Electric Circuits
Exam I

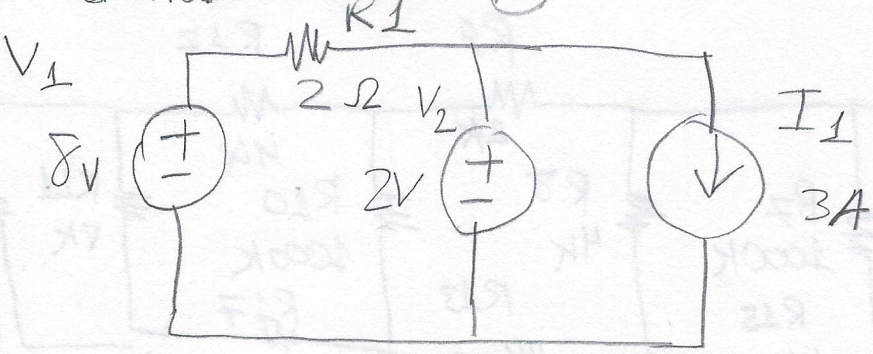
1. ____/20
2. ____/20
3. ____/16
4. ____/14
5. ____/15
6. ____/15

Total ____/100

Name ____________________

1) Short Answers (20 points)

Question 1 (4pts) A



Power of each component ?

$P_{V_1} = -24W$

$P_{V_2} = 0\,W$

$P_{R_1} = 18\,W$

$P_{I_1} = 6\,W$

KVL $8V = V_{R1} + 2V$

$\rightarrow V_{R1} = 6V \rightarrow I_{R1} = \frac{6V}{2\Omega} = 3A$

KCL at A: All current thru R_1 goes to I_1

So then, No current thru V_2, So then $P_{V_2} = 0\,W$

$P_{V_1} = (3A)(8V) = 24W$

$P_{R_1} = (3A)(6V) = 18W$

$P_{I_1} = (3A)(2V) = 6W$

Question 2 (3 points)

In thevenin and Norton equivalent circuits

T / F the Thevenin voltage, V_{TH}, can be Negative

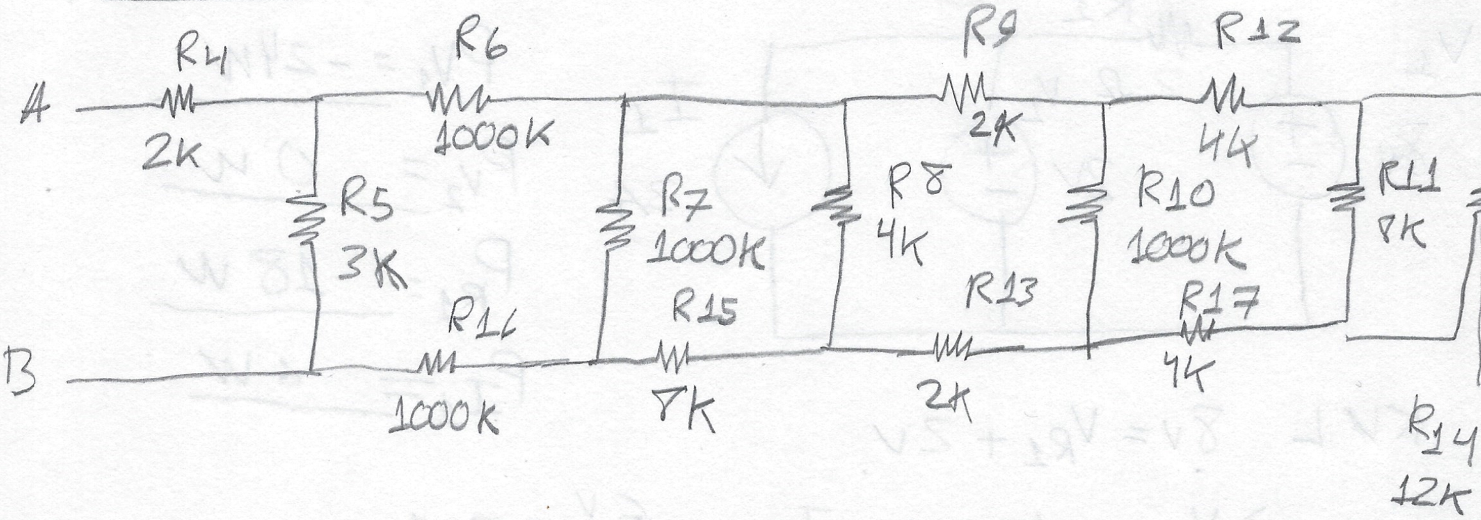
T / F the Norton current, I_N, can be Negative

