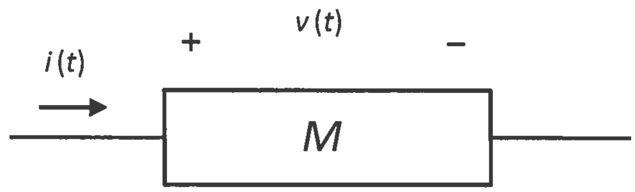
ECSE-200 Quiz # 1 (12 Sept 2014)

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. Assume that the voltage $v(t)$ = 150V exp[-(5s^{-1}) t] and that the current $i(t)$ = 25A exp[-(5s^{-1}) t] for time t > 0s. The unit s = second is explicitly indicated in the equations. Answer the questions.



a) What is the charge passing through M from left to right over the time 0s < t < 0.2s ? [2pts]

b) What is the instantaneous power $p(t)$ absorbed by circuit element M for t > 0s ? [2pts]

c) What is the energy absorbed by M over the time 0s < t < 0.2s ? [2pts]

d) You open the box M, and discover a resistor inside. What is the value of the resistance ? [2pts]

a) $$q = \underbrace{\int_{0s}^{0.2s} 25A \exp(-5s^{-1}t')\,dt'}_{(+1)} = \frac{25A}{-5s^{-1}}\left[\exp(-5s^{-1}t')\right]_{0s}^{0.2s}$$

$$= -5C\left[\exp(-1) - \exp(0)\right] = 3.16\ C \quad (+1)$$

b) $$P_{abs}(t) = i(t)\cdot v(t) \quad [+1]$$

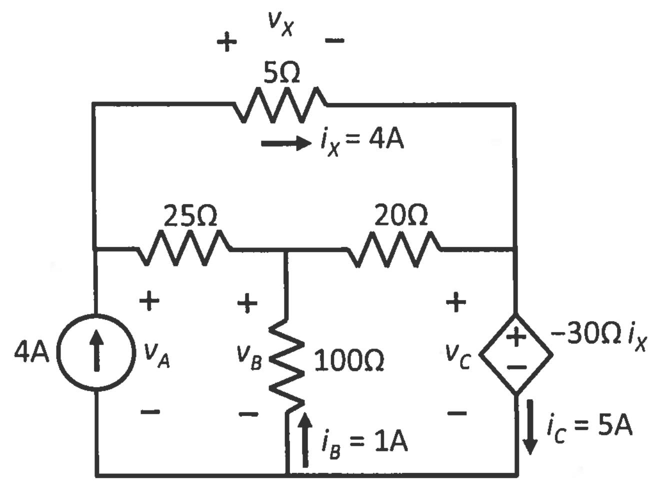
$$= 3750W \exp[-10s^{-1}t] \quad (+1)$$

c) $$U_{abs} = \int_{0s}^{0.2s} P_{abs}(t')\,dt' = \int_{0s}^{0.2s} 3750W \exp[-10s^{-1}t']\,dt' \quad [+1]$$

$$= \frac{3750W}{-10s^{-1}}\left[\exp(-10s^{-1}t')\right]_{0s}^{0.2s} = 324.2\ J \quad [+1]$$

d) $v = i \cdot R$ [+1] therefore $R = \frac{v}{i} = \frac{150V \exp(-5s^{-1}t)}{25A \exp(-5s^{-1}t)} = 6\,\Omega$ [+1]

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



a) Do the variables v_X and i_X satisfy passive sign convention? [1pt]

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

c) The independent current source is ***absorbing*** 400W from the circuit. What is the value of v_A? [2pts]

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

e) Do the variables v_C and i_C satisfy passive sign convention? [1pt]

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

g) What is the value of v_B? [2pts]

a) yes [+1]

b) $V_x = \underbrace{5\Omega \cdot i_x}_{[+1]} = 5\Omega \cdot 4A = 20V$ [+1]

c) $P_{del} = 4A \cdot V_A$ or $P_{abs} = -4A \cdot V_A$ [+1]

$\therefore \; V_A = \frac{P_{abs}}{-4A} = \frac{400W}{-4A} = -100V$ [+1]

d) $V_c = \underbrace{-30\Omega \cdot i_x}_{[+1]} = -30\Omega \cdot 4A = -120V$ [+1]

e) yes [+1]

f) $P_{abs} = V_C \cdot i_C$ [+1]

$= -120V \cdot 5A$

$= -600W$ absorbed by the dep. source [+1]

or $+600W$ delivered by the dep. source.

g) v_B and i_B do not satisfy passive sign convention,

therefore: $V_B = -100\Omega \cdot i_B$ [+1]

$= -100\Omega \cdot 1A$

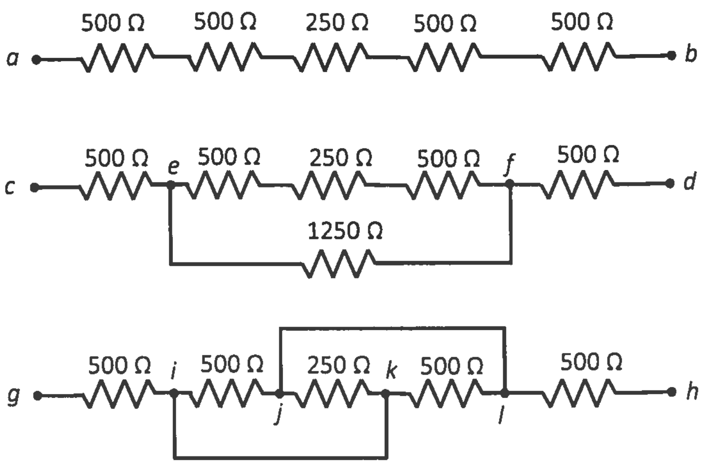
$= -100V$ [+1]

ECSE-200 Quiz #2 (19 Sept 2014)

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 diagrams below. Answer the questions.



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

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

c) What is the equivalent resistance between nodes *j* and *k*? [2pts]

d) What is the equivalent resistance between nodes *g* and *h*? [2pts]

a) $R_{ab} = 500\Omega + 500\Omega + 250\Omega + 500\Omega + 500\Omega$ [1]

$= 2250\Omega$ [1]

b) $R_{cd} = 500\Omega + (500\Omega + 250\Omega + 500\Omega) // 1250\Omega + 500\Omega$ [1]

$= 1625\Omega$ [1]

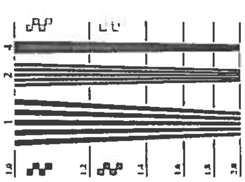
c)

$R_{jk} = 500\Omega // 250\Omega // 500\Omega$ [1]

$= 125\Omega$

d) $R_{gh} = 500\Omega + 500\Omega \,//\, 250\Omega \,//\, 500\Omega + 500\Omega$ [1]

$= 1125\Omega$



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

a) Use KVL to find the value of v_A. [1pt]

b) Use KVL to find the value of v_D. [1pt]

c) Use KVL to find the value of v_X. [1pt]

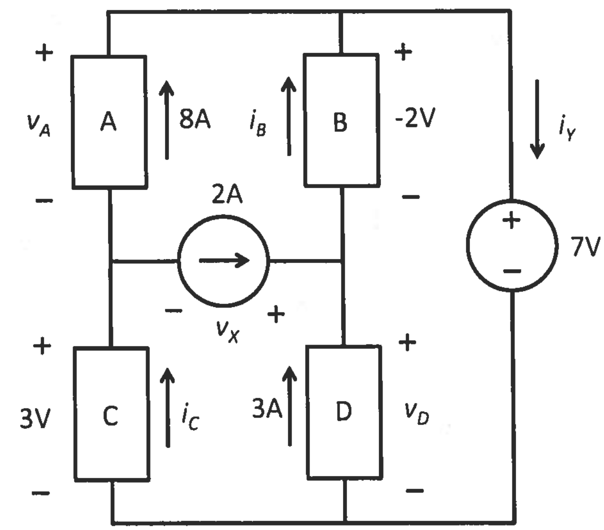
d) Use KCL to find the value of i_B. [1pt]

e) Use KCL to find the value of i_C. [1pt]

f) Use KCL to find the value of i_Y. [1pt]

g) How much power is the 2A source delivering or absorbing? [2pts]

h) How much power is the 7V source delivering or absorbing? [2pts]



a) $0 = -3V - v_A + 7V$ $\quad v_A = +4V$ [+1]

b) $0 = -v_D - (-2V) + 7V$ $\quad v_D = +9V$ [+1]

c) $0 = -3V - v_X - (-2V) + 7V$ $\quad v_X = +6V$ [+1]

d) $0 = -2A + i_B - 3A$ $\quad i_B = 5A$ [+1]

e) $0 = -i_C + 2A + 8A$ $\quad i_C = 10A$ [+1]

f) $0 = -8A - i_B + i_Y$ $\quad i_Y = 13A$ [+1]

g) $P_{del\,2A} = 2A \cdot v_X = 12W$ is being delivered by the 2A source.

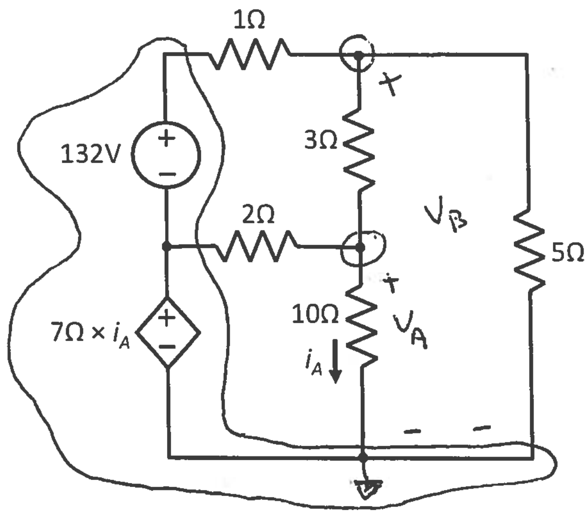
h) $P_{abs\,7V} = 7V \cdot i_y = 91W$ is being absorbed by the 7V source.

