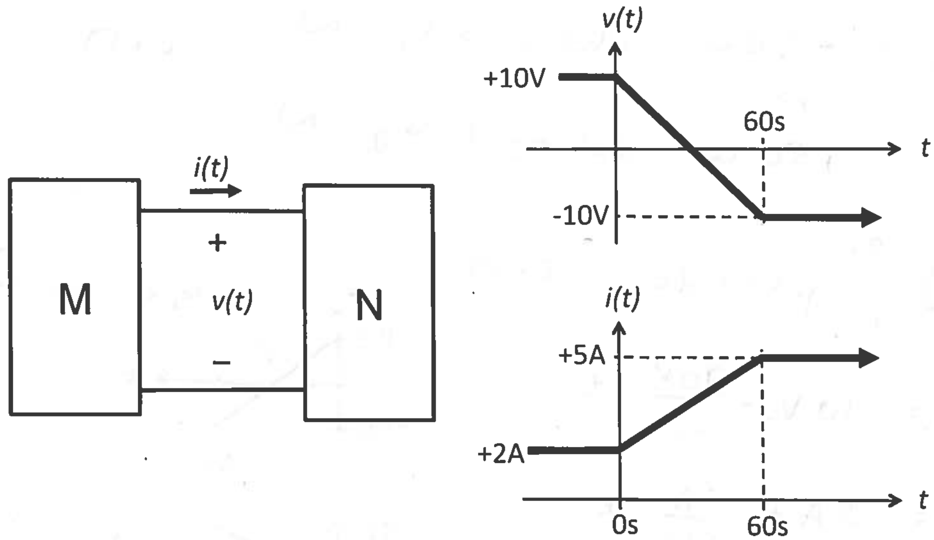
ECSE-200 Quiz # 1 (11 Sept 2015)

NAME________________________________ McGill ID#__________________

READ each question and its parts carefully before starting. Do your work INDEPENDENTLY and SHOW ALL YOUR WORK. Give units on your answers (where appropriate).

1. Consider the circuit diagram below. The current $i(t)$ and voltage $v(t)$ were measured as a function of time t, and are plotted below. The current and voltage vary linearly with time on the time interval 0s < t < 60s. Answer the questions.



a) What is the total charge $q(t)$ that flows *into* the top terminal (and *out* the bottom terminal) of the element N over the time interval 0s < t < 60s? [2pts]

b) What is the instantaneous power absorbed by element N at t = 0s ? [1pt]

c) What is the instantaneous power absorbed by element N at t = 60s ? [1pt]

d) What is the total energy $U(t)$ absorbed by the element N over the time interval 0s < t < 60s? [2pts]

a) $q = \int_{0s}^{60s} i(t)\, dt$ [+1]

$= 2A \cdot 60s + \frac{1}{2} \cdot 3A \cdot 60s$

$= 210\,C$ [+1]

b) $p(0) = 2A \cdot 10V$ absorbed

$= 20W$ absorbed by N [+1]

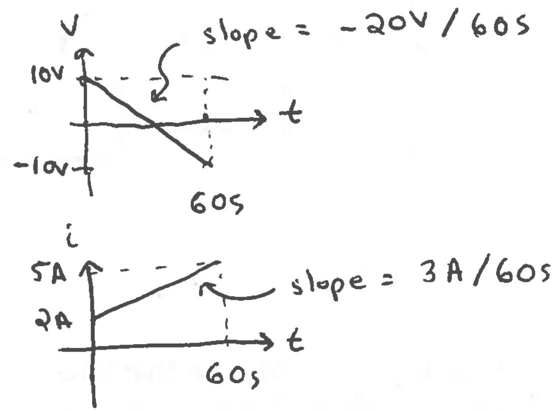
c) $p(60) = 5A \cdot (-10V)$ absorbed

$= -50W$ absorbed by N (+1)

or

$+50W$ delivered by N

d) $U = \int_{0s}^{60s} p(t)\, dt$ (+1)



$v(t) = 10V - \frac{20V}{60s} \cdot t$

$i(t) = 2A + \frac{3A}{60s} \cdot t$

$$U = \int_0^{60} (10 - \tfrac{1}{3}t)(2 + \tfrac{1}{20}t)\, dt$$

$$= \int_0^{60} 20 + (\tfrac{1}{2} - \tfrac{2}{3})t - \tfrac{1}{60} t^2\, dt$$

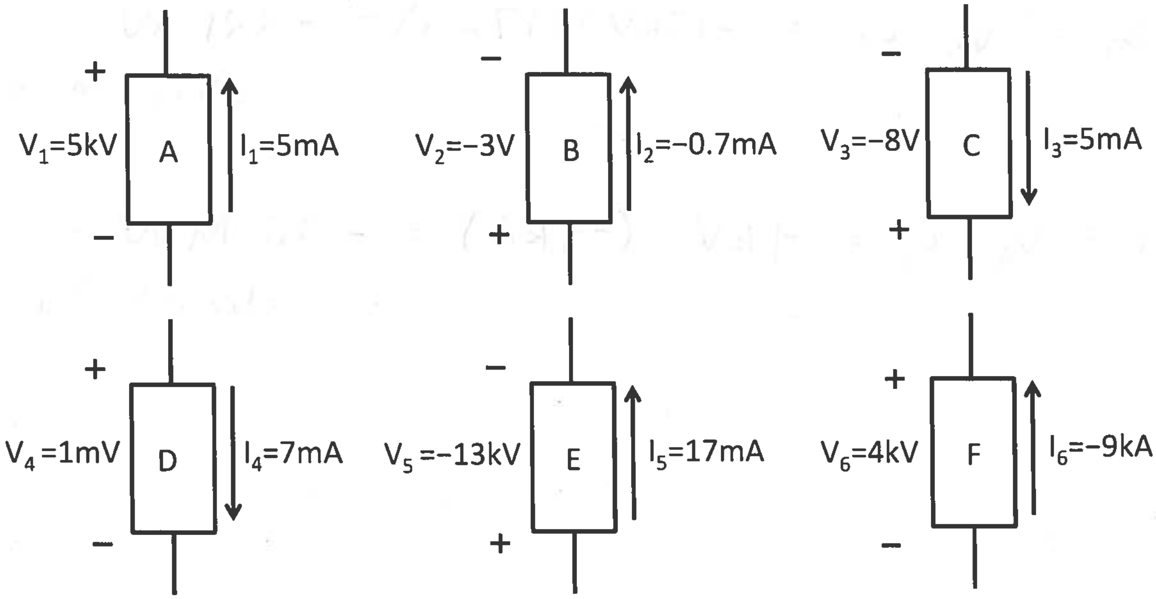
$$= \left[20t + \tfrac{1}{2}\left(\tfrac{-1}{6}\right)t^2 - \tfrac{1}{3} \cdot \tfrac{1}{60} t^3 \right]_0^{60}$$

$= 1200J + (-300)J - 1200J$

$= -300J$ absorbed by N [+1]

or $+300J$ delivered by N

2. Consider the circuit diagrams below. Answer the questions. Indicate clearly power absorption or delivery.



a) What is the power delivered or absorbed by element A? [1pt]

b) What is the power delivered or absorbed by element B? [1pt]

c) What is the power delivered or absorbed by element C? [1pt]

d) What is the power delivered or absorbed by element D? [1pt]

e) What is the power delivered or absorbed by element E? [1pt]

f) What is the power delivered or absorbed by element F? [1pt]

a) $P_{del} = V_1 \cdot i_1 = 5kV \cdot 5mA = 25\,W$ delivered by A [+1]

b) $P_{abs} = V_2 \cdot i_2 = (-3V)(-0.7mA) = 2.1mW$ absorbed by B [+1]

c) $P_{del} = V_3 \cdot i_3 = (-8V)(5mA) = -40mW$ delivered by C [+1]

d) $P_{abs} = V_4 \cdot i_4 = (1mV)(7mA) = 7\mu W$ absorbed by D [+1]

work space

e) $p_{abs} = V_5 \cdot i_5 = (-13kV)(17mA) = -221\ W$

absorbed by E

[+1]

f) $p_{del} = V_6 \cdot i_6 = 4kV \cdot (-9kA) = -36\ MW$

delivered by F

[+1]

ECSE-200 Quiz #2 (十八 Sept 2015)

NAME______________________________ McGill ID#__________________

READ each question and its parts carefully before starting. SHOW ALL YOUR WORK. Give units on your answers (where appropriate).

1. Consider the circuit diagram below. Answer the questions.

a) What is the value of v_2 ? [2pts]

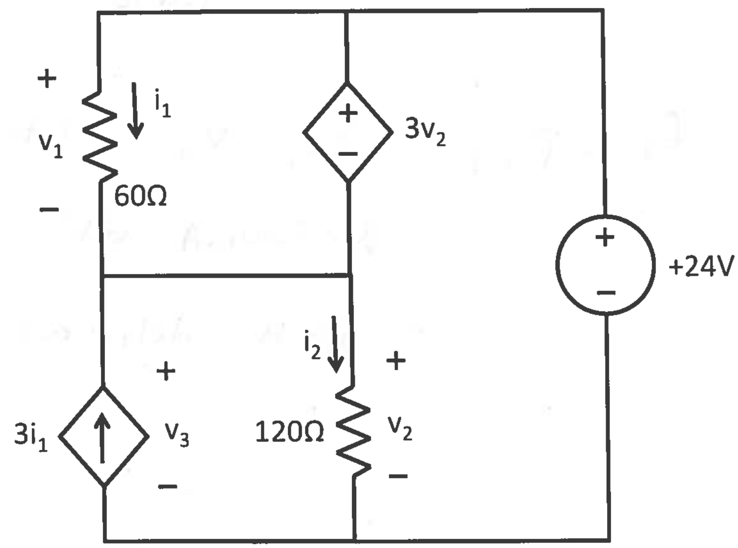
b) What is the value of i_2 ? [2pts]

c) What is the value of v_3 ? [2pts]

d) What is the value of v_1 ? [2pts]

e) What is the value of i_1 ? [2pts]

f) How much power is the dependent current source delivering or absorbing? [2pts]



a) KVL: $0 = -v_2 - 3v_2 + 24V$ [+1]

$v_2 = \frac{24V}{4} = 6V$ [+1]

b) Ω : $v_2 = i_2 \cdot 120\Omega$ [+1]

$i_2 = \frac{6V}{120\Omega} = 50mA$ [+1]

c) KVL: $0 = -v_3 + v_2$ [+1]

$v_3 = v_2 = 6V$ [+1]

d) KVL: $0 = -v_3 - v_1 + 24V$ [+1]

$v_1 = 24V - v_3 = 18V$

e) Ω : $v_1 = i_1 \cdot 60\Omega$ [+1]

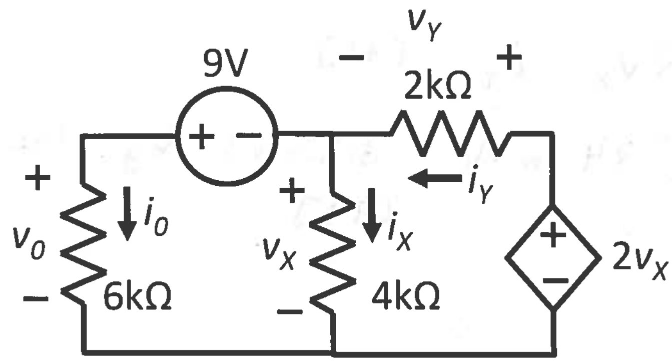
$$i_1 = \frac{18V}{60\Omega} = 300mA \quad [+1]$$

f) $P_{del} = 3i_1 \cdot v_3$ [+1]

$= 3 \cdot 300mA \cdot 6V$

$= 5.4W$ delivered by dep. current source.

