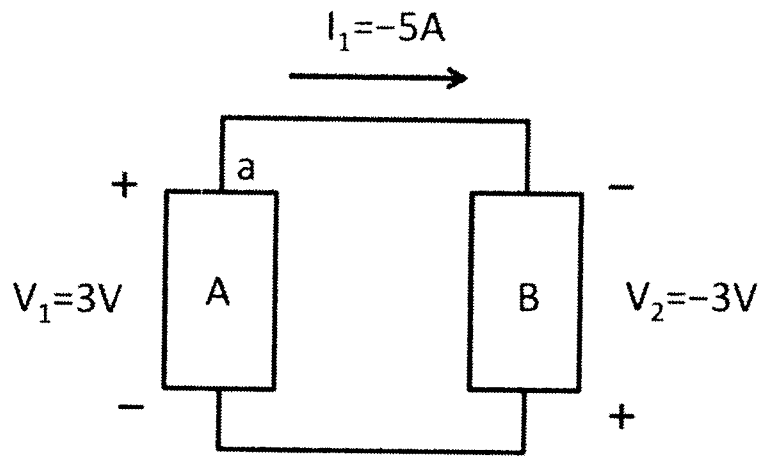
ECSE-200 Quiz #1 (8 January 2010)

NAME____ McGill ID#____________________

READ each question and its parts very carefully. Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit below composed of elements "A" and "B", and answer all parts of the question.



a) Indicate which circuit element is absorbing power and which circuit element is delivering power.

b) How much charge flows into terminal "a" of the circuit element "A" over a 1 hour interval of time? Express your answer in SI units.

a) $P_{\text{delivered by A}} = V_1 \times I_1$ (V_1 and I_1 are defined opposite to passive sign convention)

$= 3V \times (-5A)$

$= -15W$

A is absorbing power.

$P_{\text{delivered by B}} = V_2 \times I_1$ (V_2 and I_1 are defined opposite to passive sign convention)

$= (-3V) \times (-5A)$

$= +15W$

B is delivering power.

[+1 for correct answer
+1 for correct work]

b) $Q_{\text{into A}} = -I_1 \times \Delta t$ [+1]

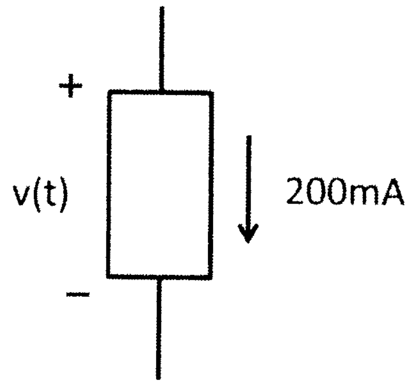
$= -(-5A) \times 1hr \times \frac{3600s}{hr}$

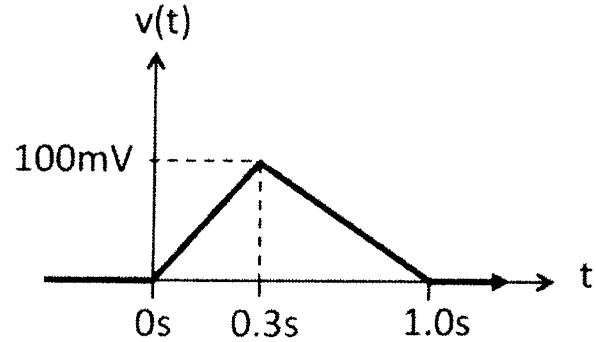
$= 18000\ C$

[+1]

$= 18\ kC$

2. Consider the circuit element and plot below, answer all parts of the question.





a) At what time is the circuit element absorbing the most power?

b) What is the charge that passes through the circuit element over the time interval 0s < *t* < 1s ?

c) What is the net total energy absorbed by the circuit element over the time interval 0s < *t* < 1s ? Consider carefully the sign of your answer.

a) $P_{abs}(t) = 200\,mA \times v(t)$

$\therefore$ maximum in $P_{abs}(t)$ is at maximum in $v(t)$.

$t = 0.3s$ [+1]

b) $Q_{\downarrow} = 200\,mA \times \Delta t$ [+1]

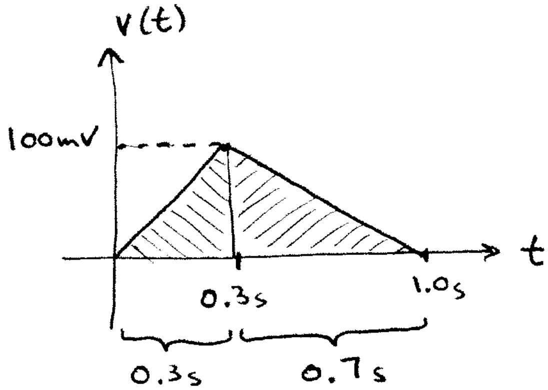
$= 200\,mA \times 1.0s$

$= 200\,mC$ [+1]

c) $U_{abs}(1s) - U_{abs}(0s) = \int_{0s}^{1s} P_{abs}(t')\,dt'$ [+1]

$= 200\,mA \int_{0s}^{1s} v(t')\,dt'$

Evaluate the integral geometrically.



$$\int_{0s}^{0.3s} v(t')dt' = \frac{100mV \times 0.3s}{2} = 0.015 \text{ Vs} \quad [+1/2]$$

$$\int_{0.3s}^{1.0s} v(t')dt' = \frac{100mV \times 0.7s}{2} = 0.035 \text{ Vs} \quad [+1/2]$$

$$U_{abs}(1s) - U_{abs}(0s) = 200mA \int_{0s}^{1s} v(t')dt'$$

$$= 200mA\,(0.015\text{Vs} + 0.035\text{Vs})$$

$$= 10\text{ mJ} \quad [+1]$$

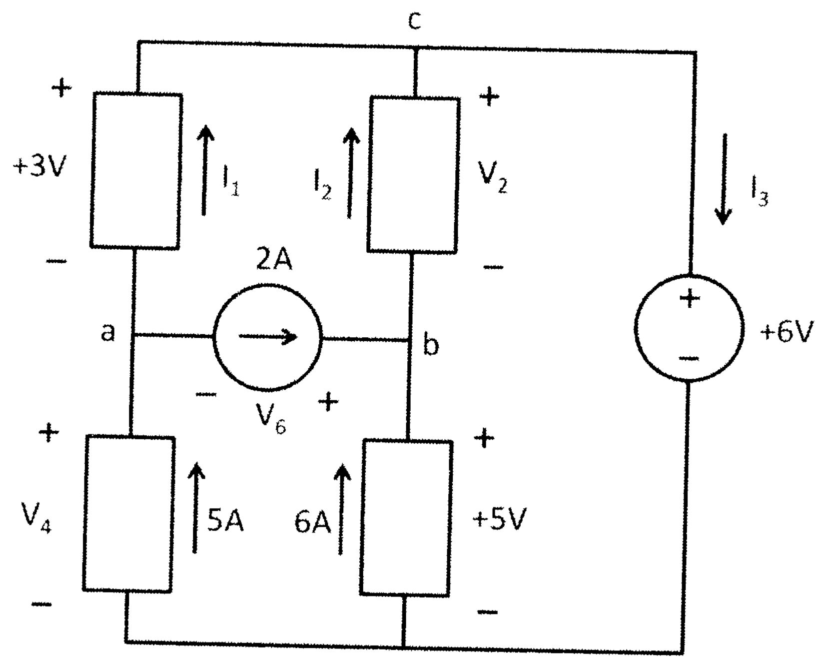
ECSE-200 Quiz #2 (15 January 2010)

NAME____ McGill ID#____________________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit below, and answer all parts of the question.



a) Write down the KCL equation at node a and solve to find I_1. [1pt]

b) Write down the KCL equation at node b and solve to find I_2. [1pt]

c) Write down the KCL equation at node c and solve to find I_3. [1pt]

d) Write down an appropriate KVL equation and solve to find V_2. [1pt]

e) Write down an appropriate KVL equation and solve to find V_4. [1pt]

f) Write down an appropriate KVL equation and solve to find V_6. [1pt]

work space

a) $0 = -5A + 2A + I_1$ [+1/2]

$I_1 = 3A$ [+1/2]

b) $0 = -2A - 6A + I_2$ [+1/2]

$I_2 = 8A$ [+1/2]

c) $0 = -I_1 - I_2 + I_3$ [+1/2]

$I_3 = I_1 + I_2 = 11A$ [+1/2]

d) $0 = -5V - V_2 + 6V$ [+1/2]

$V_2 = 1V$ [+1/2]

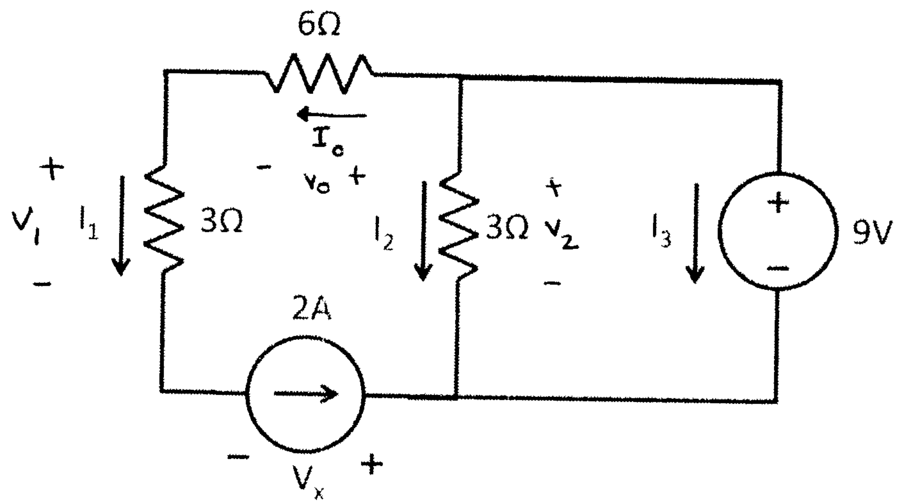
e) $0 = -V_4 - 3V + 6V$ [+1/2]

$V_4 = 3V$ [+1/2]

f) $0 = -V_4 - V_6 + 5V$ [+1/2] (can also use upper left loop)

$V_6 = 5V - V_4 = 2V$ [+1/2]

2. Consider the circuit below, and answer all parts of the question below. Indicate clearly which equations, if any, are instances of KCL, KVL or Ohm's Law. If you introduce any new variables, indicate clearly on the circuit diagram below the definitions of these variables.



a) What is the voltage V_x? [4 pts]

b) What is the total power delivered or absorbed by the independent voltage source? [4 pts]

a) $0 = I_1 - I_o$ (KCL)

$I_o = I_1$

$0 = 2A - I_1$ (KCL)

$I_1 = 2A$

$\therefore\ I_o = I_1 = 2A$

$V_o = I_o \cdot 6\Omega = 12V$ (Ohm) [+1]

$V_1 = I_1 \cdot 3\Omega = 6V$ (Ohm) [+1]

$0 = -9V + V_o + V_1 - V_x$ (KVL) [+1]

$V_x = -9V + 12V + 6V = \underline{\underline{9V}}$ [+1]

work space

b) $0 = -9V + V_2$ (KVL)

$V_2 = 9V$ [+1]

$V_2 = I_2 \cdot 3\Omega$ (Ohm)

$I_2 = \frac{V_2}{3\Omega} = \frac{9V}{3\Omega} = 3A$ [+1]

$0 = -2A - I_2 - I_3$ (KCL)

$I_3 = -2A - I_2 = -2A - 3A = -5A$ [+1]

$$P_{\substack{\text{delivered} \\ \text{by V} \\ \text{source}}} = -P_{\substack{\text{absorbed} \\ \text{by V} \\ \text{source}}}$$

$$= -(9V \cdot I_3)$$

$$= -(9V \cdot (-5A))$$

$$= \underline{+45\,W}$$

[+1]

ie 45 W is being delivered by the independent voltage source

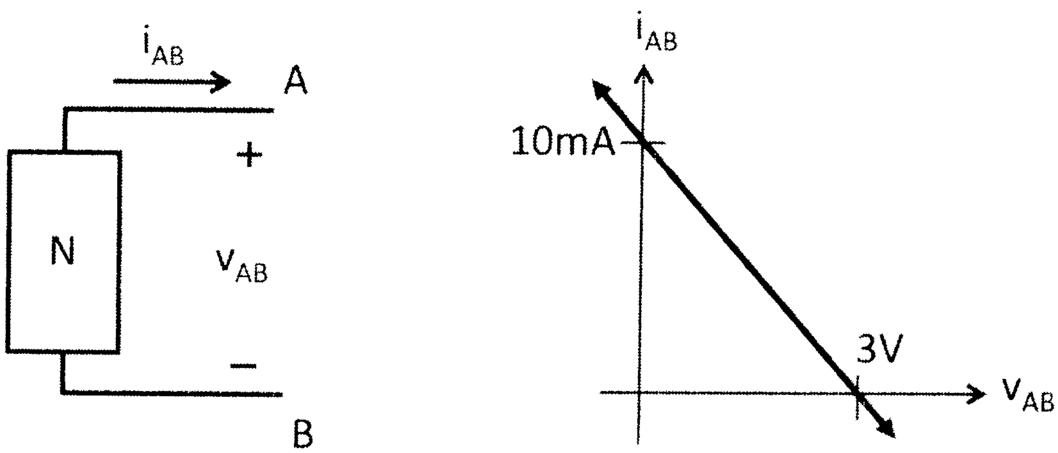
ECSE-200 Quiz #3 (22 January 2010)

