Name: ______________________________ (please print)

Signature: ___________________________

Section (underline one): Trombetta   Shattuck

ECE 2300 – Exam #2
April 20, 2013

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. It is assumed that your work will begin on the same page as the problem statement. If you choose to begin your work on another page, you must indicate this on the page with the problem statement, with a clear indication of where the work can be found. **If your work continues on to another page, indicate clearly where your work can be found. Failure to indicate this clearly will result in a loss of credit.**
4. Show all units in solutions, intermediate results, and figures. Units in the exam 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. ________________/30

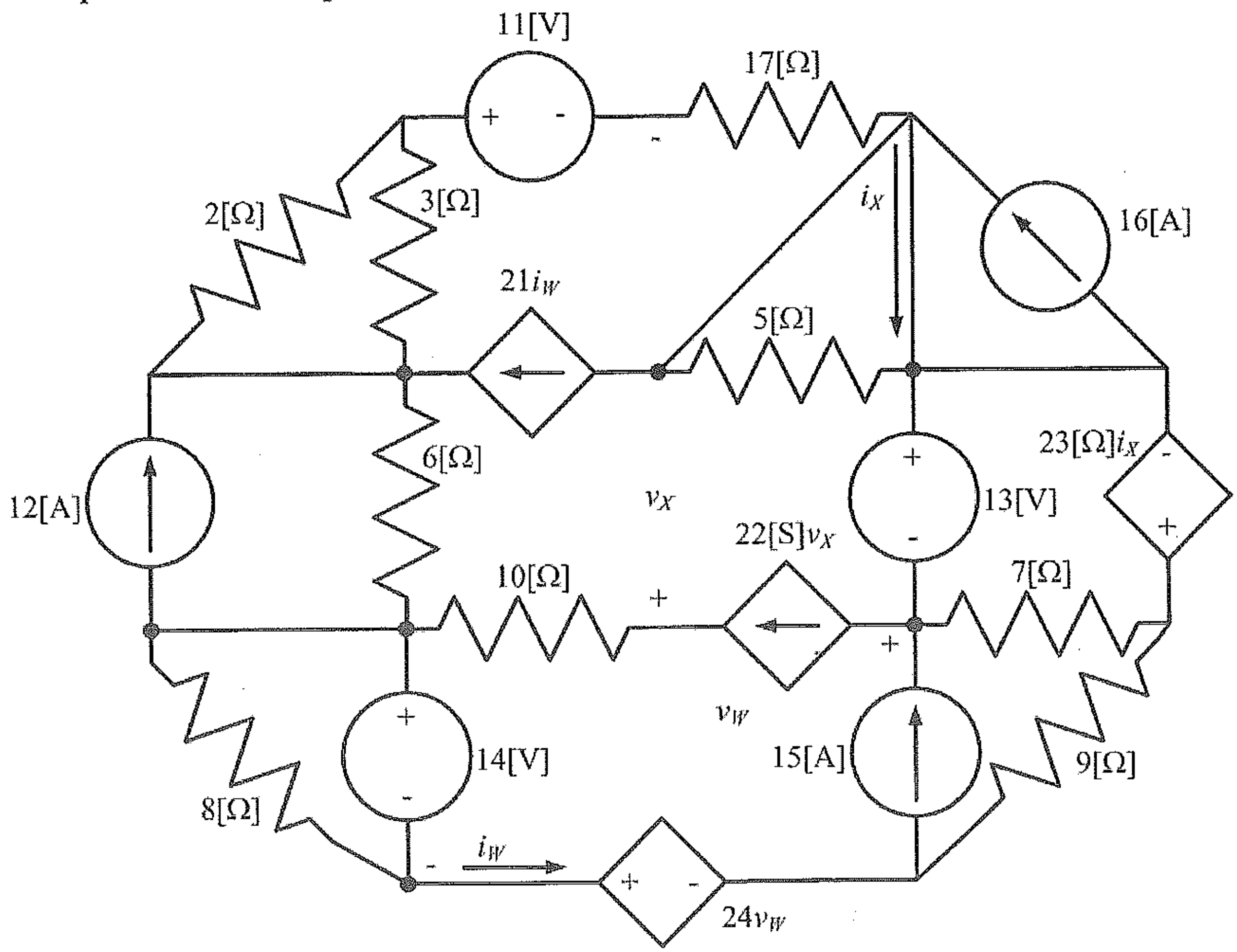
2. ________________/30

3. ________________/40

Total________________/100

Room for extra work

1. (30 points) Use the node-voltage method to write a complete set of equations that could be used to solve the circuit below. Do not simplify the circuit. Do not attempt to solve the equations. You must define all circuit variables.



