Name: ______________________________ (please print)

Signature: ___________________________

ECE 2201 – Exam 1
September 30, 2017

Keep this exam closed and face up until you are told to begin.

1. This exam is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit.
3. Show your work clearly. If the grader has difficulty following or understanding your work, you will lose credit.
4. Show all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
5. Do not use red ink. Do not use red pencil.
6. You will have 90 minutes to work on this exam.

1. _______________/35

2. _______________/35

3. _______________/30

Total = 100

Room for extra work

1. {35 Points} Six devices are connected together as shown in Figure 1. The current i_R and voltage v_W are given as follows:

$$i_R(t) = 4.5\left[\frac{A}{s}\right]t - 6.8[mA] \quad \text{and} \quad v_W(t) = 1.785\left[\frac{kV}{s}\right]t + 3.4[V]$$

The voltages $v_X(t)$, $v_Y(t)$ and the current $i_Q(t)$ are shown in Figures 2, 3 and 4, respectively.

a) If at t=5[ms], Device C is delivering power, which way are the electrons moving through Device C at t=5[ms]?
b) Find the power delivered by Device F at t=7[ms]. Are the electrons losing or gaining energy when moving through Device F at t=7[ms]?
c) If power absorbed by Device A at t=6[ms] is equal to 47[mW], what is $i_s(6[ms])$?
d) For 0<t<15[ms], during which time intervals does Device B deliver power?

