Name: ______________________________ (please print)

Signature: ___________________________

ECE 2202 – Exam 1

October 7, 2023

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

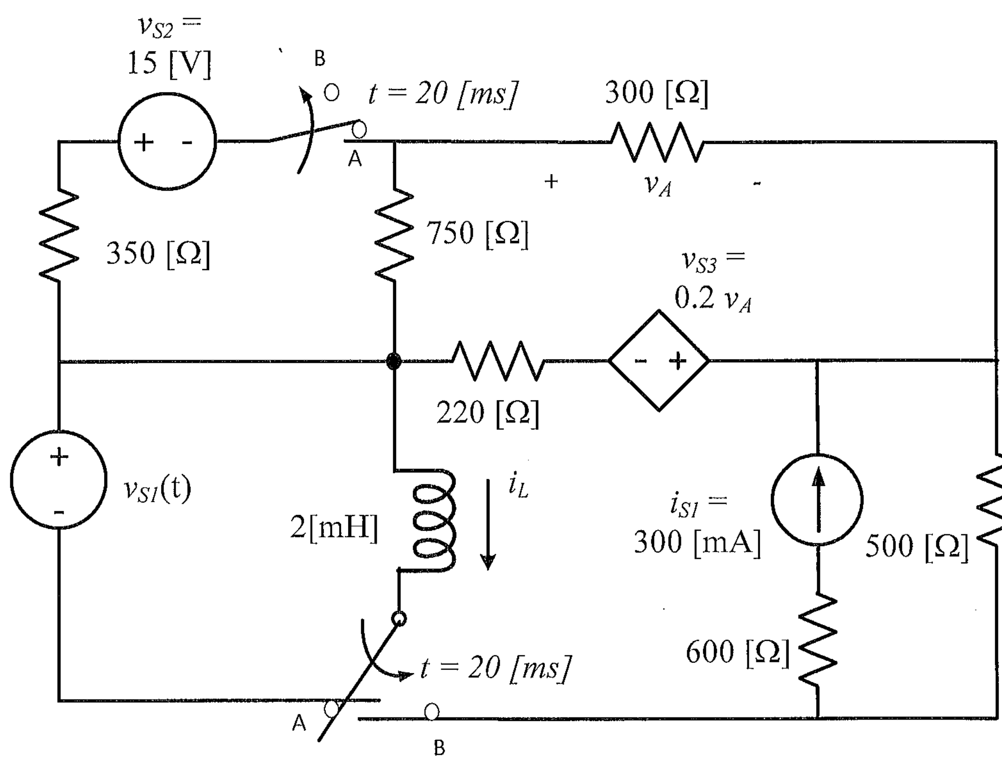
Total = 100

Room for extra work

1. {35 Points} In the circuit shown, both switches were in position 'A' for a long time, and moved to position 'B' at t = 20 [ms]. At t = 0, the current in the inductor i_L was 1.8 [mA]. The source $v_{S1}(t)$ has the value

$$v_{S1}(t) = 0.6\left[\frac{V}{s^2}\right]t^2 \quad 0 \le t \le 20\ [ms]$$

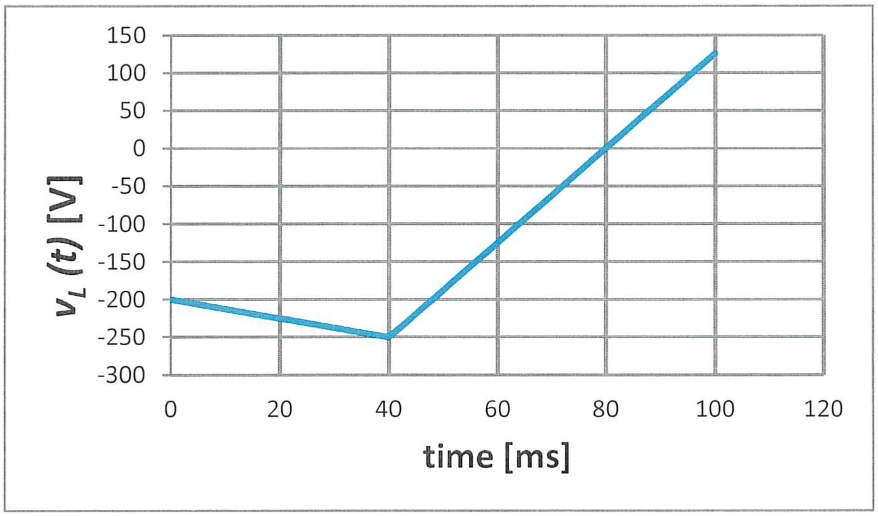
Find the power delivered by the current source i_{S1} at t = *20 [ms]*$^+$.

