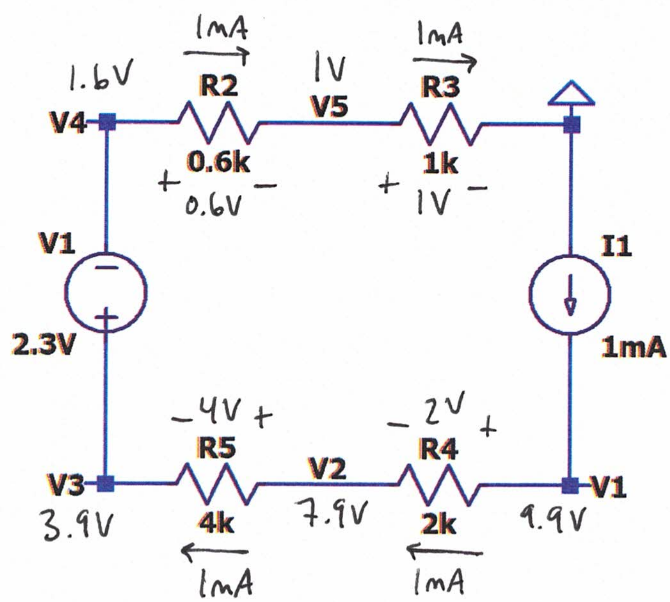
Midterm Exam – Wednesday, March 9
EE220 – Circuits I
Spring 2022

To get full credit:

- Show your work.
- Put a box around each of your answers.
- Make sure to **follow all instructions.**

1. Determine the voltages (**V1, V2, V3, V4, V5**) labeled in the circuit below. (15 points)

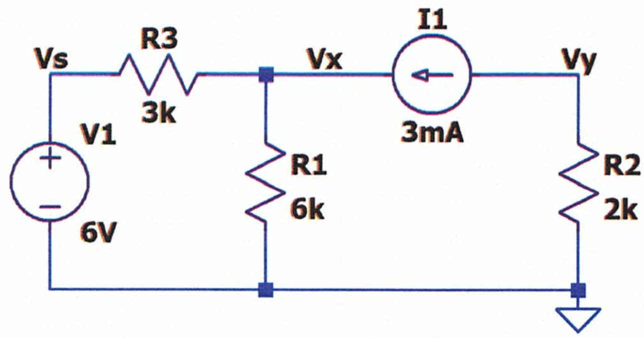
(2 mins)



$V_1 = 9.9V$
$V_2 = 7.9V$
$V_3 = 3.9V$
$V_4 = 1.6V$
$V_5 = 1V$

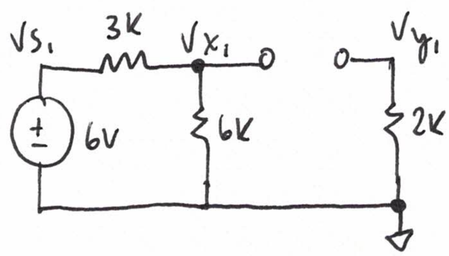
2. Determine **Vx** in the following circuit **using superposition**. Then, determine the current flowing through R1. (15 points)

(7 mins)



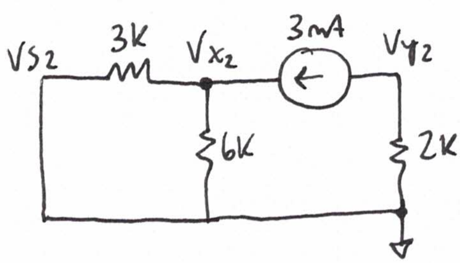
$V_x = V_{x_1} + V_{x_2}$

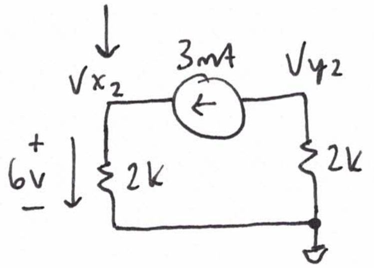
(1)



$V_{x_1} = 6V \cdot \frac{6K}{3K+6K} = 4V$

(2)





