Name: ______________________________ (please print)

Signature: ___________________________

ECE 2300 -- Exam #1
October 12, 2013

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. It is assumed that your work will begin on the same page as the problem statement. If you choose to begin your work on another page, you must indicate this on the page with the problem statement, with a clear indication of where the work can be found. **If your work continues on to another page, indicate clearly where your work can be found. Failure to indicate this clearly will result in a loss of credit.**
4. Show all units in solutions, intermediate results, and figures. Units in the exam will be included between square brackets.
5. Do not use red ink. Do not use red pencil.
6. You will have 90 minutes to work on this exam.

1. _______________/20

2. _______________/20

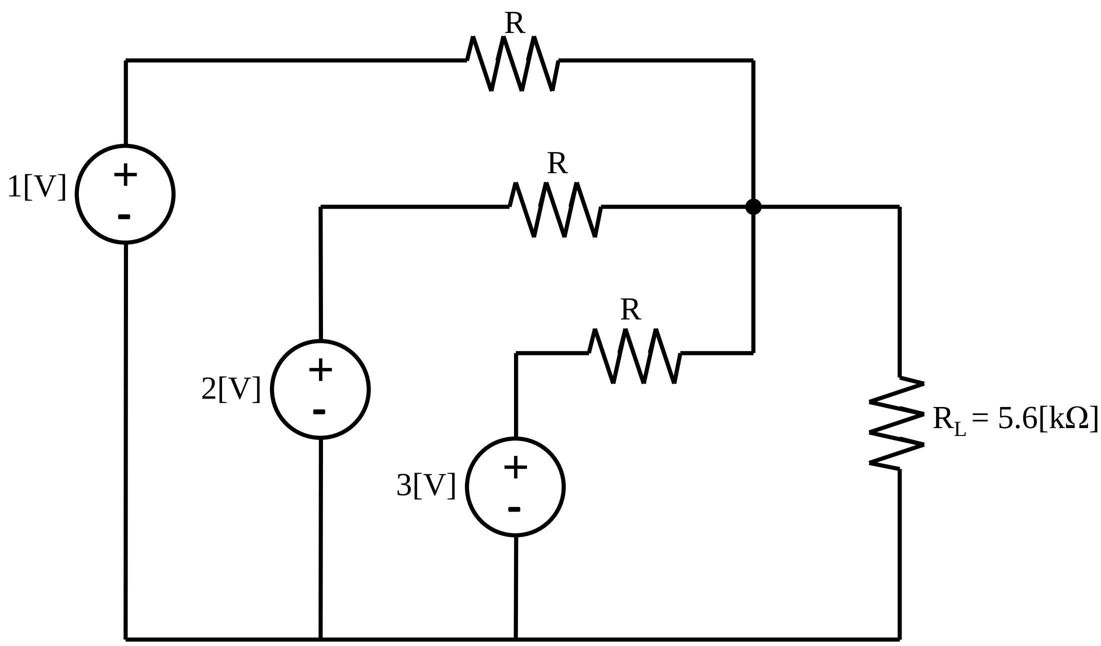
