Name: ______________________________ (please print)

Signature: ___________________________

ECE 2202 –Exam 1
October 10, 2020

Online

1. This quiz is open book, open notes.
2. 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 all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
4. If the grader has difficulty following your work because it is messy or disorganized, you will lose credit.
5. Do not use red ink. Do not use red pencil.
6. You will have 90 minutes to work on this exam, and 15 minutes to download/print, scan and submit.

________________/30

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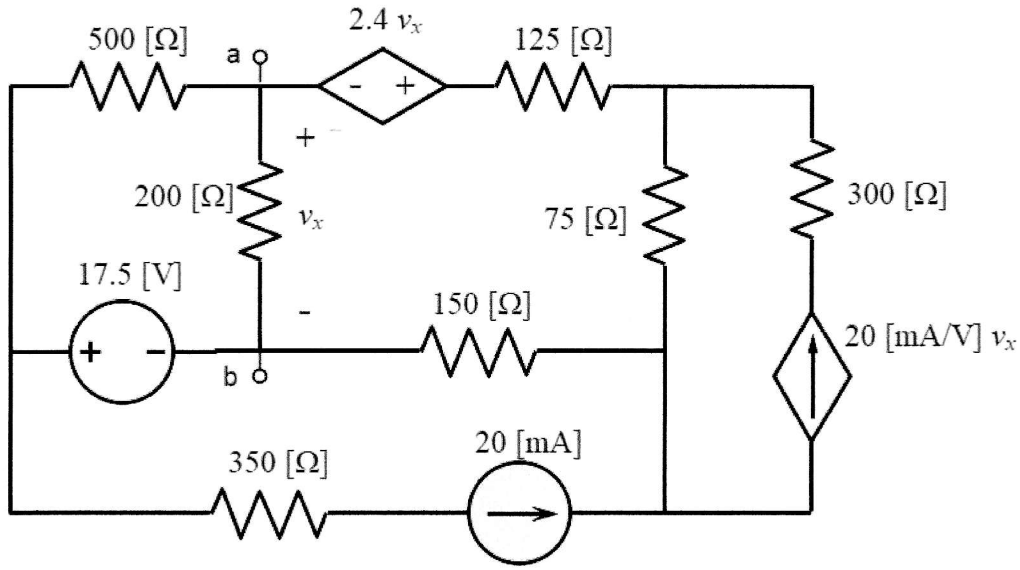
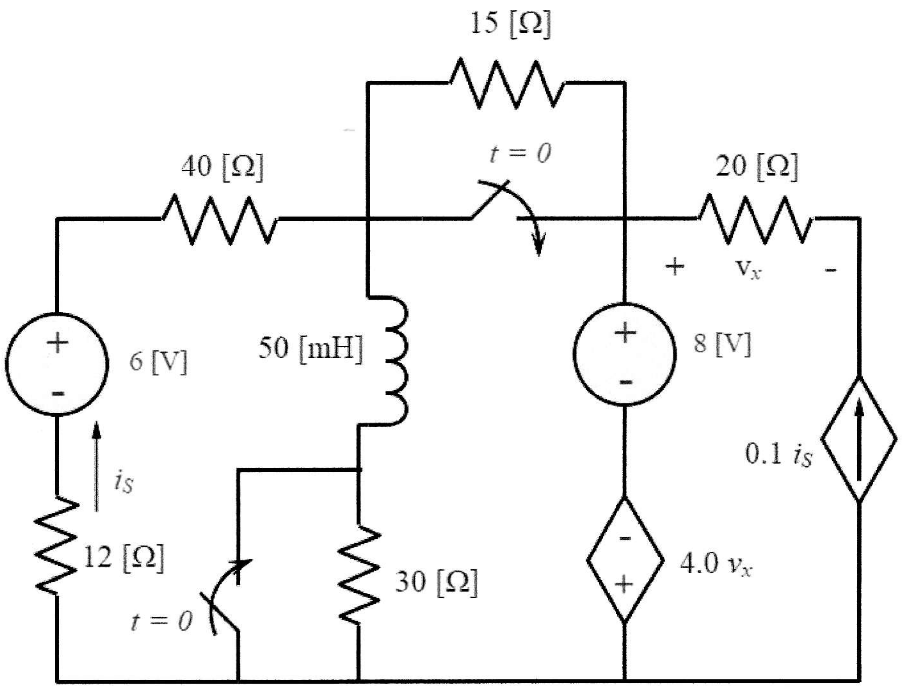
Room for extra work

1. [30 points] Find the Norton equivalent as seen by the 200 [Ω] resistor in the circuit below.



