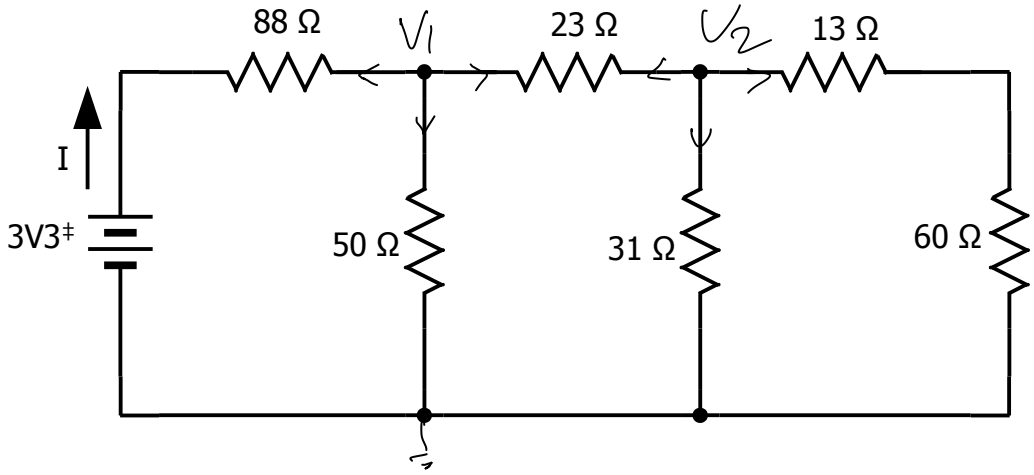
ECE3 Fall 2020
Practice Problems 2

1. This is the problem from Practice Problems 1. Using Node Voltage Analysis, determine the current I.



$$\frac{V_1 - 3.3}{88} + \frac{V_1}{50} + \frac{V_1 - V_2}{23} = 0$$

$$\frac{V_2 - V_1}{23} + \frac{V_2}{31} + \frac{V_2}{73} = 0$$

$$1150(V_1 - 3.3) + 2024V_1 + 4600(V_1 - V_2) = 0$$

$$7774V_1 - 4600V_2 = 3795$$

$$2263(V_2 - V_1) + 1679V_2 + 713V_2 = 0$$

$$4655V_2 - 2263V_1 = 0$$

$V_1 = 0.7$
$V_2 = 0.34$

$V_1 = 0.70$ V
$V_2 = 0.34$ V

‡ 3V3 is shorthand for 3.3 V. You will see this often on schematics.

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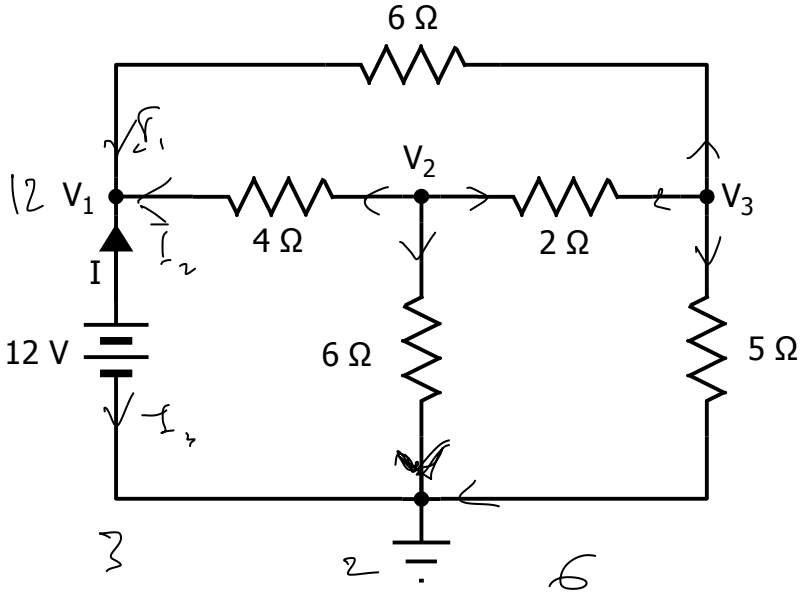
2. This is the problem from Lecture 2.

   Using Node Voltage Analysis, V_1, V_2, and V_3.

   Then find the current through the battery.