3. _______________/30

4. _______________/30

Total = 100

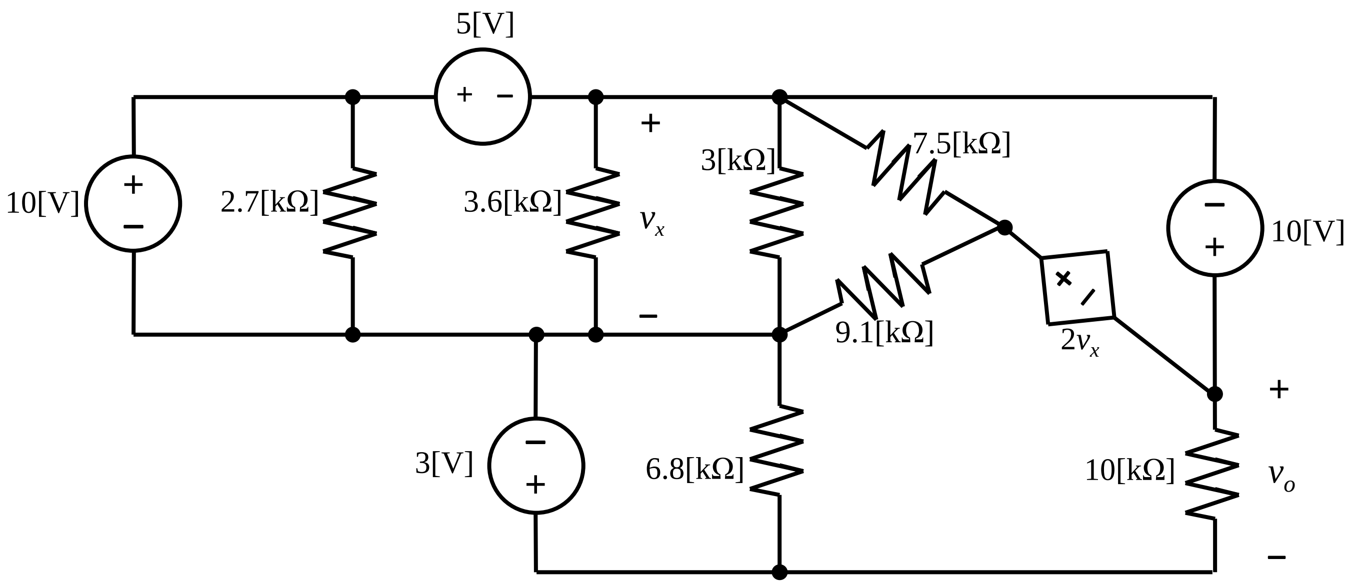
Room for extra work

1. {20 Points} Use the circuit below to solve this problem. Find the value of R, if the absorbed power by R_L is equal to 30[mW].



Room for extra work

2. {20 Points} Find v_o by using the circuit shown below.



Room for extra work

3. {30 Points} A device can be modeled as an ideal current source in parallel with a resistance. The device is shown in Figure 1. The characteristics of the device are given in terms of the relationship between the voltage across the device, and the current through the device, as shown in Figure 2. Two identical versions of this device are connected to a circuit using terminals a and b to show the polarity, as shown in Figure 3.
a) Find a model for the device showing terminals a and b.
b) Find the power delivered by Device 1.

