

UNIVERSITY OF TORONTO  
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, APRIL 2007

First Year – Industrial and Mechanical Engineering Programs

ECE 110H1 S – ELECTRICAL FUNDAMENTALS

Exam. Type: A

Examiners – L. de Windt and B. Wang

NAME : (PLEASE PRINT)	FAMILY NAME	GIVEN NAME
STUDENT NUMBER :		

EXAMINATION TYPE : Type A – Paper for which no data are permitted other than the information printed on the examination paper.

CALCULATORS : ONLY Non-programmable scientific type allowed (models as specified in the Faculty Calendar).

DURATION : 2.5 hours

- INSTRUCTIONS :
- DO NOT UNSTAPLE THIS EXAM. BOOK.
  - Answer all six questions.
  - All six questions are of equal weight.
  - All work is to be done on these pages. Show methods, compute numerical results when requested and state units.
  - Place your final answer in the corresponding box. You may use the back of the preceding page for rough work.

$$e = 1.6 \times 10^{-19} \text{ C}, \quad \epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}, \quad \mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

Question	Mark
1	
2	
3	
4	
5	
6	
Total	

Part A

Two point charges are located according to Figure 1.1 below.

- i) Determine the net electric field (magnitude and direction) at the origin.
- ii) If a third point charge ( $+q$ ) is added to reduce the net field at the origin to zero, where (i.e. the coordinates) should the point charge be located?

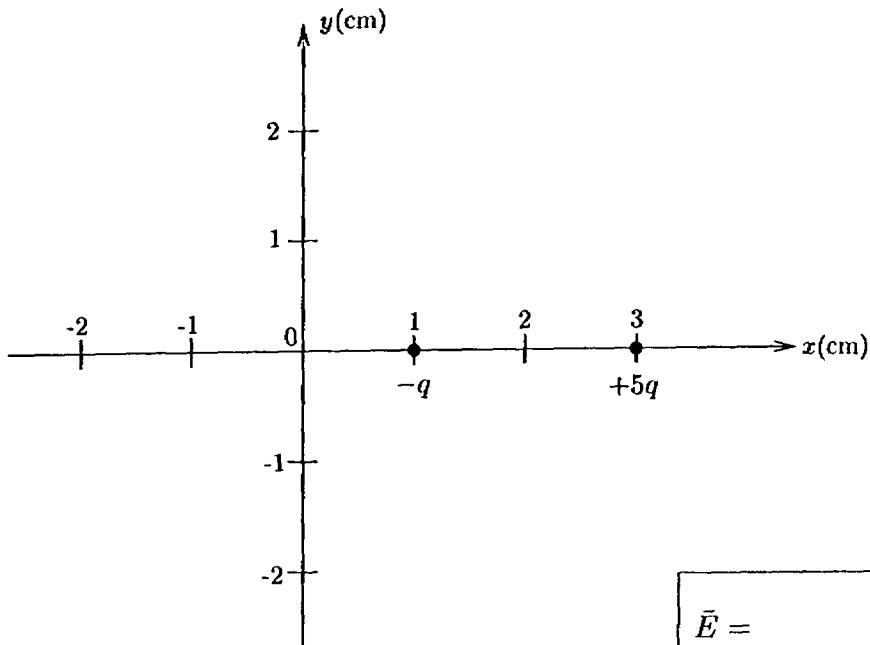


Figure 1.1

$\bar{E} =$

Coordinates:

**Part B**

- i) A rigid conducting loop is halfway into a magnetic field. Suppose the magnetic field begins to increase rapidly in strength. What happens to the loop (circle the correct answer below)?

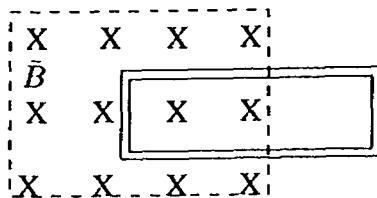


Figure 1.2

- 1) The loop is pushed upward.
  - 2) The loop is pushed downward.
  - 3) The loop is pulled to the left, into the magnetic field.
  - 4) The loop is pushed to the right, out of the magnetic field.
  - 5) The tension in the wires increases but the loop does not move.
- ii) The magnetic field in Figure 1.3 decreases from 1.0 T to 0.4 T in 1.2 s. A 6 cm diameter conducting loop with a resistance of  $0.01 \Omega$  is placed perpendicular to  $\bar{B}$  as shown. What are the magnitude and the direction (cw or ccw) of the current induced in the loop during the 1.2 s time interval?

