Name: ______________________________ (please print)

Signature: ___________________________

ECE 2201 – Final Exam
December 5, 2018

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 170 minutes to work on this exam.

1. _______________/30

2. _______________/35

3. _______________/35

4. _______________/35

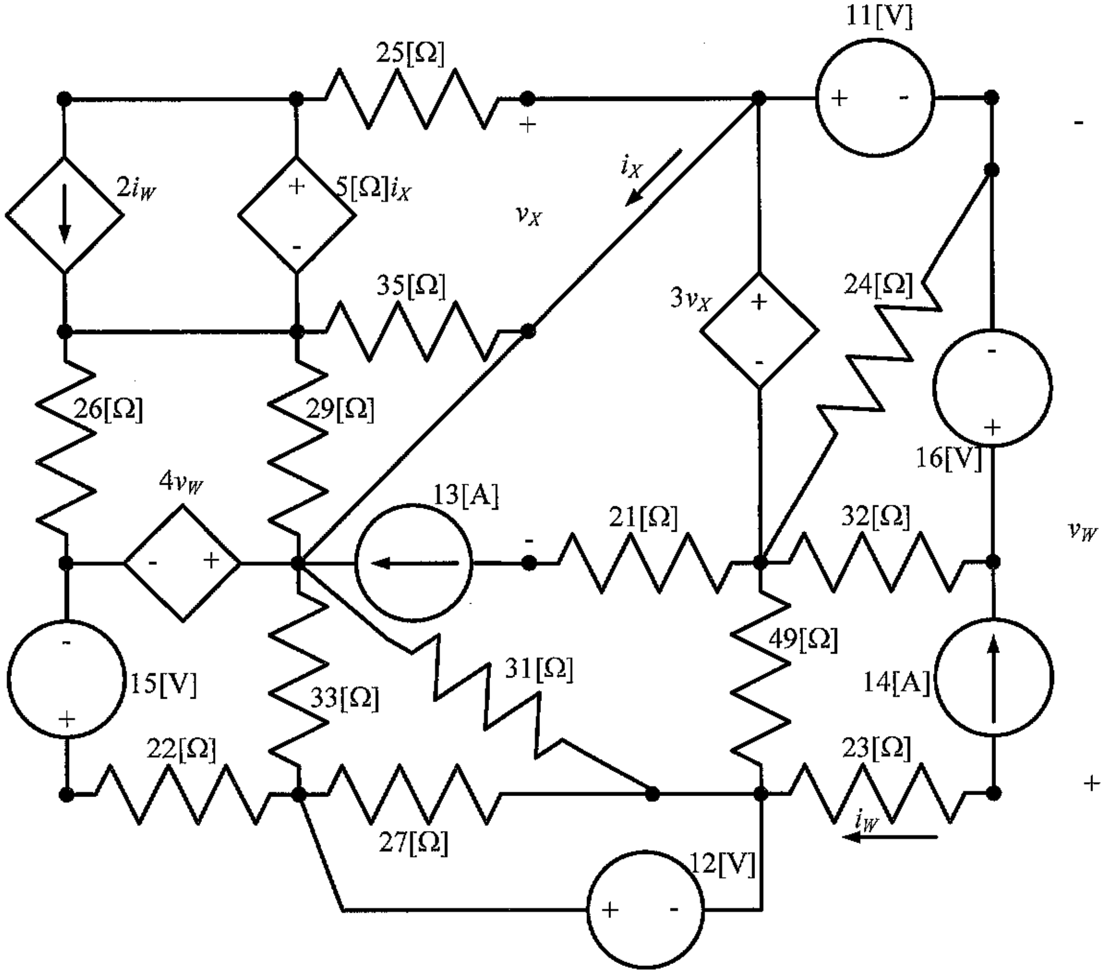
5. _______________/35

6. _______________/30

Total = 200

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 this circuit. Do not simplify the circuit. Do not attempt to simplify or solve your equations. **Define all your variables clearly.**



Room for extra work

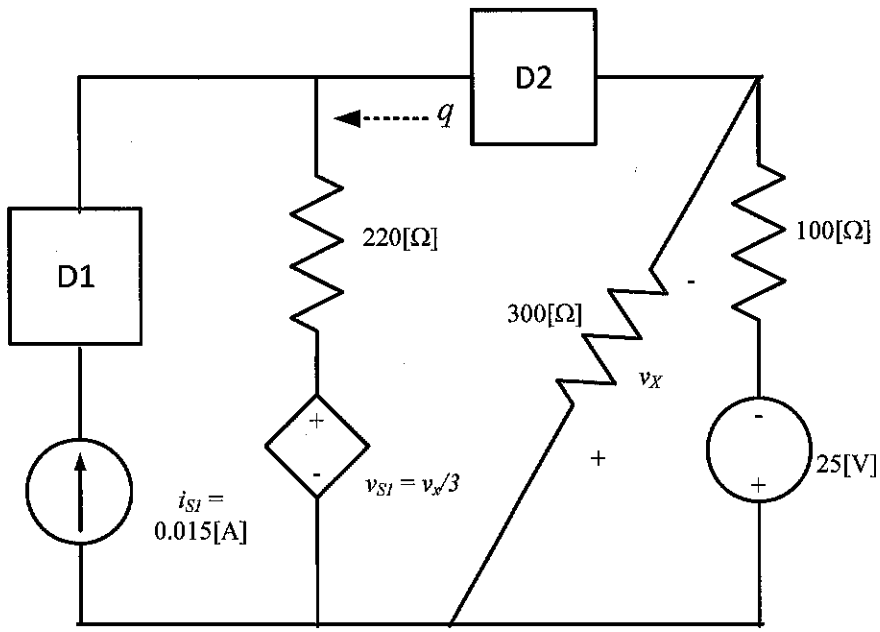
2. {35 Points} The following information is known about the devices D1 and D2 in the circuit below. (1) The energy delivered by D1 as a function of time is

$$w_{del\ by\ D1}(t) = 4t^3 + 3t^2 - 5\ [J].$$

(2) Positive charge q is moving from right to left through D2, as shown by the arrow in the figure, and is given by

$$q(t) = 2.5t^3 + 1.5t^2\ [Coul].$$

Find the energy delivered by the source i_{S1} as a function of time.



Room for extra work

3. {35 Points} A device can be modeled as a current source in parallel with a resistance. When this device is connected to a current source as shown in Figure 1, the power absorbed by the current source is 392[W]. When the same device is connected to a resistor as shown in Figure 2, v_M is measured to be 47[V]. When the device is connected to the circuit shown in Figure 4, the Thévenin equivalent circuit as seen by the device is shown in Figure 3.

a) Find v_S in Figure 4.

b) Find a model for the device and draw it showing terminals A and B.

c) What is the power absorbed by the device in Figure 3?

