CONCEPT: INTRODUCTION TO KIRCHHOFF'S LOOP RULE

● So far we have only seen SINGLE source circuits. To solve circuits with MULTIPLE sources, we will need new "TOOLS"

● Kirchhoff's LOOP rule states that the SUM of all the VOLTAGES around a LOOP is _____.

→ ΣV = _____ - This rule is also called Kirchhoff's _____ Law.

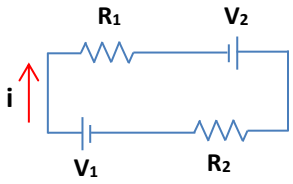
- This works for ANY circuit, but is especially useful for circuits with MULTIPLE sources.

● For each LOOP in a circuit, we can write one LOOP EQUATION.

- Each equation adds/subtracts voltages of batteries and resistors.

- The voltage of resistors is written as _____ (from _____)

→ ΣV = _____ = _____



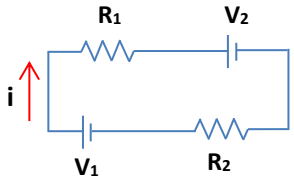
● Each voltage is added or subtracted depending on **(1)** DIRECTION OF CURRENT, and **(2)** DIRECTION OF LOOP.

(1) FIRST, use DIRECTION of CURRENT to put **+/–** signs on the ends of each resistor:

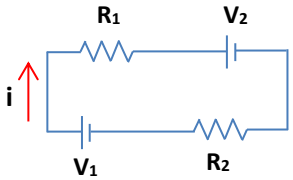
- RESISTOR → Positive end is where _____ the resistor.
- BATTERY → Positive end is positive (longer) terminal (does not depend on direction of current)

(2) SECOND, choose DIRECTION OF LOOP, which is just the sequence in which we will add/subtract voltages.

- When "crossing" elements in this direction, you ADD a voltage if you crossed from _____ to _____.



EXAMPLE: Write a Loop Equation for the circuit above (repeated below), but now using the opposite Direction of Loop.



CONCEPT: DIRECTION OF CURRENT IN LOOP EQUATIONS

- In complex circuits, you often will **NOT** know the DIRECTION OF CURRENTS, so you will _____ / _____ them**:**

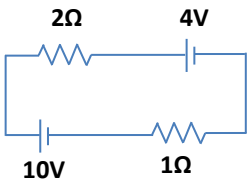
  (0) NEW: _____ direction of ALL currents

  (1) LABEL **+/–** Signs → Battery **+** is on longer terminal. Resistor **+** is where _____ enters the resistor**.**

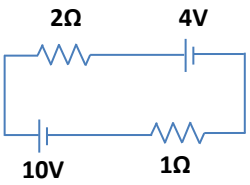
  (2) "CROSS**"** elements in chosen DIRECTION OF LOOP, adding the voltage if you crossed from _____ to _____**.**

EXAMPLE**:** Write Loop Equations for the circuits below, based on the indicated direction of current, then find their current**.**

(a) current is clockwise



(b) current is counter-clockwise



CONCEPT: SOLVING CIRCUITS WITH MULTIPLE SOURCES

- We combine Kirchhoff's Junction Rule ($\Sigma I_{IN} = \Sigma I_{OUT}$) and Loop Rule ($\Sigma V = 0$) to solve circuits with MULTIPLE sources:

1) LABEL DIRECTIONS:

→ LABEL Junctions, Loops (arbitrary) and direction of Currents (assumed)

→ LABEL **+/-** on Voltage Sources (**+** terminal) and Resistors (current enters)

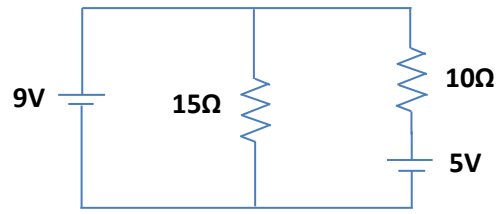
2) WRITE EQUATIONS:

→ WRITE a Junction Equation for each Junction

→ WRITE a Loop Equation for each Loop

3) SOLVE SYSTEM OF EQUATIONS

EXAMPLE: For the circuit below, find the current through each of the 3 branches.