T / F The Thevenin resistance, R_{Th}, can be Negative

✓ Note, if $R_{TH} = \frac{V_{TH}}{I_N}$, well then R_{TH} can be Negative

②

Question 3 (3 points)



Approximately, the resistance between A and B in the above circuit is ______________ $(5k\Omega)$

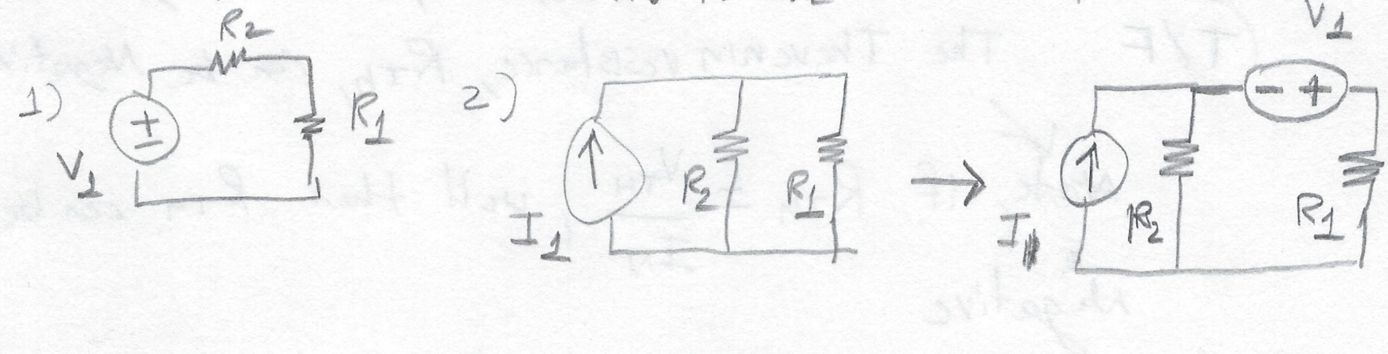
Question 4 (4 points)

Super position on a circuit with only two resistors results in the following expressions

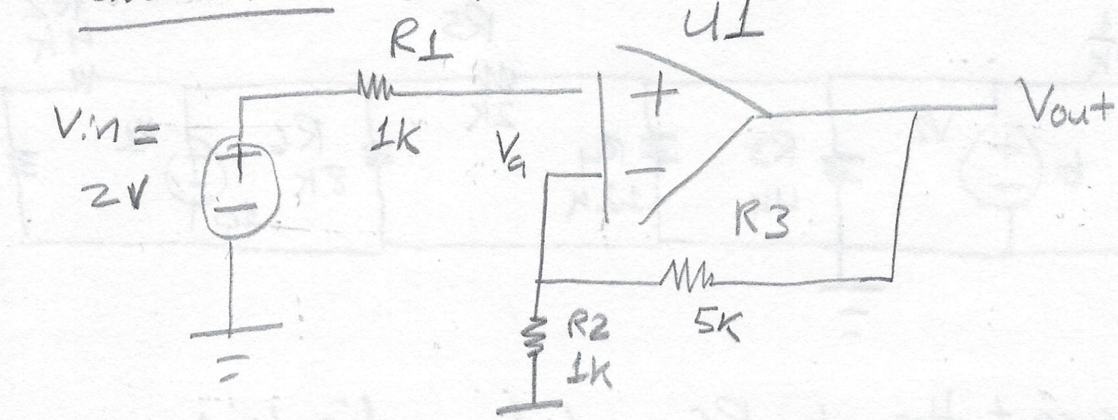
1) $V_{R1_{V_1}} = \frac{R1}{R1 + R2} V_1$ The voltage contribution due to voltage source V1

2) $V_{R1_{I_1}} = \left[\frac{R_2}{R1 + R2} I_1\right] R_1$ the voltage contribution due to current source I_1