ECSE-200 Quiz #3 (26 Sept 2014)

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) Write down the node voltage equations and control variable equations required to solve the circuit. Indicate clearly in your diagram the definition of all node voltage variables. [3pts]

b) Solve the equations to determine the node voltages. [2pts]

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

a) $$0 = \frac{V_A}{10\Omega} + \frac{V_A - 7\Omega\, i_A}{2\Omega} + \frac{V_A - V_B}{3\Omega} \quad [+1]$$

$$0 = \frac{V_B}{5\Omega} + \frac{V_B - V_A}{3\Omega} + \frac{V_B - (7\Omega\, i_A + 132V)}{1\Omega} \quad [+1]$$

$$i_A = V_A / 10\Omega \quad [+1]$$

b) $$0 = \left(\frac{1}{10} + \frac{1}{2} - \frac{7}{20} + \frac{1}{3}\right) V_A - \frac{1}{3} V_B = 0.5833\, V_A - 0.3333\, V_B$$

$$132 = \left(-\frac{1}{3} - \frac{7}{10}\right) V_A + \left(\frac{1}{5} + \frac{1}{3} + 1\right) V_B = -1.0333\, V_A + 1.5333\, V_B$$

$$V_A = \frac{\begin{vmatrix} 0 & -0.3333 \\ 132 & 1.5333 \end{vmatrix}}{\begin{vmatrix} 0.5833 & -0.3333 \\ -1.0333 & +1.5333 \end{vmatrix}} = 80.0\,V \quad [+1]$$

$$V_B = \frac{\begin{vmatrix} 0.5833 & 0 \\ -1.0333 & 132 \end{vmatrix}}{\begin{vmatrix} 0.5833 & -0.3333 \\ -1.0333 & +1.5333 \end{vmatrix}} = 140.0\,V \quad [+1]$$

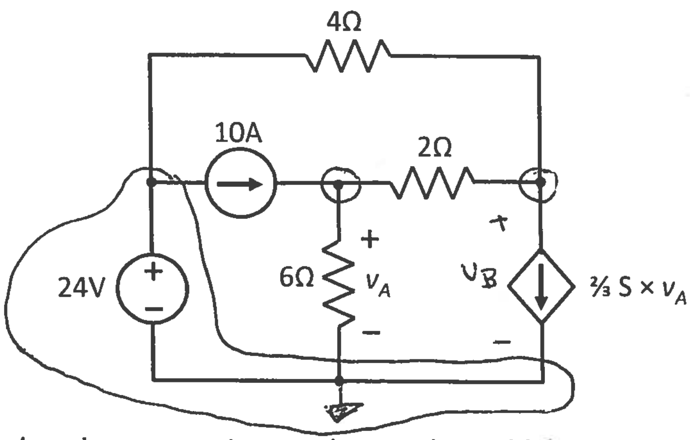
c)

$$P_{del} = (7\Omega \cdot i_A) \cdot \left(\frac{V_A}{10\Omega} + \frac{V_B}{5\Omega} \right) \quad [+1]$$

$$= 7\Omega \cdot \frac{80V}{10\Omega} \cdot \left(\frac{80V}{10\Omega} + \frac{140V}{5\Omega} \right)$$

$$= 2016\ W \quad \text{delivered by source} \quad [+1]$$

2. Consider the circuit diagram below. Recall that 1S = 1A/V. Answer the questions.



a) Write down the node voltage equations and control variable equations required to solve the circuit. Indicate clearly in your diagram the definition of all node voltage variables. [3pts]

b) Solve the equations to determine the node voltages. [2pts]

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

d) The 6Ω resistor is replaced by an open circuit, and consequently the voltage v_A is defined across the open circuit. What is the new value of v_A? [1pt]

a) $$0 = -10A + \frac{V_A}{6\Omega} + \frac{V_A - V_B}{2\Omega} \quad [+1]$$

$$0 = \frac{2}{3}S\, V_A + \frac{V_B - V_A}{2\Omega} + \frac{V_B - 24V}{4\Omega} \quad [+1]$$

$V_A \rightarrow$ control variable is a node voltage [+1]

b) $$10 = \left(\frac{1}{6} + \frac{1}{2}\right) V_A - \frac{1}{2} V_B = \frac{2}{3} V_A - \frac{1}{2} V_B$$

$$6 = \left(\frac{2}{3} - \frac{1}{2}\right) V_A + \left(\frac{1}{2} + \frac{1}{4}\right) V_B = \frac{1}{6} V_A + \frac{3}{4} V_B$$

$$V_A = \frac{\begin{vmatrix} 10 & -1/2 \\ 6 & +3/4 \end{vmatrix}}{\begin{vmatrix} +2/3 & -1/2 \\ +1/6 & +3/4 \end{vmatrix}} = 18V \quad [+1] \qquad V_B = \frac{\begin{vmatrix} +2/3 & 10 \\ +1/6 & 6 \end{vmatrix}}{\begin{vmatrix} +2/3 & -1/2 \\ +1/6 & +3/4 \end{vmatrix}} = 4V \quad [+1]$$

c) $$P_{abs} = V_B \times \frac{2}{3}S\, V_A \quad [+1]$$

$$= 4V \times \frac{2}{3}S \times 18V = 48W$$ absorbed by source

or

$-48W$ delivered by source [+1]

d) If $6\Omega \to \infty$, then $\frac{1}{6\Omega} \to 0$. Making the substitution gives:

$$0 = -10A + \frac{V_A - V_B}{2\Omega}$$

$$0 = \frac{2}{3}S\, V_A + \frac{V_B - V_A}{2\Omega} + \frac{V_B - 24V}{4\Omega}$$

$$10 = \frac{1}{2} V_A - \frac{1}{2} V_B$$

$$6 = \frac{1}{6} V_A + \frac{3}{4} V_B$$

$$V_A = \frac{\begin{vmatrix} 10 & -1/2 \\ 6 & +3/4 \end{vmatrix}}{\begin{vmatrix} +1/2 & -1/2 \\ +1/6 & +3/4 \end{vmatrix}} = 22.909\,V \quad [+1]$$

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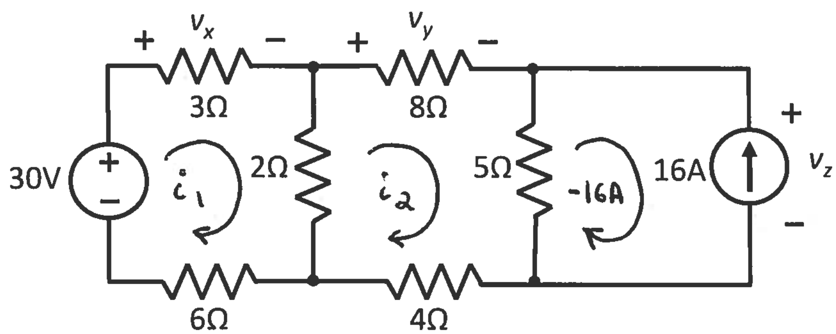
READ each question and its parts carefully before starting. SHOW ALL YOUR WORK. Give units on your answers (where appropriate).

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



a) Write the mesh current equations required to solve this circuit. Be sure to define your mesh currents on the diagram. [2pts]

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

c) What are the values of v_x, v_y and v_z? [6pts]

a) mesh 1: $0 = -30V + 3\Omega\, i_1 + 2\Omega(i_1 - i_2) + 6\Omega\, i_1$ [+1]

mesh 2: $0 = 2\Omega\,(i_2 - i_1) + 8\Omega\, i_2 + 5\Omega\,(i_2 + 16A) + 4\Omega\, i_2$ [+1]

b) $30 = 11\, i_1 - 2 i_2$

$-80 = -2 i_1 + 19 i_2$

$$i_1 = \frac{\begin{vmatrix} 30 & -2 \\ -80 & 19 \end{vmatrix}}{\begin{vmatrix} 11 & -2 \\ -2 & 19 \end{vmatrix}} = 2.0\text{ A} \quad [+1]$$

$$i_2 = \frac{\begin{vmatrix} 11 & 30 \\ -2 & -80 \end{vmatrix}}{\begin{vmatrix} 11 & -2 \\ -2 & 19 \end{vmatrix}} = -4.0\text{ A} \quad [+1]$$

c) $v_x = 3\Omega \cdot i_1$ [+1]

$= 6\text{ V}$ [+1]

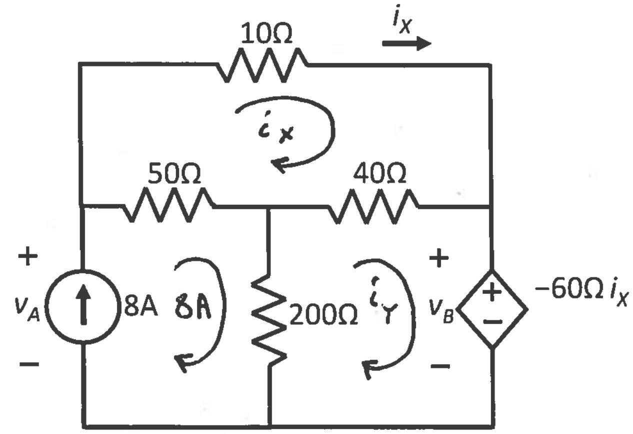
$v_y = 8\Omega \cdot i_2$ [+1]

$= -32\text{ V}$ [+1]

$v_z = 5\Omega\,(i_2 + 16A)$ [+1]

$= 60\text{ V}$ [+1]

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



a) Write the mesh current equations required to solve this circuit. Be sure to define your mesh currents on the diagram. [2pts]

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

c) What are the values of v_A and v_B? [4pts]

a) $0 = 10\Omega \cdot i_x + 40\Omega\,(i_x - i_Y) + 50\Omega\,(i_x - 8A)$ [+1]

$0 = -60\Omega\, i_x + 200\Omega\,(i_Y - 8A) + 40\Omega\,(i_Y - i_x)$ [+1]

b) $400 = 100\, i_x - 40\, i_Y$

$1600 = -100\, i_x + 240\, i_Y$

$i_x = \dfrac{\begin{vmatrix} 400 & -40 \\ 1600 & 240 \end{vmatrix}}{\begin{vmatrix} 100 & -40 \\ -100 & 240 \end{vmatrix}} = 8\text{ A}$ [+1] $\qquad i_Y = \dfrac{\begin{vmatrix} 100 & 400 \\ -100 & 1600 \end{vmatrix}}{\begin{vmatrix} 100 & -40 \\ -100 & 240 \end{vmatrix}} = 10\text{ A}$ [+1]

c) $V_A = 50\Omega\,(8A - i_x) + 200\Omega\,(8A - i_Y)$ [+1]

or $10\Omega\, i_x - 60\Omega\, i_x$

$= -400V$ [+1]

$V_B = -60\Omega\, i_x$ [+1]

$= -480V$ [+1]

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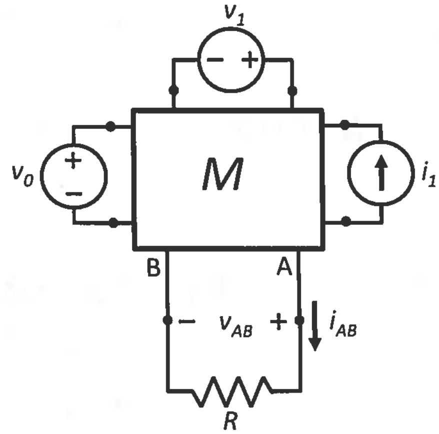
READ each question and its parts carefully before starting. SHOW ALL YOUR WORK. Give units on your answers (where appropriate).