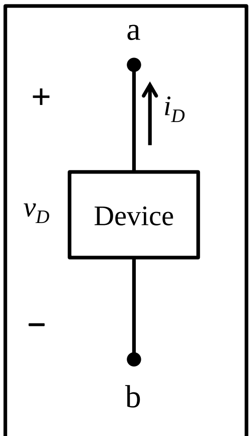


Figure 1

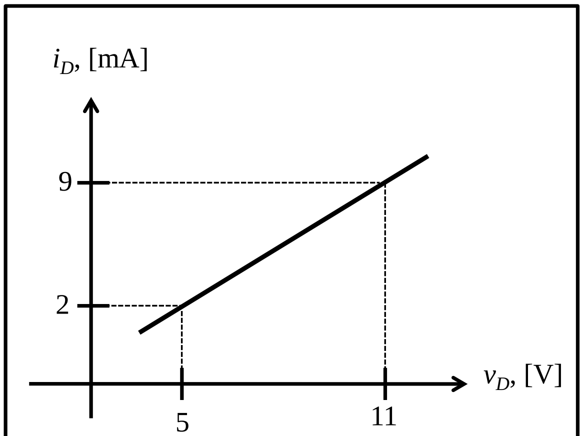


Figure 2

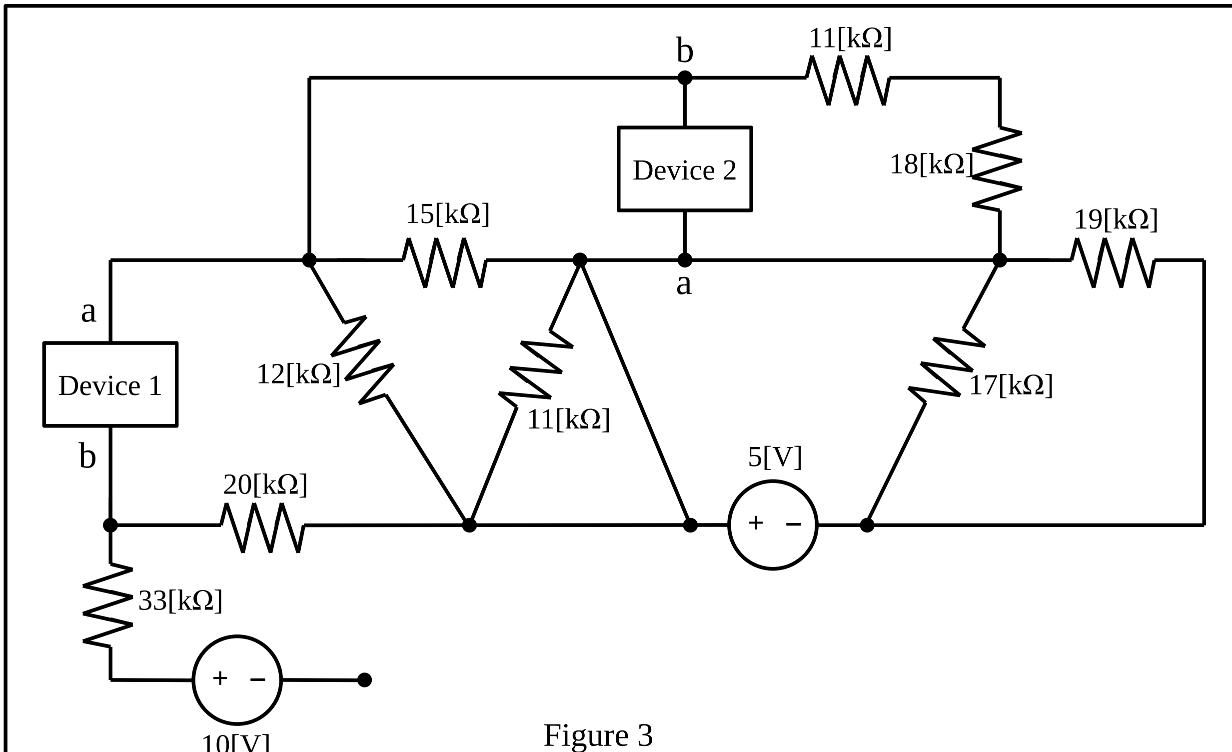


Figure 3

Room for extra work

4. {30 Points} A multi-range voltmeter is shown in Figure 1. The meter uses an analog meter, marked with three ranges, each starting at zero, and going to 10[V], 30[V] and 50[V], respectively.
a) Find the values for R_1, R_2, and R_3.
b) Assume that a resistor R_X is placed between the 30[V] terminal and the Common terminal. Find R_X so that the voltage at the 50[V] terminal with respect to the Common terminal will be 150[V] when the meter reads full scale.
c) With the R_X value you found in Part b) connected between the 30[V] terminal and the Common terminal, and with the source in Figure 2 connected with terminal **a** connected to the 50[V] terminal and terminal **b** connected to the Common terminal, find the reading on the 30[V] scale.
d) Repeat your steps in Part c), but this time connect the source in Figure 2 with terminal **a** connected to the 50[V] terminal and terminal **b** connected to the 10[V] terminal. Describe what would happen in this case.

