Name: ______________________________ (please print)

Signature: ____________________________

ECE 2201 – Final Exam
July 7, 2021

Keep this exam closed and face up until you are told to begin.

1. This quiz is open book, open notes. You may not work with another person or try to obtain the answer to the quiz online.
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 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 140 minutes to work on this quiz, and 20 minutes to scan and upload.

1. _______________/35

2. _______________/50

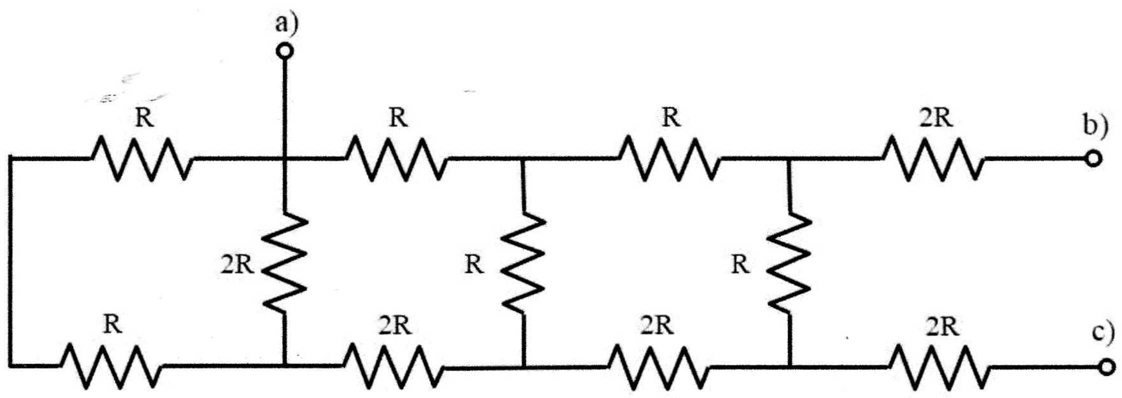
3. _______________/55

4. _______________/60

Total = 200

Room for extra work

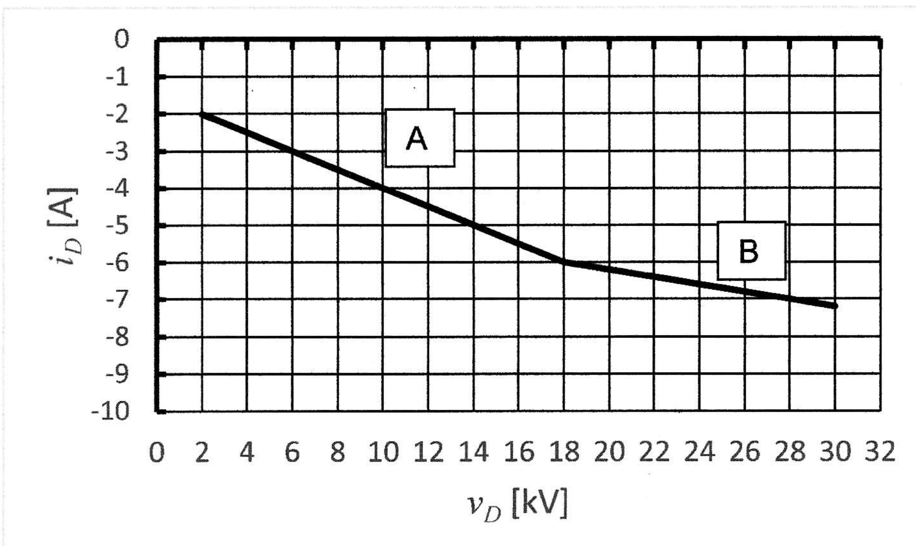
1. (35 points) For the resistor network shown, find the equivalent resistance at terminals a), b).

