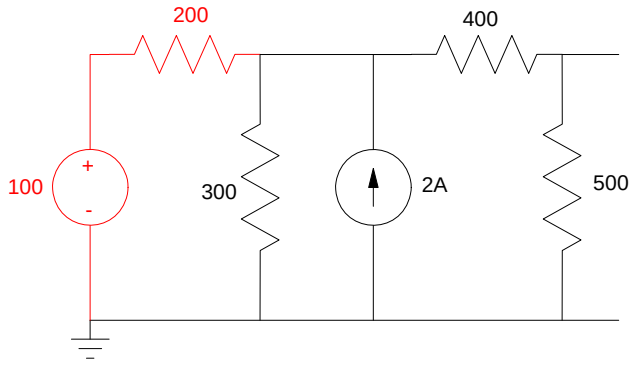
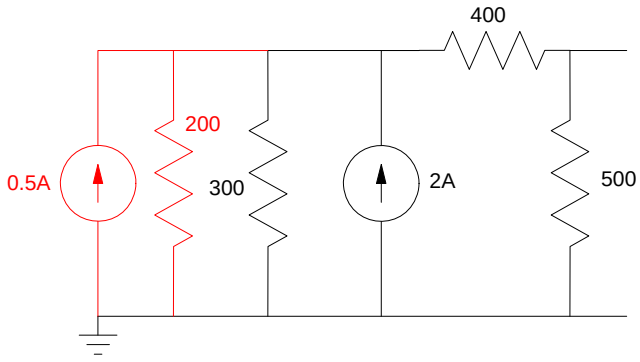
EE 206 Test #2 - Name _____

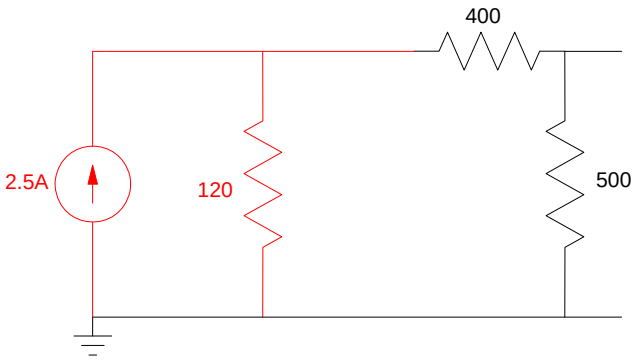
Thevenin Equivalents - Max Power Transfer - Superposition - Operational Amplifiers. March 8, 2019

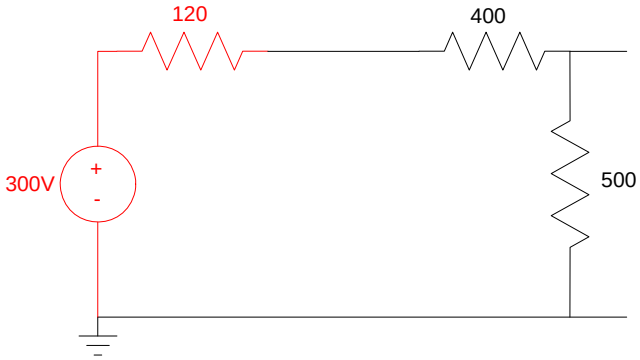
1) Determine the Thevenin equivalent for the following circuit.

