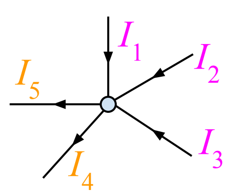
## Pre-lab

In this lab, we will use what we have learned so far in linear algebra and MATLAB on something practical: circuit analysis. Using circuit analysis, we can solve the unknown properties of a circuit, such as voltage, current, resistance, impedance, power, among others, across its components, such as resistors, transistors, capacitors, etc. There are many essential laws that we can readily use to conduct the circuit analysis, and one of which is Ohm's law that you may have learned from your high school physics class. To recap, Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points. The mathematical formulation to describe Ohm's law is given as follows:

$$I = \frac{V}{R}$$

For a circuit with resistors connected together in series or parallel or combination of both, we sometimes can just find an equivalent resistance and then solve the circuit by just using Ohm's law as shown above. However, there exists more complex circuits, like bridge circuit, that cannot be solved by Ohm's law. For this type of circuit, we can use **Kirchhoffs Circuit Law**. Kirchhoffs laws consists of two separate laws: **Kirchhoffs Current Law** and **Kirchhoffs Voltage Law** .

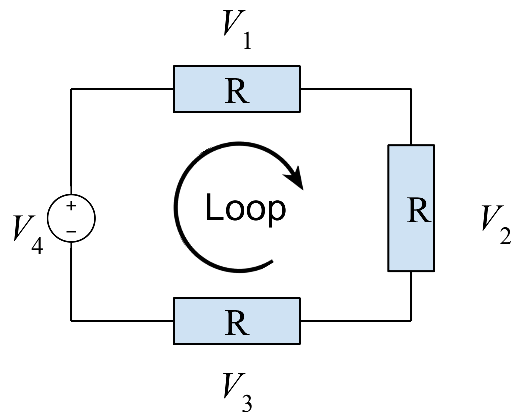
**Kirchhoffs Current Law** states that the algebraic sum of currents entering and leaving a node must equal to zero, $I_{\text{(entering)}} + I_{\text{(leaving)}} = 0$ which can also be referred to as Conservation of Charge. The term **Node** refers to the connection or junction of two or more current carrying paths/elements such as cables other components.




In the graph above, there are three currents $I_1$, $I_2$ and $I_3$, entring the code, and two currents leaving the node. Therefore, the equation can be written as:

$$I_1 + I_2 + I_3 - I_4 - I_5 = 0$$

**Kirchhoffs Voltage Law** states that the algebraic sum of all voltages within the loop must be equal to zero. This law is also known as conservation of energy.



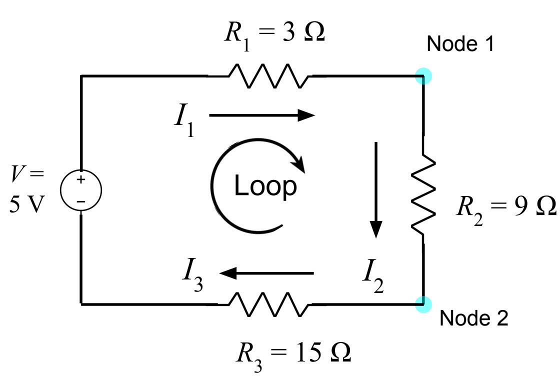

Starting at any point in the loop (say point $A$), continue in the same direction (cheoose either clockwise or counter-clockwise, but be consistent) noting the direction the voltage drops, and return to the same starting point. Summing all the voltage drop gives:

$$V_1 + V_2 + V_3 - V_4 = 0$$

Note that by following the sign convention of denoting voltage drop as positive and voltage rise as negative, and because of this, $V_4$ has a negative sign in front of it. You can certainly choose to use the opposite of this sign convention if that makes more sense to you as long as you are consistent with your sign convention throughout the analysis.

<u>Exercise (practice on your own, no submission required)</u>:

Given the circuit below:




1. Build the equation for Node 1 using Kirchhoffs Circuit Law.

2. Build the equation for Node 2 using Kirchhoffs Circuit Law.
3. Build the equation for the loop using Kirchhoffs Voltage Law. (*Hint:* $V = IR$)
4. Convert the above system of three equations into the matrix form $Ax = b$, then solve for $I_1$, $I_2$, and $I_3$. Do it in MatLab using the various techniques you practiced last week.
5. Does $I_1 = I_2 = I_3$?
6. Verify your solution (i.e. the current value of $I_1$, $I_2$, and $I_3$) using the simple method by finding an equivalent resistance of resistors in series.