Name: ______________________________ (please print)

Signature: ____________________________

ECE 2201 – Exam 1
March 4, 2023

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

1. This exam is closed book, closed notes. You may use any calculator. You may **not** use a cell phone, tablet computer, nor laptop computer. You may have a crib sheet in the form of one 8 ½" x 11" piece of paper, with material written on both sides.
2. Print your name, and provide your signature above.
3. 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. You may separate the pages as you work.
4. Show all units in solutions, intermediate results, and figures. Units in the exam will be included between square brackets.
5. If the grader has difficulty following your work because it is messy or disorganized, you will lose credit.
6. Do not use red ink. Do not use red pencil.
7. You will have 90 minutes to work on this exam.

1. ________________/30

2. ________________/40

3. ________________/30

Total = 100

Room for extra work

1. (30 points) The revolutionary new Trombattuck device is shown in the diagram in Figure 1 below and labeled TB. The plots of terminal voltage v_T and terminal current i_T for this device are shown in the graphs in Figures 2 and 3. Find the energy delivered by the TB device over the time period 1 to 4[ms].

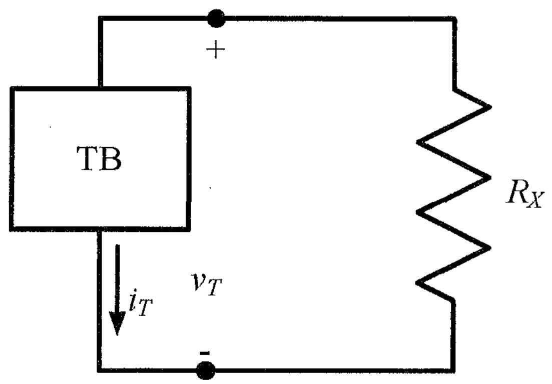


Figure 1

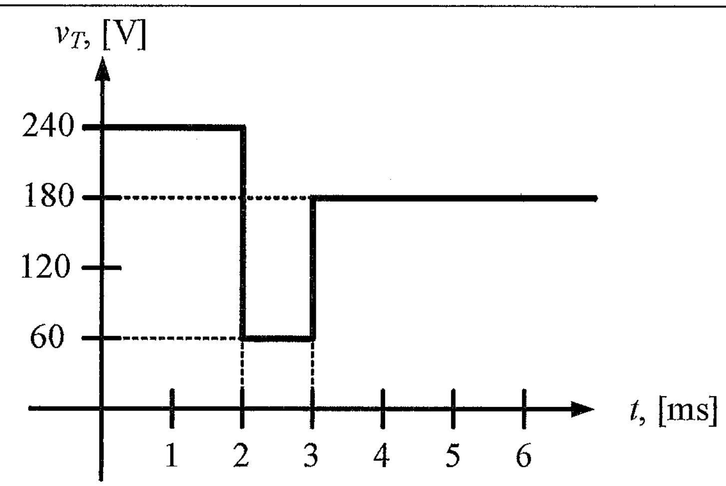


Figure 2

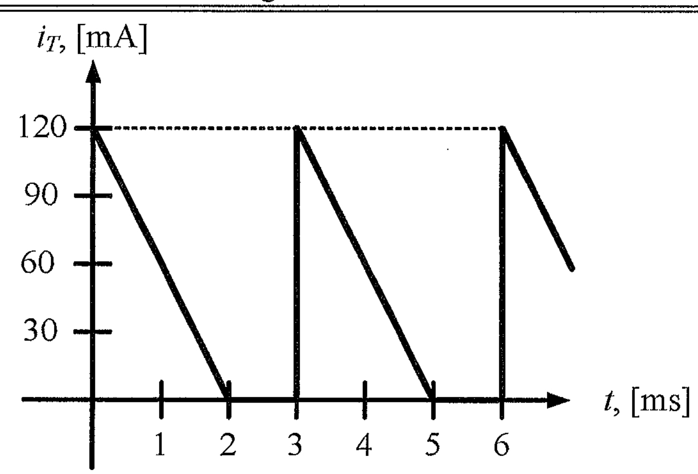
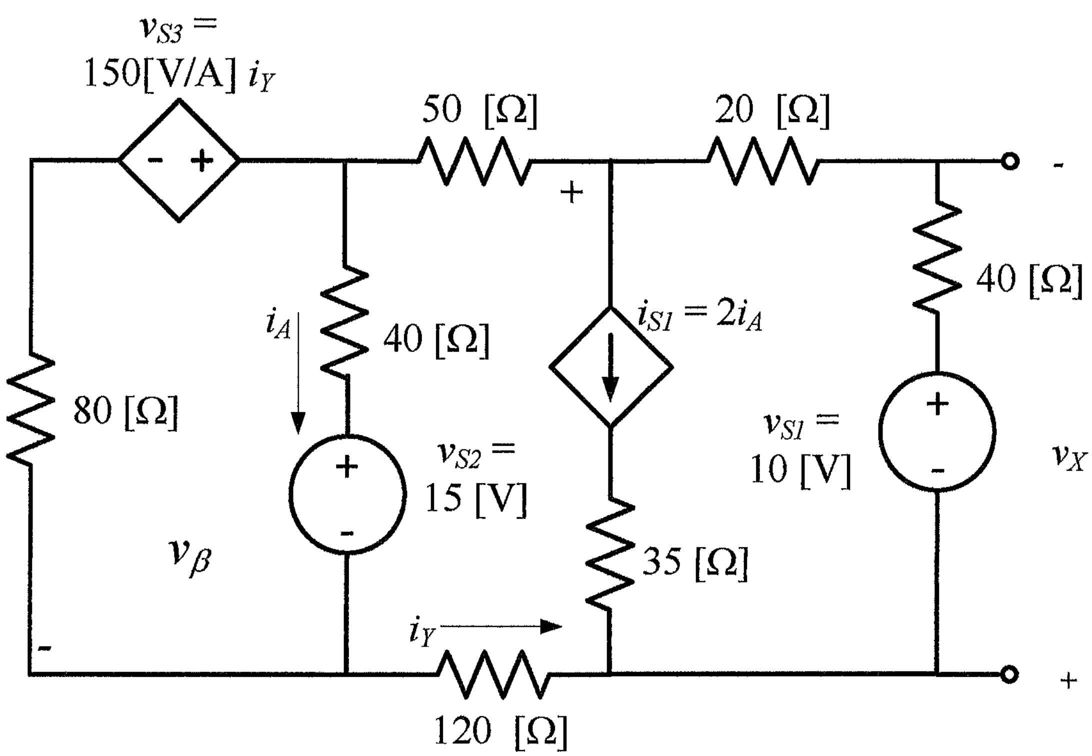


Figure 3

Room for extra work

2. (40 points) In the circuit below, v_x is known to be -14.60 [V].

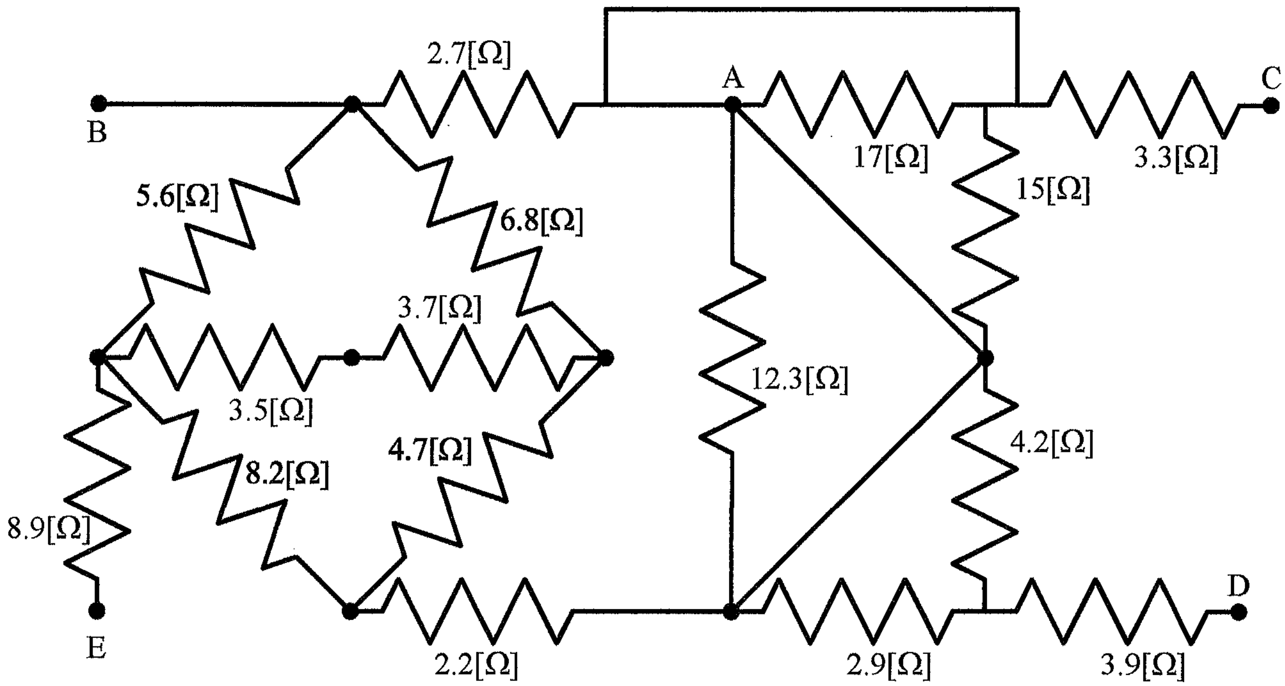
a) Find the power delivered by the dependent current source.
b) Find v_β.