Room for extra work

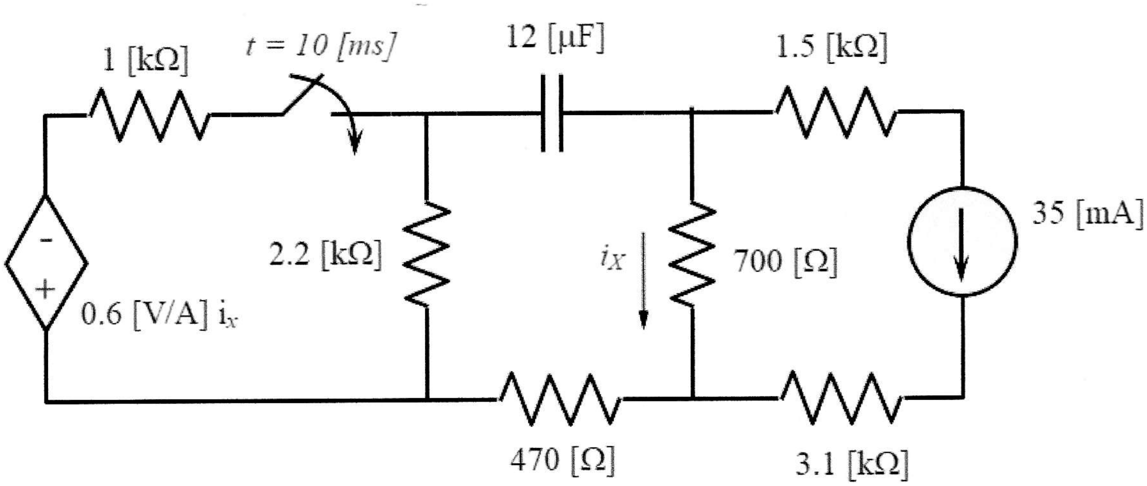
2. [40 points] In the circuit below, both switches were open for a long time, and then closed at t = 0. Find the energy stored in the inductor at t = 10 [ms].



Room for extra work

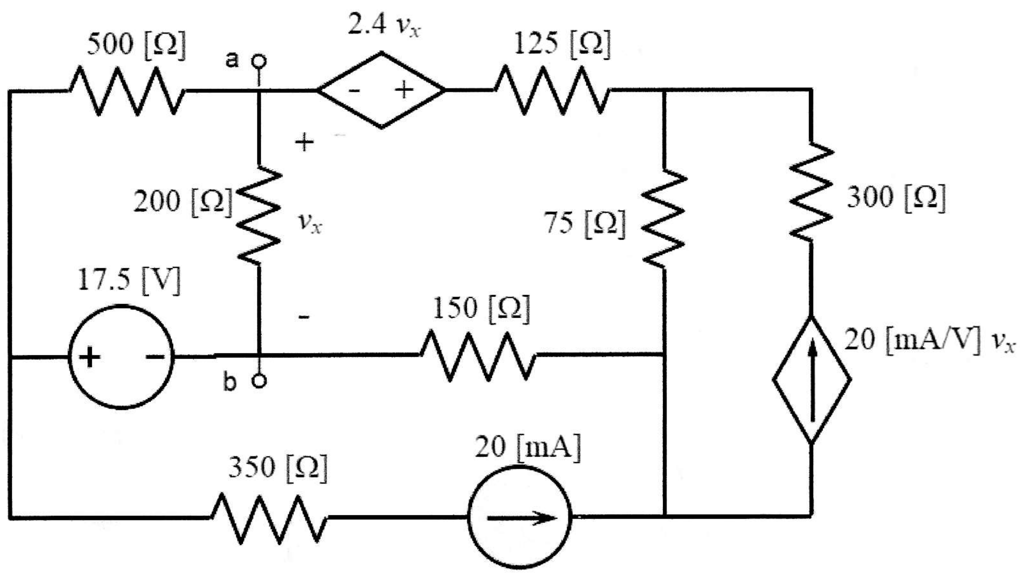
3. [30 points] The switch in the circuit below was open for a long time and then closed at t = 10 [ms].

a. Find $i_X(10\ [\text{ms}]^+)$.
b. Find the Thevenin equivalent resistance seen by the capacitor for t > 10 [ms].



