What to Do?

- When faced with a complex circuit….
  - If the circuit has **ONE** emf, anayzing the circuit using the process from last class is usually simpler
  - If the circuit has **MULTIPLE**, emfs, then Kirchhoff's Laws will be needed

Kirchhoff's Law – Basic Principles

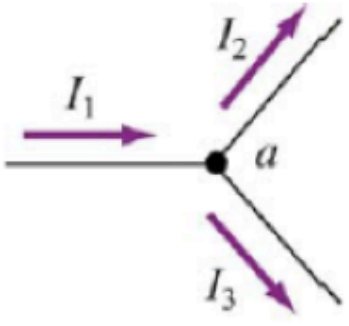
- **Kirchhoff's Laws support the conservation of charge and energy in a circuit**
- **Two Laws:**
  - Kirchhoff's First Law: The Junction Rule
    - At any junction point, the sum of all currents entering the junction must equal the sum of all currents leaving the junction
  - Kirchhoff's First Law: The Loop Rule
    - The sum of the changes in electric potential ('voltage') around any closed path of a circuit must be zero.

Junction Rule

At any junction point, the sum of all currents entering the junction must equal the sum of all currents leaving the junction

No loss of current

Conservation of charge



Write junctions as equalities

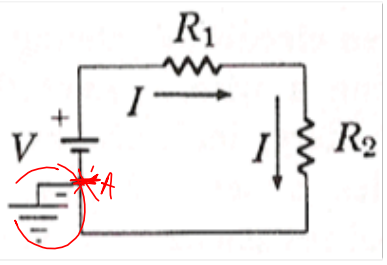
$$I_1 = I_2 + I_3$$

Loop Rule

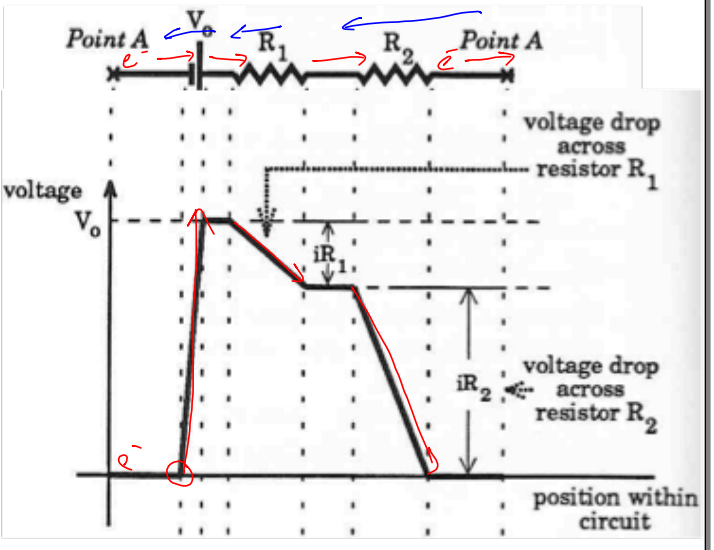
The sum of the changes in electric potential ('voltage') around any closed path of a circuit must be zero.

All available voltage is used

Conservation of energy



Imagine you 'unfold' the circuit

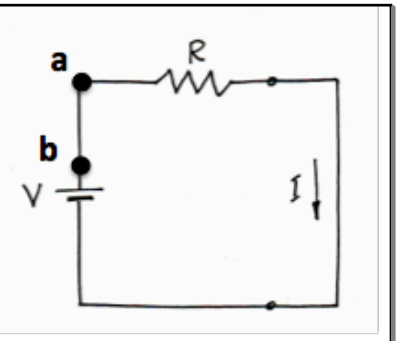


What are we assuming about the wires?

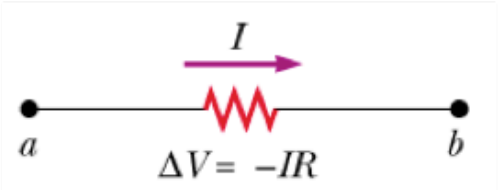
Tracing Current Through a Loop

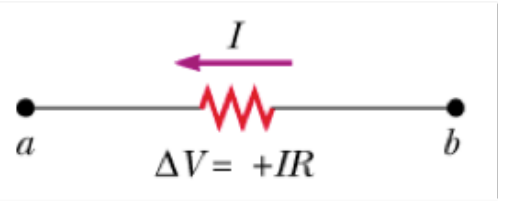
- Follow conventional current
  - A + direction will move from high to low electric potential (voltage)
  - A - direction will move from ~~high to low~~ low high electric potential (voltage)

