Name: SOLUTIONS! (please print)

Signature: ______________________

ECE 2201 – Exam 1
October 13, 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.
3. Show your work clearly. If the grader has difficulty following or understanding 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 90 minutes to work on this exam.

1. ______________	/30
2. ______________	/35
3. ______________	/35
	Total = 100

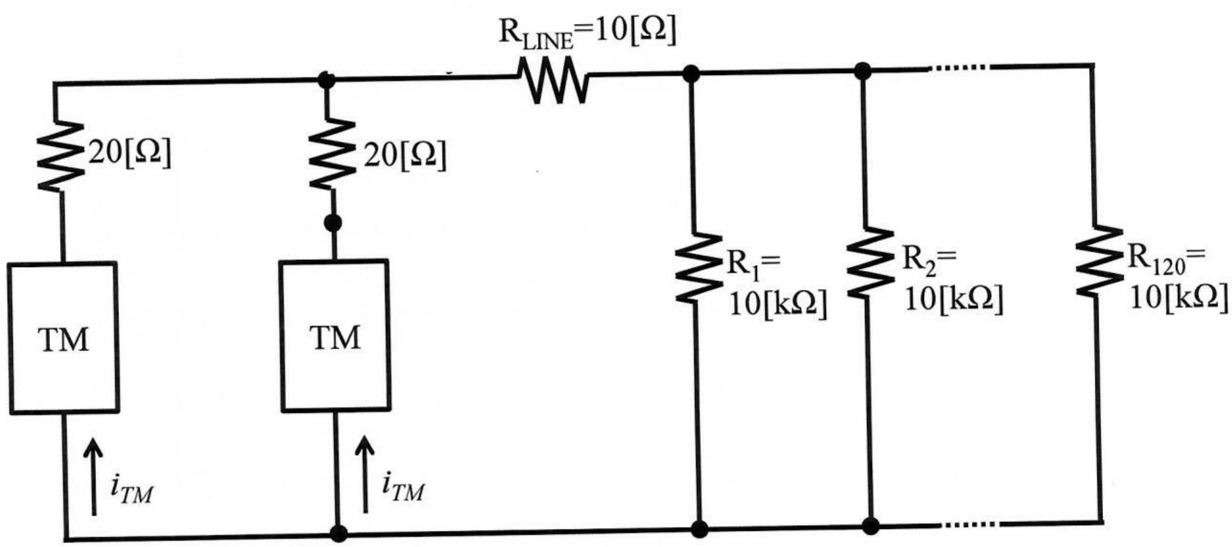
Room for extra work

1. {30 Points} Two units of the latest version of the TrombettaMax (TM) are placed in series with 20 [Ω] resistors, and installed in the circuit below. The current through each TrombettaMax is as follows.

$$i_{TM} = 220e^{\frac{-t}{25[ms]}}\ [A]$$

The load connected to the circuit consists of 120 resistors (R_1, R_2, … R_{120}) of value 10 [kΩ] each, connected in parallel. The load is connected to the TrombettaMax devices through a 10 [Ω] line resistor R_{LINE}.