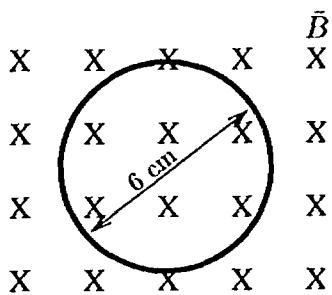
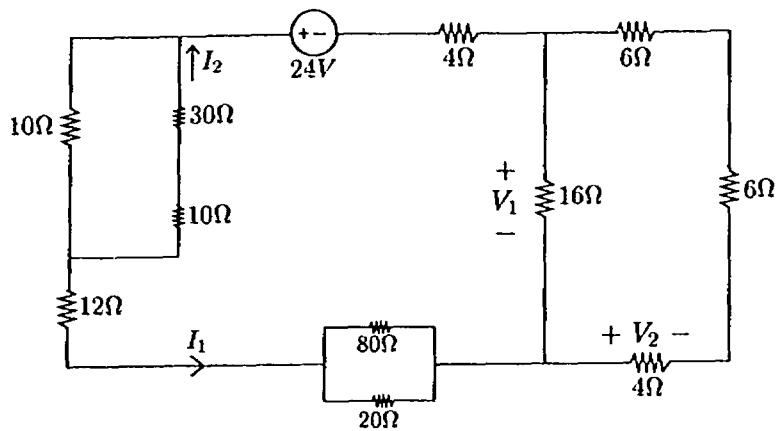


Figure 1.3

Part A

Determine the values of  $V_1$ ,  $V_2$ ,  $I_1$ , and  $I_2$  in Figure 2.1

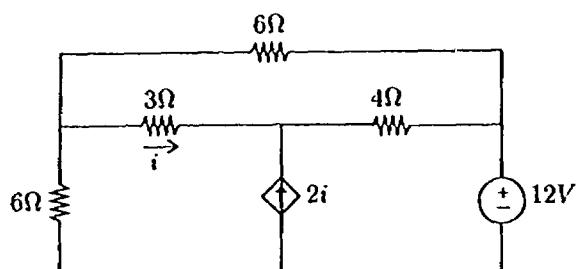


$$\begin{aligned}V_1 = \\V_2 = \\I_1 = \\I_2 =\end{aligned}$$

Figure 2.1

Part B

Determine the value of  $i$  in Figure 2.2.

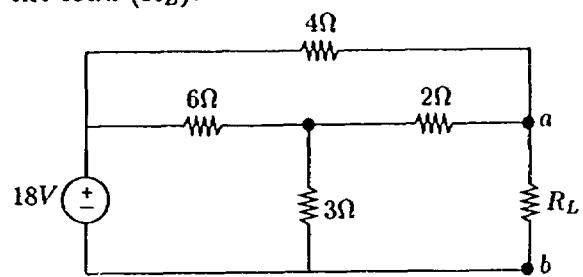


$$i =$$

Figure 2.2

Part A

For the circuit shown in Figure 3.1, determine the maximum power that can be transferred to the load ( $R_L$ ).



$$P_{\max} =$$

Figure 3.1

**Part B**

Find the Norton equivalent circuit for the circuit shown in Figure 3.2.