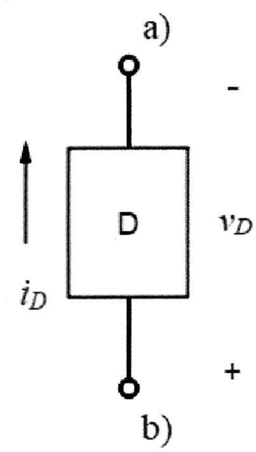


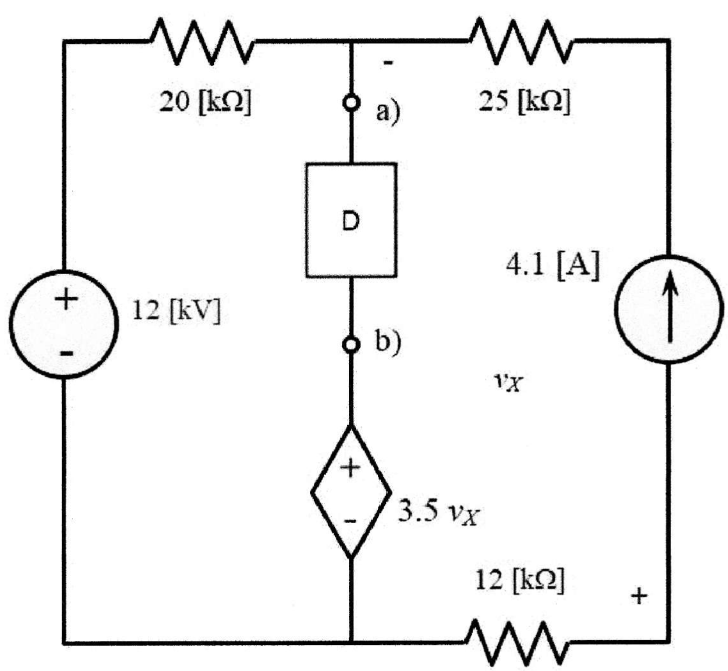
2. (50 points) Device D, shown below, can be modeled as either a Thevenin equivalent or as a Norton equivalent. The relationship between the device current i_D and voltage v_D is shown in the graph. The graph indicates that the device can operate in two different regions. It is operating in region A if the voltage v_D is less than 18 [kV]. It is operating in region B if v_D is greater than 18 [kV].

The device is inserted into the circuit shown, with terminals a), b) connected as indicated on the circuit diagram. It is known that v_X = -4900 [V].

a) In which region is the device operating? How do you know?
b) Find a model for the device in the region you determined in part a).
c) Find the power delivered to the circuit by device D.