NAME____ McGill ID#____________________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit and plot below. The sub-circuit N consists of ideal resistors and independent sources. The plot on the right describes the behaviour of the sub-circuit N. Answer all parts of the question. Note that



a) Write down the Thévenin equivalent and Norton equivalent circuits below. Clearly label the terminals A and B in each equivalent circuit. [4pts]

b) What is the maximum power that the sub-circuit N can deliver to a circuit? [2pts]

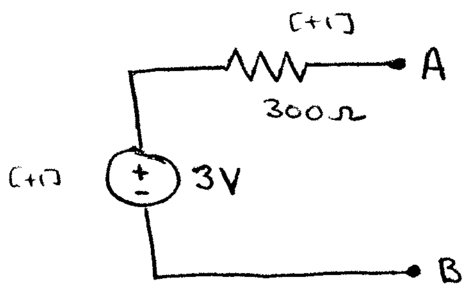
c) What resistance should be connected to the terminals A and B in order for the sub-circuit N to deliver maximum power? [2pts]

d) What is the maximum power that the sub-circuit N can deliver if it is also necessary that the current delivered is 6mA? [2pts]

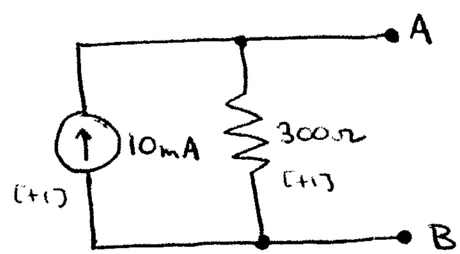
e) What resistance should be connected to the terminals A and B in order to achieve the maximum power condition identified in part d)? [2pts]

a) $R_T = \frac{V_{oc}}{i_{sc}} = \frac{3V}{10mA} = 300\Omega$

Thévenin



Norton



b) $P_{max} = \frac{V_{oc}}{2} \cdot \frac{i_{sc}}{2}$ [+1]

$= \frac{3V}{2} \cdot \frac{10mA}{2}$

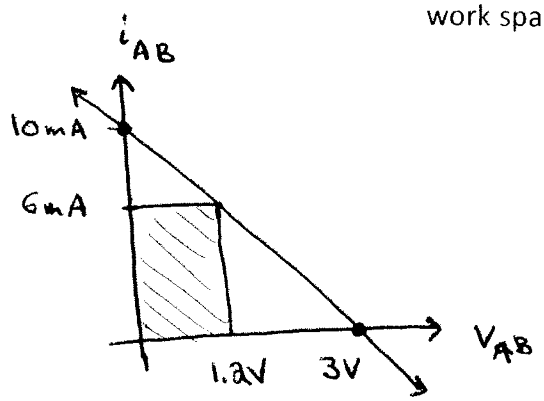
$= 7.5\ mW$ [+1]

c) By the maximum power transfer theorem:

$R_L = R_T$ [+1]

$= 300\Omega$ [+1]

d)



If $i_{AB} = 6mA$, then $V_{AB} = V_{cc} - i_{AB} R_T$

$$= 3V - i_{ab} \cdot \frac{3V}{10mA}$$

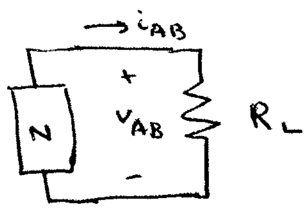
$$= 3V - \frac{6mA \cdot 3V}{10mA}$$

$$= 1.2V \quad [+1]$$

$P_{del} = i_{AB} \cdot V_{AB}$, thus maximum power occurs when the area of the box is maximum, ie the condition $i_{AB} = 6mA$.

$$P_{del} = i_{AB} \cdot V_{AB} = 6mA \cdot 1.2V = 7.2\ mW \quad [+1]$$

e) For the condition in d), we have $i_{AB} = 6mA$ and $V_{AB} = 1.2V$. Ohm's Law requires:

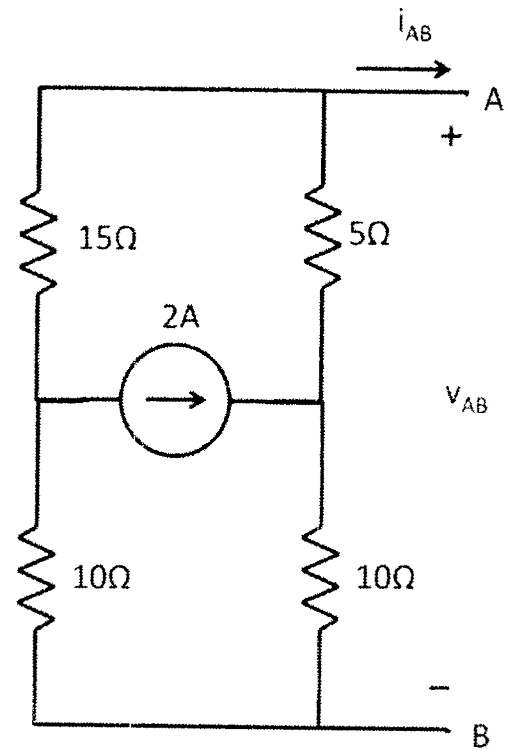


$$R_L = \frac{V_{AB}}{i_{AB}} \quad [+1]$$

$$= \frac{1.2V}{6mA}$$

$$= 200\Omega \quad [+1]$$

2. Consider the circuit below, and answer all parts of the question below.

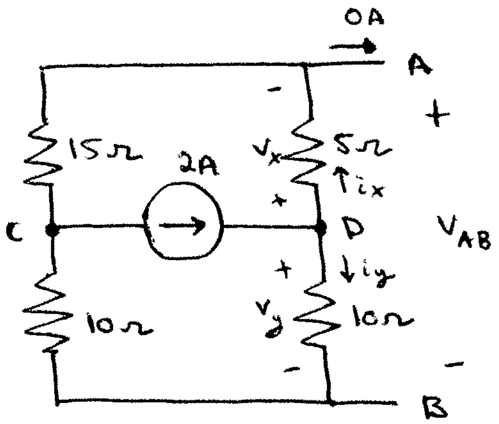


a) What is the value of v_{AB} with an open circuit applied across nodes A and B? [4 pts]

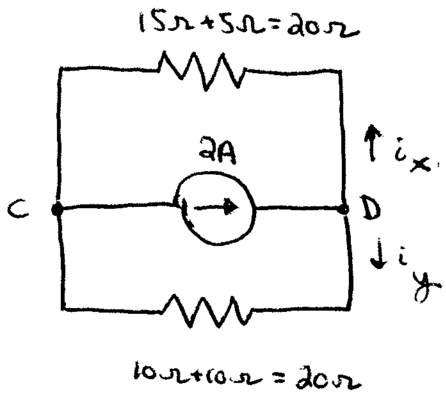
b) What is the value of i_{AB} with a short circuit applied across nodes A and B? [4 pts]

Hint: Consider carefully Thévenin's theorem or Norton's theorem.

c) What is the value of v_{ab} when a parallel combination of one 3Ω resistor and one 5Ω resistor is connected across nodes A and B? [3pts]



From the perspective of the source:



Current division gives:

$i_x = 2A \cdot \frac{20\Omega}{20\Omega + 20\Omega} = 1A$ [+1/2]

$i_y = 2A \cdot \frac{20\Omega}{20\Omega + 20\Omega} = 1A$ [+1/2]

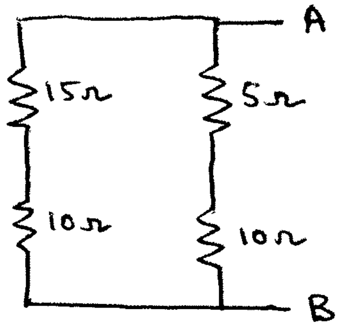
Returning to the original circuit:

$v_x = 5\Omega \cdot i_x = 5V$ [+1] $\qquad v_y = 10\Omega \cdot i_y = 10V$ [+1]

KVL: $0 = -v_y + v_x + v_{AB}$

$v_{AB} = v_y - v_x = 10V - 5V = 5V$ [+1]

b) Turning off the 2 A source, the equivalent resistance is:



$$R_T = (5\Omega + 10\Omega) \,//\, (15\Omega + 10\Omega) \quad [+1]$$

$$= \frac{15\Omega \cdot 25\Omega}{15\Omega + 25\Omega}$$

$$= 9.375\Omega \quad [+1]$$

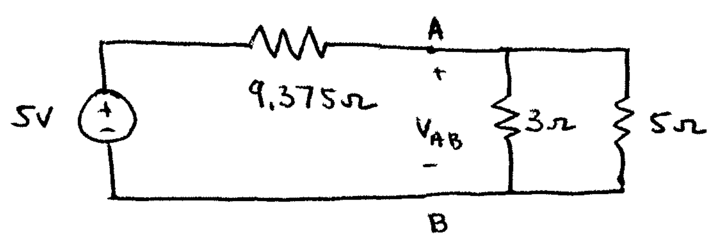
The short circuit current is:

$$i_{sc} = \frac{V_{oc}}{R_T} \quad [+1]$$

$$= \frac{5V}{9.375\Omega}$$

$$= 0.533\ A \quad [+1]$$

c) Use Thévenin equivalent:



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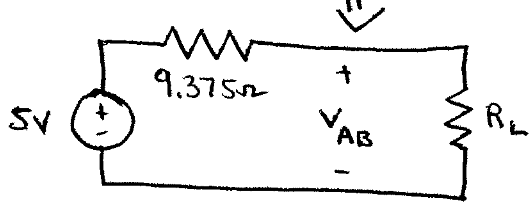


$$R_L = 3\Omega \,//\, 5\Omega$$

$$= \frac{3\Omega \cdot 5\Omega}{3\Omega + 5\Omega} = 1.875\Omega \quad [+1]$$

Recognizing the voltage divider:

$$V_{AB} = 5V \cdot \frac{1.875\Omega}{1.875\Omega + 9.375\Omega} \quad [+1]$$

$$= 0.833\ V \quad [+1]$$

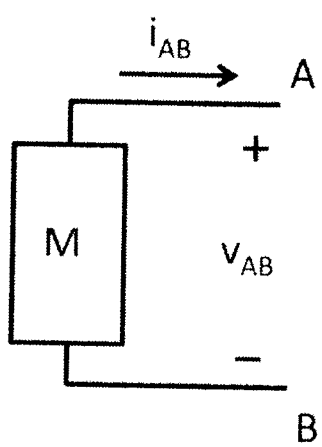
ECSE-200 Quiz #4 (28 January 2010)

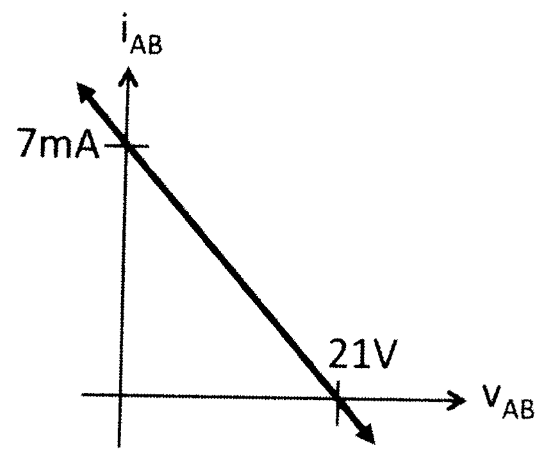
NAME_______________________________________ McGill ID#_______________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit and plot below. The sub-circuit M consists of ideal resistors and independent sources. The plot on the right describes the behaviour of the sub-circuit M. Answer all parts of the question.





