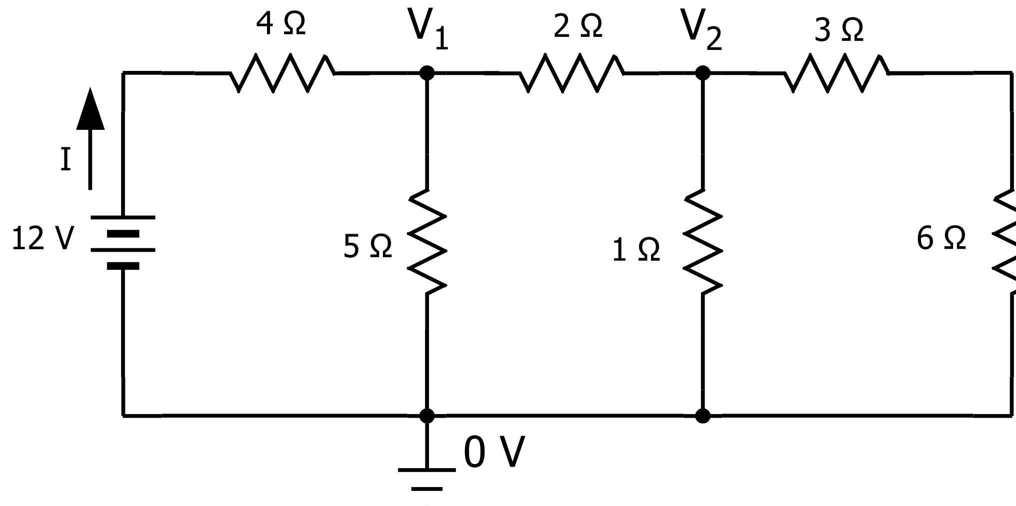
EE3 Fall 2021
Practice Problems 2



1. This is a similar circuit to that in Lecture1. Only the resistor values are different. It can be solved using series-parallel equivalents. But solve it using the NVA process below.
   a. Assuming that all of the currents at Node 1 (where V_1 is) are *leaving* the node, write an Ohm's Law expression for the current going through the 4 Ω resistor.
   b. Under the same assumption, write an Ohm's Law expression for the current through the 5 Ω resistor.
   c. Continuing, write an expression for the current through the 2 Ω resistor.
   d. Now, following the same procedure, write Ohm's Law expressions for the three currents leaving Node 2.
   e. Now, combine the answers to 1a,b,c into a KCL equation.
   f. Combine the three answers to 1d into a KCL equation.
2. You now have 2 equations in 2 unknowns. Solve them for V_1 and V_2.
3. Now that you know V_1, you can compute I.

Currents leaving a node are given + signs. By the Passive Sign Convention, the end of the resistor where the current enters must be the + end.