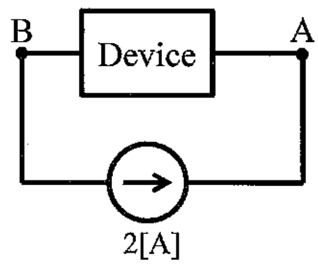


Figure 1

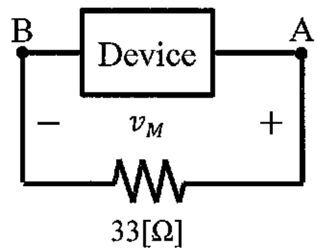


Figure 2

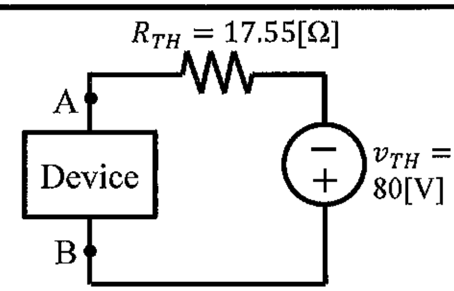


Figure 3

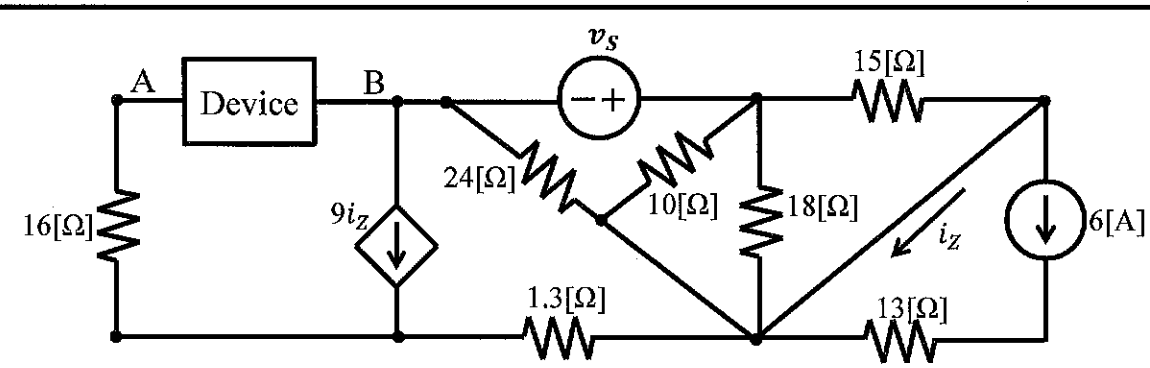


Figure 4

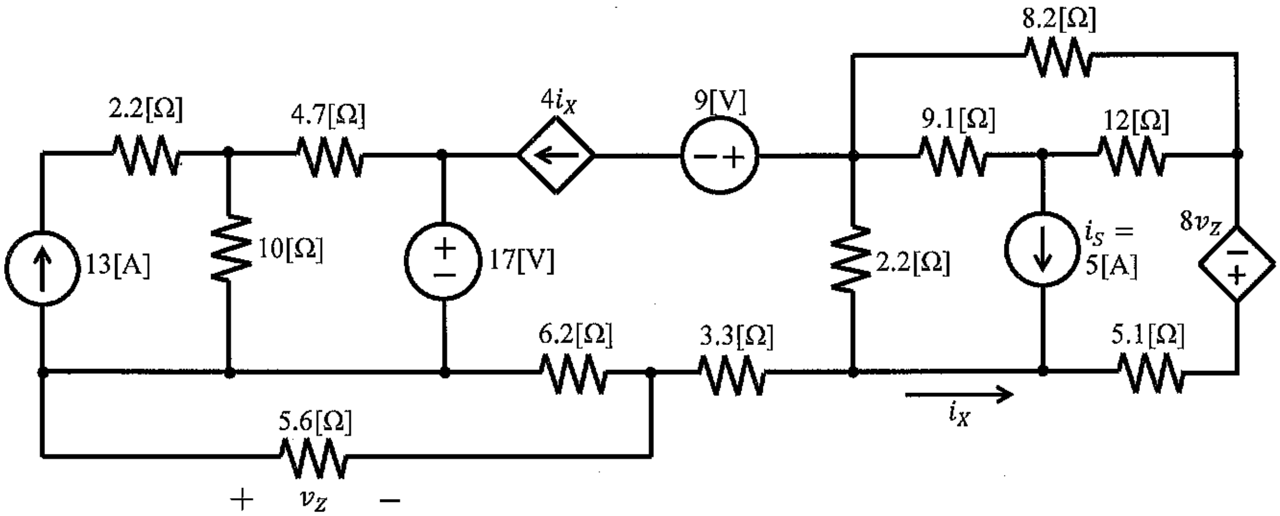
Room for extra work

4. {35 Points} Use the following circuit to solve this problem.

a) Find the Norton equivalent circuit as seen by i_S.

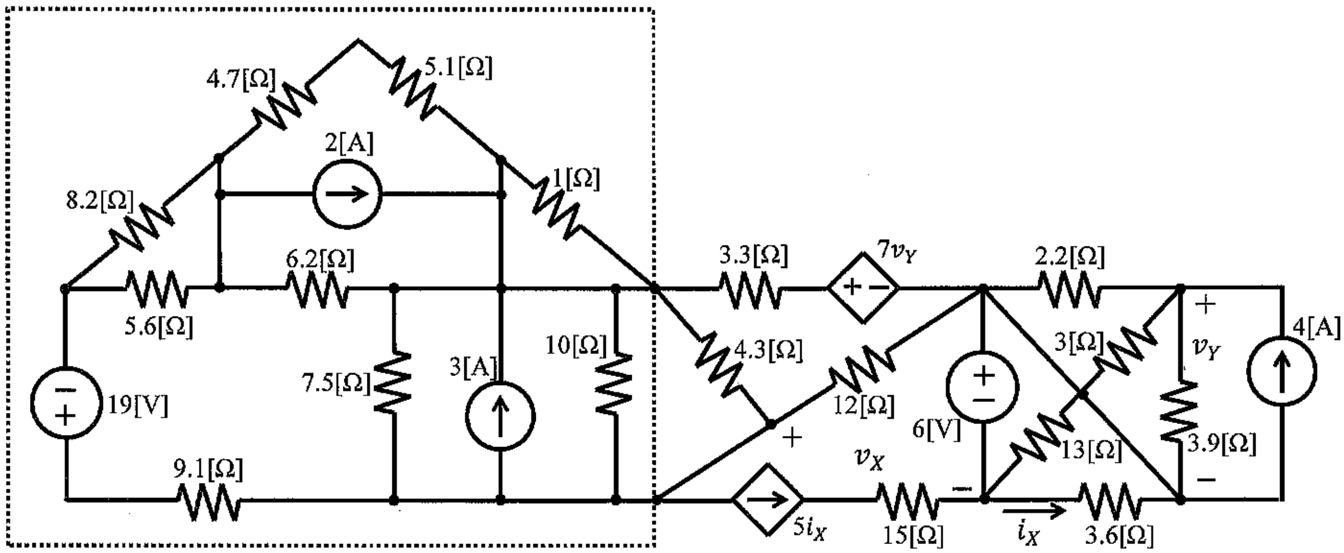
b) Find the power absorbed by i_S.

c) Do the electrons gain or lose energy as they go through i_S? Explain your reasoning.