2. Consider the circuit diagram below. It is known that v_O = 27 V. Answer the questions.



a) What is the value of i_O? [2pts]

b) What is the value of v_X? [2pts]

c) What is the value of i_X? [2pts]

d) What is the value of i_Y? [2pts]

e) What is the value of v_Y? [2pts]

f) How much power is the dependent source delivering or absorbing? [2pts]

a) Ω : $V_o = i_o \cdot 6k\Omega$ [+1]

$$i_o = \frac{V_o}{6k\Omega} = 4.5\,mA \quad [+1]$$

b) KVL: $0 = -V_o + 9V + V_x$ [+1]

$$V_x = V_o - 9V = 18V \quad [+1]$$

c) Ω : $V_x = i_x \cdot 4k\Omega$ [+1]

$$i_x = \frac{V_x}{4k\Omega} = 4.5\,mA \quad [+1]$$

d) KCL: $0 = i_o + i_x - i_Y$ [+1]

$$i_Y = i_o + i_x = 9\,mA \quad [+1]$$

e) Ω : $V_Y = i_Y \cdot 2k\Omega$ [+1]

$$= 18V \quad [+1]$$

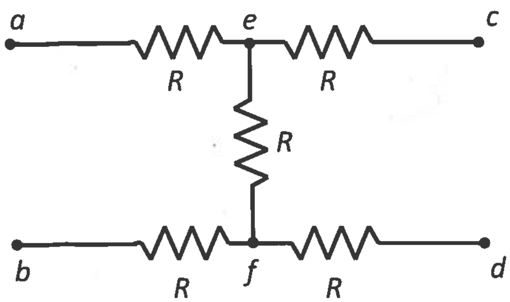
f) $P_{del} = 2v_x \cdot i_Y$ [+1]

$= 324 \text{ mW}$ delivered by the dep. source [+1]

NAME____ McGill ID#____________________

READ each question and its parts carefully before starting. SHOW ALL YOUR WORK. Give units on your answers (where appropriate).

1. Consider the circuit diagram below. Answer the questions. Express your answers in terms of *R*.



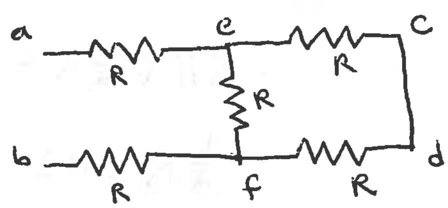
a) What is the equivalent resistance between *a* and *b* if a short circuit is attached between c and *d* ? [2pts]

b) What is the equivalent resistance between *a* and *d* if a short circuit is attached between c and *f* ? [2pts]

c) What is the equivalent resistance between e and *f* if a short circuit is attached between *a* and *d*, and a short circuit is attached between *b* and *c* ? [2pts]

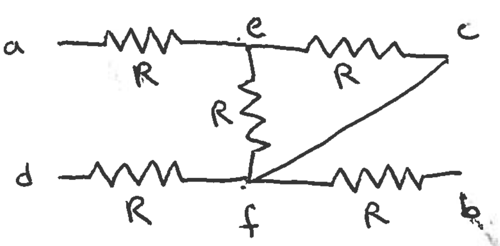
d) What is the equivalent resistance between *e* and *f* if a short circuit is attached between *a* and *d*, a short circuit is attached between *b* and *c*, and a short circuit is attached between c and *d* ? [2pts]

a)



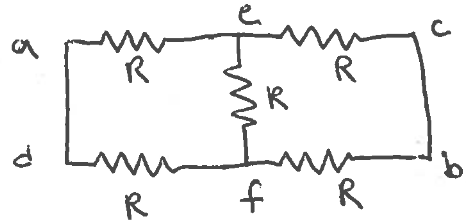
$$R_{ab} = 2R + R // 2R \quad [+1]$$
$$= 2R + \tfrac{2}{3}R$$
$$= 2\tfrac{2}{3}R \quad [+1]$$

b)



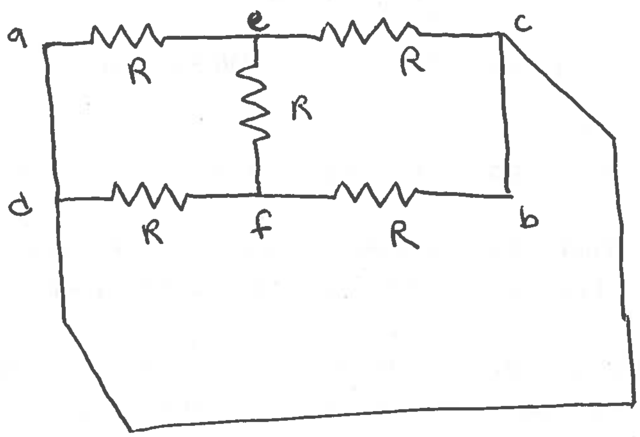
$$R_{ad} = 2R + R // R \quad [+1]$$
$$= 2R + \tfrac{1}{2}R$$
$$= 2\tfrac{1}{2}R \quad [+1]$$

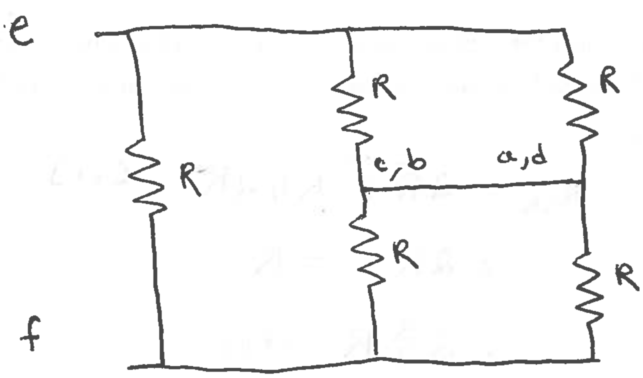
c)



$$R_{ef} = R // 2R // 2R \quad [+1]$$
$$= R // R$$
$$= \tfrac{1}{2}R \quad [+1]$$

d)



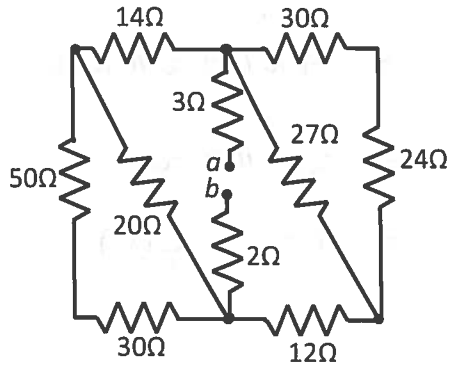


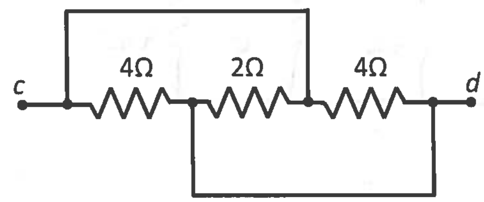
$$R_{ef} = R \,//\, (R//R + R//R) \quad [+1]$$

$$= R \,//\, \left(\tfrac{1}{2}R + \tfrac{1}{2}R\right)$$

$$= \tfrac{1}{2}R \quad [+1]$$

2. Consider the circuit diagram below. Answer the questions.





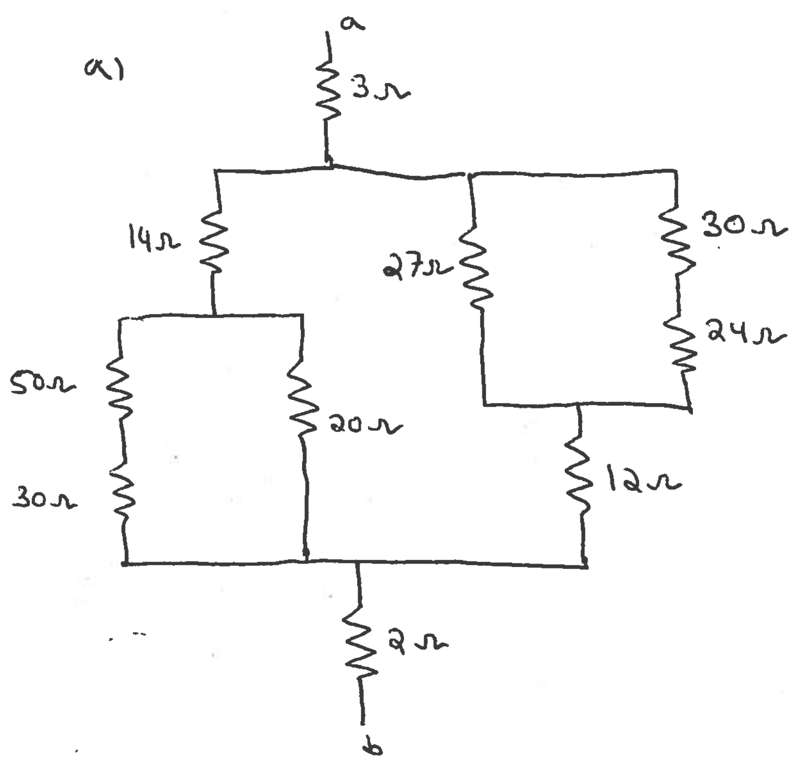
a) What is the equivalent resistance between *a* and *b* ? [2pts]

b) If an independent voltage source is connected across nodes *a* and *b* to produce 2 kW of heat in the resistors, what is the voltage that should be used? [2pts]

c) What is the equivalent resistance between *c* and *d* ? [2pts]

b) If an independent current source is connected across nodes *c* and *d* to produce 841 mW of heat in the resistors, what is the current that should be used? [2pts]

a)



$$R_{ab} = 3\Omega + 2\Omega + (14\Omega + 20\Omega \,//\, (50\Omega + 30\Omega)) \,//\, (12\Omega + 27\Omega \,//\, (24\Omega + 30\Omega))$$ [+1]

$$= 5\Omega + (14\Omega + 20\Omega \,//\, 80\Omega) \,//\, (12\Omega + 27\Omega \,//\, 54\Omega)$$