$V_2 = 6.61$ V
$V_3 = 6.12$ V

$I = 2.33$ A

$$\frac{V_2 - 12}{4} + \frac{V_2}{6} + \frac{V_2 - V_3}{2} = 0$$

$$\frac{V_3 - V_2}{2} + \frac{V_3}{5} + \frac{V_3 - 12}{6} = 0$$

$$3(V_2 - 12) + 2V_2 + 6(V_2 - V_3) = 0$$

$$11V_2 - 6V_3 = 36$$

$$15(V_3 - V_2) + 6V_3 + 5(V_3 - 12) = 0$$

$$26V_3 - 15V_2 = 60$$

$V_2 = 6.6$ V
$V_3 = 6.12$ V

$$\frac{V_2}{6} + \frac{V_3}{5} = I$$

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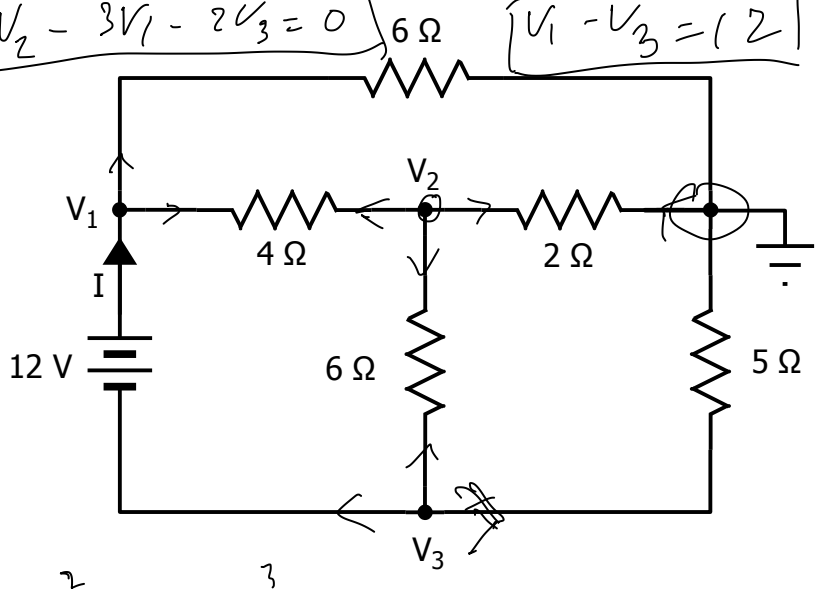
3. This is the same circuit as Problem 2. The reference node has moved.

   Using Node Voltage Analysis, find V_1, V_2, and V_3.

   Then find the current through the battery.

   (Note: with the ground at a different node, you now have 3 unknown nodes. But you also know the voltage relationship between 2 of them.)



$$\frac{V_2 - V_1}{4} + \frac{V_2 - V_3}{6} + \frac{V_2}{2} = 0$$

$$3V_2 - 3V_1 + 2V_2 - 2V_3 + 6V_2 = 0$$

$$11V_2 - 3V_1 - 2V_3 = 0$$

$$V_1 - V_3 = 12$$

$$\frac{V_1}{6} + \frac{V_1 - V_2}{4} = I$$

$$2V_1 + 3V_1 - 3V_2 = 12I$$

$$5V_1 - 3V_2 = 12I$$

$V_1 = 5.88$

$V_2 = 0.49$

$V_3 = -6.12$

$$V_1 = 5.88 \text{ V}$$
$$V_2 = 0.49 \text{ V}$$
$$V_3 = -6.12 \text{ V}$$
$$I = 2.33 \text{ A}$$

$$\frac{V_3 - V_2}{6} + \frac{V_3}{5} + I = 0 \Rightarrow 5V_3 - 5V_2 + 6V_3 + 30I = 0$$

$$11V_3 - 5V_2 + 30I = 0$$

$$11V_3 - 5V_2 + 30\,\frac{5V_1 - 3V_2}{12} = 0$$

$$11V_3 - 5V_2 + 12.5V_1 - 7.5V_2 = 0$$

$$11V_3 - 5V_2 + 2.5(5V_1 - 3V_2) = 0$$

$$11V_3 + 12.5V_1 - 12.5V_2 = 0$$

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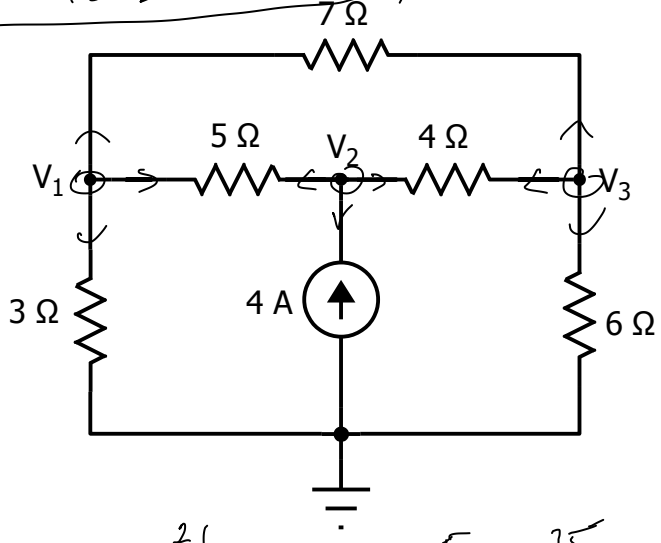
$$\frac{V_3 - V_2}{4} + \frac{V_3}{6} + \frac{V_3 - V_1}{7} = 0$$

