ECE 109 - NODE ANALYSIS - INVESTIGATION 14
NODE VOLTAGES

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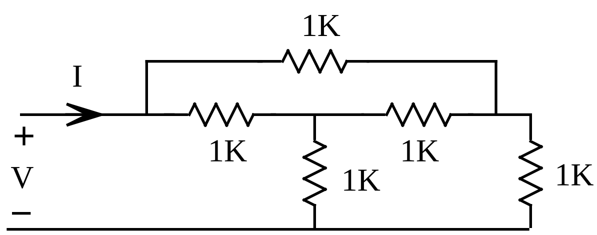
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

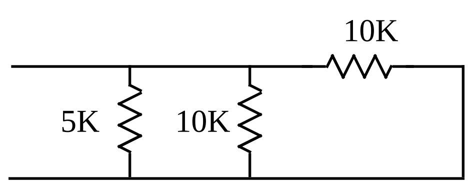
As we've seen, it's pretty straightforward to analyze series and parallel resistor circuits with voltage and current division. But more general circuits like the following



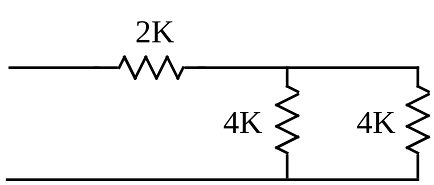
require more general methods. One very good way to analyze such circuits is with **node equations**. The advantages of node equations are that they are very straightforward to write, always work and more often than not require less work. The objective of this Investigation is to lay the foundation for the development of node equations by reviewing our earlier work with node voltages. Be sure to take a look at the **Computer Demos** on Node Equations.

1. We begin with some review problems. Find the equivalent resistances of the following circuits

a.

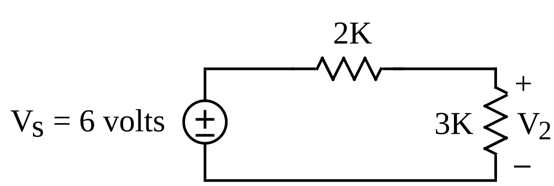


b.

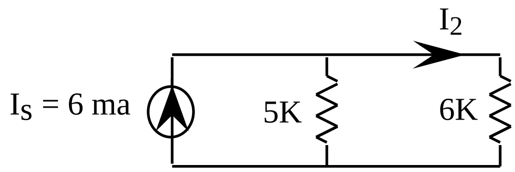


2. For the following circuits

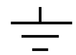
a. Use voltage division to find V_2 in the following circuit



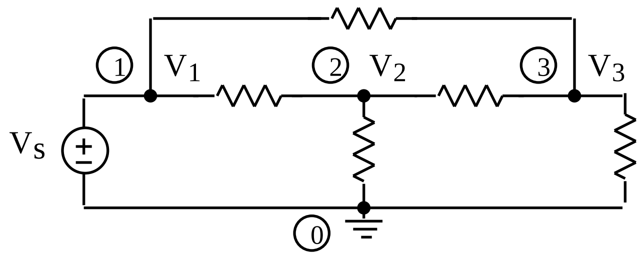
b. Use current division to find I_2 in the following circuit



3. As we've said before, the node voltages in a given circuit are the voltage drops from the nodes to one arbitrarily chosen node which we refer to as the **reference node** and mark with the symbol

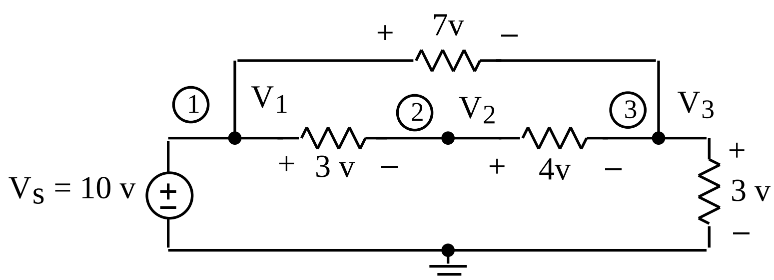


Memorize the definition of node voltages. The reference node is usually labeled node number 0. Describe how you would use a voltmeter to measure the node voltages V_1, V_2 and V_3 - the voltage drops from the nodes to the reference - in a circuit like the following

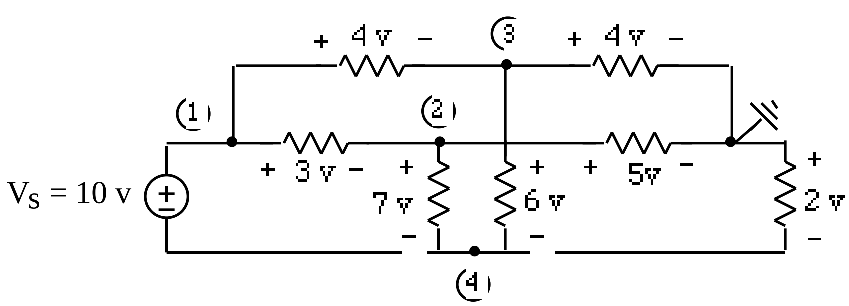


Draw pictures showing how the voltmeter would be connected. Note that we have included the dots for emphasis but usually don't include them unless there is ambiguity about whether or not two crossing wires are touching.