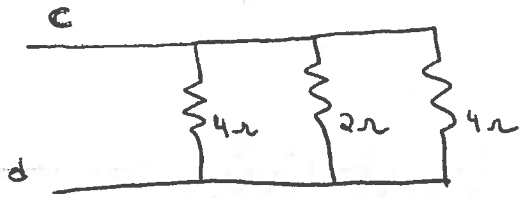
$$= 5\Omega + (14\Omega + 16\Omega) \,//\, (12\Omega + 18\Omega)$$

$$= 20\Omega$$ [+1]

b) $P = V^2 / R_{ab}$ [+1]

$$V = \sqrt{P \cdot R_{ab}} = \sqrt{2000\,W \cdot 20\Omega} = 200\,V$$ [+1]

c)



$$R_{cd} = 4\Omega \,//\, 4\Omega \,//\, 2\Omega \quad [+1]$$
$$= 2\Omega \,//\, 2\Omega$$
$$= 1\Omega \quad [+1]$$

d)

$$P = i^2 R_{cd} \quad [+1]$$

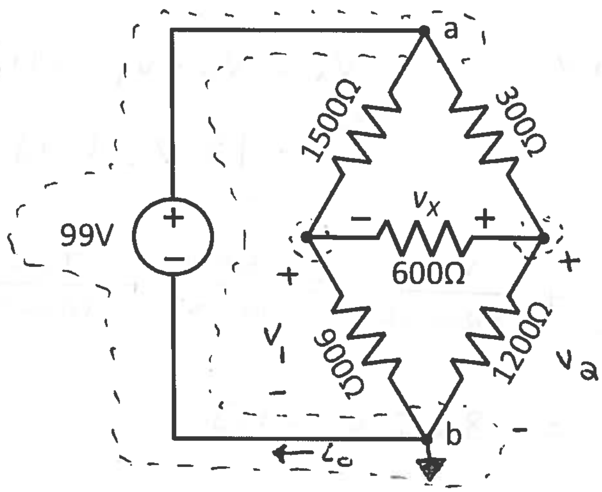
$$i = \sqrt{\frac{P}{R_{cd}}} = \sqrt{\frac{841\,mW}{1\Omega}} = 917\,mA \quad [+1]$$

ECSE-200 Quiz #4 ($[1+(-1)^{1/2}][1-(-1)^{1/2}]$ Oct 2015)

NAME____ McGill ID#__________________

READ each question and its parts carefully before starting. SHOW ALL YOUR WORK. Give units on your answers (where appropriate).

1. Consider the circuit diagram. Answer the questions.



a) How many node voltages are required to solve the circuit by the node voltage method? [1pt]

b) Write the node voltage equations required to solve the circuit. Define your node voltages on the diagram. [4pts]

c) What are the node voltages? [2pts]

d) What is v_x? [2pts]

e) What is the equivalent resistance of the resistor circuit between nodes a and b? [1pt]

a) 2 [+1]

b) KCL at node 1: $0 = \frac{v_1}{900} + \frac{v_1 - v_2}{600} + \frac{v_1 - 99}{1500}$ [+2]

KCL at node 2: $0 = \frac{v_2}{1200} + \frac{v_2 - v_1}{600} + \frac{v_2 - 99}{300}$ [+2]

$\frac{99}{15} = \left(\frac{1}{9} + \frac{1}{6} + \frac{1}{15}\right)v_1 - \frac{1}{6}v_2$

$\frac{99}{3} = -\frac{1}{6}v_1 + \left(\frac{1}{12} + \frac{1}{6} + \frac{1}{3}\right)v_2$

$\rightarrow$

$6.6 = 0.3444\,v_1 - 0.1666\,v_2$

$33 = -0.1666\,v_1 + 0.5833\,v_2$

work space

$$v_1 = \frac{\begin{vmatrix} 6.6 & -0.1666 \\ 33 & 0.5833 \end{vmatrix}}{\begin{vmatrix} 0.3444 & -0.1666 \\ -0.1666 & 0.5833 \end{vmatrix}} = 54.0\ \text{V} \quad [+2]$$

$$v_2 = \frac{\begin{vmatrix} 0.3444 & 6.6 \\ -0.1666 & 33 \end{vmatrix}}{\begin{vmatrix} 0.3444 & -0.1666 \\ -0.1666 & 0.5833 \end{vmatrix}} = 72.0\ \text{V} \quad [+2]$$

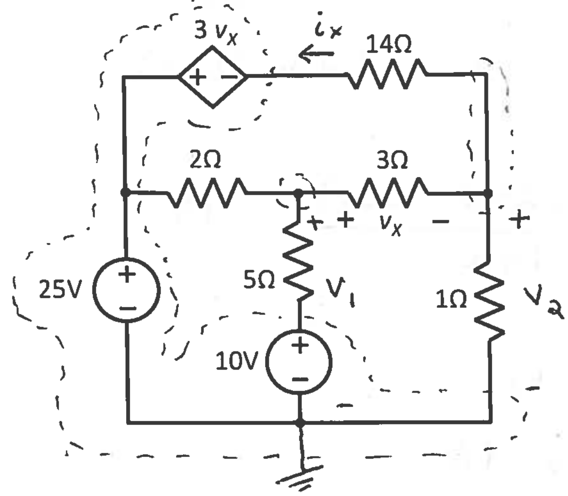
d) $0 = -v_2 + v_x + v_1 \quad \therefore \quad v_x = v_2 - v_1$ [+1]

$= 18\ \text{V}$ [+1]

e) $$i_o = \frac{v_1}{900\,\Omega} + \frac{v_2}{1200\,\Omega} = \frac{54\text{V}}{900\,\Omega} + \frac{72\text{V}}{1200\,\Omega} = 120\ \text{mA}$$

$$R_{ab} = \frac{99\text{V}}{i_o} = 825\,\Omega \quad [+1]$$

2. Consider the circuit diagram. Answer the questions.



a) How many node voltages and control variables are required to solve the circuit by the node voltage method? [1pt]

b) Write the node voltage equations and control variable equations required to solve the circuit. Define your node voltages on the diagram. [5pts]

c) What are the node voltages? What is v_x? [3pts]

d) How much power does the dependent source deliver? [1pt]

a) 2 node voltages + 1 control variable [1]

b) KCL at node 1: $0 = \frac{V_1 - 10V}{5\Omega} + \frac{V_1 - 25V}{2\Omega} + \frac{V_1 - V_2}{3\Omega}$ [+2]

KCL at node 2: $0 = \frac{V_2}{1\Omega} + \frac{V_2 - V_1}{3\Omega} + \frac{V_2 - (25V - 3v_x)}{14\Omega}$ [+2]

control equation: $v_x = V_1 - V_2$ [+1]

c) $14.5 = 1.033\, V_1 - 0.333\, V_2$

$1.786 = -0.119\, V_1 + 1.190\, V_2$

$$V_1 = \frac{\begin{vmatrix} 14.5 & -0.333 \\ 1.786 & 1.190 \end{vmatrix}}{\begin{vmatrix} 1.033 & -0.333 \\ -0.119 & 1.190 \end{vmatrix}} = 15.0V \quad [+1]$$

$$V_2 = \frac{\begin{vmatrix} 1.033 & 14.5 \\ -0.119 & 1.786 \end{vmatrix}}{\begin{vmatrix} 1.033 & -0.333 \\ -0.119 & 1.190 \end{vmatrix}} = 3.00V \quad [+1]$$

$v_x = v_1 - v_2 = 15 - 3 = 12\,V$ [+1]

d) $i_x = \dfrac{v_2 - (25V - 3v_x)}{14\Omega} = 1A$

$P_{del} = 3v_x \cdot i_x$

$= 3 \cdot 12V \cdot 1A$

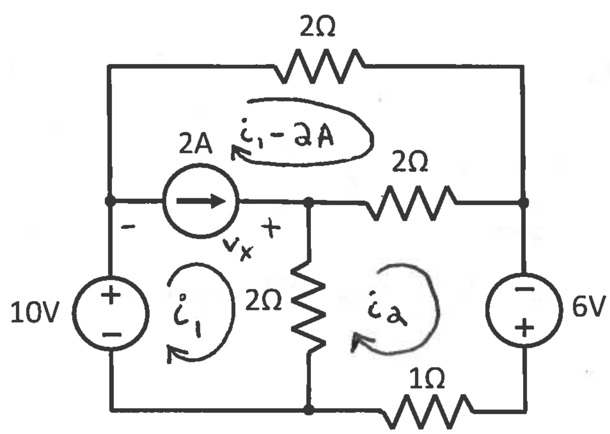
$= 36\,W$ delivered by source [+1]

ECSE-200 Quiz #5 (111111111/12345679 Oct 2015)

NAME____ McGill ID#__________________

READ each question and its parts carefully before starting. SHOW ALL YOUR WORK. Give units on your answers (where appropriate).

1. Consider the circuit below. Answer the questions.



a) Write the mesh current equations required to solve this circuit. Clearly define your mesh current variables on the diagram. [4pts]

b) Solve for the unknown mesh currents. [2pts]

c) How much power does the 2A source deliver to the circuit? [2pts]

a) KVL on super-mesh 1:

$$0 = -10V + (i_1 - 2A)2\Omega + (i_1 - 2A - i_2)2\Omega + (i_1 - i_2)2\Omega$$

[+2]

KVL on mesh 2:

$$0 = -6V + i_2 \cdot 1\Omega + (i_2 - i_1)2\Omega + (i_2 - (i_1 - 2A))2\Omega$$

[+2]

b) $18 = 6i_1 - 4i_2$

$2 = -4i_1 + 5i_2$

$$i_1 = \frac{\begin{vmatrix} 18 & -4 \\ 2 & 5 \end{vmatrix}}{\begin{vmatrix} 6 & -4 \\ -4 & 5 \end{vmatrix}} = 7A \text{ [+1]}$$

$$i_2 = \frac{\begin{vmatrix} 6 & 18 \\ -4 & 2 \end{vmatrix}}{\begin{vmatrix} 6 & -4 \\ -4 & 5 \end{vmatrix}} = 6A \text{ [+1]}$$

c) KVL on mesh 1:

$$0 = -10V - v_x + (i_1 - i_2)\cdot 2\Omega$$ [+1 for correct KVL eq.]

$$v_x = -10V + (7A - 6A)\cdot 2\Omega = -8V$$

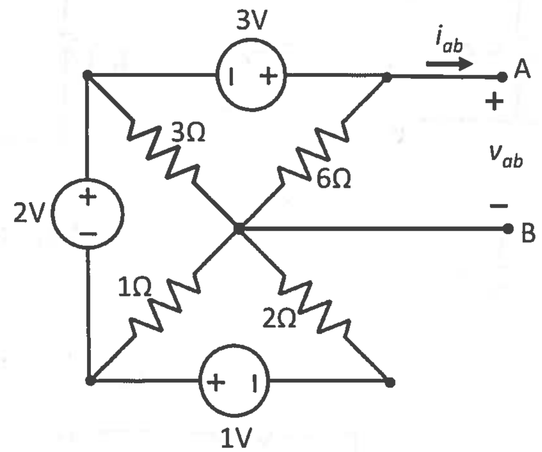
$$P_{del} = 2A \cdot v_x$$

$= -16W$ delivered by 2A source

or [+1 for either]

$+16W$ absorbed by 2A source

2. Consider the circuit below. Answer the questions. Be sure to identify terminals A and B in your equivalent circuit diagrams.