Sketch the circuit that results in the above expressions



Question 5 (3 points)



The above op-amp circuit has 5/−5 supply voltages. When considering the circuit,

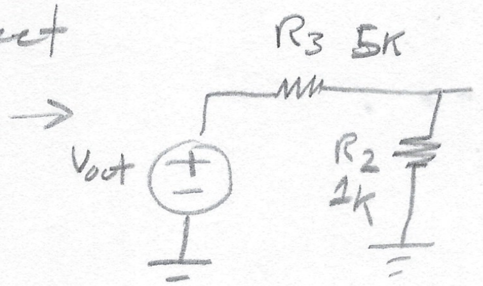
the current through R1 is approx. $I_{R1} \sim$ 0A

the voltage at Va is approx. $V_a \sim$ 2 V

the voltage at Vout is approx. $V_{out} \sim$ 5V

→ Note, remember ur non-inverting OP-Amp on ur crib sheet

→



we know $V_a = 2V$

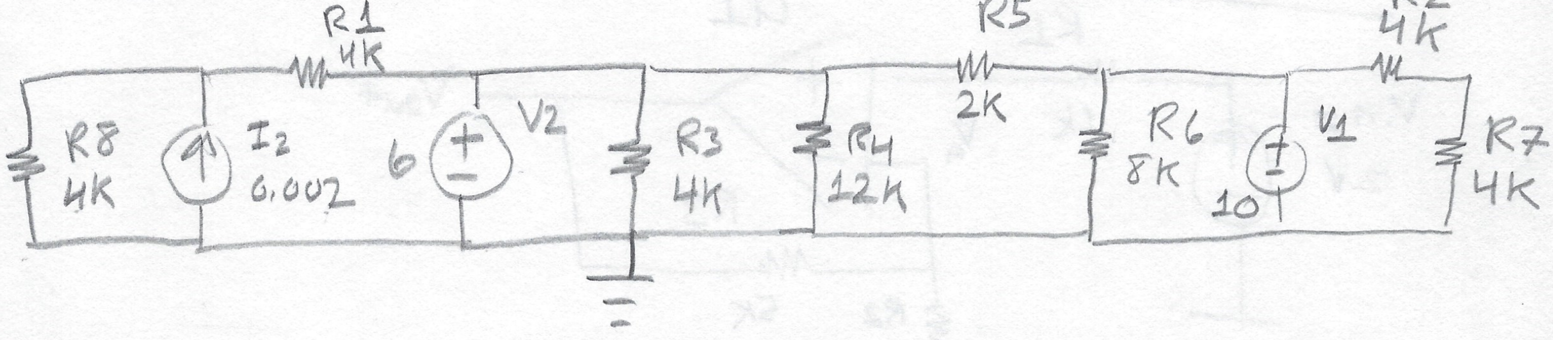
So

$$V_a = \frac{R_2}{R_2 + R_3} V_{out}$$

$$\rightarrow \frac{R_2 + R_3}{R_2} V_a = V_{out} = \frac{6}{1}(2) = 12V$$

→ we don't have 12V, so it saturates, → 5V

④ Question 6 (3 points)

