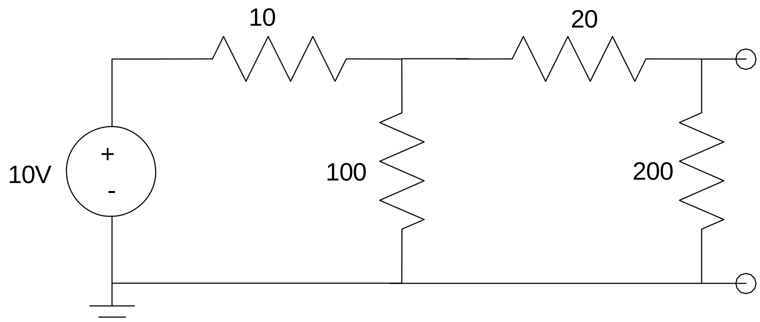
EE 206: Homework #5 Solution

Thevenin Equivalents, Maximum Power Transfer. Due Wed, Feb 24th

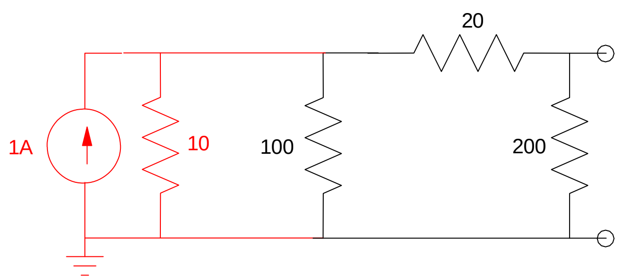
Thevenin Equivalents

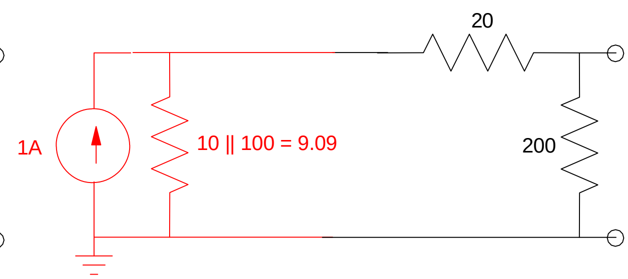
1) Find the Thevenin equivalent for the following circuit by transforming between Thevenin and Norton equivalents:

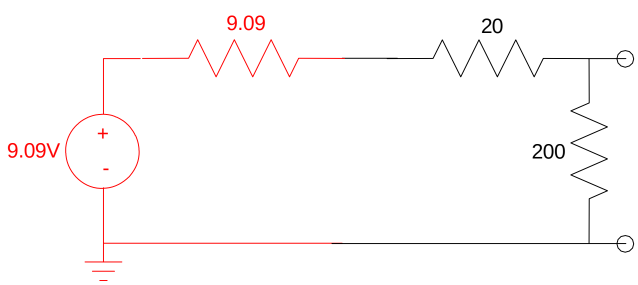


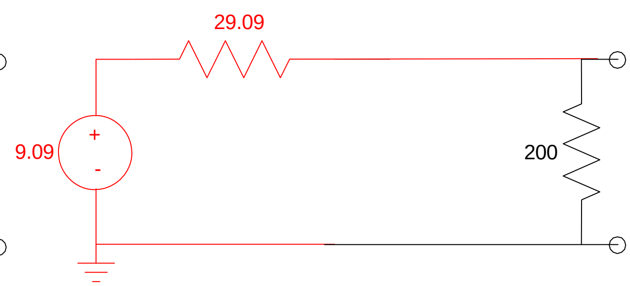
Switch back and forth between Thevenin and Norton equivalents