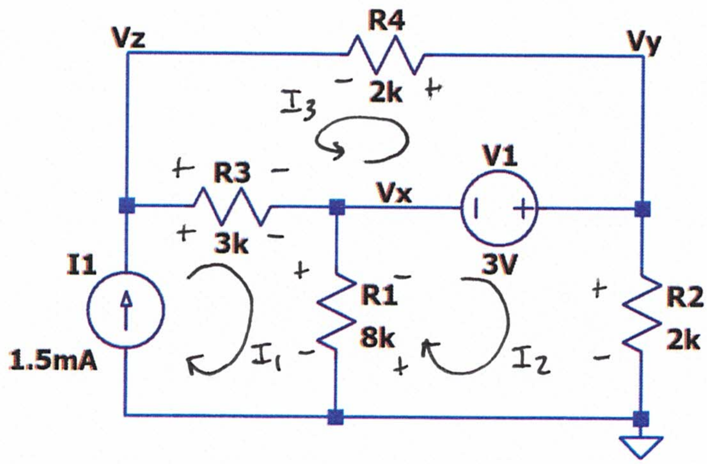
$V_{x_2} = 6V$

$\therefore V_x = 4V + 6V = 10V$

$\therefore I(R_1) = 10V/6K = 1.667mA$

3. Determine each of the loop currents in the following circuit **using mesh analysis.** Use the loop currents you find to determine **Vx, Vy, and Vz.** (20 points)

(9 mins)



① $\boxed{I_1 = 1.5mA}$

② $+3V - I_2 \cdot 2K - (I_2 - I_1) \cdot 8K = 0 \rightarrow 3V - I_2 \cdot 2K - I_2 \cdot 8K + (1.5mA \cdot 8K) = 0$

③ $+3V - I_3 \cdot 2K - (I_3 + I_1) \cdot 3K = 0 \rightarrow 3V - I_3 \cdot 2K - I_3 \cdot 3K - (1.5mA \cdot 3K) = 0$

② $3V - I_2 \cdot 10K + 12V = 0 \rightarrow 15V = I_2 \cdot 10K$

③ $3V - I_3 \cdot 5K - 4.5V = 0 \rightarrow -1.5V = I_3 \cdot 5K$

$\boxed{\therefore I_2 = 1.5mA}$

$\boxed{\therefore I_3 = -0.3mA}$

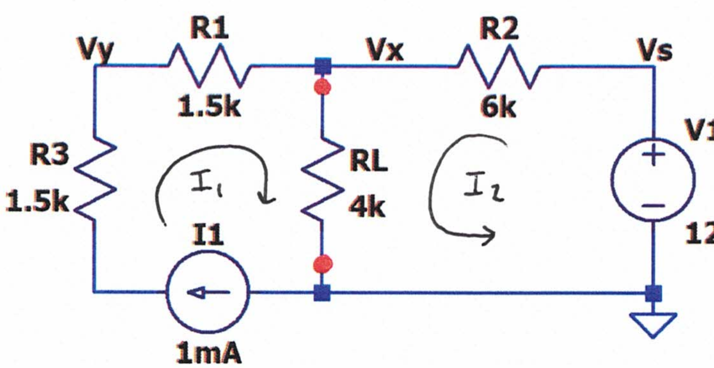
$\boxed{V_x = (I_1 - I_2) \cdot 8K = 0V}$

$\boxed{V_y = I_2 \cdot 2K = 3V}$

$\boxed{V_z = V_y - (I_3 \cdot 2K) = 3.6V}$

4. Determine **Vx** labeled in the circuit below using any method you choose. Then, find the Thevenin and Norton equivalent circuits **when the load resistor (RL) is removed**. Verify that your equivalent circuits are correct by connecting the load resistor across the terminals of your equivalent circuits and comparing the output voltage to your original calculation of **Vx**. (20 points)

(9 mins)



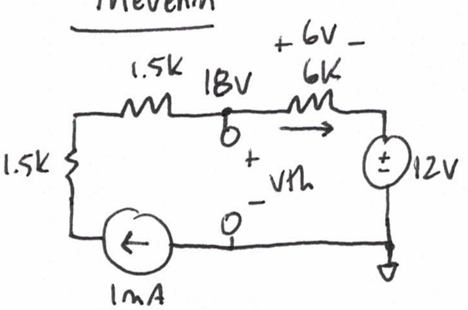
* $I_1 = 1mA$

* $12V - I_2 \cdot 6K - (I_2 + 1mA) \cdot 4K = 0 \rightarrow 12V - I_2 \cdot 10K - 4V = 0$