$$42V_3 - 42V_2 + 28V_3 + 24V_3 - 24V_1 = 0$$

$$\boxed{94V_3 - 42V_2 - 24V_1 = 0}$$

4. Find the three voltages. You may need to dig a little to work this problem.



$$\frac{V_2 - V_1}{5} + \frac{V_2 - V_3}{4} = 4$$

$$4V_2 - 4V_1 + 5V_2 - 5V_3 = 80$$

$$\boxed{9V_2 - 4V_1 - 5V_3 = 80}$$

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

$$21V_1 - 21V_2 + 15V_1 - 15V_3 + 35V_1 = 0$$

$$\boxed{71V_1 - 21V_2 - 15V_3 = 0}$$

$V_1 = 7.2$ V
$V_2 = 17.4$ V
$V_3 = 9.6$ V

$V_1 = 7.188$
$V_2 = 17.43$
$V_3 = 9.625$

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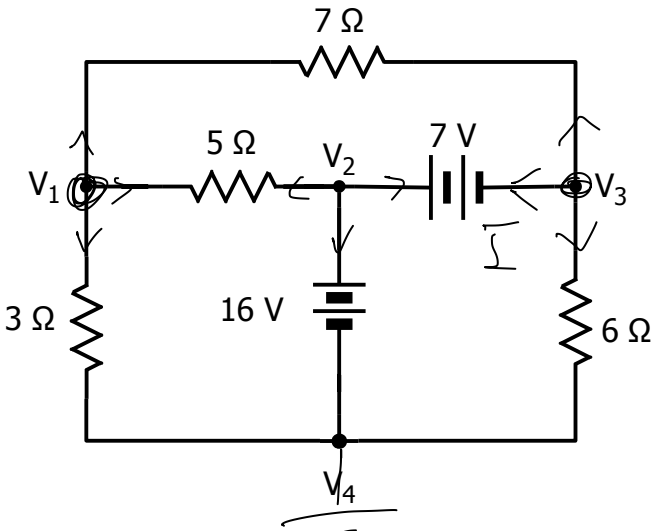
5. Choose (judiciously) a reference node. Then find the current through the 7 V battery.

   You may need to dig a little to work this problem. Note: if you choose to solve this problem using Mesh Current Analysis, you are on your own.



$V_2 = 16$

$V_2 - V_3 = 7 \Rightarrow V_3 = 9$

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

CHOOSING V_4 TO BE THE REFERENCE NODE,
$I_7 = -1.84$ A (left to right, into the node)

CHOOSING V_2 TO BE THE REFERENCE NODE,
$I_7 = -1.84$ A (left to right, into the node)

$$\frac{V_1 - 16}{5} + \frac{V_1 - 9}{7} + \frac{V_1}{3} = 0$$

$$21(V_1 - 16) + 15(V_1 - 9) + 35V_1 = 0$$

$$71V_1 = 471 \Rightarrow V_1 = 6.63\,(V)$$

$$\frac{V_3 - V_1}{7} + \frac{V_3}{6} + I = 0$$

$$\frac{9 - 6.63}{7} + \frac{9}{6} + I = 0$$

$$I = -1.84\,A$$

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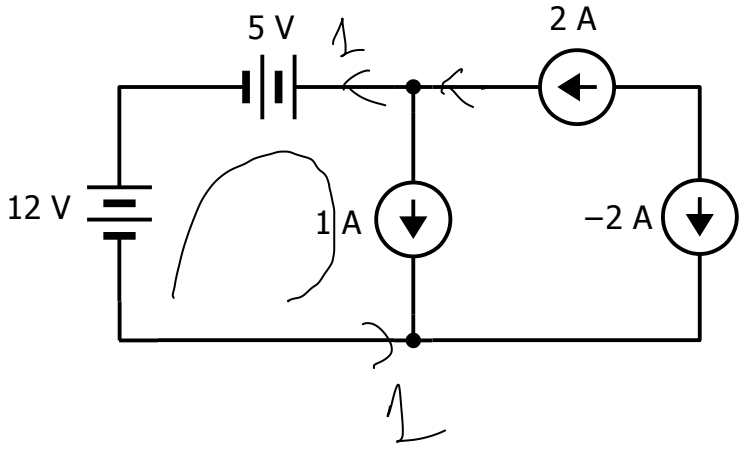
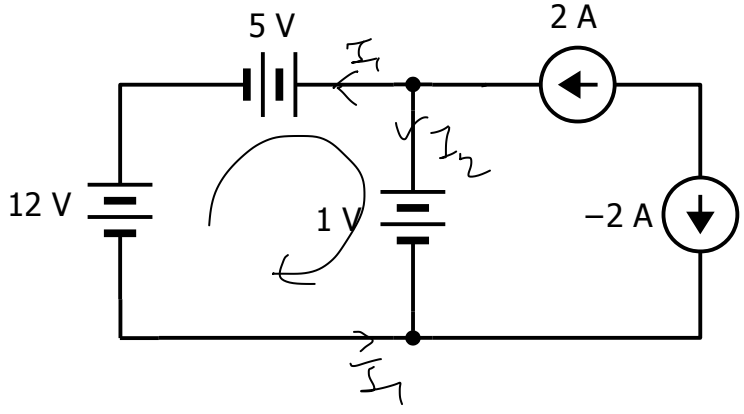
These problems will exercise your knowledge of KVL and KCL. Be sure to watch the video. "Legal" means that KCL and KVL are satisfied.

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



Circuit is legal.

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



Circuit is illegal.

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