$I_n R_n = V_{th}$ $\qquad R_{th} = R_n$





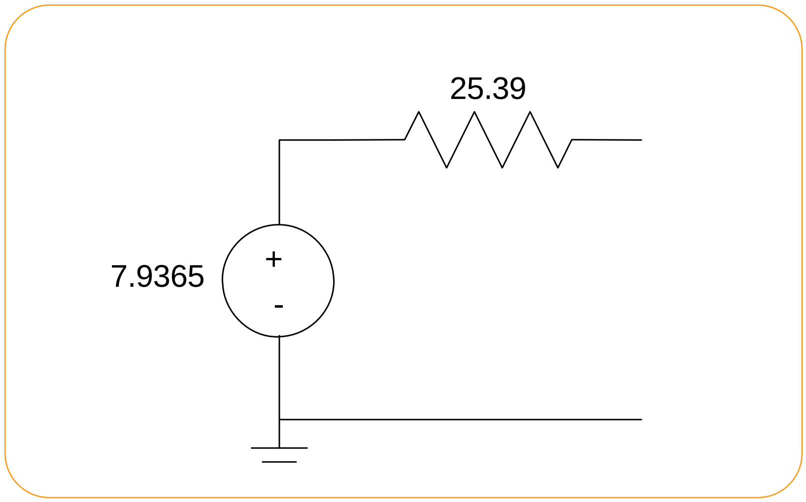




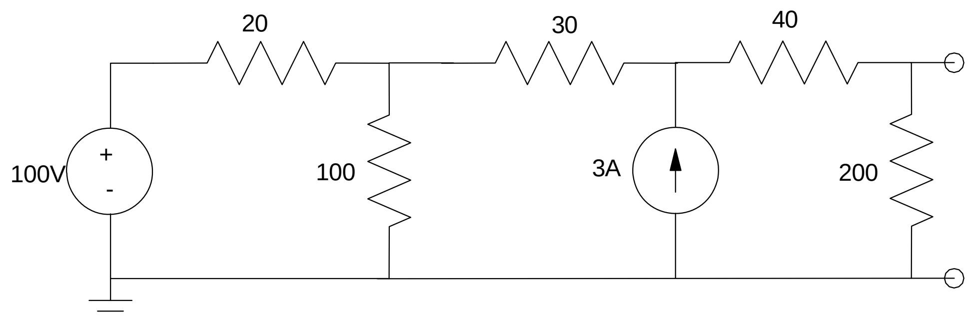
At this point we know the answer:

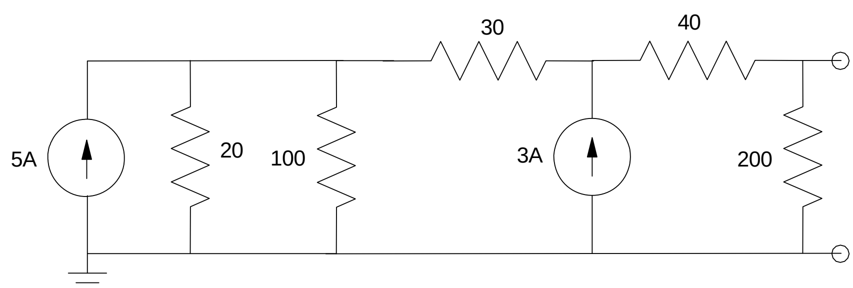
$$R_{th} = 200||29.09 = 25.39\Omega$$

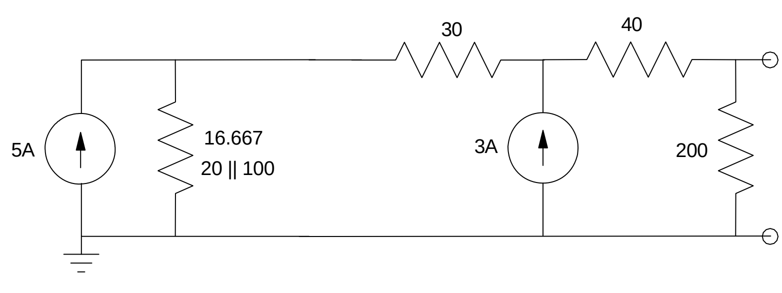
$$V_{th} = \left(\frac{200}{200+29.09}\right) \cdot 9.09V = 7.9365V$$

