Name: SOLUTIONS (please print)

Signature: ____________________

ECE 2202 – Exam 1

October 5, 2024

Keep this exam closed 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 that is not given in a reasonable order will lose credit. Clearly indicate your answer (for example by enclosing it in a box).
3. Show all units in solutions, intermediate results, and figures. Units in the exam 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.

1. ________________/35

2. ________________/35

3. ________________/30

Total = 100

Room for extra work

1. {35 Points}Use the figures below for this problem.

   a) Find the Thevenin Equivalent of the circuit in Figure 1 at terminals A, B. Draw the equivalent circuit, clearly labeling the terminals A and B.

   b) Find the Thevenin Equivalent of the circuit in Figure 2 at terminals C, D. Draw the equivalent circuit, clearly labeling the terminals C and D.

   c) The circuits in Figures 1 and 2 are connected together by connecting terminals A and C, and terminals B and D, and a voltage source is inserted between them, as shown in Figure 3. Find the power delivered by the voltage source v_{S1}.

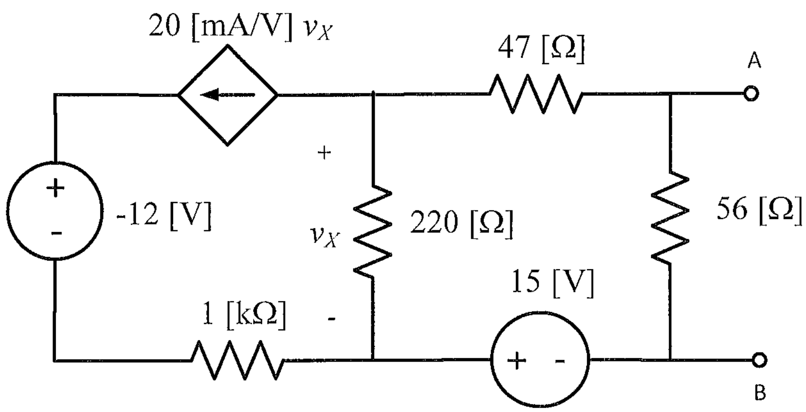


Figure 1

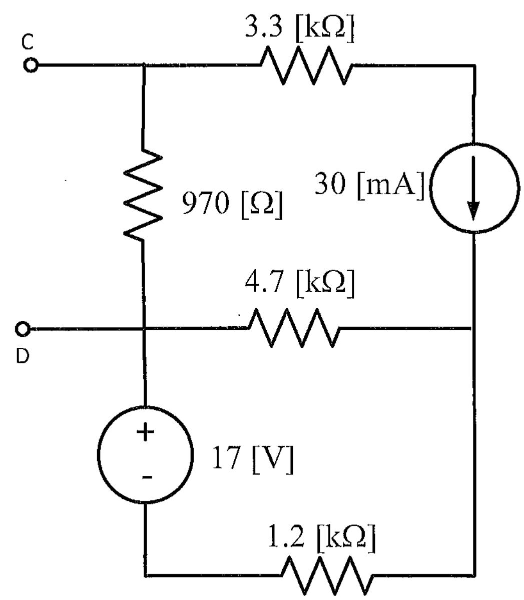


Figure 2

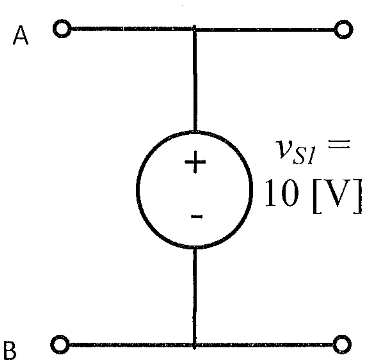


Figure 3

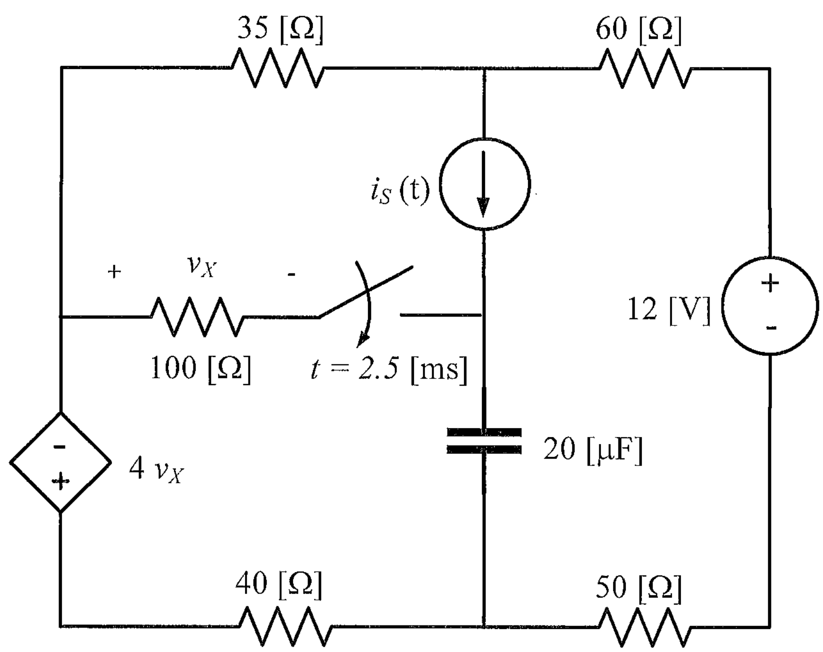
Room for extra work

Room for extra work

2. {35 Points} In the circuit below, the switch was open for a long time, and then closed at t = 2.5[ms]. The current source $i_S(t)$ was zero for t < 0, and then turned on at t = 0. At t = 0, there was no energy stored in the capacitor.

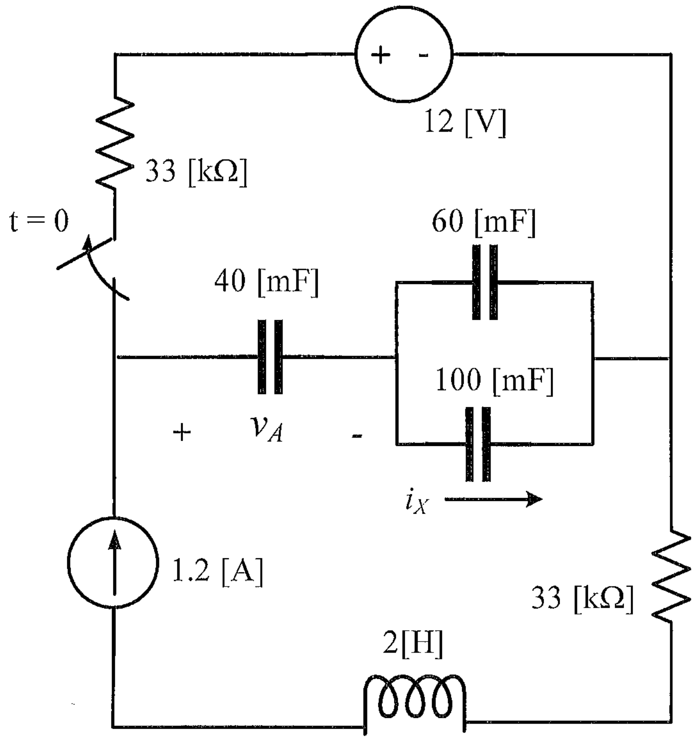
$$i_S(t) = 0 \quad t < 0$$
$$i_S(t) = 725\left[\frac{A}{s^2}\right]t^2 \quad t \geq 0$$

a) Find $v_x(2.5[\text{ms}]^-)$.
b) Find $v_x(2.5[\text{ms}]^+)$.
c) Find the Thevenin equivalent resistance seen by the capacitor at t = 2.5 [ms]$^+$.