Room for extra work

2. (<u>30 points</u>) The Norton equivalent for the circuit shown in Figure 1, as seen at terminals a and b, is given in Figure 2. When a 5[V] source is connected to terminals a and b, the current in the source is 0.4679[A], as shown in Figure 2. Find the Norton equivalent parameters i_N and R_N.

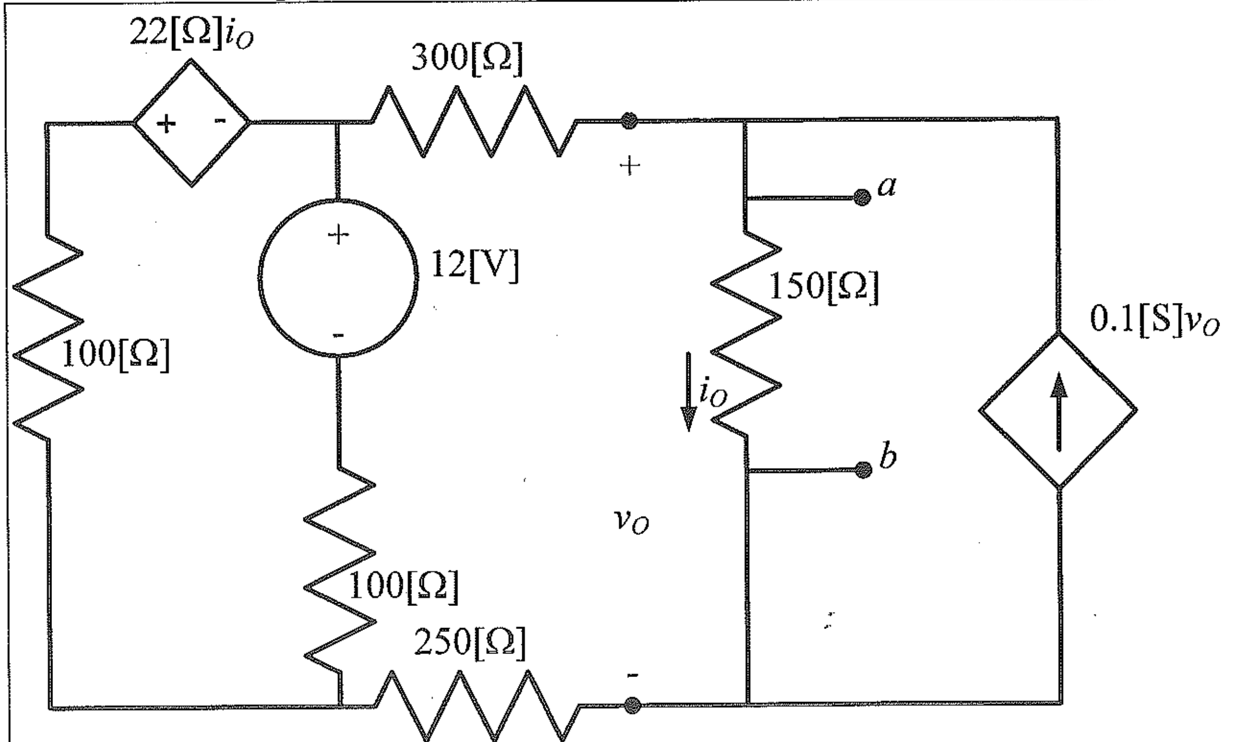


Figure 1

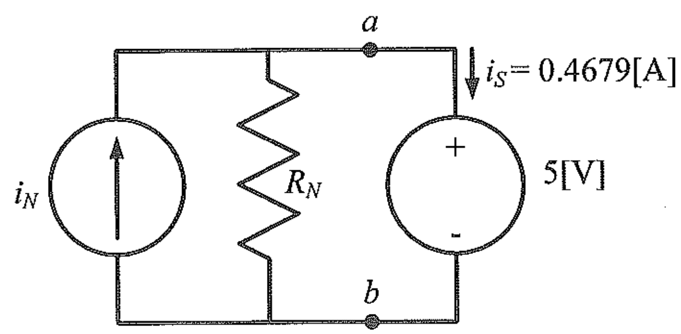
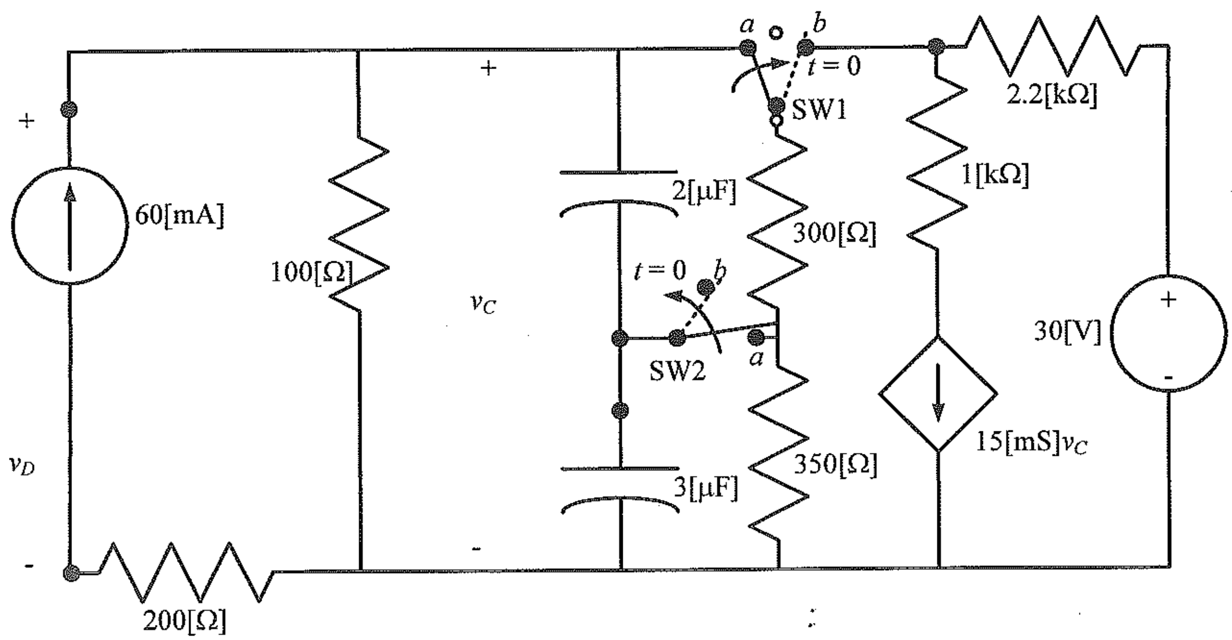