$I_2 = 0.8mA$

$\therefore V_x = 1.8mA \cdot 4K = 7.2V$ ✓

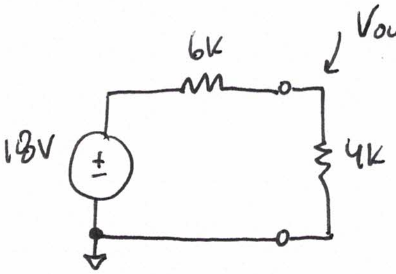
Thevenin



$V_{th} = 18V$

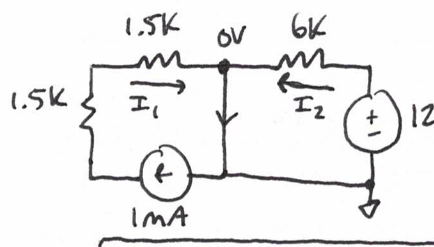
$R_{th} = 6K$

$V_{out,Th} = 18V \cdot \frac{4K}{10K}$ ✓



$V_{out,Th} = 7.2V$

Norton

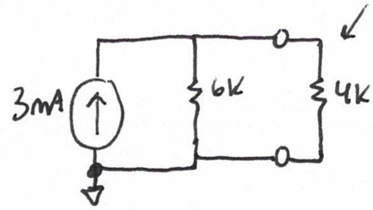


$12V / 6K = 2mA$

$I_N = I_1 + I_2 = 1mA + 2mA = 3mA$

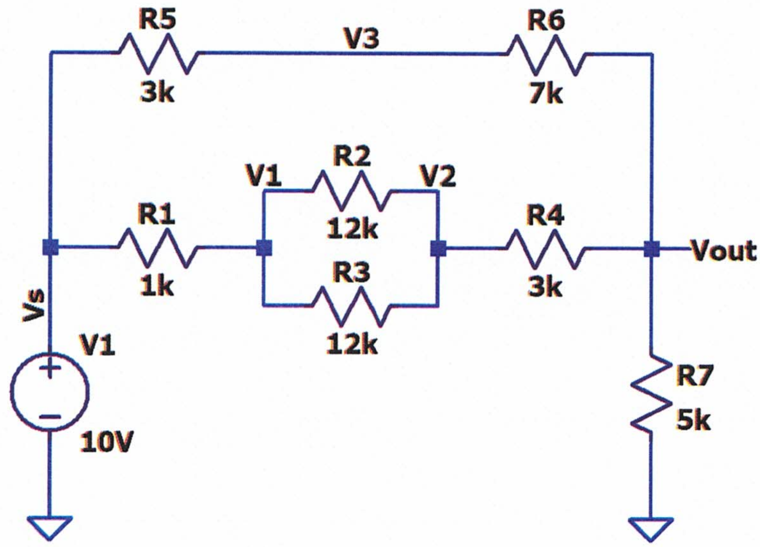
$R_N = 6K$

$V_{out,N} = 3mA \cdot (6K // 4K)$



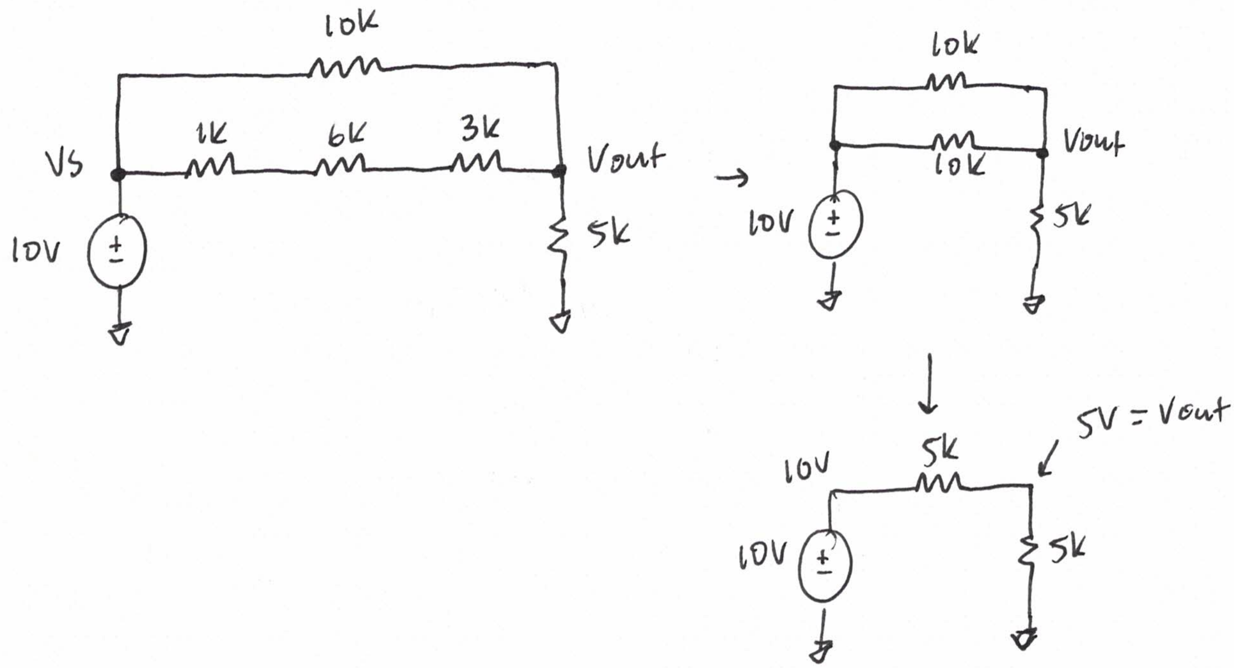
$V_{out,N} = 7.2V$ ✓

5. Determine **Vout** in the circuit given below. Also, determine the current that flows through resistor **R7.