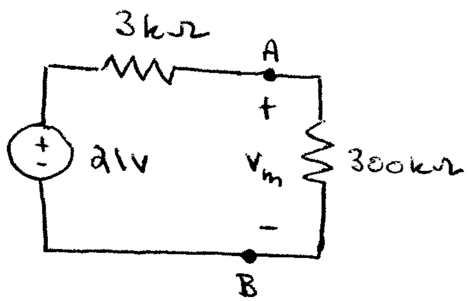
a) A voltmeter with total internal resistance of 300kΩ is connected across terminals A and B. What voltage does the voltmeter measure? Give your numerical answer to 4 significant digits or as an exact fraction. [4pts]

b) What power does the sub-circuit M deliver to the voltmeter of part a)? [2pts]

c) An ammeter with total internal resistance of 6Ω is connected across terminals A and B. What current does the ammeter measure? Give your numerical answer to 4 significant digits or as an exact fraction. [2pts]

a) From the plot: $V_{oc} = 21V$ $\quad i_{sc} = 7mA$ [+1]

$$R_T = \frac{V_{oc}}{i_{sc}} = \frac{21V}{7mA} = 3k\Omega \quad [+1]$$



$$V_m = 21V \cdot \frac{300k\Omega}{3k\Omega + 300k\Omega} \quad [+1]$$

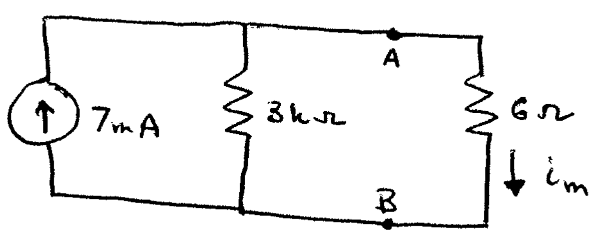
$$= 20.79V \quad [+1]$$

b) Power absorbed by meter $= P_{abs}$

$$= \frac{v_m^2}{R_m} \quad [+1]$$

$$= \frac{(20.79V)^2}{300k\Omega} = 1.441 \text{ mW} \quad [+1]$$

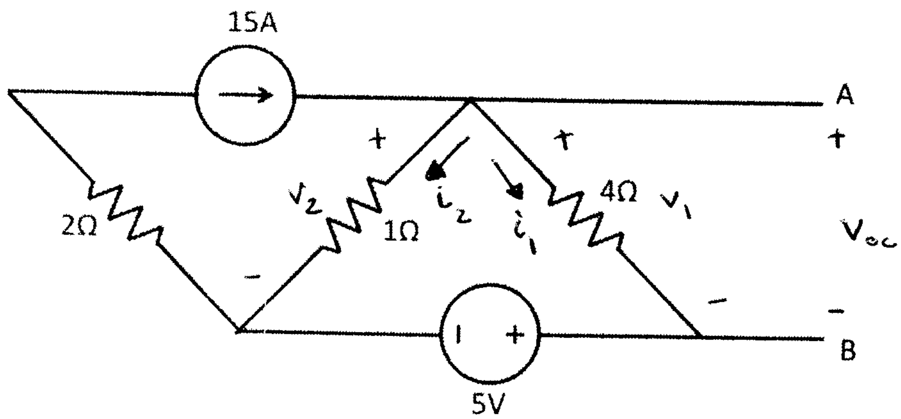
c)



$$i_m = 7mA \cdot \frac{3k\Omega}{3k\Omega + 6\Omega} \quad [+1]$$

$$= 6.986 \text{ mA} \quad [+1]$$

2. Consider the circuit below, and answer all parts of the question below.



a) What is the open-circuit voltage across the terminals A and B? Indicate clearly the polarity of the open circuit voltage. [4 pts]

b) What is the Thévenin resistance looking into the terminals A and B? [4 pts]

a) Under open circuit conditions:

KCL: $0 = -15A + i_1 + i_2$ [+1]

KVL: $0 = -v_2 + v_1 + 5V$ [+1]

Ohm's Law: $v_1 = i_1 \cdot 4\Omega$ $\quad v_2 = i_2 \cdot 1\Omega$ [+1]

Combining:

$15 = i_1 + i_2$

$0 = -i_2 + 4i_1 + 5$

Adding equations gives: $15 = 5i_1 + 5$

$i_1 = 2A$

$\therefore$ $V_{oc} = v_1 = 2A \cdot 4\Omega$

$= 8V$ [+1]

(polarity indicated by definition in diagram)

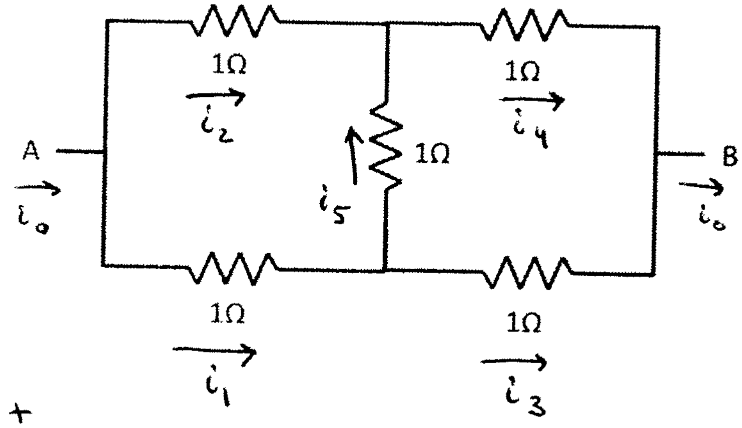
b) Turning off sources:

$$R_{eq} = 1\Omega \,//\, 4\Omega = \frac{1 \cdot 4}{1+4}\,\Omega = \frac{4}{5}\,\Omega$$

[+1] [+1]

3. Answer all parts of the question below.

a) What is the equivalent resistance between nodes A and B of the circuit below? [5 pts]



[+1]

KCL:

$0 = -i_o + i_1 + i_2$ (1)

$0 = +i_o - i_3 - i_4$ (2)

$0 = -i_2 - i_5 + i_4$ (3)

$0 = -i_1 + i_5 + i_3$ (4)

[+1]

KVL + Ohm:

$0 = +i_2 - i_5 - i_1$ (5)

$0 = +i_4 - i_3 + i_5$ (6)

full points awarded for using symmetry argument to find $i_5 = 0$.

(6) − (5): $2i_5 + i_4 - i_3 + i_1 - i_2 = 0$

(3): $i_2 = i_4 - i_5$

(4): $i_1 = i_3 + i_5$

Substitute (3), (4) into (6) − (5):

$$2i_5 + i_4 - i_3 + (i_3 + i_5) - (i_4 - i_5) = 0$$

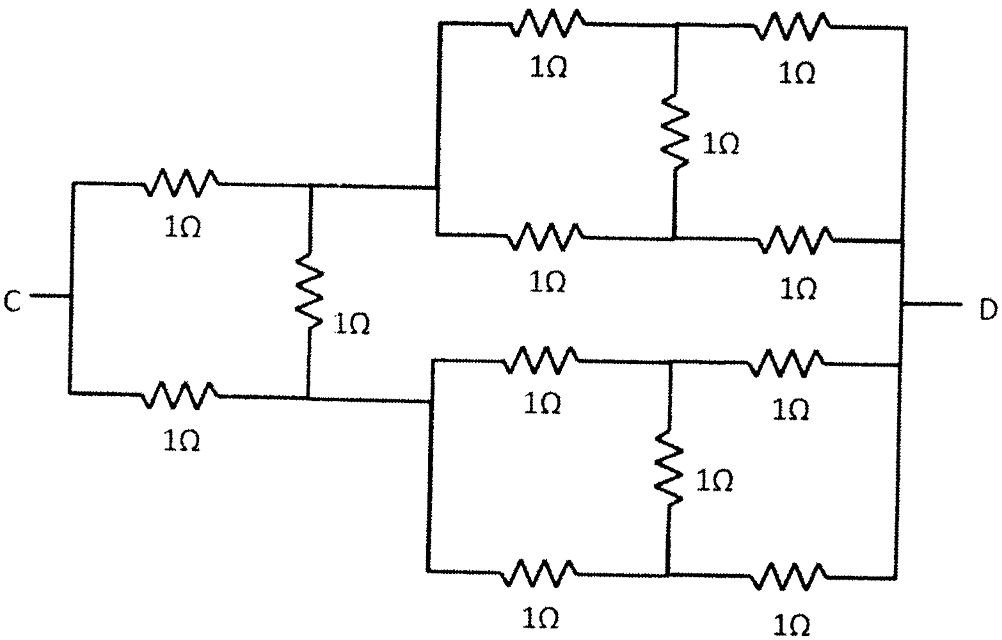
$i_5 = 0$ [+1]

$\therefore$ $\underset{(4)}{i_1 = i_3}$, $\underset{(3)}{i_2 = i_4}$, $\underset{(5)}{i_1 = i_2}$, $\underset{(6)}{i_3 = i_4}$, $\underset{(1)}{i_1 = \frac{1}{2} i_o}$

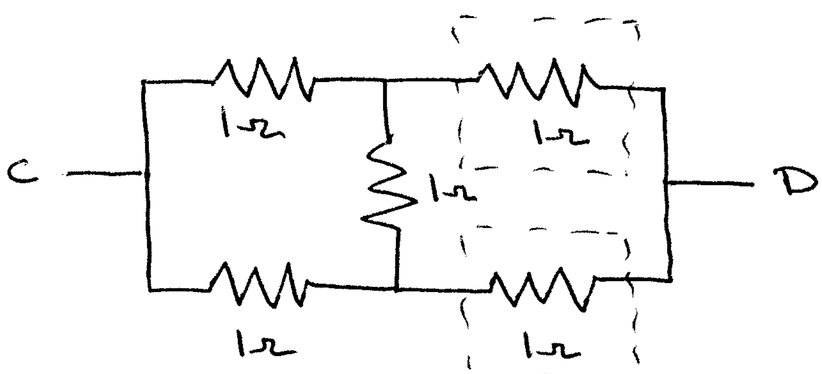
$$\therefore \quad R_{eq} = \frac{V_o}{i_o} = \frac{i_1 + i_3}{i_o} = \frac{\frac{1}{2}i_o + \frac{1}{2}i_o}{i_o} = 1\Omega \ \text{[+1]}$$

[+1]

b) What is the equivalent resistance between nodes C and D of the circuit below? [2 pts]



Recognizing the same circuit block from before:

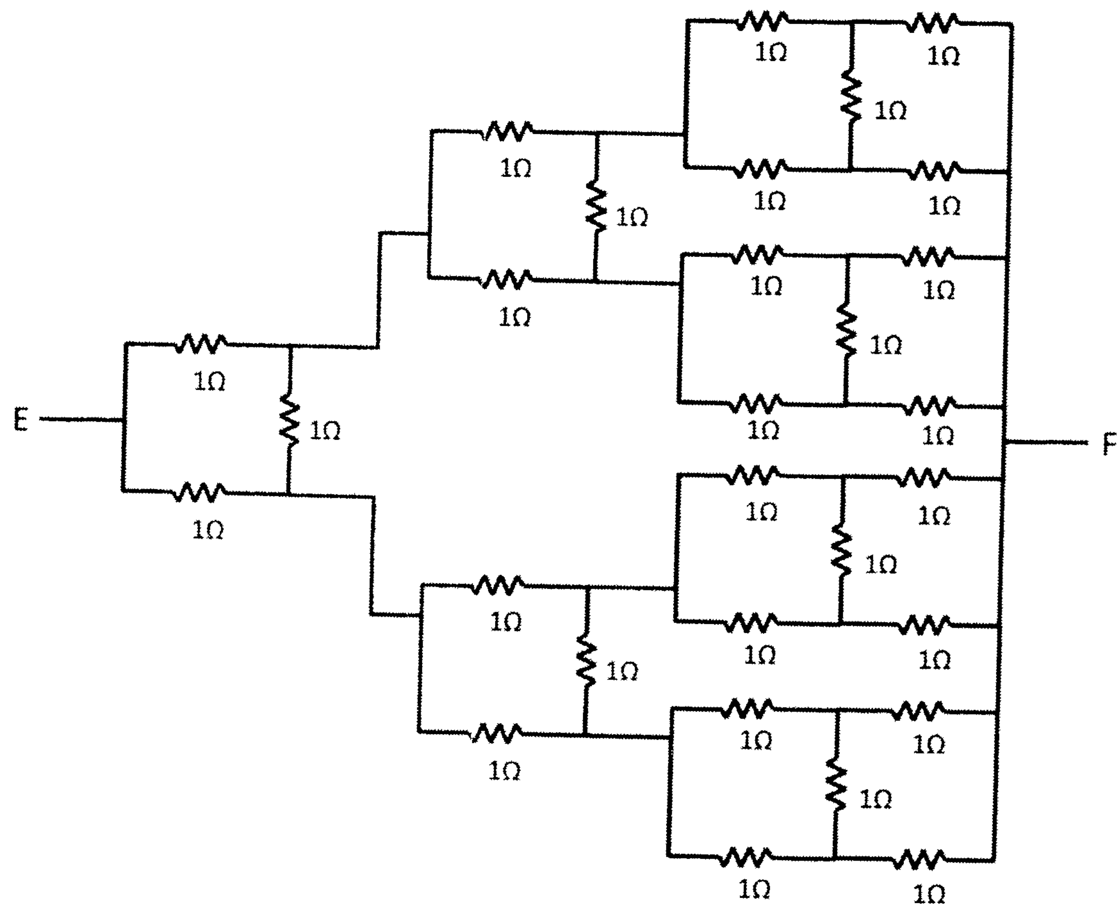


[+1]

