SNS COLLEGE OF TECHNOLOGY

(AN AUTONOMOUS INSTITUTION)

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Department of Biomedical Engineering

Course Name: 23EET103- ELECTRIC CIRCUITS & ELECTRON DEVICES

II Year : IV Semester

Unit 1:DC CIRCUITS

Topic : Voltage Divider Rule & Current Divider Rule

Voltage Divider Rule
&
Current Divider Rule

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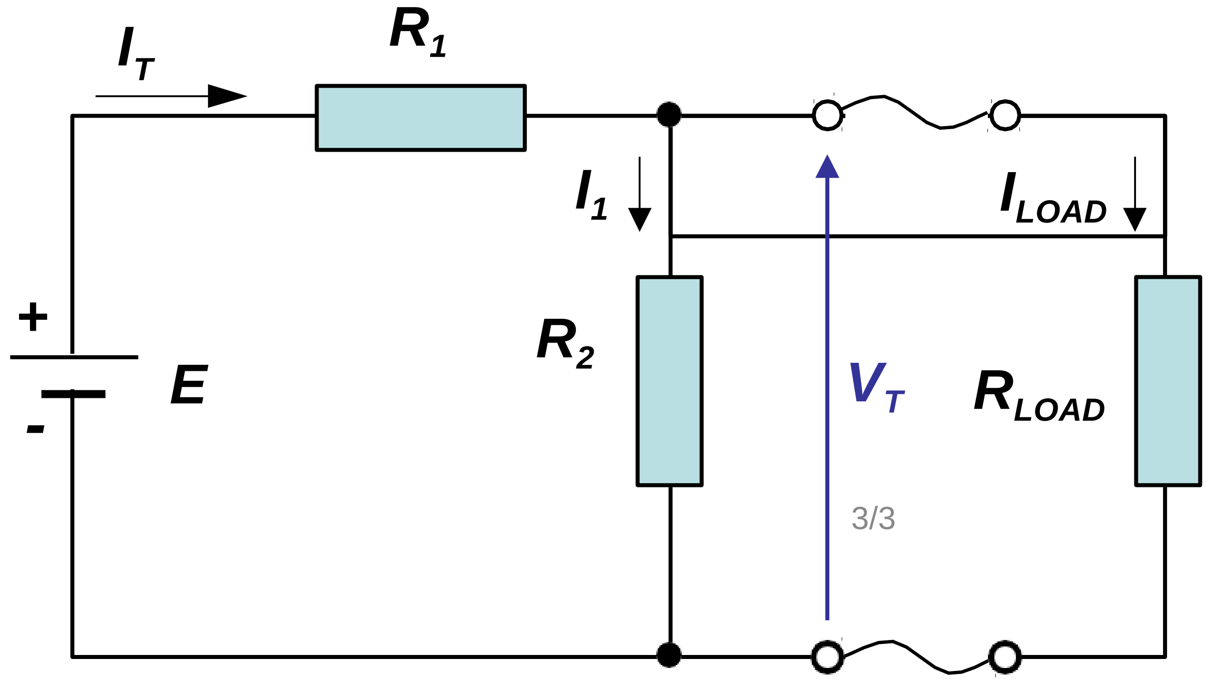
• DC CIRCUITS

Voltage Divider Principle

•**Voltage divider circuits are used in electronics to supply a** ***range of voltages needed by a system from a single source.***

•**The voltage divider uses the principles of Ohm's law to** ***generate the necessary voltages.***



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V_T no load conditions.