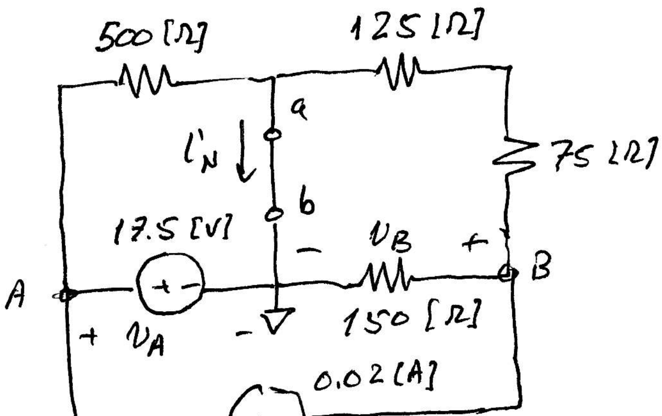
Room for extra work

1. [30 points] Find the Norton equivalent as seen by the 200 [Ω] resistor in the circuit below.



After removing the 200 [Ω] resistor, we need 2 of v_{oc}, i_N, or test source to find Norton resistance. Finding $i_N = i_{sc}$ will make $v_x = 0$ and simplify considerably. Using a test source will also simplify the circuit. But we will do all three here.

i_N:



$$\frac{v_B}{150} - 0.02 + \frac{v_B}{200} = 0$$

$$\Rightarrow v_B = 1.714 \text{ [V]}$$

$$i_N = \frac{17.5}{500} + \frac{v_B}{200} = 43.57 \text{ [mA]}$$

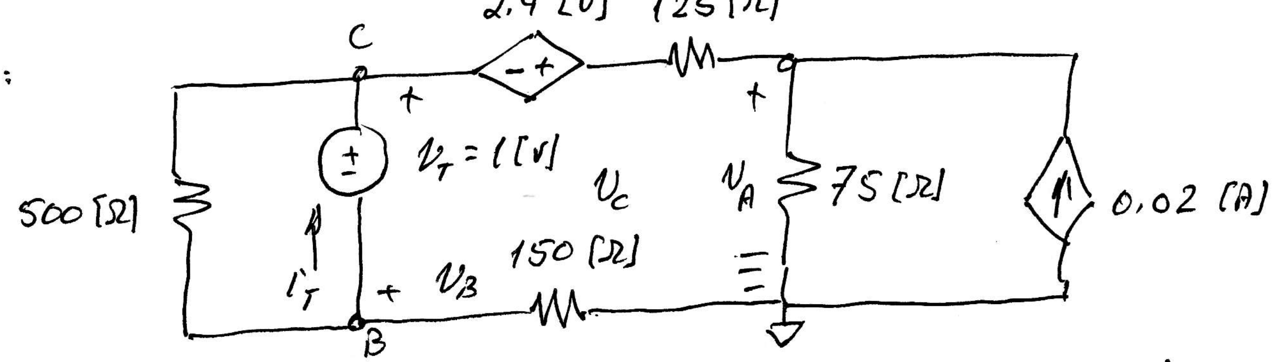
i_N: 14

R_{TH}: 14, v_{oc} 14

Model: 2

Room for extra work

R_N:



$$v_x = 1 \text{ [V]} \Rightarrow 2.4 v_x = 2.4 \text{ [V]}, \quad 20 \left[\tfrac{mA}{V}\right] v_x = 0.02 \text{ [A]}$$

$$\frac{v_A}{75} - 0.02 + \frac{v_A - v_C - 2.4}{125} = 0$$

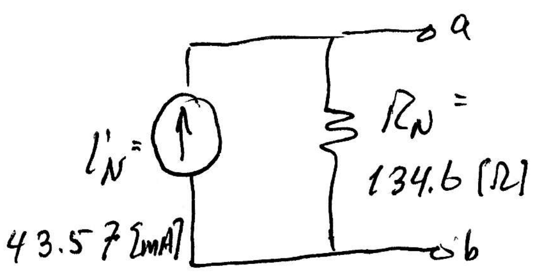
$$\frac{v_C - v_A + 2.4}{125} + \frac{v_B}{150} = 0 \qquad v_C - v_B = 1 \text{ [V]}$$

$$v_A = 1.907 \text{ [V]} \qquad v_B = -0.8143 \text{ [V]} \qquad v_C = 0.1857 \text{ [V]}$$