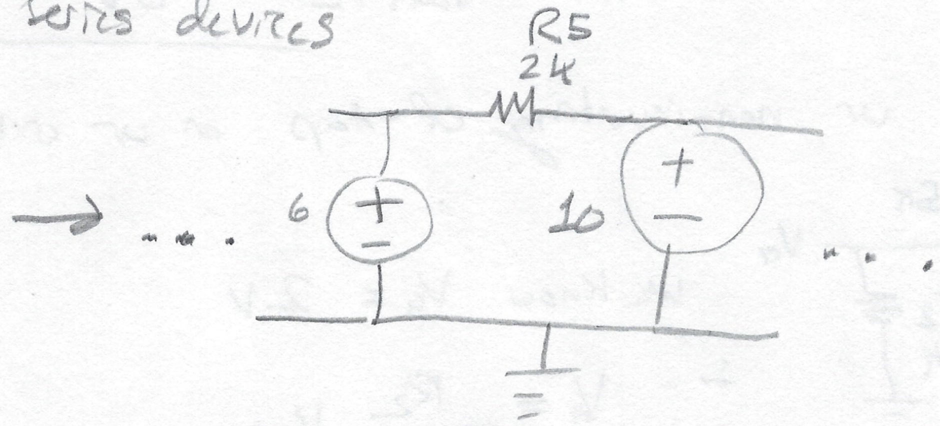


Determine the current through R5 including direction

I_{R5} = ______ Left or right

Note, This question is designed to Screw with ur mind

Parallel devices don't need to be in order, Just Like Series devices

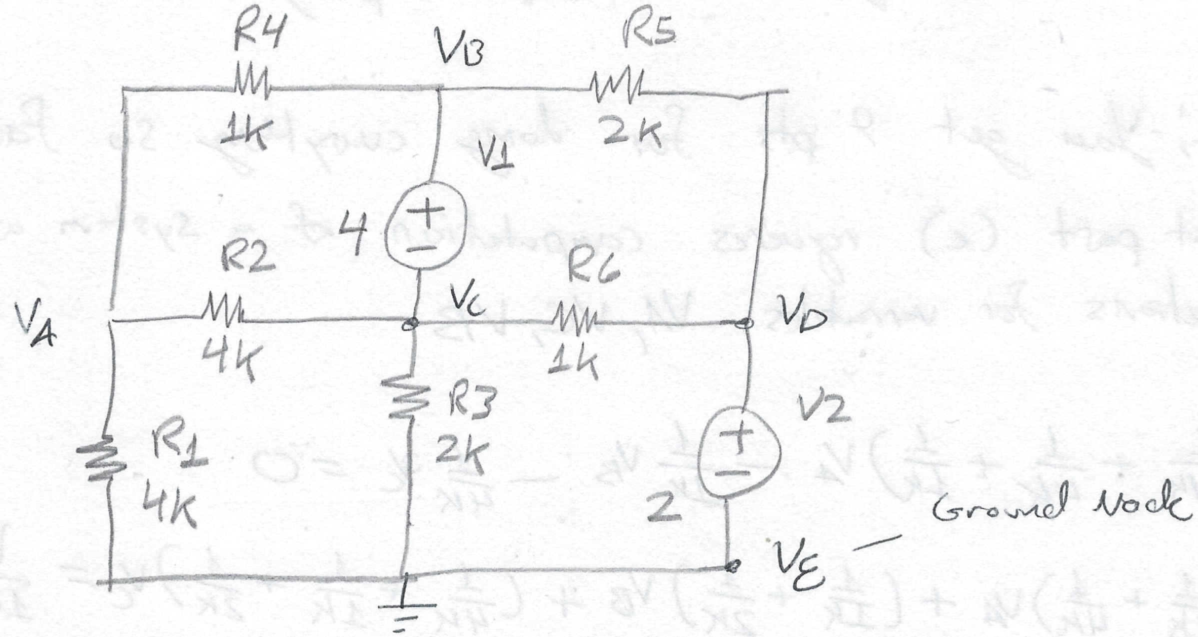


$|V_{R5}| = 4V \quad |I_5| = \frac{4}{2k} = \underline{0.002 A}$

current flows from High Potential to Low Potential

Left

2) Circuit Analysis — Node/Mesh (20 points)



In the above circuit,

a) Clearly Label each node as VA, VB, etc (2pts)

b) Identify a ground node (1 pt)

c) Based on your choice in part b), indicate any nodes with known voltages and any pairs of nodes with known relationships (2pts)

$V_D = 2V \qquad V_B - V_C = 4V \qquad V_E = 0V$

d) Determine the set of Linear equations needed to determine the nodal voltages. Clearly indicate each expression. (put a box around them). (4 pts)

obviously we are doing Node analysis due to the voltage sources

Node A: $\boxed{\frac{V_A - 0}{4K} + \frac{V_A - V_C}{4K} + \frac{V_A - V_B}{1k} = 0}$

Super Node (5 currents Leaving the super Node)

$$\boxed{\frac{V_B - V_A}{1K} + \frac{V_B - V_D}{2k} + \frac{V_C - V_A}{4K} + \frac{V_C - 0}{2K} + \frac{V_C - V_D}{1K} = 0}$$

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e) Determine the Voltages across R2. (1pt)