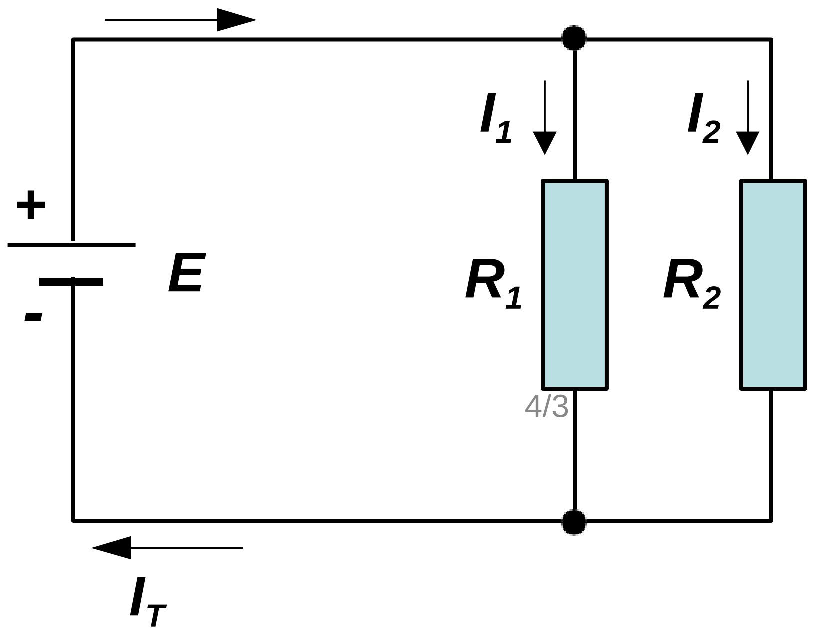
$$V_T = E\,\frac{R_2}{R_1 + R_2}$$

V_T loaded conditions ($I_{LOAD} << I_1$)

$$V_T \sim E\,\frac{R_2}{R_1 + R_2}$$

Current Divider Principle

- In parallel circuits the current IT divides up through the various branch networks, I1, I2.
- The ratio between any two branch currents is the inverse ratio of the branch resistances.



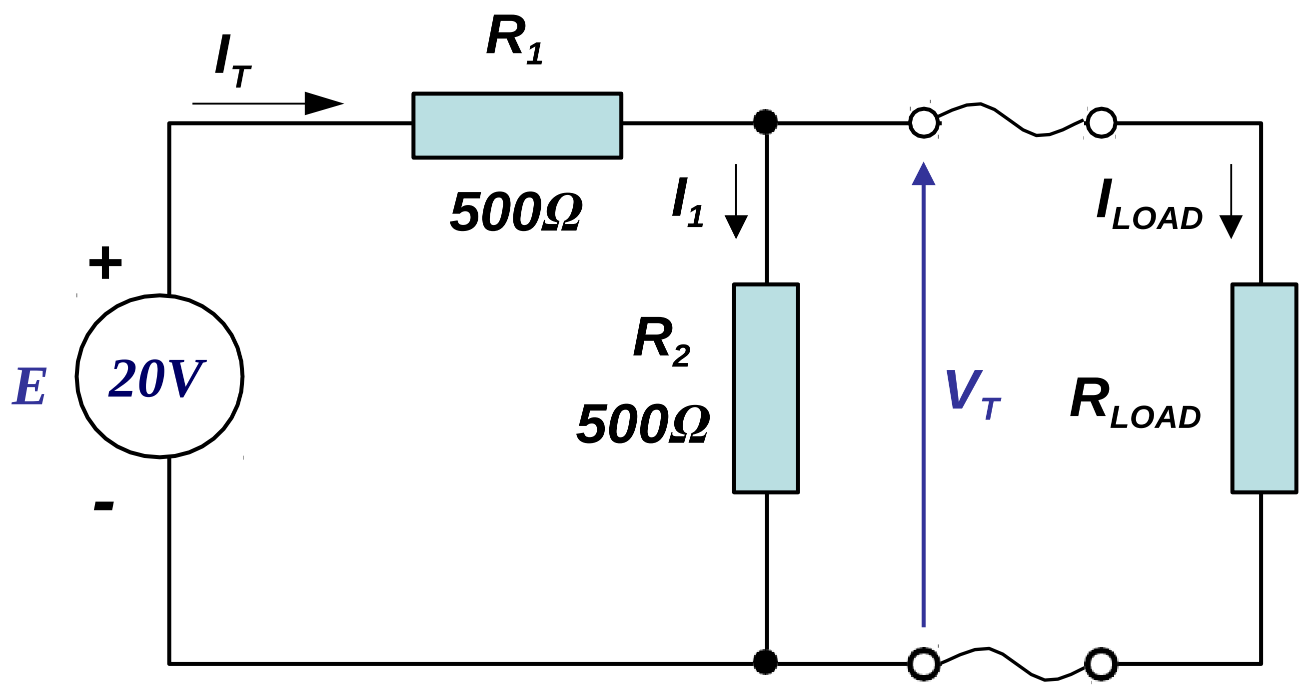
$$I_1 = I_T \frac{R_2}{R_1 + R_2}$$

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

This procedure is only suitable where there are two parallel branches.

Voltage Divider Principle

•Determine the voltage VT under no load conditions and when a resistance of 2000 ohms in connected.



