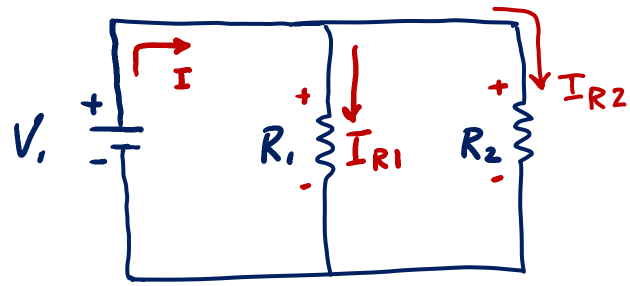
KIRCHOFF'S VOLTAGE LAW: EXAMPLE 1

GIVEN: Consider the circuit shown, where

R_1=20Ω R_2=40Ω V_1=20V

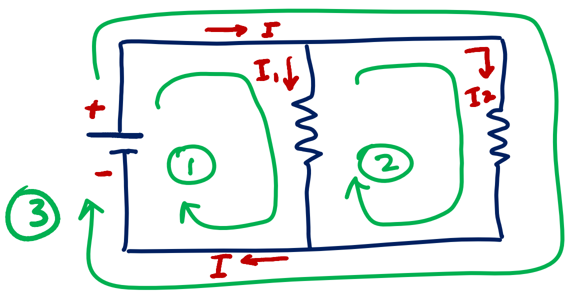


REQUIRED:

(a) The current through R_1.
(b) The current through R_2.
(c) The current leaving the voltage source.

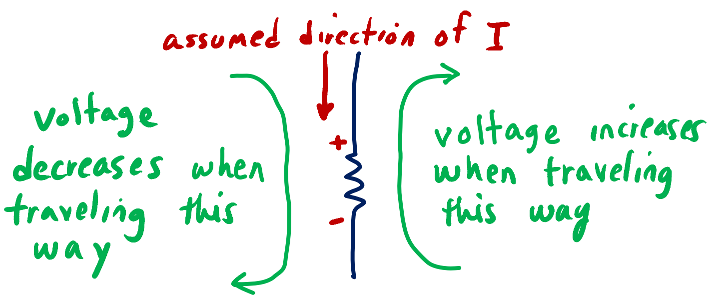
SOLUTION:

(a) First, we identify the loops in the circuit. As shown below, we can choose any two of the three loops.



We use the assumed direction of current to determine whether voltage increases or decreases across a resistor.

Kirchoff's Voltage Law: *The sum of the voltage drops around any closed loop is zero.*



Energy is always dissipated by resistors.

Voltage decreases in the direction of positive current flow.

When applying KVL, assume voltage decreases across a resistor in the assumed direction of current flow (and increases opposite the direction of current flow).

voltage increases across V_1

Applying KVL to Loop 1: $V_1 - V_{R1} = 0$

$$V_{R1} = V_1 = 20V$$

voltage is assumed to decrease in the assumed direction of I_{R1} (V_{R1} = negative)

Applying Ohm's Law to R_1 yields . . .

$$V_{R1} = I_{R1} \cdot R_1 \longrightarrow I_{R1} = \frac{V_{R1}}{R_1} = \frac{20V}{20\Omega} = 1A$$

(b) To find I_{R2}, we can use either Loop 2 or Loop 3. Let's apply KVL to Loop 2.

POSITIVE since Loop 2 is opposite the assumed direction of I_{R1}

NEGATIVE since Loop 2 is in the same direction as the assumed direction of I_{R2}

$$V_{R1} - V_{R2} = 0$$

$$20V - V_{R2} = 0$$

$$V_{R2} = 20\,V$$

Applying Ohm's Law:

$$V_{R2} = I_{R2} \cdot R_2 \longrightarrow I_{R2} = \frac{V_{R2}}{R_2} = \frac{20V}{40\Omega} = \underline{\underline{0.5A}}$$

(c) First determine the equivalent resistance of the circuit:

$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{20\Omega} + \frac{1}{40\Omega}} = \frac{1}{\frac{3}{40\Omega}} = 13.33\Omega$$

Applying Ohm's Law:

$$V = IR$$

$$I = \frac{V_1}{R_{eq}} = \frac{20V}{13.33\Omega} = \underline{\underline{1.5A}}$$

DISCUSSION:

- Kirchhoff's Voltage Law is a useful tool for circuit analysis.
- The voltage drops across both resistors were equal even though the currents were different. The voltage drop is ALWAYS the same across two resistors in parallel.
- Notice that $I_{R1} + I_{R2} = I$. This means that current is conserved. We will learn later that this is an application of Kirchhoff's Current Law (KCL).