Room for extra work

3. (30 points) Use the circuit shown below to solve. In your work, show your work clearly enough so that a well-prepared ECE 2201 student would be able to follow your steps. Redraw the circuit diagram as needed.

a) Find the equivalent resistance as seen from terminals D and C.
b) Find the equivalent resistance with respect to terminals B and E.



Room for extra work

Room for extra work

1. (30 points) The revolutionary new Trombattuck device is shown in the diagram in Figure 1 below and labeled TB. The plots of terminal voltage v_T and terminal current i_T for this device are shown in the graphs in Figures 2 and 3. Find the energy delivered by the TB device over the time period 1 to 4[ms].

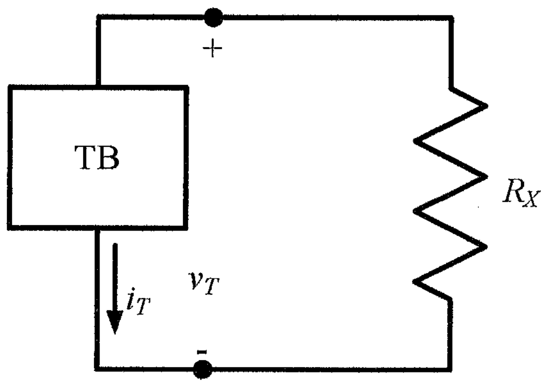


Figure 1

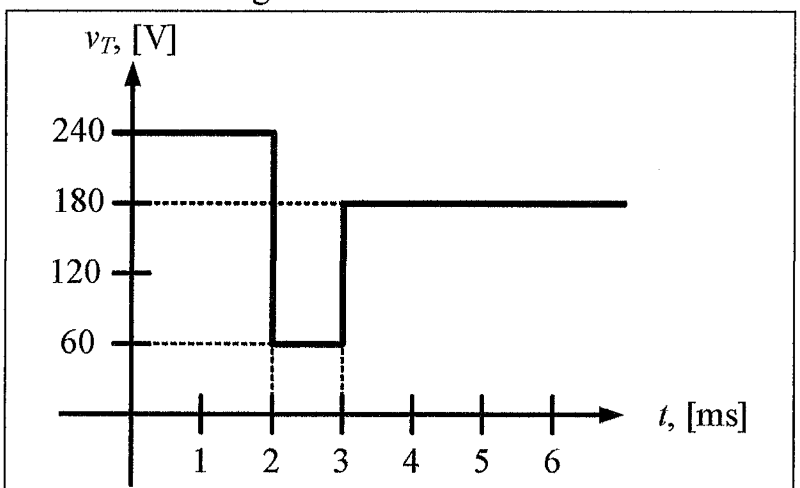


Figure 2

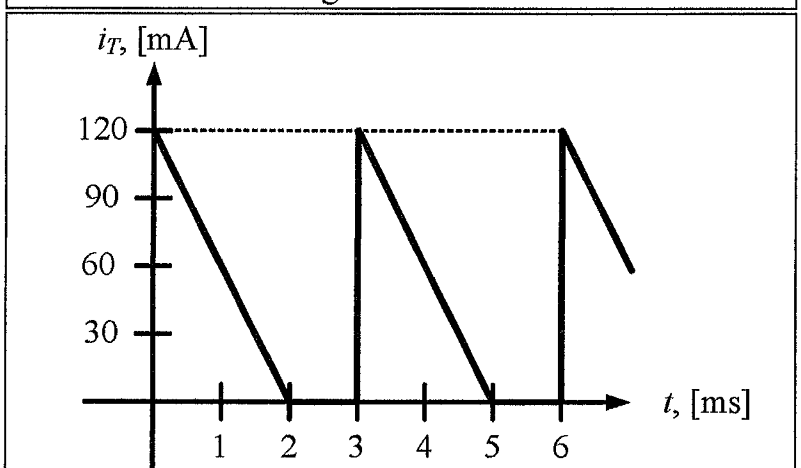
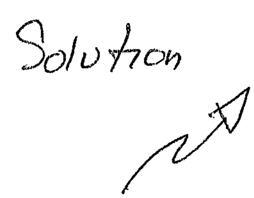


Figure 3



Room for extra work