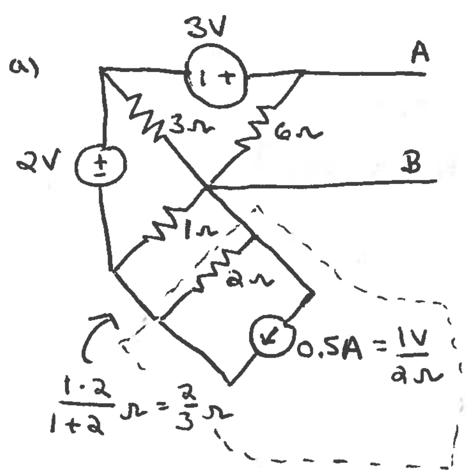


a) What is the Norton equivalent circuit with respect to the terminals A and B? [4pts]

b) What is the Thévenin equivalent circuit with respect to the terminals A and B? [2pts]

c) Draw a diagram of i_{AB} versus v_{AB}, indicating clearly the intercepts on the axes. [2pts]

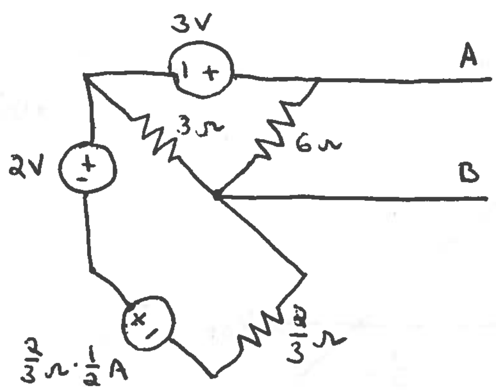
a)



$0.5A = \frac{1V}{2\Omega}$

$\frac{1 \cdot 2}{1+2}\Omega = \frac{2}{3}\Omega$

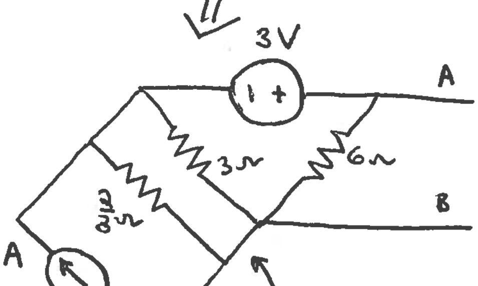
[+2 for first transformation]



$\frac{2}{3}\Omega \cdot \frac{1}{2}A = \frac{1}{3}V$

add voltage sources in series:

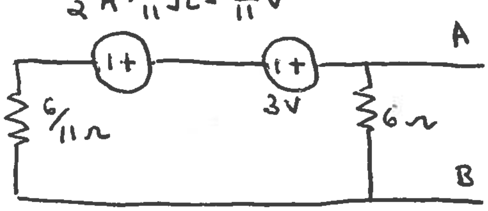
$2V + \frac{1}{3}V = \frac{7}{3}V$



$\frac{\frac{7}{3}V}{\frac{2}{3}\Omega} = \frac{7}{2}A$

$\frac{\frac{2}{3} \cdot 3}{\frac{2}{3} + 3} = \frac{6}{11}\Omega$

$\frac{7}{2}A \cdot \frac{6}{11}\Omega = \frac{21}{11}V$



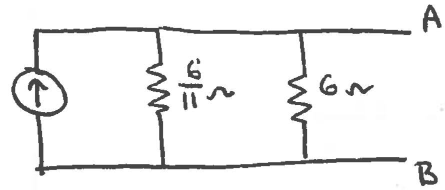
add voltage sources in series:

$\frac{21}{11}V + 3V = \frac{54}{11}V$

cont. next page

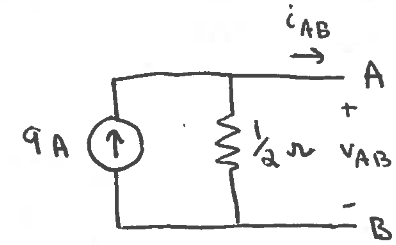
work space

$$\frac{54/11\,V}{6/11\,\Omega} = 9A$$



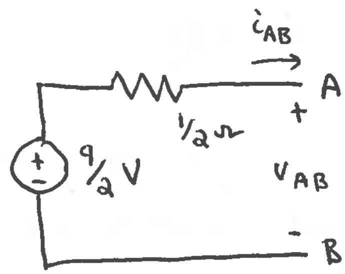
$$\frac{\frac{6}{11}\cdot 6}{\frac{6}{11}+6}\,\Omega = \frac{1}{2}\,\Omega$$

$\Longrightarrow$



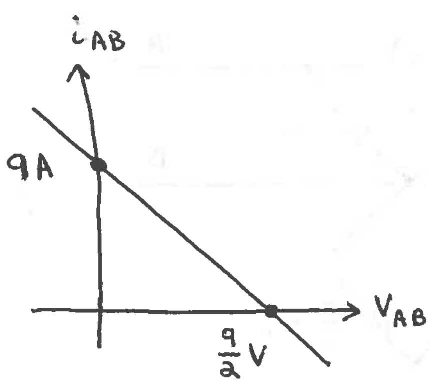
[+1 for i_{sc}, +1 for R_T]

b) $v_{oc} = i_{sc} R_T$ [+1]



[+1/2 for v_{oc}
+1/2 for R_T]

c)



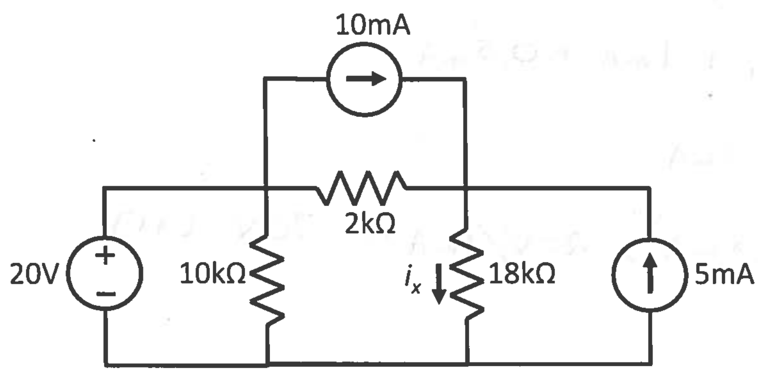
[+1/2 for shape
+1/2 for values]

ECSE-200 Quiz #6 ($\pi^{2.4220462456}$ Oct 2015)

NAME______________________________________ McGill ID#________________

READ each question and its parts carefully before starting. SHOW ALL YOUR WORK. Give units on your answers (where appropriate).

1. Consider the circuit diagram below. Answer the questions.



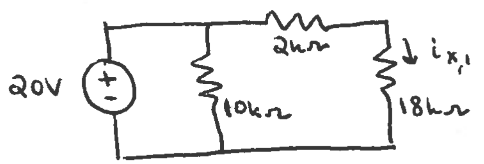
a) What is the current i_x? [2pts]

b) If the 10mA source is turned off, what is the value of i_x? [1pt]

c) If the 20V source is turned off, what is the value of i_x? [1pt]

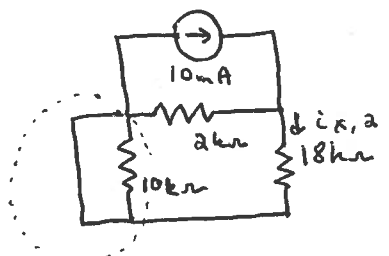
d) What should the value of the voltage source be so that i_x = 5mA? [1pt]

a)

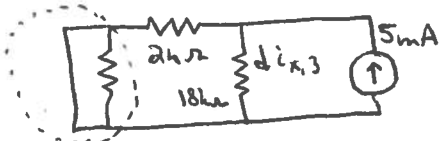


$i_{x,1} = 20V / 20k\Omega = 1mA$

equivalent to a short



$$i_{x,2} = \frac{10mA \cdot 2k\Omega}{2k\Omega + 18k\Omega} = 1mA$$



$$i_{x,3} = \frac{5mA \cdot 2k\Omega}{2k\Omega + 18k\Omega} = 0.5mA$$

[+1 for any valid approach to solving this problem, eg. node voltage]

$i_x = i_{x,1} + i_{x,2} + i_{x,3} = 2.5mA$ [+1]

work space

b) $i_x = i_{x,1} + i_{x,3} = 1.5\,mA$ [+1]

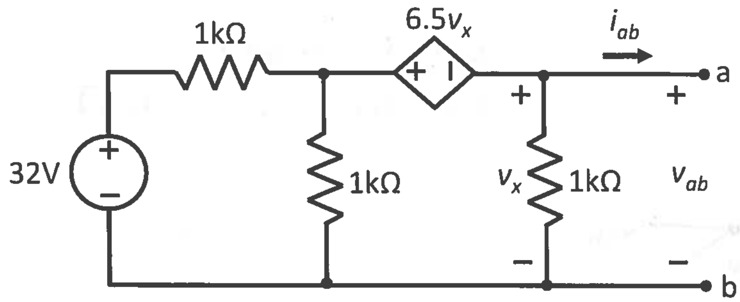
c) $i_x = i_{x,2} + i_{x,3} = 1.5\,mA$ [+1]

d) $5\,mA = i_{x,1} + 1\,mA + 0.5\,mA$

$i_{x,1} = 3.5\,mA$

$V = 3.5\,mA \times 20V/1mA = 70V$ [+1]

2. Consider the circuit below. Answer the questions.



a) What is the open circuit voltage at the terminals a and b? [2pts]

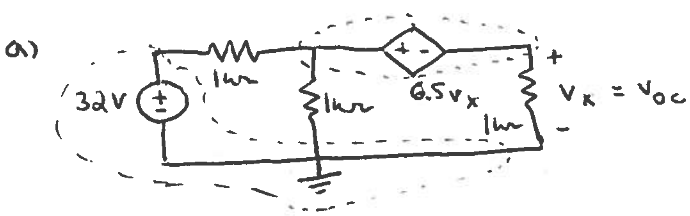
b) What is the short circuit current at the terminals a and b? [2pts]

c) Draw the Thévenin equivalent circuit with respect to the terminals a and b. [2pts]

d) Draw the i_{ab} versus v_{ab} diagram. Label the axes of your diagram. [2pts]

e) What is v_{AB} when a resistance R = 1kΩ is attached to the terminals a and b? [1pt]

a)