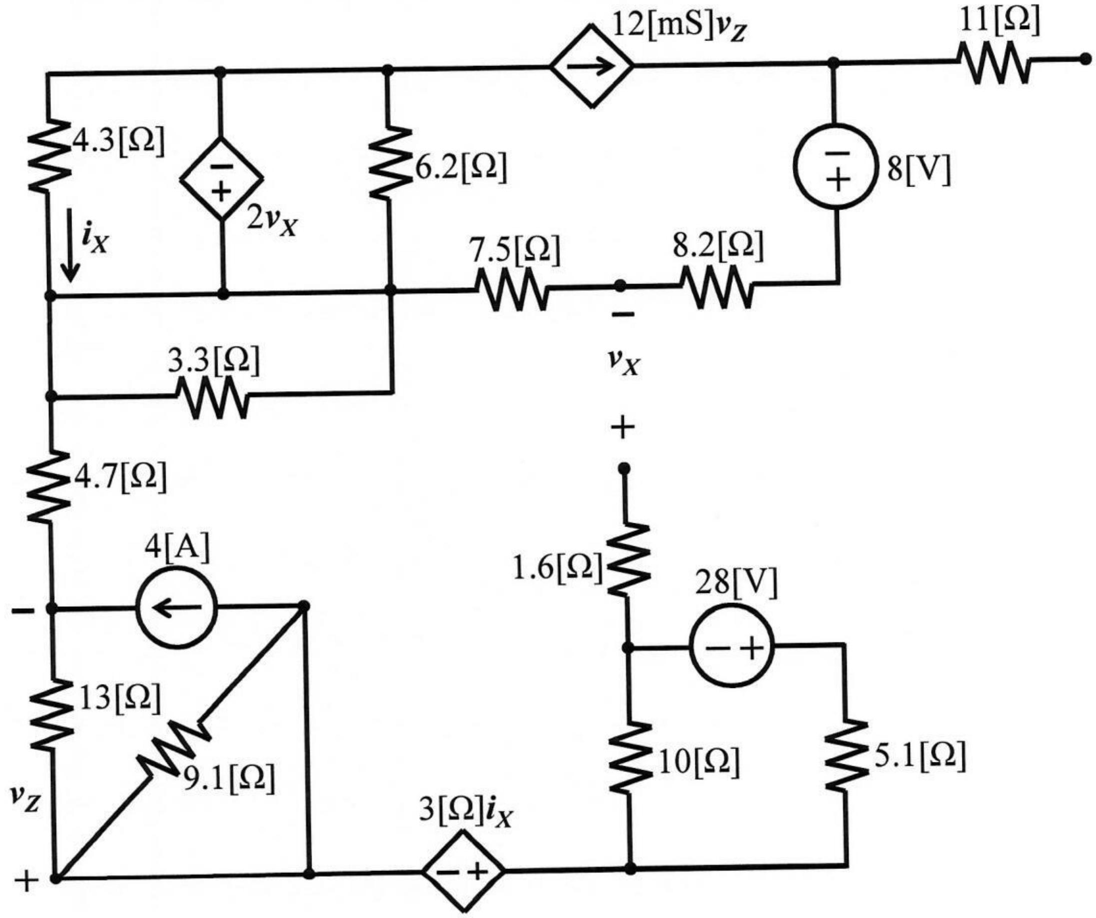
a) Find the **power** absorbed by the load (all 120 resistors) at t = 0 [ms].
b) Find the **power** absorbed by the first load resistor, R_1, at t = 10 [ms].
c) Find the **energy** delivered by each of the TM devices between 0 and 30 [ms].



Room for extra work

2. {35 Points} Use the circuit below to solve this problem.

a) Which way are the electrons moving through the 8[V] voltage source?
b) Are the electrons losing or gaining energy as they move through the 28[V] voltage source?
c) Find the power absorbed by the $2v_X$ voltage source.



Room for extra work

3. {35 Points} A device can be modeled using a current source in parallel with a resistor. This device is connected to a circuit as shown in Figure 1, where the current i_M is measured to be 2.5[A]. The same device is then connected to a circuit as shown in Figure 2, and i_P is measured to be 1.3[A].

a) Find the device model, and draw it showing terminals A and B.
b) Find the power delivered by the device if the device is connected to the circuit shown in Figure 3. Show your steps clearly.