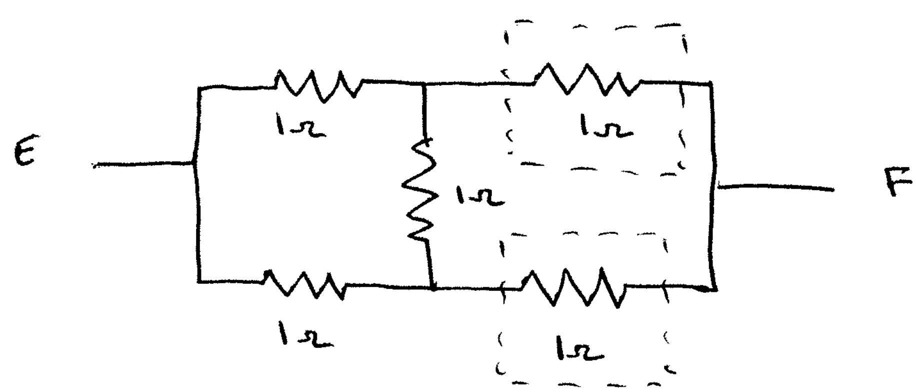
Recognizing the circuit block again:

$R_{eq} = 1\Omega$ [+1]

c) What is the equivalent resistance between nodes E and F of the circuit below? [2 pts]



Recognizing the circuit blocks from before:



[+1]

Recognizing the same circuit again: $R_{eq} = 1\Omega$ [+1]

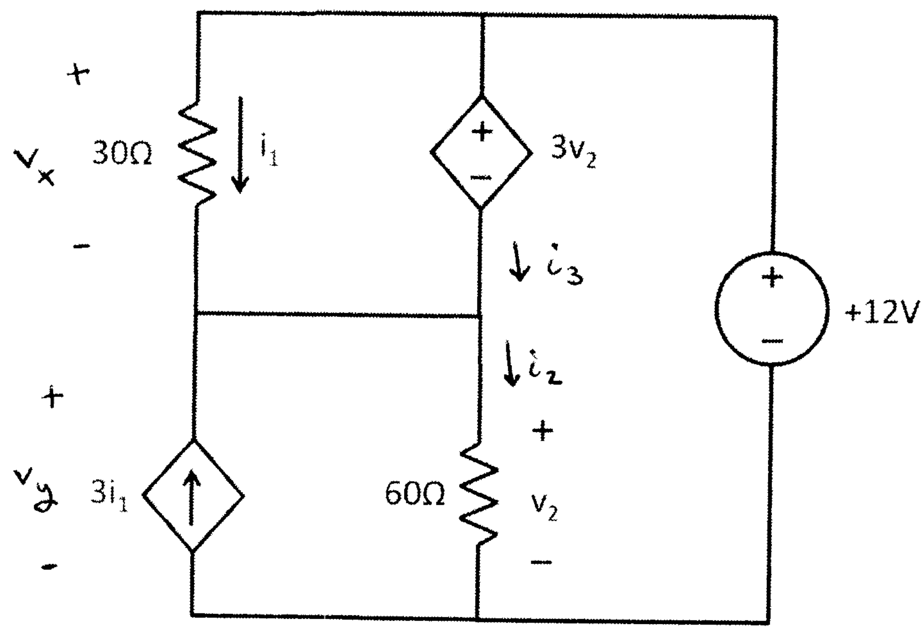
ECSE-200 Quiz #5 (5 February 2010)

NAME________________________________ McGill ID#____________________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit below. Answer all parts of the question.



a) What is the power delivered or absorbed by the current dependent current source? [5pts]

b) What is the power delivered or absorbed by the voltage dependent voltage source? [3pts]

a) KVL: $-v_2 - 3v_2 + 12V = 0$

$$v_2 = \frac{12V}{4} = 3V \quad (+1)$$

KVL: $v_x = 3v_2 = 9V \quad (+1)$

Ohm: $i_1 = \frac{v_x}{30\Omega} = \frac{9V}{30\Omega} = 300\,mA \quad (+1)$

Source equation: $3i_1 = 900\text{ mA}$ [+1]

KVL: $v_g = v_2 = 3V$

Power delivered by current source:

$$P_{del} = 3i_1 \cdot v_g = 900\text{ mA} \cdot 3V = 2.7\text{ W} \quad [+1]$$

b) Ohm: $i_2 = \frac{3V}{60\Omega} = 50\text{ mA}$ [+1]

KCL: $0 = -i_1 - 3i_1 + i_2 - i_3$

$$i_3 = -4i_1 + i_2$$

$$= -4 \cdot 300\text{ mA} + 50\text{ mA}$$

$$= -1150\text{ mA} \quad [+1]$$

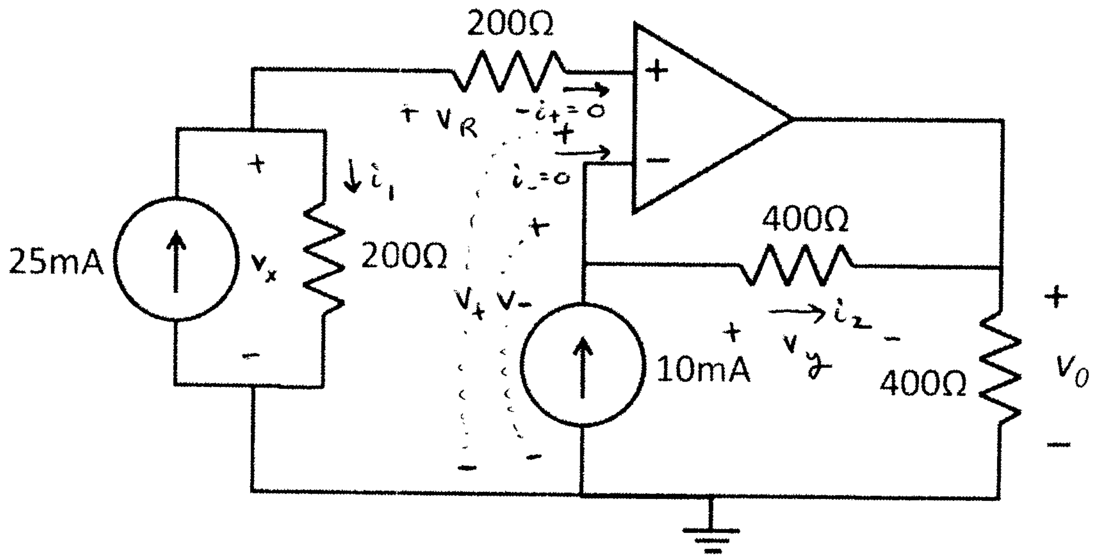
Power delivered by voltage source:

$$P_{del} = (-i_3) \cdot 3v_2$$

$$= 1150\text{ mA} \cdot 9V$$

$$= 10.35\text{ W} \quad [+1]$$

2. Consider the circuit below, and answer all parts of the question below. Assume ideal op-amp behaviour.



a) What is the power delivered or absorbed by the 10mA current source? [4pts]

b) What is the voltage v_O? [2pts]

c) If you attempted to measure the voltage v_O with a voltmeter having 39.6kΩ total internal resistance, what voltage would you measure? [2pts]

a) KCL: $0 = -25\,mA + i_1 + i_+$

ideal op-amp: $i_+ = i_- = 0$

$i_1 = 25\,mA$ [+1]

Ohm: $v_x = 25mA \cdot 200\Omega = 5V$

KVL: $0 = -v_x + v_R + v_+$

Ohm: $v_R = i_+ \cdot 200\Omega = 0V$

$v_+ = v_x = 5V$ [+1]

ideal op-amp:

$v_- = v_+ = 5V$ [+1]

Power delivered by 10mA source: $P_{del} = 10mA \cdot v_-$

$= 50\,mW$ [+1]

b) KCL: $0 = -10mA + i_- + i_2$ $i_- = 0$

$i_2 = 10mA$

Ohm: $v_y = i_2 \cdot 400\Omega = 10mA \cdot 400\Omega = 4V$ [+1]

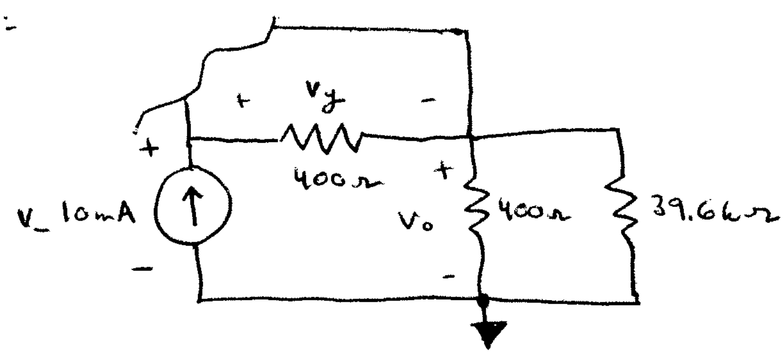
KVL: $0 = -v_- + v_y + v_o$

$v_o = v_- - v_y$

$= 5V - 4V$

$= 1V$ [+1]

c) The circuit is modified with the voltmeter in parallel:



We notice that $v_- = v_+ = 5V$ and $v_y = 4V$, unchanged from before. Thus KVL gives:

[+1]

$v_o = v_- - v_y = 1V$ [+1]

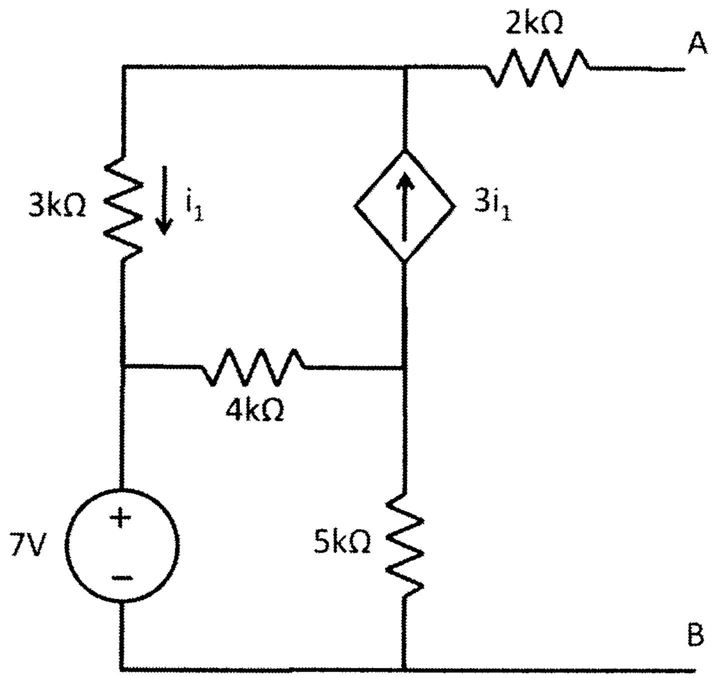
ECSE-200 Quiz #6 (12 February 2010)

NAME____ McGill ID#____________________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit below. Answer all parts of the question.