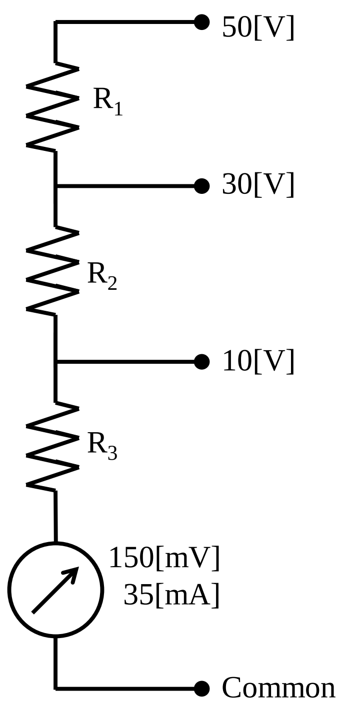


Figure 1

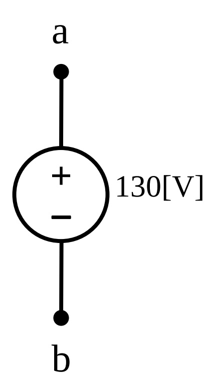
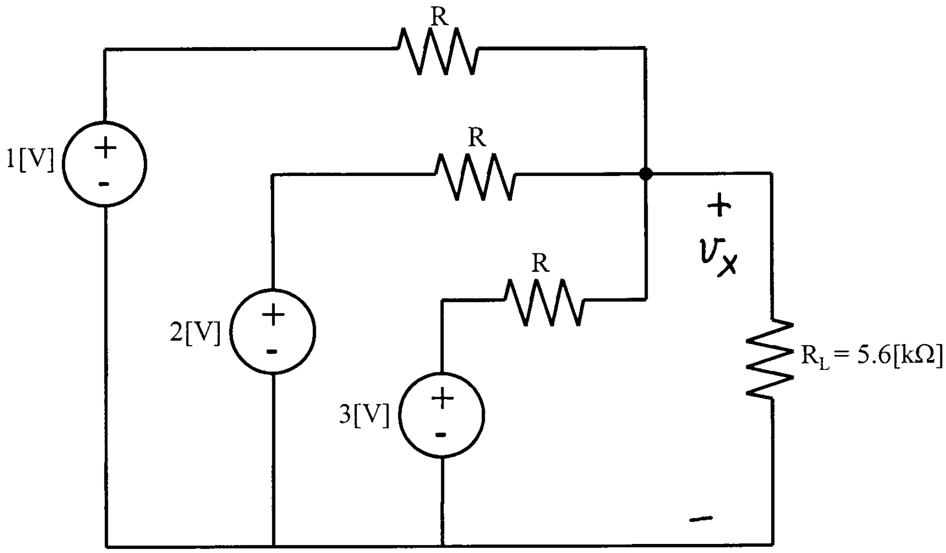


Figure 2

Room for extra work

Solutions:

1. {20 Points} Use the circuit below to solve this problem. Find the value of R, if the absorbed power by R_L is equal to 30[mW].



Since the power absorbed by R_L is 30[mW],

$$P_{ABS.BY.R_L} = 0.030[W] = \frac{(v_X)^2}{5600[\Omega]}.$$

Thus

$$(v_X)^2 = 168[V]^2$$

or

$$v_X = \pm 12.96[V]$$

So, the two solutions will be

$$\frac{1[V]-12.96[V]}{R} + \frac{2[V]-12.96[V]}{R} + \frac{3[V]-12.96[V]}{R} = \frac{12.96[V]}{5600[\Omega]}$$