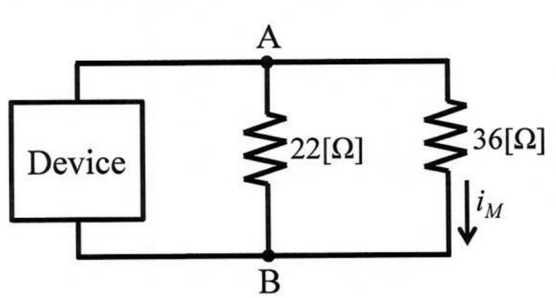


Figure 1

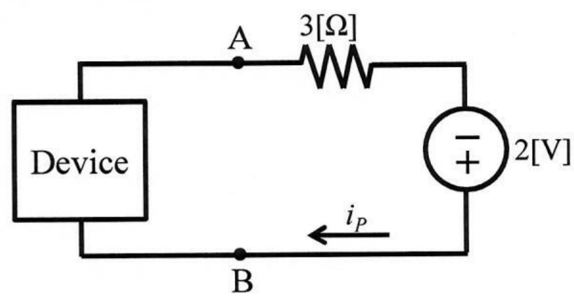


Figure 2

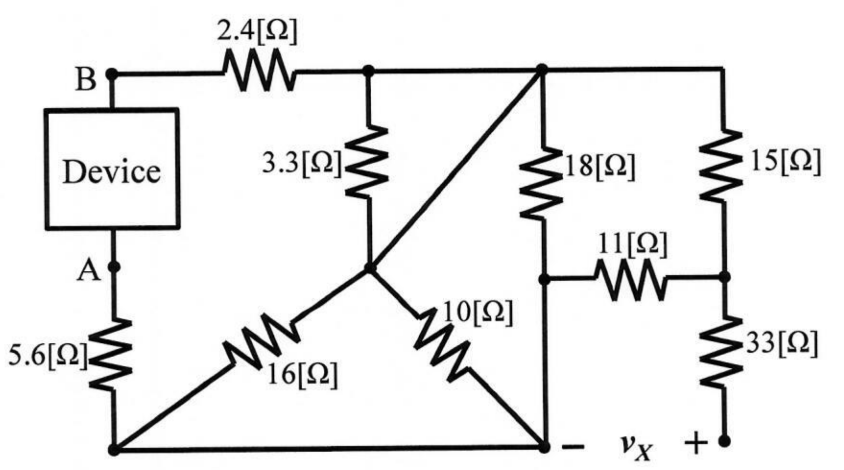


Figure 3

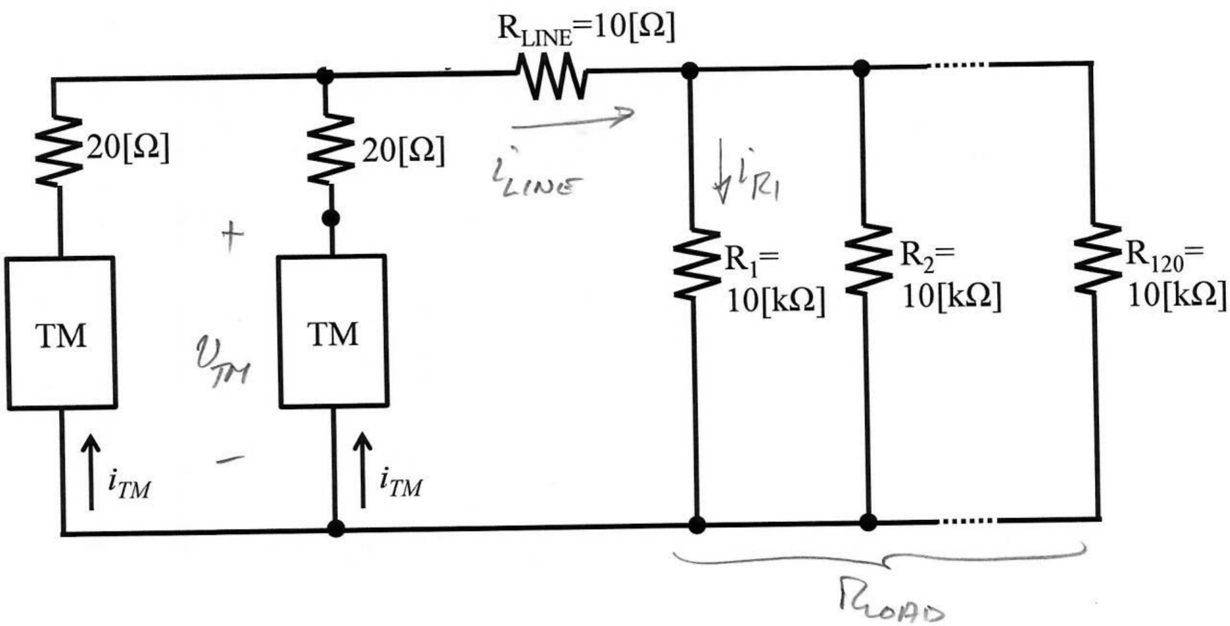
Room for extra work

1. {30 Points} Two units of the latest version of the TrombettaMax (TM) are placed in series with 20 [Ω] resistors, and installed in the circuit below. The current through each TrombettaMax is as follows.