Figure 2

Room for extra work

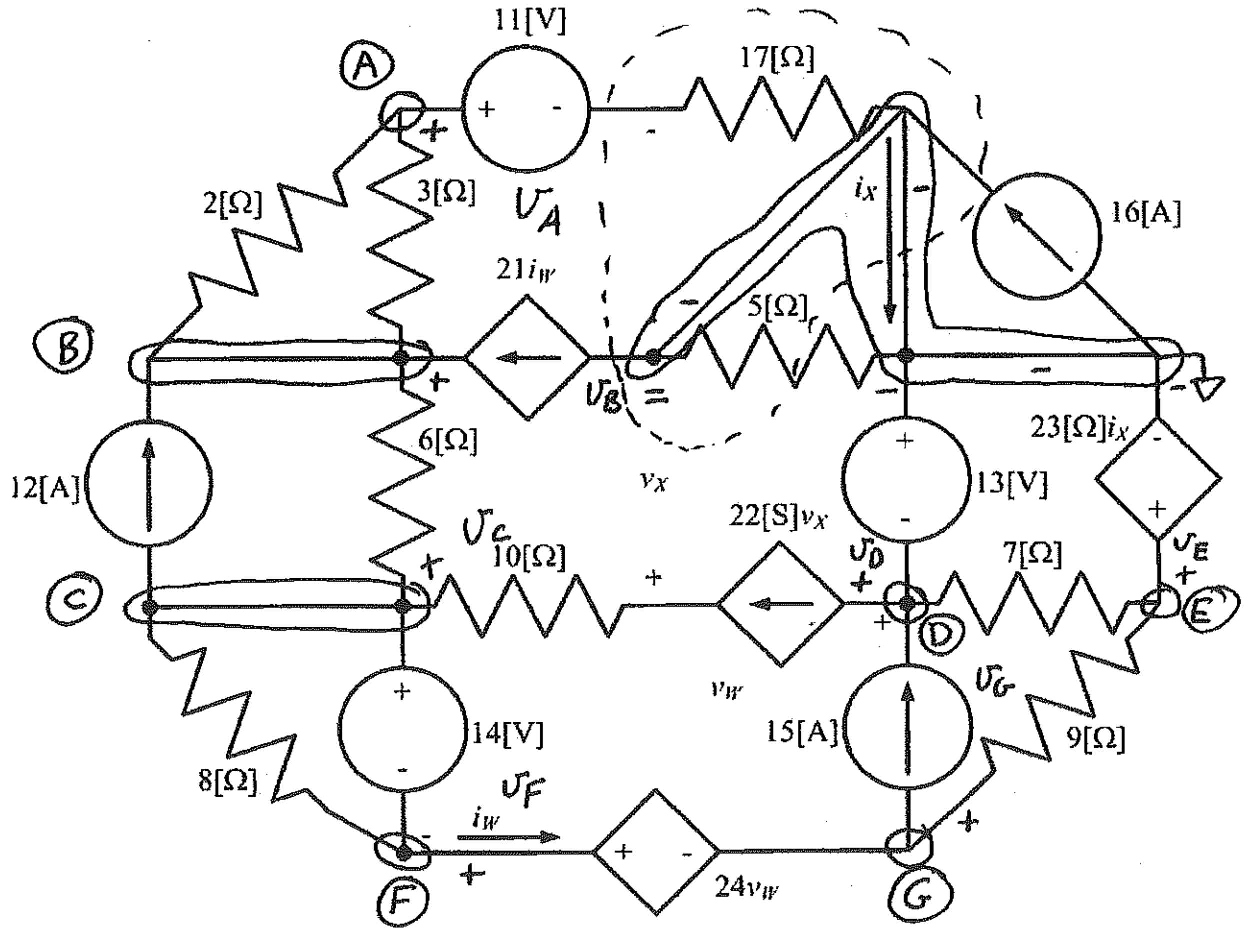
3. (40 points) In the circuit below, the switches SW1 and SW2 were in position *a* for a long time. At $t = 0$, switches SW1 and SW2 moved to position *b*. Find the energy stored in the 3[μF] capacitor for $t = 0.30$[ms].



Room for extra work

Room for extra work

1. (30 points) Use the node-voltage method to write a complete set of equations that could be used to solve the circuit below. Do not simplify the circuit. Do not attempt to solve the equations. You must define all circuit variables.



We will write 7+4=11 equations.

(A) $$\frac{v_A - 11[V]}{17[\Omega]} + \frac{v_A - v_B}{3[\Omega]} + \frac{v_A - v_B}{2[\Omega]} = 0$$

(B) $$\frac{v_B - v_A}{2[\Omega]} + \frac{v_B - v_A}{3[\Omega]} + (-21 i_W) + \frac{v_B - v_C}{6[\Omega]} - 12[A] = 0$$

(C+F+G) $$12[A] + \frac{v_C - v_B}{6[\Omega]} - 22[S]v_X + 15[v] + \frac{v_G - v_E}{9[\Omega]} = 0$$

see next page

Room for extra work

(C+F) $v_C - v_F = 14[V]$

(F+G) $v_F - v_G = 24\, v_W$

(D) $v_D = -13[V]$

(E) $v_E = 23[\Omega]\, i_X$

(v_X) $-v_X + (22[S]\, v_X)\, 10[\Omega] + v_C - v_A + 11[V] = 0$

(v_W) $v_W = v_D - v_F$

(i_W) $-i_W + 15[A] + \dfrac{v_G - v_E}{9[\Omega]} = 0$

(i_X) $i_X + \dfrac{0}{5[\Omega]} + 21\, i_W + \dfrac{11[V] - v_A}{17[\Omega]} - 16[A] = 0$

2. (30 points) The Norton equivalent for the circuit shown in Figure 1, as seen at terminals a and b, is given in Figure 2. When a 5[V] source is connected to terminals a and b, the current in the source is 0.4679[A], as shown in Figure 2. Find the Norton equivalent parameters i_N and R_N.