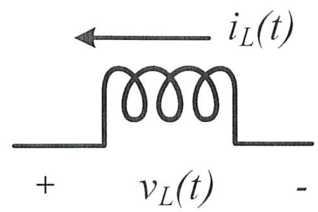


Room for extra work

2. {35 Points} The voltage $v_L(t)$ across a 500 [mH] inductor is given in the graph below. It is known that $i_L(60\ [mS]) = 21.5$ [A]. The value of the inductor current at t = 0 is not known.

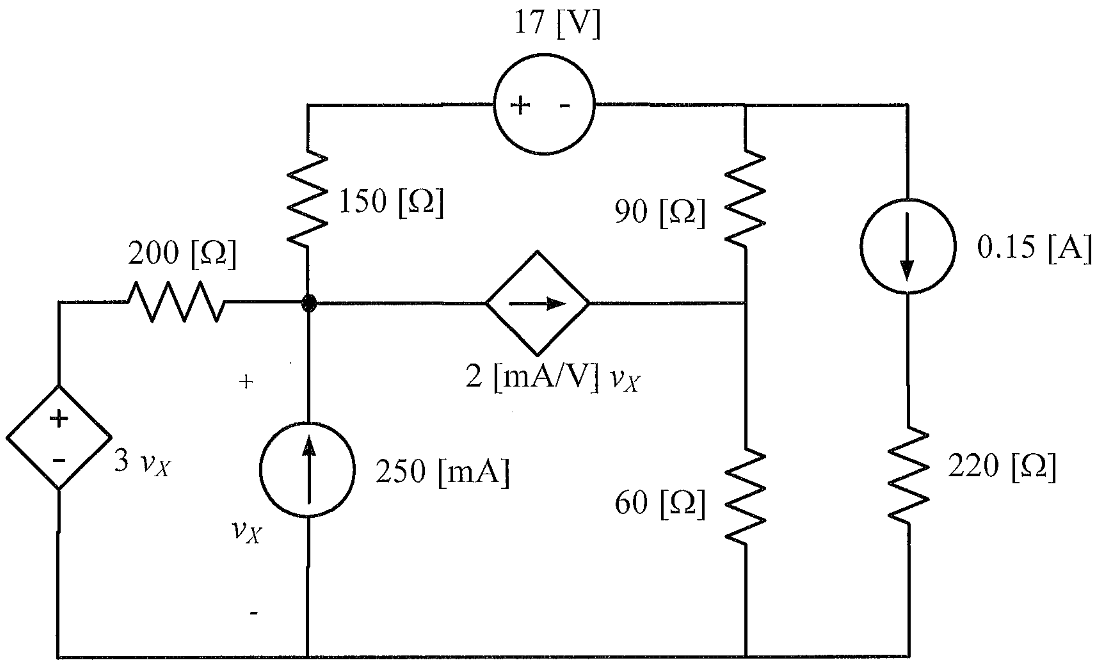
   Find i_L at 80 [mS]. The inductor voltage polarity and current direction are shown in the figure.





Room for extra work

3. {30 Points} For the circuit below, do the following.
   a. Find the Thevenin equivalent seen by the 250 [mA] current source.
   b. Find the power delivered by the 250 [mA] current.