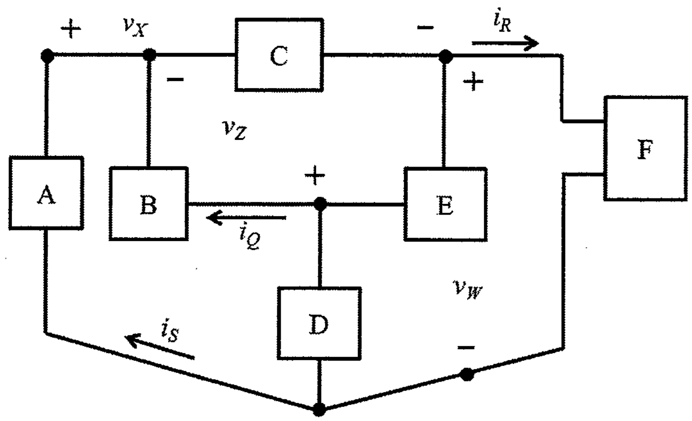


Figure 1

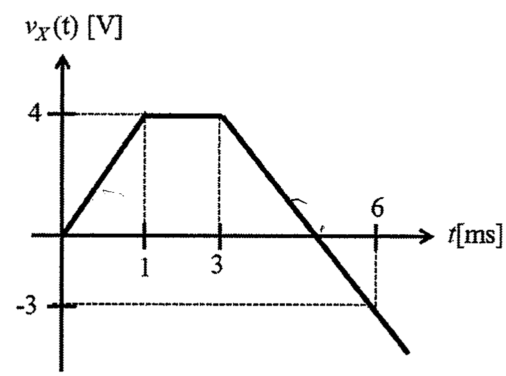


Figure 2

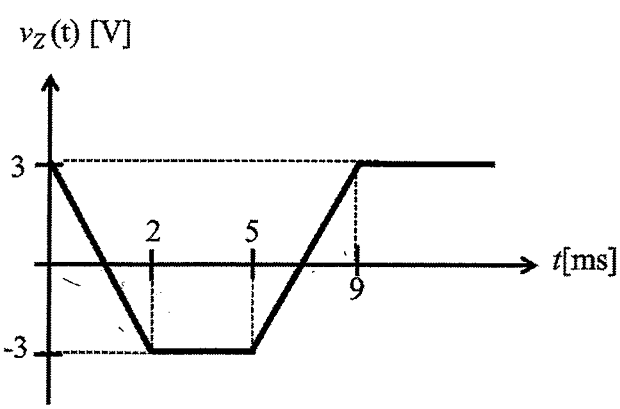


Figure 3

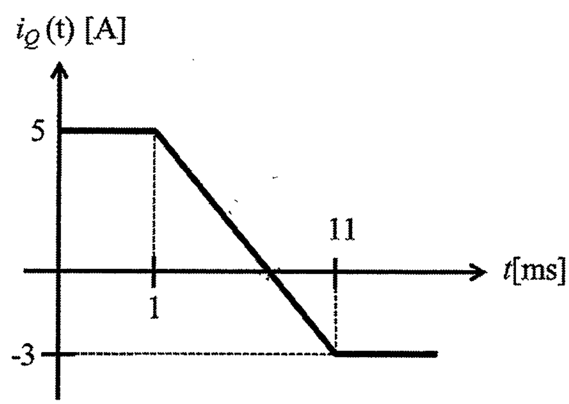


Figure 4

Room for extra work

2. {35 Points} A revolutionary new device called the Gulinator (G) is connected at terminals 1 and 2 to three devices (D) as shown. The following information is known.

- Electrons carry the current in the Gulinator, and they are leaving the Gulinator through terminal 1. The magnitude of the electron charge moving through the Gulinator is

$$q_G(t) = 227e^{-0.04\left[\frac{1}{ms}\right]t}\ [C], t > 0.$$

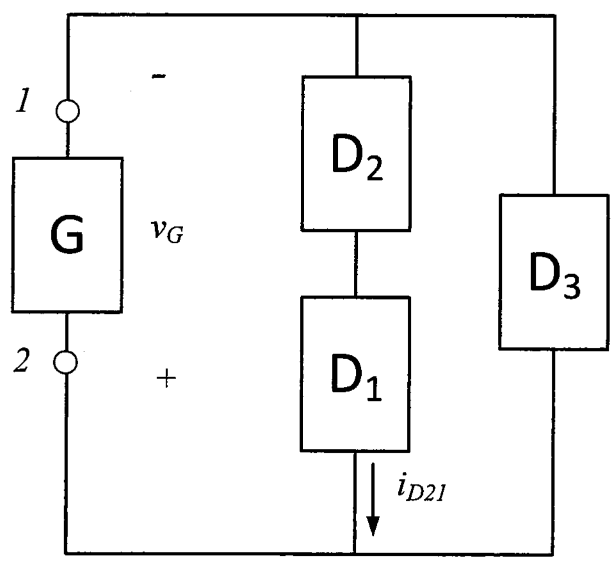
- The power delivered by the Gulinator to the devices is

$$p_{del\ by\ G}(t) = 1.0896e^{-0.14\left[\frac{1}{ms}\right]t}[kW], t > 0.$$

- The current i_{D21} is

$$i_{D21}(t) = -4000e^{-0.04\left[\frac{1}{ms}\right]t}\ [A], t > 0.$$

a) Find an expression for the voltage $v_G(t)$.
b) Find the energy delivered by the Gulinator in the time interval $0 < t < 0.25$ [s].
c) Find an expression for the power absorbed by device D_3.



Room for extra work

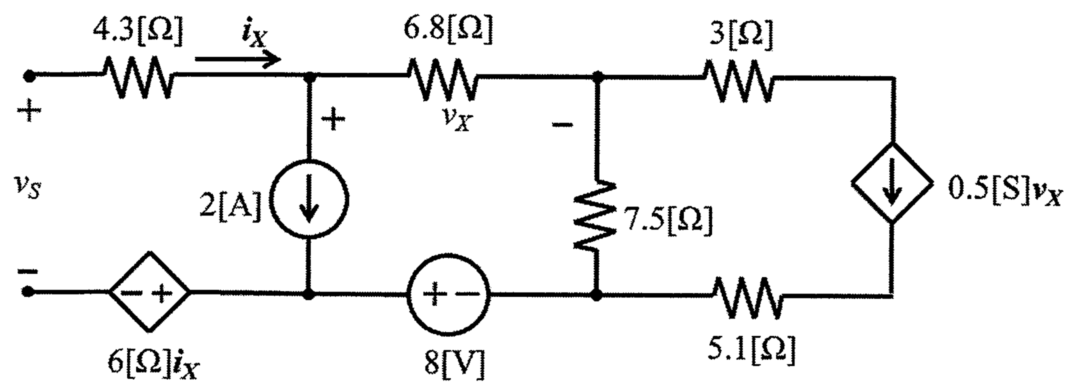
Room for extra work

3. {30 Points} For the circuit given below, find:

a) v_X

b) v_S

c) power delivered by the dependent current source.



Name: ~~Solutions~~ (please print)

Signature: ______________________

ECE 2201 – Exam 1
September 30, 2017

Keep this exam closed and face up until you are told to begin.

1. This exam is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution which is not given in a reasonable order will lose credit.
3. Show your work clearly. If the grader cannot follow or understand your work, you will lose credit.
4. Show all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
5. Do not use red ink. Do not use red pencil.
6. You will have 90 minutes to work on this exam.

1. ______________/35

2. ______________/35

3. ______________/30

Total = 100

1. {35 Points} Six devices are connected together as shown in Figure 1. The current i_R and voltage v_W are given as follows:

$$i_R(t) = 4.5\left[\frac{A}{s}\right]t - 6.8[mA] \quad \text{and} \quad v_W(t) = 1.785\left[\frac{kV}{s}\right]t + 3.4[V]$$

The voltages $v_X(t)$, $v_Z(t)$ and the current $i_Q(t)$ are shown in Figures 2, 3 and 4, respectively.

a) If at t=5[ms], Device C is delivering power, which way are the electrons moving through Device C at t=5[ms]?
b) Find the power delivered by Device F at t=7[ms]. Are the electrons losing or gaining energy when moving through Device F at t=7[ms]?
c) If power absorbed by Device A at t=6[ms] is equal to 47[mW], what is $i_s(6[ms])$?
d) For 0 < t < 15[ms], during which time intervals does Device B deliver power?