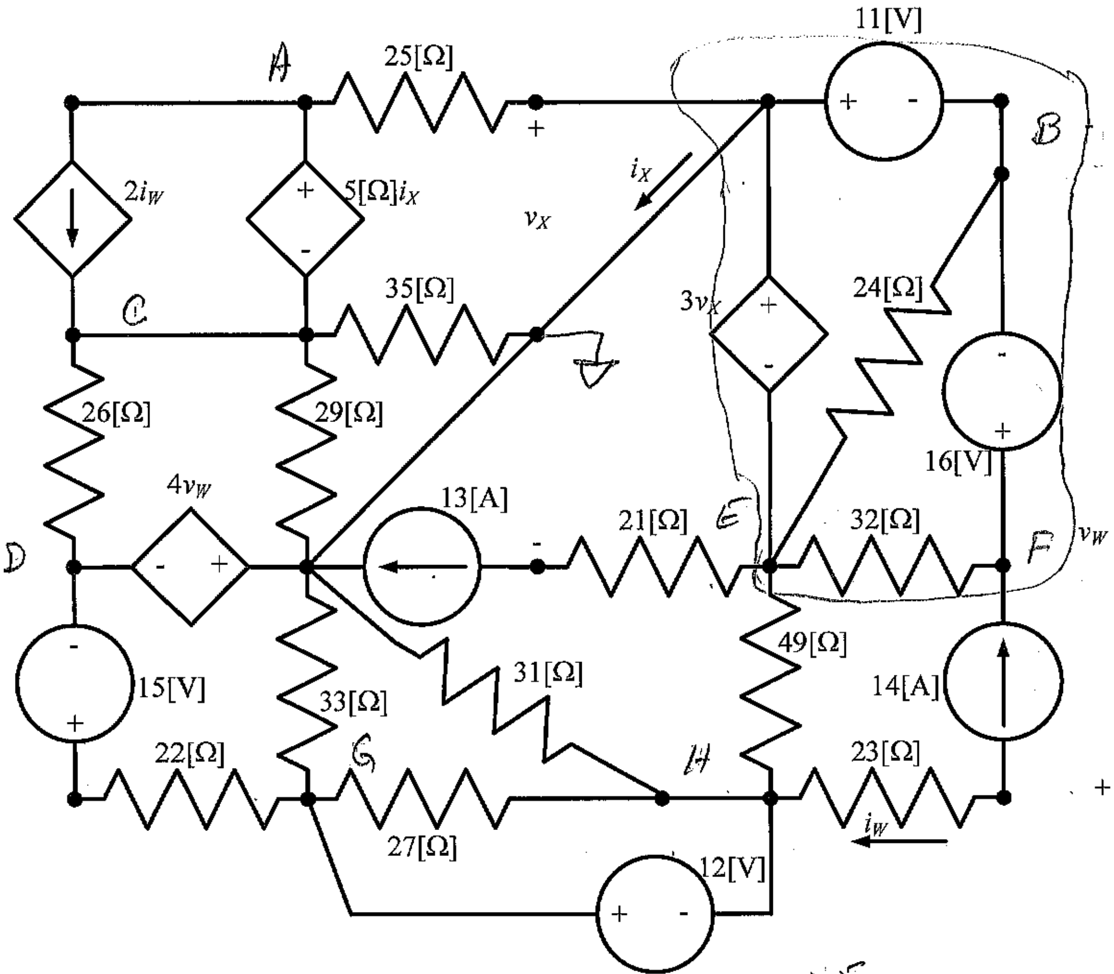
Room for extra work

5. {35 Points} Use the following circuit to solve this problem.
a) Simplify part of the circuit shown in the dashed box to a current source in parallel with a resistor.
b) Find v_X.



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 this circuit. Do not simplify the circuit. Do not attempt to simplify or solve your equations. **Define all your variables clearly.**



A, C: $\frac{v_A}{25} + \frac{v_C}{35} + \frac{v_C - v_D}{26} + \frac{v_C}{29} = 0 \quad v_A - v_C = 5[\Omega] i_X$ +5 +1

B: $v_B = -11\,[V]$ +1 D: $v_D = -4 v_w$ +1 E: $v_E = -3 v_x$ +1

F: $v_F = 16 - 11$ +1 G, H: $\frac{v_G}{33} + \frac{v_G - v_D}{22} + \frac{v_H}{31} + \frac{v_H - v_E}{49} + 14 = 0$ +5

$v_G - v_H = 12V$ +1

i_x: $i_x - \frac{v_A}{25} + 13 + \frac{v_E - v_H}{49} - 14 = 0$ +6

i_w: $i_w = -14\,[A]$ +1 v_x: $v_x - 13 \times 21 + v_E = 0$ +3

v_w: $-v_w - 14 \times 23 + v_H + 11 = 0$ +4

2. {35 Points} The following information is known about the devices D1 and D2 in the circuit below. (1) The energy delivered by D1 as a function of time is

$$w_{del\ by\ D1}(t) = 4t^3 + 3t^2 - 5\ [J].$$

(2) Positive charge q is moving from right to left through D2, as shown by the arrow in the figure, and is given by

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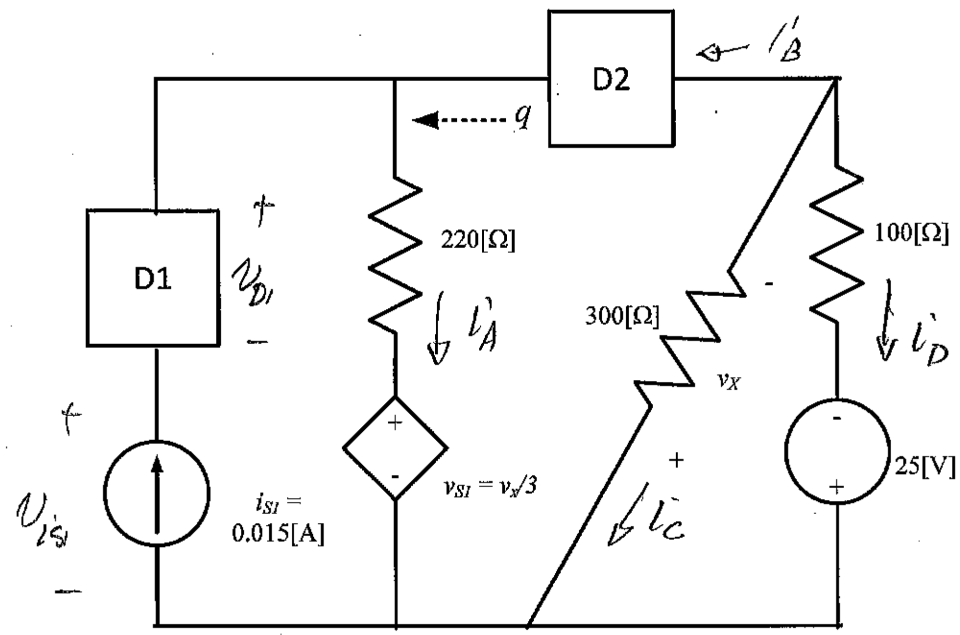
Find the energy delivered by the source i_{S1} as a function of time.