** Note that you can reduce the resistance between Vs and Vout down to a single equivalent resistor. (15 points) (2 mins)

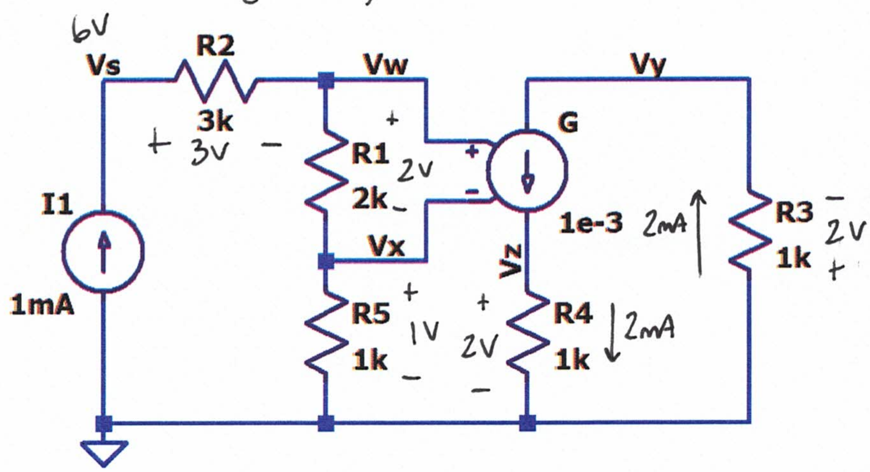


Vout = 5V

I(R7) = 1mA



6. Determine each of the voltages labeled in the circuit below **(Vs, Vw, Vx, Vy, Vz).** Do R4 and R5 dissipate the same amount of power? Show your power calculations to support your answer. (15 points) (3 mins)



$Vs = 3V + 2V + 1V = 6V$

$Vw = 2V + 1V = 3V$

$Vx = 1K \cdot 1mA = 1V$

$Vy = 0 - 2V = -2V$

$VZ = 2mA \cdot 1K = 2V$

$P(R5) = 1V \cdot 1mA = 1W$

$P(R4) = 2V \cdot 2mA = 4W$

∴ R4 dissipates more power than R5.