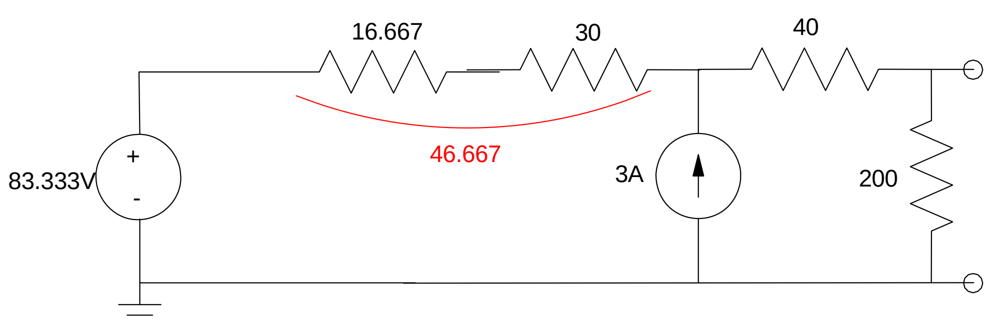


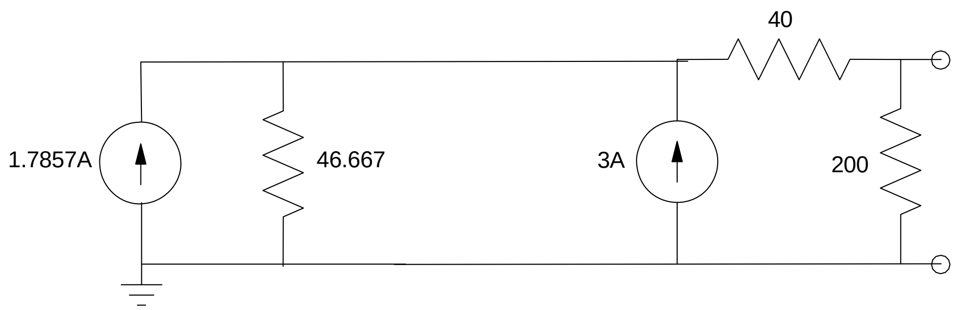
2) Find the Thevenin equivalent for the following circuit by transforming between Thevenin and Norton equivalents:

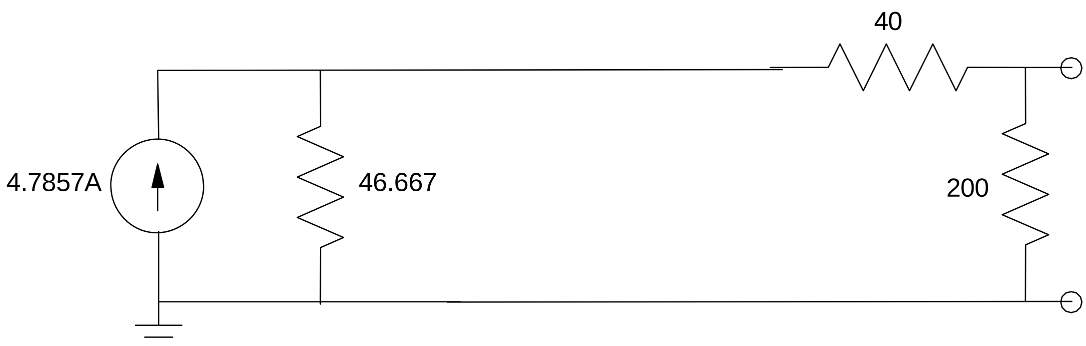


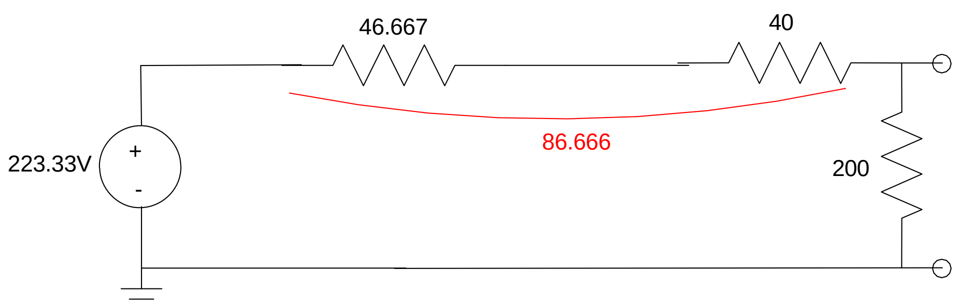


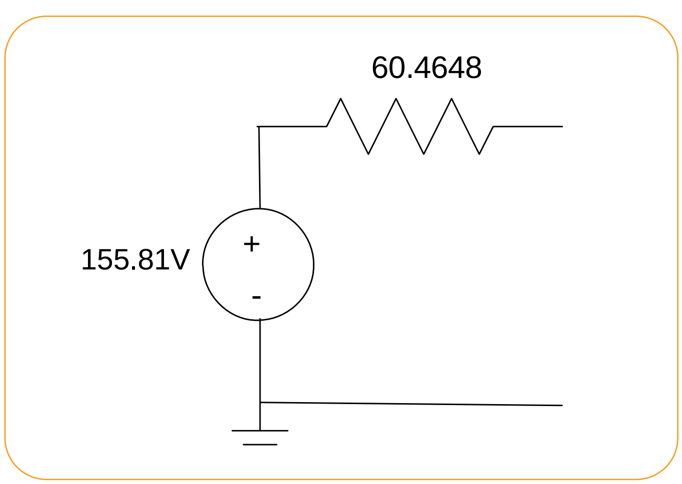




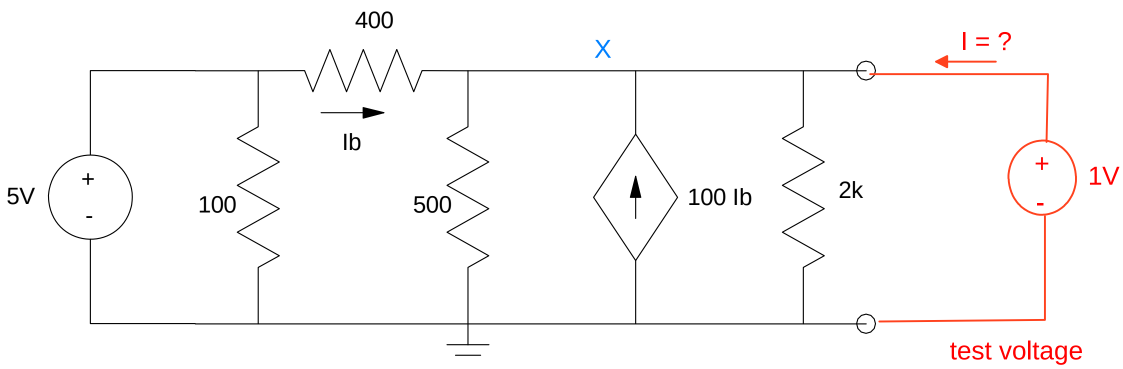

40
1.7857A
46.667
3A
200


40
4.7857A
46.667
200


46.667
40
86.666
223.33V
+
-
200


60.4648
155.81V
+
-

3) Find the Thevenin equivalent for the following circuit:



Find the open-circuit voltage

$$\left(\frac{X-5}{400}\right)+\left(\frac{X}{500}\right)-100\left(\frac{5-X}{400}\right)+\left(\frac{X}{2000}\right)=0$$

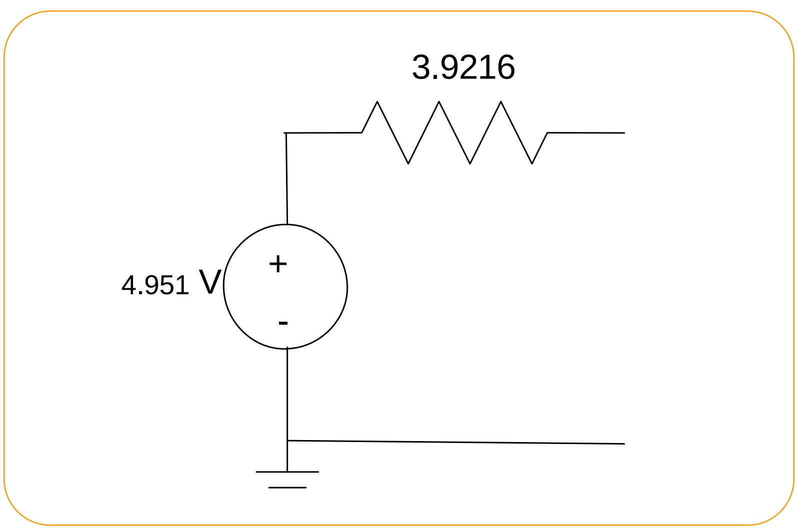
$$X=4.951V$$

Turn off the power supplies (5V goes to 0V). Measure the resistance at the output.