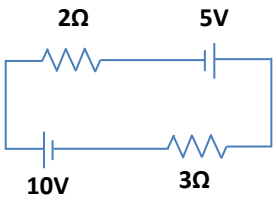
CONCEPT: COMBINING VOLTAGE SOURCES IN SERIES

● You can combine Voltage Sources connected in SERIES to simplify the circuit → V_{EQ} = _____

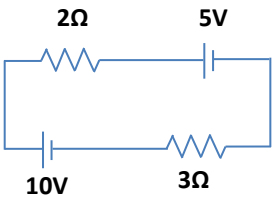
- If the Voltage Sources are pushing charge in OPPOSITE directions, their voltages will _____.

EXAMPLE: For each circuit below, combine the batteries and resistors, then find the magnitude and direction of the current.

(a)

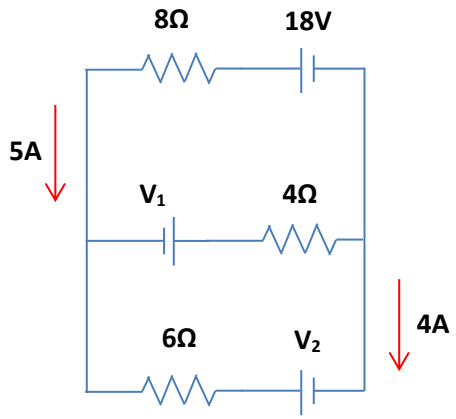


(b)



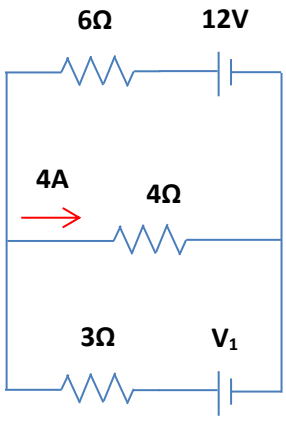
EXAMPLE: FIND TWO VOLTAGES IN 2-BATTERY CIRCUIT

For the circuit below, calculate voltages V_1 and V_2.



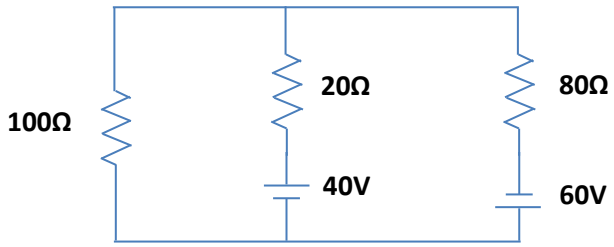
PRACTICE: FIND ONE VOLTAGE AND ONE CURRENT IN 2-BATTERY CIRCUIT

For the circuit below, calculate **(a)** the voltage V_1 shown**,** and **(b)** the current through the 6-Ohm resistor**.**



PRACTICE: FIND VOLTAGE OF ONE RESISTOR IN 2-BATTERY CIRCUIT

For the circuit below, calculate the voltage across the 100-Ohm resistor.

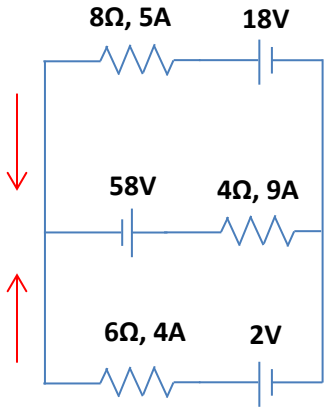


CONCEPT: HOW TO CHECK YOUR WORK (KIRCHHOFF'S RULES)

- Once you know ALL values (voltages, currents, and resistances) in a circuit, you can check your with a simple rule:

  - ALL branches MUST have the same magnitude and "direction" (_____) of _____.

EXAMPLE 1: Check if all numbers below "match up"



EXAMPLE 2: Check if all numbers below "match up"