ANSWER KEY

McGill University
Faculty of Engineering

COURSE: ECSE200 – Fundamentals of Electrical Engineering

FINAL EXAMINATION

Examiner: Thomas Szkopek ______________

Date: 14 June 2007 Time: 10:00 - 13:00

INSTRUCTIONS

A) *Read* all four exam questions *very carefully.*

B) Answer all four (×4) questions in this exam paper in the space provided. Use the reverse side of exam sheets if necessary. Show *all* solution steps and indicate your final answer *clearly*.

C) Individual question values are indicated in the margin at the start of each question. Partial marks of *at most* 50% will be given for correct solution technique, but incorrect answer. Total exam value is 70 points.

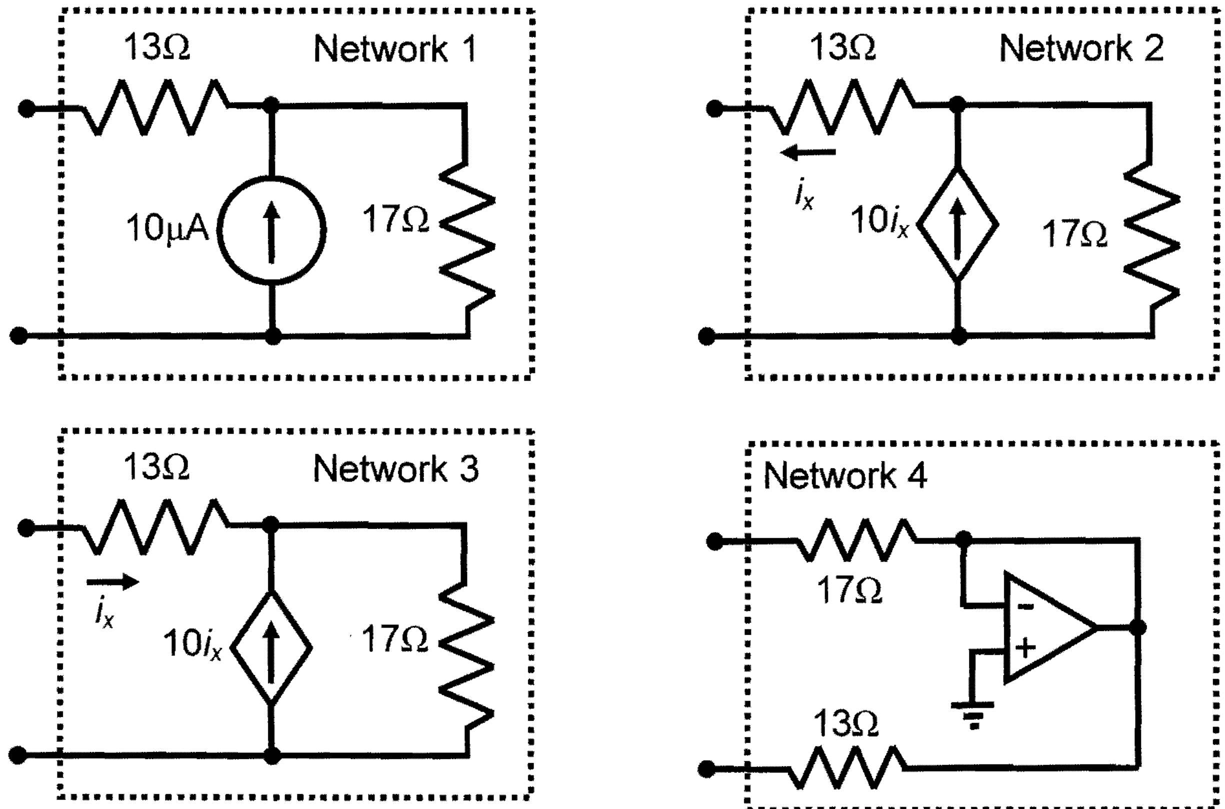
D) Closed book examination. Only "Faculty Standard" calculators are permitted.

IDENTIFICATION

NAME: ______________________________

ID NUMBER: ______________________________

(16/70) 1. Consider the four networks below. Assume *ideal op-amp behaviour* holds for *all applied voltages and currents*. Answer the four question parts below:



(4/16) (a) Is the terminal I-V behaviour of network 1 *equivalent* to that of an ideal resistor? If so, state the equivalent resistance. If not, justify why the behaviour is not that of an ideal resistor.