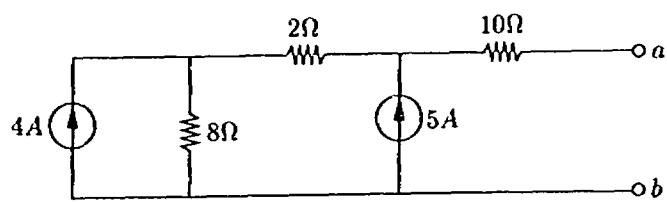
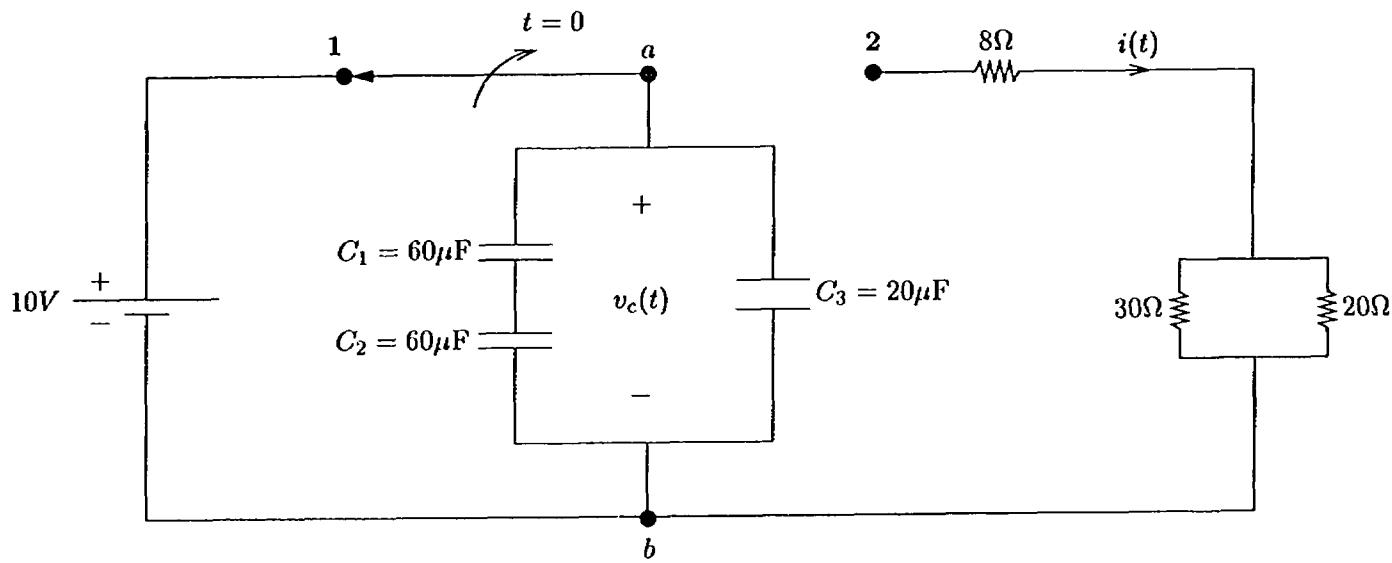


Figure 3.2

Norton Equivalent Circuit

In the circuit below, the switch is in position 1 until all three capacitors are fully charged. At  $t = 0$ , the switch moved to position 2. Determine:

- i) The charge  $q_1$ ,  $q_2$ , and  $q_3$  on the top plate of each capacitor at  $t = 0$ .
- ii) The total energy stored in capacitors at  $t = 0$ .
- iii) The equivalent capacitance between nodes  $a$  and  $b$ .
- iv) The differential equation of the circuit for  $t > 0$  in terms of  $v_c(t)$ .
- v) The time constant  $\tau$  for  $t > 0$ .
- vi) The voltage  $v_c(t)$  for  $t \geq 0$ .
- vii) The initial current through the  $8\Omega$  resistor, just after the switch moved to position 2.
- viii) The time at which the current through the  $8\Omega$  resistor decay to half the value it had just after the switch moved to position 2.



- |   |                     |
|---|---------------------|
| i) $q_1(t = 0) =$                       | v) $\tau =$         |
| $q_2(t = 0) =$                          | vi) $v_c(t) =$      |
| $q_3(t = 0) =$                          | vii) $i(t = 0^+) =$ |
| ii) $W_c(t = 0) =$                      | viii) $t_x =$       |
| iii) $C_{eq} =$                         |                     |
| iv) Differential Equation for $t > 0$ : |                     |