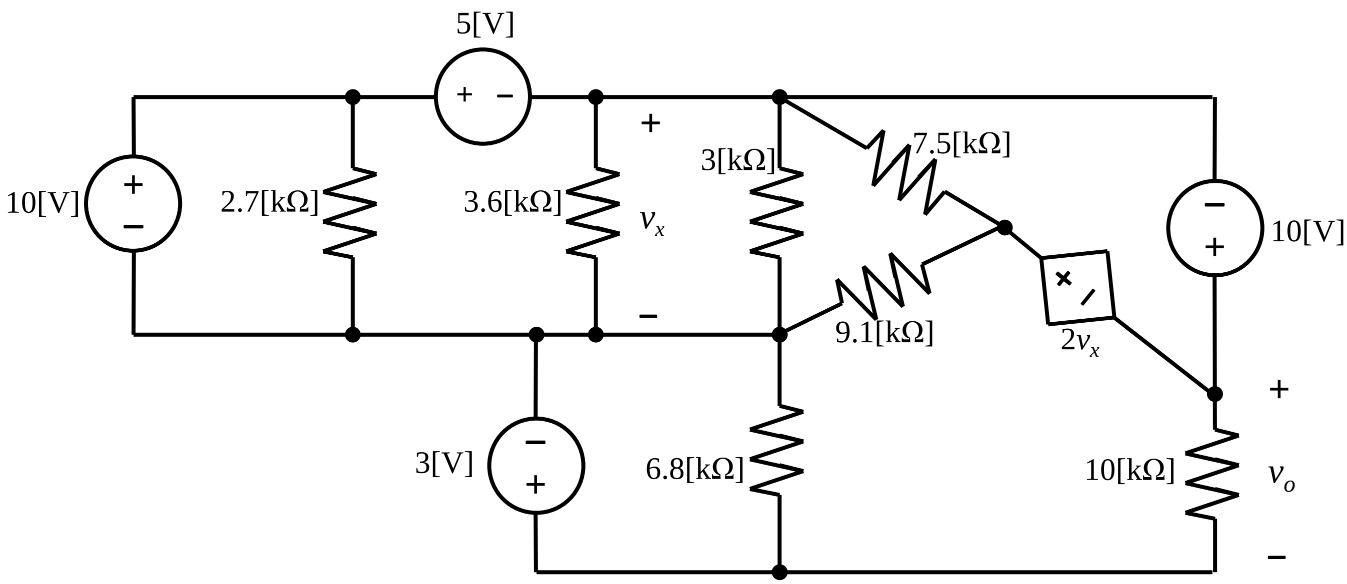
$$\boxed{R = -14.2[k\Omega]}$$

OR

$$\frac{1[V]+12.96[V]}{R} + \frac{2[V]+12.96[V]}{R} + \frac{3[V]+12.96[V]}{R} = \frac{-12.96[V]}{5600[\Omega]}$$

$$\boxed{R = -19.4[k\Omega]}$$

2. {20 Points} Find v_o by using the circuit shown below.



Solution: Take KVL around the outside of the circuit, to get

$$v_o + 3\{V\} - 10\{V\} + 5\{V\} - 10\{V\} = 0$$

Solving, we get

$$\boxed{v_o = 12\{V\}}$$

3. {30 Points} A device can be modeled as an ideal current source in parallel with a resistance. The device is shown in Figure 1. The characteristics of the device are given in terms of the relationship between the voltage across the device, and the current through the device, as shown in Figure 2. Two identical versions of this device are connected to a circuit using terminals a and b to show the polarity, as shown in Figure 3.

a) Find a model for the device showing terminals a and b.

b) Find the power delivered by Device 1.