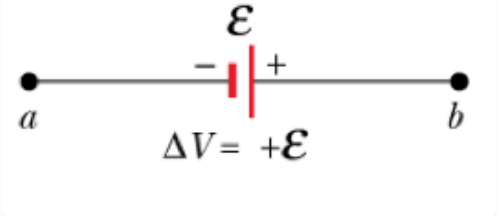
Tracing Current Through a Loop

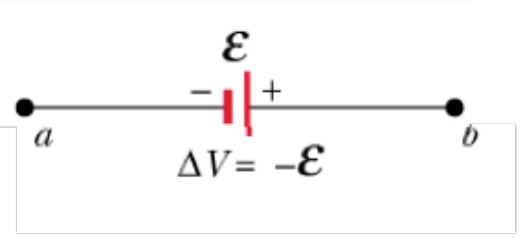


- Loop Rule – looking at voltage drops.
  - In a positive direction, a voltage drop is –IR, an emf is + V
  - In a negative direction, a voltage drop is +IR, an emf is - V









Steps for Kirchoff's Laws

1. Label all voltage sources and resistors

2. Label any currents through the branches of the circuit

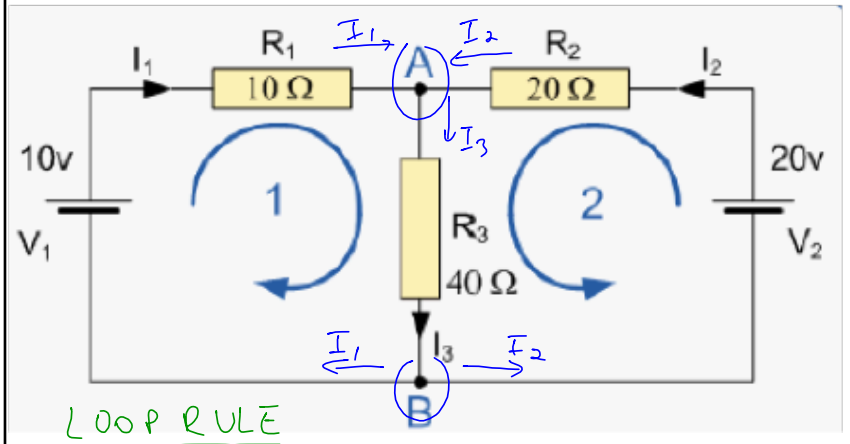
3. Apply junction rule at any nodes (junctions)

4. Apply loop rule for independent loops through the circuit

5. Solve equations for unknown variables.

Example 11

Apply Kirchhoff's Laws to determine the currents through the circuit below.



Junction Rule

A) ① $I_1 + I_2 = I_3$

B) $I_3 = I_1 + I_2$

$I_1 = -0.144\ A$

$I_2 = 0.429\ A$

$I_3 = 0.285\ A$

LOOP RULE

Loop 1

② $+10 - I_1 \cdot R_1 - I_3 \cdot R_3 = 0$

$10 - I_1(10) - I_3(40) = 0$

Loop 2

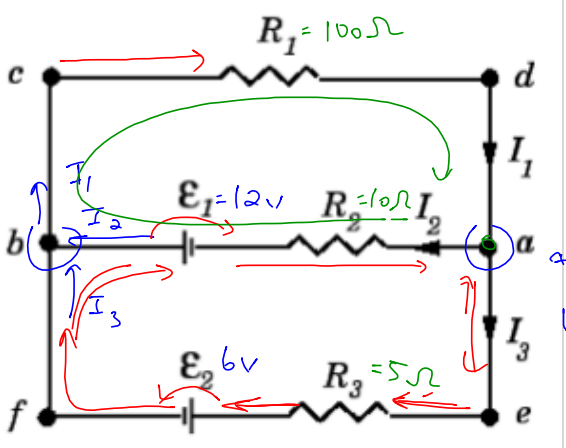
③ $+20 - I_2 R_2 - I_3 R_3 = 0$

$20 - I_2(20) - I_3(40) = 0$

Use equations 1, 2, and 3 to solve for the three currents

Example 12

Apply Kirchhoff's Laws to determine the currents through the circuit below.



$R_1 = 100\ \Omega$ $\quad \xi_1 = 12\ v$

$R_2 = 10\ \Omega$ $\quad \xi_2 = 6\ v$

$R_3 = 5\ \Omega$

① Junction Rule

a.) $I_1 = I_2 + I_3$

b.) $I_2 + I_3 = I_1$

$-I_3 \cdot R_3 - 6 - 12 + I_2 \cdot R_2 = 0$

$-I_3 \cdot 5 - 18 + I_2 \cdot 10 = 0$

$-I_2 \cdot R_2 + 12 - I_1 \cdot R_1 = 0$

$-I_2 \cdot 10 + 12 - I_1 \cdot 100 = 0$