$$i_T' = \frac{1}{500} + \frac{v_C - v_A + 2.4}{125} = 7.4296 \text{ [mA]}$$

$$\Rightarrow R_N = \frac{1}{i_T'} = 134.6 \text{ [Ω]}$$

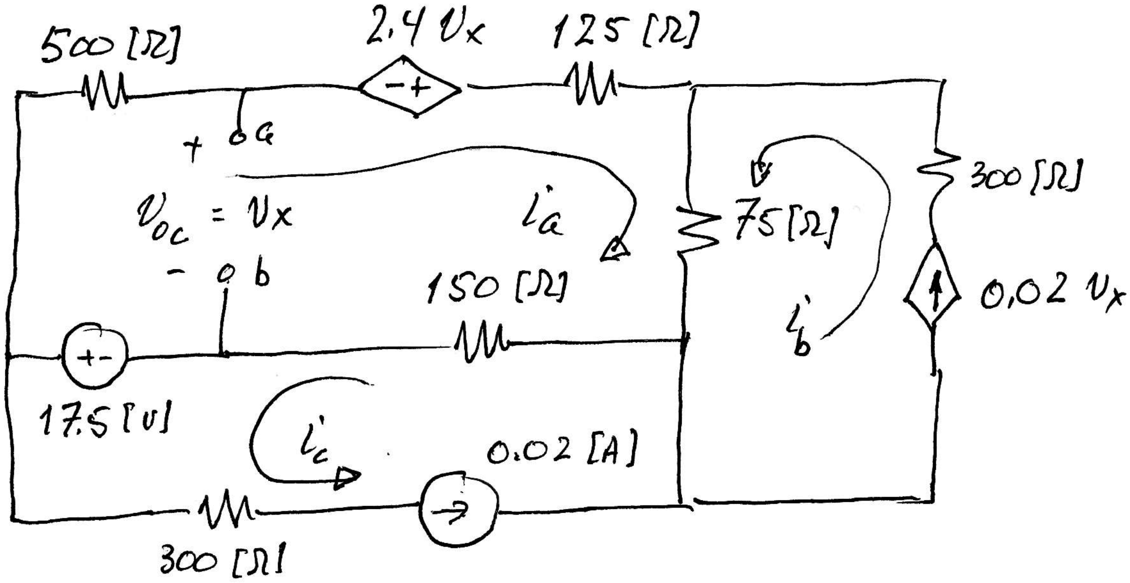
Thus the Norton equivalent is:



Just for a check, let's do V_{oc}: ↗

p.2

Room for extra work



Since we have current sources on two mesh edges, mesh-current seems like the way to go here.

$$625\, i_a' - 2.4 v_x + 75(i_a' + i_b') + 150(i_a' + i_c') - 17.5 = 0$$

$i_c' = 0.02$ [A] $\quad i_b' = 0.02\, v_x$

$v_x - 17.5 + 500\, i_a' = 0$

$i_a' = 23.27$ [mA]

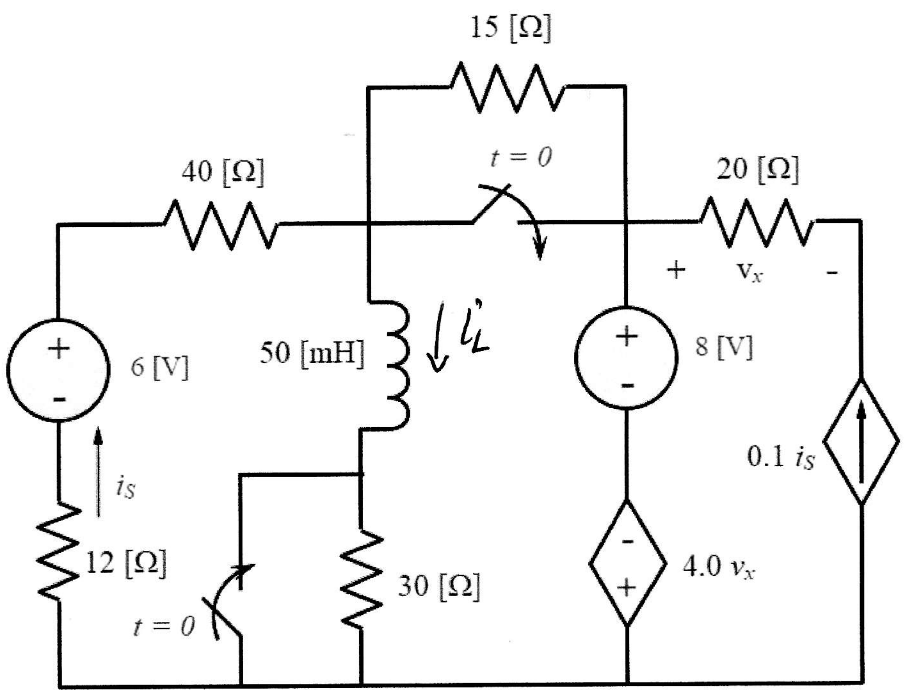
$i_b' = 117.31$ [mA]