Note; You get 9 pts for doing everything so far

The Last part (e) requires computation of a system of equations for variables VA, VC, VB

$$\left(\frac{1}{4k}+\frac{1}{4k}+\frac{1}{1k}\right)V_A - \frac{1}{1k}V_B - \frac{1}{4k}V_C = 0$$

$$-\left(\frac{1}{1k}+\frac{1}{4k}\right)V_A + \left(\frac{1}{1k}+\frac{1}{2k}\right)V_B + \left(\frac{1}{4k}+\frac{1}{1k}+\frac{1}{2k}\right)V_C = \frac{V_D}{1k}$$

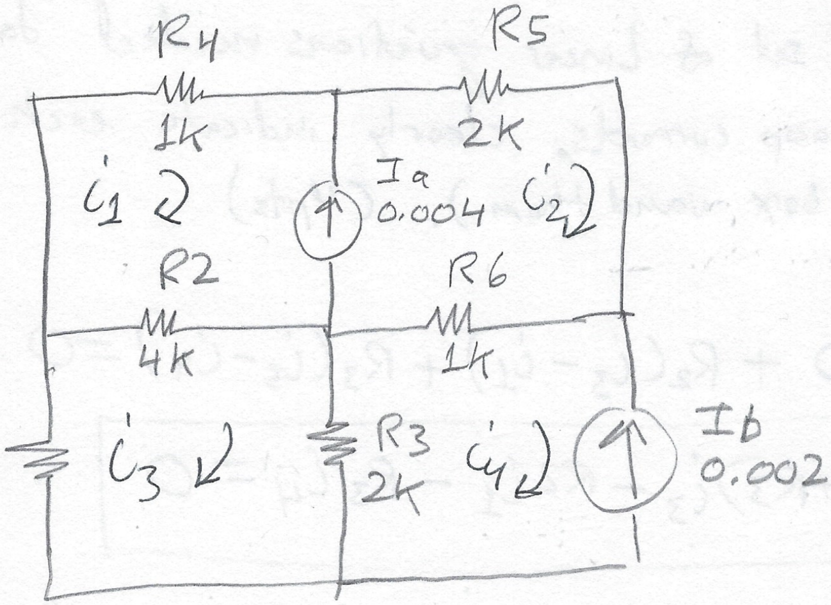
$$V_B - V_C = 4$$

$$\begin{bmatrix} & & \\ & & \\ & & \end{bmatrix}\begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} = \begin{bmatrix} 0 \\ \frac{V_D}{1k} \\ 4 \end{bmatrix}$$

→ Solve this at the end, don't waste time

$V_A = 2.79\ V$ $V_C = 0.151\ V$

$V_{R2} = 2.64\ V$



In the above circuit

a) Clearly Label current Lopps, I1, I2, etc (2pts)

b) Based on your choice in part b), indicate any Loop currents with known values and any pairs of Loop currents with known relationships (2pts)

$i_4 = -0.002$ $\quad$ $\cancel{i_1}\, i_2$ $\quad$ $i_2 - i_1 = 0.004$

recall, If the K_th two-terminal element is contained in meshes X and Y, then the element current can be expressed in terms of the two mesh currents as

$$i_K = i_X - i_Y$$

X is the mesh whose reference direction agrees with the reference direction of i_K

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c) Determine the set of Linear equations needed to determine the Loop currents, clearly indicate each expression (put a box around them). (4pts)

Loop 3:

$$R_1(i_3) + R_2(i_3 - i_1) + R_3(i_3 - i_4) = 0$$

$$\boxed{(R1 + R2 + R3)i_3 - R2 i_1 - R_3 i_4 = 0}$$

Super Loop

$$R4 i_1 + R5 i_2 + R6(i_2 - i_4) + R2(i_1 - i_3) = 0$$

$$\boxed{(R4 + R2)i_1 - R2 i_3 + (R5 + R6) i_2 - R6 i_4 = 0}$$

d) Determine the voltage across R2 (2pt)

$$\begin{bmatrix} 5K & 3K & -4k \\ -4k & 0 & 10k \\ -1 & 1 & 0 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 2 \\ 4 \\ 0.002 \end{bmatrix}$$