Room for extra work

3. {30 Points} In the circuit below, the switch was closed for a long time and opened at t = 0. It is given that $v_A(0)$ = - 17.5[kV]. Find i_X(10[ms]).



Room for extra work

1. {35 Points}Use the figures below for this problem.

   a) Find the Thevenin Equivalent of the circuit in Figure 1 at terminals A, B. Draw the equivalent circuit, clearly labeling the terminals A and B.

   b) Find the Thevenin Equivalent of the circuit in Figure 2 at terminals C, D. Draw the equivalent circuit, clearly labeling the terminals C and D.

   c) The circuits in Figures 1 and 2 are connected together by connecting terminals A and C, and terminals B and D, and a voltage source is inserted between them, as shown in Figure 3. Find the power delivered by the voltage source v_{SI}.

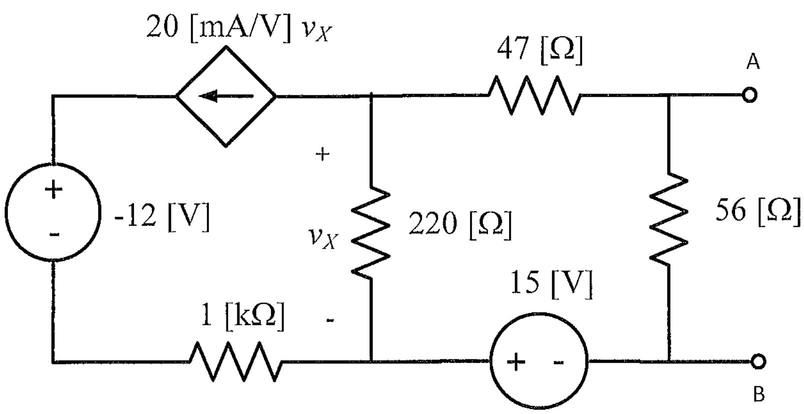


Figure 1

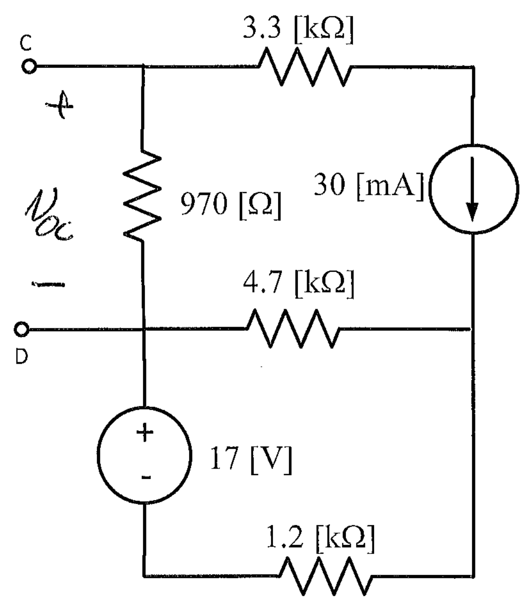


Figure 2

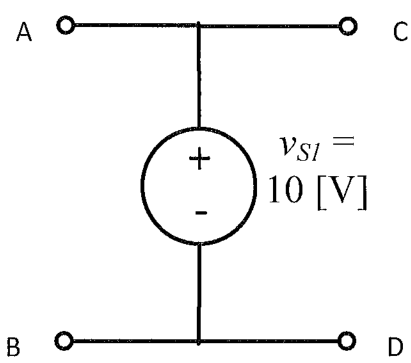
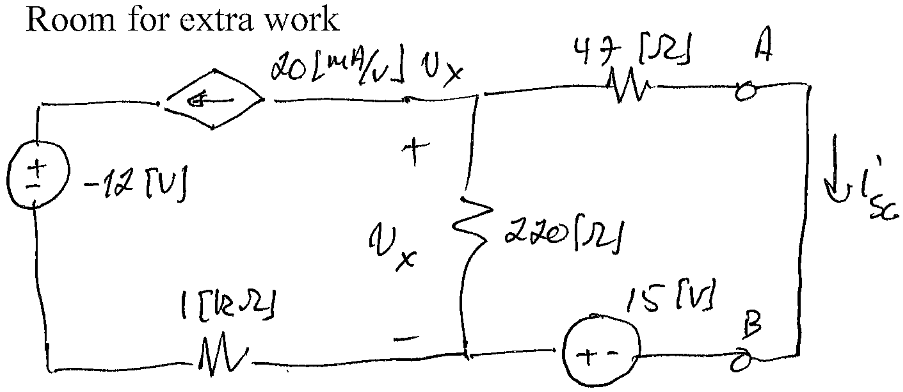


Figure 3

a) We'll find the short-circuit current, and we'll find R_{TH} via test source, since these seem simplest.

Room for extra work

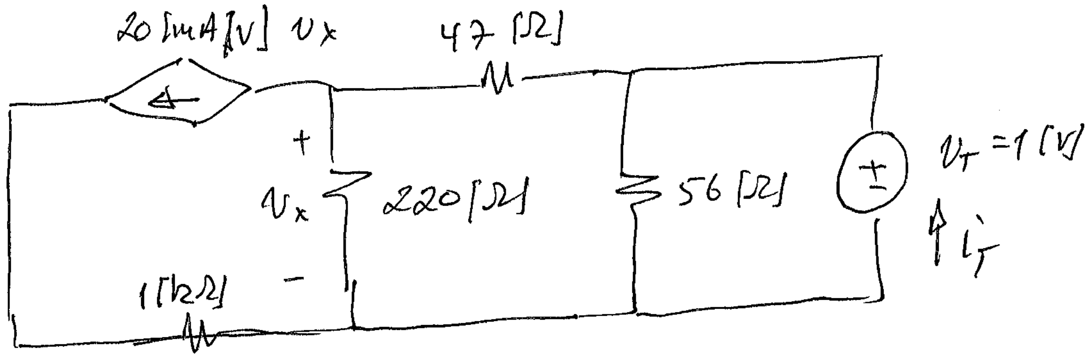


i'_{sc}:

$$\frac{v_x}{220} + 0.02 v_x + \frac{v_x + 15}{47} = 0 \Rightarrow v_x = -6.965 \text{ [V]}$$

$$i'_{sc} = \frac{v_x + 15}{47} = 0.1710 \text{ [A]}$$

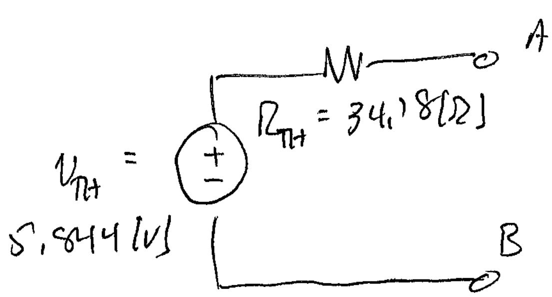
R_{TH}:



$$\frac{v_x}{220} + 0.02 v_x + \frac{v_x - 1}{47} = 0 \Rightarrow v_x = 0.4643 \text{ [V]}$$

$$i_T = \frac{1}{56} + \frac{1 - v_x}{47} \Rightarrow i_T = 0.02926 \text{ [A]}$$