$$p_{del\ D1} = \frac{dw_{del\ D1}}{dt} = 12t^2 + 6t\ [W] = v_{D1} \cdot i_{S1}$$

$$\therefore\ v_{D1} = \frac{p_{del\ D1}}{i_{S1}} = 800t^2 + 400t\ [V] \qquad +7$$

$$i_B = \frac{dq}{dt} = 7.5t^2 + 3.0t\ [A] \qquad +6$$

$$\Rightarrow i_A = 0.015 + i_B = 7.5t^2 + 3.0t + 0.015 \qquad +2$$

$$v_{i_{S1}} = v_{D1} + 220\, i_A + \frac{v_X}{3}$$

Room for extra work

KCL $i_C + i_D = i_B = 7.5t^2 + 3.0t$

KVL $300 i_C + 25 - 100 i_D = 0 \Rightarrow i_D = 3i_C + 0.25$

$i_C + 3i_C + 0.25 = 7.5t^2 + 3.0t \Rightarrow i_C = \frac{7.5t^2 + 3.0t - 0.25}{4}$

$i_C = 1.875t^2 + 0.75t - 0.0625$

+ 6

$\frac{v_x}{3} = -100 i_C = -187.5t^2 - 75t + 6.25$

$v_{is1} = \underbrace{800t^2 + 400t}_{v_{D1}} + \underbrace{1650t^2 + 660t + 8.3}_{220 i_A}$

$\underbrace{-187.5t^2 - 75t + 6.25}_{v_x/3}$

$= 2637.5t^2 + 1135t + 9.55$ +5

+ 4

$\therefore P_{del\ is1} = v_{is1} \cdot i_{s1} = 39.563t^2 + 17.025t + 0.14325$ [W]

+ 5

$W_{del\ is1} = \int P_{del\ is1}\, dt = 13.188t^3 + 8.5125t^2 + 0.14325t$ [J]

$P_{del\ D1}$, v_{D1} } +7 no solns

$v_x, \frac{v_x}{3}$ +6 (+4)

v_{is1} +7 (+4)

i_B +6

P_{is1} +4

W_{is1} +5

no calc -3

Bad ∫ -3

∫ wrong thing -3

3. {35 Points} A device can be modeled as a current source in parallel with a resistance. When this device is connected to a current source as shown in Figure 1, the power absorbed by the 2[A] current source is 392[W]. When the same device is connected to a resistor as shown in Figure 2, v_M is measured to be 47[V]. When the device is connected to the circuit shown in Figure 4, the Thévenin equivalent circuit as seen by the device is shown in Figure 3.

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c) What is the power absorbed by the device in Figure 3?

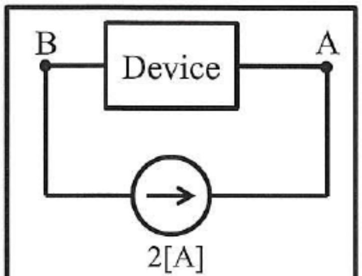


Figure 1

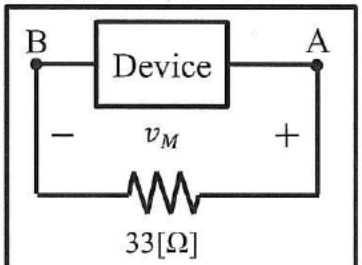


Figure 2

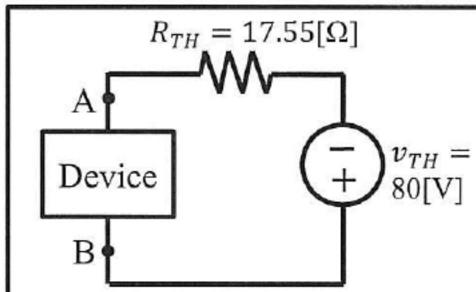


Figure 3

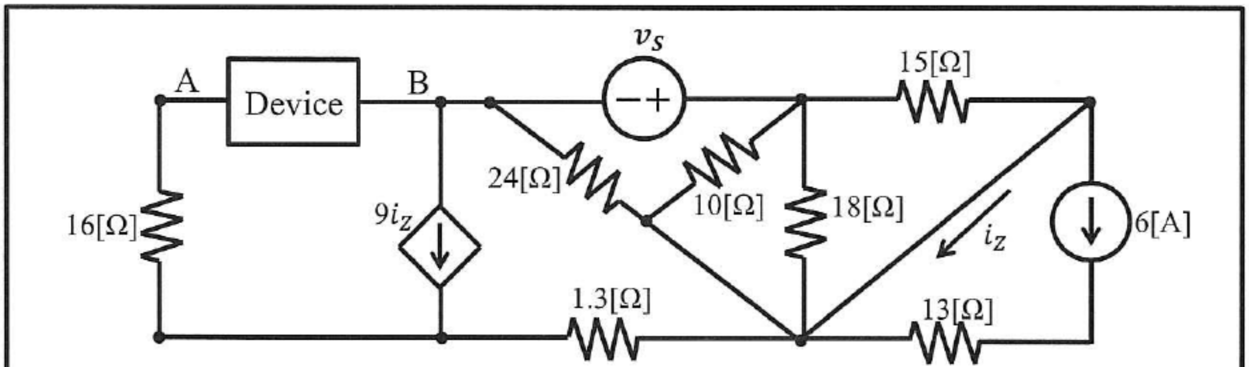


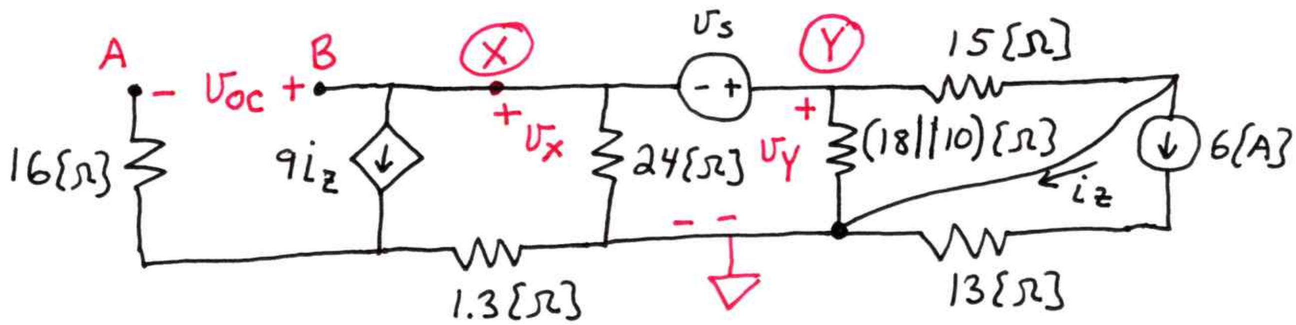
Figure 4

[redacted]

Problem 3. Part a)

We are given the Thevenin Equivalent seen by the device in Figure 3, so we can look at the Thevenin Equivalent of that device in Figure 4, using the fact that we know the open-circuit voltage $v_{OC} = v_{TH} = 80\{V\}$.