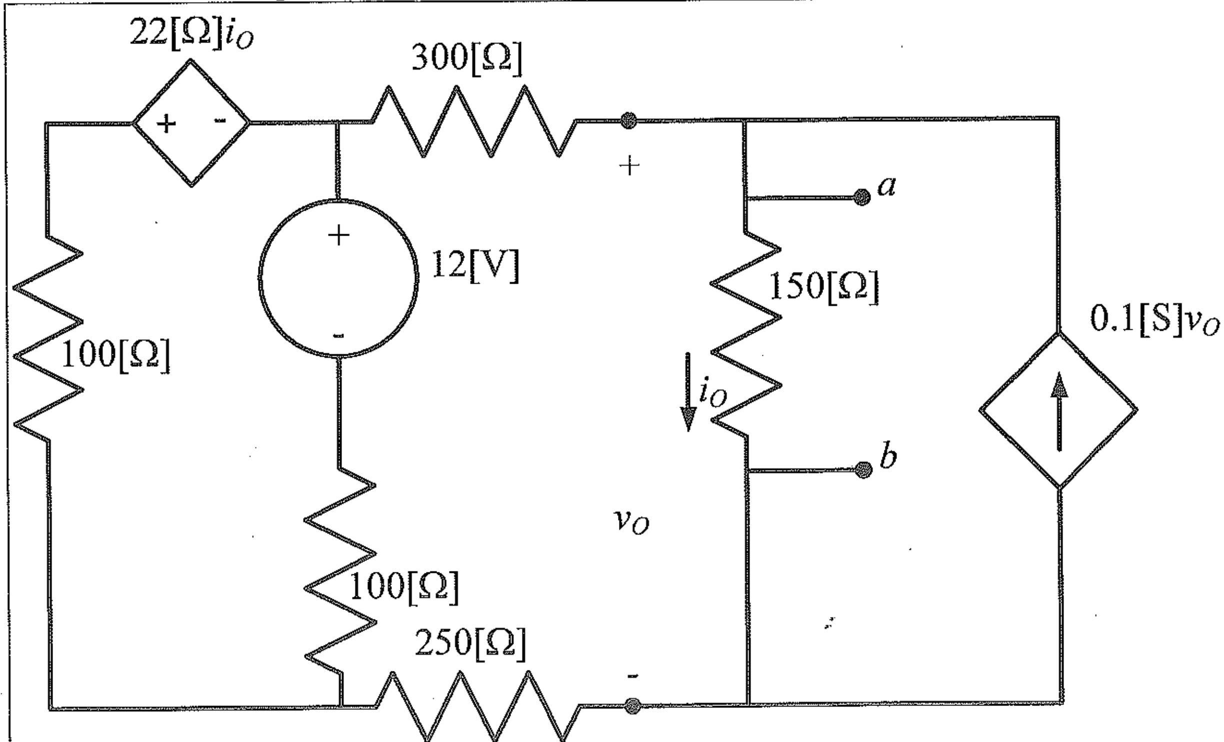


Figure 1

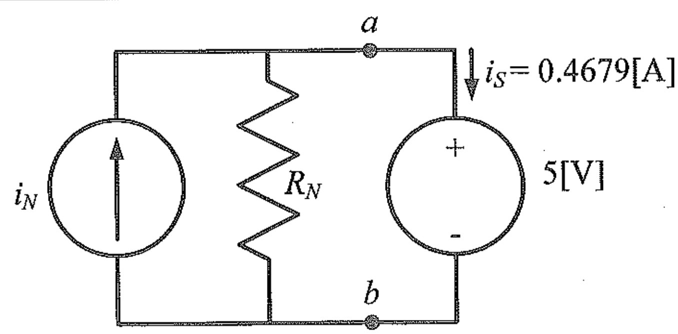


Figure 2

To find a Thevenin or Norton equivalent, we usually need to find two of i_{sc}, v_{oc}, $R_{Th} = R_N$ at terminals a, b. But because we are given information in Fig. 2, we need only one of these things:

$$i_s = 0.4679 = i_N - \frac{5}{R_N}$$

So if we know i_N or R_N we are done!

to p. 6

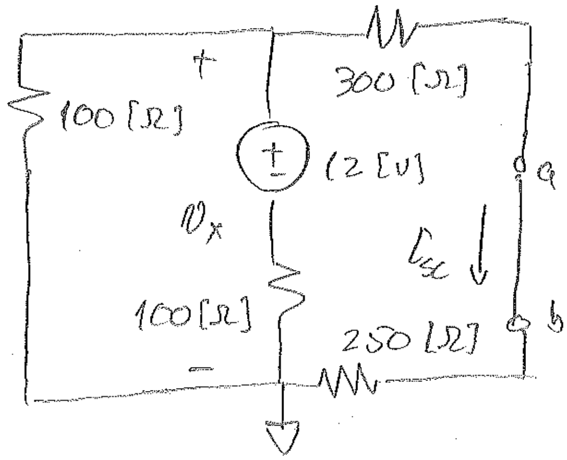
Room for extra work

Looking at the circuit, it should be clear that the simplest thing to find is i_{sc} since then $i_o = v_o = 0$!