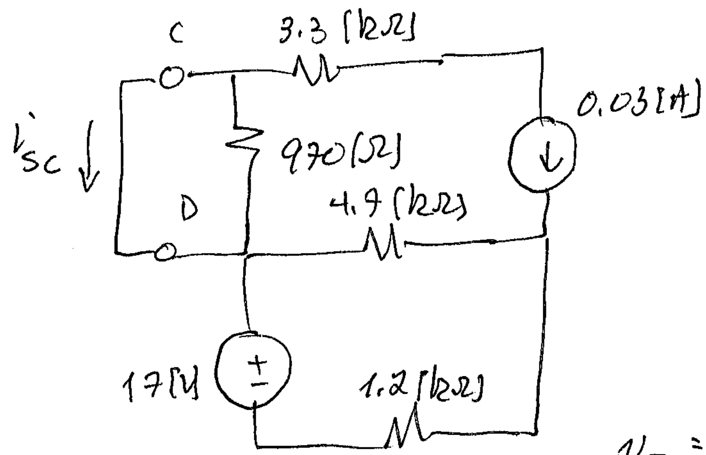
$$\Rightarrow R_{TH} = \frac{1}{i_T} = 34.18 \text{ [Ω]} \qquad v_{oc} = R_{TH} \cdot i'_{sc} = 5.844 \text{ [V]}$$



Room for extra work

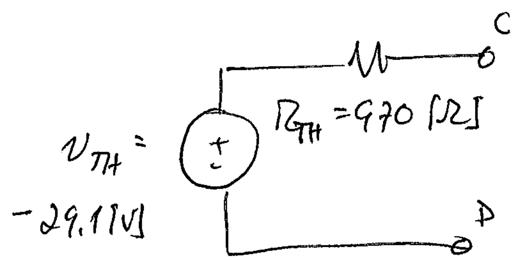
b) Open-circuit voltage is labeled on the diagram.

$$v_{OC} = (-0.03)(970) = -29.1\ [V]$$

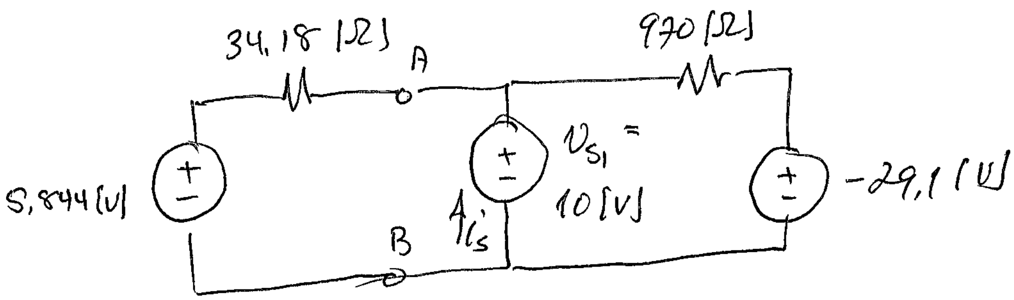


$$i_{SC} = -0.03\ [A]$$

$$\Rightarrow R_{TH} = \frac{v_{OC}}{i_{SC}} = 970\ [\Omega]$$



c)



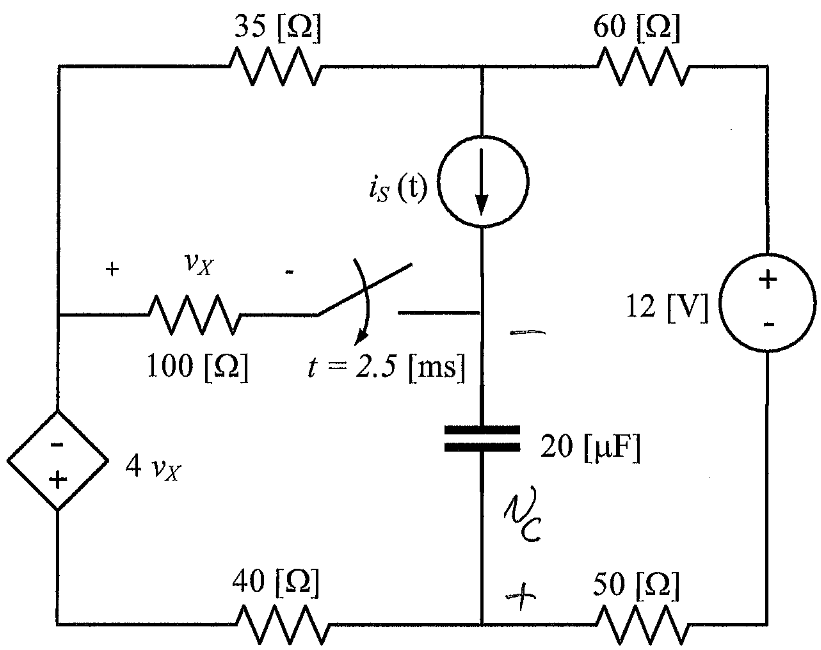
$$\frac{10 - 5.844}{34.18} + \frac{10 + 29.1}{970} = i_S = 0.1619\ [A]$$