$i_c' = 20$ [mA]

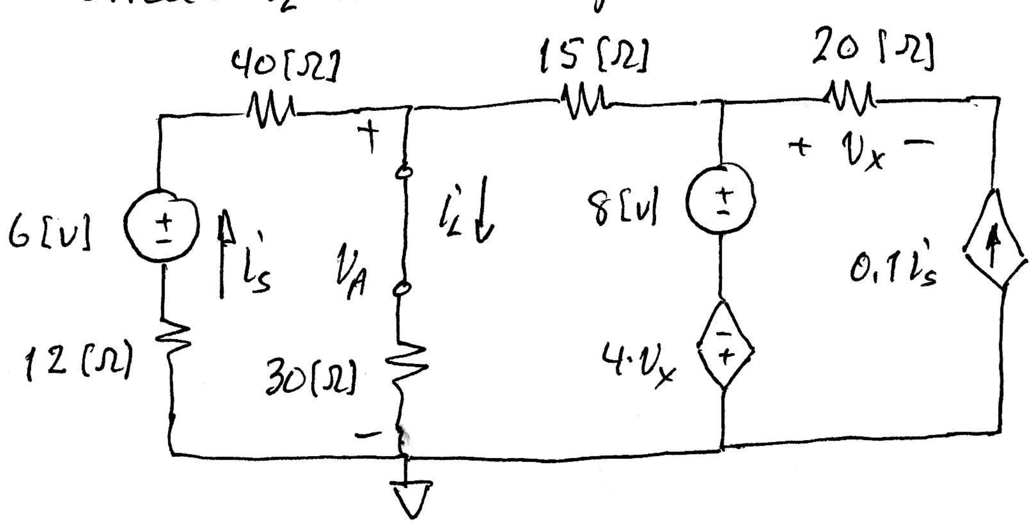
This gives $v_x = v_{oc} = 5.665$ [V]

Then $\frac{v_{oc}}{i_N'} = 134.6$ [Ω] so this checks.

2. [40 points] In the circuit below, both switches were open for a long time, and then closed at t = 0. Find the energy stored in the inductor at t = 10 [ms].



Current i_L has been defined. Draw for t < 0



+ 4

(+3)

$$\frac{V_A}{30} + \frac{V_A - 6}{52} + \frac{V_A - 8 + 4V_x}{15} = 0 \qquad V_x = -2 i_s$$

+ 7

$V_A = 5.485$ [V] $\qquad V_x = -19.80$ [mV]

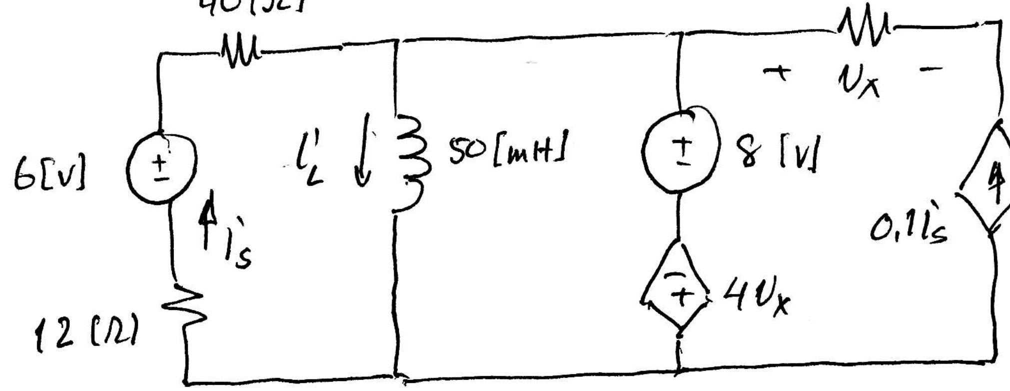
$$i_L(0) = \frac{V_A}{30} = 182.8 \text{ [mA]}$$

+2

Room for extra work

Draw for $t > 0$

+4



We have a voltage source (two, in fact) in parallel with the inductor, so we have to integrate.