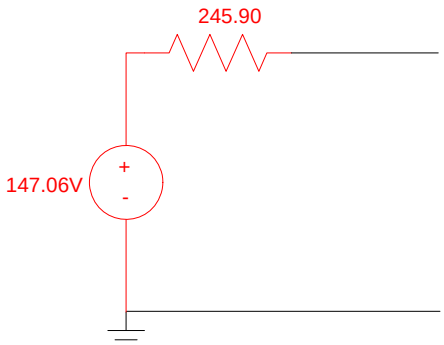
Vth	Rth
147.06 V	**245.90 Ohms**





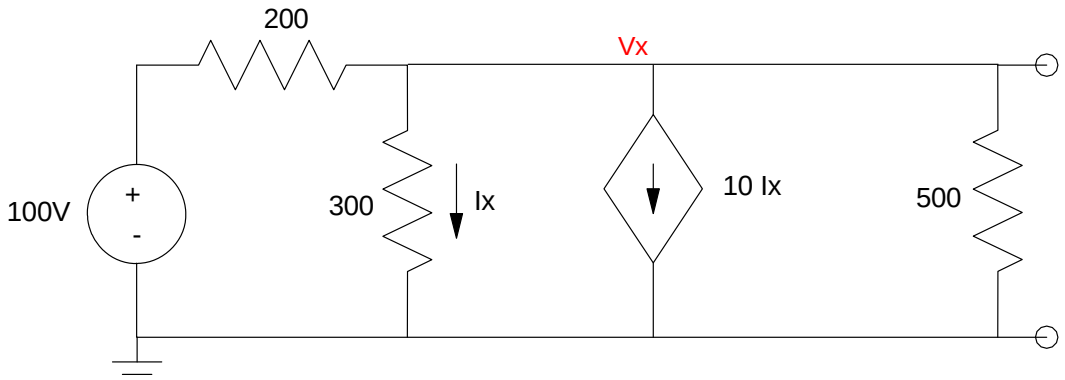






2)Determine the Thevenin equivalent for the following circuit

Vth	Rth
11.45 V	**22.9 Ohms**

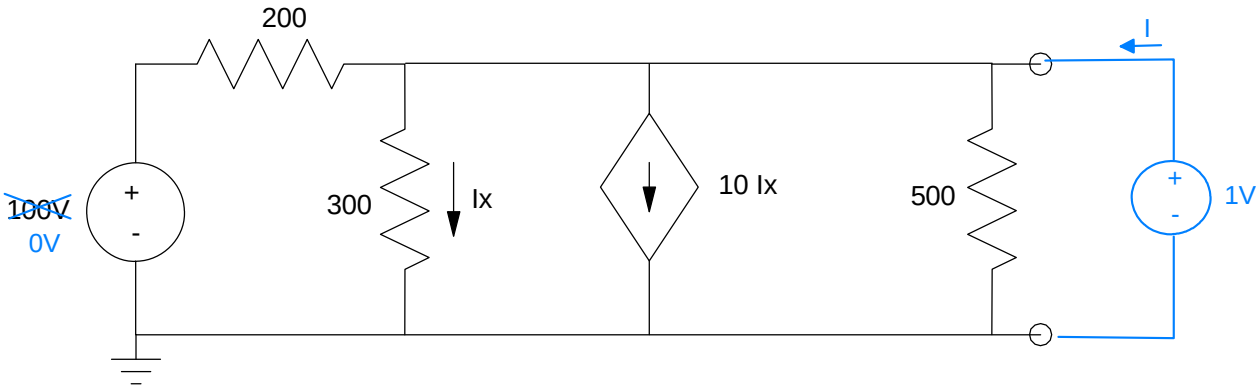


Vth: (red) Measure the open-circuit voltage (Vx)

$$I_x = \left(\frac{V_x}{300}\right)$$

$$\left(\frac{V_x - 100}{200}\right) + \left(\frac{V_x}{300}\right) + 10\left(\frac{V_x}{300}\right) + \left(\frac{V_x}{500}\right) = 0$$

$$V_x = 11.45V$$



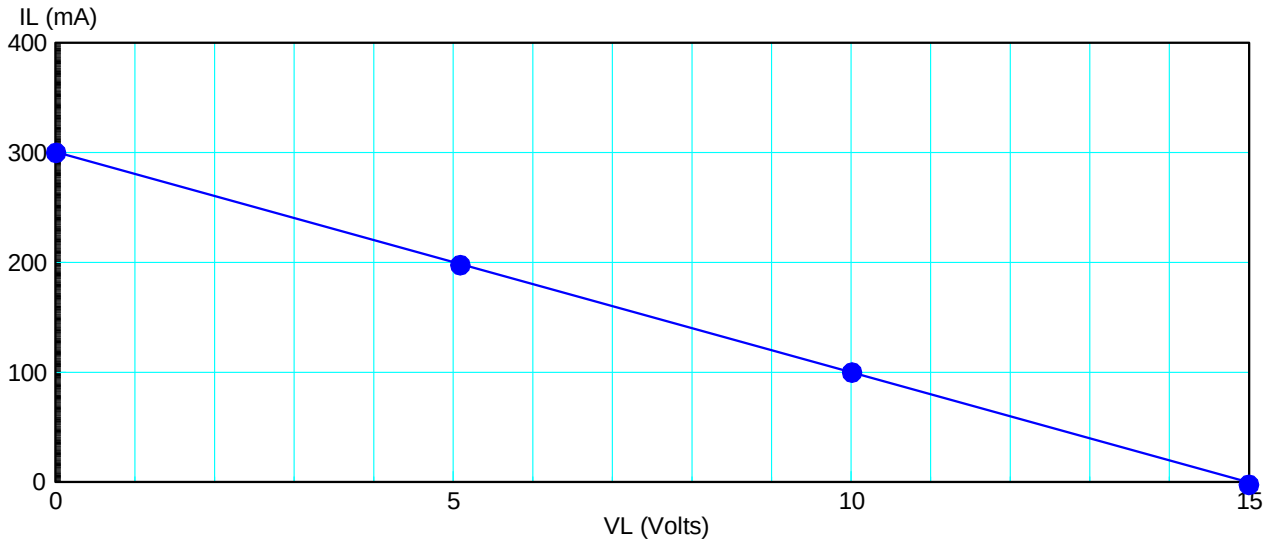
Rth: (blue) Set the voltages and currents to zero. Apply a 1V test voltage and compute the current it draws

$$I = \left(\frac{1V}{200\Omega}\right) + \left(\frac{1V}{300\Omega}\right) + 10\left(\frac{1V}{300\Omega}\right) + \left(\frac{1V}{500\Omega}\right) = 44mA$$

$$R_{th} = \left(\frac{V}{I}\right) = \left(\frac{1V}{44mA}\right) = 22.9\Omega$$

3) The voltage and current for a circuit is measured as the resistance changes.