V_T no load conditions.

$$V_T = E\frac{R_2}{R_1 + R_2}$$

V_T loaded conditions ($I_{LOAD} << I_1$)

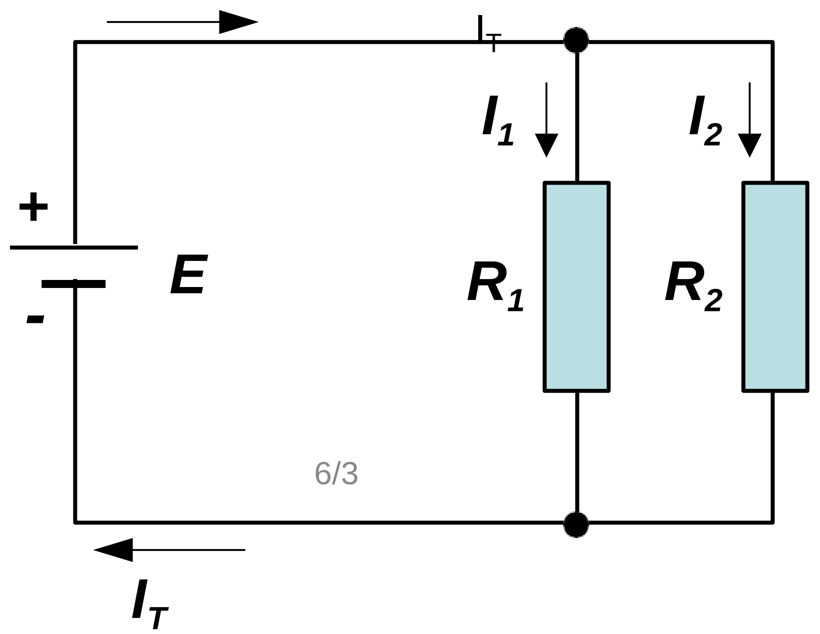
$$V_T \sim E\frac{R_2}{R_1 + R_2}$$

Current Divider Principle

- When there are only two resistances in parallel we can simplify some of the Ohm's law calculation by use of the current divider principle.

- The current divider uses the principles of Ohm's law to generate the branch currents I1 and I2.

$$I_T = \frac{E}{R_{eff}}$$



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

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

This procedure is only suitable where there are two parallel branches.

Voltage Divider Principle

The Voltage Divider Rule is used to determine the voltage across a particular resistor in a series circuit.

Advantages:

1. **Simple Calculation:** Easy to apply using Ohm's Law.
2. **Passive Implementation:** No need for active components like transistors or amplifiers.
3. **Used in Sensors:** Commonly used in voltage level adjustments for sensors and microcontrollers.
4. **Predictable Behavior:** Works reliably in purely resistive circuits.

Disadvantages:

1. **Load Sensitivity:** If a load is connected, it alters the resistance and affects voltage division.
2. **Power Dissipation:** Resistors dissipate power as heat, making it inefficient in power-sensitive applications.
3. **Limited Current Supply:** Cannot provide high currents without significant voltage drop.
4. **Not Ideal for Low Impedance Loads:** Works best when the load impedance is significantly larger than the divider resistances.

Current Divider Principle

The Current Divider Rule is used to determine the current through a particular branch in a parallel circuit.

Advantages:

1. **Efficient for Multiple Branches:** Allows current division without additional components.
2. **Reduces Power Loss in Individual Components:** Each branch gets a fraction of the current, reducing stress on individual resistors.
3. **Works with Multiple Loads:** Can distribute current among multiple loads based on their resistances.
4. **Independent Paths for Current Flow:** If one path is blocked, others continue to function.

Disadvantages:

1. **Complexity in Multi-Branch Circuits:** Becomes difficult to calculate when multiple branches with different resistances are involved.
2. **Voltage Must Be Constant Across Branches:** Works only in parallel circuits with the same voltage.
3. **Not Ideal for High Resistance Branches:** A high-resistance branch gets very little current, making it inefficient in some cases.
4. **Sensitive to Resistance Changes:** Any change in one branch affects the current distribution in all others.

Department of Biomedical Engineering

Course Name: 23EET103- ELECTRIC CIRCUITS & ELECTRON DEVICES

II Year : IV Semester

Unit 1:DC CIRCUITS

Topic : Mesh Analysis

INTRODUCTION KVL

Kirchhoff's Voltage Law - KVL - is one of two fundamental laws in electrical engineering, the other being Kirchhoff's Current Law (KCL)

KVL is a fundamental law, as fundamental as Conservation of Energy in mechanics, for example, because KVL is really conservation of electrical energy

