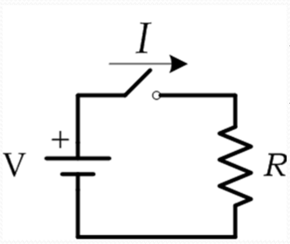
Circuit Analysis

Section 04

Ohm’s Law

- A current through a resistor is proportional to the voltage across its terminals

$$V = I \cdot R \qquad or \qquad I = \frac{V}{R}$$



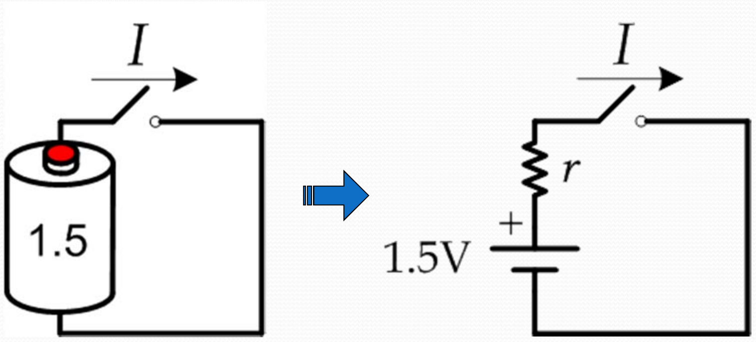
$$R \rightarrow \infty \quad I = 0 \quad short\,circuit \quad SC$$

$$R \rightarrow 0 \quad I = \infty \quad open\,circuit \quad OC$$

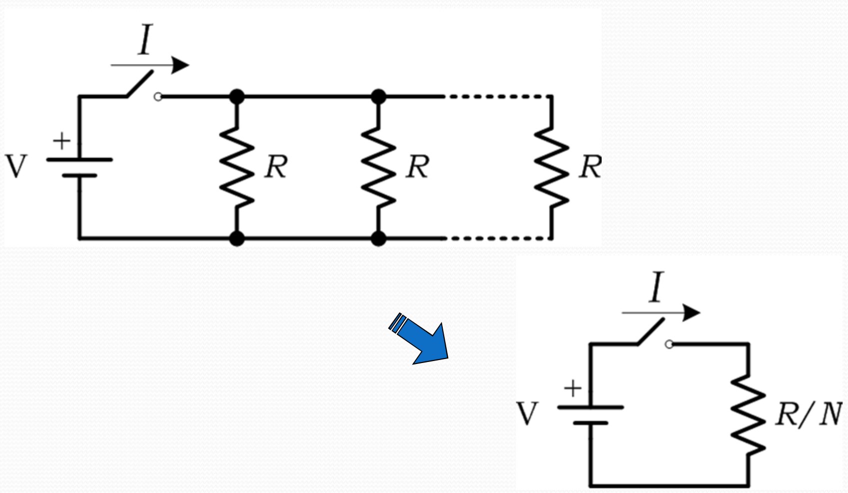
Short a 1.5 battery, what will happen?

Internal Resistance

- If you short a 1.5V battery, how much current will pass?

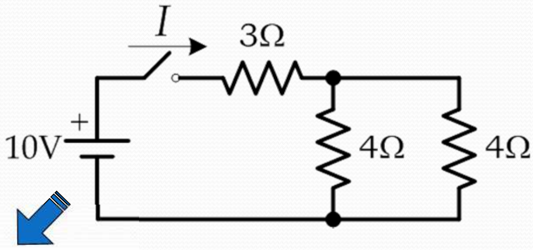


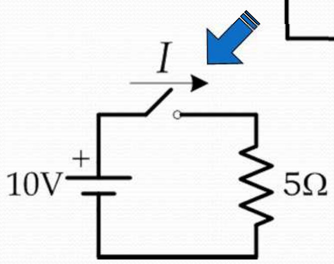
Overloading



Question

- What is the total current drawn from the source?