1. The circuit M is composed only of resistors and dependent sources, and is connected to a resistor R and three independent sources as shown. The table reports several observations that have been made with the circuit M. Answer the questions.



v_0	v_1	i_1	R	v_{AB}
1V	1V	1A	800 Ω	0V
2V	1V	-1A	800 Ω	4V
-1V	1V	2A	800 Ω	-3.5V
2V	1V	-1A	100 Ω	1.2V

a) What is v_{AB} if the sources are set to v_0 = 4V, v_1 = 2V and i_1 = -2A, and the resistor R = 800 Ω ? [2pts]

b) What is v_{AB} if the sources are set to v_0 = 0V, v_1 = 1V and i_1 = 0A, and the resistor R = 800 Ω ? [1pt]

For the remainder of the question, assume that the three sources remain connected to M, and the resistor R is removed.

c) What is the Thévenin resistance of the circuit M at the terminals A and B ? [3pts]

d) What is the open circuit voltage of the circuit M at the terminals A and B if the sources are set to v_0 = 2V, v_1 = 1V and i_1 = -1A? [2pts]

e) What is the short circuit current of the circuit M at the terminals A and B if the sources are set to v_0 = 2V, v_1 = 1V and i_1 = -1A? [2pts]

a) By principle of superposition: $v_{ab} = c_0 v_0 + c_1 v_1 + c_2 i_1$ [+1]

$\therefore v_{ab} = c_0 \cdot 4V + c_1 \cdot 2V + c_2 \cdot (-2A)$

$= 2(c_0 \cdot 2V + c_1 \cdot 1V + c_2 \cdot (-1A)) = 8V$ [+1]

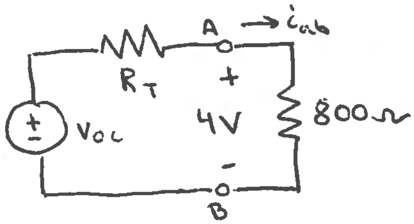
b) $v_{ab} = c_1 \cdot 1V = [\, c_0 \cdot 2V + c_1 \cdot 1V + c_2 \cdot (-1A)$

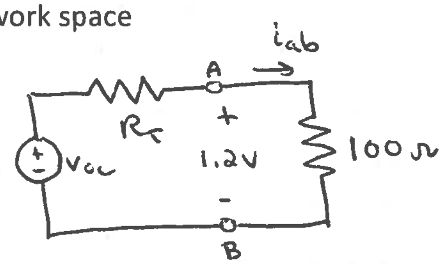
$+ c_0 \cdot (-1V) + c_1 \cdot 1V + c_2 \cdot 2A$

$- c_0 \cdot 1V - c_1 \cdot 1V - c_2 \cdot 1A\,]$

$= 4V - 3.5V + 0V = 0.5V$ [+1]

c)





$$i_{ab} = \frac{4V}{800\Omega} = 5mA \quad (+1)$$

$$i_{ab} = \frac{1.2V}{100\Omega} = 12mA \quad [+1]$$

$$V_{ab} = V_{oc} - i_{ab} \cdot R_T \qquad \therefore\ R_T = -\frac{\Delta V_{ab}}{\Delta i_{ab}} = \frac{-(1.2V - 4V)}{(12mA - 5mA)}$$

$$= 400\Omega \quad [+1]$$

d)

$$V_{ab} = V_{oc} - i_{ab} \cdot R_T \quad [+1]$$

$$V_{oc} = V_{ab} + i_{ab} \cdot R_T$$

$$= 4V + 5mA \cdot 400\Omega$$

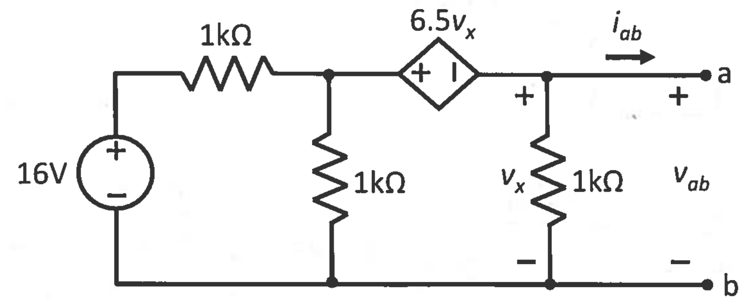
$$= 6V \quad [+1]$$

e)

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

$$i_{sc} = \frac{V_{oc}}{R_T} = \frac{6V}{400\Omega} = 15mA \quad [+1]$$

2. Consider the circuit below. Answer the questions (be sure to identify terminals a and b in any equivalent circuit diagrams).

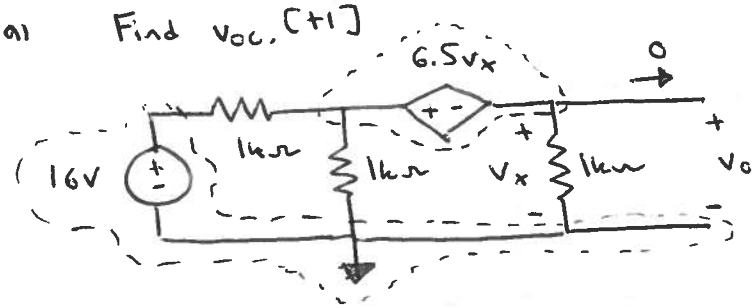


a) What is the Thévenin equivalent circuit with respect to terminals a and b? [5pts]

b) What is the Norton equivalent circuit with respect to terminals a and b? [2pts]

c) A resistor R is attached to terminals a and b. Give one value of R that will result in 1mW of power being absorbed by R. [3pts]

a) Find V_{oc}. [+1]

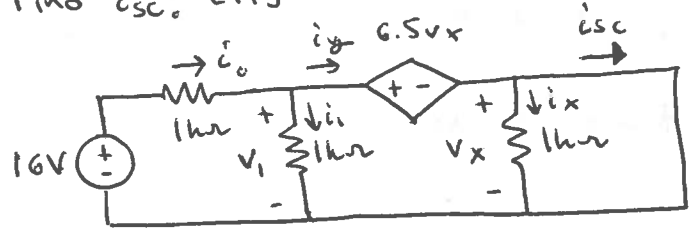


$$0 = \frac{V_x}{1k\Omega} + \frac{V_x + 6.5V_x}{1k\Omega} + \frac{V_x + 6.5V_x - 16V}{1k\Omega}$$

$$16V_x = 16V$$

$$V_{oc} = V_x = 1V$$

Find i_{sc}. [+1]



$V_x = 0 \quad i_x = 0$

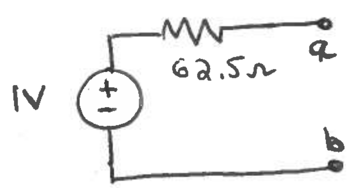
$0 = -v_1 + 6.5V_x + V_x$

$v_1 = 0 \quad i_1 = 0$

$i_o = \frac{16V}{1k\Omega} = 16mA$

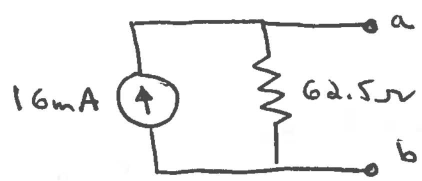
$i_{sc} = i_y - i_x = i_y = i_o - i_1 = i_o = 16mA$

$$\underbrace{R_T}_{[+1]} = \frac{V_{oc}}{i_{sc}} = \frac{1V}{16mA} = 62.5\Omega$$



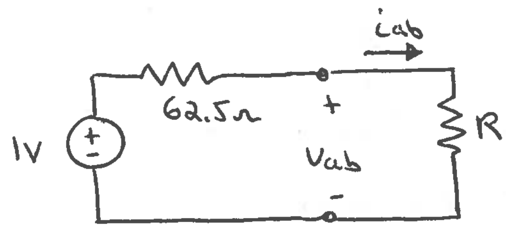
[+2]

b)



[+2]

c)



we require

$$1mW = P_{abs} = i_{ab} \cdot V_{ab} \quad [+1]$$
$$= i_{ab}^2 \cdot R$$
$$= v_{ab}^2 / R$$

Thévenin circuit requires : $V_{ab} = V_{oc} - i_{ab} \cdot R_T$ [+1]

$$= V_{oc} - \frac{P_{abs}}{V_{ab}} \cdot R_T$$

$$\therefore \quad 0 = \frac{P_{abs}}{V_{ab}} \cdot R_T + V_{ab} - V_{oc}$$

$$0 = V_{ab}^2 - V_{oc} V_{ab} + p_{abs} \cdot R_T$$

$$V_{ab} = \frac{-(-v_{oc}) \pm \sqrt{v_{oc}^2 - 4 p_{abs} R_T}}{2}$$

$$= 0.933V \ , \ 0.0670V$$

$$i_{ab} = \frac{1mW}{V_{ab}} = 1.07 \, mA \ , \ 14.9 \, mA$$

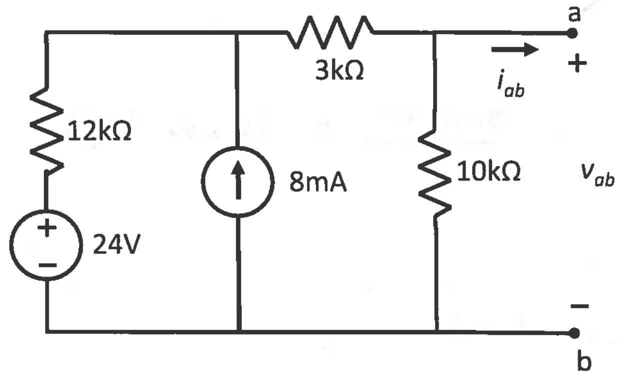
$$R = \frac{V_{ab}}{i_{ab}} = 872 \Omega \ , \ 4.50 \Omega$$ [+1] for either

ECSE-200 Quiz #6 (17 Oct 2014)

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 in the diagram below. Answer the questions.