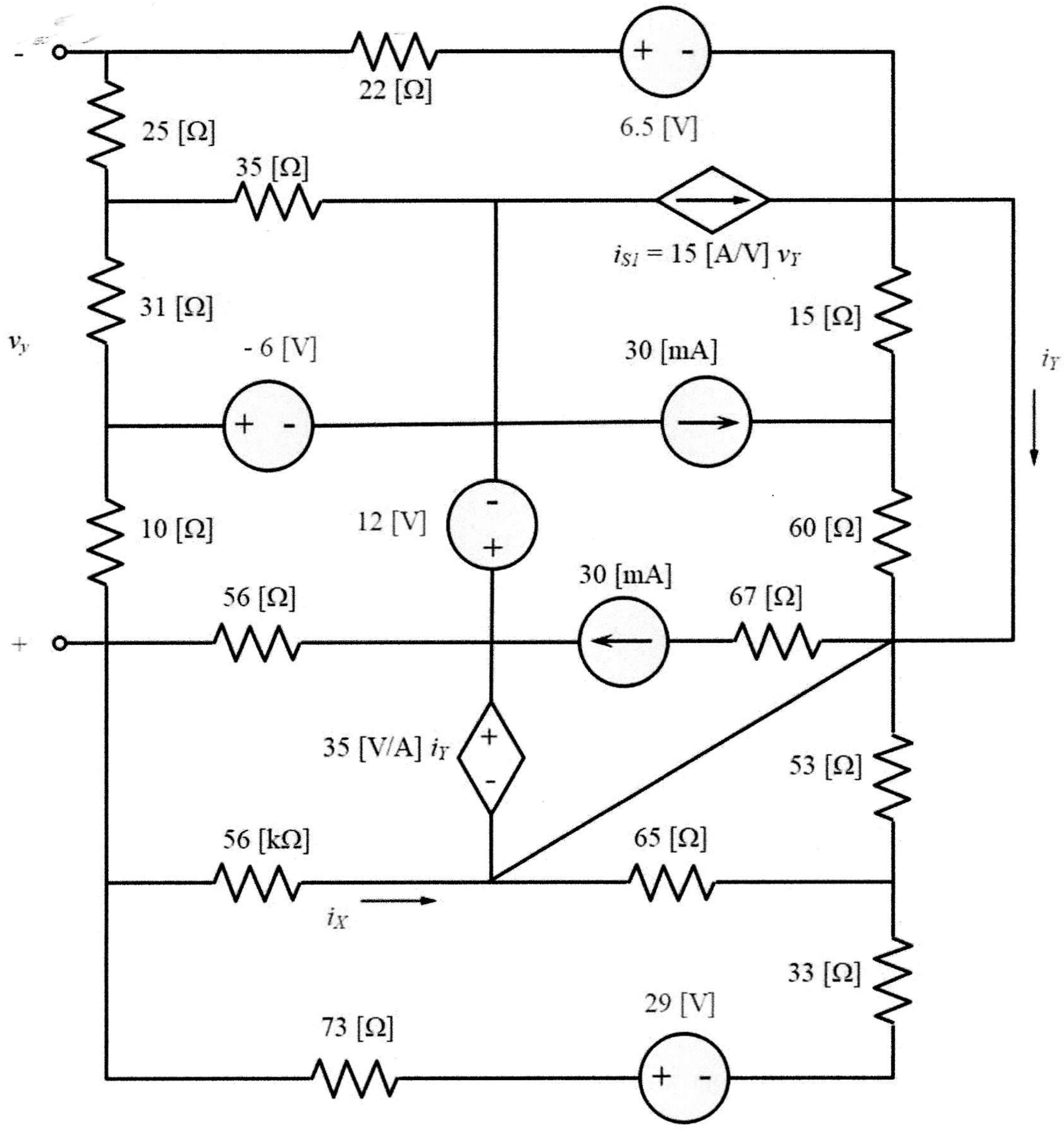






Room for extra work

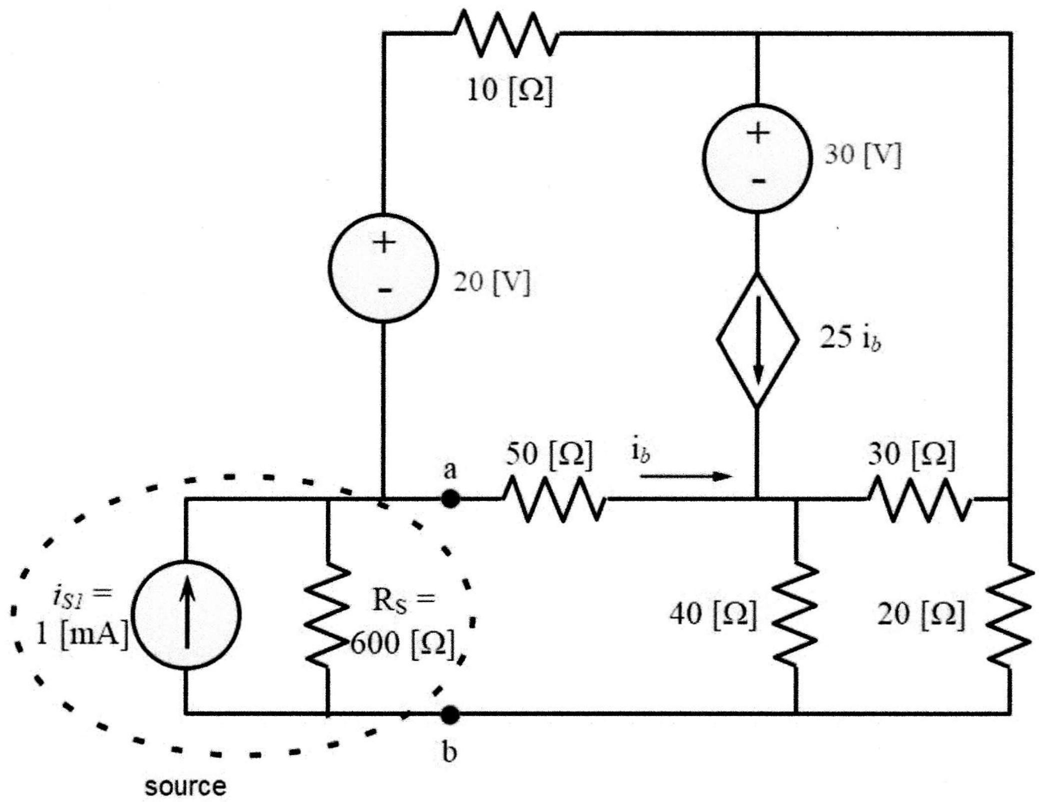
3. (55 points) For the following circuit, use the **node voltage method** to write a complete set of equations that could be used to solve the circuit. Do not simply the circuit. Do not attempt to solve the equations. Label your node voltages clearly.



Room for extra work

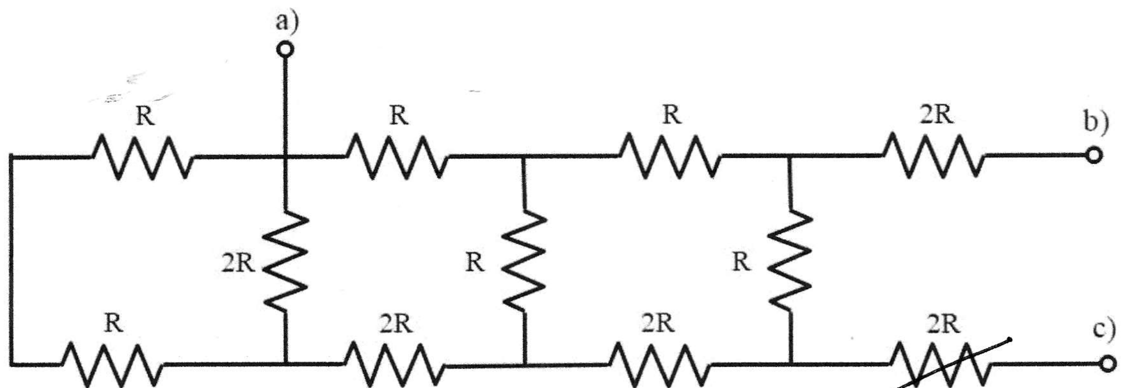
4. (60 points) In the circuit below, i_{S1} and the resistor R_S are intended to represent the Norton equivalent of a source connected to an amplifier circuit at the terminals a, b. The source is enclosed by a dashed line.

