# EE 109 Homework 1

**Name:** ________________________________________

**Due:**

**Score:** ________

**Neatly show your work to get full credit and clearly show your final answer.**

1.) **[5 pts.]** Use KCL to solve for $I_0$.

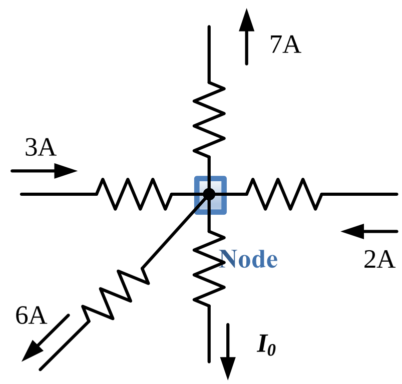
$$\sum_{i=1}^{n} I_i(node) = 0 \rightarrow \ -3-2+7+6+I_0 = 0$$

$$\rightarrow I_0 = -8^A$$

Another approach:

$$\sum I_{in}(node) = \sum I_{out}\,(node)$$

$$\rightarrow \ 3+2 = 7+6+I_0 \rightarrow I_0 = -8^A$$

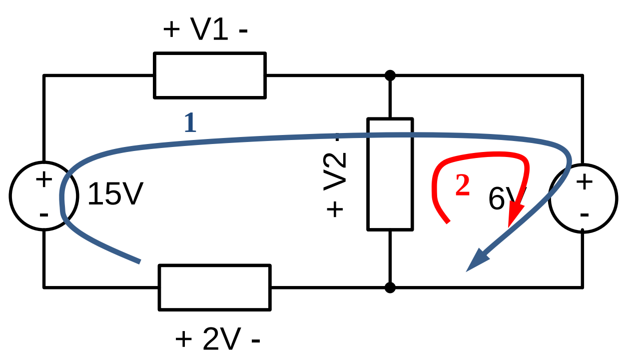



2.) **[8 pts.]** Use KVL to solve for V1 and V2.

$$\sum_{i=1}^{n} v_i(loop) = 0 \rightarrow$$

$$1)\ \ -15+v_1+6-2 = 0 \ \ \rightarrow v_1 = 11^v$$

$$2)\ \ +v_2+6 = 0 \rightarrow v_2 = -6^v$$




3.) **[9 pts.]** Solve for the currents $i_1$, $i_2$, $i_3$.

$$\sum_{i=1}^{n} I_i(@\ node\ 1) = 0 \rightarrow$$

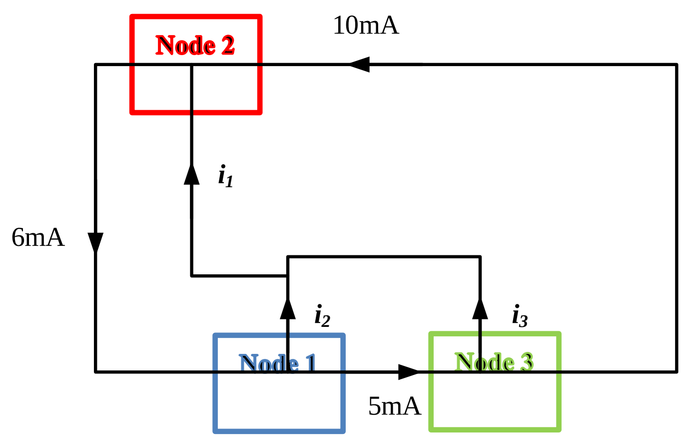
$$-6+5+i_2 = 0 \ \rightarrow i_2 = 1^A$$

$$\sum_{i=1}^{n} I_i(@\ node\ 2) = 0 \rightarrow$$

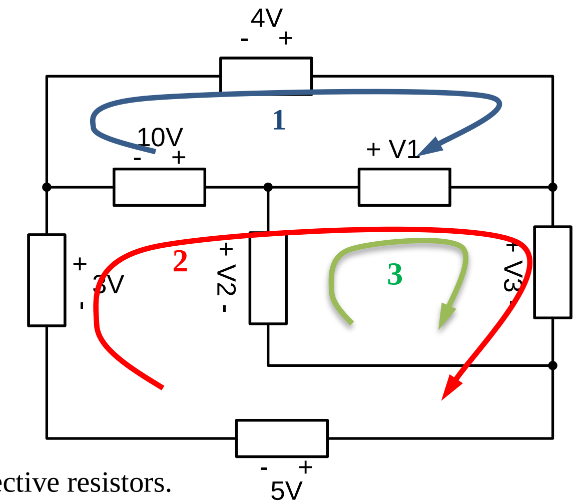
$$+6-10-i_1 = 0 \rightarrow i_1 = -4^A$$