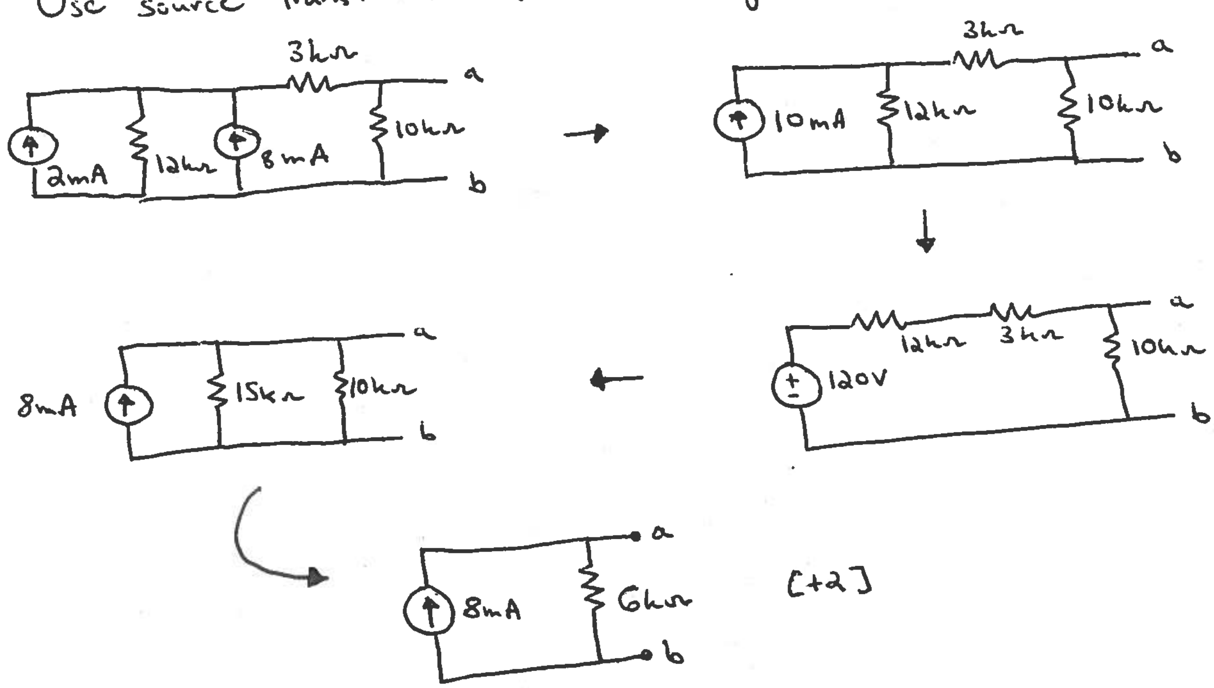


a) What is the Norton equivalent circuit with respect to the terminals *a* and *b*? Be sure to label the nodes *a* and *b* in your circuit diagram. [4pts]

b) Draw the diagram of i_{AB} versus v_{AB}. Be sure to label your axes and intercepts. [1pt]

c) What is the maximum power that this circuit can deliver to a load resistor attached to the terminals *a* and *b*? What is the optimally chosen value of a load resistor to achieve maximum power transfer? [4pts]

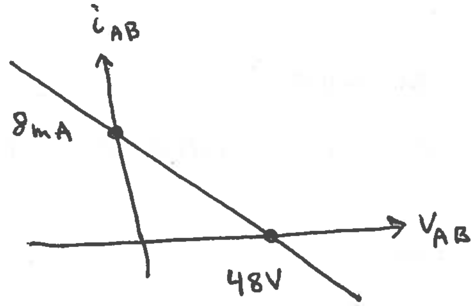
a) Use source transformations. [+2 for any valid method]



[+2]

work space

b)



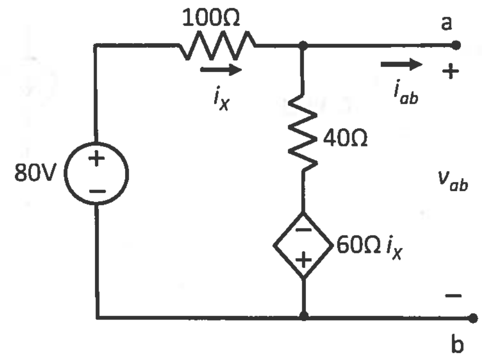
[+1]

$V_{oc} = i_{sc} R_T$
$= 8mA \cdot 6k\Omega$
$= 48V$

c) $P_{max} = \underbrace{\frac{V_{oc}}{2} \cdot \frac{i_{sc}}{2}}_{[+1]} = \frac{8mA \cdot 48V}{4} = 96mW$ (+1)

$\underbrace{R_L = R_T}_{[+1]} = 6k\Omega$ [+1]

2. Consider the circuit below. Answer the questions.

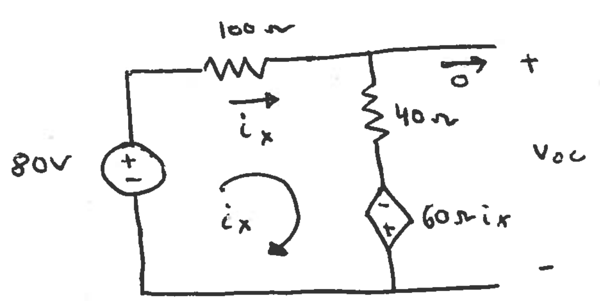


a) What is the Norton equivalent circuit with respect to the terminals *a* and *b*? Be sure to label the nodes *a* and *b* in your circuit diagram. [4pts]

b) Draw the diagram of i_{AB} versus v_{AB}. Be sure to label your axes and intercepts. [1pt]

c) What is the maximum power that this circuit can deliver to a load resistor attached to the terminals *a* and *b*? What is the optimally chosen value of a load resistor to achieve maximum power transfer? [4pts]

a) Find V_{oc} and i_{sc}, and use $R_T = V_{oc}/i_{sc}$. [+2 for any valid method]

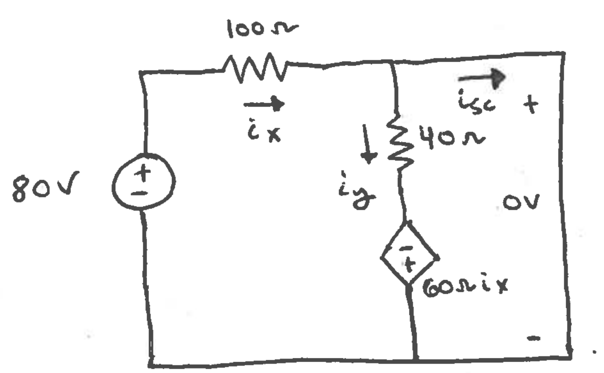


KVL:

$0 = -80V + 100\Omega \cdot i_x + 40\Omega\, i_x - 60\Omega\, i_x$

$i_x = \frac{80V}{80\Omega} = 1A$

$V_{oc} = 40\Omega i_x - 60\Omega i_x = -20V$



KVL: $0 = -80V + 100\Omega\, i_x$

$i_x = \frac{80V}{100\Omega} = 0.8A$

KVL: $0 = 40\Omega\, i_y - 60\Omega\, i_x$

$i_y = \frac{60\Omega\, i_x}{40\Omega} = 1.2A$

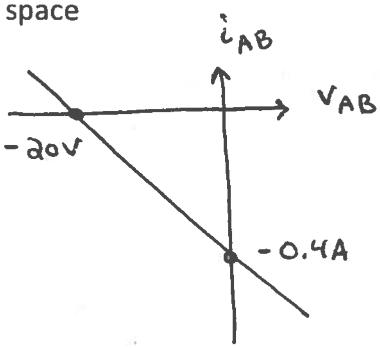
KCL: $0 = -i_x + i_y + i_{sc}$

$i_{sc} = i_x - i_y = -0.4A$

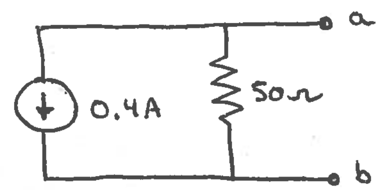
$R_T = V_{oc}/i_{sc} = -20V/-0.4A = 50\Omega$

work space

b)



[+1]



[+2]

c) $$P_{max} = \underbrace{\frac{V_{oc}}{2} \cdot \frac{i_{sc}}{2}}_{[+1]} = \frac{-20V \cdot -0.4A}{4} = 2W \quad [+1]$$

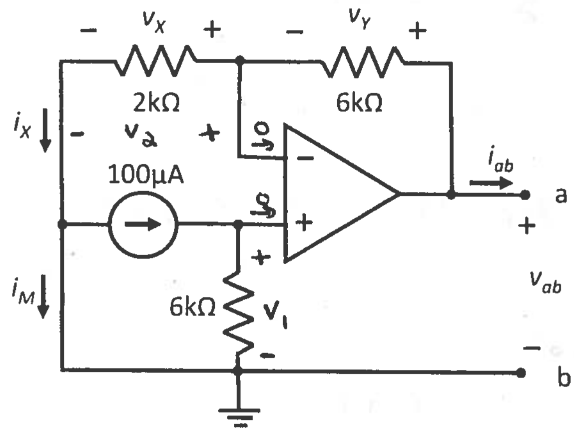
$$\underbrace{R_L = R_T}_{[+1]} = 50\Omega \quad [+1]$$

ECSE-200 Quiz #7 (24 Oct 2014)

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 ideal op-amp behaviour. Answer the questions.