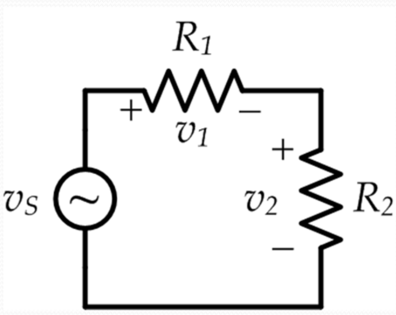




$$R_L = 4//4 + 3 = 2 + 3 = 5\Omega$$

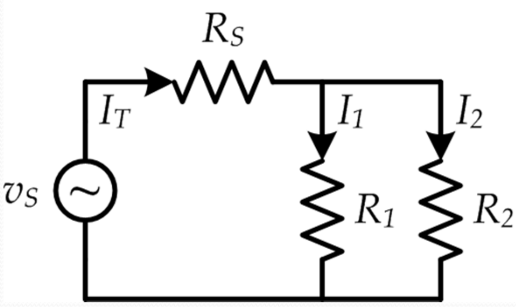
$$I = \frac{V}{R} = \frac{10}{5} = 2A$$

Voltage Divider



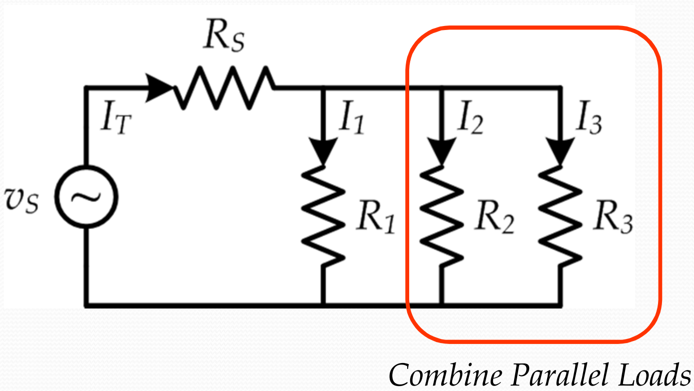
$$v_1 = v_s \frac{R_1}{R_1 + R_2} \qquad v_2 = v_s \frac{R_2}{R_1 + R_2}$$

Current Divider



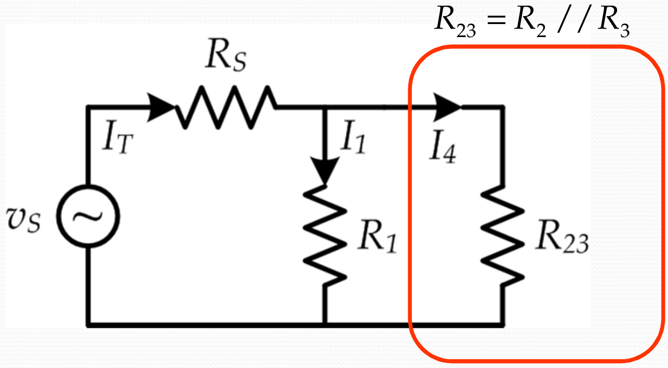
$$I_1 = I_T \frac{R_2}{R_1 + R_2} \qquad I_2 = I_T \frac{R_1}{R_1 + R_2}$$

Multiple Loads



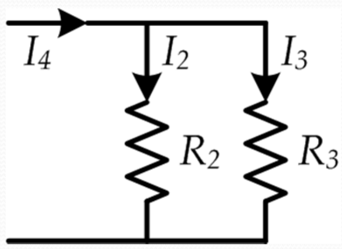
Multiple Loads

$$R_{23} = R_2 // R_3$$



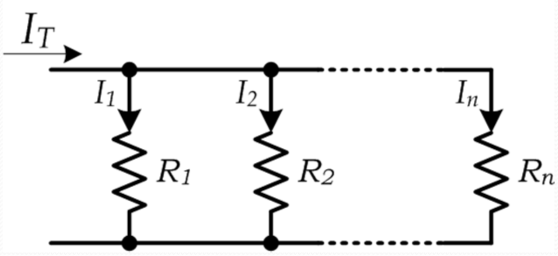
$$I_1 = I_T \frac{R_{23}}{R_1 + R_{23}} \qquad I_4 = I_T \frac{R_1}{R_1 + R_{23}}$$

Multiple Loads



$$I_2 = I_4 \frac{R_3}{R_2 + R_3} \qquad I_3 = I_4 \frac{R_2}{R_2 + R_3}$$

Current Divider

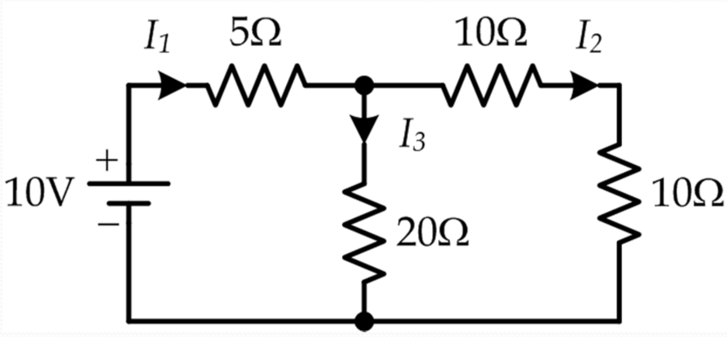


$$R_p = R_1 // R_2 // \cdots // R_n$$

$$I_k = I_T \frac{R_p}{R_k}$$

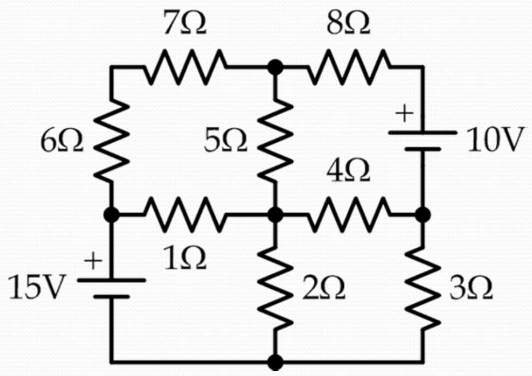
Process Check

- Calculate all currents in the circuit..
  - What is your plan?!