1a. $\frac{V_1-12}{4}$

1b. $\frac{V_1-0}{5}$

1c. $\frac{V_1-V_2}{2}$

1d. $\frac{V_2-V_1}{2};\ \frac{V_2-0}{1};\ \frac{V_2-0}{3+6}$

1e. $\frac{V_1-12}{4}+\frac{V_1}{5}+\frac{V_1-V_2}{2}=0$

1f. $\frac{V_2-V_1}{2}+\frac{V_2-0}{1}+\frac{V_2-0}{3+6}=0$

2. From 1e: $19\,V_1-10\,V_2=60$
   From 1f: $-9\,V_1+29\,V_2=0$
   $V_1=3.7744$ V; $V_2=1.1714$ V

3. $I=\frac{12-3.77}{4}=2.06$ A

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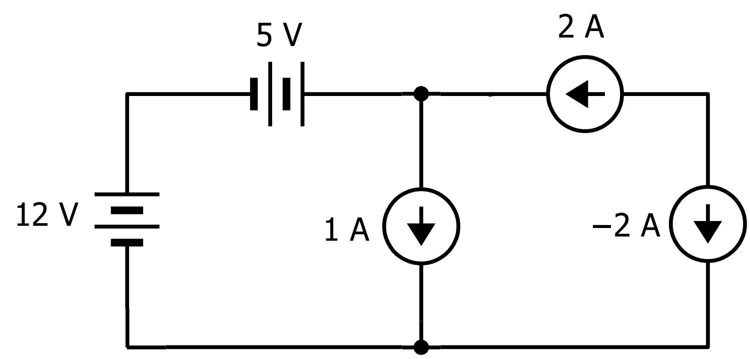
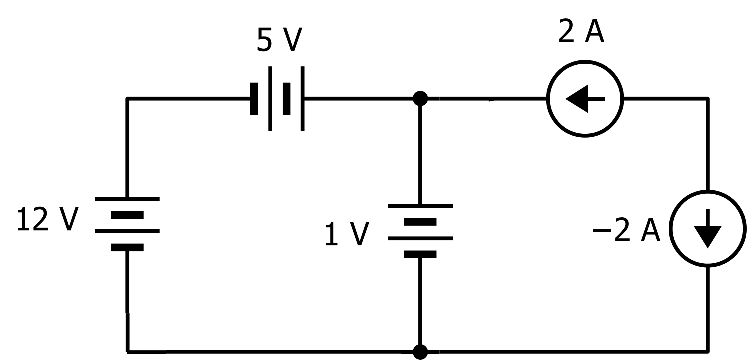
4. Is this a "legal" circuit? If not, why not?



Circuit is legal.
KVL is satisfied in all three loops.
KCL is satisfied at both nodes.

5. Is this a "legal" circuit? If not, why not?



Circuit is illegal.
KVL not satisfied in left loop.

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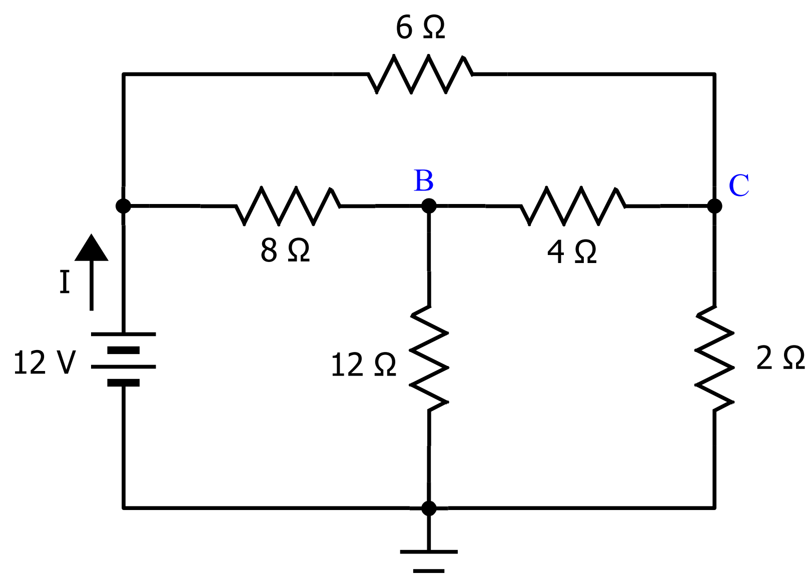
6. Using your knowledge of Node Voltage Analysis (NVA),find the current I.



I = 2.24 A

Node B: $\frac{V_B - 12}{8} + \frac{V_B}{12} + \frac{V_B - V_C}{4} = 0$

Node C: $\frac{V_C - V_B}{4} + \frac{V_C}{2} + \frac{V_C - 12}{6} = 0$

Node B: $\left(\frac{1}{8} + \frac{1}{12} + \frac{1}{4}\right) V_B - \left(\frac{1}{4}\right) V_C = \left(\frac{1}{8}\right) 12$

Node C: $\left(\frac{-1}{4}\right) V_B + \left(\frac{1}{4} + \frac{1}{2} + \frac{1}{6}\right) V_C = \left(\frac{1}{6}\right) 12$

2x2 matrix to get V_B and V_C.

$V_B = 5.243$ V; $V_C = 3.612$ V.