$$i_{TM} = 220e^{\frac{-t}{25[ms]}}\ [A]$$

The load connected to the circuit consists of 120 resistors (R_1, R_2, … R_{120}) of value 10 [kΩ] each, connected in parallel. The load is connected to the TrombettaMax devices through a 10 [Ω] line resistor R_{LINE}.

a) Find the **power** absorbed by the load (all 120 resistors) at t = 0 [ms].
b) Find the **power** absorbed by the first load resistor, R_1, at t = 10 [ms].
c) Find the **energy** delivered by each of the TM devices between 0 and 30 [ms].



Simplify the load: $R_{Load} = \frac{10\,000}{120} = 83.33\ [\Omega]$ +3

a) $\therefore$ $P_{abs\ by\ R_{LOAD}} = i_{LINE}^2 \cdot R_{LOAD}$ +3

$i_{LINE} = 2 \cdot i_{TM}$ and $i_{LINE}\big|_{t=0} = 2\cdot(220)e^{-t/25[ms]}\big|_{t=0}$

$= 2\cdot(220) = 440\ [A]$

$\therefore P_{abs\ by\ R_{LOAD}} = (440)^2 \cdot 83.33 = 16.13\ [MW]\ \ (1.613\times10^7\ [W])$

+2

Room for extra work

b) The current will split evenly among the parallel resistors, so

$$i_{R1}' = \frac{i_{LINE}}{120} = \frac{2i_{TM}}{120} = \frac{11}{3} e^{-t/25[ms]} \ [A] \quad +3$$

$$P_{abs\ by\ R1} = i_{R1}'^2 \Big|_{t=10[ms]} \cdot 10000 = 10^4 \cdot \left(\frac{11}{3}\right)^2 e^{-2t/25[ms]} \Big|_{t=10[ms]} \quad +3$$

$$= 6.041 \times 10^4 \ [W]$$

c)

$$v_{TM} = 20 i_{TM} + 10 i_{LINE} + R_{LOAD} \cdot i_{LINE}$$

$$= 20 i_{TM} + 10 \cdot 2 i_{TM} + 83.33 \cdot 2 i_{TM} = 206.67 \, i_{TM} \quad +5$$

$$P_{del\ by\ TM} = v_{TM} \cdot i_{TM} = 206.67 \cdot i_{TM}^2 = 10^7 e^{-2t/25[ms]} \ [W]$$

$$w_{del\ by\ TM} = \int_0^{30[ms]} (1 \times 10^7) e^{-2t/25[ms]} dt \ [J] \quad +7$$

$$= -(1 \times 10^7)\left(\frac{25[ms]}{2}\right) e^{-2t/25[ms]} \Big|_0^{30[ms]} \ [J]$$

$$w_{del\ by\ TM} = 1.137 \times 10^8 \ [J] = 113.7 \ [MJ] \quad \begin{matrix} +2 \text{ calc} \\ +2 \text{ units} \end{matrix}$$

