Lecture 5: Resistive Circuits

Electric Circuits must contain a power source, a complete path for electricity to flow, and a load.

Power source examples: battery, power supply, generator.

Electrical symbols:

Battery ⇒  ⇐ DC voltage source

Independent Power supply ⇒ DC voltage source V 

⇒ AC voltage source V 

Current Source: (can be AC or DC) I 

Dependent Power supply ⇒ DC Voltage  AC Voltage  Current 

Circuit Path: For current to continuously flow through a circuit, circuit must contain at least one complete path from the positive terminal of a power source to the negative terminal of the same power source.

Circuit Path examples: wires, ground, traces on a circuit board

Electrical symbols:

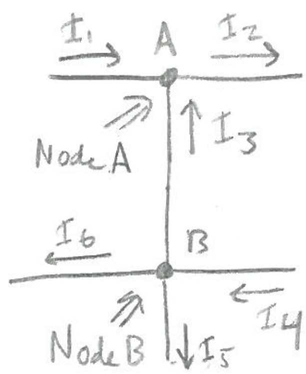
Wires or traces ⇒ ————————

Ground ⇒

Ground   Chassis Ground

Nodes: Nodes are points in a circuit where multiple circuit paths are connected.

Symbol:



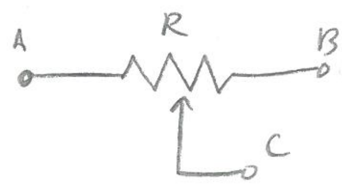
Loads: A load is a device that can draw current from a power source.

Examples: resistors, inductors, capacitors, light bulbs, motors, heaters, etc.

Electric Symbols:

Resistor:  ⇐ Fixed value

 ⇐ Variable resistor

Potentiometer: 

A to B is Fixed value resistance

A to C is variable resistance

Inductor: 

Capacitor:  or  ⇐ Indicates polarity

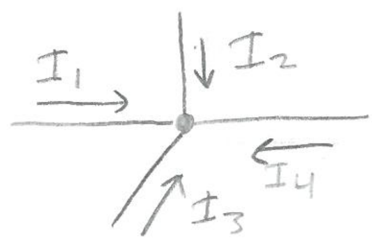
— is +

 is negative

Resistive circuits can be analyzed using Ohm's Law and Kirchhoff's circuit laws.

Kirchhoff's Current Law (KCL): The algebraic sum of the currents into a node at any instant is zero.

E.g.



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

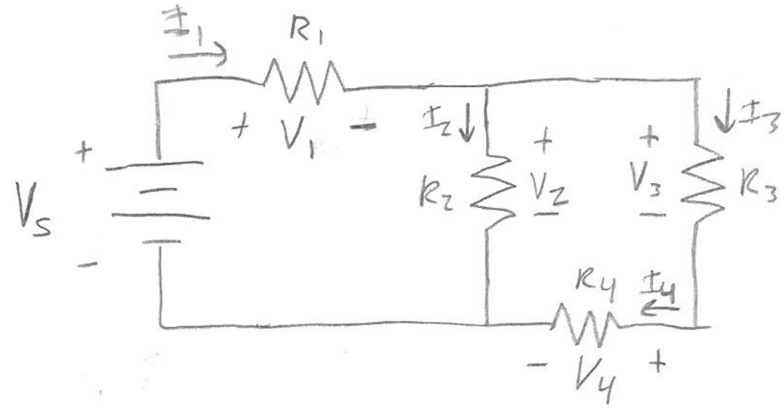
Q. How can this be if all currents are flowing <u>into</u> the node?

A. One or more currents must be negative.

* In fact, in analyzing resistive circuits, even if we define current in the direction opposite to it's actual flow, so long as we maintain proper conventional use of Ohm's Law and Kirchhoff's circuit laws, we will get the correct answer. The current will just have a negative value.

Kirchhoff's Voltage Law (KVL): The algebraic sum of the voltages around any closed path in a circuit is zero at any instant.

E.g.



Loop 1: $V_s - V_1 - V_2 = 0$

Loop 2: $V_s - V_1 - V_3 - V_4 = 0$

Loop 3: $V_2 - V_3 - V_4 = 0$

Q. What if we defined V_4 in the opposite direction?

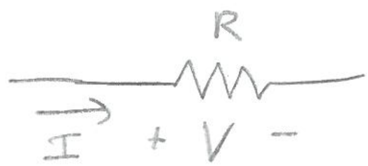
A. Loop 2: $V_s - V_1 - V_3 + V_4 = 0$

Loop 3: $V_2 - V_3 + V_4 = 0$

★ Again, if we follow convention in analysis, but define the polarity of voltage drop across a resistor in the wrong direction, we will still get the correct answer, just with the opposite sign.