$i_1 = -0.000375$ A

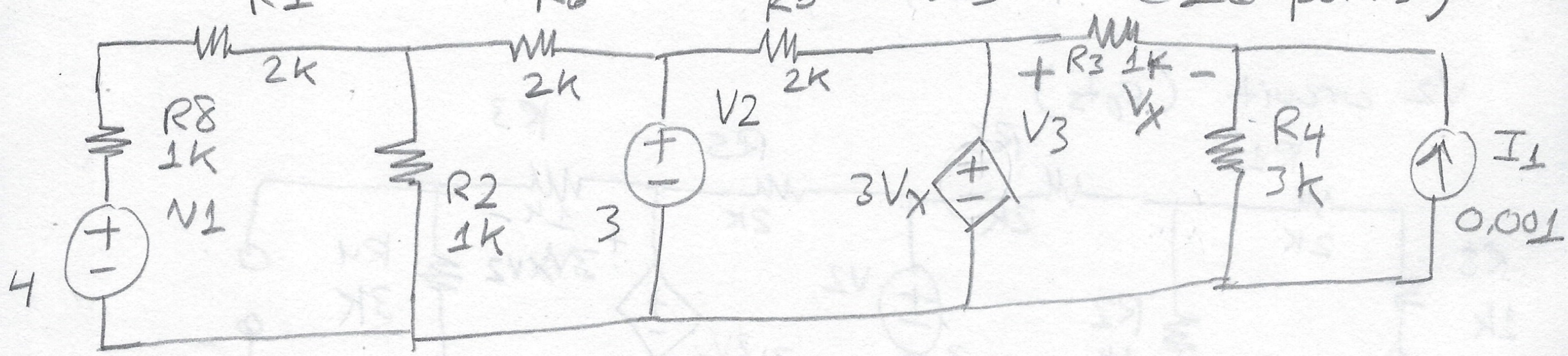
$i_2 = 0.001625$ A

$i_3 = 0.00025$ A

$V_{R2} = 4K(i_1 - i_3)$

$= -2.5$ V

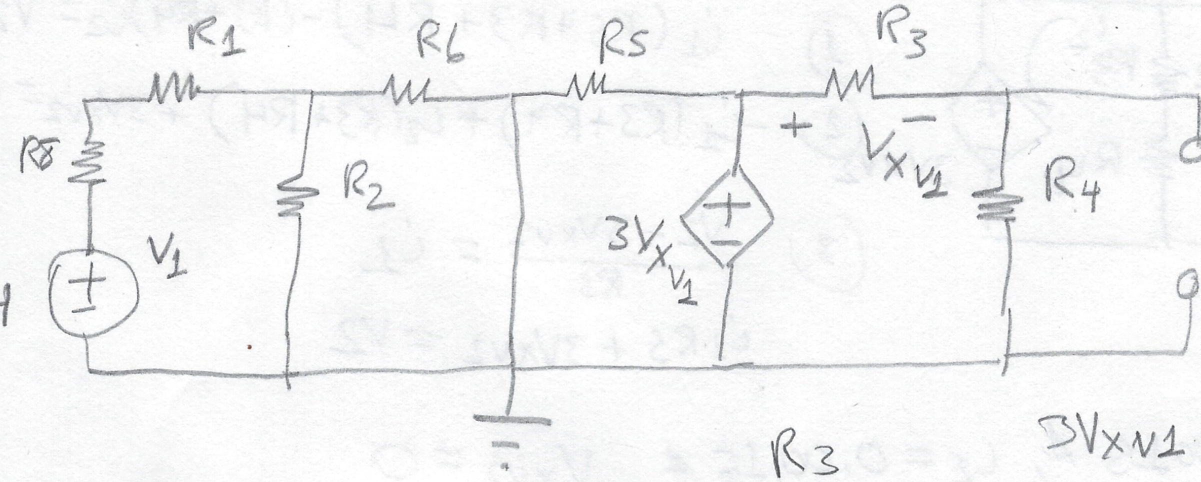
3) Circuit Analysis II – Superposition/Dependent Sources (16 points)

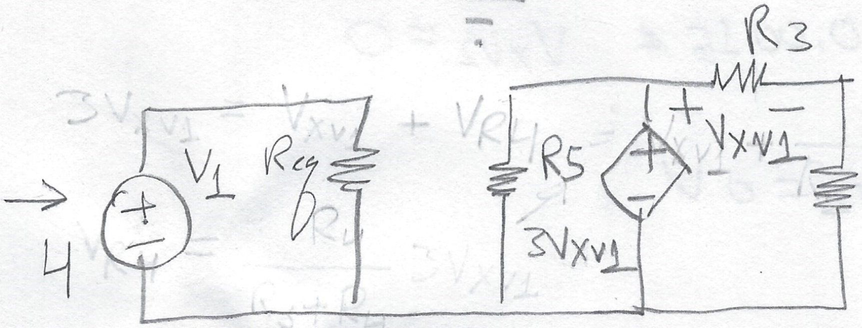


Use superposition to determine the voltage V_x in the above circuit. Include a schematic of the circuit associated with each source.