**Additional Space for Question 4.**

**Page 9 of 11**

**Question 5**

Page 10 of 11

For the circuit shown in Figure 5, the operational amplifiers are ideal and operating in their linear regions. Determine:

i) The input resistance seen by the  $0.2V$  voltage source,  $R_{in1}$

ii) The voltage  $v_{01}$

iii) The voltage  $v_{02}$

iv) The voltage  $v_{03}$

v) The voltage  $v_{04}$

vi) The current  $i_F$

vii) The current  $i_0$

i)  $R_{in1} =$

ii)  $v_{01} =$

iii)  $v_{02} =$

iv)  $v_{03} =$

v)  $v_{04} =$

vi)  $i_F =$

vii)  $i_0 =$

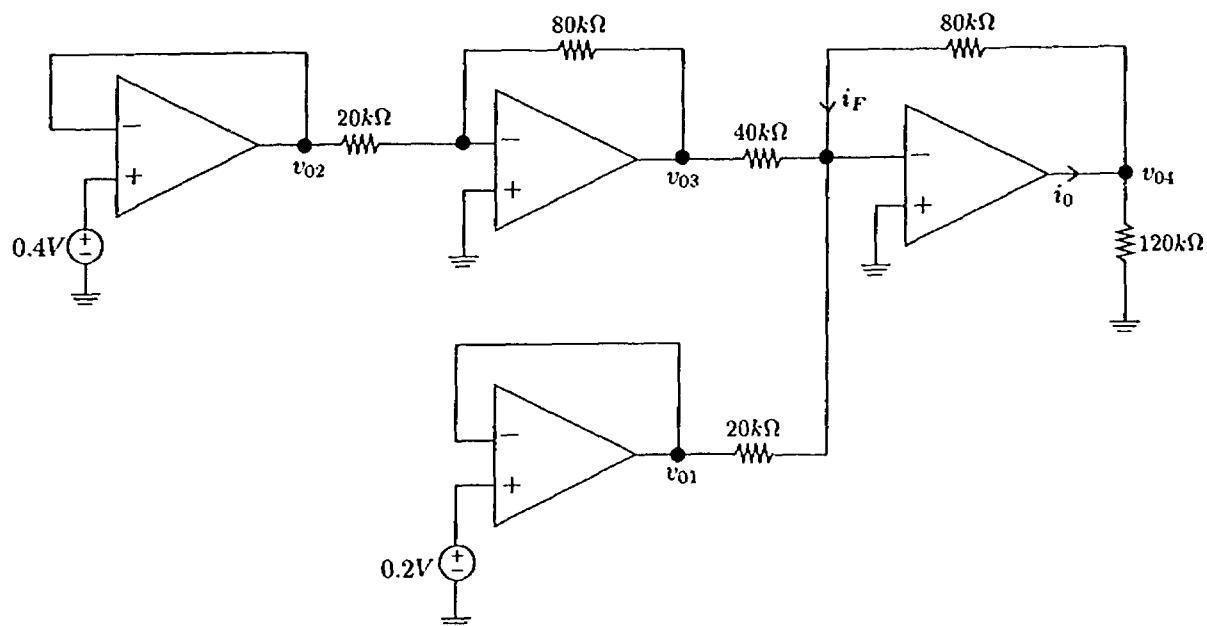


Figure 5

For the circuit shown in Figure 6, the voltage source is sinusoidal with magnitude of  $100\sqrt{2}$  V peak, an angular frequency of 377 rad/sec and a phase angle of  $0^\circ$ . The voltage source supplies 1000 VA at a 0.94 leading power factor. Determine:

- i) The current  $i(t)$ .
- ii) The reactive power absorbed by the Load,  $Q_{\text{Load}}$ .
- iii) The impedance of the Load,  $Z_{\text{Load}}$ .
- iv)  $R$  and  $C$  or  $R$  and  $L$ . Assuming a series model for  $Z_{\text{Load}}$ .

i)	$i(t) =$
ii)	$Q_{\text{Load}} =$
iii)	$Z_{\text{Load}} =$
iv)	$R =$ $C =$ or $L =$

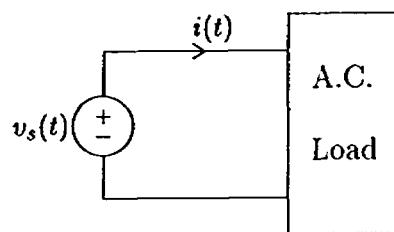


Figure 6