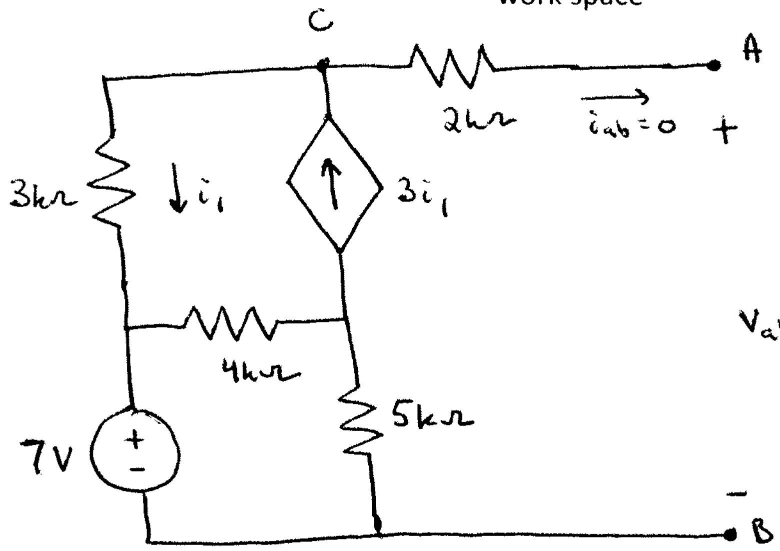
a) What is the open-circuit voltage at the terminals A and B? Indicate clearly the polarity of your answer. [4pts]

b) What is the short circuit current at the terminals A and B? Indicate clearly the polarity of your answer. [4pts]

c) What voltage will appear across the terminals A and B if a 200Ω resistor is connected across the terminals A and B? Indicate clearly the polarity of your answer. [3pts]

work space

a)



$V_{ab} = V_{oc}$

KCL at C: $-3i_1 + i_1 + i_{ab} = 0$ [+1]

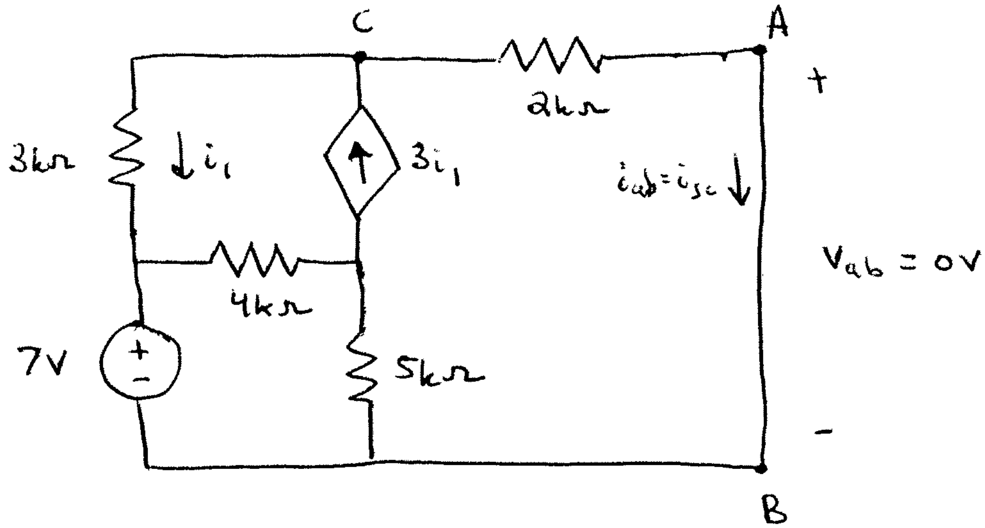
$i_1 = \frac{1}{2} i_{ab} = 0A$ [+1]

KVL + Ohm: $-7V - 3k\Omega \cdot i_1 + 2k\Omega \cdot i_{ab} + V_{oc} = 0$ [+1]

$V_{oc} = 7V$ [+1]

work space

b)



KCL at C: $-3i_1 + i_1 + i_{sc} = 0$ [+1]

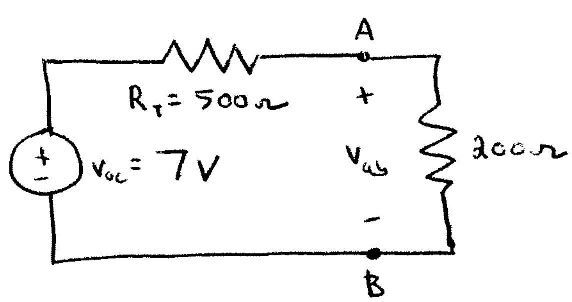
$i_{sc} = 2i_1$ [+1]

KVL + Ohm: $-7V - 3k\Omega \cdot i_1 + 2k\Omega \cdot i_{sc} = 0$ [+1]

$-7V - 3k\Omega \cdot \frac{1}{2} i_{sc} + 2k\Omega\, i_{sc} = 0$

$i_{sc} = \dfrac{7V}{2k\Omega - \frac{3}{2}k\Omega} = 14mA$ [+1]

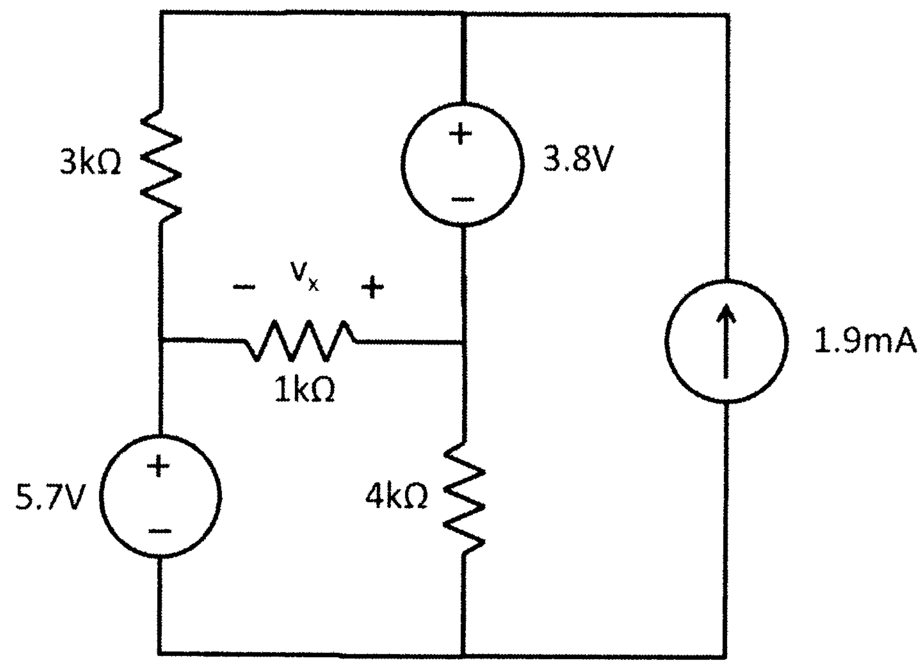
c) $R_T = \dfrac{V_{oc}}{i_{sc}} = \dfrac{7V}{14mA} = 500\Omega$ [+1]



$V_{ab} = 7V \cdot \dfrac{200\Omega}{200\Omega + 500\Omega}$ [+1]

$= 2V$ [+1]

2. Consider the circuit below, and answer all parts of the question below. Consider your solution technique carefully before proceeding.

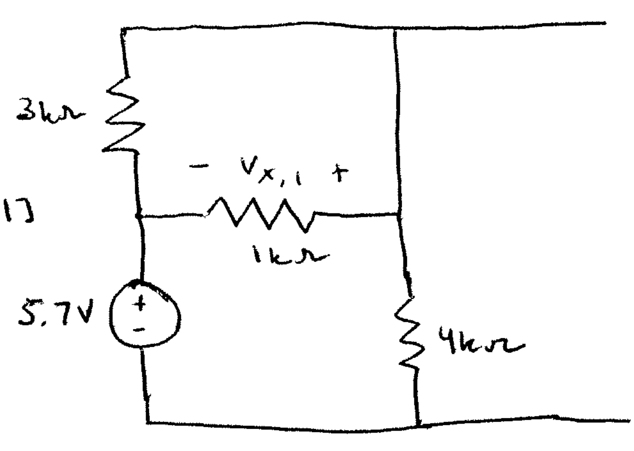


a) What is the voltage v_x? [10pts]

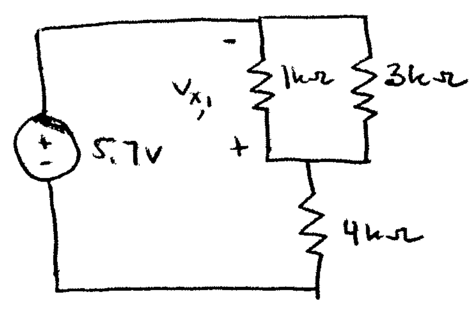
b) To what current should the independent current source be adjusted so that v_x = +100mV? [3pts]

a) Use the principle of superposition.

[+1]



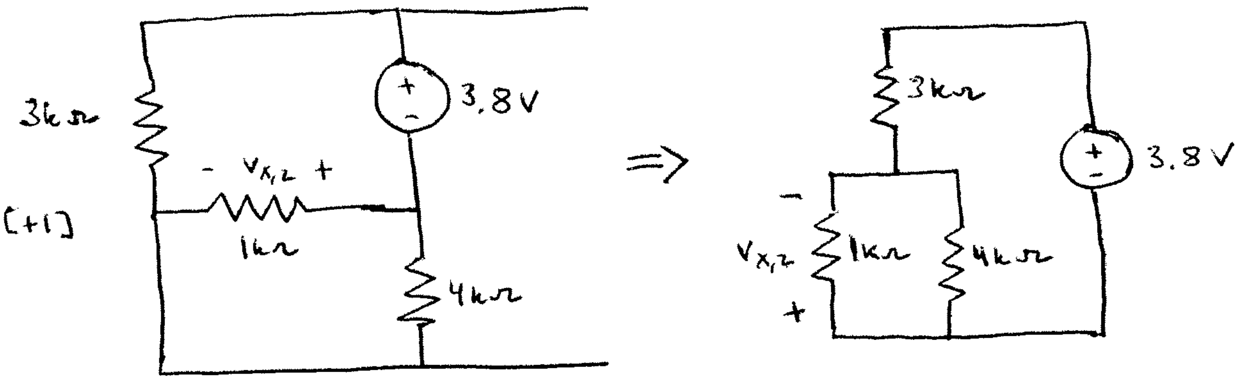
=>



$$v_{x,1} = -5.7V \cdot \frac{1k\Omega // 3k\Omega}{1k\Omega // 3k\Omega + 4k\Omega} \quad [+1]$$

$$= -5.7V \cdot \frac{3/4}{3/4 + 4} = -0.9V \quad [+1]$$

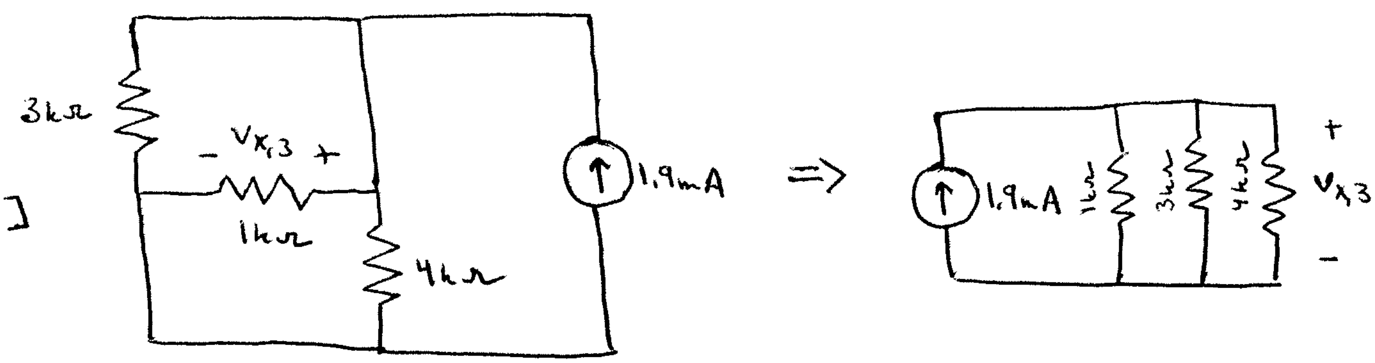
work space



[+1]

$$v_{x,2} = -3.8\text{V} \cdot \frac{1\text{k}\Omega \,//\, 4\text{k}\Omega}{1\text{k}\Omega \,//\, 4\text{k}\Omega + 3\text{k}\Omega} \quad [+1]$$

$$= -3.8\text{V} \cdot \frac{4/5}{4/5 + 3} = -0.8\text{V} \quad [+1]$$



[+1]

$$v_{x,3} = 1.9\text{mA} \cdot (1\text{k}\Omega \,//\, 3\text{k}\Omega \,//\, 4\text{k}\Omega) \quad [+1]$$

$$= 1.9\text{mA} \, \frac{1}{\frac{1}{1\text{k}\Omega} + \frac{1}{3\text{k}\Omega} + \frac{1}{4\text{k}\Omega}} = 1.2\text{V} \quad [+1]$$

$$\therefore \quad v_x = v_{x,1} + v_{x,2} + v_{x,3}$$

$$= -0.9\text{V} + (-0.8\text{V}) + 1.2\text{V}$$

$$= -0.5\text{V} \quad [+1]$$

work space

b)

$$100\,mV = v_{x,1} + v_{x,2} + v_{x,3}' \quad [+1]$$

$$0.1V = -0.9V - 0.8V + v_{x,3}'$$

$$v_{x,3}' = 1.8V$$

$$i_{source}' = \frac{v_{x,3}'}{v_{x,3}} \cdot i_{source} \qquad \text{(linearity)} \; [+1]$$

$$= \frac{1.8V}{1.2V} \cdot 1.9\,mA$$

$$= 2.85\,mA \quad [+1]$$

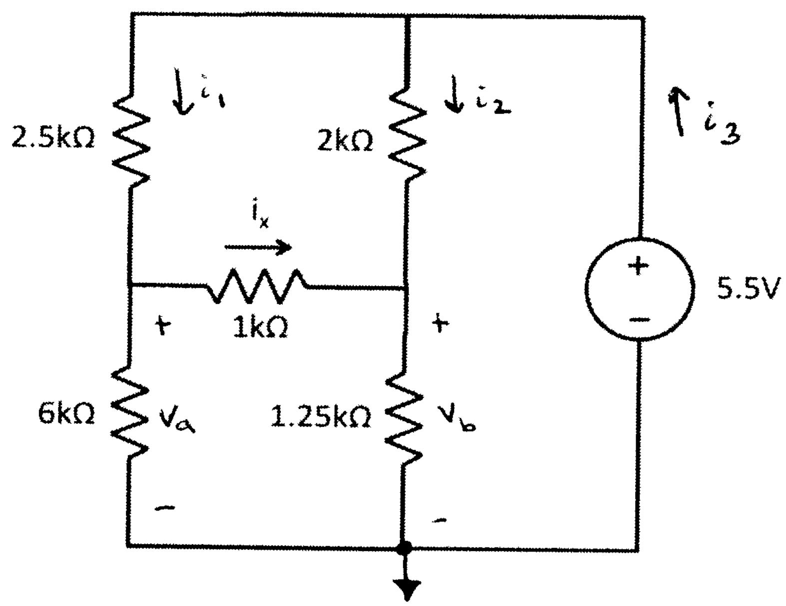
ECSE-200 Quiz #7 (19 February 2010)