[+1 for open circuit conditions]

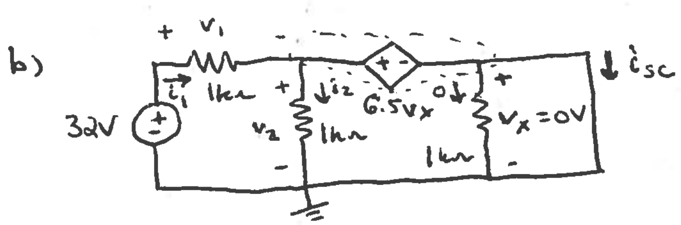
KCL:

$$0 = \frac{v_{oc}}{1k\Omega} + \frac{v_{oc} + 6.5v_{oc}}{1k\Omega} + \frac{v_{oc} + 6.5v_{oc} - 32V}{1k\Omega}$$

$$0 = 16v_{oc} - 32V$$

$$v_{oc} = 2V \text{ [+1]}$$

b)



[+1 for short circuit conditions]

KVL:

$0 = -v_a + 6.5v_x \rightarrow v_a = 0V$, $i_a = 0A$

KVL:

$0 = -32V + v_1 + v_a \rightarrow v_1 = 32V$, $i_1 = \frac{32V}{1k\Omega} = 32mA$

KCL:

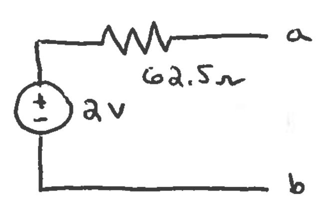
$0 = -i_1 + i_a + 0 + i_{sc}$

$i_{sc} = 32\ mA$ [+1]

c) $R_T = \frac{v_{oc}}{i_{sc}}$ [+1]

$= 2V/32mA = \frac{1}{16}\ k\Omega$

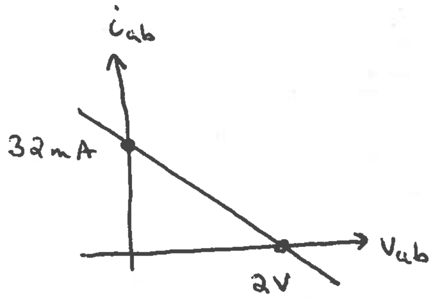
$= 62.5\ \Omega$



[+1]

work space

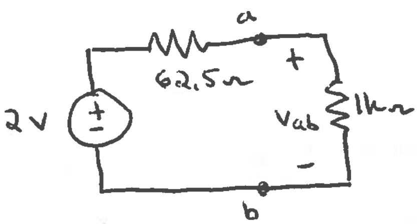
d)



[+1 for shape]

[+1 for correct values]

e)



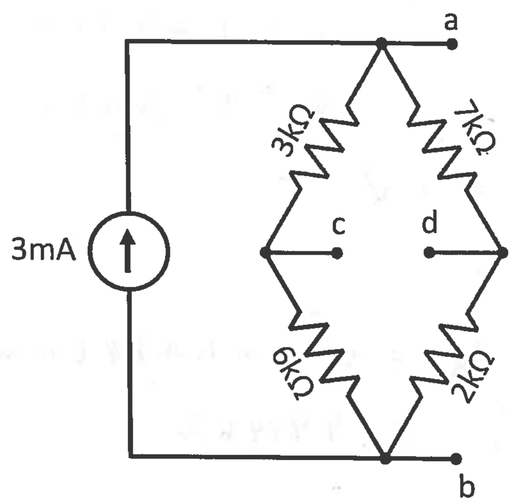
$$V_{ab} = 2V \cdot \frac{1k\Omega}{1k\Omega + 62.5\Omega} = 1.882\ V \quad [+1]$$

ECSE-200 Quiz #7 (Calcium's Z Feb 2015)

NAME____ McGill ID#____________________

READ each question and its parts carefully before starting. Do your work INDEPENDENTLY. Show ALL your work. Give units on answers. THINK ABOUT YOUR TECHNIQUE BEFORE YOU SOLVE!

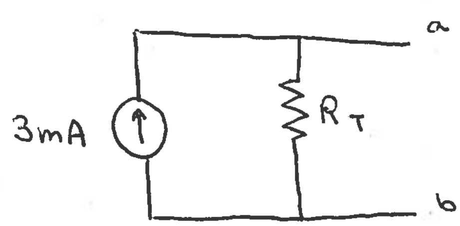
1. Consider the circuit diagram below. Answer the questions.



a) What is the maximum power that the circuit can deliver to an optimally chosen load resistor connected to terminals a and b? [3pts]

b) What is the maximum power that the circuit can deliver to an optimally chosen load resistor connected to terminals c and d? [3pts]

a)



$$R_T = (3k\Omega + 6k\Omega) // (2k\Omega + 7k\Omega)$$
$$= 4.5k\Omega$$

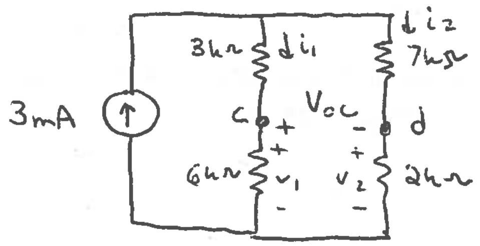
Choose $R_L = R_T$, then:

$$P_{max} = \frac{V_{oc}}{2} \cdot \frac{i_{sc}}{2} \quad [+1]$$
$$= \frac{1}{4} i_{sc}^2 R_T$$
$$= 10.125\,mW \quad [+2]$$

work space

Find v_{oc}.

b)



$$i_1 = \frac{9k\Omega}{9k\Omega + 9k\Omega} \cdot 3mA = 1.5mA$$

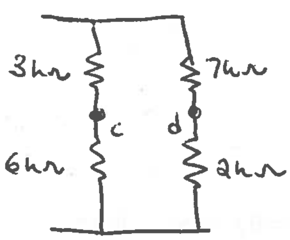
$$i_2 = \frac{9k\Omega}{9k\Omega + 9k\Omega} \cdot 3mA = 1.5mA$$

$$v_1 = 1.5mA \cdot 6k\Omega = 9V$$

$$v_2 = 1.5mA \cdot 2k\Omega = 3V$$

$$V_{oc} = v_1 - v_2 = 6V$$

Find R_T.

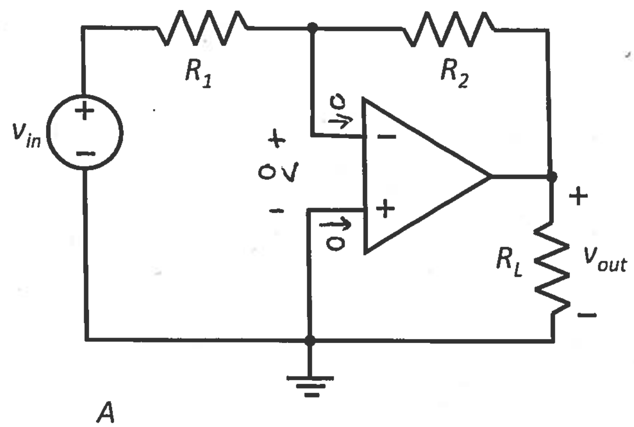


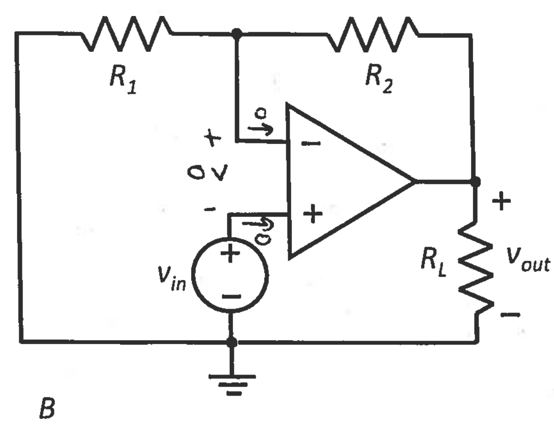
$$R_T = (3k\Omega + 7k\Omega) \,//\, (2k\Omega + 6k\Omega)$$
$$= 4.444\,k\Omega$$

Choose $R_L = R_T$, then:

$$P_{max} = \frac{V_{oc}}{2} \cdot \frac{i_{sc}}{2} \quad [+1]$$
$$= \frac{1}{4}\frac{V_{oc}^2}{R_T}$$
$$= 2.025\,mW \quad [+2]$$

2. Consider the circuits below. Assume ideal op-amp behaviour. Answer the questions.





a) For circuit A, what is v_{out}/v_{in}? [3pts]

b) For circuit B, what is v_{out}/v_{in} ? [3pts]

a) $0 = \frac{0 - v_{in}}{R_1} + \frac{0 - V_{out}}{R_2}$

$\therefore \frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1}$ [+3]

b) $0 = \frac{v_{in}}{R_1} + \frac{v_{in} - V_{out}}{R_2}$

$\therefore \frac{V_{out}}{V_{in}} = 1 + \frac{R_2}{R_1}$ [+3]

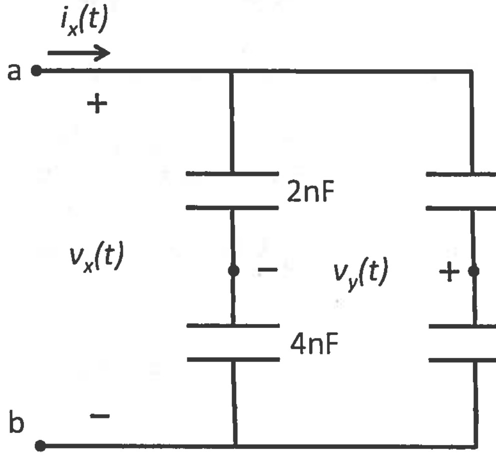
work space

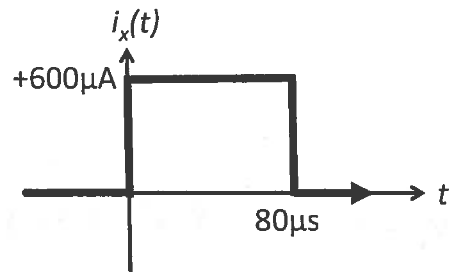
ECSE-200 Quiz #8 (27 Feb 2015)

NAME____ McGill ID#____________________

READ each question and its parts carefully before starting. Do your work INDEPENDENTLY. Show ALL your work. Give units on answers. THINK ABOUT YOUR TECHNIQUE BEFORE YOU SOLVE!