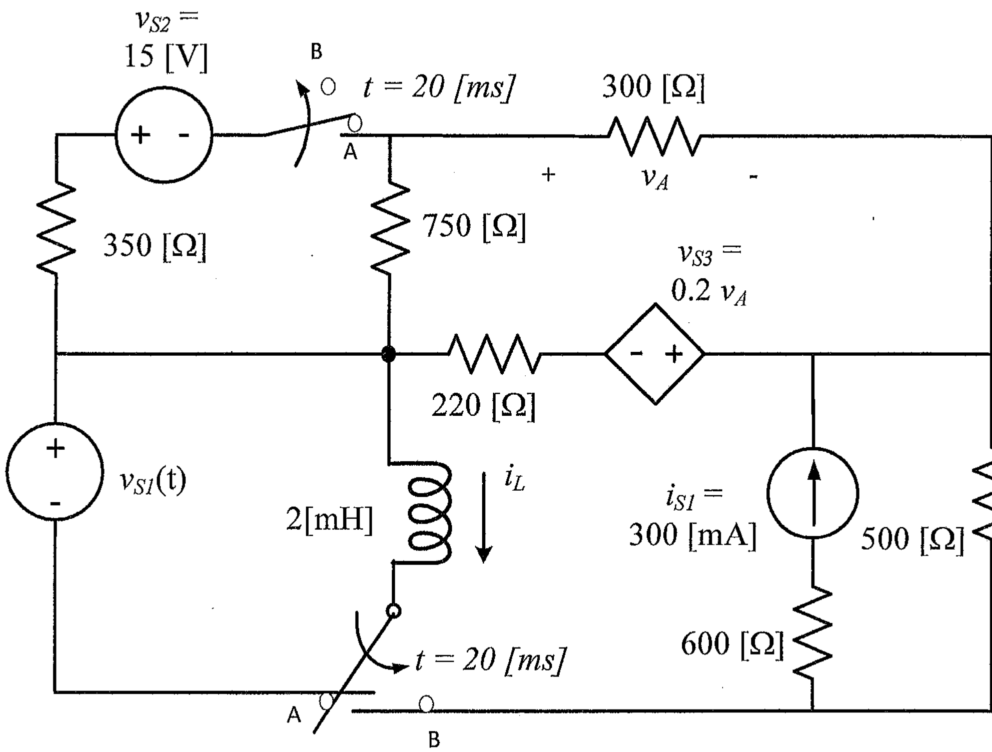


Room for extra work

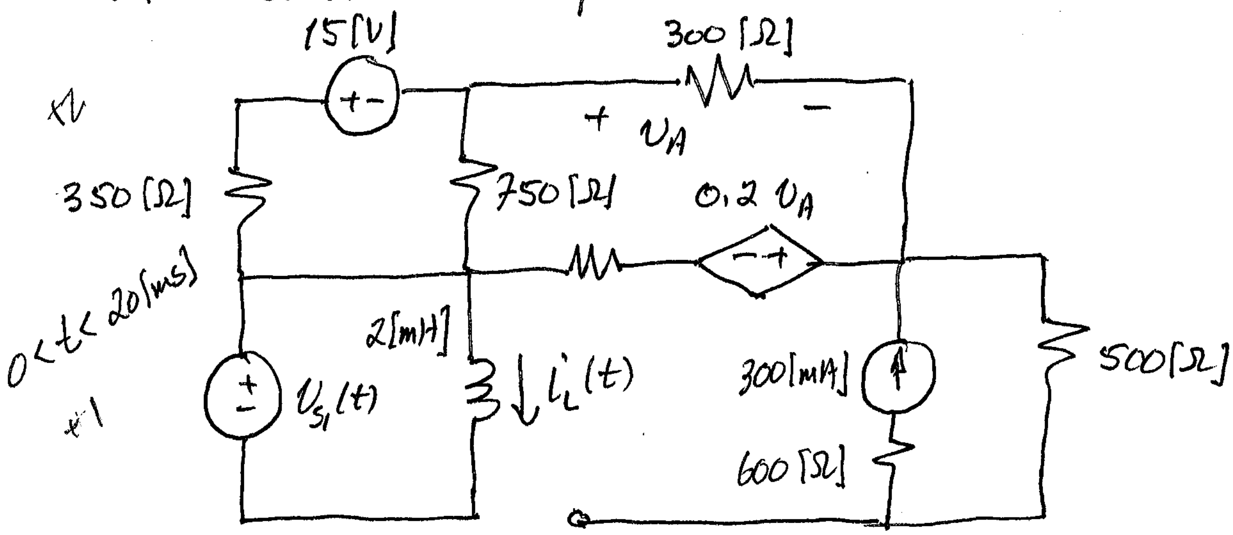
1. {35 Points} In the circuit shown, both switches were in position 'A' for a long time, and moved to position 'B' at t = 20 [ms]. At t = 0, the current in the inductor i_L was 1.8 [mA]. The source $v_{S1}(t)$ has the value