V1 circuit (5pts)

So the trick with superposition is that you can't turn off the Dependent Source





$$3V_{xv1} = V_{xv1} + \frac{R_4}{R_3+R_4} V_{xv1}$$

$$= \frac{7}{4} V_{xv1}$$

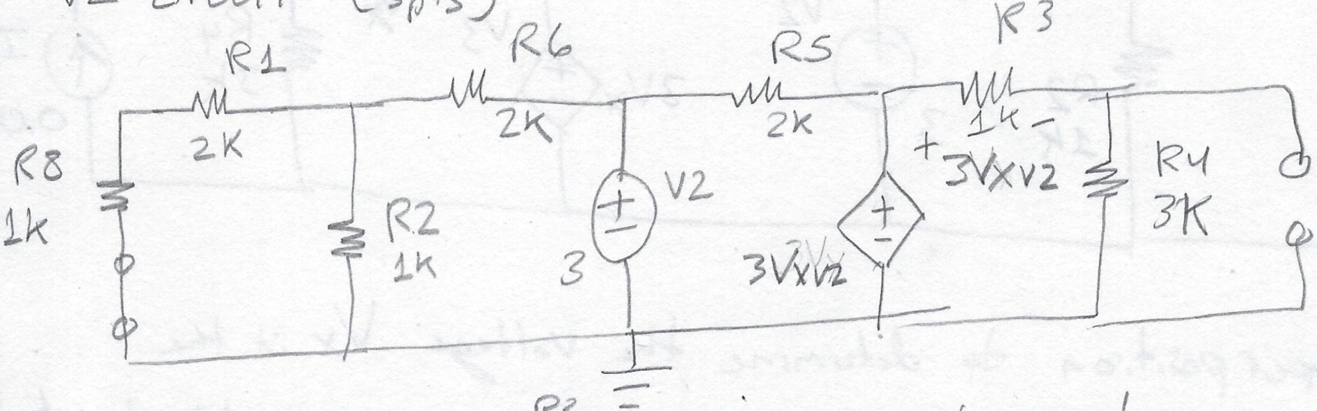
$$V_{xv1} = \frac{12}{7} V_{xv1}$$

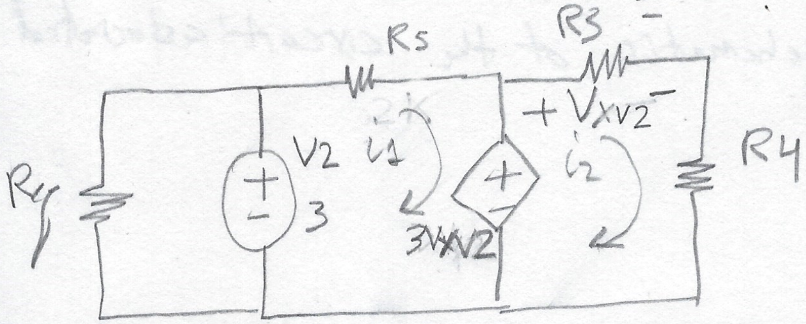
$$V_{xv1} = 0\,V$$

(10)

Note, current flows from high potential to Low Potential. There's only One potential, 0V

V2 circuit (5pts)





mesh analysis

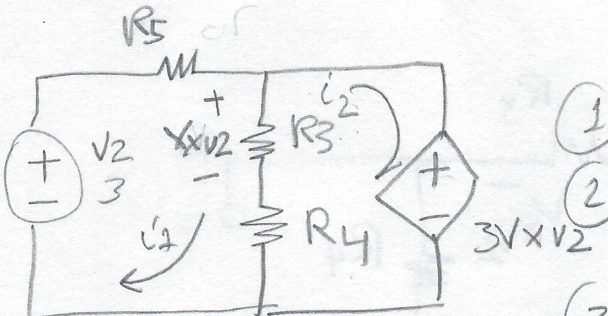
$i_1 R_5 + 3V_{xv2} = V2$ (1)