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

b) What is the current i_X? [1pt]

c) What is the current i_M? [1pt]

d) What is the voltage v_Y? [1pt]

e) What is the voltage v_{AB}? [2pts]

f) What is the Thévenin equivalent of the circuit with respect to the terminals a and b? [1 pt]

a) $i_1 = i_2 = 0$ [+1]

$v_1 = 100\,\mu A \cdot 6k\Omega = 0.6V$ [+1]

$v_2 = v_1$ [+1]

$\therefore\ v_X = 0.6V$ [+1]

b) $i_X = \dfrac{v_X}{2k\Omega} = 300\,\mu A$ [+1]

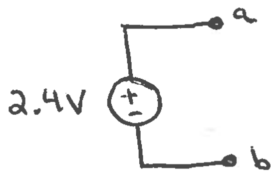
c) $i_M = i_X - 100\,\mu A = 200\,\mu A$ [+1]

d) $v_y = i_x \cdot 6k\Omega$

$= 1.8V$ [+1]

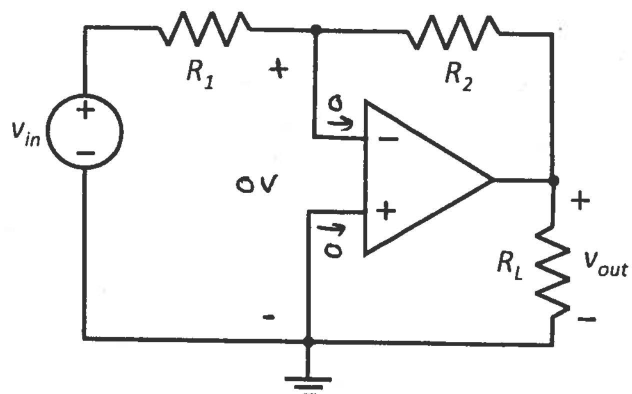
e) $\underbrace{v_{AB} = v_x + v_y}_{[+1]} = 2.4V$ [+1]

f) v_{AB} is independent of i_{AB}.

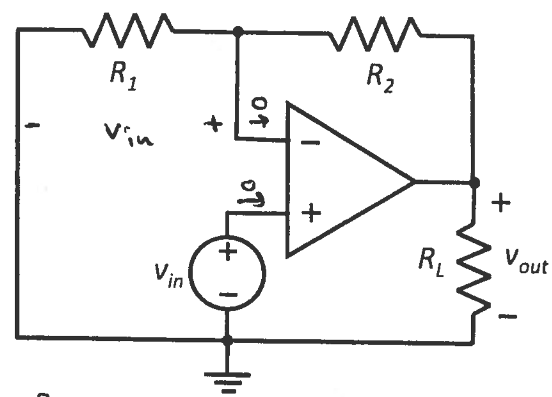


[+1]

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



A



B

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

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

c) If you wish to minimize the power delivered by the independent voltage source, which circuit would you use, *A* or *B*? [1pt]

d) Assume circuits *A* and *B* have the same values of R_1, R_2, R_L and v_{in}. Which circuit will deliver more power to the load resistor R_L, *A* or *B*? [1pt]

a) $$0 = \frac{0 - v_{in}}{R_1} + \frac{0 - v_{out}}{R_2} \quad [+2]$$

$$\frac{v_{out}}{v_{in}} = -\frac{R_2}{R_1} \quad [+1]$$

b) $$0 = \frac{v_{in}}{R_1} + \frac{v_{in} - v_{out}}{R_2} \quad [+2]$$

$$\frac{v_{out}}{v_{in}} = \left(1 + R_2/R_1\right) \quad [+1]$$

c) In circuit A, ind. source delivers $v_{in} \cdot (v_{in}/R_1) > 0\,W$.
In circuit B, ind. source delivers $v_{in} \cdot 0 = 0\,W$.
∴ B [+1]

d) v_{out} is larger in circuit B than in A for same R_1, R_2, R_L and v_{in}. ∴ B [+1]

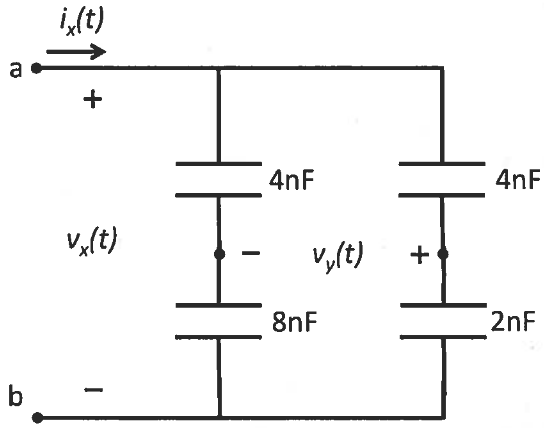
work space

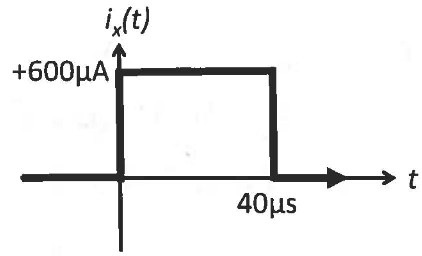
ECSE-200 Quiz #8 (31 Oct 2014)

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 $v_x(40\mu s)$? [2pts]

c) Plot $v_x(t)$ versus t. Clearly label your axes. [1pt]

d) What is the total energy stored in the capacitors at $t = 40\mu s$? [2pts]

e) What is the value of $v_y(40\mu s)$? [4pts]

a) $C_{eq} = \dfrac{1}{1/4nF + 1/8nF} + \dfrac{1}{1/4nF + 1/2nF}$ [+1]

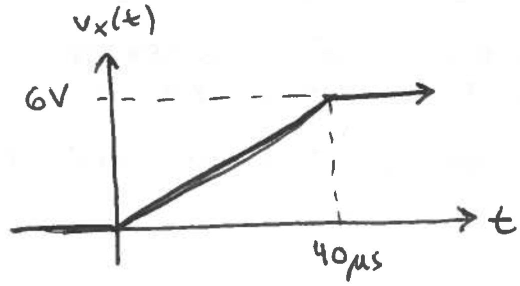
$= 4nF$ [+1]

b) $i_x = C_{eq} \cdot \dfrac{dv_x}{dt}$ $\therefore$ $v_x(40\mu s) - v_x(0) = \dfrac{1}{C_{eq}} \cdot \int_0^{40\mu s} i_x \, dt$ [+1]

$v_x(40\mu s) - 0 = \dfrac{1}{4nF} \cdot 600\mu A \cdot 40\mu s$

$v_x(40\mu s) = 6V$ [+1]

c)

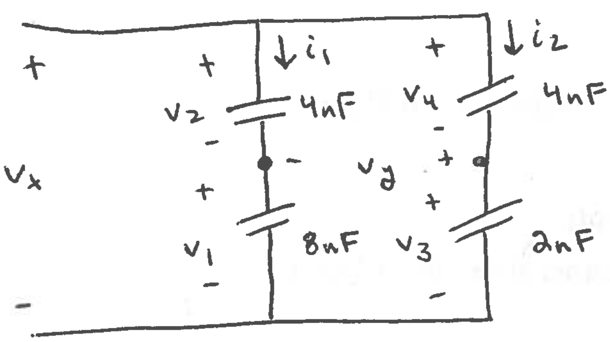


[+1]

d)

$$U = \frac{1}{2} C_{eq} v_x^2 \quad [+1]$$
$$= \frac{1}{2} \cdot 4nF \cdot (6V)^2$$
$$= 72nJ \quad [+1]$$

e)



$$i_1 = 8nF \frac{dv_1}{dt} = 4nF \frac{dv_2}{dt} \quad [+1]$$
$$\frac{dv_1}{dt} = \frac{1}{2} \cdot \frac{dv_2}{dt}$$
$$v_1(t) - v_1(0) = \frac{1}{2}(v_2(t) - v_2(0))$$
$$2v_1 = v_2$$

KVL: $0 = -v_x + v_2 + v_1$

$$v_1 = \frac{1}{3} v_x = 2V \text{ at } t = 40\mu s$$

$$i_2 = 2nF \frac{dv_3}{dt} = 4nF \frac{dv_4}{dt} \quad [+1]$$
$$\frac{dv_3}{dt} = 2 \frac{dv_4}{dt}$$
$$v_3(t) - v_3(0) = 2(v_4(t) - v_4(0))$$
$$\frac{1}{2} v_3 = v_4$$

KVL: $0 = -v_x + v_3 + v_4$

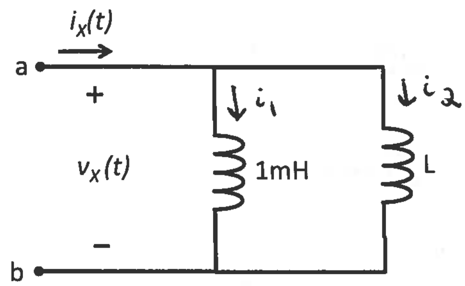
$$v_3 = \frac{2}{3} v_x = 4V \text{ at } t = 40s$$

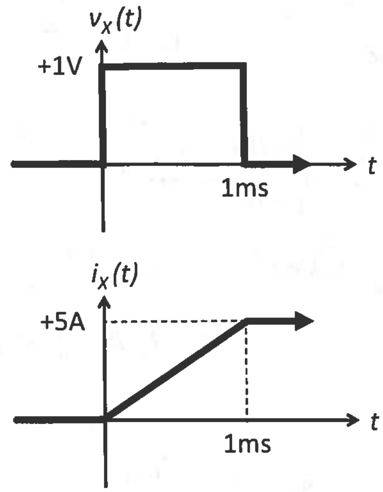
KVL: $0 = -v_1 - v_y + v_3$

$$v_y = v_3 - v_1 \quad [+1]$$

$$v_y = 4V - 2V$$
$$= 2V \quad [+1]$$

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





a) What physical principle is violated if inductor current is not a continuous function of time? [1pt]

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

c) What is the inductance L? [2pts]

d) What is the energy stored in the 1mH inductor at t = 1ms? [2pts]

e) What is the energy stored in L at t = 1ms? [2pts]

a) conservation of energy [+1]

b) $v_x = L_{eq} \frac{di_x}{dt}$ [+1] $\quad L_{eq} = \frac{v_x}{di_x/dt} = \frac{1V}{5A/ms}$

$= 200\,\mu H$ [+1]

c) $\frac{1}{L_{eq}} = \frac{1}{1mH} + \frac{1}{L}$ [+1]