Converting to [V], [A], [s], we have...

+4

$0 < t < 0.002\,[s]$ $\quad i_T' = 0.120[A] - 60[\frac{A}{s}]t$ $\quad v_T = 240\,[V]$ +2

$0.002\,[s] < t < 0.003\,[s]$ $\quad i_T' = 0$ $\quad v_T = 60\,[V]$ +2

$0.003\,[s] < t < 0.005\,[s]$ $\quad i_T' = 0.120[A] - 60[\frac{A}{s}](t - 0.003[s])$ $\quad v_T = 180\,[V]$

+6

$$p_{del\ by\ TB} \overset{+3}{=} -v_T\, i_T' \quad \Rightarrow \quad w_{del\ by\ TB} \overset{+3}{=} \int_{0.001[s]}^{0.004[s]} -v_T \cdot i_T'\, dt$$

$$w_{del\ by\ TB} = -\int_{0.001[s]}^{0.002[s]} 240[V] \cdot (0.120[A] - 60[\tfrac{A}{s}]t)\, dt$$

time regimes +6

$$- \int_{0.003[s]}^{0.004[s]} 180[V] \cdot (0.120[A] - 60[\tfrac{A}{s}](t - 0.003[s]))\, dt$$

First integral is $\quad -240\int_{0.001[s]}^{0.002[s]} (0.120 - 60t)\, dt = -7.2 \times 10^{-3}\,[J]$

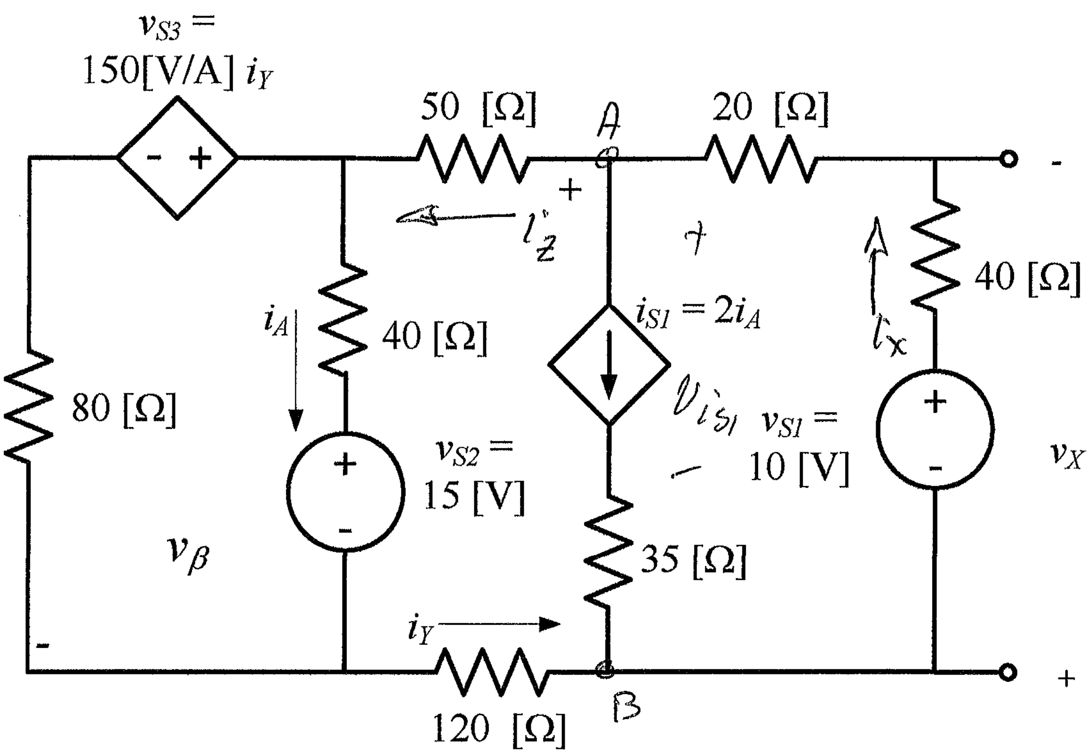
Second integral is $\quad -180\int_{0.003[s]}^{0.004[s]} (0.120 - 60t + 0.18)\, dt = -1.62 \times 10^{-2}\,[J]$

