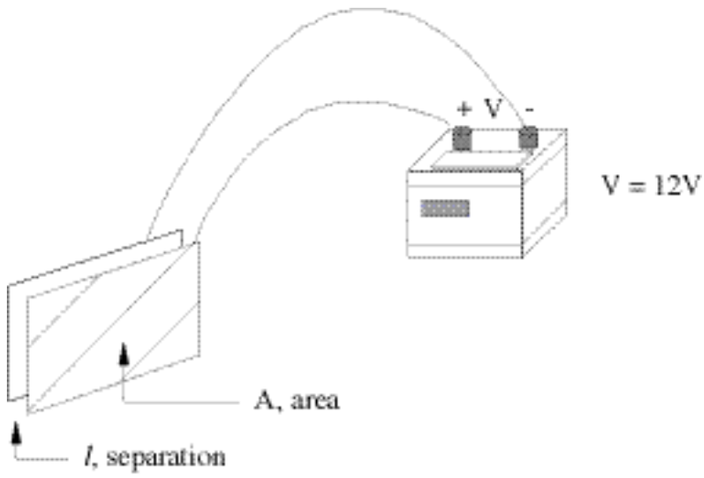
[2] (iv) If the electric potential at the origin is 0, determine the electric potential at $y = h$. Explain your result.

V *(x=0, y=h)* =

Question 1: Electricity and Magnetism

PART C: Capacitors

A 12 V battery is connected to the parallel plates as shown in the figure below.



[2] (i) If the positively charged parallel plate has an electrical charge of 12 nC and the negatively charged plate -12 nC, compute the capacitance C for the given parallel plate capacitor.

C =

[2] (ii) If the spacing between the parallel plates is l = 0.001 m, compute the area A of the parallel plates.

A =

[1] (iii) Potential difference is generally expressed as $V_f - V_i = -\int_i^f \boldsymbol{E} \quad d\boldsymbol{r}$.

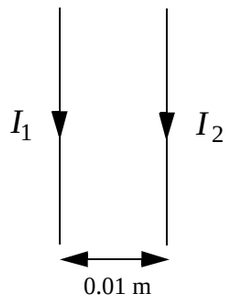
Using this expression, compute the strength of the electric field between the charged parallel plates.

| **E** | =

Question 1: Electricity and Magnetism

PART D: Magnetic Field and Magnetic Force

Two long, parallel conductors separated by a distance of 0.10 m carry currents in the same direction. The first conductor carries a current $I_1 = 10A$ and the second conductor carries current $I_2 = 8A$.



[3] (i) Calculate the magnetic field at conductor 2 due to the current I_1 in conductor 1.

| **B** | =

Direction:

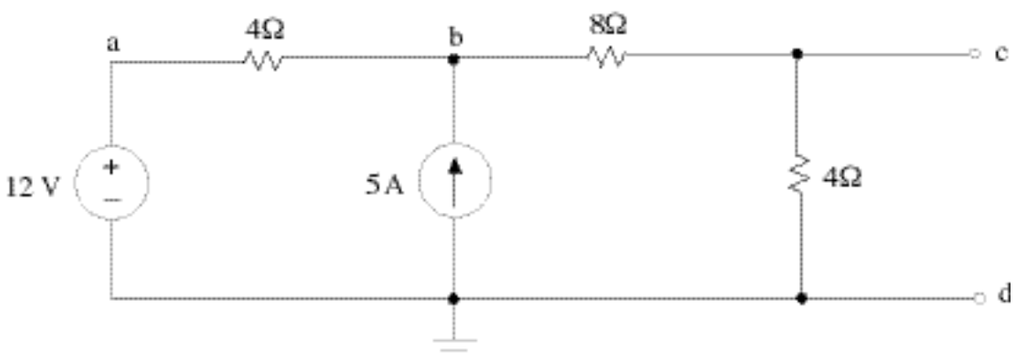
[3] (ii) Calculate the magnetic force per unit length exerted on I_2 by I_1.

| **F** | =

Direction:

Question 2: DC Circuits

Consider the circuit shown below.



[4] (i) Use Nodal Analysis to find the voltage V_b.

V_b =

[2] (ii) Determine the voltage V_{cd}.

V_{cd} =

[4] (iii) Find the total power supplied by the sources.

ΣP_s =

Question 2: DC Circuits

[7] (iv) Use the Principle of Superposition to determine the voltage V_{cd}.

V'_{cd} (due to 12 V) =

V''_{cd} (due to 5A) =

V_{cd} =

[3] (v) Determine the equivalent resistance seen between terminals c and d.