+6 integration

$$i_L = \frac{1}{0.05}\int_0^{0.01\,[s]} (8 - 4v_x)\,dt + i_L(0) \qquad i_L(0) = 182.8\ [mA]$$

+8 integrand

$$v_x = -2i_s \qquad 52 i_s - 6 + 8 - 4(-2i_s) = 0 \Rightarrow i_s = -33.33\ [mA]$$

$$\Rightarrow v_x = 66.67\ [mV] \Rightarrow -4v_x = -266.67\ [mV]$$

+2 limits

so $$i_L = \frac{1}{0.05}\int_0^{0.01\,[s]} (7.7333)\,dt + 182.8\ [mA]$$

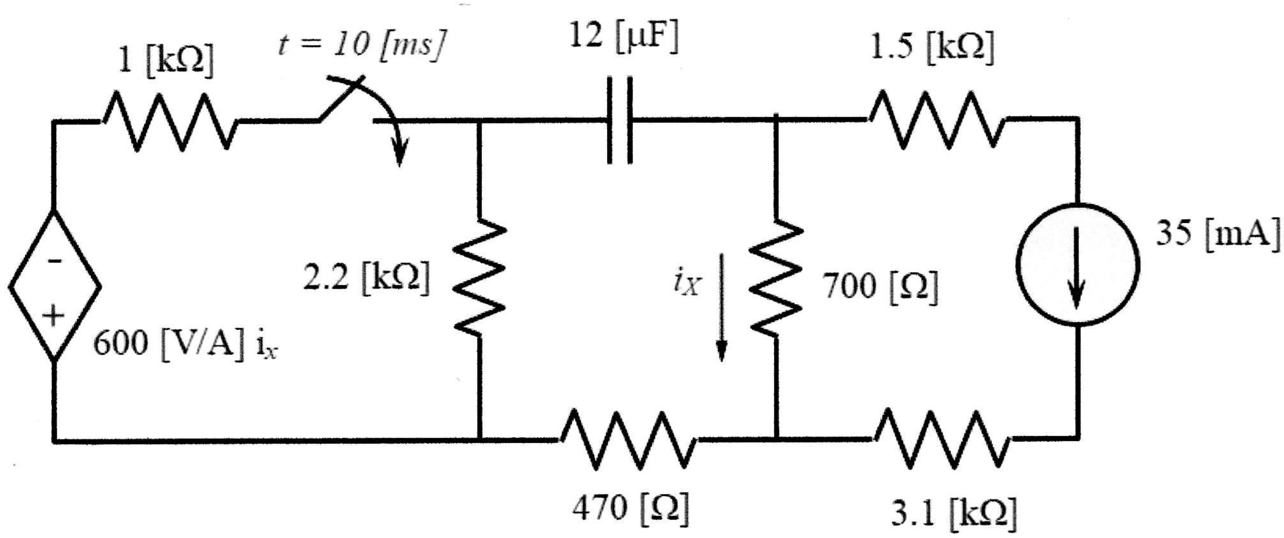
$$i_L(10\ [ms]) = 1.730\ [A]$$

+3

+4 $$w_L(10\ [ms]) = \frac{1}{2} L\, i_L(10\ [ms])^2 = 74.77\ [mJ]$$

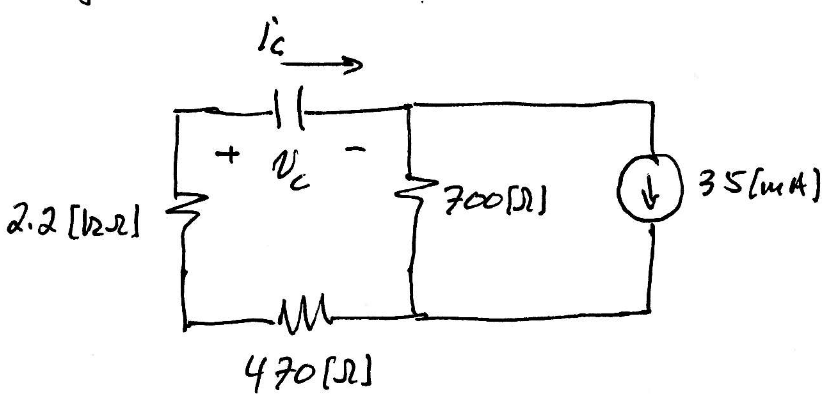
3. [30 points] The switch in the circuit below was open for a long time and then closed at t = 10 [ms].

a. Find $i_X(10\ [\text{ms}]^+)$.
b. Find the Thevenin equivalent resistance seen by the capacitor for t > 10 [ms].



a) To find $i_x(10^+[\text{ms}])$, will need $v_c(10^+[\text{ms}])$.