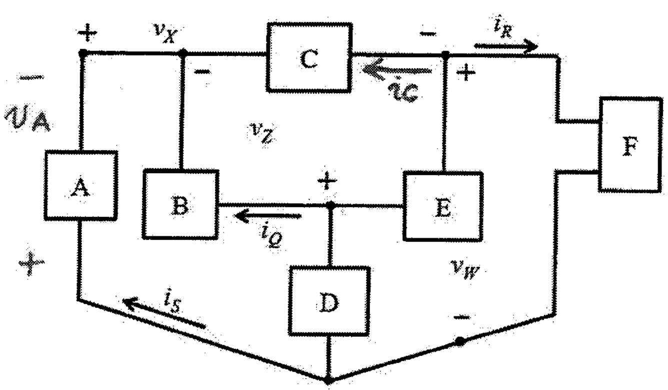


Figure 1

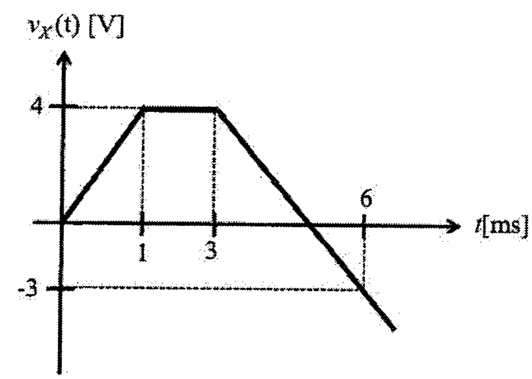


Figure 2

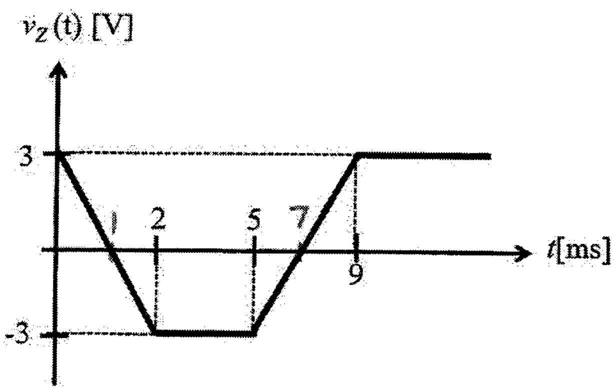


Figure 3

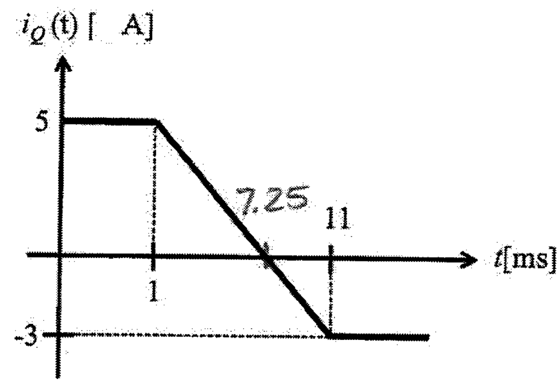


Figure 4

Room for extra work

a) $p_{DEL,C}(5[ms]) > 0 \Rightarrow v_X(5[ms]) \times i_C(5[ms]) > 0$

I need to know if $i_C(5[ms]) > 0$ or not. I can't tell from the graph, so I'll write the eq. for $v_X(t)$ for $t>3[ms]$

$v_X(t) = -\frac{7}{3}[V/ms]t + 11[V]$ for $t>3[ms]$

$v_X(5[ms]) = -0.66[V] < 0 \Rightarrow i_C(5[ms]) < 0$

e^-s are moving from right to left through Device C.

b) $p_{DEL,F}(7[ms]) = -i_R(7[ms]) \times v_W(7[ms])$

$p_{DEL,F}(7[ms]) = -24.7[mA] \times 15.895[V] =$ $\boxed{-392.6[mW]}$

F is absorbing power $\rightarrow$ e^-s moving through F lose energy

c) $p_{ABS,A}(6[ms]) = 47[mW]$ I need to define the voltage across Device A.

$p_{ABS,A}(6[ms]) = v_A(6[ms]) \times i_S(6[ms]) = 47[mW]$ (*)

I can find $v_A(6[ms])$ by using KVL:

$v_A + v_X + v_W = 0 \Rightarrow v_A(6[ms]) = -(v_X(6[ms]) + v_W(6[ms]))$

From Figure 2, $v_X(6[ms]) = -3[V]$ $v_W(6[ms]) = 14.11[V]$

$v_A(6[ms]) = -(-3+14.11)[V] = -11.11[V]$

From (*), $i_S(6[ms]) =$ $\boxed{-4.23[mA]}$

Room for extra work

d) $p_{DEL,B}(t) = -v_Z(t) \times i_Q(t)$ We need to find the zero crossings in Figures 3 and 4.

$$v_Z(t) = -3\,[V/ms]\,t + 3\,[V], \quad 0 < t < 2\,[ms]$$

$$\Rightarrow v_Z(t) = 0 \text{ at } t = 1\,[ms]$$

$$v_Z(t) = \frac{6}{4}\,[V/ms]\,t - \frac{42}{4}\,[V], \quad 5\,[ms] < t < 9\,[ms]$$

$$\Rightarrow v_Z(t) = 0 \text{ at } t = 7\,[ms]$$

$$i_Q(t) = -\frac{8}{10}\,[A/ms]\,t + \frac{58}{10}\,[A], \quad 1\,[ms] < t < 11\,[ms]$$

$$\Rightarrow i_Q(t) = 0 \text{ at } t = 7.25\,[ms]$$

$$v_Z(t) \begin{cases} > 0 & \text{for } 0 < t < 1\,[ms] \\ < 0 & \text{for } 1\,[ms] < t < 7\,[ms] \\ > 0 & \text{for } t > 7\,[ms] \end{cases}$$