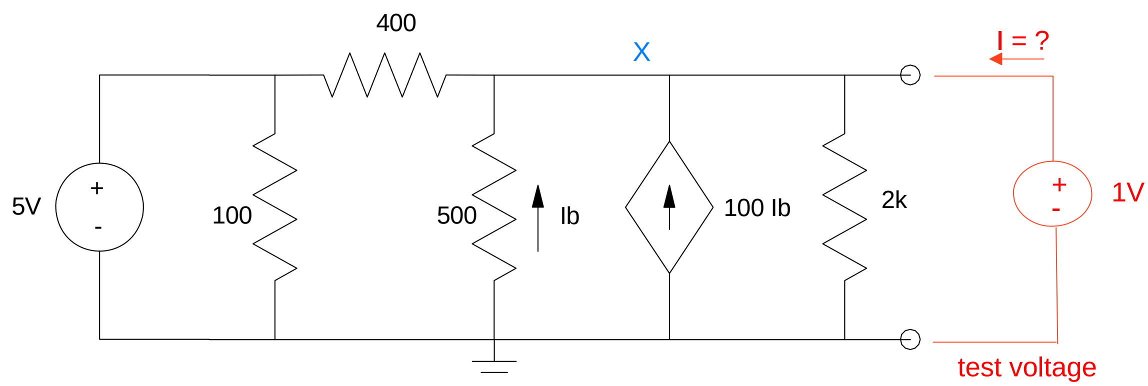
This isn't obvious, so add a 1V test voltage and compute the current

$$I=\left(\frac{1V}{400\Omega}\right)+\left(\frac{1V}{500\Omega}\right)+100\left(\frac{1V}{400\Omega}\right)+\left(\frac{1V}{2000\Omega}\right)=255mA$$

$$R_{th}=\frac{1V}{255mA}=3.9216\Omega$$



4) Find the Thevenin equivalent for the following circuit:



Compute the open-circuit voltage (write the voltage node equation at X)

$$\left(\frac{X-5}{400}\right) + \left(\frac{X}{500}\right) - 100\left(\frac{0-X}{500}\right) + \left(\frac{X}{2000}\right) = 0$$

$$X = 0.06097V$$

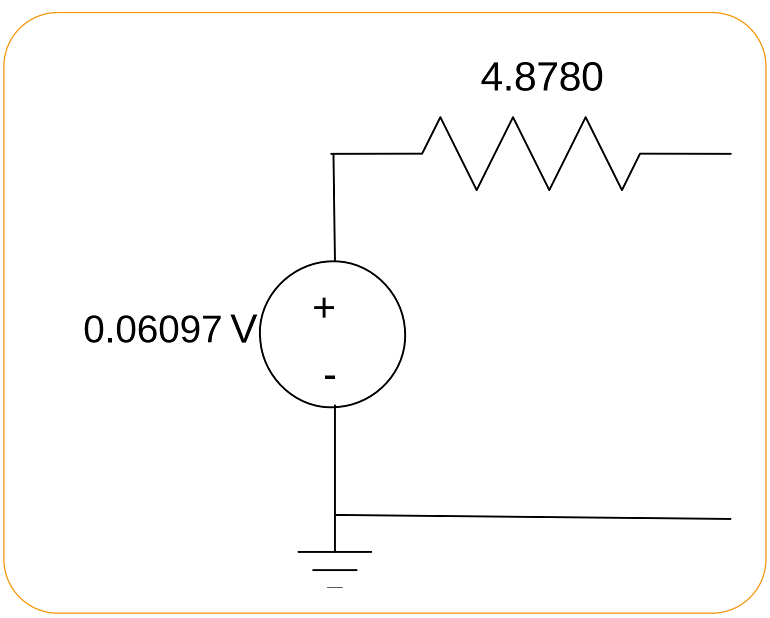
Turn off the power supply (5V becomes 0V). Compute the resistance looking in.