Draw for t < 10 [ms]:

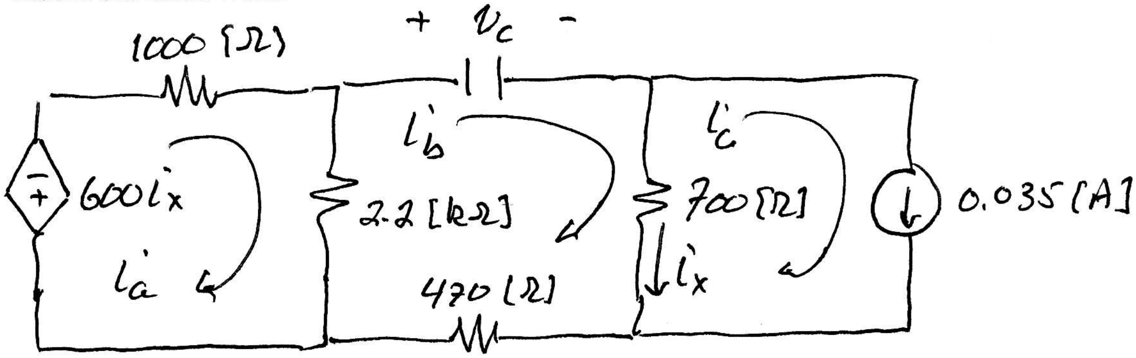


C → open-ckt
⇒ $i_c \to 0$

$v_c(10^-[\text{ms}]) = v_c(10^+[\text{ms}]) = 700 \cdot 0.035 = 24.5\ [\text{V}]$

Draw for t > 10 [ms]:

Room for extra work



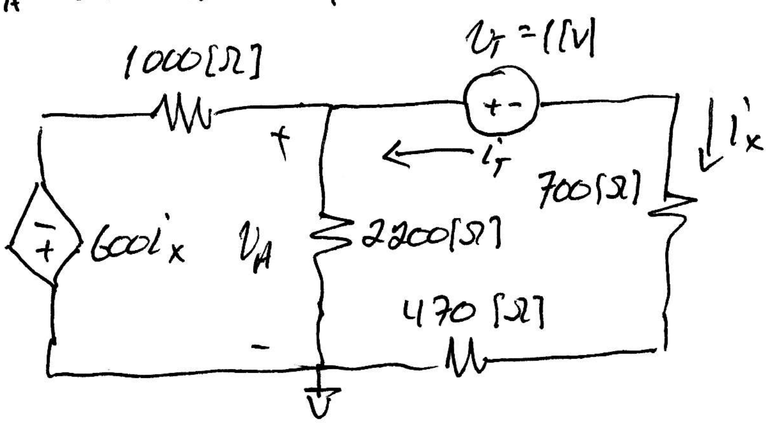
Key information: $v_c = 24.5$ [V]

$1000 i_a' + 2200(i_a' - i_b') + 600 i_x' = 0$ $i_c' = 0.035$ [A]

$24.5 + 700(i_b' - i_c') + 470 i_b' + 2200(i_b' - i_a') = 0$ $i_x' = i_b' - i_c'$

Solve: $i_x' = -28.64$ [mA] $\Rightarrow$ $i_x(10^{+}[ms]) = -28.64$ [mA]

b) R_{TH} does not depend on time. Let's use a test source:



$$\frac{v_A}{2200} + \frac{v_A - 600 i_x'}{1000} - i_T' = 0$$

$$i_T' = -i_x'$$

$$i_x' = \frac{v_A - 1}{1170}$$

$v_A = 0.1903$ [V] $i_x' = -0.6920$ [mA]

$\therefore i_T' = 0.6920$ [mA] $\Rightarrow$ $R_{TH} = \frac{1}{i_T'} = 1445$ [Ω]