+4

So $\boxed{w_{del\ by\ TB} = -7.2\times10^{-3} - 1.62\times10^{-2} = -2.34\times10^{-2}\,[J]}$

2. (40 points) In the circuit below, v_x is known to be -14.60 [V].

a) Find the power delivered by the dependent current source.
b) Find v_β.



Knowing v_x allows us to find i_x:

$$40 i_x - v_x - 10 = 0 \Rightarrow i_x = \frac{v_x + 10}{40} = -0.115 \text{ [A]}$$

KCL at A: $i_x = 2 i_A + i_z$

KVL : $v_x + 20 i_x + 50 i_z + 40 i_A + 15 + 120 i_Y = 0$

KCL at B: $i_x = 2 i_A + i_Y$

Comparing the KCL equations, we see that $i_z = i_Y$.

Then we can solve these equations to find ...

Room for extra work

$i_A \simeq -0.0715$ [A] $i_Y = i_Z = 28.00$ [mA] $= 0.0280$ [A]

a) $v_{is_1} + 35(2i_A) + v_X + 20 i_X = 0$

$\Rightarrow v_{is_1} = 21.90$ [V]

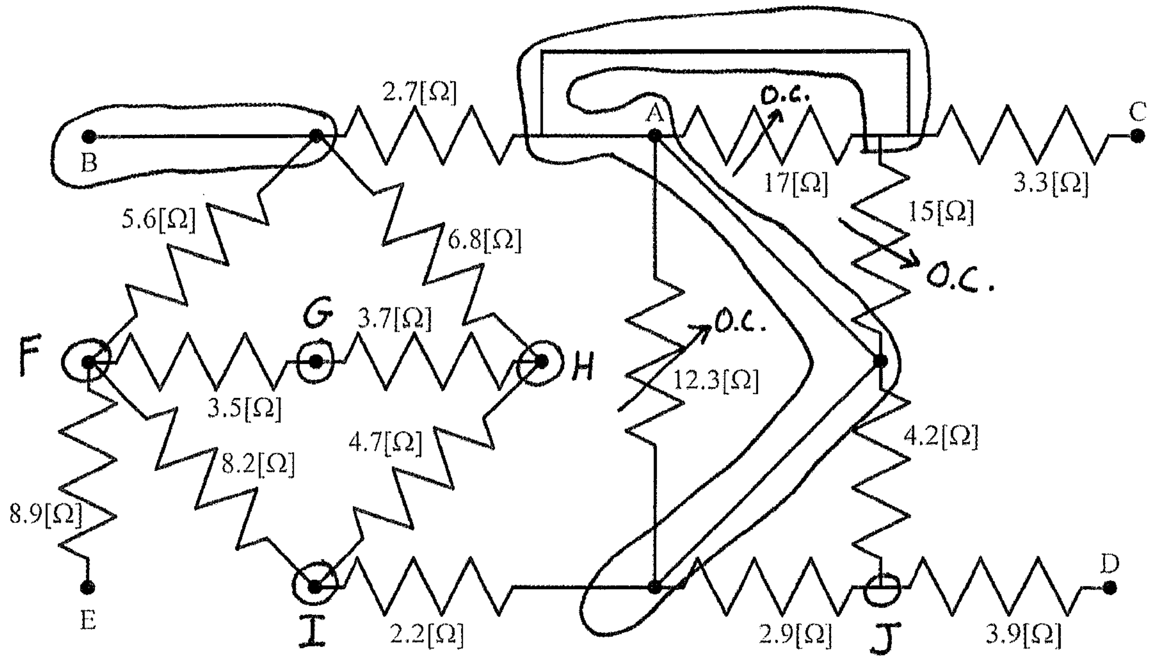
$\therefore P_{del\ by\ is_1} = -2i_A \cdot v_{is_1} = 3.132$ [W]