This isn't obvious, so add a test voltage and compute the current

$$I = \left(\frac{1}{400}\right) + \left(\frac{1}{500}\right) - 100\left(\frac{0-1}{500}\right) + \left(\frac{1}{2000}\right)$$

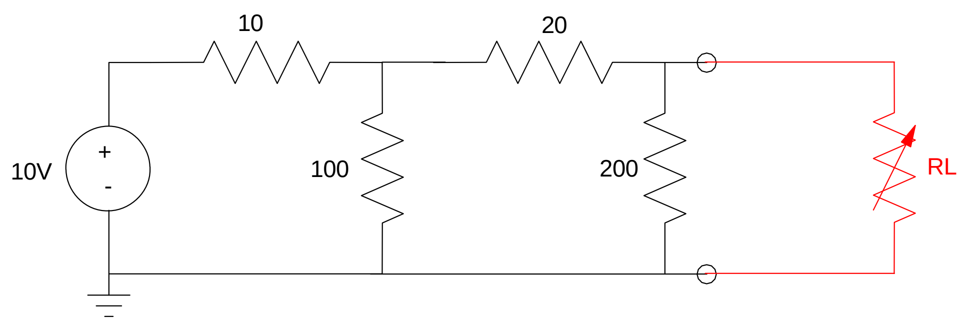
$$I = 205mA$$

$$R = \frac{1V}{205mA} = 4.878\Omega$$

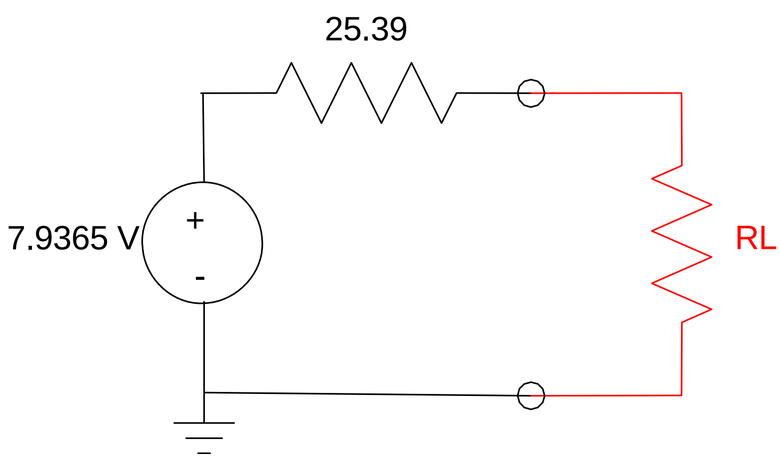


Maximum Power Transfer

5) Determine RL so that the maximum power is delivered to the load (RL)



Take the Thevenin equivalent of this circuit (problem #1)



Maximum power transfer is when RL = Rth

answer: **RL = 25.39 Ohms**

PartSim

6) Simulate the circuit of problem 5. Determine the voltage and current at the load

You can also use the Thevenin equivalent from problem #5:

	V	I	Power
R = 0	0 V	313mA	0 mW
R = 10	2.243 V	224mA	503mW
R = 25.39 max power	3.968 V	156 mA	620 mW
R = 50	5.264 V	105 mA	554 mW
R = 100	6.329 V	63 mA	401 mW
R = infinite	7.936 V	0 mA	0 mW

Note:

$$V = \left(\frac{R_L}{R_L + 25.39\Omega}\right) 7.9365V$$

$$I = \left(\frac{7.9365V}{R_L + 25.39\Omega}\right)$$

$$P = VI$$

7) Plot V vs. I on a graph and draw a line between these points. How does this line relate to the Thevenin equivalent for circuit #5?

- The y-axis interecept is I(Norton)
- The x axis intercept is V(Thevenin)
- The slope is -1/R (25.39 Volts / Amp)