R_{eq} =

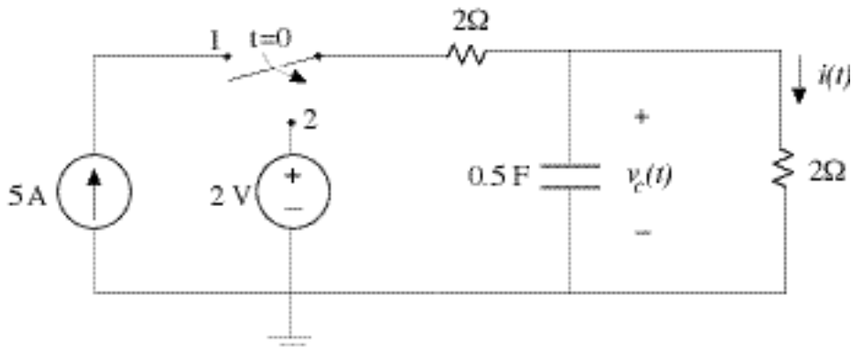
[5] (vi) Determine the Norton equivalent circuit with respect to terminals c and d.

I_N =

R_N =

Question 3: Transient Analysis

For the circuit shown below, assume that the switch stayed at position 1 for a long time and that it changed from position 1 to position 2 at time t = 0.



[4] (i) Find $v_c(t)$ for $t = 0^-$ and $t = 0^+$.

$v_c(0^-)$ =

$v_c(0^+)$ =

[10] (ii) Derive the differential equation in $v_c(t)$ for $t > 0$.

Differential equation $v_c(t)$ for $t>0$:

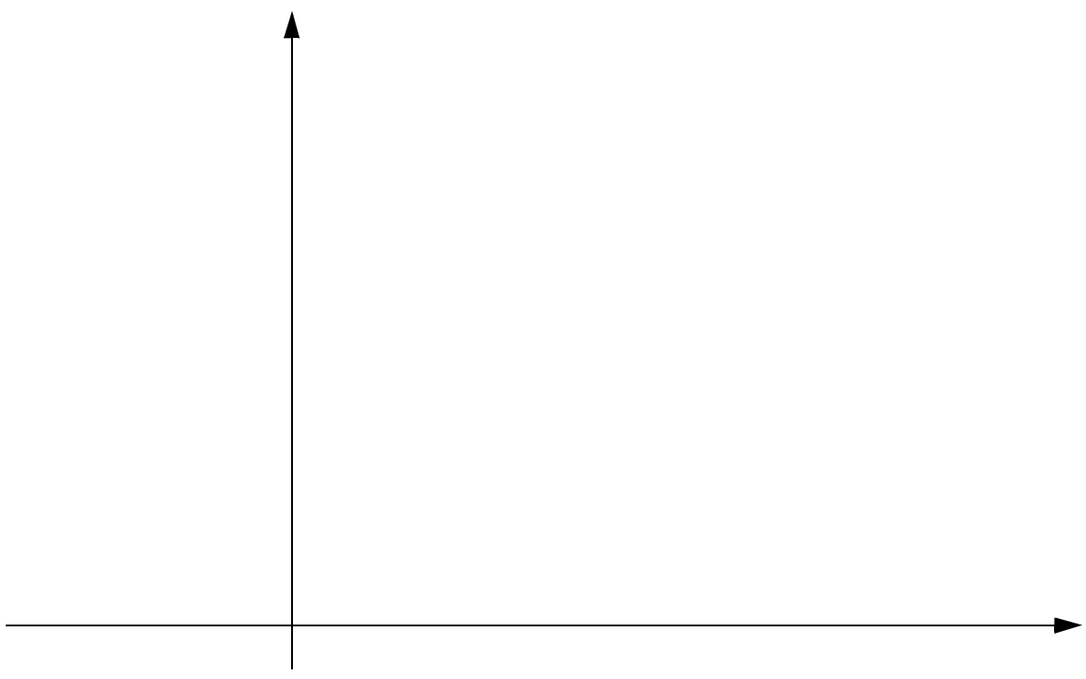
Question 3: Transient Analysis

[6] (iii) Find $v_c(t)$ and $i(t)$ as functions of time for $t > 0$.

$v_c(t)$ for $t>0$:

$i(t)$ for $t>0$:

[5] (iv) Sketch $v_c(t)$ for all time; clearly label the axes.



Question 4: AC Circuits

A 10 MHz sinusoidal wave generator has an open circuit voltage of 0.5 V (peak voltage) in magnitude. The output (Thévenin) impedance of the generator consists of a 50 Ω resistor connected in parallel to a 100 pF capacitor.

A load, which is attached to the output terminals of the generator, consists of a 100 Ω resistor connected in parallel to a 50 pF capacitor.

[5] (i) Draw a schematic diagram of the circuit in the time domain; include the value of all the components.

Time domain

[5] (ii) Draw a schematic diagram of the circuit in the frequency domain; include the value of all the components.

Frequency domain

Question 4: AC Circuits

[4] (iii) Determine the current in the load. State the value of the current in the frequency domain.

Frequency domain

[4] (iv) Give the value of the current in the load in the time domain.

Time domain

[3] (v) Give the value of the voltage across the load in the frequency domain.

Frequency domain

[4] (vi) Determine the power delivered to the load. Specifically, give the Apparent power, Real power, Reactive power and the Power Factor (PF).

Apparent power

Real power

Reactive power

Power Factor (PF)