Find the Norton equivalent of the circuit seen by the source.



Room for extra work

1. (35 points) For the resistor network shown, find the equivalent resistance at terminals a), b).



we can ignore this one

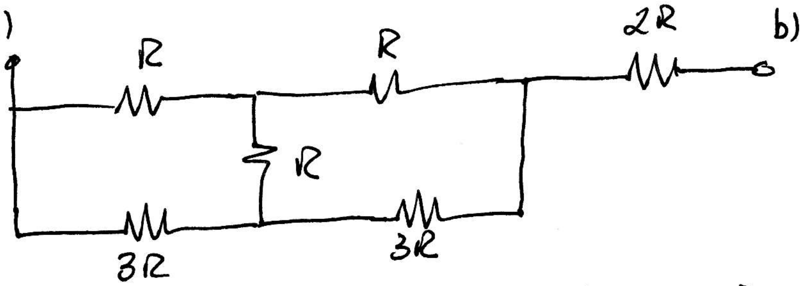
$(R+R) \parallel 2R = R$

$R + 2R = 3R$

$R + 2R = 3R$

Re-draw:

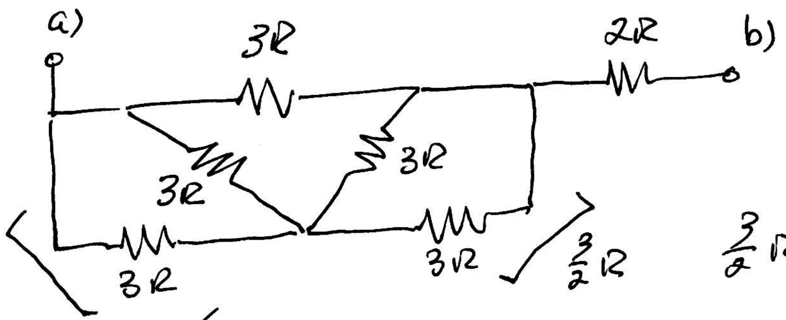
+ 8



We will do Y→Δ on the 3 resistors labeled R:

$3R \parallel 3R = \frac{3}{2}R$

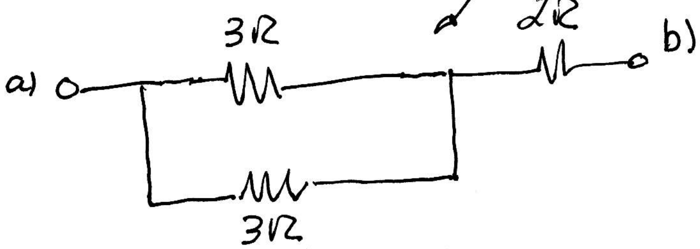
+ 11



$\frac{3}{2}R$

$\frac{3}{2}R$

$\frac{3}{2}R + \frac{3}{2}R = 3R$



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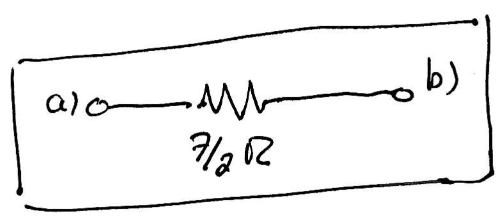