We will draw the circuit in Figure 4 with the device removed. We get



See next page

$v_{oc} = 80[V]$

(X+Y) $9i_z + \frac{v_x}{24[\Omega]} + \frac{v_y}{4.5[\Omega]} = 0$

$18[\Omega] \,//\, 10[\Omega] \,//\, 15[\Omega] = 4.5[\Omega]$

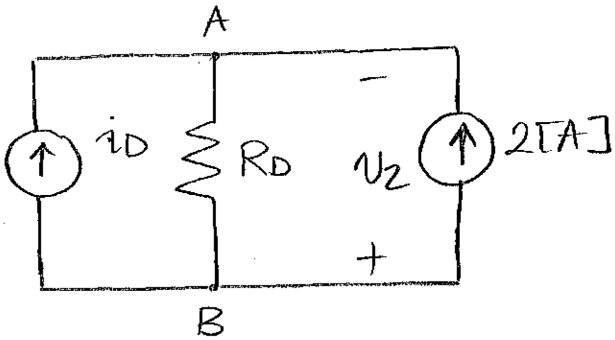
(X+Y) $v_y - v_x = v_s$

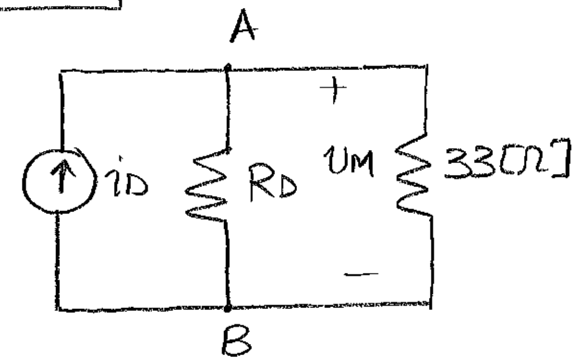
(i_z) $i_z + 6[A] - \frac{v_y}{15[\Omega]} = 0$

(v_{oc}) $-v_{oc} + v_x - 9i_z \cdot 1.3[\Omega] = 0$

Solving, we get $v_s = 3.99\,[V]$

b)





$v_2 \cdot 2[A] = 392[W]$

$v_2 = 196[V]$

$i_D + \frac{196}{R_D} + 2[A] = 0$ (1)

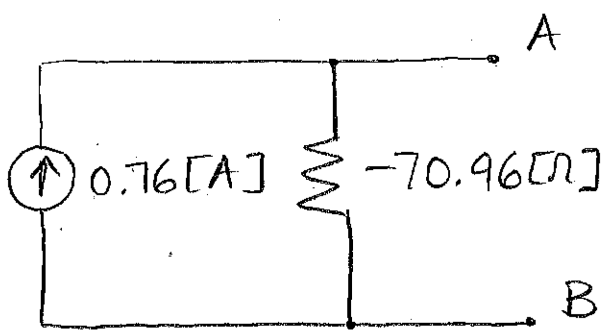
$v_M = 47[V]$

$-i_D + \frac{47}{R_D} + \frac{47}{33} = 0$ (2)

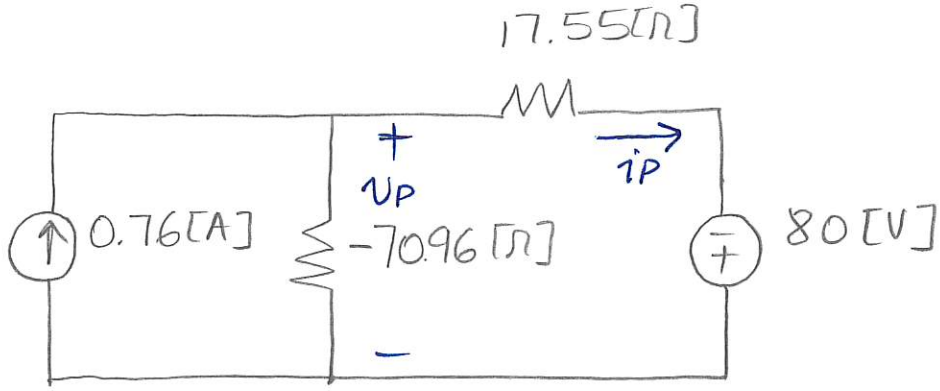
Solving (1) and (2), we get:

$i_D = 0.76[A]$

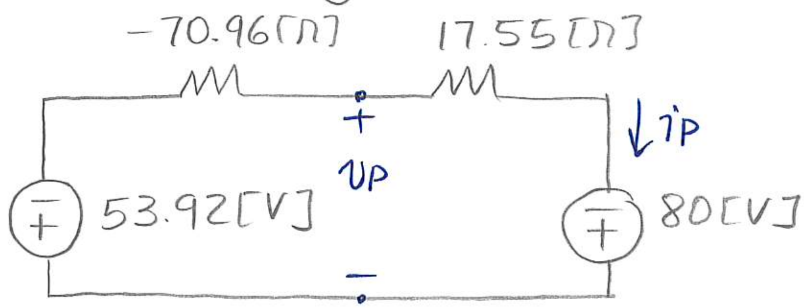
$R_D = -70.96[\Omega]$



c)



We can apply source xformation:



$$53.92 + (-70.96 + 17.55)\, i_P - 80 = 0 \Rightarrow i_P = -0.48[A]$$

$$v_P = 17.55\, i_P - 80 = -88.53\,[V]$$

$$p_{ABS,DEVICE} = -v_P \cdot i_P = \boxed{-42.49\,[W]}$$

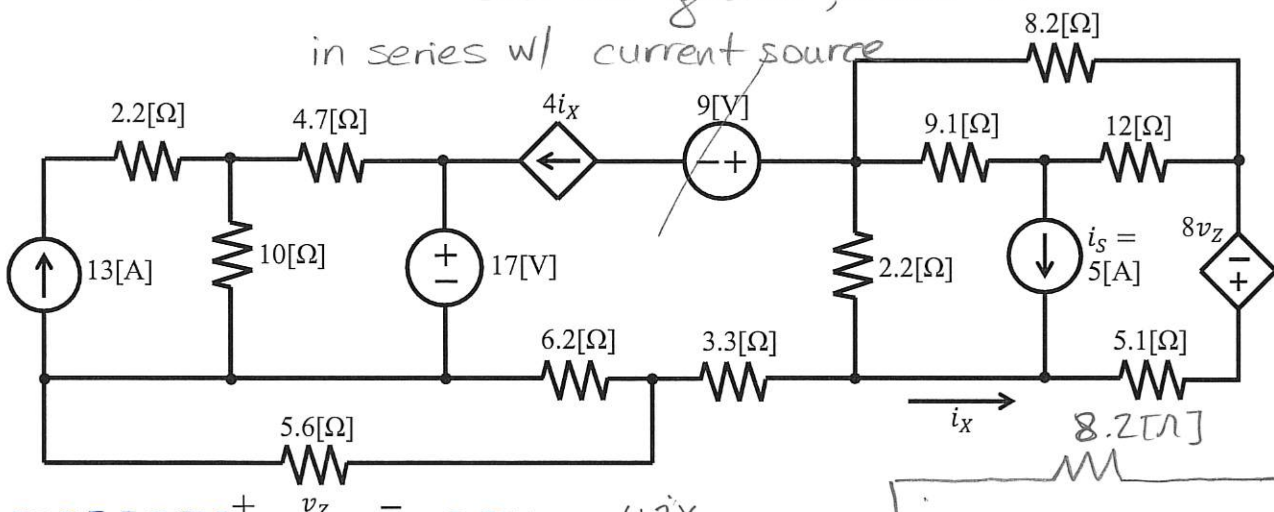
4. {30 Points} Use the following circuit to solve this problem.

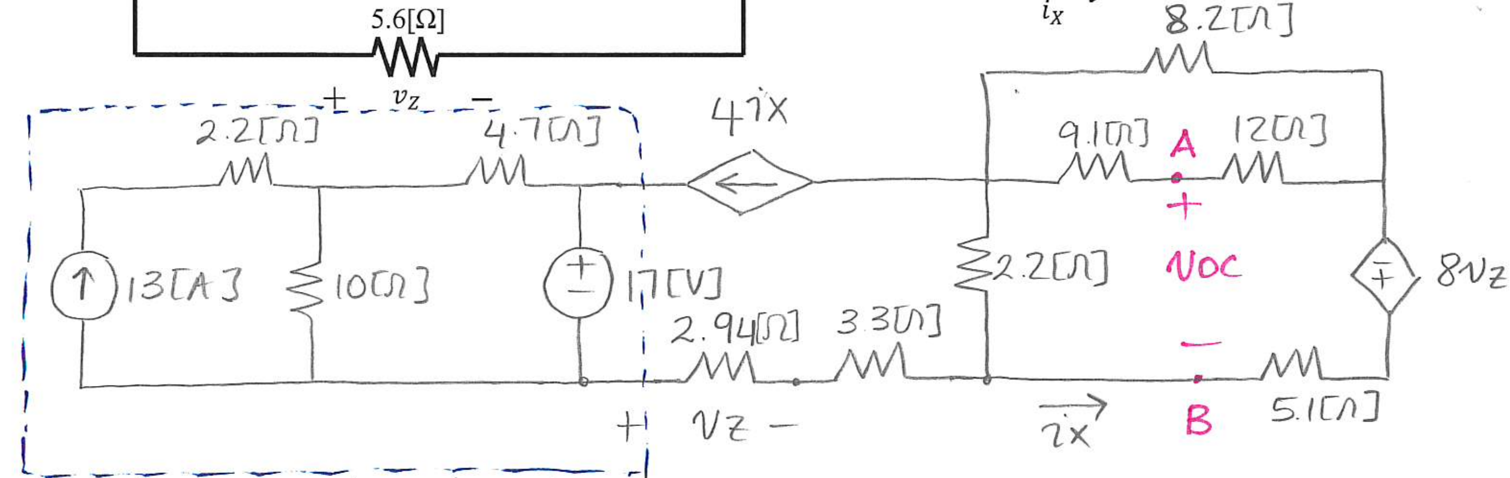
a) Find the Norton equivalent circuit as seen by i_S.

b) Find the power absorbed by i_S.

c) Do the electrons gain or lose energy as they go through i_S? Explain your reasoning.

can be ignored, since it's in series w/ current source





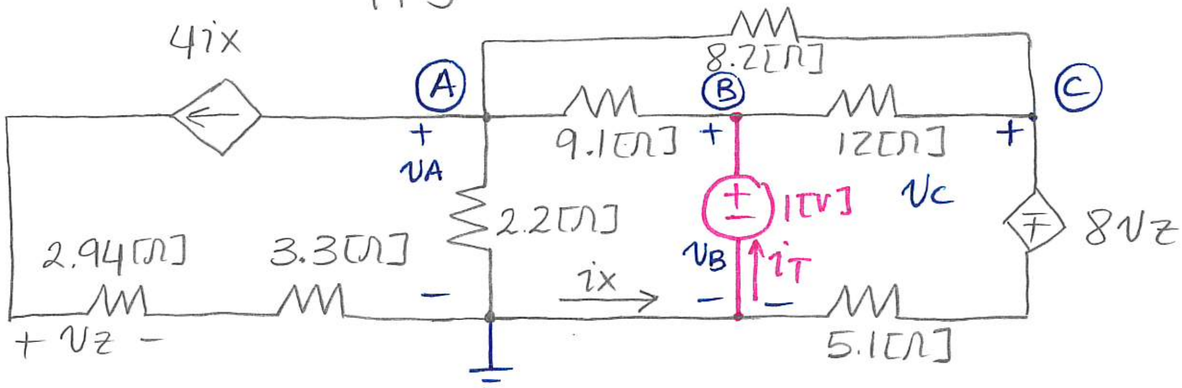
everything in this box is in series w/ a current source. Components in that box won't effect the solution, so they can be ignored

5.6[Ω]// 6.2[Ω] = 2.94[Ω]

Since is is also taken out, no independent sources are left in the circuit.

Voc = 0 isc = 0

We need to apply test source method to find R_{TH}.



(A) $4i_x + \dfrac{v_A}{2.2[\Omega]} + \dfrac{v_A - v_B}{9.1[\Omega]} + \dfrac{v_A - v_C}{8.2[\Omega]} = 0$

(B) $v_B = 1[V]$

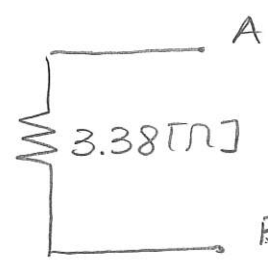
(C) $\dfrac{v_C - v_A}{8.2[\Omega]} + \dfrac{v_C - v_B}{12[\Omega]} + \dfrac{v_C + 8v_Z}{5.1[\Omega]} = 0$

(v_Z) $v_Z = 4i_x \, 2.94[\Omega]$

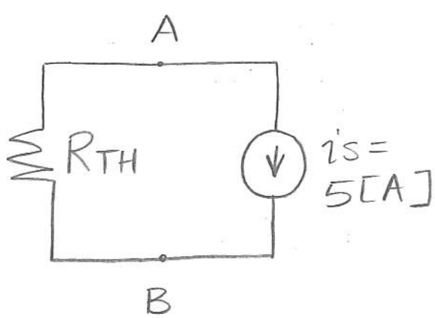
(i_x) $-4i_x + i_x - \dfrac{v_A}{2.2[\Omega]} = 0$