$$P_{del\ by\ v_{S1}} = (0.1619)(10) = 1.619\ [W]$$

2. {35 Points} In the circuit below, the switch was open for a long time, and then closed at t = 2.5[ms]. The current source $i_S(t)$ was zero for t < 0, and then turned on at t = 0. At t = 0, there was no energy stored in the capacitor.

$$i_S(t) = 0 \quad t < 0$$
$$i_S(t) = 725\left[\frac{A}{s^2}\right]t^2 \quad t \geq 0$$

a) Find v_x(2.5[ms]$^-$).
b) Find v_x(2.5[ms]$^+$).
c) Find the Thevenin equivalent resistance seen by the capacitor at t = 2.5 [ms]$^+$.



Until the switch closes, and beginning at $t=0$, we have a current source in series with a capacitor.

$$v_C(t) = \frac{-1}{C}\int_0^t i_S(t)\,dt + 0$$ ← no energy stored in capacitor at $t=0$

$$= -\frac{725}{20\times10^{-6}} \cdot \frac{1}{3}t^3 = -1.208\times10^7\, t^3$$

Room for extra work

$v_c(25[ms]^-) = v_c(25[ms]^+) = -0.1888\ [V]$

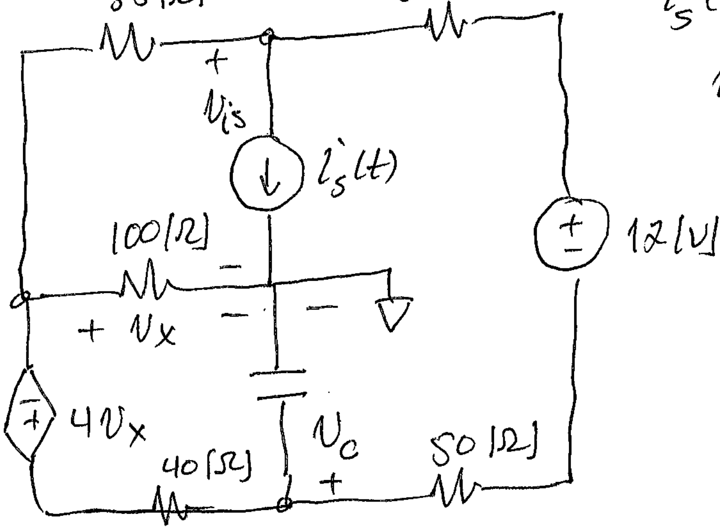
a) Just before the switch closes, $100[\Omega]$ is open-circuited, so

$$v_x(2.5[ms]^-) = 0$$

b) At $t = 2.5[ms]^+$, the switch is closed and $v_c = -0.1888[V]$.