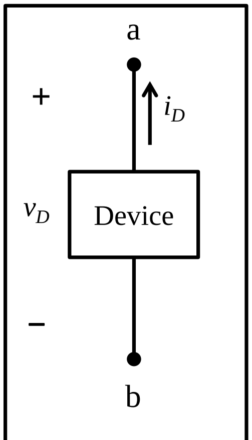


Figure 1

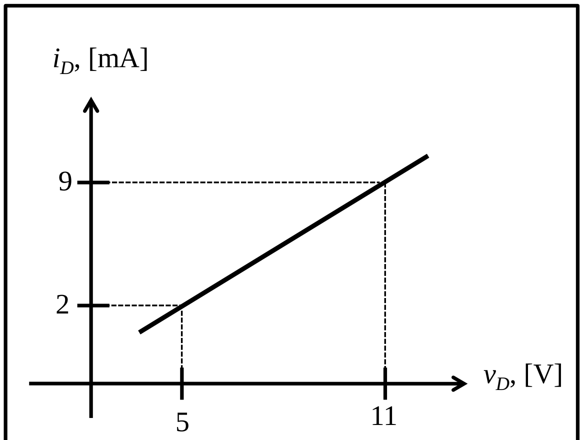


Figure 2

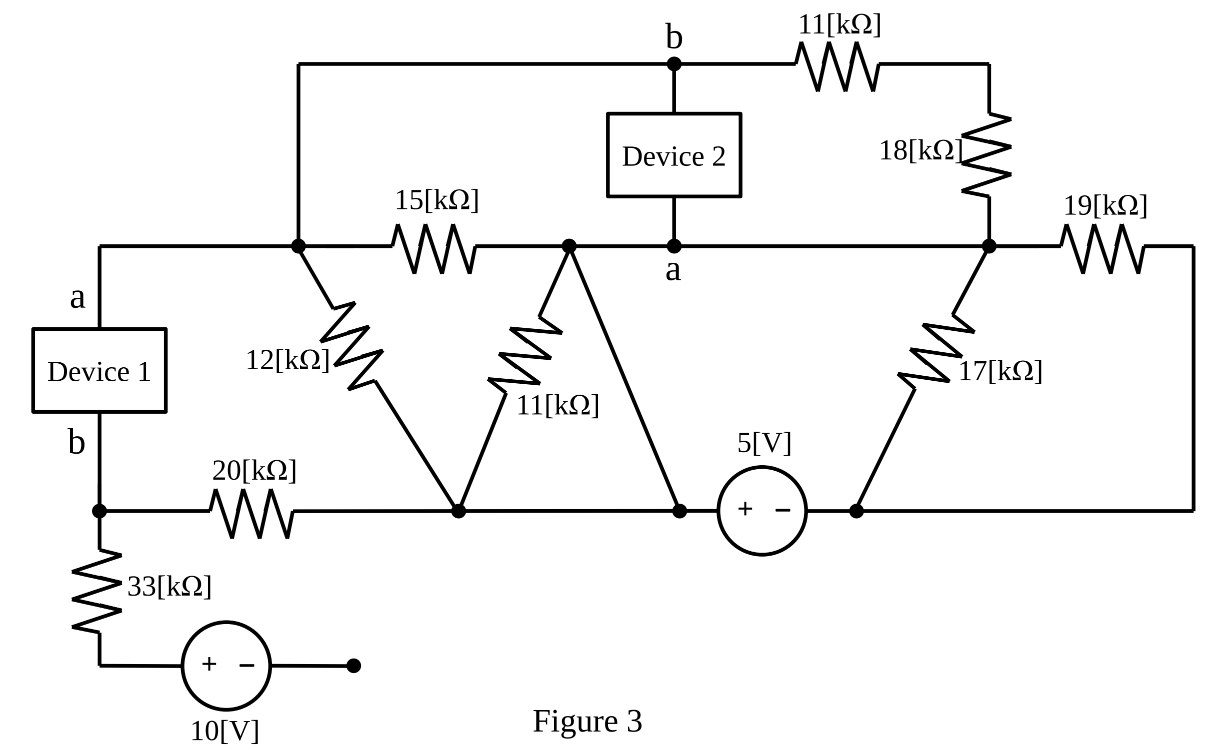
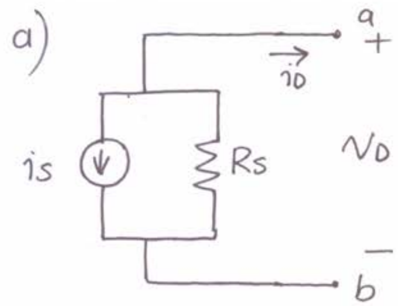


Figure 3

See next page:

a)