$L = 1/(1/L_{eq} - 1/1mH) = 1/(1/200\mu H - 1/1mH) = 250\,\mu H$ [+1]

d) $i_1(1ms) - i_1(0) = \frac{1}{1mH} \int_0^{1ms} v_x(t)\,dt$ (+½]

work space

$$i_1(1ms) - 0 = \frac{1}{1mH} \cdot 1V \cdot 1ms = 1A$$

$$U = \underbrace{\frac{1}{2} \cdot 1mH \cdot i_1^2}_{[+1/2]} = 500\mu J \quad [+1]$$

e) $$i_2(1ms) = i_x(1ms) - i_1(1ms)$$

$$= 4A \quad [+1/2]$$

$$U = \frac{1}{2} \cdot L \cdot i_2^2 \quad [+1/2]$$

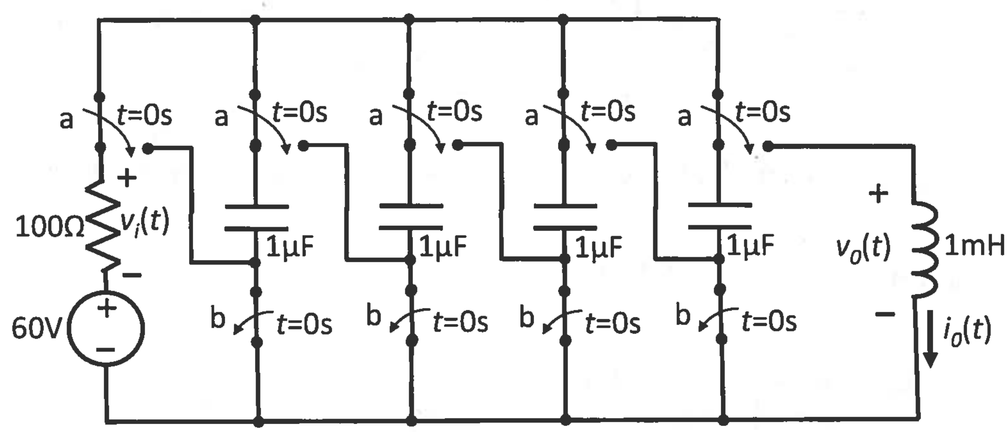
$$= \frac{1}{2} \cdot 250\mu H \cdot (4A)^2$$

$$= 2\,mJ \quad [+1]$$

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. Assume dc steady-state behaviour for $t < 0$. The switches "a" all change position and the switches "b" all open instantaneously at $t = 0$.



a) What is $v_i(0\text{-})$? [1pt]

b) What is the energy stored on the capacitors at $t = 0\text{-}$? [1pt]

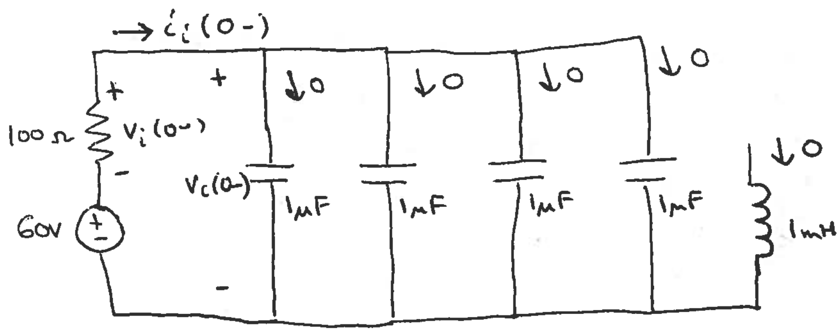
c) What is $v_i(0\text{+})$? [2pts]

d) What is $v_O(0\text{+})$? [2pts]

e) What is dv_i/dt at $t = 0\text{+}$? [2pts]

f) What is dv_O/dt at $t = 0\text{+}$? [2pts]

$t = 0^-$, dc steady state



a) $i_i(0-) = 0$ by KCL

$v_i(0-) = -100\,\Omega \cdot i_i(0-)$

$= 0\,V$ [+1]

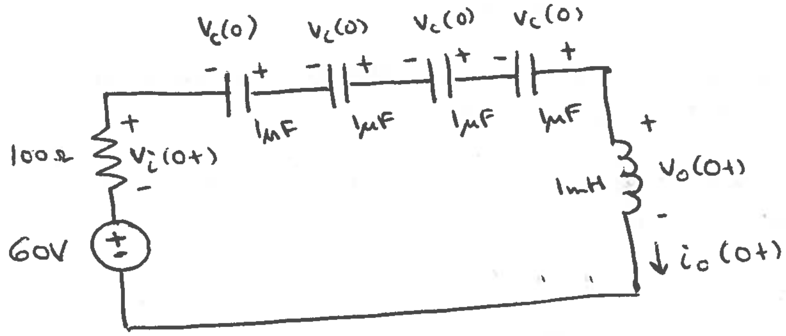
b) $v_c(0-) = 60V + v_i(0-)$

$= 60V$

$U_{total} = 4 \times \frac{1}{2} \cdot 1\mu F\,(60V)^2$

$= 7.2\,mJ$ [+1]

$t = 0+$



c) continuity:

$v_c(0+) = v_c(0-) = 60\,V$ [+1/2]

$i_o(0+) = i_o(0-) = 0\,A$ [+1/2]

$v_i(0+) = -100\,\Omega \cdot i_o(0+)$
$= 0\,V$ [+1]

d) KVL: $0 = -60V - v_i(0+) - v_c(0) - v_c(0) - v_c(0) - v_c(0) + v_o(0+)$ [+1]

$v_o(0+) = 300\,V$ [+1]

e) $v_o(0+) = L \cdot \left.\dfrac{di_o}{dt}\right|_{t=0+}$ [+1]

$$\left.\frac{dv_i}{dt}\right|_{t=0+} = -R\left.\frac{di_o}{dt}\right|_{t=0+} = -\frac{R\,v_o(0+)}{L} = \frac{-100\,\Omega \cdot 300V}{1mH}$$

$= -30\,MV/s$ [+1]

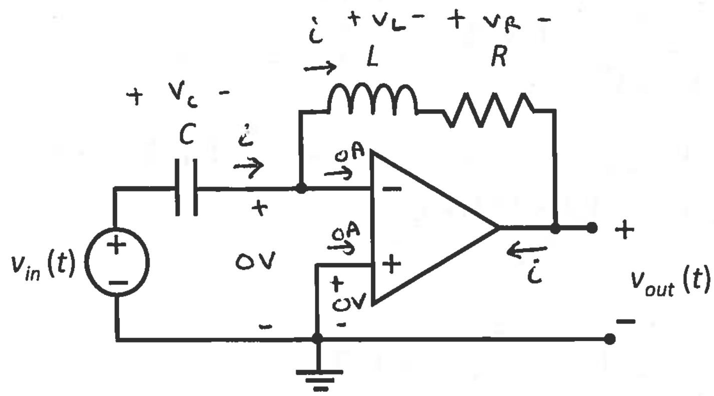
f) KVL: $0 = -60V - v_i(t) - v_c(t) - v_c(t) - v_c(t) - v_c(t) + v_o(t) \quad t > 0$

$$\therefore \quad 0 = 0 - \frac{dv_i}{dt} - 4\frac{dv_c}{dt} + \frac{dv_o}{dt}$$

$$i_o(0+) = C\left.\frac{dv_c}{dt}\right|_{t=0} = 0$$

$$\underbrace{\left.\frac{dv_o}{dt}\right|_{t=0} = \left.\frac{dv_i}{dt}\right|_{t=0}}_{[+1]} = -30\,MV/s \quad [+1]$$

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



a) Find $v_{out}(t)$ in terms of L, C, R, and $v_{in}(t)$. [2pts]

For the remainder of this question, assume $L = 10\mu H$, $R = 0\ \Omega$, and $v_{in}(t) = 1V \sin(2\pi f t)$ with the frequency $f = 1.6\times10^6$ Hz = 1.6 MHz.

b) What should the value of C be such that $v_{out}(t) = v_{in}(t)$? [2pts]

Use the value of C determined by part b) for the remainder of this question.

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

d) What is the maximum instantaneous power delivered by the independent voltage source? [2pts]

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

a) $i = C \frac{dv_c}{dt} = C \frac{dv_{in}}{dt}$ $\qquad v_L = L \frac{di}{dt}$ $\qquad v_R = iR$

$= LC \frac{d^2 v_{in}}{dt^2}$ $\qquad = RC \frac{dv_{in}}{dt}$

$0 = v_L + v_R + v_{out}$ $\quad \therefore \quad v_{out} = -v_L - v_R$

$v_{out} = \underbrace{-LC \frac{d^2 v_{in}}{dt^2}}_{[+1]} - \underbrace{RC \frac{dv_{in}}{dt}}_{[+1]}$

b) $v_{in} = 1V \sin(2\pi f t)$ $\qquad \frac{dv_{in}}{dt} = 2\pi f \cdot 1V \cdot \cos(2\pi f t)$

$\frac{d^2 v_{in}}{dt^2} = -(2\pi f)^2 \cdot 1V \sin(2\pi f t)$ $\qquad v_{out} = \underbrace{-LC \cdot (-(2\pi f)^2)}_{\text{equal to } 1} \cdot 1V \sin(2\pi f t$

$$C = \frac{1}{L \cdot (2\pi f)^2} \quad [+1]$$

$$= \frac{1}{10\mu H \cdot (2\pi \cdot 1.6\times10^6 Hz)^2} = 0.989\, nF \quad [+1]$$

c) $U_{max} = \frac{1}{2} L \cdot i_{max}^2 \quad [+1]$

$$i = C\frac{dv_{in}}{dt} = 2\pi f C \cdot 1V \cos(2\pi f t) \qquad i_{max} = 2\pi f C \cdot 1V$$