Redraw:

$t = 2.5[ms]^+$



$i_s(25[ms]^+) = 4.531\ [mA]$

$v_c(25[ms]^+) = -0.1888\ [V]$

$$\frac{v_{is} - v_c - 12}{60 + 50} + \frac{v_{is} - v_x}{35} + i_s(25[ms]^+) = 0$$

$$\frac{v_x - v_{is}}{35} + \frac{v_x - v_c + 4v_x}{40} + \frac{v_x}{100} = 0$$

$v_{is} = 3.123\ [V]$

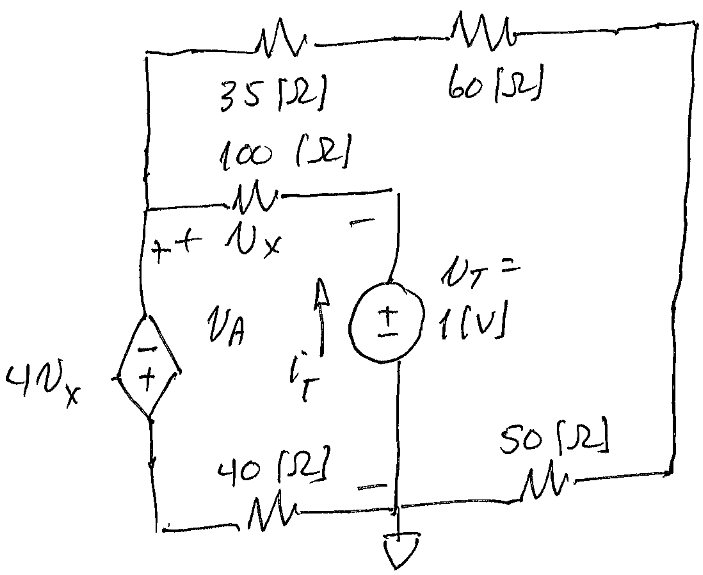
$v_x = 0.5166\ [V]$

$\therefore\ v_x(2.5[ms]^+) = 0.5166\ [V]$

↗ p.2

Room for extra work

c) Since we are asked only for R_{TH}, we'll use a test source. Redraw...



$$\frac{v_A - 1}{100} + \frac{v_A + 4v_X}{40} + \frac{v_A}{145} = 0$$

$$v_X + 1 - v_A = 0$$

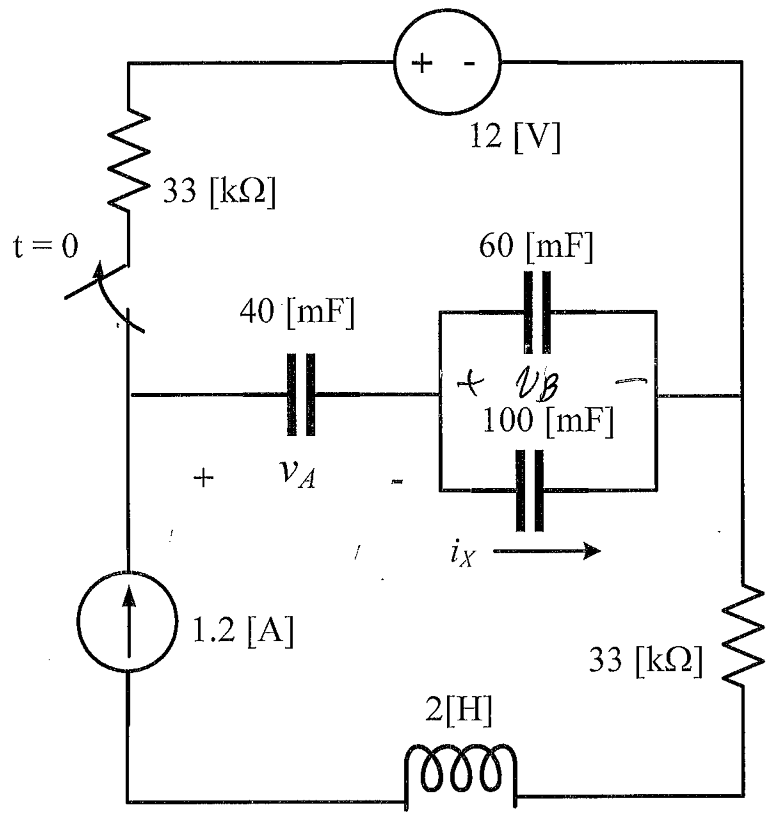
$v_A = 0.7752$ [V]