+ 8

$3R \parallel 3R = \frac{3}{2}R$

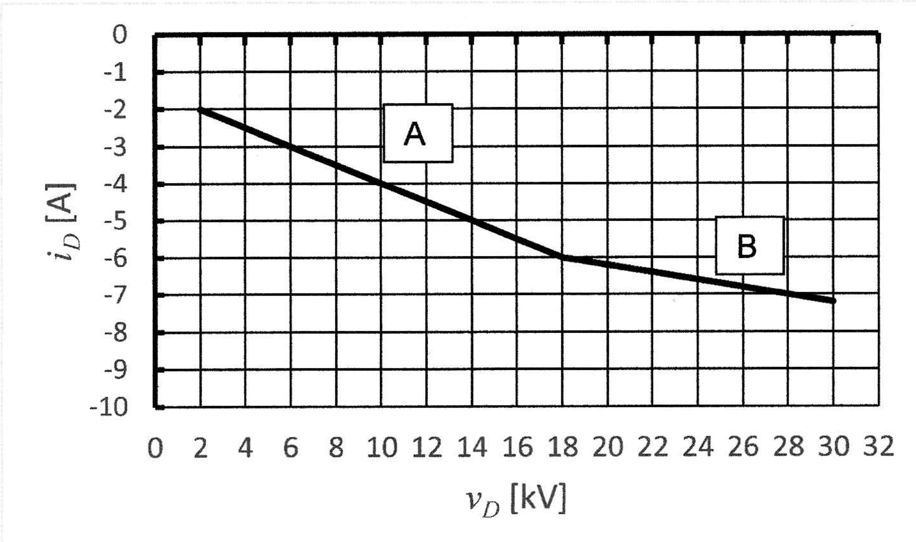
$\frac{3}{2}R + 2R = \frac{7}{2}R$

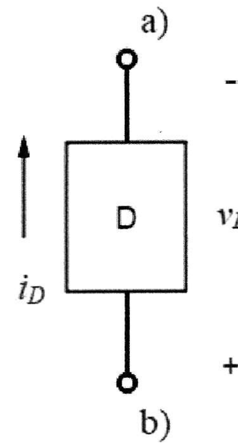
+8

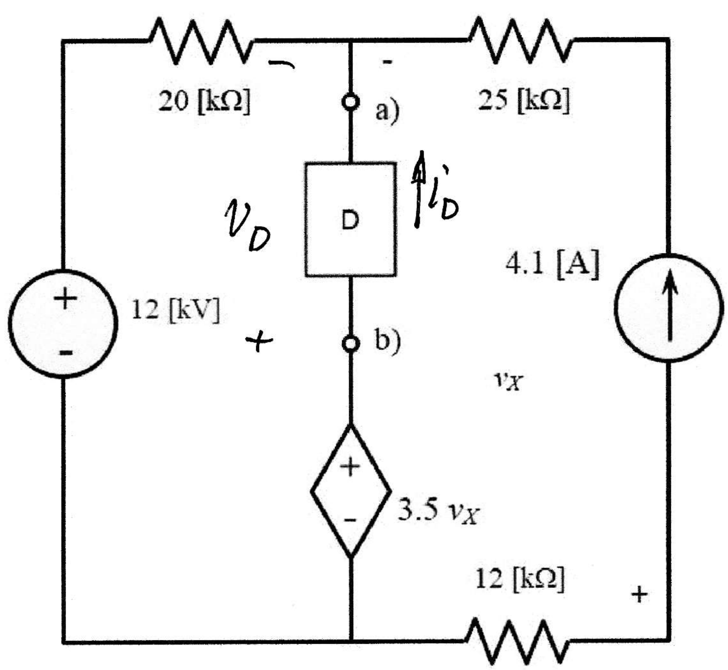
2. (50 points) Device D, shown below, can be modeled as either a Thevenin equivalent or as a Norton equivalent. The relationship between the device current i_D and voltage v_D is shown in the graph. The graph indicates that the device can operate in two different regions. It is operating in region A if the voltage v_D is less than 18 [kV]. It is operating in region B if v_D is greater than 18 [kV].

The device is inserted into the circuit shown, with terminals a), b) connected as indicated on the circuit diagram. It is known that v_X = -4900 [V].

a) In which region is the device operating? How do you know?
b) Find a model for the device in the region you determined in part a).
c) Find the power delivered to the circuit by device D.







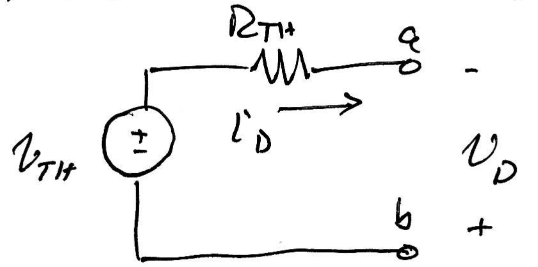
Room for extra work

a) KVL: $v_x - v_D + 3.5 v_x + 4.1(12000) = 0$

+8 $\Rightarrow v_D = 4.5 v_x + 4.1(12000) = 27150$ [V]

+4 This is in region B.

b) We'll use a Thevenin equivalent:



$v_D - i_D R_{TH} + v_{TH} = 0$

We choose two points in region B...

+10
+10 $v_D = 18000$ [V], $i_D = -6$ [A]

$v_D = 28000$ [V], $i_D = -7$ [A]

$v_{TH} = 42000$ [V]