R	infinity	100 Ohms	25 Ohms	0 Ohms
V	15V	10V	5V	0V
I	0mA	100mA	200mA	300mA



From this data, determine the Thevenin equivalend and the maximum power you can get out of this circuit.

Vth	Rth	R for maximum power transfer	Max power to R
15 V	**50 Ohms**	**50 Ohms**	**1.125 W**

The voltage is

$$V = \left(\frac{R}{R+R_{th}}\right) V_{th}$$

When R = infinity, V = Vth = 15V

When R = 0

$$I = \left(\frac{V_{th}}{R_{th}}\right) = 300mA$$

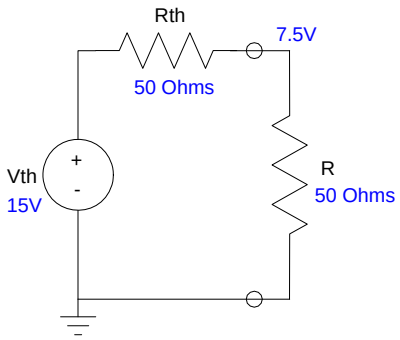
$$R_{th} = 50\Omega$$

max power transfer is when R = Rth

At R = Rth

V = 7.5V

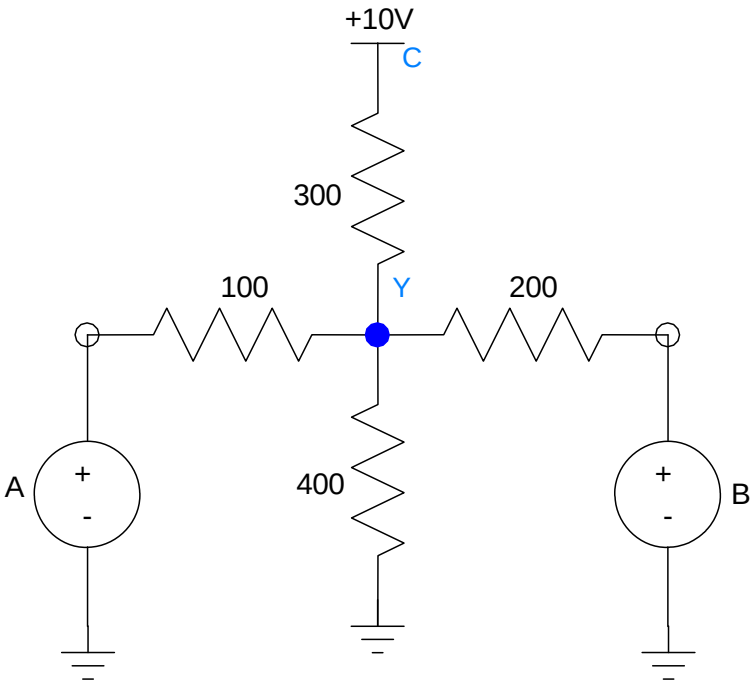
$$P = \left(\frac{V^2}{R}\right) = \left(\frac{7.5^2}{50}\right) = 1.125W$$



4) Find the voltage at Y as a function of A and B

$$Y = aA + bB + c$$

a	b	c
0.48	**0.24**	**1.6**



Using superposition

A = A, B = C = 0

$$Y = \left(\frac{300||200||400}{300||200||400+100}\right)A$$

$$Y = \left(\frac{92.31}{92.31+100}\right)A$$

$$Y = 0.48A$$

B = B, A=C = 0

$$Y = \left(\frac{100||300||400}{100||300||400+200}\right)B$$

$$Y = \left(\frac{63.15}{63.15+200}\right)B$$

$$Y = 0.24B$$

C = 10, A=B=0.