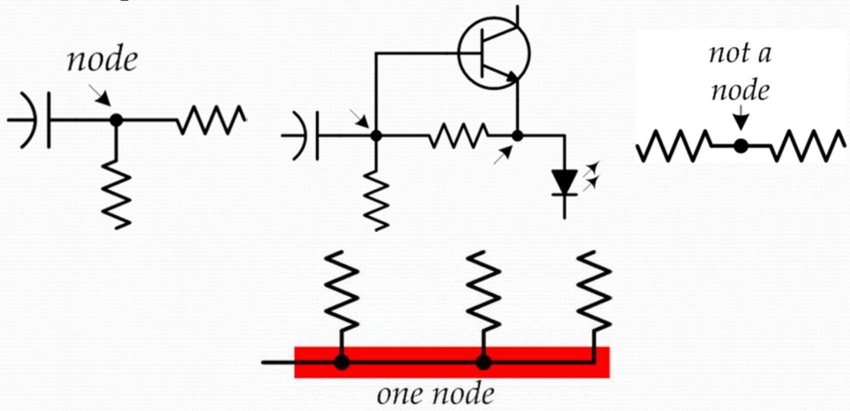
Multiple Sources

- What if more than one source in the circuit?
  - How to solve for all currents?



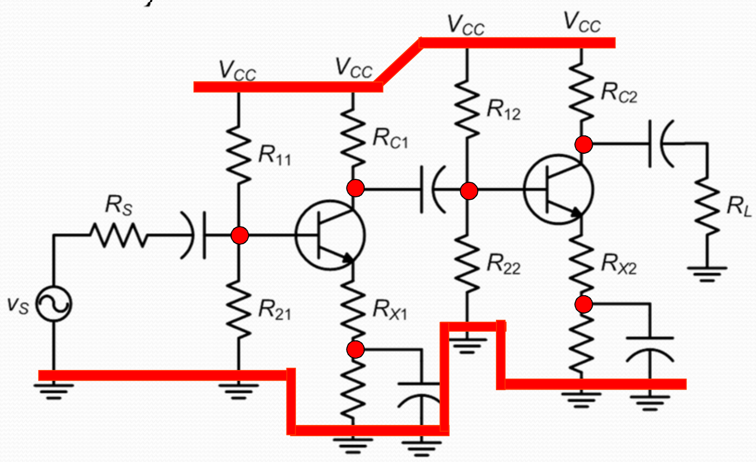
Nodes and Loops

- A Node
  - a point in a circuit where 3 or more elements meet



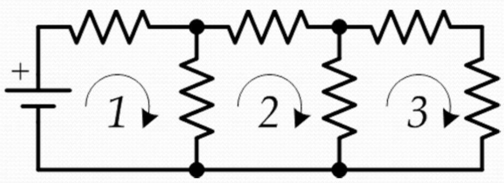
Nodes and Loops

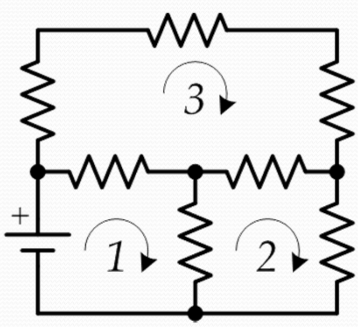
- How many nodes in the circuits?