NAME________________________ McGill ID#______________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit below. Answer all parts of the question.



a) What is the current i_x? Consider using the node-voltage method. Label clearly any variables that you introduce. [5pts]

b) What is the current flowing through 5.5V source? Clearly identify the direction of current. [3pts]

a) $$\frac{V_a}{6k\Omega} + \frac{V_a - V_b}{1k\Omega} + \frac{V_a - 5.5V}{2.5k\Omega} = 0 \qquad [+1]$$

$$\frac{V_b}{1.25k\Omega} + \frac{V_b - V_a}{1k\Omega} + \frac{V_b - 5.5V}{2k\Omega} = 0 \qquad [+1]$$

first equation: $$V_a\left(\frac{1}{6} + \frac{1}{1} + \frac{1}{2.5}\right) = \frac{V_b}{1} + 2.2V$$

$$\frac{23.5}{15} V_a = V_b + 2.2V$$

work space

Second equation: $V_b\left(\frac{1}{1.25}+\frac{1}{1}+\frac{1}{2}\right)=\frac{V_a}{1}+2.75V$

$$V_b = \frac{1}{2.3}V_a + \frac{2.75}{2.3}\ V$$

Substitution: $\frac{23.5}{15}V_a = \left(\frac{1}{2.3}V_a + \frac{2.75}{2.3}V\right) + 2.2V$

$$V_a = \frac{\frac{2.75}{2.3}+2.2}{\frac{23.5}{15}-\frac{1}{2.3}}\ V = 3V \quad [+1]$$

$$V_b = \frac{3V}{2.3} + \frac{2.75V}{2.3} = 2.5V \quad [+1]$$

$$i_x = \frac{V_a - V_b}{1k\Omega} = \frac{3V-2.5V}{1k\Omega} = 0.5\,mA \quad [+1]$$

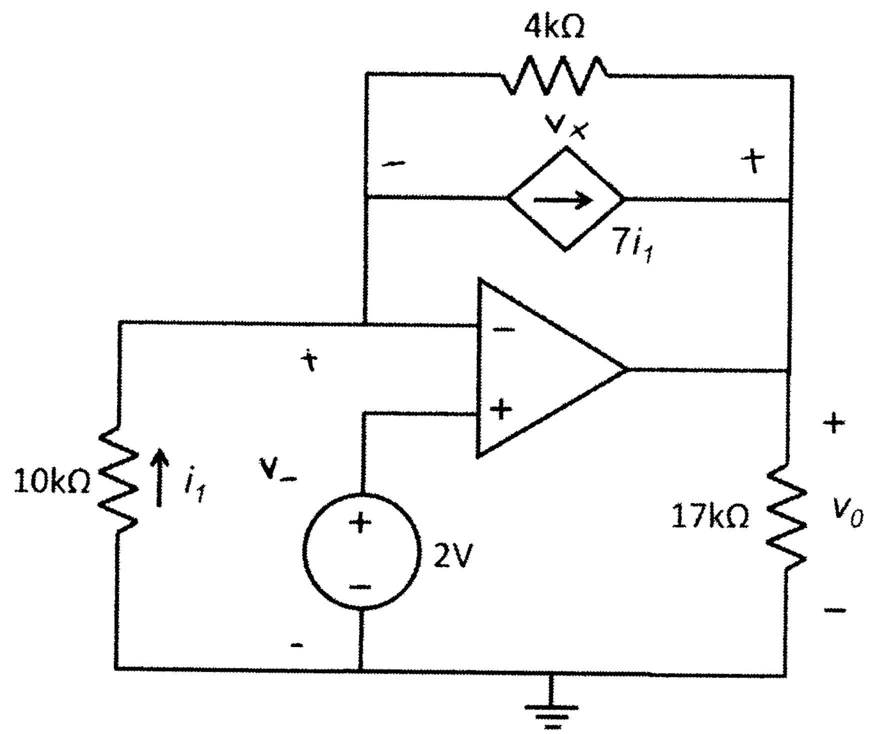
b) $i_1 = \frac{5.5V - V_a}{2.5k\Omega} = \frac{5.5V-3V}{2.5k\Omega} = 1\,mA \quad [+1]$

$i_2 = \frac{5.5V - V_b}{2\,k\Omega} = \frac{5.5V-2.5V}{2\,k\Omega} = 1.5\,mA \quad [+1]$

KCL: $i_3 = i_1 + i_2$

$= 2.5\,mA \quad [+1]$

2. Consider the circuit below, and answer all parts of the question below. Assume ideal op-amp behaviour.



a) What is the voltage v_O? Consider the node-voltage equation at the inverting input of the op-amp. [3pts]

b) What is the power delivered or absorbed by the dependent current source? [3pts]

a) $V_- = V_+ = 2V$

$$0 = \frac{2V}{10k\Omega} + \frac{2V - V_o}{4k\Omega} + 7i_1 \quad [+]$$

$$i_1 = -\frac{2V}{10k\Omega} = -0.2mA \quad [+1]$$

Combining: $0 = 0.2mA + \left(0.5mA - \frac{V_o}{4k\Omega}\right) + 7(-0.2mA)$

$V_o = 4k\Omega\,(0.2mA + 0.5mA - 1.4mA)$

$= -2.8V \quad [+1]$

b) KVL: $0 = -2V - v_x + v_o$

$v_x = v_o - 2V$

$= -2.8V - 2V$

$= -4.8V$ [+1]

$7i_1 = 7 \cdot (-0.2mA) = -1.4mA$ [+1]

Power delivered = $P_{del} = 7i_1 \cdot v_x$

$= -1.4mA \cdot -4.8V$

$= 6.72\ mW$ [+1]

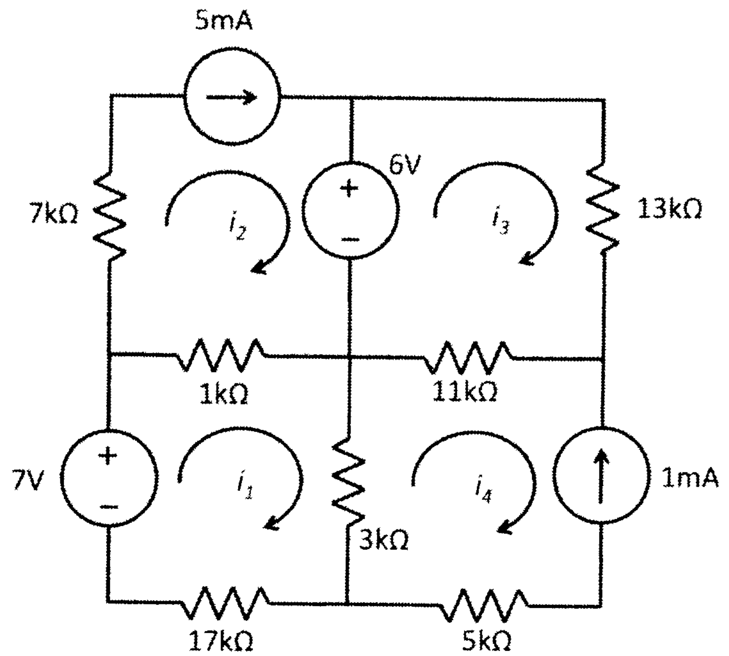
ECSE-200 Quiz #8 (5 March 2010)

NAME____ McGill ID#____________________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit below. Note that 4 mesh currents have been identified. Answer all parts of the question.



a) What is the mesh current i_2? [1pt]

b) What is the mesh current i_4? [1pt]

c) What is the mesh current i_1? [2pts]

d) What is the mesh current i_3? [2pts]

e) What is the power delivered or absorbed by the 6V source? [2pts]

f) What is the power absorbed by the 11kΩ resistor? [2pts]

a) $i_2 = 5\,mA$

b) $i_4 = -1\,mA$

work space

c) $0 = -7V + 1k\Omega\,(i_1 - i_2) + 3k\Omega\,(i_1 - i_4)$

$+ 17k\Omega \cdot i_1$ [+1]

$0 = -7V + 1k\Omega(i_1 - 5mA) + 3k\Omega(i_1 - (-1mA)) + 17k\Omega \cdot i_1$

$$i_1 = \frac{7V + 5V - 3V}{1k\Omega + 3k\Omega + 17k\Omega} = \frac{3}{7}\,mA = 0.4286\,mA \quad [+1]$$

d) $0 = -6V + 13k\Omega \cdot i_3 + 11k\Omega\,(i_3 - (-1mA))$ [+1]

$$i_3 = \frac{6V - 11V}{13k\Omega + 11k\Omega} = -\frac{5}{24}\,mA = 0.2083\,mA \quad [+1]$$

e) Power delivered by 6V source:

$P_{del} = 6V \cdot (i_3 - i_2)$ [+1]

$= 6V \cdot \left(-\frac{5}{24}\,mA - 5\,mA\right)$

$= -31.25\,mW$ [+1]

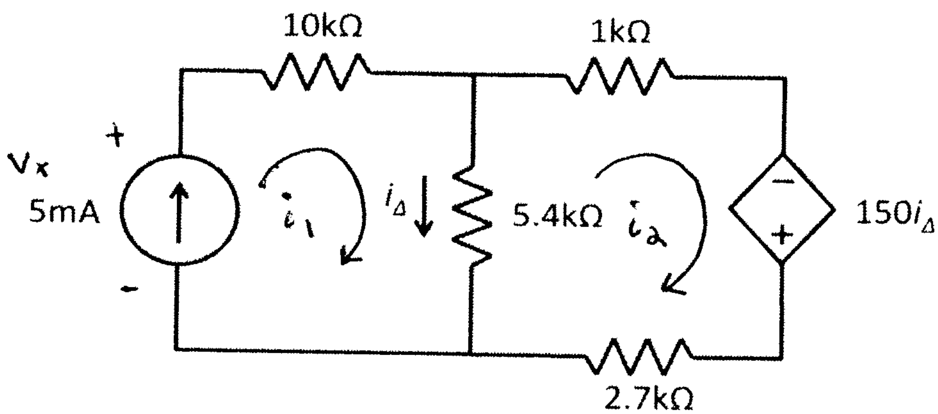
f) Power absorbed by $11k\Omega$ resistor:

$P_{abs} = (i_4 - i_3)^2 \cdot 11k\Omega$ [+1]

$= \left(-1mA - \left(-\frac{5}{24}\,mA\right)\right)^2 \cdot 11k\Omega$

$= 6.894\,mW$ [+1]

2. Consider the circuit below, and answer all parts of the question below.



a) What is i_Δ? [4pts]

b) What is the power delivered by the independent source? [3pts]

c) What is the power delivered by the dependent source? [2pts]

a) $i_1 = 5mA$ [+1] $\qquad i_\Delta = i_1 - i_2$ [+1]

$$0 = 5.4k\Omega\,(i_2 - i_1) + 1k\Omega \cdot i_2 - \underset{(\Omega)}{150}\, i_\Delta + 2.7k\Omega\, i_2 \quad [+1]$$

Substitute:

$$0 = 5.4k\Omega\,(i_2 - 5mA) + 1k\Omega \cdot i_2 - \underset{(\Omega)}{150}\,(5mA - i_2) + 2.7k\Omega\, i_2$$

$$i_2 = \frac{5.4k\Omega \cdot 5mA + 150\Omega \cdot 5mA}{5.4k\Omega + 1k\Omega + 150\Omega + 2.7k\Omega} = 3mA$$

$$i_\Delta = i_1 - i_2 = 5mA - 3mA = 2mA \quad [+1]$$

b) Power delivered by ind. source: $P_{del} = V_x \cdot 5mA$ [+1]