4. Now let's calculate some node voltages from circuit element voltages
   a. Calculate and then put in a Table the node voltages V_1, V_2 and V_3 of



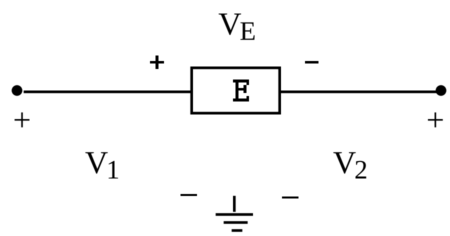
   b. Calculate and then put in a Table the node voltages of the following circuit. Note that two crossing wires are not connected unless there's a dot at the intersection



   c. Calculate and then put in a Table the node voltages of a circuit you make up

d. Describe how you calculated the node voltages in these circuits

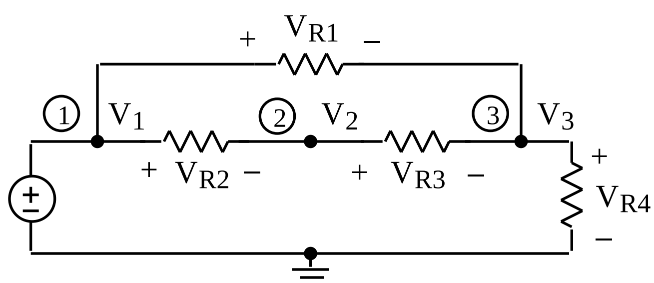
5. The objective of this problem is calculate circuit element voltages from node voltages.
   a. First make use of KVL to show that the voltage V_E across an arbitrary circuit element E as follows



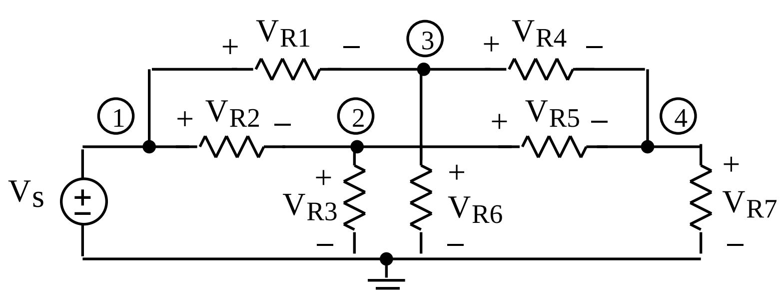
can be calculated in terms of the node voltages V_1 and V_2 as follows

V_E = (Voltage at the node with the **plus**) – (Voltage at the node with the **minus**) = $V_1 - V_2$

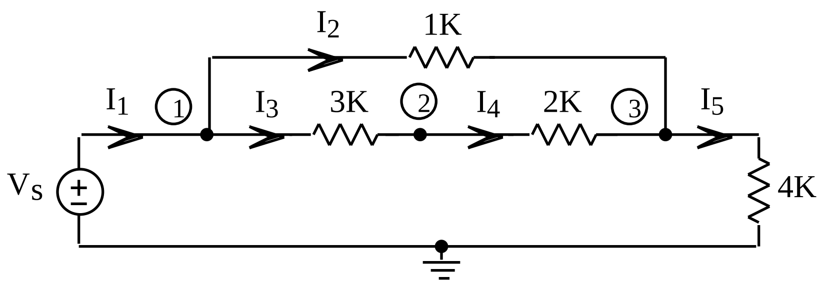
   b. Make use of the result from part (a) to calculate and then put in a Table the circuit element voltages of the following circuit with node voltages $V_1 = 5$ volts, $V_2 = 4$ volts and $V_3 = 2$ volts



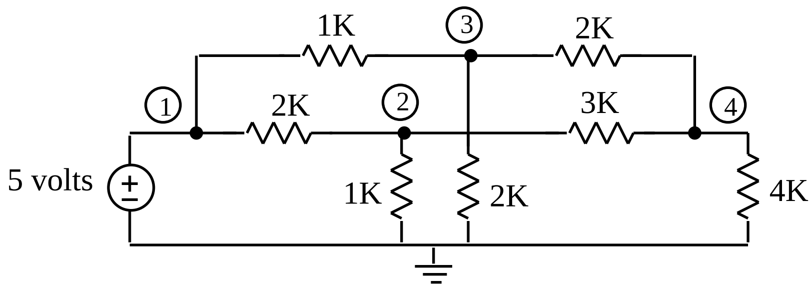
   c. Calculate and then put in a Table the circuit element voltages of the following circuit with node voltages $V_1 = 5$ volts, $V_2 = 4$ volts, $V_3 = 2$ volts and $V_4 = 1$ volt



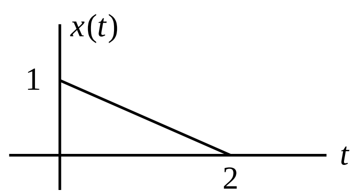
6. Calculate and then put in a Table the currents in the following circuit with node voltages $V_1 = 4$ volts, $V_2 = 3.59$ volts and $V_3 = 3.31$ volts



7. Determine whether the measured node voltages V_2 = 2 volts, V_3 = 3 volts, V_4 = 2.5 volts are correct for the following circuit. Hint - check KCL at the nodes



8. Math Review: Given $x(t)$ as follows



a. Sketch $y_1(t) = x(-t+1)$
b. Sketch $y_2(t) = x(-t-1)$