1. Consider the circuit diagram below. Assume that $i_x(t)$ is given by the plot below, and that the capacitors are storing zero energy for $t < 0$s.





a) What is the equivalent capacitance between nodes a and b ? [2pts]

b) What is the value of $v_x(80\mu s)$? [2pts]

c) What is the total energy stored in the capacitors at $t = 80\mu s$? [2pts]

d) What is the value of $v_y(80\mu s)$? [4pts]

a) $$C_{eq} = \frac{1}{\frac{1}{2nF} + \frac{1}{4nF}} + \frac{1}{\frac{1}{2nF} + \frac{1}{1nF}} \quad [+1]$$

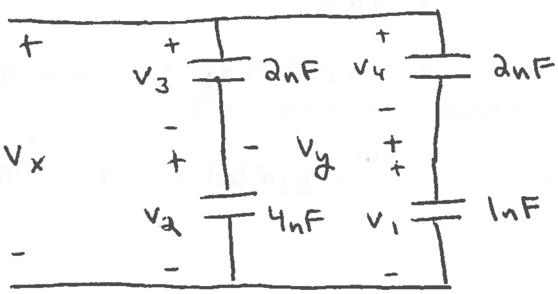
$$= 2nF \quad [+1]$$

b) $$V_x(80\mu s) = V_x(0) + \frac{1}{C_{eq}} \int_0^{t=80\mu s} i_x(t')\,dt' \quad [+1]$$

$$= 0V + \frac{600\mu A \cdot 80\mu s}{2nF} = 24V \quad [+1]$$

c) $$U(80\mu s) = \frac{1}{2} C_{eq} V_x^2(80\mu s) \quad [+1]$$

$$= 576\,nJ$$



KCL:

$$2nF \frac{dv_3}{dt} = 4nF \frac{dv_2}{dt} \quad [+1]$$

$$\frac{dv_3}{dt} = 2 \frac{dv_2}{dt}$$

KVL:

$$v_x = v_2 + v_3$$

$$\frac{dv_x}{dt} = \frac{dv_2}{dt} + \frac{dv_3}{dt} = 3 \frac{dv_2}{dt}$$

$$\therefore v_2(80\mu s) = v_2(0) + \tfrac{1}{3} v_x(80\mu s) - \tfrac{1}{3} v_x(0)$$

$$= 8V$$

KVL:

$$v_y = \underbrace{v_1 - v_2}_{[+1]} = 8V \quad [+1]$$

KCL:

$$1nF \frac{dv_1}{dt} = 2nF \frac{dv_4}{dt} \quad [+1]$$

$$\frac{dv_4}{dt} = \frac{1}{2} \frac{dv_1}{dt}$$

KVL:

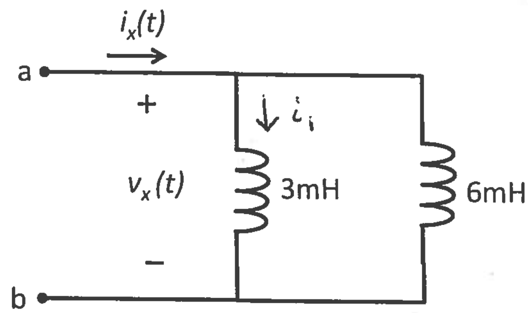
$$v_x = v_1 + v_4$$

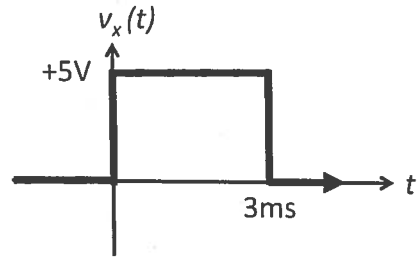
$$\frac{dv_x}{dt} = \frac{dv_1}{dt} + \frac{dv_4}{dt} = \frac{3}{2} \frac{dv_1}{dt}$$

$$\therefore v_1(80\mu s) = v_1(0) + \tfrac{2}{3} v_x(80\mu s) - \tfrac{2}{3} v_x(0)$$

$$= 16V$$

2. Consider the circuit diagram below. Assume that $v_x(t)$ is given by the plot below, and that the inductors are storing zero energy for $t < 0s$.





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

b) What is the value of i_x(3ms) ? [2pts]

c) What is the total energy stored in the inductors at t = 3ms ? [2pts]

d) What is the energy stored in the 3mH inductor at t = 3ms ? [4pts]

a) $$L_{eq} = \underbrace{\frac{3mH \cdot 6mH}{3mH + 6mH}}_{[+1]} = 2\,mH \quad [+1]$$

b) $$i_x(3ms) = i_x(0) + \frac{1}{L_{eq}} \int_0^{t=3ms} v_x(t')\,dt' \quad [+1]$$

$$= 0 + \frac{5V \cdot 3ms}{2mH} = 7.5\,A \quad [+1]$$

c) $$U(3ms) = \frac{1}{2} L_{eq}\, i_x^2(3ms) \quad [+1]$$

$$= 56.25\,mJ \quad [+1]$$

d) $$i_1(3ms) = i_1(0) + \frac{1}{3mH} \int_0^{3ms} v_x(t')\,dt' \quad [+1]$$

$$= 5A \quad [+1]$$

$$U_1(3ms) = \frac{1}{2} \cdot 3mH \cdot 5A^2 \quad [+1]$$

$$= 37.5\,mJ \quad [+1]$$

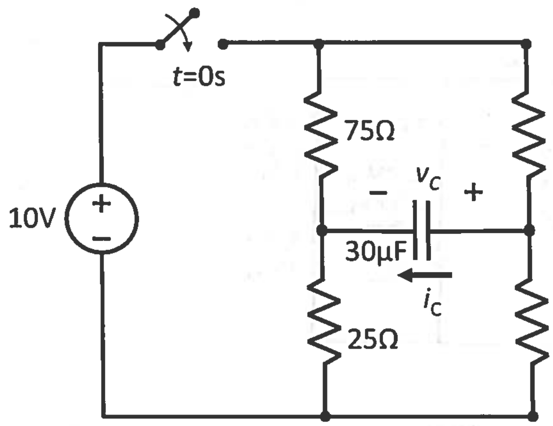
work space

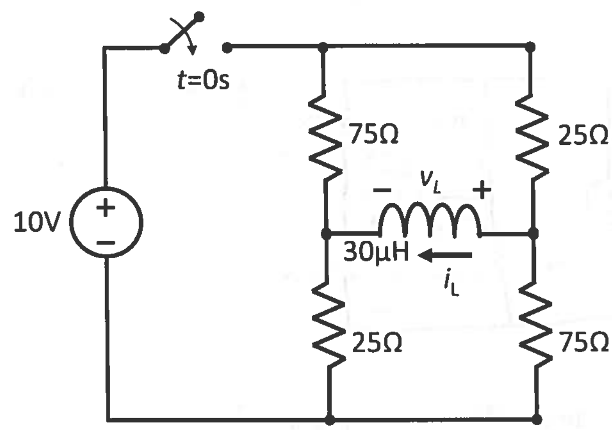
ECSE-200 Quiz #9 ($[\varphi^7 - (-\varphi)^{-7}]$ / √5 Mar 2015, φ = the golden ratio, satisfying $\varphi^2 = \varphi + 1$)

NAME____ McGill ID#____________________

READ each question and its parts carefully before starting. Do your work INDEPENDENTLY. Show ALL your work. Give units on answers. THINK ABOUT YOUR TECHNIQUE BEFORE YOU SOLVE!

1. Consider the circuits below. Assume dc steady-state behaviour for $t < 0$. The switches close instantaneously at $t = 0$.





a) What is $v_c(0+)$? [1pt]

b) What is $i_c(0+)$? [2pts]

c) What is dv_c/dt at $t = 0+$? [2pts]

d) What is $v_c(\infty)$? [1pt]

e) What is $i_L(0+)$? [1pt]

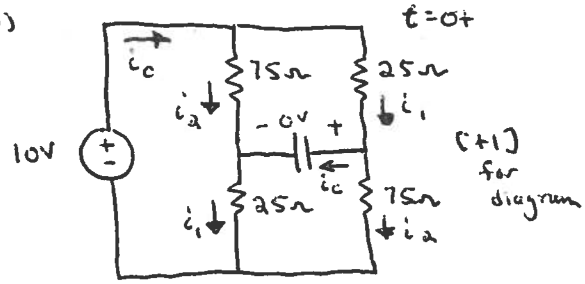
f) What is $v_L(0+)$? [2pts]

g) What is di_L/dt at $t = 0+$? [2pts]

h) What is $i_L(\infty)$? [1pt]

a) $V_c(0+) = V_c(0-) = 0\,V$ [+1]

b)



$i_c = \dfrac{10V}{75Ω \| 25Ω + 75Ω \| 25Ω}$

$= 266.\bar{6}$ mA

$i_1 = \dfrac{i_c \times 75Ω}{(75+25)Ω} = 200$mA

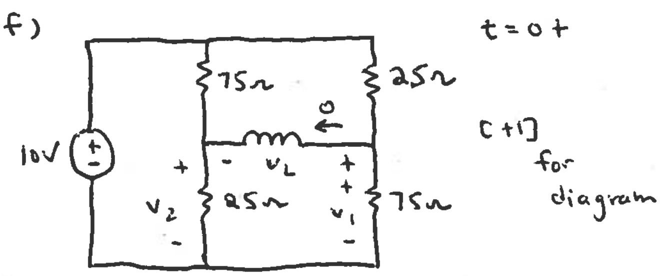
$i_2 = \dfrac{i_c \times 25Ω}{(75+25)Ω} = 66.\bar{6}$mA

$i_c(0+) = i_1 - i_2$

$= 133.\bar{3}$ mA [+1]

e) $i_L(0+) = i_L(0-) = 0\,A$ [+1]

f)



$V_1 = \dfrac{10V \cdot 75Ω}{25Ω + 75Ω} = 7.5V$

$V_2 = \dfrac{10V \cdot 25Ω}{25Ω + 75Ω} = 2.5V$

$V_L(0+) = V_1 - V_2 = 5\,V$ [+1]

c) $i_c = C \dfrac{dv_c}{dt}$ [+1]

$$\frac{dv_c}{dt} = \frac{i_c}{C} = \frac{133.\bar{3}\,mA}{30\,\mu F}$$

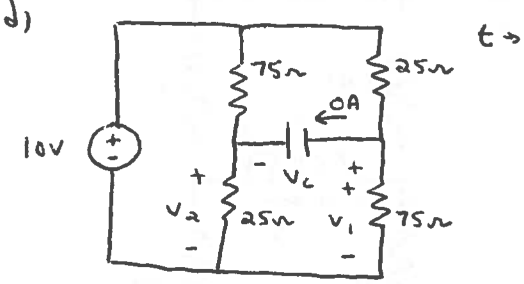
$$= 4.444\ \frac{kV}{s} \quad [+1]$$

g) $v_L = L \dfrac{di_L}{dt}$ [+1]

$$\frac{di_L}{dt} = \frac{v_L}{L} = \frac{5V}{30\,\mu H}$$

$$= 166.\bar{6}\ \frac{kA}{s} \quad [+1]$$

d)