KCL : $i_D + i_s + \frac{v_D}{R_s} = 0$

Using the graph,

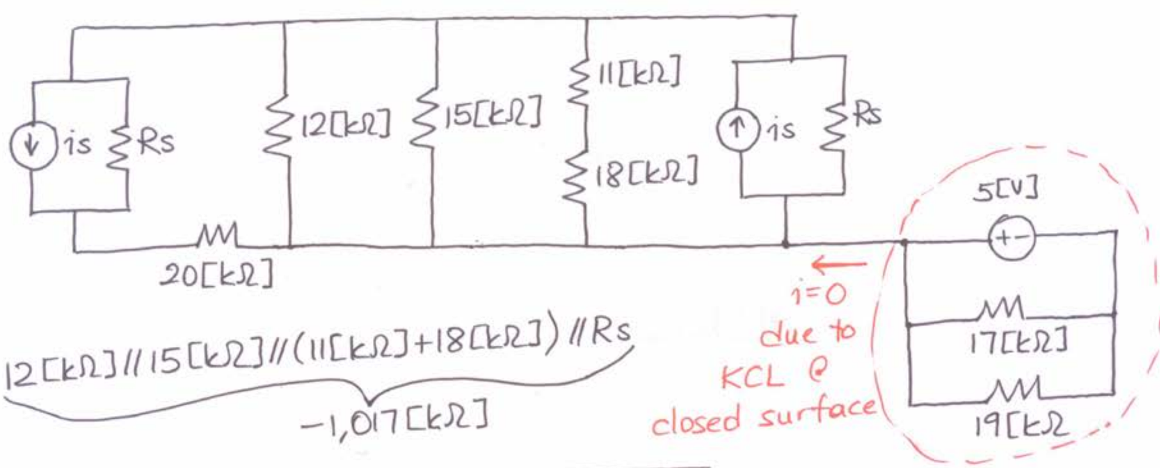
$2[mA] + i_s + \frac{5[V]}{R_s} = 0$

$9[mA] + i_s + \frac{11[V]}{R_s} = 0$

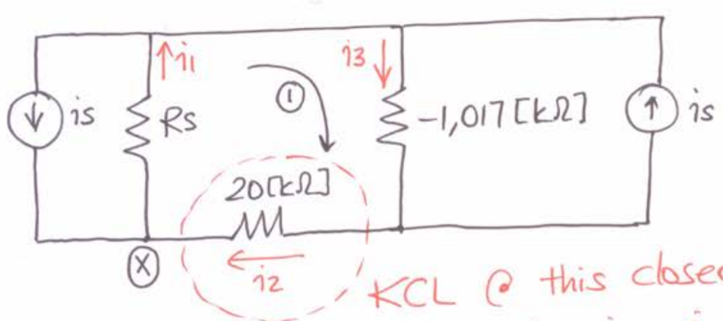
$R_s = -857[\Omega]$

$i_s = 3,834[mA]$

b) Let's redraw the circuit w/ the Devices connected. Note that 11[kΩ] resistor is shorted, 33[kΩ] resistor is ignored due to open circuit.



$12[k\Omega] // 15[k\Omega] // (11[k\Omega] + 18[k\Omega]) // R_s = -1,017[k\Omega]$



KCL @ node Ⓧ :

$-i_s + i_1 - i_2 = 0$ (1)

KCL @ this closed surface :

$-i_s + i_1 + i_s - i_3 = 0$

$i_1 = i_3$ (2)

See next page.

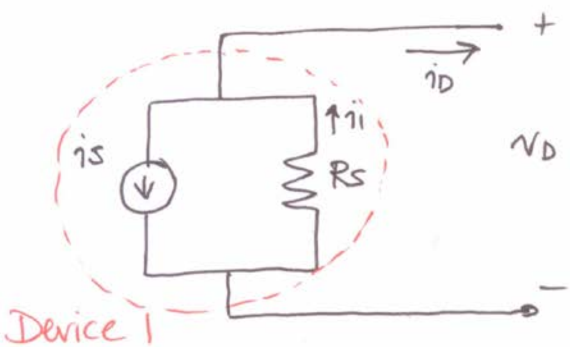
Q4. Part b) continued.

KVL loop ①: $i_1 R_S + i_3(-1{,}017[k\Omega]) + i_2 \cdot 20[k\Omega] = 0$ (3)

Solving equations (1), (2) and (3) for unknowns i_1, i_2 and i_3 gives:

$i_1 = i_3 = 4{,}23[mA]$

To find the power delivered by Device 1, we need to find the voltage across Device 1 (v_D) and the current through Device 1 (i_D).



$i_D = i_1 - i_S = 4{,}23[mA] - 3{,}834[mA] = 0{,}396[mA]$

$v_D = -i_1 \cdot R_S = -4{,}23[mA] \cdot (-0{,}857[k\Omega]) = 3{,}625[V]$

$P_{DEL,DEVICE1} = v_D \cdot i_D = 3{,}625[V] \cdot 0{,}396[mA]$

$$P_{DEL,DEVICE1} = 1{,}435[mW]$$

4. {30 Points} A multi-range voltmeter is shown in Figure 1. The meter uses an analog meter, marked with three ranges, each starting at zero, and going to 10[V], 30[V] and 50[V], respectively.
a) Find the values for R_1, R_2, and R_3.
b) Assume that a resistor R_X is placed between the 30[V] terminal and the Common terminal. Find R_X so that the voltage at the 50[V] terminal with respect to the Common terminal will be 150[V] when the meter reads full scale.
c) With the R_X value you found in Part b) connected between the 30[V] terminal and the Common terminal, and with the source in Figure 2 connected with terminal **a** connected to the 50[V] terminal and terminal **b** connected to the Common terminal, find the reading on the 30[V] scale.
d) Repeat your steps in Part c), but this time connect the source in Figure 2 with terminal **a** connected to the 50[V] terminal and terminal **b** connected to the 10[V] terminal. Describe what would happen in this case.