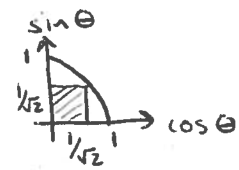
$$U_{max} = \frac{1}{2} \cdot L(2\pi f C \cdot 1V)^2 = \frac{1}{2} \cdot 10\mu H(2\pi \cdot 1.6\times10^6 Hz \cdot 0.989\, nF \cdot 1V)^2$$

$$= 0.494\, nJ \quad [+1]$$

d) $p_{del} = v_{in} \cdot i = 1V\sin(2\pi f t) \cdot 2\pi f C \cdot 1V\cos(2\pi f t)$

$$= 2\pi f C \cdot (1V)^2 \sin(2\pi f t)\cos(2\pi f t) \quad [+1]$$

$$\max(\sin\theta \cdot \cos\theta) = \frac{1}{2}$$



$$\therefore \max(p_{del}) = 2\pi f C \cdot (1V)^2 \cdot 1/2$$

$$= 2\pi \cdot 1.6\times10^6 Hz \cdot 0.989\, nF \cdot (1V)^2 \cdot 1/2$$

$$= 4.97\, mW \quad [+1]$$

e) $\overbrace{p'_{del} = -v_{out} \cdot i}^{[+1]} = -v_{in} \cdot i$

$$\max(p'_{del}) = \max(-v_{in} \cdot i) = \max(v_{in} \cdot i) = \max(p_{del})$$

periodic, symmetric
sin(θ) cos(θ)

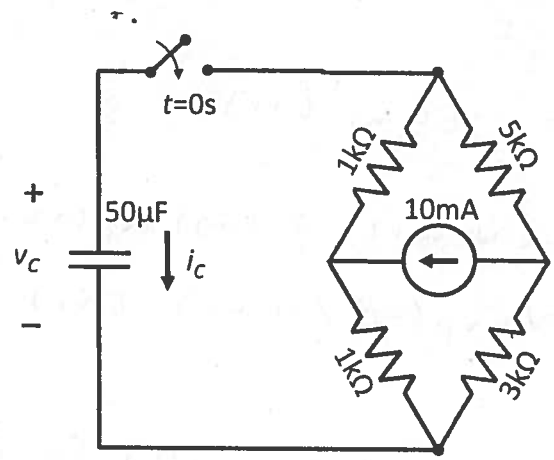
$$\max(p'_{del}) = 4.97\, mW \quad [+1]$$

ECSE-200 Quiz #10 (14 Nov 2014)

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 capacitor is storing zero energy and is in dc steady-state for $t < 0$. The switch closes instantaneously at $t = 0$.



a) What is $v_c(t)$ for $t > 0$? [6pts]

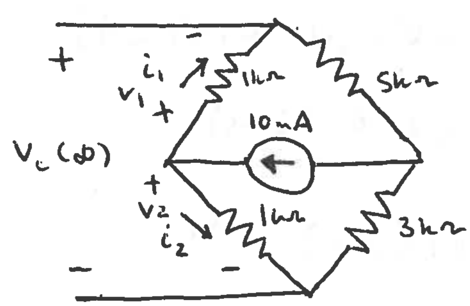
b) Plot $v_c(t)$ versus t. Indicate the time constant with an appropriate tangent. [2pts]

c) What is $i_c(t)$ for $t > 0$? [2pts]

a) $t < 0$ $\quad V_c(0-) = 0V$

$t = 0$ $\quad V_c(0+) = V_c(0-) = 0V$ [+1]

$t \to \infty$



$$i_1 = \frac{10mA \times (1+3)}{(1+3)+(1+5)} = 4mA$$

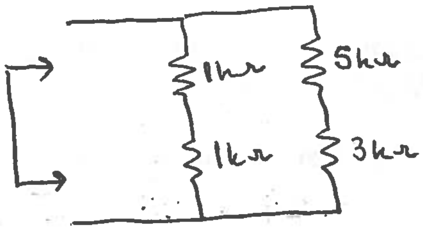
$$v_1 = i_1 \cdot 1k\Omega = 4V$$

$$i_2 = \frac{10mA \times (1+5)}{(1+3)+(1+5)} = 6mA$$

$$v_2 = i_2 \cdot 1k\Omega = 6V$$

$$V_c(\infty) = v_2 - v_1$$
$$= 2V \quad [+1]$$

R_T for $t > 0$

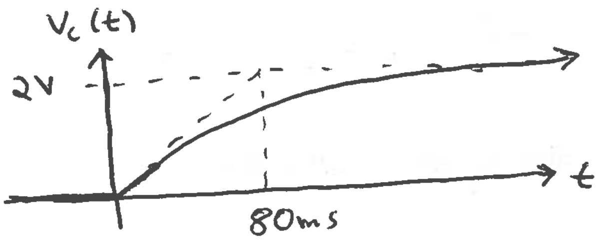


$$R_T = (1k\Omega + 1k\Omega) \,//\, (3k\Omega + 5k\Omega)$$
$$= \frac{2 \cdot 8}{2+8} k\Omega = 1.6\, k\Omega \quad [+1]$$

$$\tau = R_T \cdot C \quad [+1]$$
$$= 1.6k\Omega \cdot 50\mu F = 80\,ms \quad [+1]$$

$$v_c(t) = v_c(\infty) + (v_c(0^+) - v_c(\infty)) \exp(-t/\tau)$$
$$= 2V - 2V \exp(-t/80ms) \quad [+1]$$

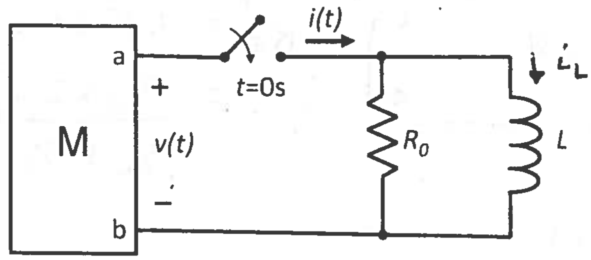
b)

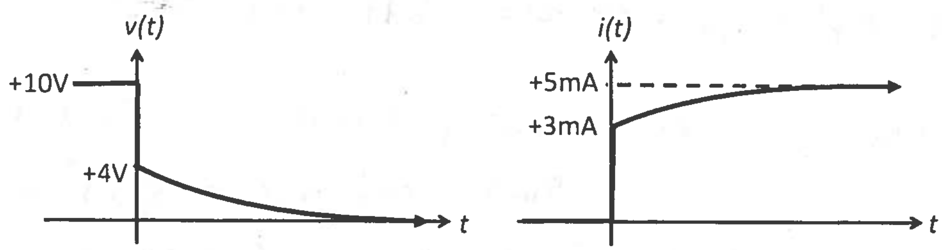


[+1] for shape
[+1] for values

c) $$i_c = C \frac{dv_c}{dt} \quad [+1]$$
$$= 50\mu F \cdot \frac{d}{dt}\left[2V - 2V \exp(-t/80ms)\right]$$
$$= 50\mu F(-2V)\left(\frac{-1}{80ms}\right) \exp(-t/80ms)$$
$$= 1.25mA \exp(-t/80ms) \quad [+1]$$

2. Consider the circuit below. The circuit M is composed of independent sources, dependent sources, and resistors. The circuit is in dc steady-state for $t < 0$. The switch closes instantaneously at $t = 0$. For time $t > 0$, the time constant for the circuit response is $\tau = 5\mu s$.





a) What is open circuit voltage of the circuit M? [1pt]

b) What is the Thévenin resistance of circuit M? [1pt]

c) What is the resistance R_O? [2pts]

d) What is the inductance L? [2pts]

e) At what time t does the current $i(t)$ = 4mA ? [2pts]

f) What is the maximum instantaneous power absorbed by the inductor? [1pt]

a) $v(t) = V_{oc}$ for $t < 0$

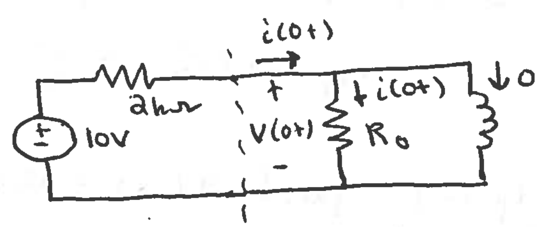
$\therefore V_{oc} = 10\,V$ [+1]

b) $i(t) = i_{sc}$ for $t \to \infty$

$\therefore i_{sc} = 5\,mA$ $\qquad R_T = V_{oc}/i_{sc} = \dfrac{10V}{5mA} = 2k\Omega$ [+1]

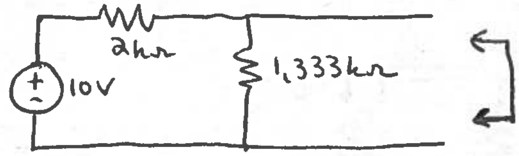
c) $i_L(0+) = i_L(0-) = 0\,mA$ [+1]

$\therefore$ at $t = 0+$



$R_0 = \dfrac{v(0+)}{i(0+)} = \dfrac{4V}{3mA} = 1.333\,k\Omega$ [+1]

d) From Thévenin equivalent:



$$R_T' = 1.333\,k\Omega \,//\, 2\,k\Omega$$

$$= \frac{4/3 \times 2}{4/3 + 6/3}\,k\Omega = 800\,\Omega$$

$\tau = L/R_T'$ [+1]

$L = \tau \cdot R_T' = 5\mu s \times 800\Omega = 4\,mH$ [+1]

e) By inspection: $i(t) = i(\infty) + (i(0^+) - i(\infty))\exp(-t/\tau)$

$$= 5mA - 2mA\exp(-t/5\mu s) \quad [+1]$$

$$4mA = 5mA - 2mA\exp(-t/5\mu s)$$

$$-1 = -2\exp(-t/5\mu s)$$

$$\ln\left(\tfrac{1}{2}\right) = -t/5\mu s$$

$$t = \ln 2 \cdot 5\mu s = 3.47\mu s \quad [+1]$$

f) By KCL: $i_L = i - v/R_0$

$$= (5mA - 2mA\exp(-t/5\mu s)) - 4V\exp(-t/5\mu s)/1.333k\Omega$$

$$= 5mA - 5mA\exp(-t/5\mu s)$$

$$p_{abs} = v \cdot i_L = 4V\exp(-t/5\mu s)\cdot(5mA - 5mA\exp(-t/5\mu s))$$

$$= 20mW[\exp(-t/5\mu s) - \exp(-2t/5\mu s)]$$

Find max: $\dfrac{dp_{abs}}{dt} = 20mW\left[-\frac{1}{5\mu s}\exp(-t/5\mu s) + \frac{2}{5\mu s}\exp(-2t/5\mu s)\right] = 0$