Re-drawing with i_{sc} in place:

$22[\Omega] i_o = 0$

$0.1[S] v_o = 0$



$$\frac{v_x - 12}{100} + \frac{v_x}{100} + \frac{v_x}{550} = 0$$

$\Rightarrow v_x = 5.5$ [V]

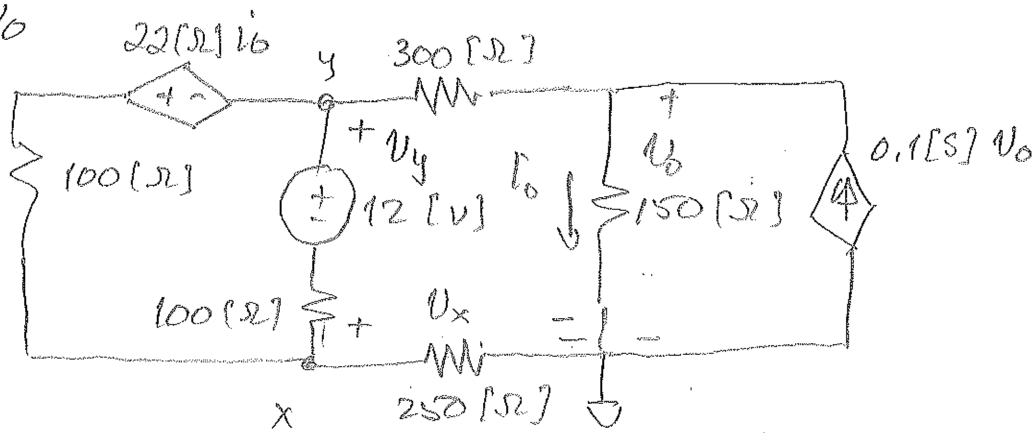
$\Rightarrow i_{sc} = \frac{v_x}{550} = 0.01$ [A]

Now: $i_s = i_N = 0.01$ [A]

$0.4679 = 0.01 - \frac{5}{R_N} \Rightarrow R_N = -10.92$ [Ω].

We will find v_{oc} and R_N for fun!

$v_{oc} = v_o$



next page

$$\frac{v_o}{150} - 0.1\, v_o + \frac{v_o - v_y}{300} = 0$$

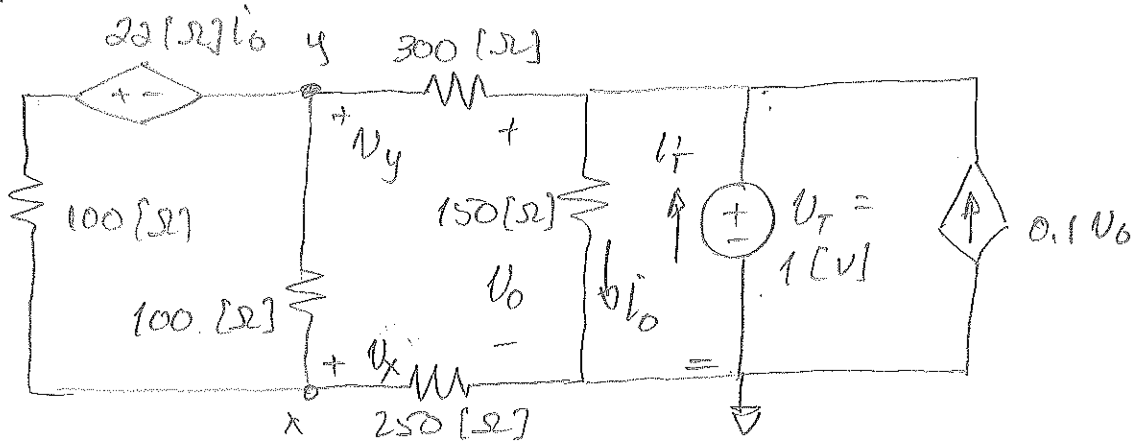
$$\frac{v_y - v_x - 12}{100} + \frac{v_y - v_x + 22 i_o'}{100} + \frac{v_y - v_o}{300} = 0$$

$$\frac{v_x}{250} + \frac{v_x - v_y - 22 i_o'}{100} + \frac{v_x - v_y + 12}{100} = 0$$