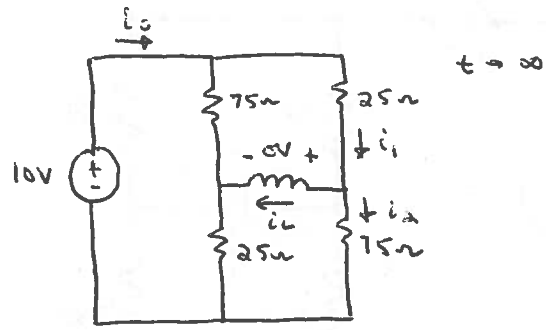


$$v_1 = \frac{10V \cdot 75\Omega}{25\Omega + 75\Omega} = 7.5V$$

$$v_2 = \frac{10V \cdot 25\Omega}{25\Omega + 75\Omega} = 2.5V$$

$$v_c(\infty) = v_1 - v_2 = 5V \quad [+1]$$

e)



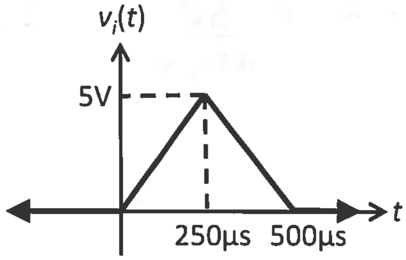
$$i_0 = \frac{10V}{75\Omega \| 25\Omega + 75\Omega \| 25\Omega} = 266.\bar{6}\,mA$$

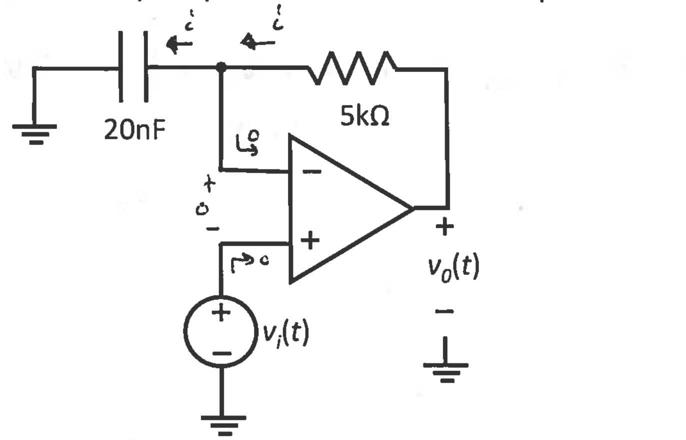
$$i_1 = \frac{i_0 \cdot 75\Omega}{25\Omega + 75\Omega} = 200\,mA$$

$$i_2 = \frac{i_0 \cdot 25\Omega}{25\Omega + 75\Omega} = 66.\bar{6}\,mA$$

$$i_L(\infty) = i_1 - i_2 = 133.\bar{3}\,mA \quad [+1]$$

2. Consider the circuit and diagram below. Assume ideal op-amp behaviour. Answer the questions.





a) Find an expression for $v_o(t)$ in terms of $v_i(t)$. [2pts]

b) Plot the voltage $v_o(t)$ versus t for the $v_i(t)$ given above. Label your axes. [2pts]

c) What is the maximum energy that is stored on the capacitor? [2pts]

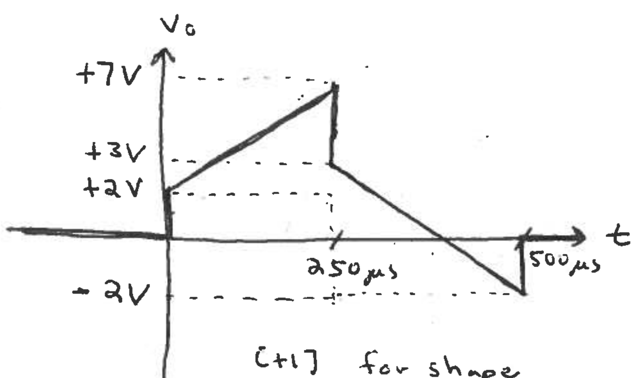
d) What is the maximum instantaneous power absorbed by the capacitor? [2pts]

e) What is the maximum instantaneous power delivered by the op-amp? [2pts]

a) $i = 20nF \cdot \frac{dv_i}{dt}$ $\quad v_o = v_i + 5k\Omega \cdot i$ [+1]

$$= v_i + 100\mu s \frac{dv_i}{dt} \quad [+1]$$

b) $\frac{dv_i}{dt} = \pm \frac{5V}{250\mu s} = \pm 0.02\, V/\mu s$ $\qquad 100\mu s \cdot \frac{dv_i}{dt} = \pm 2V$



[+1] for shape
[+1] for labels

c) $U_{max} = \frac{1}{2} C v_{i,max}^2$ [+1]

$$= \frac{1}{2} \cdot 20nF \cdot (5V)^2$$

$$= 250\, nJ \quad [+1]$$

d) $P_{abs,max} = \max(v_i \cdot i) = 5V \cdot 20nF \cdot \frac{5V}{250\mu s} = 2mW$ [+1]

[+1]

work space

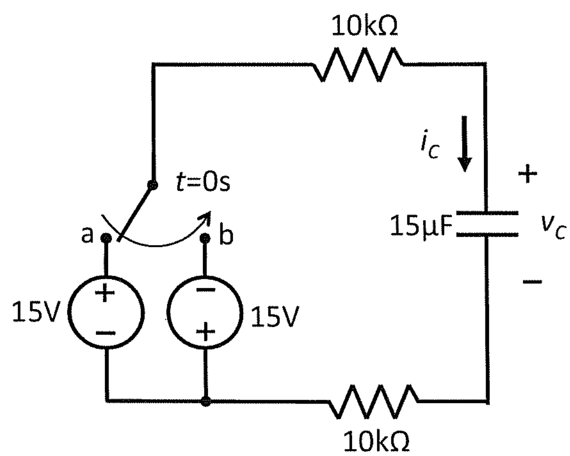
e) $P_{del,max} = \max(v_o \cdot i) = 7V \cdot 20nF \cdot \frac{5V}{250\mu s} = 2.8\,mW$ [+1]

[+1]

NAME____ McGill ID#____________________

READ each question and its parts carefully before starting. Do your work INDEPENDENTLY. Show ALL your work. Give units on answers. THINK ABOUT YOUR TECHNIQUE BEFORE YOU SOLVE!

1. Consider the circuit below. The circuit is in dc steady-state for $t < 0$ with the switch in position a. The switch moves from position a to position b instantaneously at t = 0s.



a) What is $v_c(t)$ for $t > 0$? [5pts]

b) Plot $v_c(t)$ versus t. Indicate the time constant with an appropriate tangent. [2pts]

c) What is $i_c(t)$ for $t > 0$? [3pts]

a) $V_C(0+) = V_C(0-) = 15V$ [+1]

$V_C(\infty) = -15V$ [+1]

$\tau = R_T C$ [+1]

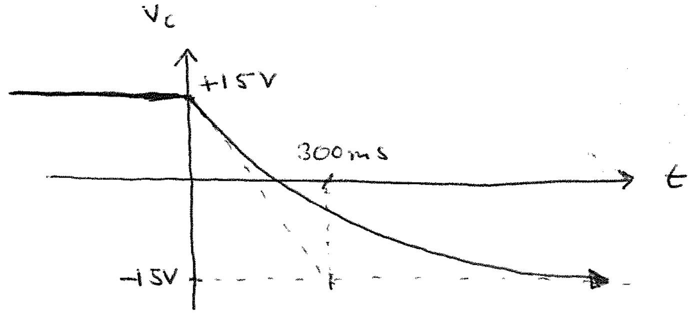
$= (10k\Omega + 10k\Omega) \cdot 15\mu F$

$= 300ms$ [+1]

$t>0$ $V_C(t) = V_C(\infty) + [V_C(0+) - V_C(\infty)] \exp(-t/\tau)$

$= -15V + 30V \exp(-t/300ms)$ [+1]

b)



[+1] for shape
[+1] for values

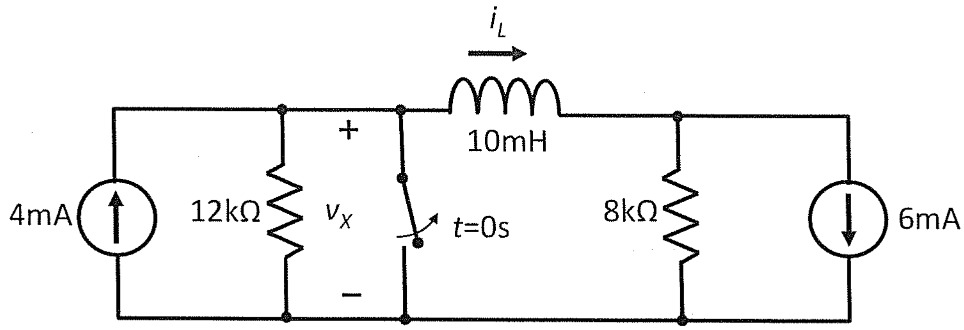
c) $i_c = C \dfrac{dv_c}{dt}$ [+2]

$$= 15\mu F \cdot \frac{d}{dt}\left[-15V + 30V \exp(-t/300ms)\right]$$

$$= 15\mu F \cdot 30V \cdot \frac{-1}{300ms} \cdot \exp(-t/300ms)$$

$$= -1.5mA \exp(-t/300ms)$$ [+1]

2. Consider the circuit below. The circuit is in dc steady-state for $t < 0$ with the switch closed. The switch opens instantaneously at $t = 0$s.