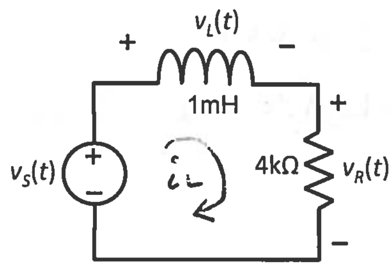
$\therefore \exp(-t/5\mu s) = 1/2 \qquad t = 3.47\mu s$

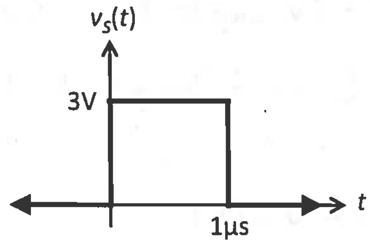
$\max(p_{abs}) = p_{abs}(3.47\mu s) = 20mW[1/2 - 1/4] = 5mW$ [+1]

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 in dc steady-state for $t < 0$





a) What is $v_R(t)$ for $0 < t < 1\mu s$? [3pts]

b) What is $v_R(t)$ for $1\mu s < t$? [3pts]

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

d) Give an expression for $v_R(t)$ that is valid for all time t using the unit step function $u(t)$. [1pt]

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

a) $V_R(0+) = 4k\Omega \cdot i_L(0+) = 4k\Omega \cdot i_L(0-) = 0V$ [+1]

$V_R(\infty) = 3V - v_L(\infty) = 3V$ [+1]

$\tau = \frac{1mH}{4k\Omega} = 0.25\mu s$

$V_R(t) = 3V - 3V\exp(-t/0.25\mu s)$ $0 < t < 1\mu s$ [+1]

b) $V_R(1\mu s+) = V_R(1\mu s-) = 3V - 3V\exp(-1/0.25)$

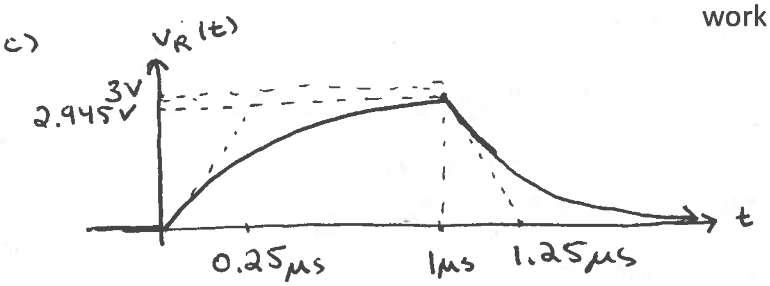
inductor current continuity $= 2.945V$ [+1]

$V_R(\infty) = 0V - v_L(\infty) = 0V$ [+1]

$V_R(t) = 2.945V\exp(-(t-1\mu s)/0.25\mu s)$ $1\mu s < t$ [+1]

work space

c)



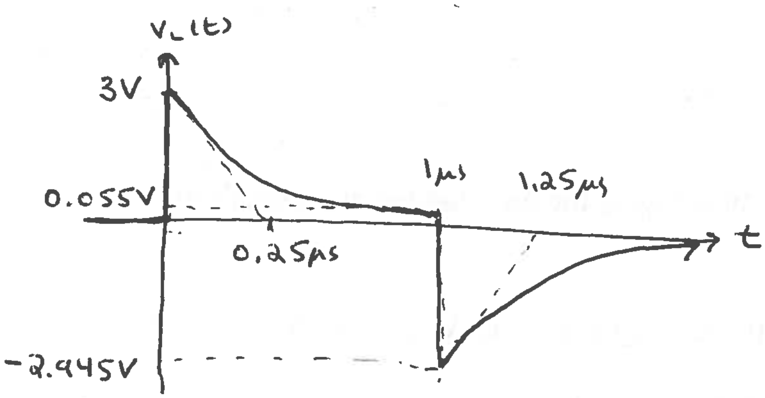
[+2] for shape and correct sign

d) $v_R(t) = 3V\,[1 - \exp(-t/0.25\mu s)]\,u(t)$

$+ (-3V)\cdot[1 - \exp(-(t-1\mu s)/0.25\mu s)]\,u(t-1\mu s)$

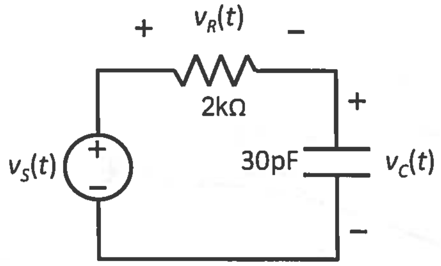
[+1]

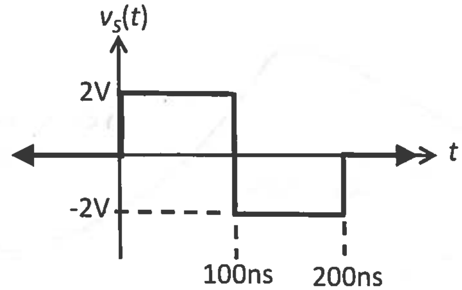
e) $v_L(t) = v_s(t) - v_R(t)$



[+2] for shape and correct sign

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





a) What is $v_C(t)$ for $0 < t < 100\text{ns}$? [3pts]

b) What is $v_C(t)$ for $100\text{ns} < t < 200\text{ns}$? [3pts]

c) What is $v_C(t)$ for $200\text{ns} < t$? [3pts]

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

e) Give an expression for $v_C(t)$ that is valid for all time t using the unit step function $u(t)$. [1pt]

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

a) $V_c(0+) = V_c(0-) = 0V$ [+1] $\tau = 2k\Omega \cdot 30pF = 60ns$

$V_c(\infty) = 2V$ [+1]

$V_c(t) = 2V - 2V\exp(-t/60ns)$ $\quad 0 < t < 100ns$ [+1]

b) $V_c(100ns+) = V_c(100ns-) = 2V - 2V\exp(-100/60)$

$= +1.622V$ [+1]

$V_c(\infty) = -2V$ [+1]

$V_c(t) = -2V + 3.622V\exp(-(t-100ns)/60ns)$ $\quad 100ns < t < 200ns$ [+1]

c) $V_c(200ns+) = V_c(200ns-) = -2V + 3.622V\exp(-100/60)$

$= -1.316V$ [+1]

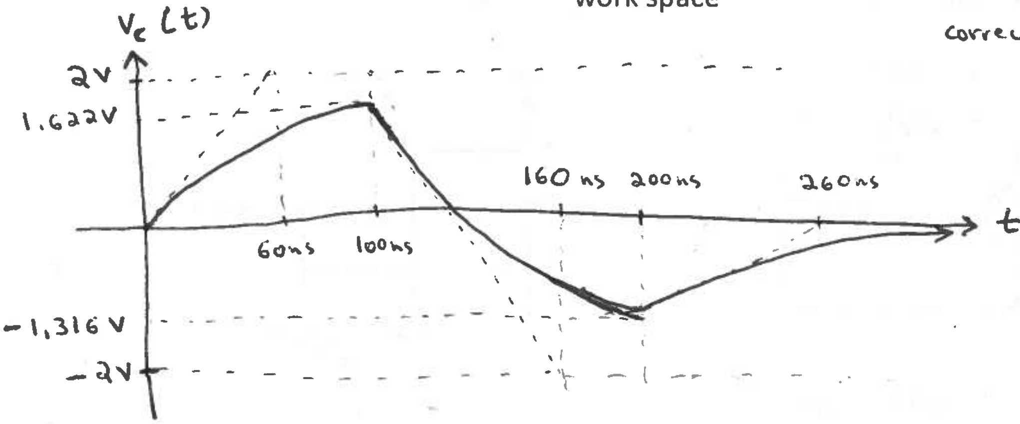
$V_c(\infty) = 0V$ [+1]

$V_c(t) = -1.316V\exp(-(t-200ns)/60ns)$ $\quad 200ns < t$ [+1]

work space

[+2] for shape and correct sign

d)

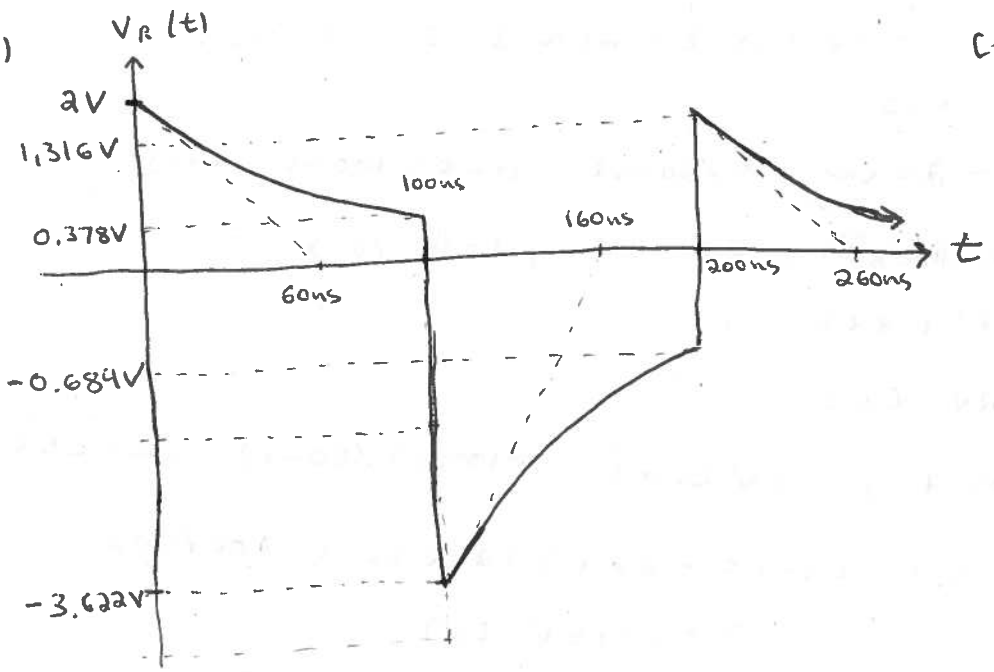


e)

$$
\begin{aligned}
V_c(t) = {} & 2V[1 - \exp(-t/60ns)]\, u(t) \\
& - 4V[1 - \exp(-(t - 100ns)/60ns]\, u(t - 100ns) \\
& + 2V[1 - \exp(-(t - 200ns)/60ns]\, u(t - 200ns)
\end{aligned}
$$

[+1]

f)



[+2] for shape and correct sign.