$$v_{S1}(t) = 0.6\left[\frac{V}{s^2}\right]t^2 \quad 0 \leq t \leq 20\ [ms]$$

Find the power delivered by the current source i_{S1} at $t = 20\ [ms]^+$.



with switches in position A, the circuit is ...



Room for extra work

The only relevant thing here is that the inductor is in parallel with v_{S1}. So...

+9 $$i_L(t) = \frac{1}{L}\int_0^t v_{S1}(t)\,dt + i_L(0)$$

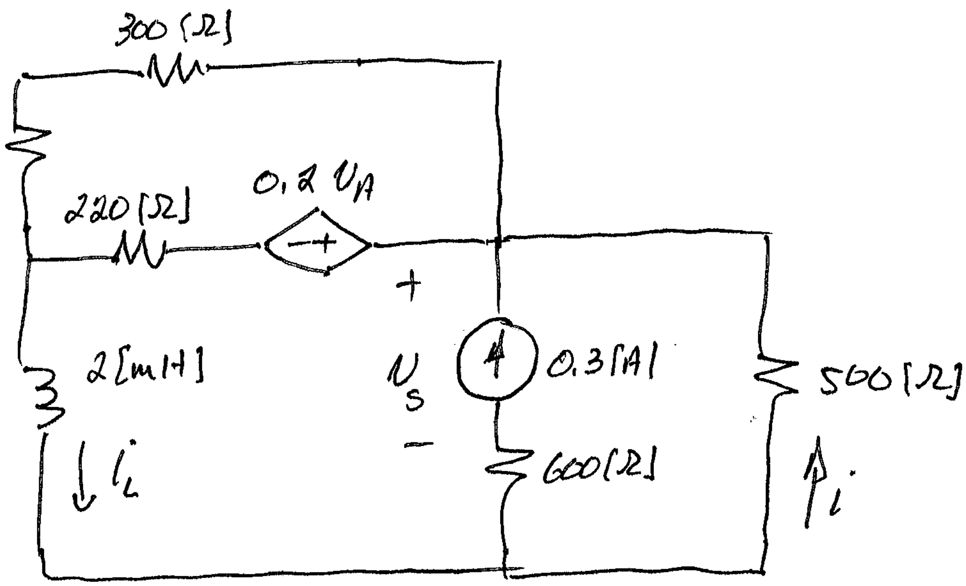
+2 $$i_L(0.02\,[s]) = \frac{1}{0.002}\int_0^{0.02[s]} 0.6\,t^2\,dt + 0.0018\,[A] = 2.6\,[mA]$$

After the switch moves...

$t > 20\,[ms]$

+1

+3



With $i_L = 2.6\,(mA)$, this circuit is valid for $20[ms]^+$. We need $v_s(20[ms])^+$:

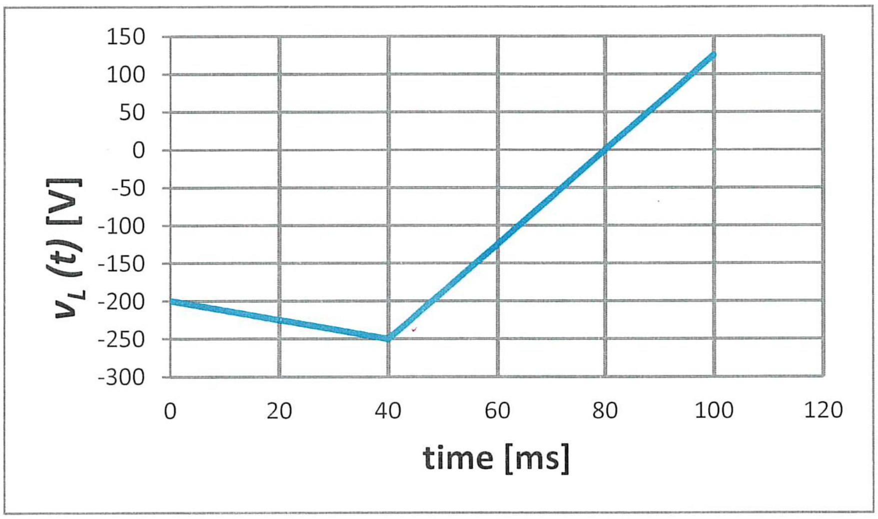
+12 $0.0026 = 0.3 + i \Rightarrow i = -0.2974\,[A]$

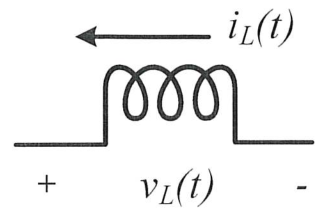
+3 $v_s - 600(0.3) + 500i = 0 \Rightarrow v_s = 328.7\,[V]$

+3 $P_{del\ by\ i_{S1}} = (328.7)(0.3) = 98.61\,[W]$ $t = 20[ms]^+$

2. {35 Points} The voltage $v_L(t)$ across a 500 [mH] inductor is given in the graph below. It is known that $i_L(60$ ~~[mS]~~$) = 21.5$ [A]. The value of the inductor current at t = 0 is not known. [ms]

Find i_L at 80 [mS]. The inductor voltage polarity and current direction are shown in the figure.





Although we could integrate from 0 to 40 [ms], and then 40 [ms] to 60 [ms], and finally from 60 [ms] to 80 [ms], it's easier than that:

+5

+3

$$i_L(t) = -\frac{1}{L}\int_{t_0}^{t} v_L(t)\,dt + i_L(t_0)$$

With $t_0 = 60$ [ms] and $i_L(t_0) = 21.5$ [A], we have

$$v_L(t) = mt + b \qquad 40\,[ms] \le t \le 100\,[ms]$$

$$v_L(40\,[ms]) = -250\ [V] \qquad v_L(80\,[ms]) = 0$$

+8

$$\Rightarrow \quad v_L(t) = 6250\left[\tfrac{V}{s}\right]t - 500\,[V]$$

Room for extra work

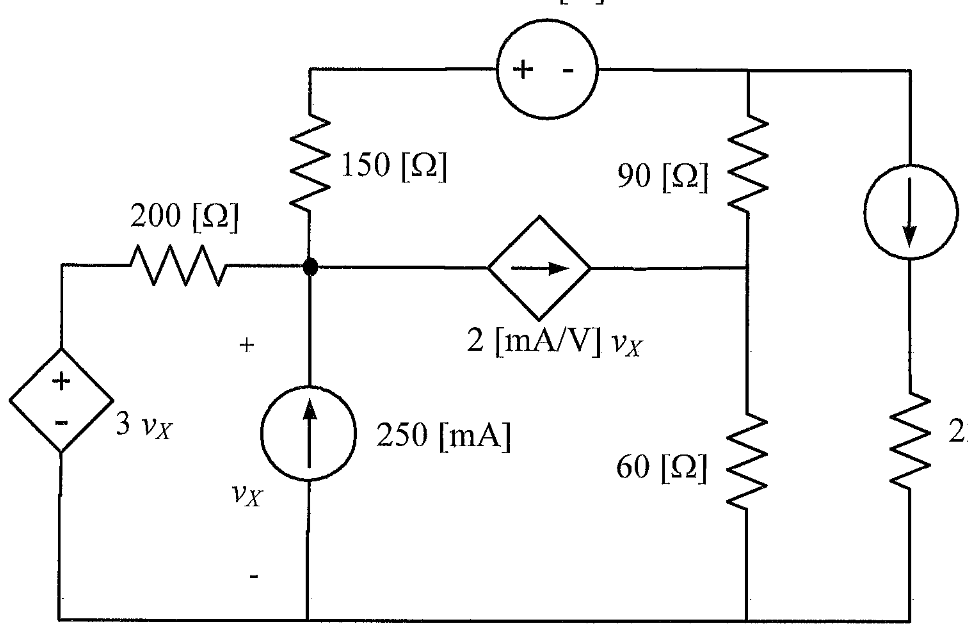
Then +10 +2 +3

$$i_L'(80\,[ms]) = -\frac{1}{0.5}\int_{0.06\,[s]}^{0.08\,[s]} (6250t - 500)\,dt + 21.5\,[A]$$

+2

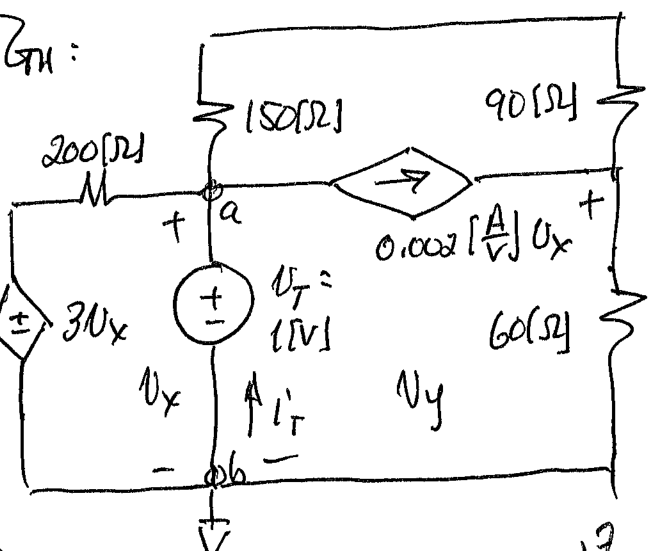
$$\boxed{i_L'(80\,[ms]) = 24\,[A]}.$$

3. {30 Points} For the circuit below, do the following.
   a. Find the Thevenin equivalent seen by the 250 [mA] current source.
   b. Find the power delivered by the 250 [mA] current.



We need two of i_{sc}, v_{oc}, v_T/i_T. We'll do all three here. Finding i_{sc} simplifies things because with the short, $v_X = 0$. Finding v_T/i_T also simplifies things. Find v_{oc} is hardest.

R_{TH}:



$v_X = 1[V]$

$\frac{v_y}{60} - 0.002 + \frac{v_y - 1}{240} = 0$

$\Rightarrow v_y = 0.296[V]$

$-i_T + \frac{v_X - 3v_X}{200} + 0.002v_X + \frac{v_X - v_y}{240} = 0$

$v_y = 0.296[V]$ $\quad i_T = -5.0667$ [mA]

$\Rightarrow R_{TH} = -197.4$ [Ω]