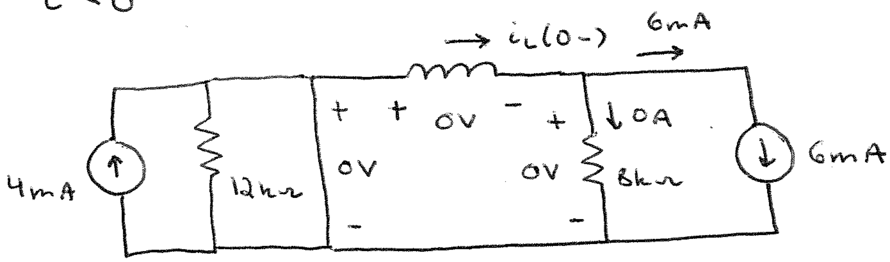


a) What is $i_L(t)$ for $t > 0$? [5pts]

b) Plot $i_L(t)$ versus t. Indicate the time constant with an appropriate tangent. [2pts]

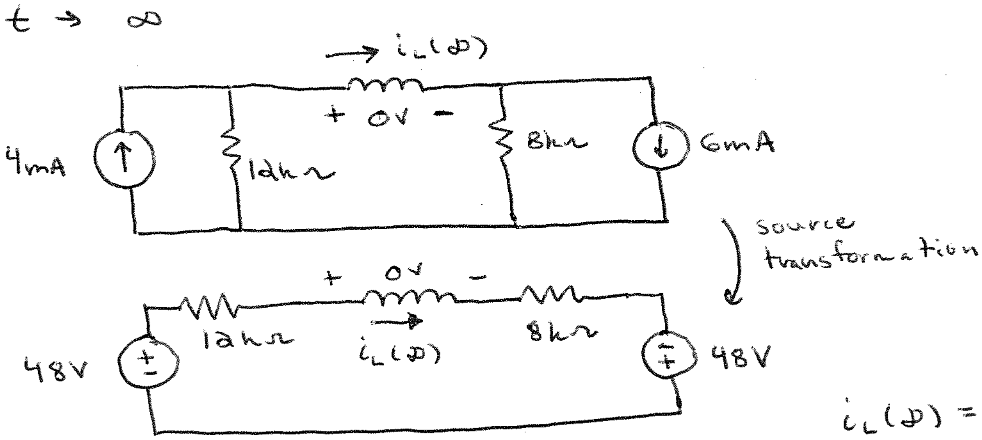
c) What is $v_X(t)$ for $t > 0$? [3pts]

a) $t < 0$



$i_L(0+) = i_L(0-) = 6\,mA$ [+1]

$t \to \infty$



$i_L(\infty) = \dfrac{48V + 48V}{12k\Omega + 8k\Omega} = 4.8\,mA$ [+1]

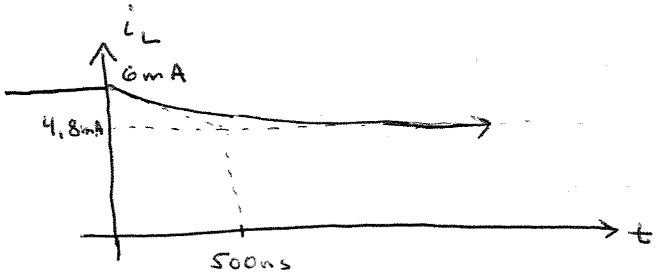
$\tau = L/R_{TH}$ [+1]

$= 10mH / 20k\Omega = 500\,ns$ [+1]

$t > 0$ $\quad i_L(t) = i_L(\infty) + [i_L(0+) - i_L(\infty)] \exp(-t/\tau)$

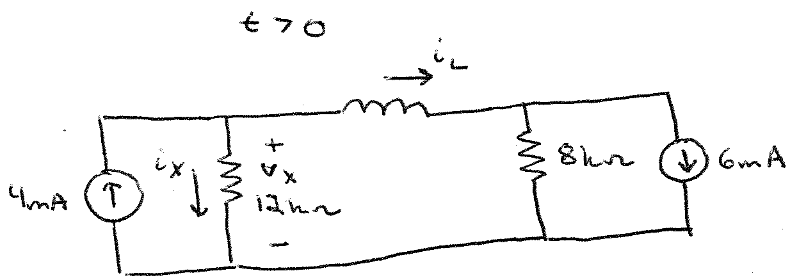
$$= 4.8\,mA + 1.2\,mA \exp(-t / 500\,ns) \quad [+1]$$

b)



[+1] for shape
[+1] for values

c)



$$i_x = 4\,mA - i_L$$

$$V_x = 12k\Omega \cdot i_x = 12k\Omega \cdot (4\,mA - i_L) \quad [+2]$$

$$= 48V - 12k\Omega \cdot [4.8\,mA + 1.2\,mA \exp(-t/500\,ns)]$$

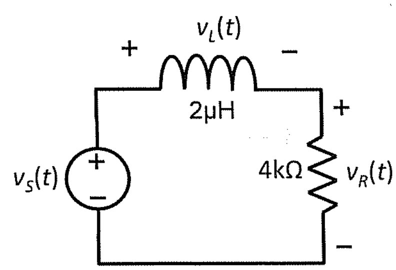
$$= -9.6V + 14.4V \exp(-t/500\,ns) \quad [+1]$$

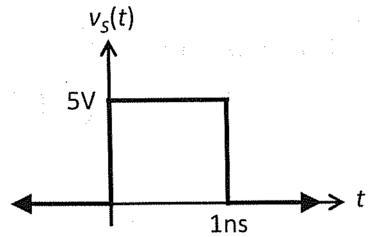
ECSE-200 Quiz #11 ($1 / [1/2 - 1/4 + 1/8 - 1/16 + \dots]^3$ Mar 2015)

NAME____ McGill ID#____________________

READ each question and its parts carefully before starting. Do your work INDEPENDENTLY. Show ALL your work. Give units on answers. THINK ABOUT YOUR TECHNIQUE BEFORE YOU SOLVE!

1. Consider the circuit below. The circuit is in dc steady-state for $t < 0$





a) What is $v_R(t)$ for $0 < t < 1\text{ns}$ and $1\text{ns} < t$? [4pts]

b) Plot $v_R(t)$ versus t. Label your axes. [2pts]

c) What is $v_L(t)$ for $0 < t < 1\text{ns}$ and $1\text{ns} < t$? [2pts]

d) Plot $v_L(t)$ versus t. Label your axes. [2pts]

a) $\underline{0 < t < 1\text{ns}}$

$v_R(0+) = v_R(0-) = 0\,V$ [+1/2]

$v_R(\infty) = 5V$ [+1/2]

$\tau = L/R = 2\mu H / 4k\Omega = 0.5ns$ [+1/2]

$v_R(t) = v_R(\infty) + [v_R(0+) - v_R(\infty)] \exp(-t/\tau)$

$= 5V - 5V \exp(-t/0.5ns)$ [+1/2]

$\underline{1ns < t}$

$v_R(1ns+) = v_R(1ns-) = 5V - 5V \exp(-2) = 4.323V$ [+1/2]

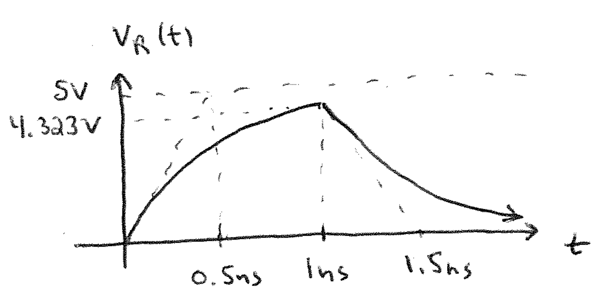
$v_R(\infty) = 0V$ [+1/2]

$\tau = 0.5ns$ [+1/2]

$v_R(t) = v_R(\infty) + [v_R(1ns+) - v_R(\infty)] \exp\left(-\frac{t-1ns}{\tau}\right)$

$= 4.323V \exp\left(-\frac{t-1ns}{0.5ns}\right)$ [+1/2]

b)



[+1] for shape

[+1] for values

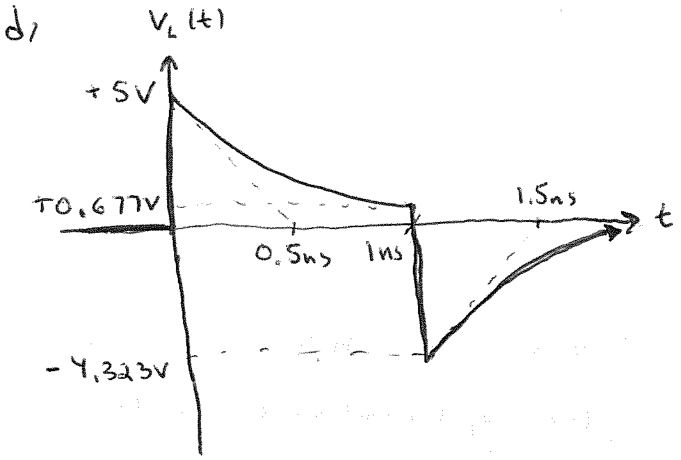
c) $0 < t < 1\,\text{ns}$

$$v_L(t) = 5V - v_R(t) \quad [+1/2]$$
$$= 5V \exp(-t/0.5\text{ns}) \quad [+1/2]$$

$1\,\text{ns} < t$

$$v_L(t) = 0V - v_R(t) \quad [+1/2]$$
$$= -4.323V \exp\left(-\frac{t - 1\text{ns}}{0.5\text{ns}}\right) \quad [+1/2]$$

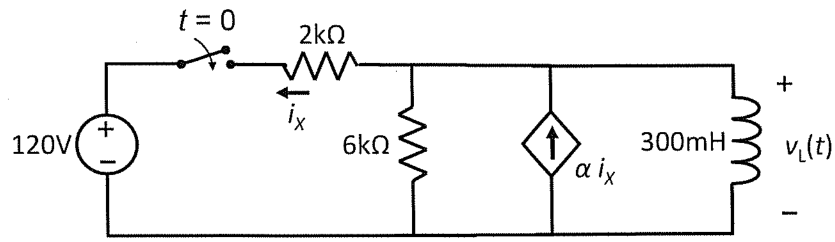
d)



[+1] for shape

[+1] for values

2. Consider the circuit below. The circuit is in dc steady-state for $t < 0$ with the switch open. The switch closes at $t = 0$.



a) What condition must the time constant τ satisfy for stable response after the switch closes? [1pt]

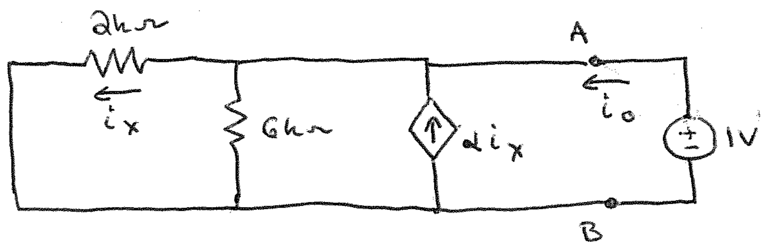
b) What condition must α satisfy for stable response after the switch closes? [4pts]

c) What happens if $\tau = 0$? [0pts, just think about it...]

a) $\tau > 0$ [+1]

b) $\tau = \frac{L}{R_T} > 0 \rightarrow R_T > 0$ [+1]

Find R_T by turning off independent source, and applying a test source. [+2 for any valid method to find R_T]



KCL: $i_o = \frac{1V}{2k\Omega} + \frac{1V}{6k\Omega} - \alpha i_x$ $\qquad i_x = \frac{1V}{2k\Omega}$

$= \frac{1V}{2k\Omega} + \frac{1V}{6k\Omega} - \alpha \frac{1V}{2k\Omega}$

$= 1mA \left(\frac{1}{2} + \frac{1}{6} - \alpha/2 \right)$

$R_T = \frac{1V}{i_o} > 0$ if $\frac{1}{2} + \frac{1}{6} - \frac{\alpha}{2} > 0$

$\frac{4}{3} - \alpha > 0$ or $\alpha < \frac{4}{3}$ [+1]

work space