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b) $i_{R1}' = 2.458 \ [A]$

$v_{R1} = 2.458 \times 10k\Omega = 24.578 \ [kV]$

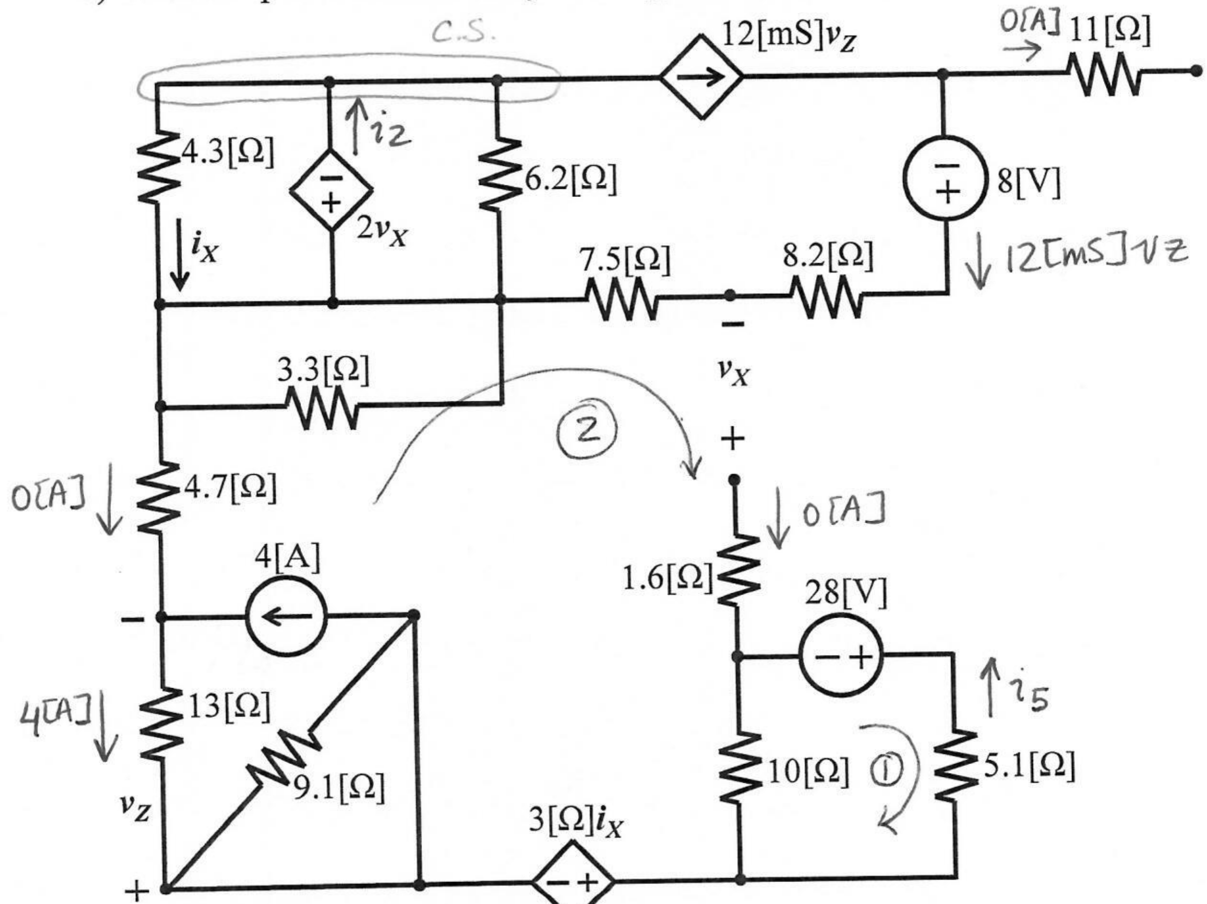
$i_{LINE}' = 294.96 \ [A]$

a) $i_{LINE} = 440 \ [A]$

$v_{Req} = 36.67 \ [kV]$

2. {35 Points} Use the circuit below to solve this problem.

a) Which way are the electrons moving through the 8[V] voltage source?
b) Are the electrons losing or gaining energy as they move through the 28[V] voltage source?
c) Find the power absorbed by the $2v_X$ voltage source.



a) Current through 8[V] is 12[mS]v_Z. $v_Z = -4[A] \times 13[\Omega]$

$v_Z = -52[V]$

12[mS]$v_Z < 0$ → Positive current flows from bottom to top, meaning that e⁻'s move from top to bottom.

b) $p_{ABS,28[V]} = 28[V] \cdot i_5 < 0 \Rightarrow$ 28[V] delivers power.

KVL around ①: $-28[V] - i_5(5.1[\Omega] + 10[\Omega]) = 0 \Rightarrow i_5 < 0$

⇒ e's gain energy.

Room for extra work

c) $p_{ABS,2v_x} = 2v_x \cdot i_z$ We need v_x and i_z.