+4

analysis +7

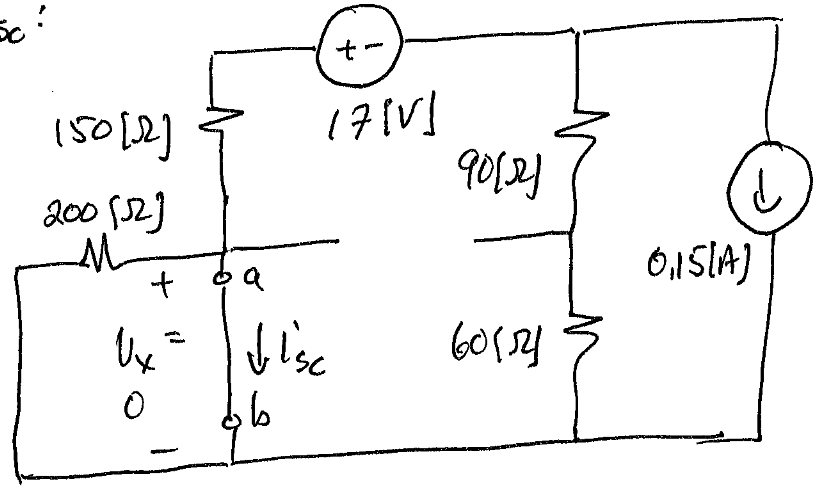
+2

7

Room for extra work

i'_{sc}:

+4



analysis +7

$v_x = 0$

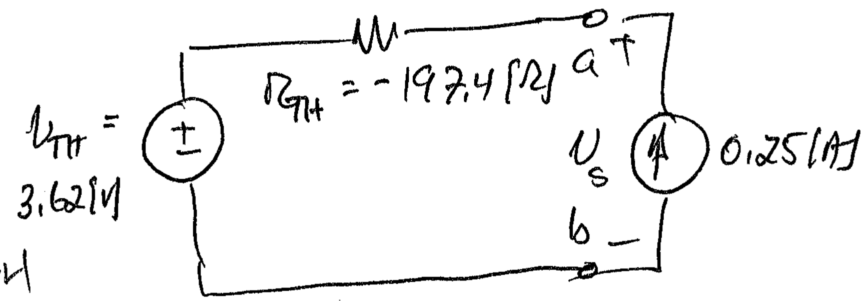
200 [Ω] is shorted.

$(i'_{sc} + 0.15)(150) - 17 + 150 i'_{sc} = 0$

$i'_{sc} = -18.333$ [mA]

+2

$v_{TH} = i'_{sc} \cdot R_{TH} = 3.62$ [V]



+4

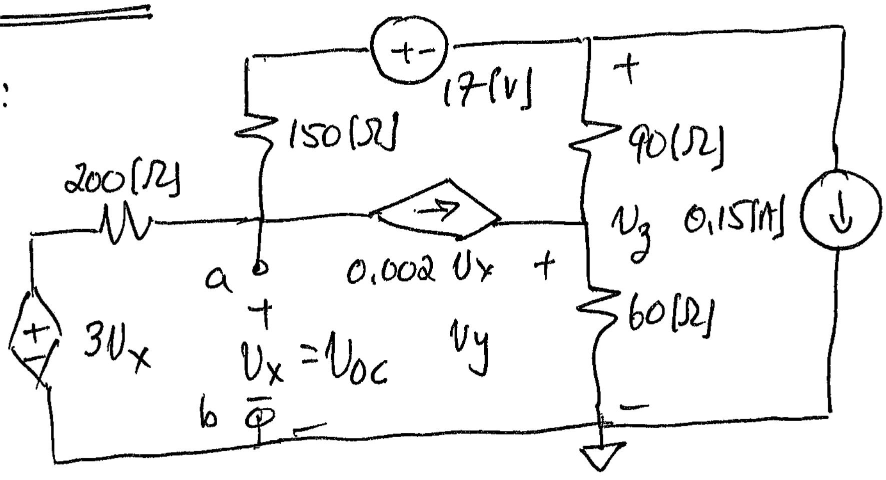
$v_s = -45.73$ [V]

P_{del} by 0.25 [A] $= 0.25\, v_s$

$= -11.43$ [W]

v_{oc}:

+4



So this checks!

+7

$$\frac{v_x - 3v_x}{200} + \frac{v_x - v_z - 17}{150} + 0.002\, v_x = 0$$

$$\frac{v_y}{60} + \frac{v_y - v_z}{90} - 0.002\, v_x = 0$$

$$\frac{v_z - v_y}{90} + 0.15 + \frac{v_z - v_x + 17}{150} = 0$$

$v_x = 3.62$ [V] $= v_{TH}$ ✓

$v_y = -6.83$ [V]

$v_z = -17.72$ [V]

+2