$i_o' = \frac{v_o}{150}$ $\quad v_x = -2.5484\ [V]$ $\quad v_y = 2.9494\ [V]$

$i_o' = -0.7282\ [mA]$ $\quad v_o = v_{oc} = -0.1092\ [V]$

$R_{TH} = R_N$:



$$\frac{v_y - v_x + 22 i_o'}{100} + \frac{v_y - v_x}{100} + \frac{v_y - 1}{300} = 0$$

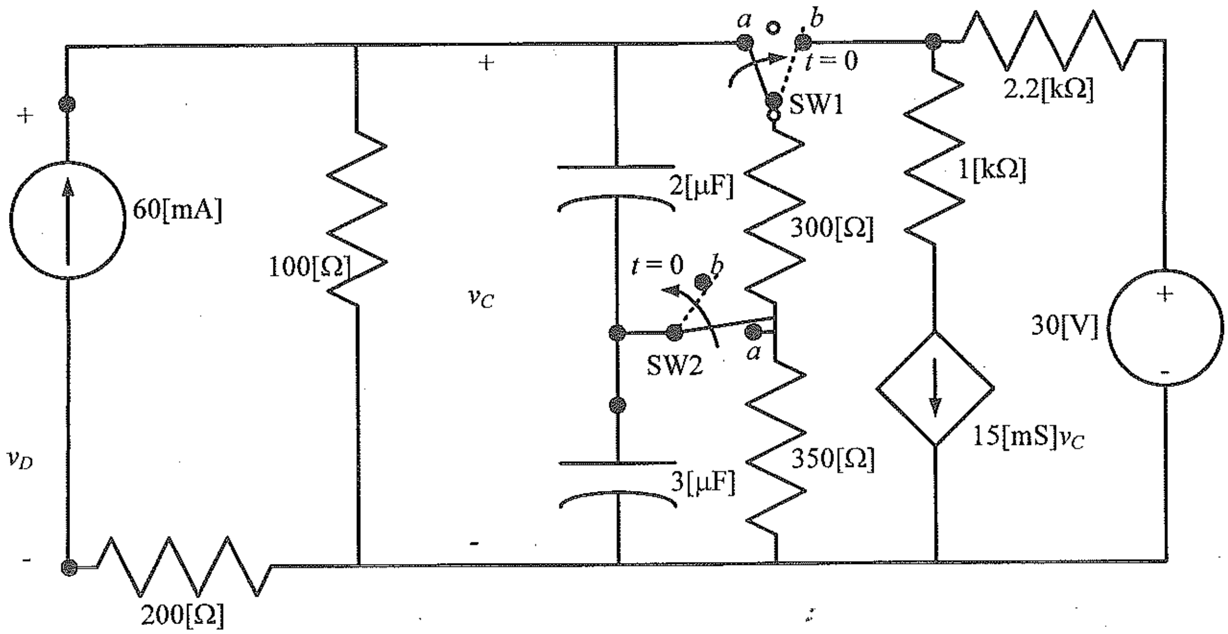
$$\frac{v_x}{250} + \frac{v_x - v_y - 22 i_o'}{100} + \frac{v_x - v_y}{100} = 0$$

$i_o' = \frac{1}{150}$ $\quad v_x = 0.4472\ [V]$ $\quad v_y = 0.4633\ [V]$ $\quad i_o' = 6.6667\ [mA]$