$$Y = \left(\frac{100||200||400}{100||200||400+300}\right)10$$

$$Y = \left(\frac{57.14}{57.14+300}\right)10$$

$$Y = 1.6$$

Method #2: Voltage Nodes

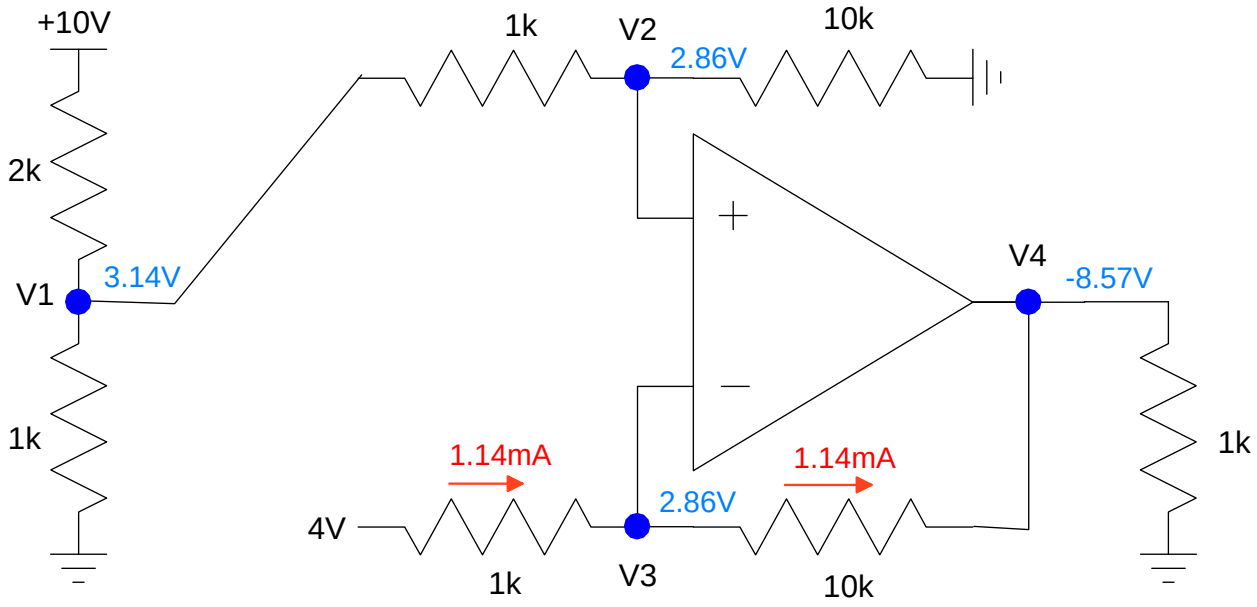
$$\left(\frac{Y-A}{100}\right) + \left(\frac{Y}{400}\right) + \left(\frac{Y-B}{200}\right) + \left(\frac{Y-10}{300}\right) = 0$$

$$\left(\frac{1}{100} + \frac{1}{400} + \frac{1}{200} + \frac{1}{300}\right)Y = \left(\frac{1}{100}\right)A + \left(\frac{1}{200}\right)B + \left(\frac{10}{300}\right)$$

$$Y = 0.48A + 0.24B + 1.6$$

5) Determine the votlages V1, V2, V3, V4. Assume ideal op-amps.

V1	V2	V3	V4
3.14V	**2.86V**	**2.86V**	**-8.57V**



Use votlage division for V1

$$1k||11k = 916.67$$

$$V_1 = \left(\frac{916.67}{916.67+2000}\right)10V = 3.14V$$

$$V_2 = \left(\frac{10k}{10k+1k}\right)V_1 = 2.86V$$

$$V_3 = V_2 = 2.86V$$

$$I = \left(\frac{4V-2.86V}{1k}\right) = 1.14mA$$

$$V_4 = V_3 - 10k \cdot 1.14mA$$

$$V_4 = -8.57V$$

or

$$V_4 = \left(\frac{10k}{1k}\right)(V_1 - 4V)$$

Bonus! Wealth inequality exists in the United State: presently, 3 families own over half of the wealth of the country.

Is wealth inequality a good thing or a bad thing? Explain.

Good:

- People need incentives to work
- If you want to start a company, it's much easier to go to a few people with lots of extra money than it is to go to a lot of people with a few extra dollars.
- To make progress, you *need* to have a surplus. Concentrating the wealth makes sure someone has more than they need.

Bad

- If you concentrate the wealth, public policy will favor the few rather than the many.
- If you concentrate the wealth, you also concentrate opportunities. The country is no longer a meritocracy.
- Too much inequality is harmful to the economy. 70% of our economy is based upon consumption. For our economy to work, people have to have money to buy things.

Example: Which has a greater impact on the economy

- One person making $50 million per year
- 1000 people making $50,000 per year?

1000 People will

- Buy 1000 houses, employing construction workers
- Buy 1000 cars, employing workers in the auto industry
- Have 1000 kids who go to school, employing teachers
- Make 1000 meals each day, employing farmers, grocers, truckers,
- etc

The ultra-rich are actually job killers, not job creators.