KVL: $0 = -V_x + 10k\Omega \cdot i_1 + 5.4k\Omega \cdot i_\Delta$ [+1]

$V_x = 10k\Omega \cdot 5mA + 5.4k\Omega \cdot 2mA$

$= 60.8V$

$$P_{del} = 60.8\,V \cdot 5\,mA$$

$$= 304\ mW \quad [+1]$$

c) Power delivered by dep. source:

$$P_{del} = (150\, i_\Delta) \cdot i_2 \quad [+1]$$

$$= (150\,\Omega \cdot 2mA)(3mA)$$

$$= 0.9\ mW \quad [+1]$$

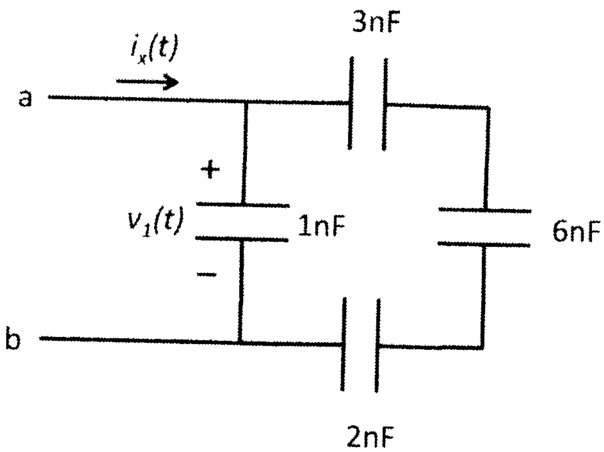
ECSE-200 Quiz #9 (12 March 2010)

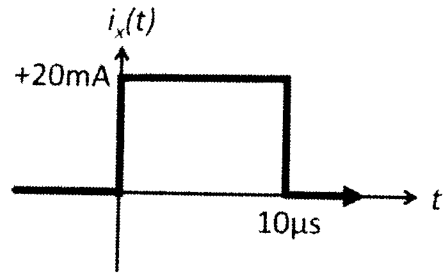
NAME_________________________________ McGill ID#________________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit and plot below. Assume the capacitors are all initially uncharged for $t<0$. Answer all parts of the question.



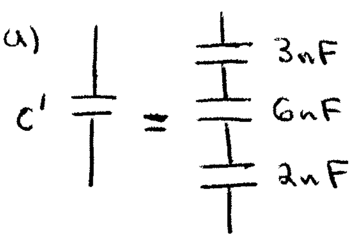


a) What is the equivalent capacitance of the sub-circuit with respect to the terminals a and b? [3pts]

b) What is the $v_1(t)$ at t = 10~~m~~μs? [3pts]

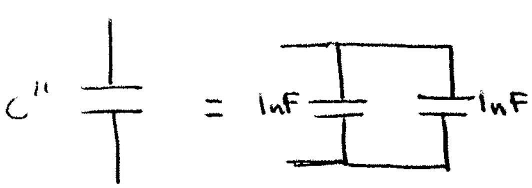
c) What is the charge separation on the 6nF capacitor at t = 10~~m~~μs? Indicate the definition of your algebraic variable clearly. [3pts]

a)



$$\frac{1}{C'} = \frac{1}{3nF} + \frac{1}{6nF} + \frac{1}{2nF}$$

$$= \frac{2+1+3}{6\ nF} = \frac{1}{1nF} \quad [+1]$$



$$C_{eq} = C'' = (1+1)\,nF \quad [+1]$$

$$= 2nF \quad [+1]$$

work space

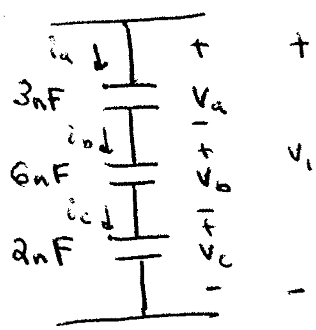
b) $i_x = C_{eq} \dfrac{dv_1}{dt}$ since v_1 appears across C_{eq}

$$v_1(t) = v_1(0) + \frac{1}{C_{eq}} \int_0^t i_x(t')\,dt' \qquad [+1]$$

$$v_1(10\mu s) = \underset{\substack{\uparrow \\ [+1]}}{0\,V} + \frac{1}{2nF}\, 20mA \cdot 10\mu s$$

$\therefore\ v_1(10\mu s) = 100\,V \quad [+1]$

c)



$V_a + V_b + V_c = 100V \quad (KVL) \quad [+1]$

$i_a = i_b = i_c$

$3\dfrac{dv_a}{dt} = 6\dfrac{dv_b}{dt} = 2\dfrac{dv_c}{dt} \quad \begin{pmatrix} KCL + \\ cap.\ eq. \end{pmatrix} \quad [+1]$

if $v_a(0) = v_b(0) = v_c(0) = 0$, then

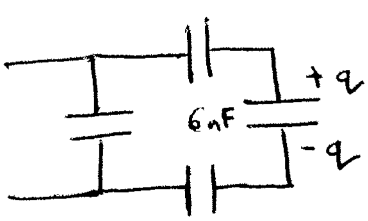
$3v_a = 6v_b = 2v_c$

Substituting the above:

$$(6v_b/3) + v_b + (6v_b/2) = 100V$$

$$v_b = \frac{100V}{2+1+3}$$

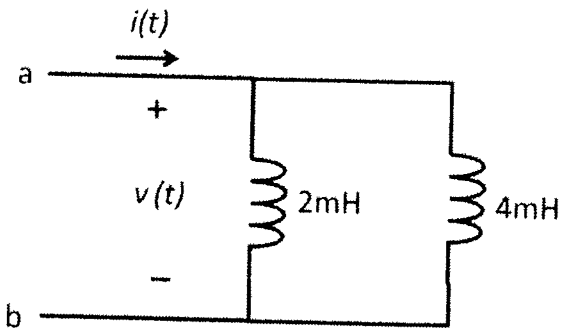
$$= 16.66\ V$$

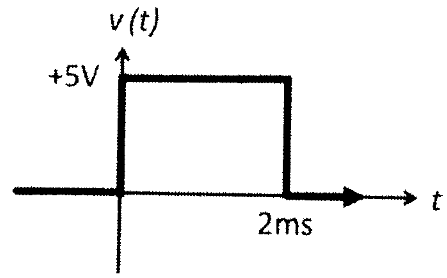


$q = 6nF \cdot v_b = 6nF \cdot 16.66V$

$= \underline{100\,nC} \quad [+1]$

2. Consider the circuit and plot below. Assume the inductors are initially storing no energy for $t<0$. Answer all parts of the question.





a) What is the equivalent inductance between terminals a and b? [2pts]

b) Draw a diagram of i(t) versus t, labeling the time and current axis? [3pts]

c) What is the total energy stored in both inductors at t = 2ms? [2pts]

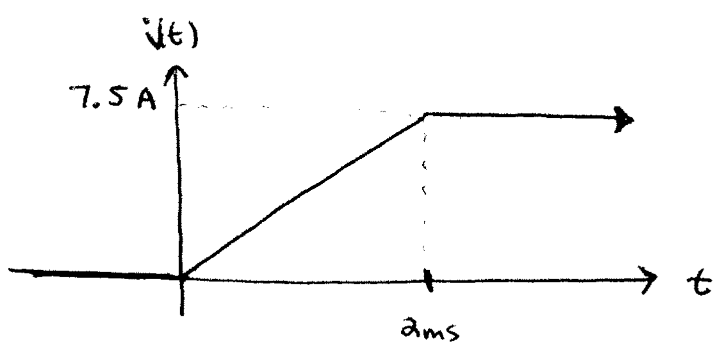
a) $L_{eq} = \left(\frac{1}{2mH} + \frac{1}{4mH}\right)^{-1} = \frac{2\cdot 4}{2+4} mH = \frac{4}{3} mH$

[+1] [+1]

b) $v(t) = L_{eq} \frac{di}{dt}$

$i(t) = i(0) + \frac{1}{L_{eq}} \int_0^t v(t')dt'$ [+1]

$= 0 + \frac{1}{L_{eq}} \times$ (area under v(t) versus t graph, up to time t)



[+1] for shape

$i(2ms) = \frac{5V \cdot 2ms}{4/3\ mH} = 7.5\ A$ [+1]

work space

c)

$$U = \frac{1}{2} L_{eq}\, i^2 \qquad [+1]$$

$$= \frac{1}{2} \cdot \frac{4}{3}\,\text{mH} \cdot (7.5\,\text{A})^2$$

$$= 37.5\ \text{mJ} \qquad [+1]$$

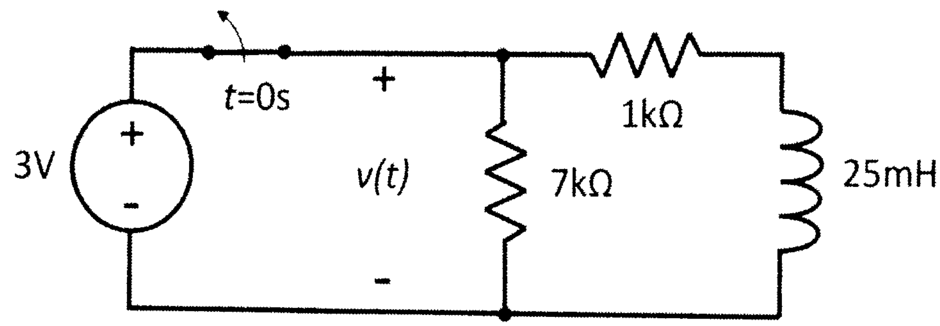
ECSE-200 Quiz #10 (19 March 2010)

NAME________________________________ McGill ID#____________________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit below. Note that the switch opens at t=0s. Assume the circuit is in dc steady state for t<0. Answer all parts of the question.



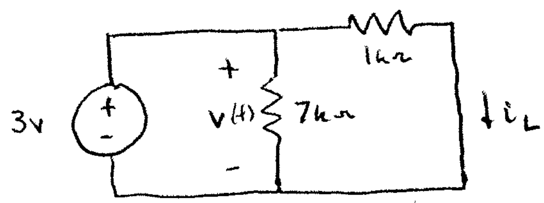
a) What is v(0−)? [2pts]

b) What is the energy stored in the inductor at t=0− ? [2pts]

c) What is v(0+)? [3pts]

d) What is the power delivered or absorbed by the inductor at the instantaneous moment t=0+ ? [4pts]

(a)



$t<0$, KVL: $v(0^-) - 3V = 0$

$v(0^-) = 3V$ [+2]

b) For $t = 0^-$, $i_L = \frac{v(0^-)}{1k\Omega} = \frac{3V}{1k\Omega} = 3mA$ [+1/2]

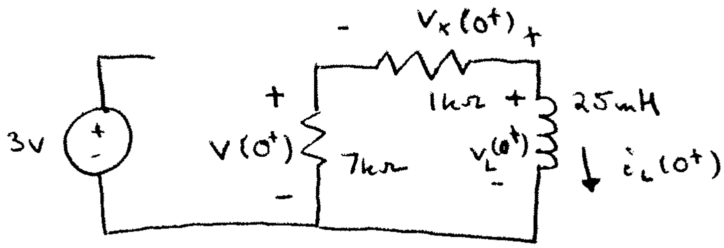
$U(0^-) = \frac{1}{2} L\, i_L^2(0^-)$ [+1/2]

$= \frac{1}{2} \cdot 25mH \cdot (3mA)^2$

$= 112.5\, nJ$ [+1]

work space

c)



$$i_L(0+) = i_L(0^-) = 3mA$$
[+1]

$$v(0+) = -i_L(0^+) \cdot 7k\Omega \quad [+1]$$

$$= -21V \quad [+1]$$

d) KVL: $v_L(0+) - v(0+) - v_x(0^+) = 0$ [+1]

$$v_x(0+) = -i_L(0^+) \cdot 1k\Omega \quad [+1]$$

$$= -3V$$

$$\therefore v_L(0+) = v(0+) + v_x(0+)$$

$$= -24V$$

Power absorbed by the inductor:

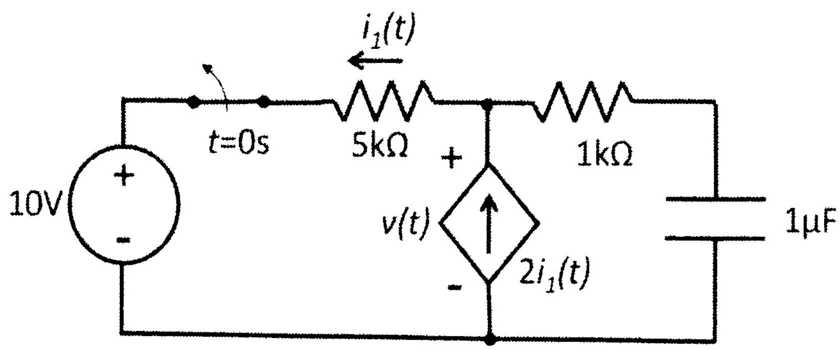
$$P_{abs}(0+) = v_L(0+) \cdot i_L(0+) \quad [+1]$$

$$= -24V \cdot 3mA$$

$$= -72\ mW \quad [+1]$$

or the inductor delivers 72mW at $t = 0+$

2. Consider the circuit below. Note that the switch opens at t=0s. Assume the circuit is in dc steady state for t<0. Answer all parts of the question.