KVL around ②:

$-v_x + i_5 \cdot 10[\Omega] + 3[\Omega] i_x + v_z - 12[mS] v_z \cdot 7.5[\Omega] = 0$ (1)

$-28[V] - i_5 \cdot 15.1[\Omega] = 0$ (2)

$4.3[\Omega] i_x + 2v_x = 0$ (3)

KCL @ c.s.: $i_x - i_z - \dfrac{2v_x}{6.2[\Omega]} + 12[mS] v_z = 0$ (4)

Solving equations (1), (2), (3) and (4), we get

$v_x = -27.49 [V]$
$i_z = 21.03 [A]$

$p_{ABS,2v_x} = 1.156 [kW]$

3. {35 Points} A device can be modeled using a current source in parallel with a resistor. This device is connected to a circuit as shown in Figure 1, where the current i_M is measured to be 2.5[A]. The same device is then connected to a circuit as shown in Figure 2, and i_P is measured to be 1.3[A].

a) Find the device model, and draw it showing terminals A and B.
b) Find the power delivered by the device if the device is connected to the circuit shown in Figure 3. Show your steps clearly.

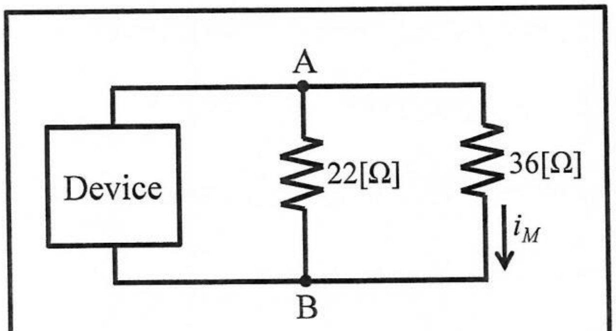


Figure 1

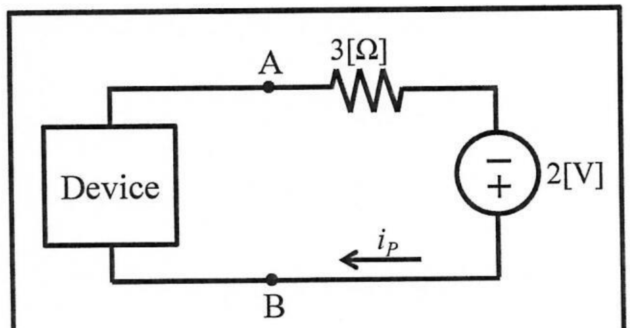


Figure 2

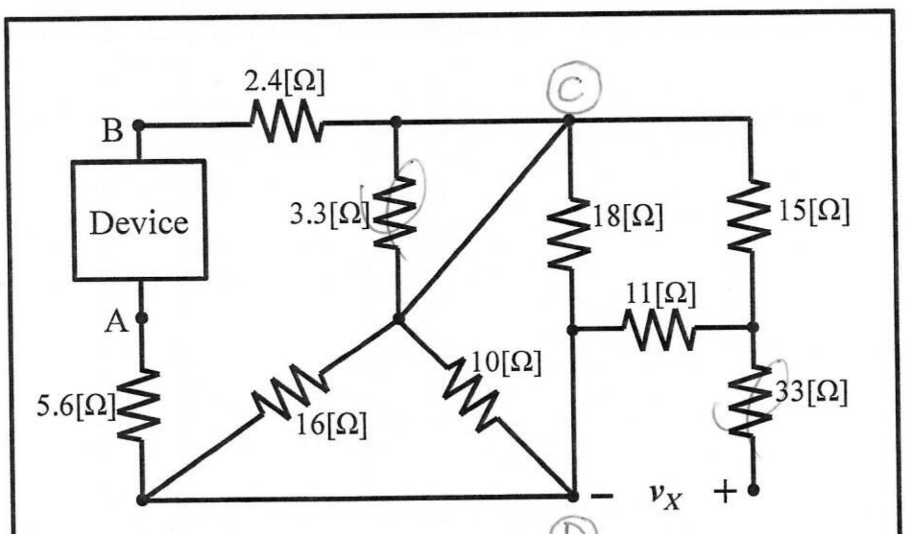
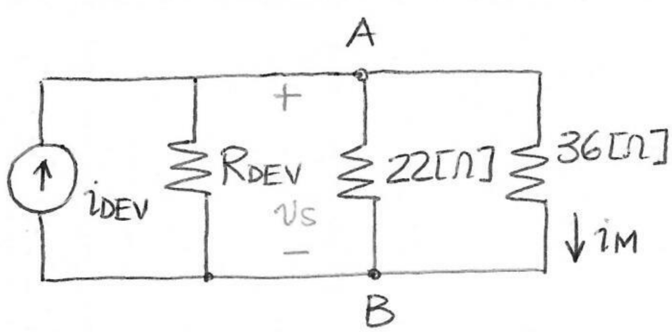