(i_T) $-i_x + i_T - \dfrac{v_C + 8v_Z}{5.1[\Omega]} = 0$

Solving, we get $i_T = 0.295[A]$



$R_{TH} = \dfrac{1[V]}{i_T} = 3.38[\Omega]$

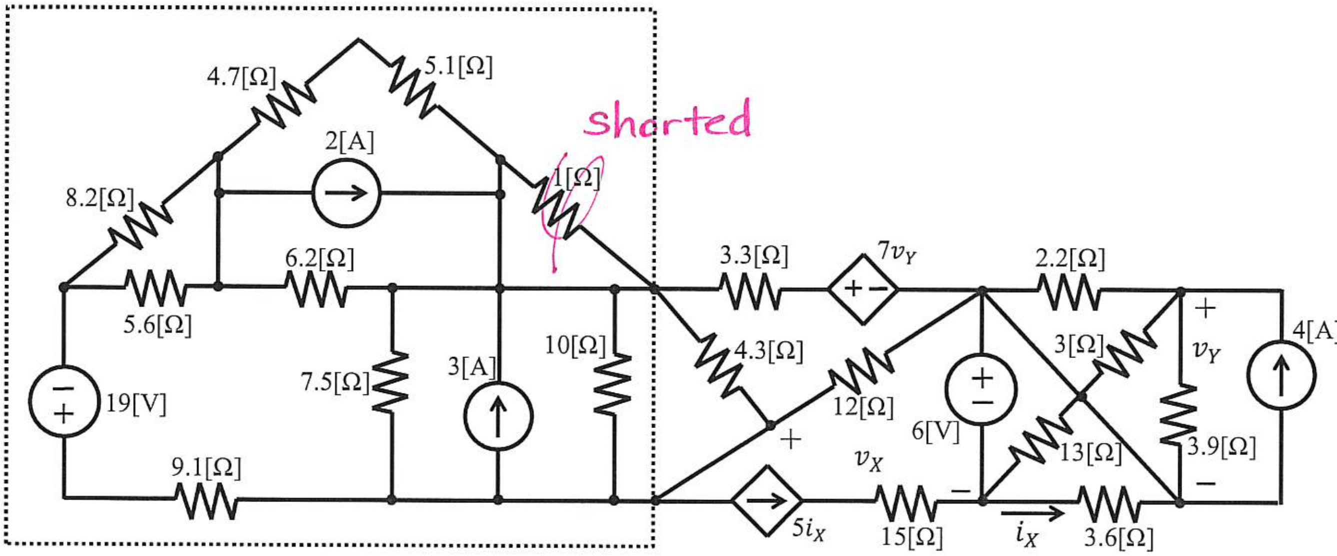


$p_{ABS,is} = p_{DEL,RTH} = -R_{TH} \cdot i_s^2$

$p_{ABS,is} =$ **-84.5 [W]**

i_s delivers power → e^-s gain energy as they go through i_s.

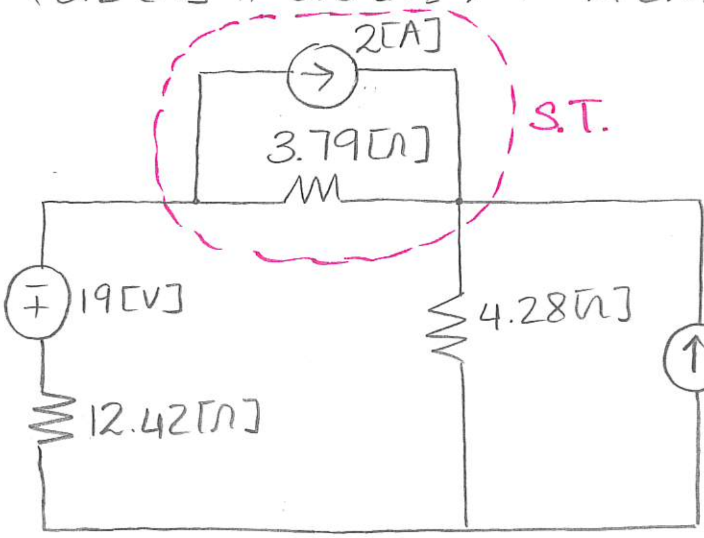
5. {35 Points} Use the following circuit to solve this problem.
a) Simplify part of the circuit shown in the dashed box to a current source in parallel with a resistor.
b) Find v_X.

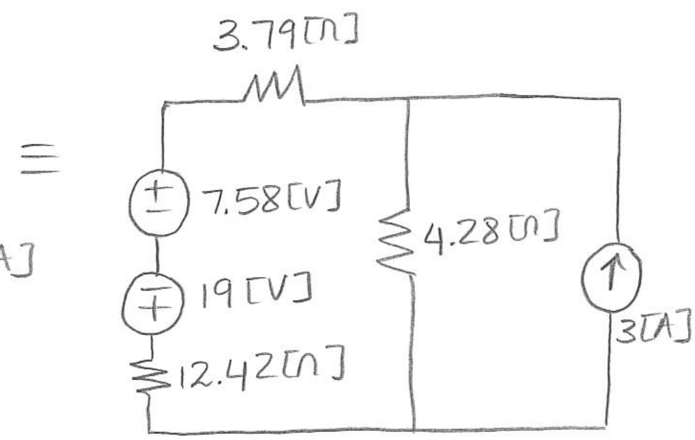


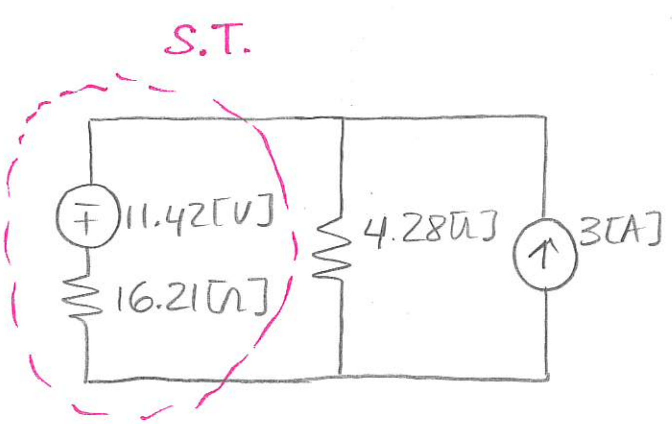
$(4.7[\Omega] + 5.1[\Omega]) \,//\, 6.2[\Omega] = 3.79[\Omega]$