$$i_Q(t) \begin{cases} > 0 & \text{for } 0 < t < 7.25\,[ms] \\ < 0 & \text{for } t > 7.25\,[ms] \end{cases}$$

$$-v_Z(t) \times i_Q(t) \begin{cases} < 0, & 0 < t < 1\,[ms] \\ \boxed{> 0, \quad 1\,[ms] < t < 7\,[ms]} \\ < 0, & 7\,[ms] < t < 7.25\,[ms] \\ \boxed{> 0, \quad 7.25\,[ms] < t < 15\,[ms]} \end{cases}$$

Device B delivers power for $1\,[ms] < t < 7\,[ms]$ and $7.25\,[ms] < t < 15\,[ms]$

2. {35 Points} A revolutionary new device called the Gulinator (G) is connected at terminals 1 and 2 to three devices (D) as shown. The following information is known.

- Electrons carry the current in the Gulinator, and they are leaving the Gulinator through terminal 1. The magnitude of the electron charge moving through the Gulinator is

$$q_G(t) = 227e^{-0.04\left[\frac{1}{ms}\right]t}\,[C], t > 0.$$

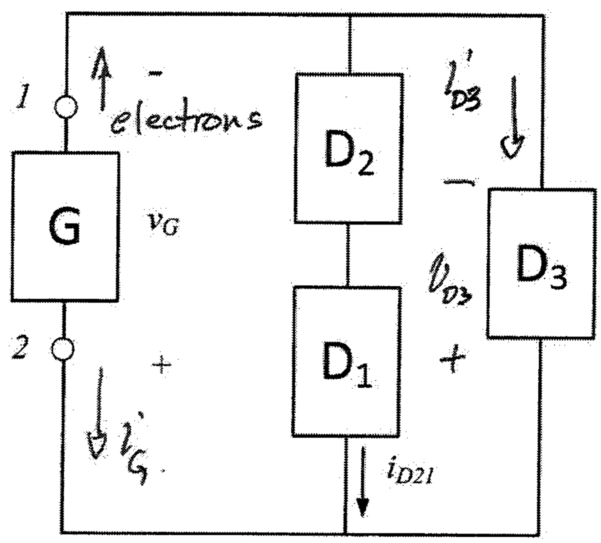
- The power delivered by the Gulinator to the devices is

$$p_{del\ by\ G}(t) = 1.0896e^{-0.14\left[\frac{1}{ms}\right]t}\,[kW], t > 0.$$

- The current i_{D21} is

$$i_{D21}(t) = -4000e^{-0.04\left[\frac{1}{ms}\right]t}\,[A], t > 0.$$

a) Find an expression for the voltage $v_G(t)$.
b) Find the energy delivered by the Gulinator in the time interval $0 < t < 0.25$ [s].
c) Find an expression for the power absorbed by device D_3.



Because electrons are moving upward, current is moving downward, as indicated. This is true even if the number of electrons is decreasing with time, as it is here. So we should write

$$i'_G = \left|\frac{dq_G(t)}{dt}\right|$$

$$i'_G(t) = \left|\frac{dq_G(t)}{dt}\right| = (0.04)(227)e^{-0.04\left[\frac{1}{ms}\right]t}\left[\frac{Coul}{ms}\right]$$

$$= 9080\,e^{-40\left[\frac{1}{s}\right]t}\ [A]$$

↑ note units

+6

Now we can find $v_g(t)$ ↗

Room for extra work

a)

$$v_G(t) = \frac{P_{del\ by\ G}}{i_G} = \frac{1089.6\ e^{-0.14[\frac{1}{ms}]t}\ [W]}{9080.0\ e^{-0.04[\frac{1}{ms}]t}\ [A]}$$

$$\therefore\ v_G(t) = 0.12\ e^{-100[\frac{1}{s}]t}\ [V]$$

+6

b)