(4/16) (b) Is the terminal I-V behaviour of network 2 *equivalent* to that of an ideal resistor? If so, state the equivalent resistance. If not, justify why the behaviour is not that of an ideal resistor.

(4/16) (c) Is the terminal I-V behaviour of network 3 *equivalent* to that of an ideal resistor? If so, state the equivalent resistance. If not, justify why the behaviour is not that of an ideal resistor.

(4/16) (d) Is the terminal I-V behaviour of network 4 *equivalent* to that of an ideal resistor? If so, state the equivalent resistance. If not, justify why the behaviour is not that of an ideal resistor. [Hint: Consider carefully the flow of current.]

work space

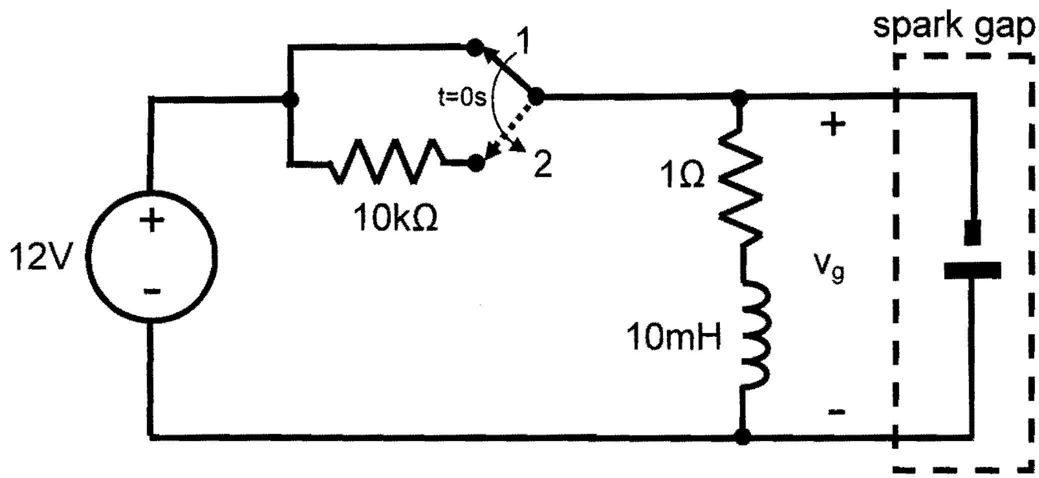
a) No, $V_{oc} \neq 0$ and/or $I_{sc} \neq 0$

b) $\begin{cases} \text{No, since } R = V/I < 0 \\ \text{Yes, } R = V/I = -140\,\Omega \end{cases}$

c) Yes, $R = V/I = 200\,\Omega$

d) Yes, $R = V/I = 30\,\Omega$

(19/70) 2. Consider the circuit below. The spark gap can be modeled as an open circuit. Answer the five question parts below.



(2/19) (a) With the switch in position 1, what is the steady state current through the inductor?

(2/19) (b) How long must the switch remain in position 1 so that the current flowing through the inductor is 99% of its final value?

(4/19) (c) Under steady state conditions with the switch in position 1, how *long* will it take to dissipate an *energy* in the 1Ω resistor equal to the energy that is stored in the inductor?

(10/19) (d) The switch has remained in position 1 sufficiently long that steady state conditions have been achieved, then at t=0, the switch moves to position 2 instantaneously, where it stays indefinitely. Calculate $v_g(t)$ for $0<t$, assuming still that the spark gap remains an open circuit.

(1/19) (e) Plot $v_g(t)$ for all *t*. The plot need not be to scale.