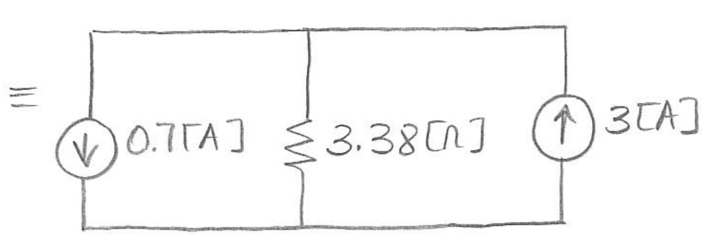
$(8.2[\Omega] \,//\, 5.6[\Omega]) + 9.1[\Omega] = 12.42[\Omega]$

$7.5[\Omega] \,//\, 10[\Omega] = 4.28[\Omega]$

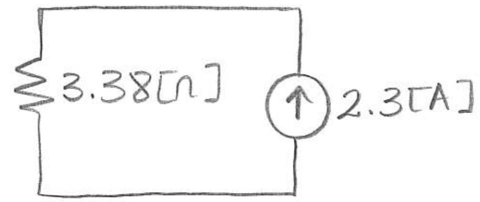








$4.28[\Omega] \,//\, 16.21[\Omega] = 3.38[\Omega]$

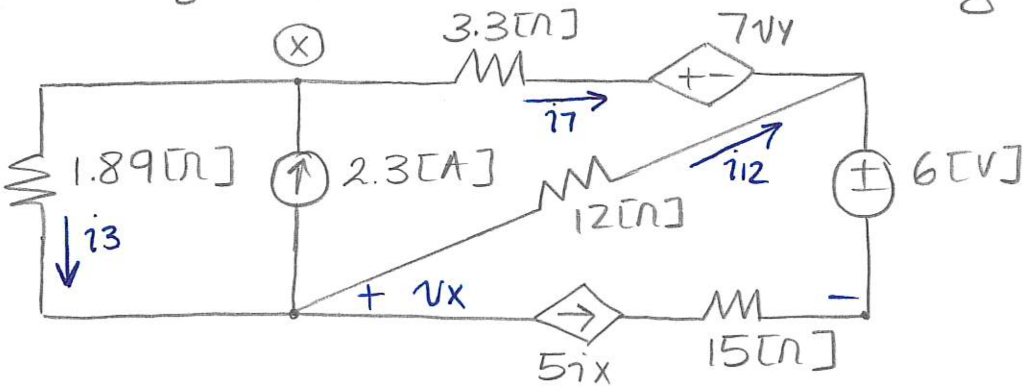


b) $3.38[\Omega] \parallel 4.3[\Omega] = 1.89[\Omega]$

$-6[V] - i_x \cdot 3.6[\Omega] = 0 \Rightarrow i_x = -1.66[A]$

$v_y = (2.2[\Omega] \parallel 3[\Omega] \parallel 3.9[\Omega]) \cdot 4[A] = 3.83[V]$

Now that we had the values of v_y and i_x, components to the right of 6[V] source can be ignored.



KCL: $-i_3 + 2.3[A] + i_{12} + 5(-1.66[A]) = 0$

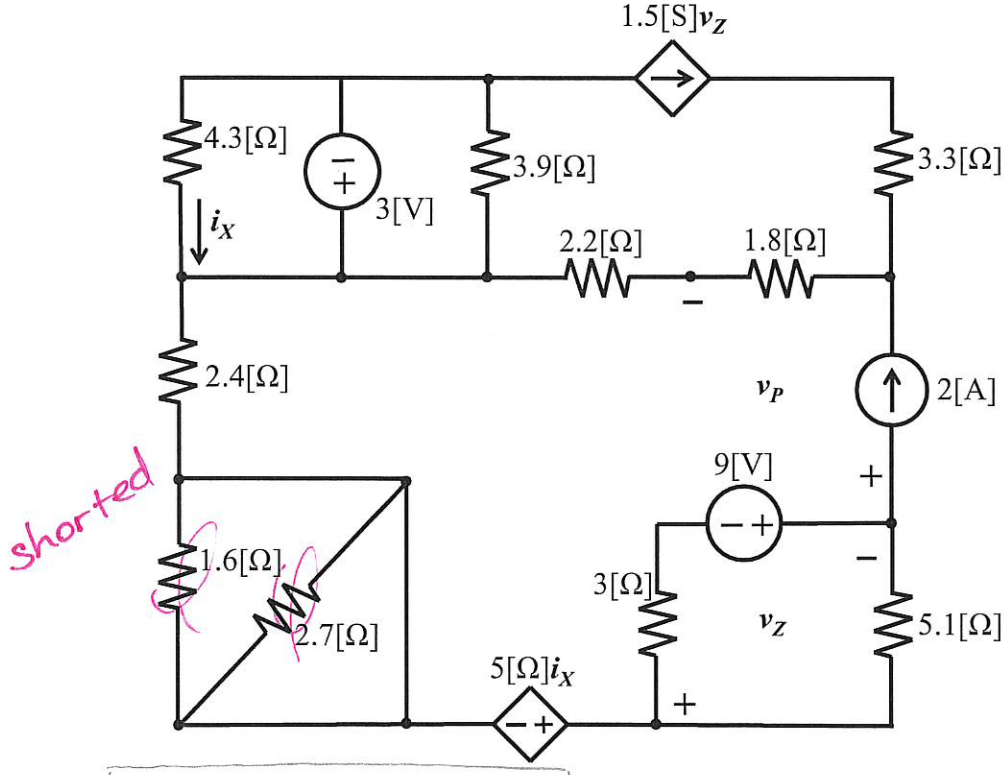
KVL: $-i_3 \cdot 1.89[\Omega] + i_7\, 3.3[\Omega] + 7v_y - i_{12} \cdot 12[\Omega] = 0$

KCL @ ⓧ : $i_3 - 2.3[A] + i_7 = 0$

Solving, we get: $i_{12} = 3.81[A]$

$v_x = 12[\Omega]\, i_{12} + 6[V] = \boxed{51.72[V]}$

6. {30 Points} Use superposition theorem in the circuit shown below to find v_P.



v_P due to 3[V]

2[A] → open-circuit
9[V] → short-circuit

$v_Z = 0$

$i_X = -3[V]/4.3[\Omega]$

$i_X = -0.697$ [A]

$-v_P + 5[\Omega]i_X = 0$

$v_P = -3.48$ [V]

v_P due to 2[A]

3[V] and 9[V] → short-circuit → $i_X = 0$

$v_Z = (3[\Omega] \parallel 5.1[\Omega]) \cdot 2[A] = 3.75$ [V]

$-v_P - v_Z - 2[A] \cdot 2.4[\Omega] - 2.2[\Omega](1.5[S]v_Z + 2[A]) = 0$

$v_P = -25.325$ [V]

v_P due to 9[V]

2[A] → open-circuit
3[V] → short-circuit → $i_X = 0$

$-v_Z = \frac{5.1}{5.1+3} \cdot 9[V] = 5.66$ [V] (VDR)

$-v_P - v_Z - 2.2[\Omega] \cdot 1.5[S]\, v_Z = 0 \Rightarrow v_P = 24.34$ [V]

v_P due to all 3 sources: $v_P = -3.48 - 25.325 + 24.34$

$v_P = -4.465$ [V]