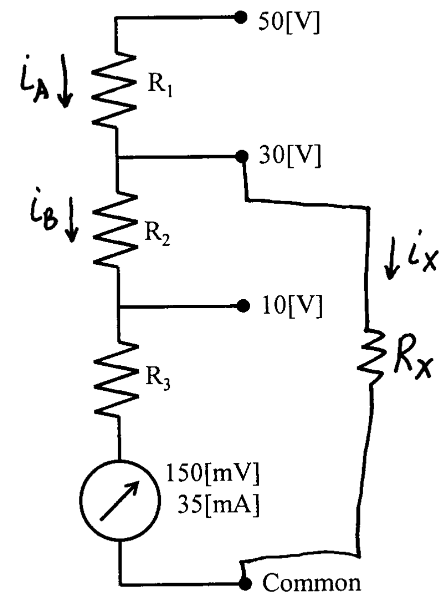


Figure 1

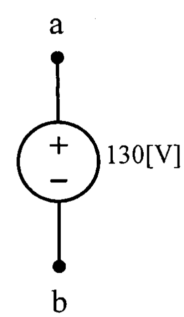


Figure 2

Solution: a) At full scale, the current through all three resistors will be 35[mA]. So, using the voltages, we have:

$$R_1 = \frac{50[V] - 30[V]}{35[mA]}$$

$$\boxed{R_1 = 571.4[\Omega]}$$

$$R_2 = \frac{30[V] - 10[V]}{35[mA]}$$

$$\boxed{R_2 = 571.4[\Omega]}$$

$$R_3 = \frac{10[V] - 0.15[V]}{35[mA]}$$

$$\boxed{R_3 = 281.4[\Omega]}$$

b) We add R_X to the diagram in Fig. 1. At full scale, with 150[V] at the top with respect to Common, we have

$$i_A = \frac{150[V] - 30[V]}{571.4[\Omega]} = 210[mA]$$

(See next page)

4.b) continued. With $i_B = 35[mA]$, since the meter is full scale, then by KCL, we have

$$i_X = (210 - 35)[mA] = 175[mA]$$

Then, by Ohm's Law

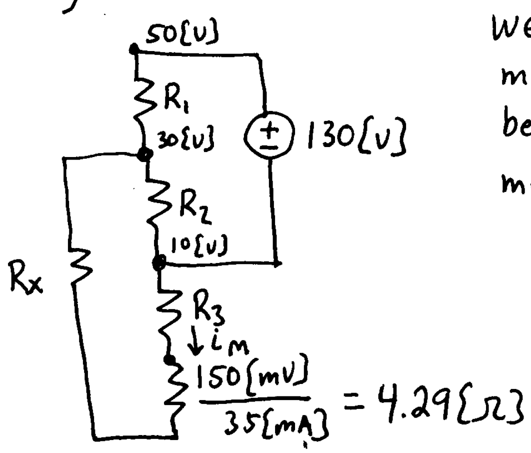
$$R_X = \frac{30[V]}{175[mA]} = \boxed{171.4[\Omega]}$$

c) We are connecting 130[V] to a meter which we have just made, with 150[V] full scale. Since the scales are proportional,

$$\frac{v_{READING}}{30[V]} = \frac{130[V]}{150[V]}$$

$$\boxed{v_{READING} = 26[V]}$$

d) We draw the circuit, and get:



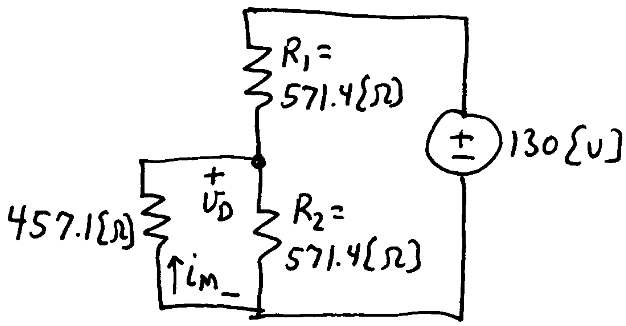
We label the current through the meter as i_M. This current must be between 0 and 35[mA] to have a meaningful reading.

$$R_X + R_3 + 4.29[\Omega] = 457.1[\Omega]$$

So, we can redraw this on the next page, as

Problem 4, Part d), continued.

Room for extra work



$$457.1[\Omega] \| 571.4[\Omega] = 254[\Omega]$$

By VDR,

$$v_D = 130[V] \frac{254[\Omega]}{254[\Omega] + 571.4[\Omega]}$$

$$v_D = 40.0[V]$$

$$i_m = \frac{-v_D}{457.1[\Omega]} = -87.5[mA]$$

This current is negative, and outside the range for a meaningful measurement. Thus, the meter will not show a meaningful reading.