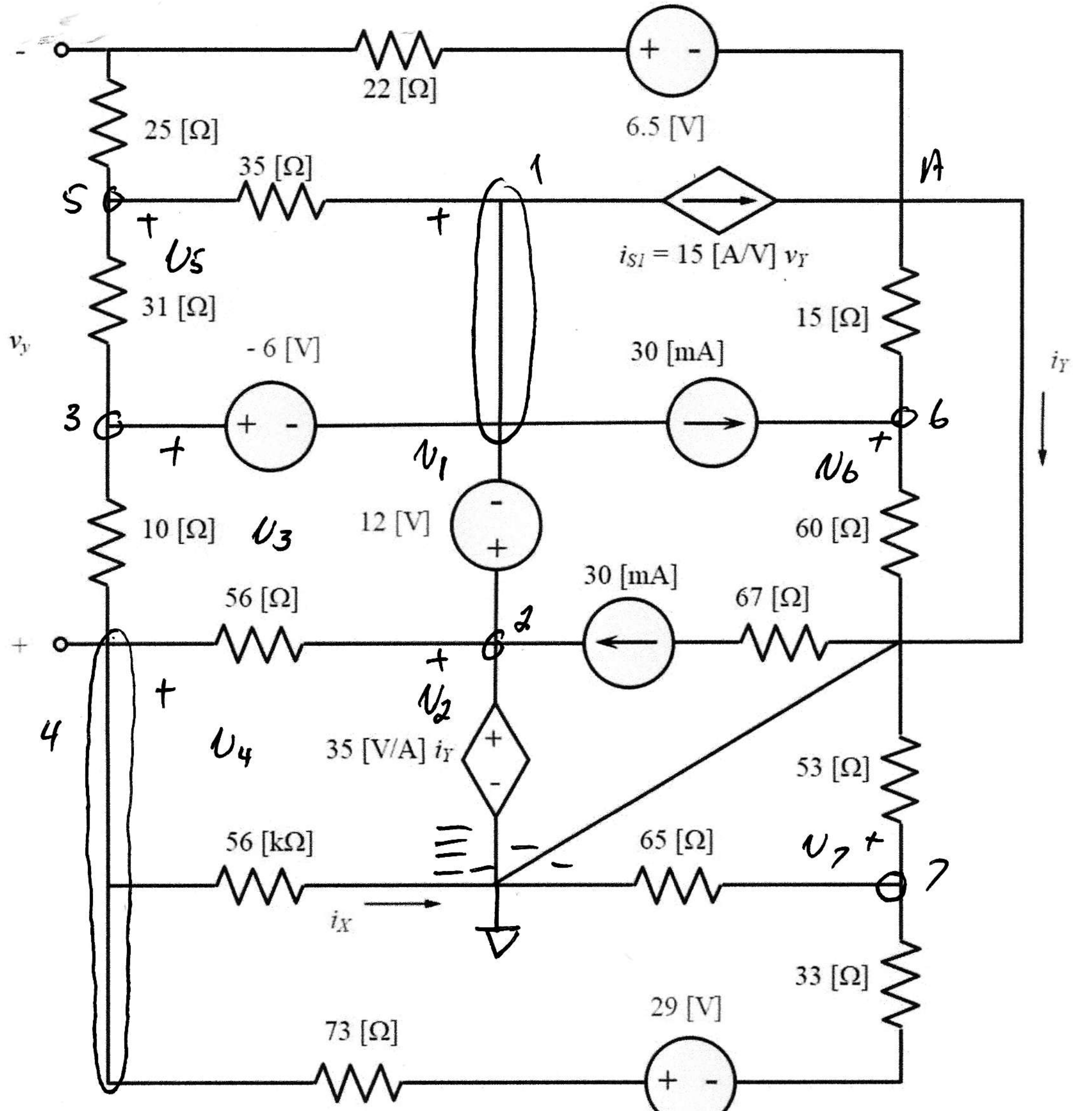
$R_{TH} = -10000$ [Ω]

c) $i_D = \dfrac{v_D + 42000}{-10000} = -6.915$ [A]

+4

+6 $P_{del\ by\ D} = -v_D i_D = -(27150)(-6.915) = 187.74$ [kW]

3. (55 points) For the following circuit, use the **node voltage method** to write a complete set of equations that could be used to solve the circuit. Do not simply the circuit. Do not attempt to solve the equations. Label your node voltages clearly.



Room for extra work

+4 1: $v_1 = -12 + 35\,[\frac{V}{A}]\,i_Y$

+4 2: $v_2 = 35\,[\frac{V}{A}]\,i_Y$

+5 3: $v_3 = -6 - 12 + 35\,[\frac{V}{A}]\,i_Y$

+8 4: $\frac{v_4 - v_2}{56} + \frac{v_4}{56} + \frac{v_4 - v_3}{10} + \frac{v_4 - v_7 - 29}{33 + 73} = 0$

+6 5: $\frac{v_5 - 6.5}{22 + 25} + \frac{v_5 - v_1}{35} + \frac{v_5 - v_3}{31} = 0$