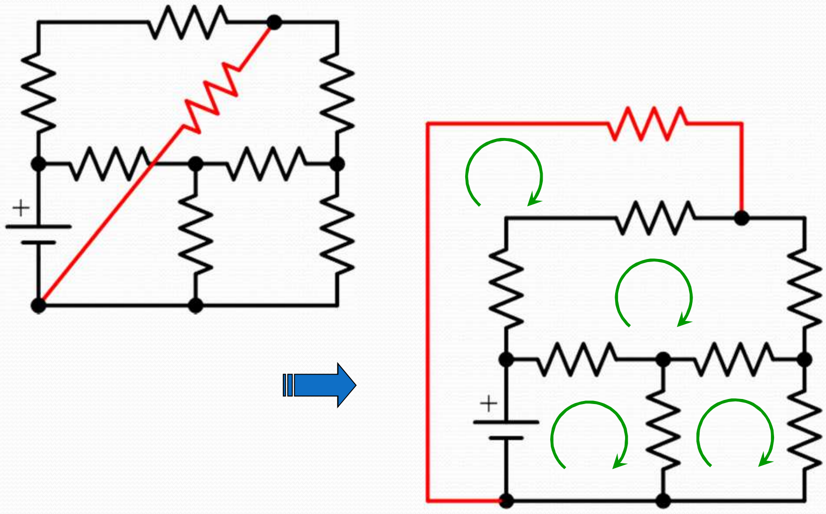
Nodes and Loops

- A Loop:
  - a closed ring in a planer circuit





Planer Circuit



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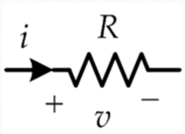
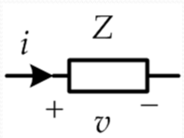
Voltage Drop

- A current passing through a load generates a voltage drop



$v = i \cdot R$



$v = i \cdot Z$

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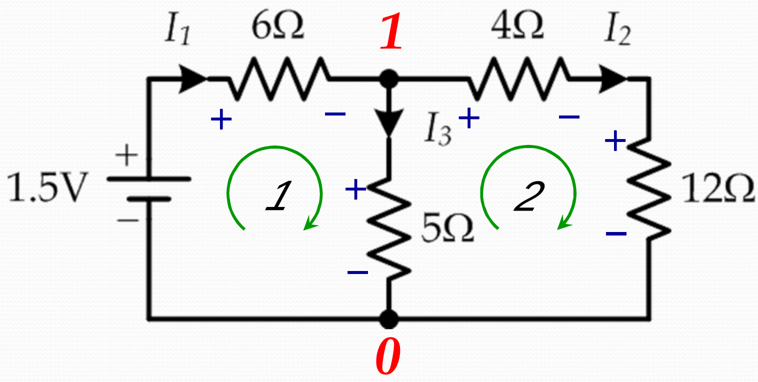
KVL and KCL

- *(nodes, loops, planner circuit, voltage drop) then what?*
- To solve for all currents and volts in a circuit:
  - KVL: Kirchhoff's Voltage Law
  - the algebraic sum of voltages in a loop is zero
  - KCL: Kirchhoff's Current Law
  - the algebraic sum of currents into a node is zero

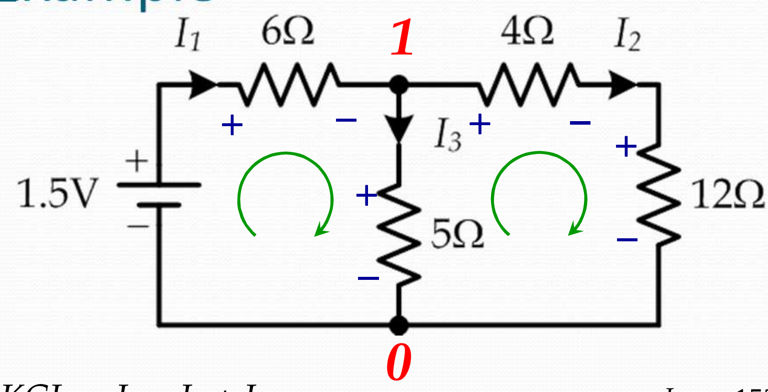
Circuit Analysis

1. count nodes minus one (possible ground)
2. mark a current for each branch
   - name and direction
3. write KCL equations for each node
4. count the loops
5. write the KVL equations for each loop
6. solve for all unknowns

Example



Example

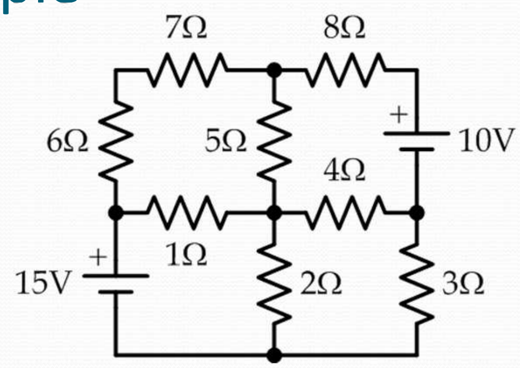


$$KCL: \quad I_1 = I_2 + I_3$$

$$KVL: \begin{aligned} -1.5 + 6I_1 + 5I_3 &= 0 \\ -5I_3 + 4I_2 + 12I_2 &= 0 \end{aligned}$$

$$\Rightarrow \begin{aligned} I_1 &= 152.9 \quad mA \\ I_2 &= 36.4 \quad mA \\ I_3 &= 116.5 \quad mA \end{aligned}$$

Example



8 branches → 8 currents $I_1..I_8$ → 8 equations

4 nodes → 4 eqs

4 loops → 4 eqs