b) $-v_\beta - 20 i_X - v_X - 120 i_Y = 0$

$\Rightarrow v_\beta = 13.55$ [V]

3. (30 points) Use the circuit shown below to solve. In your work, show your work clearly enough so that a well-prepared ECE 2201 student would be able to follow your steps. Redraw the circuit diagram as needed.

a) Find the equivalent resistance as seen from terminals D and C.
b) Find the equivalent resistance with respect to terminals B and E.



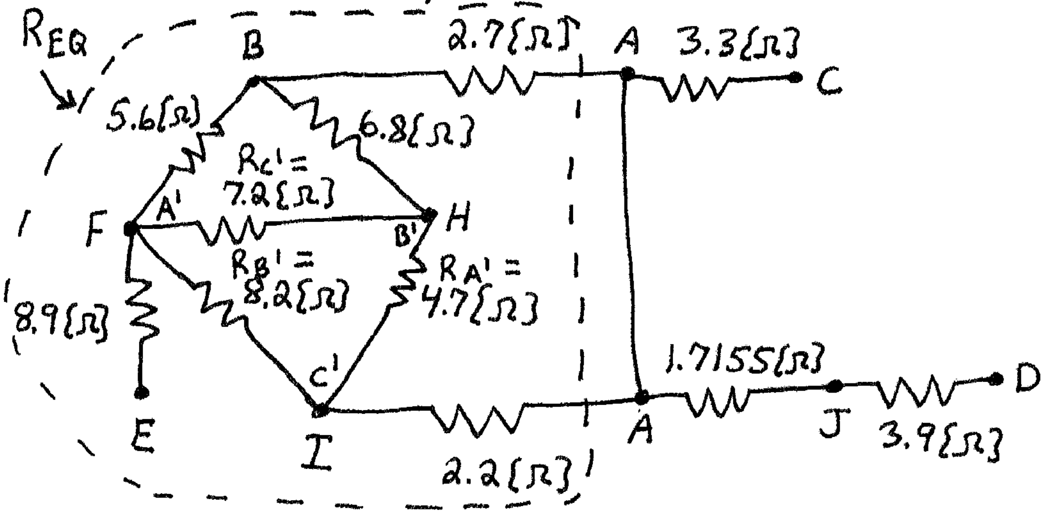
We begin by indicating and naming the nodes, on the diagram above. We can see that the 12.3{Ω} resistor, the 17{Ω} resistor, and the 15{Ω} resistor, all are shorted; that is, they each have a wire across them. Thus, we can replace each with an open circuit.

We have series resistors and parallel resistors,

$3.5\{\Omega\} + 3.7\{\Omega\} = 7.2\{\Omega\}$, and

$4.2\{\Omega\} || 2.9\{\Omega\} = 1.7155\{\Omega\}$. see next page

With these simplifications, we can redraw



a) Looking from terminals C and D, the equivalent resistance shown as R_{EQ} is in parallel with a wire which is node A. So we can replace it with an open circuit. Thus the resistance seen from C and D, R_{CD}, is

$$R_{CD} = 3.3\{\Omega\} + 1.7155\{\Omega\} + 3.9\{\Omega\} = \boxed{8.9155\{\Omega\}.}$$

b) With respect to B and E, the three resistors R_{CD} are all open circuited, and can be replaced with short circuits. We have two series resistors, $2.2\{\Omega\} + 2.7\{\Omega\} = 4.9\{\Omega\}$.