+6 6: $-0.03 + \frac{v_6}{60} + \frac{v_6}{15} = 0$

+6 7: $\frac{v_7}{65} + \frac{v_7}{53} + \frac{v_7 + 29 - v_4}{33 + 73} = 0$

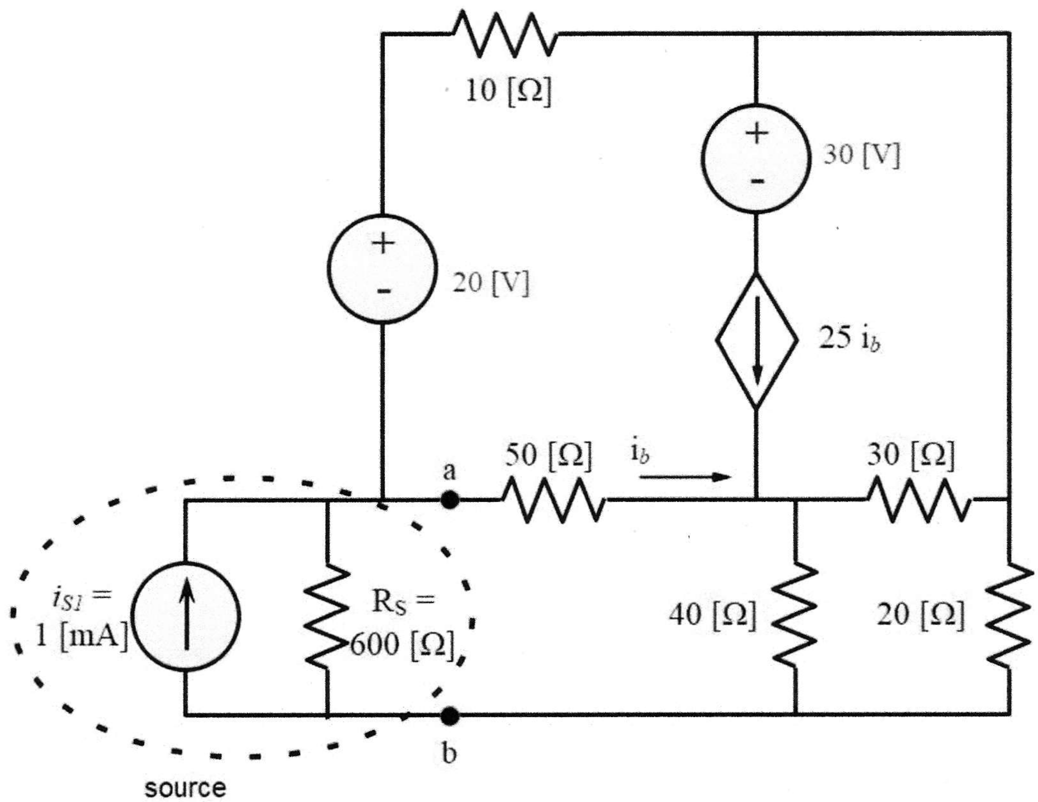
+8 v_Y: $v_Y - \left(\frac{v_5 - 6.5}{22 + 25}\right)25 + v_5 - v_4 = 0$

+8 i_Y: $i_Y - 15\,[\frac{A}{V}]\,v_Y - \left(\frac{v_5 - 6.5}{22 + 25}\right) - \frac{v_6}{15} = 0$

at A

4. (60 points) In the circuit below, i_{S1} and the resistor R_S are intended to represent the Norton equivalent of a source connected to an amplifier circuit at the terminals a, b. The source is enclosed by a dashed line.

Find the Norton equivalent of the circuit seen by the source.

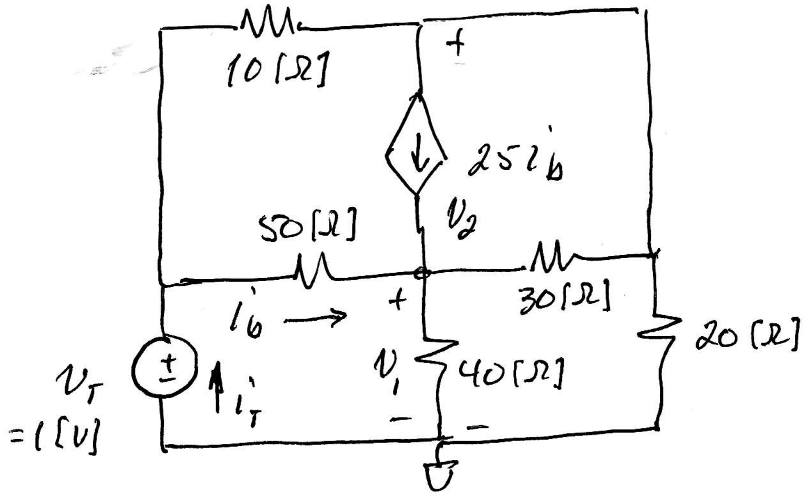


we remove the source (which is i_{s1} and R_S) and then find 2 of V_{OC}, i_{sc}, R_{TH} from test source at a, b.

we will do all three. Note that we can ignore the 30 [V] source.