$(R3+R4)i_2 - 3V_{xv2} = 0$ (2)

$i_2 R_3 = V_{xv2} \rightarrow i_2 R3 - V_{xv2} = 0$ (3)

$i_1 = 0.0015\ A,\ i_2 = 0 \quad V_{xv2} = 0$

or



(1) $i_1(R5+R3+R4) - (R3+R4)i_2 = V2$

(2) $-i_1(R3+R4) + i_2(R3+R4) + 3V_{xv2} = 0$

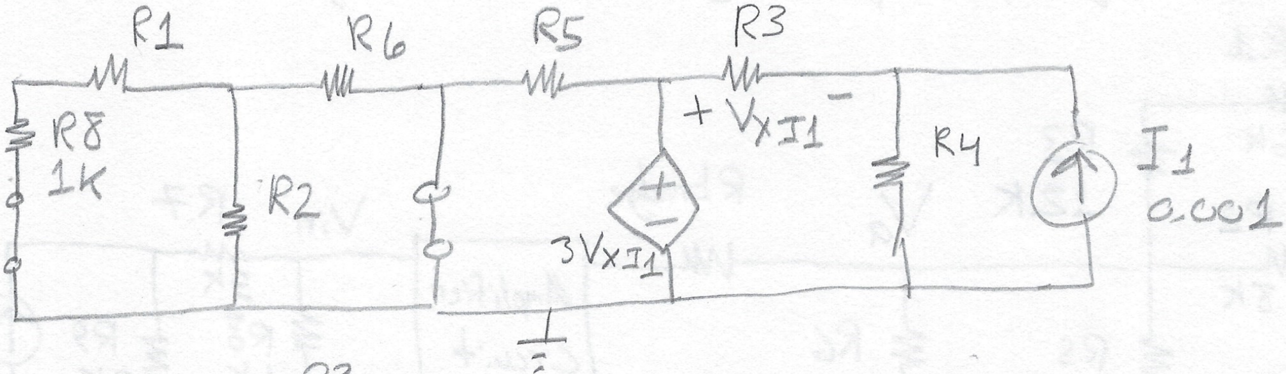
(3) $\dfrac{V2 - 3V_{xv2}}{R5} = i_1$

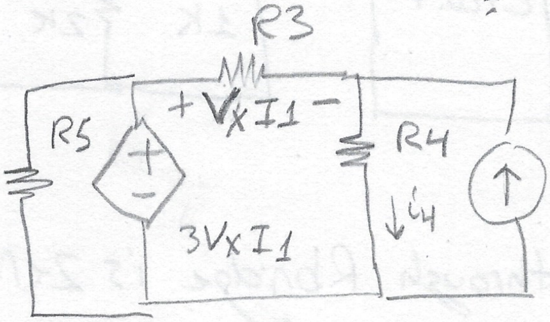
$i_1 R5 + 3V_{xv2} = V2$

$i_1 = 0.0015\ A,\ i_2 = 0.0015\ A \quad V_{xv2} = 0$

$V_{xv2} = 0\ V$

I_1 circuit (5pts)





KCL

$$I_1 + \frac{V_{xI1}}{R3} = i_4$$

KVL

$$3V_{xI1} = V_{xI1} + i_4 R4$$
$$= V_{xI1} + R4\left[I_1 + \frac{V_{xI1}}{R3}\right]$$

KVL (cont.)

$$3V_x I_1 = R_4 I_1 + V_x I_1\left[1 + \frac{R4}{R3}\right]$$

$$\rightarrow V_x I_1\left[3 - \left(1 + \frac{R4}{R3}\right)\right] = R_4 I_1$$

$$V_x I_1 = \frac{R_4 I_1}{3 - \left(1 + \frac{R4}{R3}\right)} = -3V \qquad V_x I_1 = -3V$$

Voltage across V_x (include polarity) (1pt)

$$V_x = V_{xV1} + V_{xV2} + V_{xI1}$$
$$= -3V$$