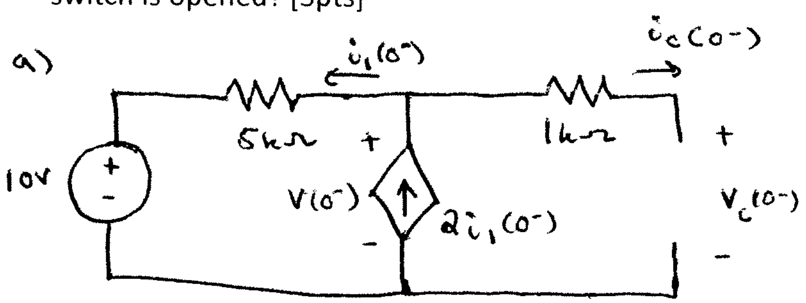


a) What is v(0−)? [4pts]

b) What is v(0+)? [4pts]

c) Find v(t) for all t>0? **Hint:** how is the charge separation on the capacitor changing in time after the switch is opened? [3pts]

a)



capacitor is open at dc steady state, therefore $i_c(0-) = 0$. [+1]

KCL: $0 = i_1(0-) + i_c(0-) - 2i_1(0-)$ [+1]

$i_1(0-) = i_c(0-) = 0$

KVL: $0 = -10V - i_1(0-) \cdot 5k\Omega + v(0-)$ [+1]

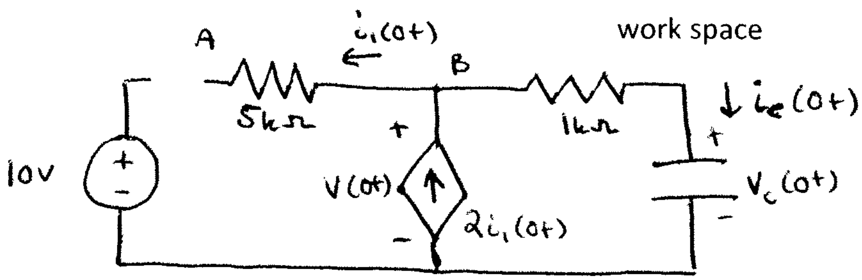
$v(0-) = 10V$ [+1]

b) First, we find $V_c(0-)$:

KVL: $0 = -v(0-) + i_c(0-) \cdot 1k\Omega + V_c(0-)$. [+1]

$V_c(0-) = 10V$

work space



by continuity of capacitor voltage, $v_c(0^+) = v_c(0^-) = 10\,V$ [+1]

By KCL at A, $i_1(0+) = 0\,A$

By KCL at B, $0 = i_1(0+) + i_c(0+) - 2i_1(0+)$

$\therefore i_c(0+) = 0\,A$ [+1/2]

By KVL: $0 = -v(0+) + i_c(0+)\cdot 1k\Omega + v_c(0+)$ [+1/2]

$v(0+) = 10\,V$ [+1]

c) We have found that $i_c(0+) = 0$, $\therefore \frac{dq}{dt} = 0$

and $\left.\frac{dv_c}{dt}\right|_{0+} = 0$ [+1]

Therefore, the circuit is in dc. steady state [+1]
(all voltages and currents have derivatives with respect to time equal to 0).

$t>0$

KVL: $0 = -v(t) + i_c(t)\cdot 1k\Omega + v_c(t)$ [+1]

$v(t) = 0\cdot 1k\Omega + 10V$

$v(t) = 10V$ for $t > 0$ [+1]

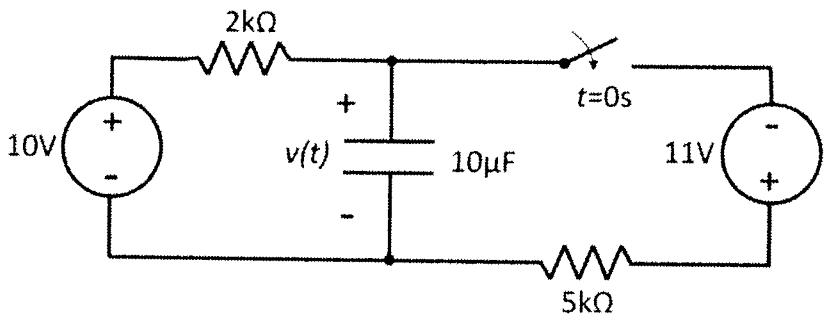
ECSE-200 Quiz #11 (26 March 2010)

NAME____ McGill ID#____________________

READ each question and its parts very carefully. SHOW ALL YOUR WORK.

Give units on your answers (where appropriate). Give only one answer to every question (multiple answers will not be accepted).

1. Consider the circuit below. Note that the switch closes at t=0s. Assume the circuit is in dc steady state for t<0. Answer all parts of the question.



a) What is v(0−)? [3pts]

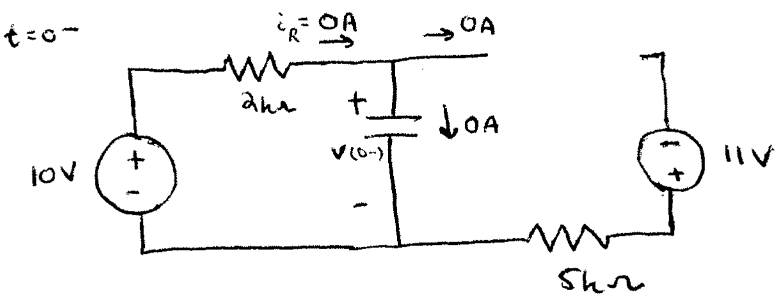
b) What is v(0+)? [1pt]

c) What is v(∞)? [3pts]

d) What is the time constant τ for t > 0 ? [3pts]

e) What is v(t) for t > 0 ? [2pts]

a) $t=0^-$



KCL → $i_R = 0\,A$ [+1]

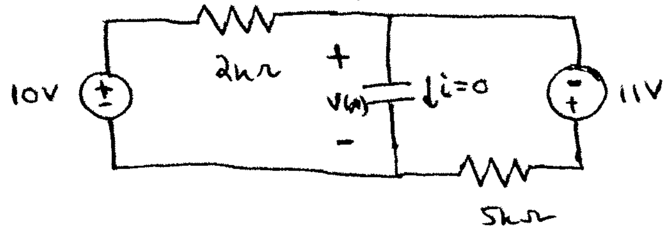
KVL: $-10V + 0 \cdot 2k\Omega + v = 0$ [+1]

$v(0^-) = 10V$ [+1]

b) continuity of capacitor voltage: $v(0+) = v(0-) = 10\,V$ [+1] c)

$t \to \infty$

work space



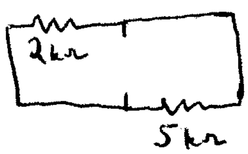
KVL: $-10V + i_R \cdot 2k\Omega - 11V + 5k\Omega \cdot i_R = 0$ [+1]

$$i_R = \frac{21V}{7k\Omega} = 3mA$$

KVL: $-10V + 3mA \cdot 2k\Omega + v(\infty) = 0$ [+1]

$$v(\infty) = 10V - 3mA \cdot 2k\Omega$$
$$= 4V \quad [+1]$$

d) $\tau = R_{eq} C$ [+1]



$R_{eq} = 2k\Omega \parallel 5k\Omega = \frac{2 \cdot 5}{2+5} k\Omega = \frac{10}{7} k\Omega$
[+1]

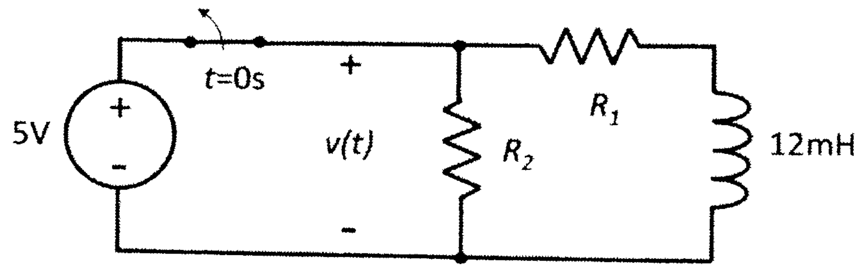
$\tau = \frac{10}{7} k\Omega \cdot 10\mu F = \frac{100}{7} ms$ [+1]

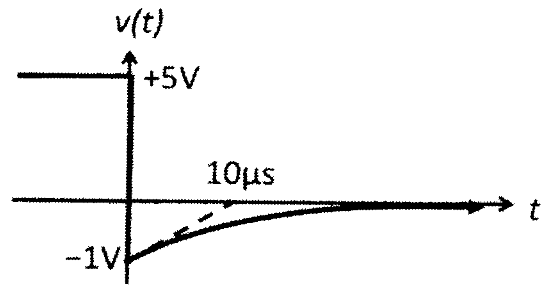
$= 14.29\ ms$

e) $v(t) = v(\infty) + (v(0+) - v(\infty)) \exp(-t/\tau)$

$$= \underbrace{4V}_{[+1]} + \underbrace{6V \exp\left(-t / \tfrac{100}{7} ms\right)}_{[+1]}$$

2. Consider the circuit and plot below. Note that the switch opens at t=0s. Assume the circuit is in dc steady state for t<0. Answer all parts of the question.





a) Express v(0+) in terms of R_1 and R_2. [3pts]

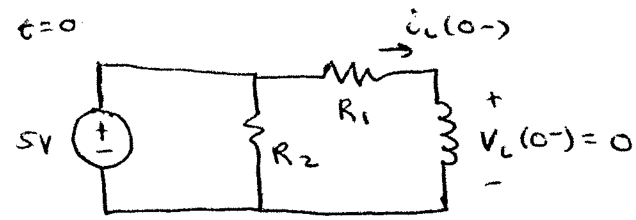
b) Express the time constant τ in terms of R_1 and R_2. [3pts]

c) Using the plot and your answers to a) and b), what are the values of R_1 and R_2? [3pts]

d) How much energy is dissipated in the resistors R_1 and R_2 over the time interval $0 < t < \infty$? [3pts]
HINT: Consider your calculation method carefully before proceeding.

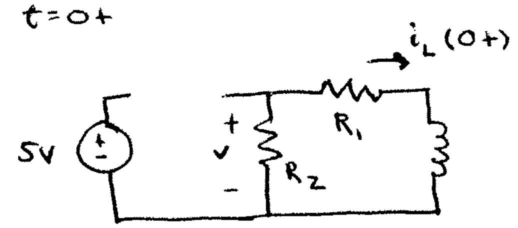
t=0

a)



$i_L(0^-) = \frac{5V}{R_1}$ [+1]

t=0+



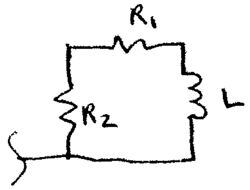
$i_L(0+) = i_L(0-)$ (cont. of inductor current)

$v(0+) = -i_L(0_+) \cdot R_2$ [+1]

$\therefore\ v(0+) = -5V \frac{R_2}{R_1}$

work space

b)



$\tau = \frac{L}{R_{eq}}$ [+1] $\quad R_{eq} = R_1 + R_2$ [+1]

$\therefore \tau = 12mH / (R_1 + R_2)$ [+1]

c) $-1V = -5V \frac{R_2}{R_1}$ $\quad 10\mu s = \frac{12mH}{R_1 + R_2}$ $\quad 5R_2 + R_2 = 1.2k\Omega$

$\therefore R_1 = 5R_2$ [+1/2] $\quad R_1 + R_2 = 1.2k\Omega$ [+1/2] $\quad R_2 = 200\,\Omega$ [+1]

$R_1 = 1000\,\Omega$ [+1]

d) energy dissipated by R_1 and R_2 over $0 < t < \infty$

= energy stored by L at $t = 0s$ } [+1]

$= \frac{1}{2} L\, i_L^2(0)$ [+1]

$= \frac{1}{2} \cdot 12mH \cdot \left(\frac{5V}{1000\Omega}\right)^2$

$= 150\,nJ$ [+1]