Nodes, Branches, and Loops
Objective of Lecture

- Describe what a single node, a distributed node, branch, and loop are.
- Explain the differences between a series and parallel connection.
- Introduce the following concepts:
  - All current entering a node must leave the node.
  - The voltage drop across components or set of components that share the same two nodes are equal.
  - The sum of all voltage drops in a loop is equal to zero.
  - Node voltage and voltage drop.
- Material is from Chapters 5-7
Nodes

- Nodes are the region where connections are made between two or more components.
Nodes

- There are three nodes in this circuit.
  - One node connects resistor $R_1$ to the independent voltage source.
    - Black dot with the blue arrow pointing to it.
  - Two other nodes connect the ends of several components together.
    - Black dots with the red arrows pointing to them.
Nodes

- A node can be a point.
  - E.g., the black point between the resistor and the independent voltage source

- A node can be distributed along a wire.
  - E.g., the blue dashed area where there is a connection between a) the current source and the two resistors and b) the current source, the voltage source and one of the resistors
Nodes

- All current entering a node must leave it.
- Nodes cannot cause charge to appear or disappear from the circuit.
- For example, in the distribute node at the top of the circuit, a current of 3 A is entering the node and 2 A + 1 A are leaving the node.

\[
\sum_{i_{\text{enter}}} = \sum_{i_{\text{leave}}}
\]
Branches

- Branches are single elements in a circuit such as a voltage source or resistor, located between two nodes.

This circuit has four branches:

- 1 independent current source
- 1 independent voltage source
- 2 resistors
Series Connections

- If the two branches are connected by a node, then they carry the same current and are in series.
- The resistor and independent voltage source are in series.
A set of components that share two nodes are in parallel.

There are three combinations of components that are in parallel in this circuit, which share the two distributed nodes.

- The 3A current source
- The combination of resistor R1 and voltage source
- and resistor R2.
Parallel Connection

- The voltage drop across the components that are in parallel are in parallel is the same, but the current flowing through each of the sets of components may not be.

- The voltage drop across R2 is 5V.
- The voltage drop across R1 and the voltage source is 6V – 1V = 5V.
- Therefore, the voltage drop across the 3A current source must be $V_c = 5V$. 
Node Voltage

- Node voltage is the measurement of the voltage at a node with respect to ground.
- This concept is used in nodal analysis, which will be presented in Week 3.
Voltage Drop

Voltage drop is the voltage across one or more components and is the difference in node voltages at the two extremes of the set of components.

The voltage drop across a resistor is calculated using Ohm’s Law.
Loops

Loops are closed paths through a circuit.

This circuit has three loops.
Loops

- The sum of voltage drops around a loop is equal to zero.

\[ \sum v = 0 \]

- This concept is applied in mesh analysis, which will also be presented during Week 3.
The identification of the nodes, branches, and loops in a circuit is an important step in circuit analysis.

Series connections occur when only two components share one node.
  - The current flowing through one component will then flow through the second.

Parallel connections occur when components share the same set of nodes.

Node voltage is the measurement of the voltage at a node with respect to ground while a voltage drop is the difference in the voltage across a component or set of components.
  - The voltage dropped across a resistor is calculated using Ohm’s Law.