work space

a) $I_L = 12\,A$

b) $\tau \ln(100) = 46.05\ ms$

<u>or</u>

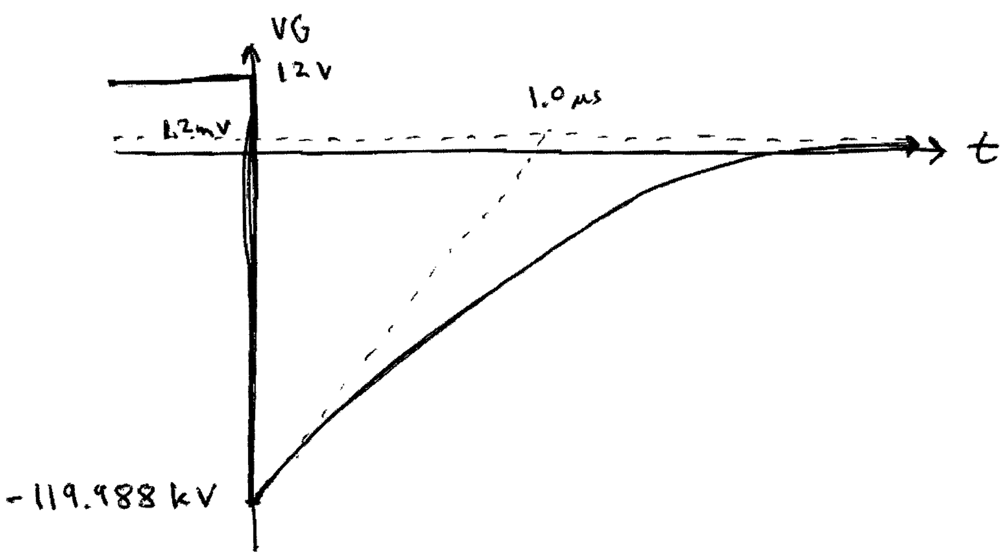
$5\tau = 50\ ms$

c) $t = \frac{E}{P} = 5\ ms$

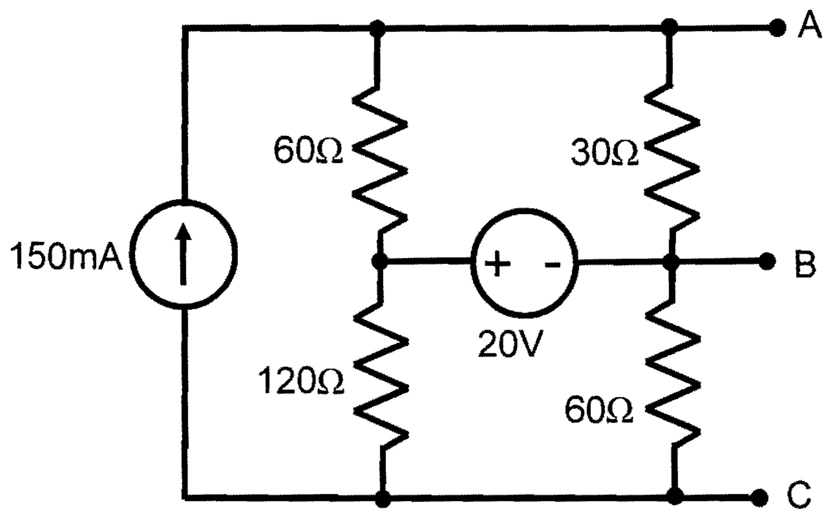
d) $v_G(t) = 1.200\ mV + (-119.988\ kV)\exp(-t\ /1.0\mu s)$

$0 \le t$

e)



(18/70) 3. Consider the circuit network illustrated below. Answer the four question parts below.



(6/18) (a) Find the Thévenin equivalent of the network with respect to the terminals A and B, assuming no electrical connection is made to the node C. Indicate in a drawing the source polarity and the node labels A and B.

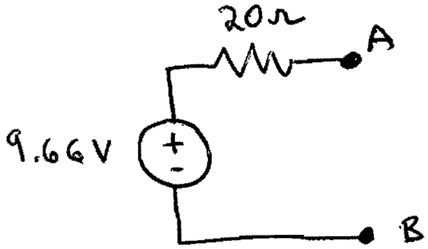
(6/18) (b) Find the Norton equivalent of the network with respect to the terminals A and C, assuming no electrical connection is made to the node B. Indicate in a drawing the source polarity and the node labels A and C.

(4/18) (c) Can more power be extracted from the network when a load resistor is connected across terminals A and B, ***or*** when a load resistor is connected across terminals A and C? Consider the optimal load in each case.