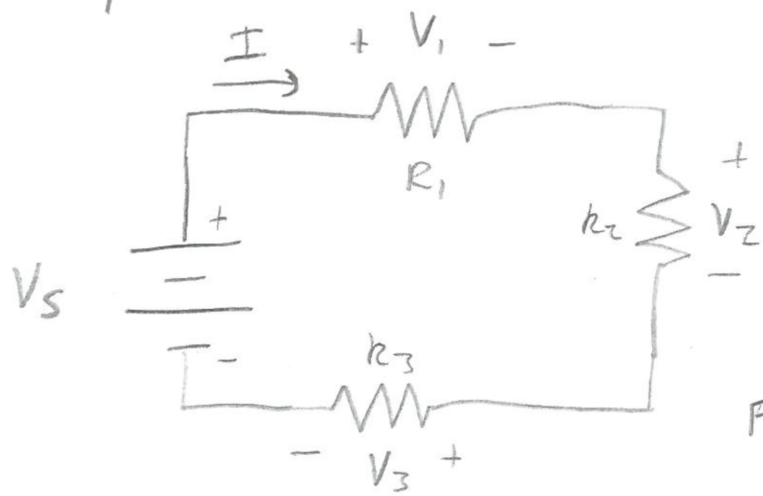
Recall: Ohm's Law

$$V = IR \quad (\text{in book: } E = IR)$$



Important: Convention is that voltage drop across resistor (from + to −) is with the direction of current.

Example



From KVL:

$$V_S - V_1 - V_2 - V_3 = 0$$

then $V_S = V_1 + V_2 + V_3$

From Ohm's Law:

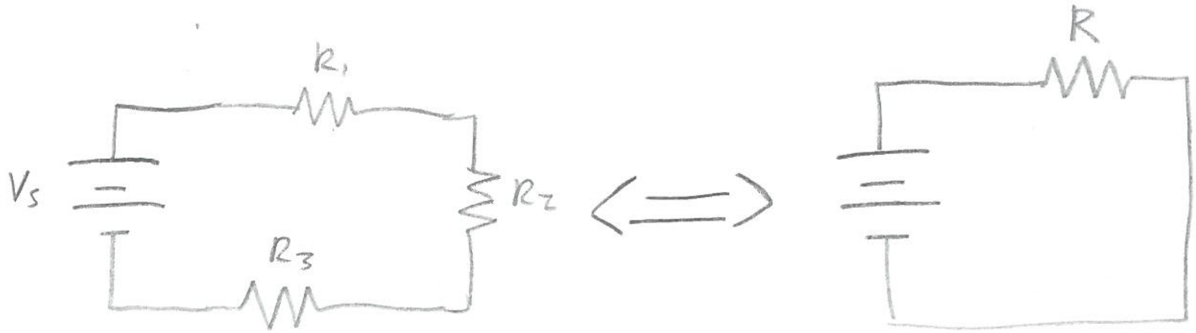
$$V_1 = IR_1, \; V_2 = IR_2, \; V_3 = IR_3$$

then $V_S = IR_1 + IR_2 + IR_3$

combining terms $V_S = I(R_1 + R_2 + R_3)$

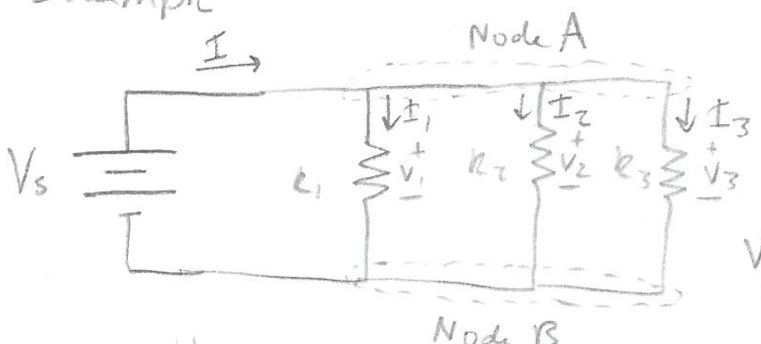
This is example of <u>series</u> resistances.

When resistors are wired in series, i.e. they share the same current, then their resistance values add algebraicly.



From the perspective of the battery, total resistance in the circuit is $R = R_1 + R_2 + R_3$

Example



From KCL:

$$I - I_1 - I_2 - I_3 = 0$$
$$I = I_1 + I_2 + I_3$$

From KVL:

$V_s - V_1 = 0 \quad V_s - V_2 = 0 \quad V_s - V_3 = 0$

$V_s = V_1 \quad V_s = V_2 \quad V_s = V_3$

From Ohm's Law:

$V_1 = I_1 R_1 \quad V_2 = I_2 R_2 \quad V_3 = I_3 R_3$

$I_1 = \frac{V_1}{R_1} \quad I_2 = \frac{V_2}{R_2} \quad I_3 = \frac{V_3}{R_3}$

then $I = \frac{V_s}{R_1} + \frac{V_s}{R_2} + \frac{V_s}{R_3}$

$$I = \underbrace{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)}_{\frac{1}{R}} V_S$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

When resistors are wired in parallel, i.e. they share the same nodes, the inverse of their resistance values sum algebraically.