Figure 3

a)



$v_s = 36[\Omega]\, i_M = 90[V]$

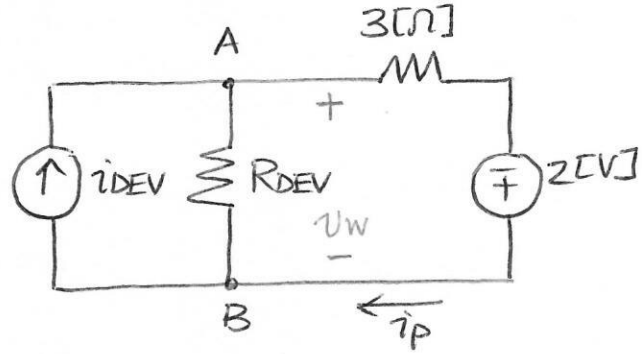
KCL @ A:

$$-i_{DEV} + \frac{90[V]}{R_{DEV}} + \frac{90[V]}{22[\Omega]} + 2.5 = 0 \quad (1)$$

Room for extra work

Alternatively, we could apply CDR : $2.5 = i_{DEV} \cdot \dfrac{R_{DEV} \parallel 22 \parallel 36}{36}$

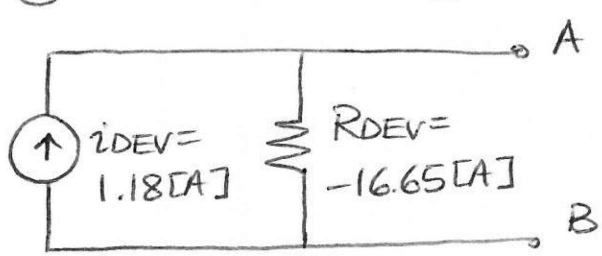
From Figure 2,



$v_W = 3i_p - 2[V]$
$= 1.9[V]$

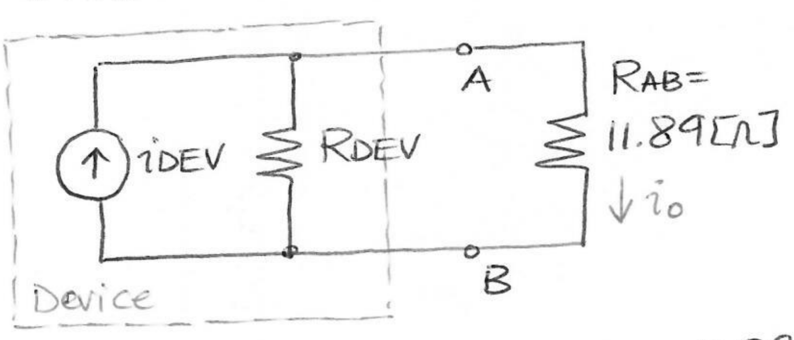
KCL @ A : $-i_{DEV} + \dfrac{1.9[V]}{R_{DEV}} + 1.3[A] = 0$ (2)

Using (1) and (2), we get : $i_{DEV} = 1.18[A]$ $R_{DEV} = -16.65[\Omega]$



b) Note that 33[Ω] resistor can be ignored (no current)
3.3[Ω] resistor can also be ignored (shorted)

$(11[\Omega] + 15[\Omega]) \parallel 18[\Omega] = 10.63[\Omega]$
$10.63[\Omega] \parallel 10[\Omega] \parallel 16[\Omega] = 3.89[\Omega]$
$5.6[\Omega] + 3.89[\Omega] + 2.4[\Omega] = 11.89[\Omega]$



CDR : $i_o = i_{DEV} \cdot \dfrac{R_{DEV}}{R_{DEV} + 11.89[\Omega]}$

$\Rightarrow i_o = 4.15[A]$

$p_{DEL,DEV} = p_{ABS,R_{AB}} = 11.89[\Omega] \cdot i_o^2 = \boxed{204.91\,[W]}$