$$\sum_{i=1}^{n} I_i(@\ node\ 3) = 0 \rightarrow$$

$$-5+i_3+10 = 0 \ \rightarrow \ i_3 = -5^A$$



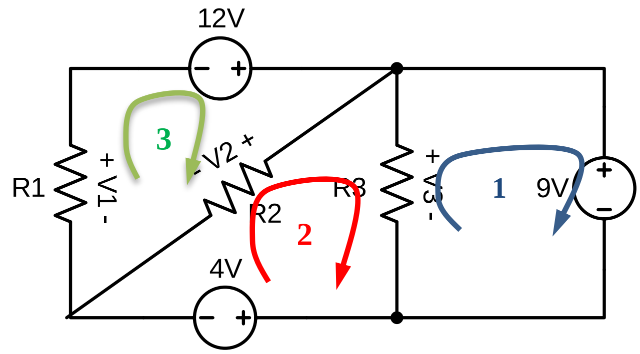
4.) **[9 pts.]** Solve for the voltages V1, V2, V3




$$\sum_{i=1}^{n} v_i(loop) = 0 \rightarrow$$

1) $-10 + v_1 + 4 = 0 \ \rightarrow v_1 = 6^v$
2) $-3 - 10 + v_1 + v_3 + 5 = 0 \rightarrow v_3 = 2^v$
3) $-v_2 + v_1 + v_3 = 0 \rightarrow v_2 = 8^v$

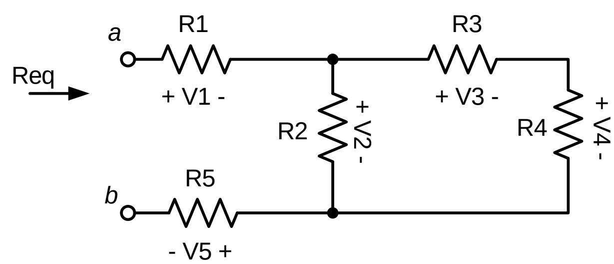
5.) **[9 pts.]** Solve for the voltages V1, V2, V3 across the respective resistors.




$$\sum_{i=1}^{n} v_i(loop) = 0 \rightarrow$$

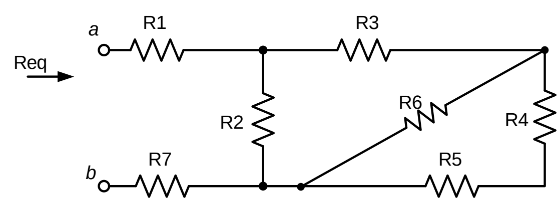
1) $-v_3 + 9 = 0 \ \rightarrow v_3 = 9^v$
2) $-v_2 + v_3 + 4 = 0 \rightarrow v_2 = 13^v$
3) $-v_1 - 12 + v_2 = 0 \rightarrow v_1 = 1^v$

6.) **[10 pts.]** Reduce the resistor network shown below to a single equivalent resistance. Leave your answer in terms of R1, R2, R4, R5, and R6.



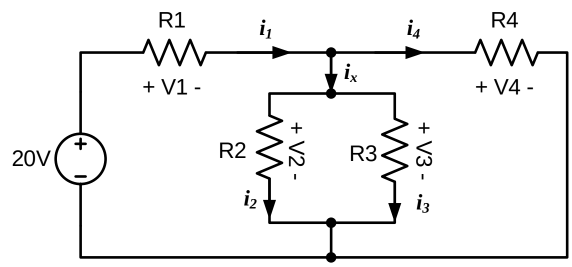

$$R_{eq} = R1 + [R2 \parallel (R3 + R4)] + R5$$
$$= R1 + \frac{R2.(R3 + R4)}{R2 + R3 + R4} + R5$$
$$= 3 + \frac{4.(4)}{4 + 2 + 2} + 1 = 6\Omega$$

7.) **[10 pts.]** Reduce the resistor network shown below to a single equivalent resistance assuming the following resistor values: R1=5Ω, R2=4Ω, R3=3Ω, R4=1Ω, R5=1Ω, R6=2Ω, R7=7Ω.
Hint: Start by combining R4 and R5 then combine those with R6 and keep going…




$$R_{eq} = R1 + [R2 \parallel (R3 + (R6 \ \parallel (R4 + R5)] + R7$$
$$R_{eq} = R1 + [R2 \parallel (R3 + (2 \parallel (2)] + R7$$
$$R_{eq} = R1 + [R2 \parallel (3 + (1)] + R7$$
$$R_{eq} = R1 + [4 \parallel (4] + R7$$
$$R_{eq} = R1 + [2] + R7 = 5 + 2 + 7 = \mathbf{14\Omega}$$