$$w_{del\ by\ G} = \int_0^{0.25[s]} 1089.6\ e^{-140[\frac{1}{s}]t}\ dt$$

$$= \frac{-1}{140}(1089.6)\ e^{-140[\frac{1}{s}]t}\Big|_0^{0.25[s]}$$

$$= 0 + \frac{1089.6}{140} = 7.783\ [J]$$

$(e^{-35} \approx 0)$

{ t in [s]; P_{del} in [W]; w_{del} in [J] }

+8

c)

$$i_{D3} = -i_{D21} - i_G = (4000 - 9080)\ e^{-40[\frac{1}{s}]t}\ [A]$$ +5

$$v_{D3} = v_G$$ +5

$$\therefore\ P_{abs\ by\ D3} = -v_G(t)\ i_{D3}(t)$$

$$= -(-5080\ e^{-40[\frac{1}{s}]t})(0.12\ e^{-100[\frac{1}{s}]t})$$

+5

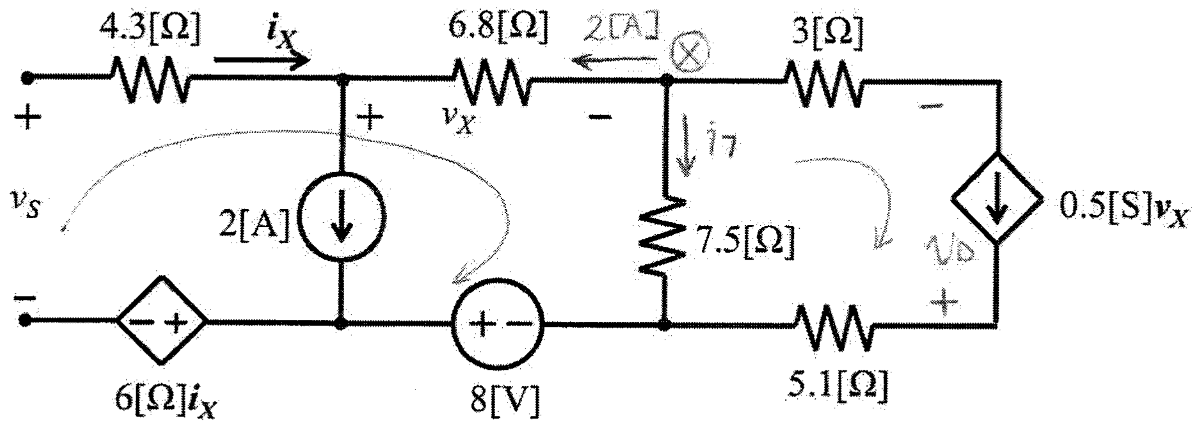
$$= 609.6\ e^{-140[\frac{1}{s}]t}\ [W]$$

3. {30 Points} For the circuit given below, find:

a) v_X

b) v_S

c) power delivered by the dependent current source.



a) $i_X = 0$ due open circuit. So, the current through 6.8 [Ω] resistor is equal to 2 [A]. Ohm's law in active sign convention gives us,

$$v_X = -2[A] \times 6.8[V] = \boxed{-13.6\,[V]}$$

b) KVL: $-v_S + i_X\, 4.3[\Omega] + v_X + i_7\, 7.5[\Omega] - 8[V] + 6[\Omega]\, i_X = 0$

$$v_S = -13.6[V] + i_7\, 7.5[\Omega] - 8[V] \quad (1)$$

Need another eq. KCL @ X: $2[A] + i_7 + 0.5[S]\, v_X = 0$

$$i_7 = 4.8\,[A] \qquad \boxed{v_S = 14.4\,[V]}$$

c) $p_{DEL,DCS} = v_D \times 0.5[S]\, v_X$

KVL: $-v_D + 0.5[S]\, v_X\, 5.1[\Omega] - i_7\, 7.5[\Omega] + 0.5[S]\, v_X\, 3[\Omega] = 0$

$$v_D = -91.08\,[V] \qquad \boxed{p_{DEL,DCS} = 619.34\,[W]}$$