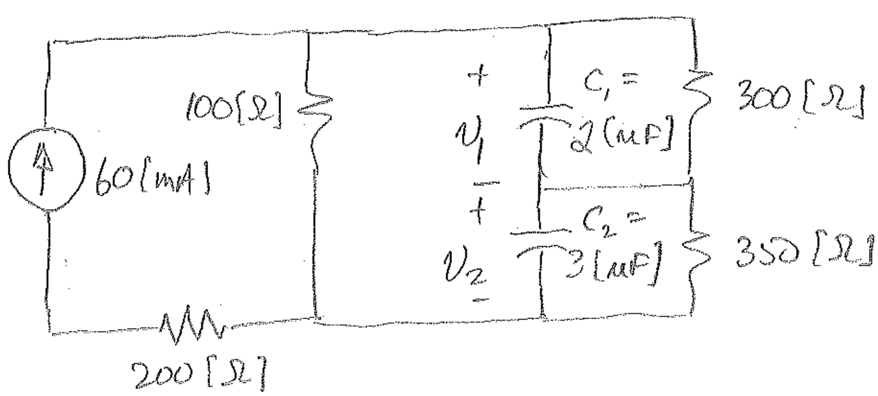
$$i_T' = i_o' - 0.1(1) + \frac{1 - v_y}{300} = -0.09154\ [A]$$

$R_N = \frac{1}{i_T'} = -10.92\ [\Omega]$ $\quad i_N' = \frac{v_{oc}}{R_N} = 0.01\ [A]$ ✓

3. (40 points) In the circuit below, the switches SW1 and SW2 were in position a for a long time. At $t = 0$, switches SW1 and SW2 moved to position b. Find the energy stored in the 3[μF] capacitor for $t = 0.30$[ms].



Re-draw for $t<0$:



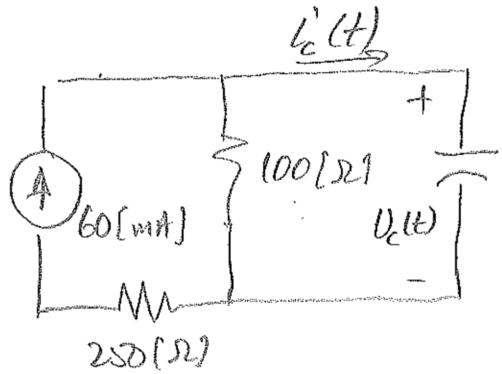
long time ⇒ C_1, C_2 → open ⇒

$$v_1(0^+) = 0.06 \cdot \frac{100}{100+(300+350)} \cdot 300 = 2.4\,[V]$$

$$v_2(0^+) = 0.06 \cdot \frac{100}{100+(300+350)} \cdot 350 = 2.8\,[V]$$

to p. 8

Room for extra work   Re-draw for $t > 0$:



$$C_{eq} = \left(\frac{1}{2\times10^{-6}} + \frac{1}{3\times10^{-6}}\right)^{-1} = 1.2\ [\mu F]$$

we have $v_c(t) = v_{c,f} + (v_c(0^+) - v_{c,f})e^{-t/\tau_c}$

where $v_{c,f} = v_c(t \to \infty)$ $v_c(0^+) = v_1(0^+) + v_2(0^+) = 5.2\ [V]$

$\tau_c = R_{TH} C_{eq}$

Now $v_{c,f} = 0.06(100) = 6\ [V]$ $R_{TH} = 100\ [\Omega]$

$\Rightarrow \tau_c = 100 \times 1.2\times10^{-6} = 0.12\ [ms]$:

$\Rightarrow v_c(t) = 6 + (5.2 - 6)e^{-t/0.12\times10^{-3}[s]}\ [V]$ $t \geq 0\ [s]$

Now for $v_2(t)$, we will need $i_c'(t)$:

$$i_c'(t) = C_{eq}\frac{dv_c}{dt} = 1.2\times10^{-6}\left(\frac{-0.8}{-0.12\times10^{-3}}\right)e^{-t/0.12\times10^{-3}[s]}$$

$$= 8\ [mA]\, e^{-t/0.12\times10^{-3}[s]} \qquad t > 0\ [s].$$

$$\therefore\ v_2(t) = \frac{1}{3\times10^{-6}}\int_0^t (0.008)e^{-t/0.12\times10^{-3}}\,dt + 2.8$$

$$= \frac{0.008}{3\times10^{-6}}\left(-0.12\times10^{-3}\right)e^{-t/0.12\times10^{-3}[s]}\Big|_0^t + 2.8$$

$$v_2(t) = -0.32\,e^{-t/0.12\times10^{-3}[s]} + 0.32 + 2.8 \quad [V]$$

$v_2(t = 0.3\ [ms]) = 3.094\ [V] \Rightarrow W_{3\mu F}(0.3[ms]) = \frac{1}{2}C_2 v_2^2$

$= 14.36\ [\mu J]$