8.) **[8 pts.]** Find an expression for the current ***i1*** if R1=4Ω, R2=3Ω, R3=6Ω, R4=2Ω.
Hint: Combine R2, R3, R4 into an equivalent resistance which will be in series with R1. From here you can use a KVL loop or Ohm's law to solve for i1.




$$\sum_{i=1}^{n} v_i(loop) = 0 \rightarrow$$

$$-20 + R1.i_1 + (R2 \parallel R3 \parallel R4).i_1 = 0$$

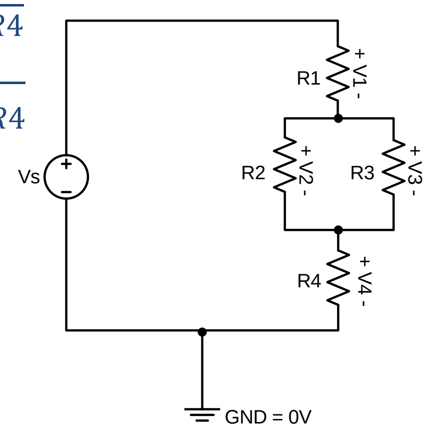
When 3 or more resistors are in parallel you can work with 2 at a time.

$$i_1 = \frac{20}{R1 + \left((R2 \parallel R3) \parallel R4\right)}$$

$$i_1 = \frac{20}{4 + \left((3 \parallel 6) \parallel 2\right)} = \frac{20}{4 + \left(\left(\frac{18}{9}\right) \parallel 2\right)} = \frac{20}{4 + \left(\frac{2 * 2}{2 + 2}\right)} = \frac{20}{5} = 4A$$

9.) **[16 pts.]** Use the generalized concept of a voltage divider (review your notes/lecture slides) to find expressions for the voltage V1 and also V4 in the circuit below. Your expression should be in terms of Vs and R1-R4.

$$i(R1) = i(R4) = \frac{v(s)}{R1 + \ R2 \parallel R3 + R4} = \frac{v(s)}{R1 + \ R2 \parallel R3 + R4} = \frac{v(s)}{R1 + \frac{R2.R3}{R2 + R3} + R4}$$




$$\boldsymbol{V1 = R1.i(R1) = R1.\frac{v(s)}{R1 + \frac{R2.R3}{R2 + R3} + R4}}$$

$$\boldsymbol{V4 = R4.i(R4) = R4.\frac{v(s)}{R1 + \frac{R2.R3}{R2 + R3} + R4}}$$

10.) **[6 pts.]** Look at the circuit from problem 9. If R4 is very large (approaches infinity) what would V4 be (approximately).

$$\lim_{R4\to\infty} V4 = \lim_{R4\to\infty} R4.\frac{v(s)}{R1 + \frac{R2.R3}{R2+R3} + R4} = \infty.\frac{v(s)}{\left(R1 + \frac{R2.R3}{R2+R3} + \infty\right)}$$

$$= \infty.\frac{v(s)}{\left(R1 + \frac{R2.R3}{R2+R3} + \infty\right)} = \frac{\infty}{\infty}.v(s) = 1 * v(s) = v(s)$$

11.) **[5 pts.]** Look at the circuit from problem 9. If R3 is very large (approaches infinity) again solve (approximately) for the voltage V4.

$$\lim_{R3\to\infty} V4 = \lim_{R3\to\infty} R4.\frac{v(s)}{R1 + \frac{R2.R3}{R2+R3} + R4} = R4.\frac{v(s)}{R1 + \frac{R2.\infty}{R2+\infty} + R4} = R4.\frac{v(s)}{R1 + \frac{R2.\infty}{\infty} + R4}$$

$$= R4.\frac{v(s)}{R1 + R2 + R4}$$

**Note: This is the appropriate voltage divider equation had R3 been removed altogether. Thus as a resistor in parallel get's large, it's as if it's not even there.**

12.) **[5 pts.]** Look at the circuit from problem 9. If R3 is effectively 0Ω (i.e. replaced by a wire), solve (approximately) for the voltage V4.

$$V4 = R4.\frac{v(s)}{R1 + \frac{R2.R3}{R2+R3} + R4} \to V4(R3 = 0) = \boldsymbol{R4.\frac{v(s)}{R1 + R4}}$$

**Note: This is the appropriate voltage divider equation had R2 and R3 been removed completely. Thus as a resistor in parallel get's small it's as if neither resistor is present.**