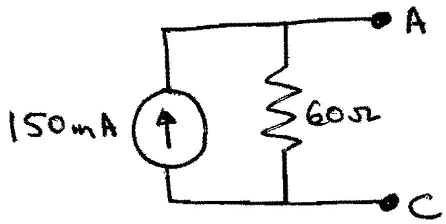
(2/18) (d) A non-ideal ammeter with 10Ω internal resistance is used to measure the short circuit current between terminals A and C. What is the percentage error in this measurement?

work space

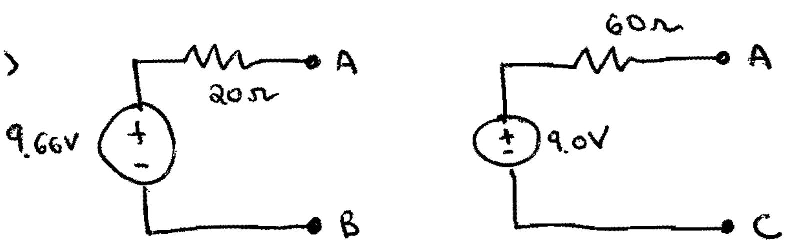
a)



b)



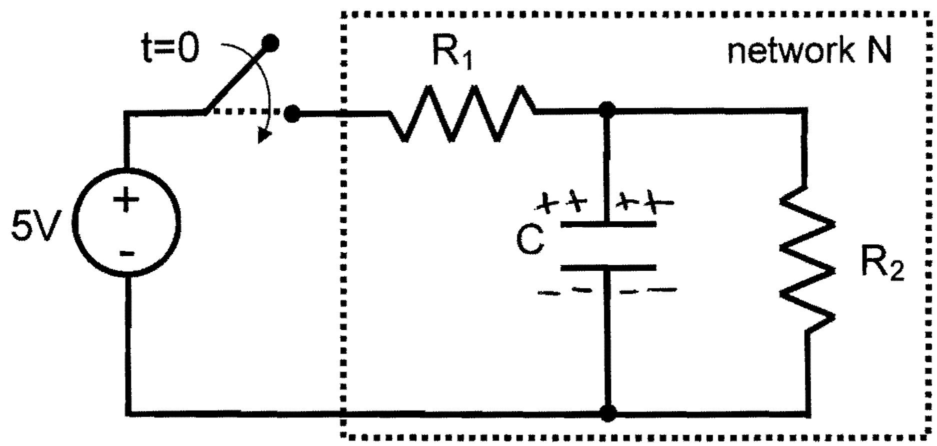
c)

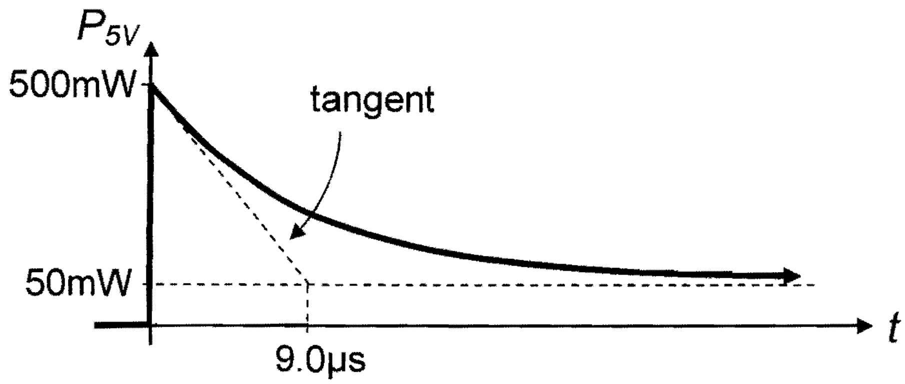


AB can deliver more power since $V_{oc_{AB}} > V_{oc_{AC}}$ and $R_{TH_{AB}} < R_{TH_{AC}}$

d) % error $= -\frac{1}{7} \times 100\% = -14.3\%$

(17/70) 4. Consider the circuit network below. The values of the ideal resistors R_1, R_2 and ideal capacitor C inside the network N have been obscured. The only available information about the circuit is the power delivered by the voltage source when the switch closes instantaneously at t=0s (illustrated below), along with the fact that the switch was open sufficiently long that the capacitor had zero charge separation at t=0s. Answer the three question parts below.





(12/17) (a) Determine the resistances R_1 and R_2, and the capacitance C.

(2/17) (b) As t→∞, what is the charge separation developed across the capacitor? Indicate the polarity of charge separation in the diagram above.

(3/17) (c) At what time does the capacitor store 25% of the final energy stored?

work space

a) $R_1 = 50\,\Omega$

$R_2 = 450\,\Omega$

$C = 200\,nF$

b) $Q = 900\,nC$ (see diagram for polarity)

c) $t = 9\,\mu s \cdot \ln 2 = 6.238\,\mu s$