KCL at top of battery: $-I + \frac{12 - V_B}{8} + \frac{12 - V_C}{6} = 0$

I = 2.24 A

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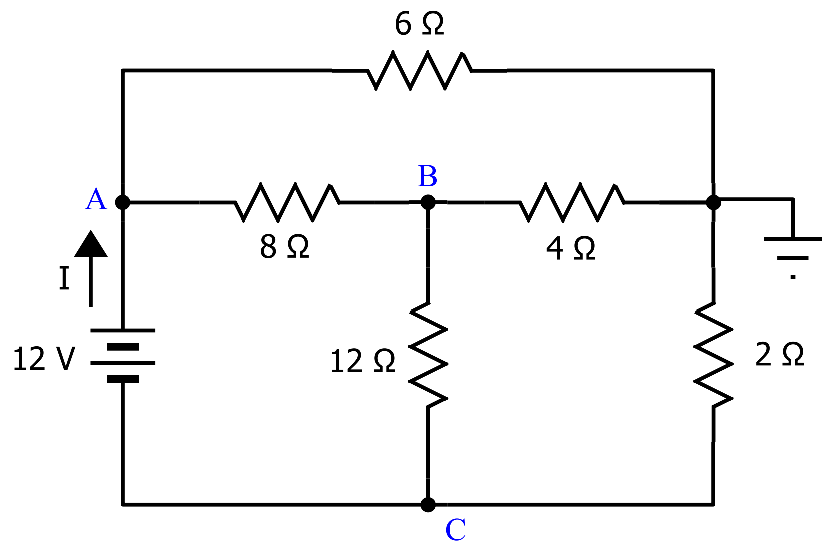
7. This is the same circuit as Problem 6. Using your knowledge of Node Voltage Analysis (NVA),find the current I. HINT: Use I as an unknown fourth variable. (Note: with the reference node at a different location, you now have 3 unknown nodes. But you also know the voltage relationship between 2 of them.)



I = 2.24 A

Node A: $-I+\dfrac{V_A-V_B}{8}+\dfrac{V_A-0}{6}=0$

Node B: $\dfrac{V_B-V_A}{8}+\dfrac{V_B-V_C}{12}+\dfrac{V_B-0}{4}=0$

Node C: $+I+\dfrac{V_C-V_B}{12}+\dfrac{V_C-0}{2}=0$

$V_A=V_C+12$

$$\begin{array}{rrrrcl}
-24I & +7V_A & -3V_B & +0V_C & = & 0 \\
0I & -3V_A & +11V_B & -2V_C & = & 0 \\
12I & +0V_A & -V_B & +7V_C & = & 0 \\
0I & +V_A & +0V_B & -V_C & = & 12
\end{array}$$

$I=2.24\ \text{A};\ V_A=8.39\ \text{V};V_B=1.63\ \text{V};V_C=-3.61\ \text{V}$

Note that $V_B-V_C=5.24$ V (compare to V_B in Problem 6). Try the other equivalencies.

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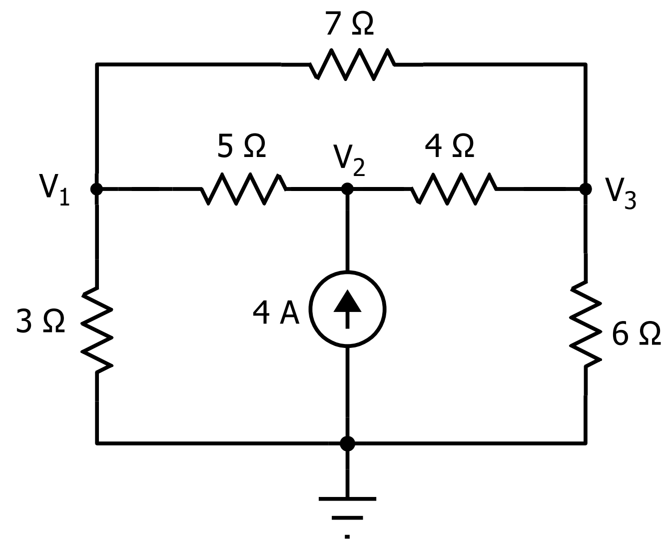
8. This is almost the circuit that we studied in Problem 1. This time, we have replaced the battery with a current source. Find the three voltages. You may need to dig a little to work this problem.



$$\frac{V_1-V_2}{5}+\frac{V_1}{3}+\frac{V_1-V_3}{7}=0$$
$$\frac{V_2-V_1}{5}-4+\frac{V_2-V_3}{4}=0$$
$$\frac{V_3-V_1}{7}+\frac{V_3-V_2}{4}+\frac{V_3}{6}=0$$

$$21V_1-21V_2+35V_1+15V_1-15V_3=0$$
$$4V_2-4V_1-80+5V_2-5V_3=0$$
$$24V_3-24V_1+42V_3-42V_2+28V_3=0$$

$$71V_1-21V_2-15V_3=0$$
$$-4V_1+9V_2-5V_3=80$$
$$-24V_1-42V_2+94V_3=0$$

$$V_1=7.2\ \mathrm{V}$$
$$V_2=17.4\ \mathrm{V}$$
$$V_3=9.6\ \mathrm{V}$$