(see next page)

We can perform a delta-to-wye transformation,

$$R_1 = \frac{R_{B'} R_{C'}}{R_{A'} + R_{B'} + R_{C'}} = \frac{8.2[\Omega](7.2[\Omega])}{4.7[\Omega] + 8.2[\Omega] + 7.2[\Omega]} =$$

$$R_1 = 2.9373[\Omega].$$

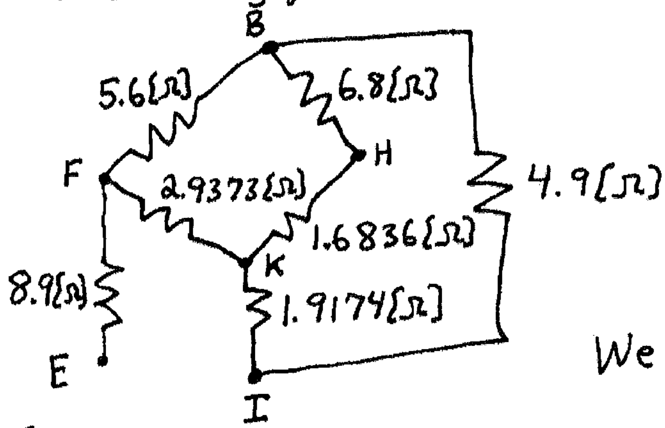
$$R_2 = \frac{R_{A'} R_{C'}}{R_{A'} + R_{B'} + R_{C'}} = \frac{4.7[\Omega](7.2[\Omega])}{4.7[\Omega] + 8.2[\Omega] + 7.2[\Omega]} =$$

$$R_2 = 1.6836[\Omega].$$

$$R_3 = \frac{R_{A'} R_{B'}}{R_{A'} + R_{B'} + R_{C'}} = \frac{4.7[\Omega](8.2[\Omega])}{4.7[\Omega] + 8.2[\Omega] + 7.2[\Omega]} =$$

$$R_3 = 1.9174[\Omega].$$

Redrawing, we have:

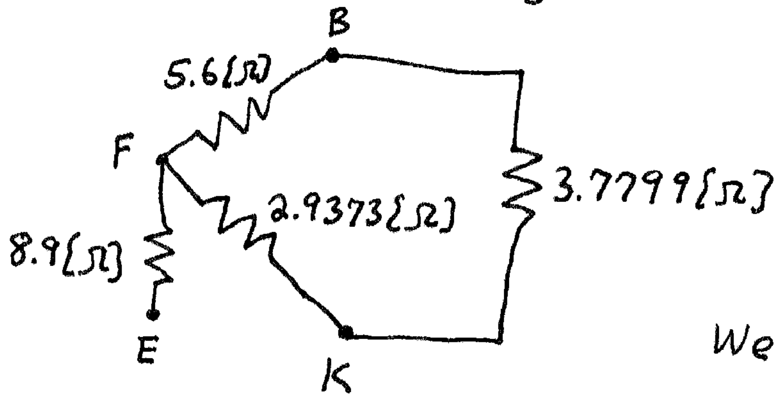


We have

$$(6.8[\Omega] + 1.6836[\Omega]) \,||\, (4.9 + 1.9174)[\Omega] = 3.7799[\Omega].$$

see next page

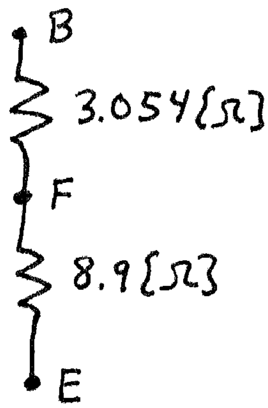
We can redraw again to obtain:



We have

$$\left(2.9373 + 3.7799\{\Omega\}\right) \parallel 5.6\{\Omega\} = 3.054\{\Omega\}.$$

We redraw one more time to obtain



the diagram, from which we see the resistance with respect to B and E, R_{BE}, is

$$R_{BE} = 3.054\{\Omega\} + 8.9\{\Omega\}$$

$$\boxed{R_{BE} = 11.954\{\Omega\}.}$$