$v_X = -0.2248$ [V]

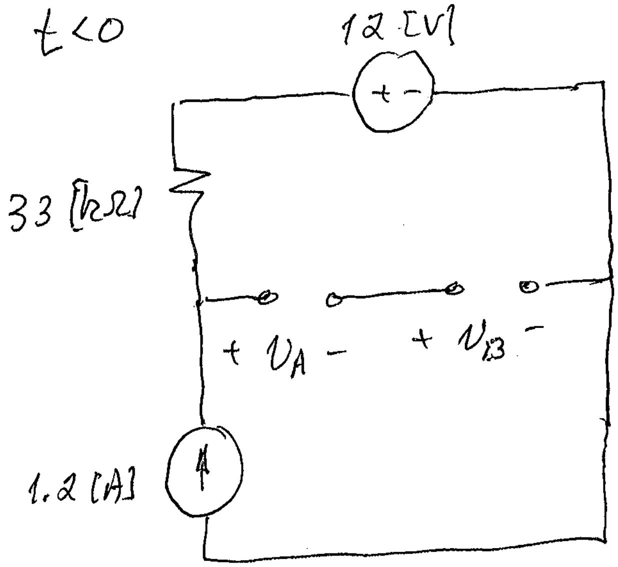
$$i_T = -\frac{v_X}{100} = 2.248 \text{ [mA]}$$

$$\Rightarrow R_{TH} = \frac{1}{i_T} = 444.84 \text{ [Ω]}$$

3. {30 Points} In the circuit below, the switch was closed for a long time and opened at t = 0. It is given that $v_A(0) = -17.5$[kV]. Find $i_X(10[\text{ms}])$.



t<0

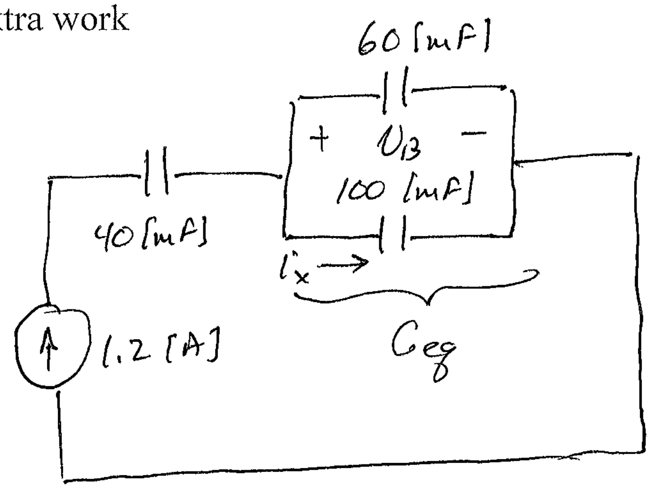


$$v_A + v_B = 1.2(33000) + 12$$
$$= 39612.\ [V]$$
$$\therefore\ v_B = 57112\ [V]$$

(ignore 2[H] and 33 [kΩ] in series w/ 1.2 [A])

Room for extra work

$t > 0$



$C_{eq} = 160$ [mF]

$$v_B(t) = \frac{1}{0.160}\int_0^t 1.2\,dt + 57112$$

$$= 7.5t + 57112 \text{ [V]} \qquad t \geq 0$$

$$i_x(t) = 0.1 \frac{d}{dt} v_B(t) = 0.75 \text{ [A]}$$

$$i_x(10\text{ [ms]}) = 0.75 \text{ [A]}$$