Room for extra work

TEST SOURCE:



$$\frac{v_1}{40} + \frac{v_1 - v_2}{30} - 25 i_b + \frac{v_1 - 1}{50} = 0$$

$$\frac{v_2 - 1}{10} + 25 i_b + \frac{v_2}{20} + \frac{v_2 - v_1}{30} = 0$$

$$i_b = \frac{1 - v_1}{50}$$

$v_1 = 0.9292$ [V]

$v_2 = 0.5212$ [V]

$i_b = 1.416$ [mA]

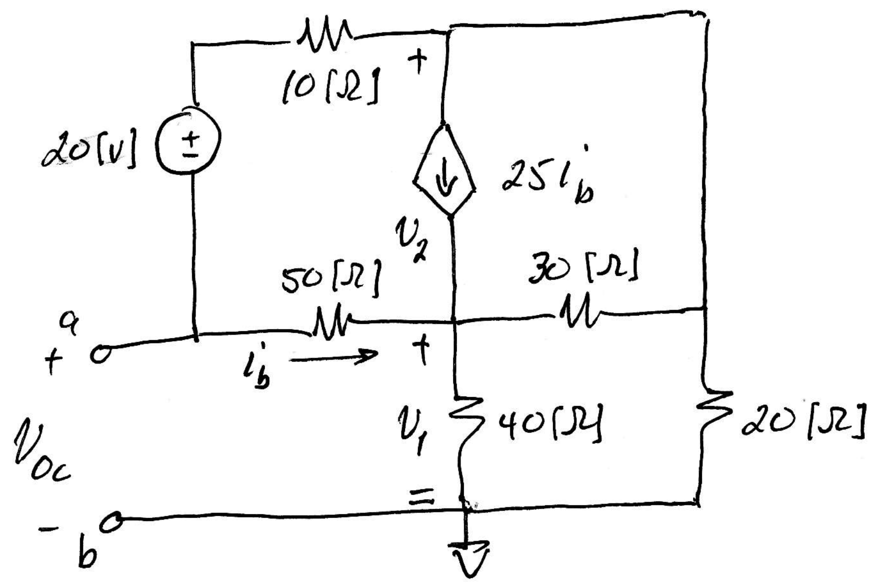
$$i_T = i_b + \frac{1 - v_2}{10} = ~~4.929~~\ 49.29 \text{ [mA]}$$

+4

$$R_N = R_{TH} = \frac{1}{i_T} = 20.29\ [\Omega]$$

$$i_N = \frac{V_{oc}}{R_N} = -0.6738\ [A]$$

Room for extra work



$$\frac{v_1}{40} + \frac{v_1 - v_2}{30} - 25 i_b + \frac{v_1 - v_2 + 20}{60} = 0$$

$$\frac{v_2 - v_1}{30} + \frac{v_2 - v_1 - 20}{60} + 25 i_b + \frac{v_2}{20} = 0$$

$$i_b = \frac{v_2 - v_1 - 20}{60}$$

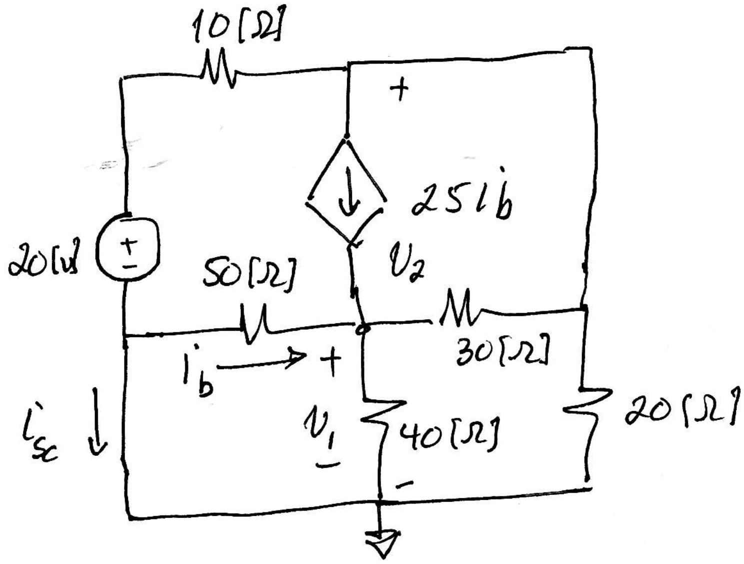
$v_1 = -11.95$ [V]

$v_2 = 5.977$ [V]

$i_b = -34.48$ [mA]

$V_{oc} = 50 i_b + v_1 = -13.67$ [V]

Room for extra work



$$\frac{v_1}{40} + \frac{v_1}{50} + \frac{v_1 - v_2}{30} - 25 i_b = 0$$

$$\frac{v_2 - 20}{10} + 25 i_b + \frac{v_2 - v_1}{30} + \frac{v_2}{20} = 0$$

$$i_b = -\frac{v_1}{50}$$

$v_1 = 0.7554$ [V]

$v_2 = 13.107$ [V]

$i_b = -15.109$ [mA]

$$i_N = i_{sc} = -i_b + \frac{v_2 - 20}{10} = -0.6739 \text{ [A]}$$

So...

+6