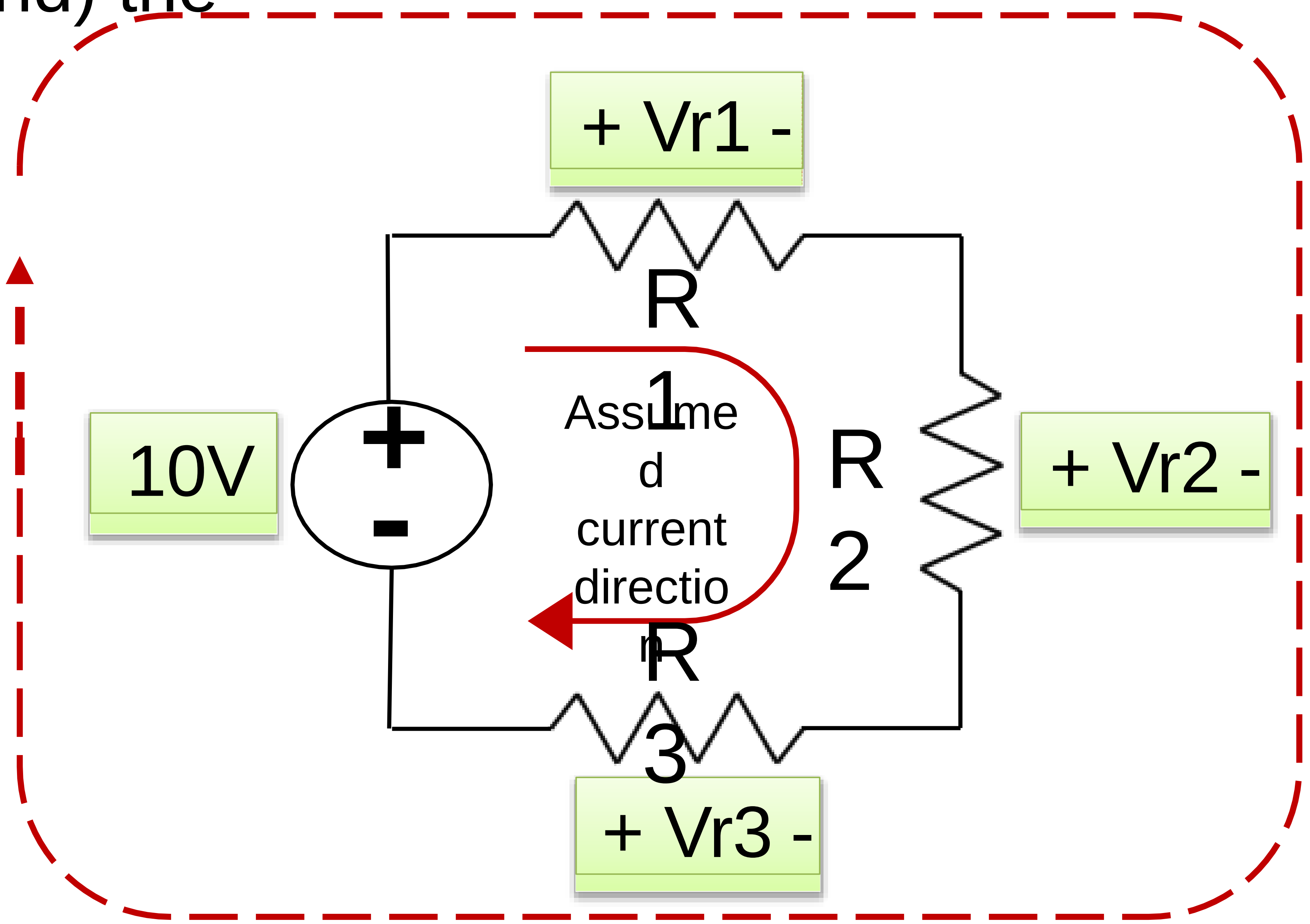
KVL and KCL are the starting point for analysis of any circuit

KCL and KVL always hold and are usually the most useful piece of information you will have about a circuit after the circuit itself

- Kirchoff’s Voltage Law (KVL) states that the algebraic sum of the voltages across any set of branches in a closed loop is zero. i.e.:

$$\sum V_{acrossbranches} = 0$$

Below is a single loop circuit. The KVL computation is expressed graphically in that voltages around a loop are summed up by traversing (figuratively walking around) the loop.



Resulting KVL Equation: $V_{r1}+V_{r2}+V_{r3}-10=0$

- The KVL equation is obtained by traversing a circuit loop in either direction and writing down unchanged the voltage of each element whose “+” terminal is entered first and writing down the negative of every element’s voltage where the minus sign is first met.

- The loop must start and end at the same point. It does not matter where you
start on the loop.

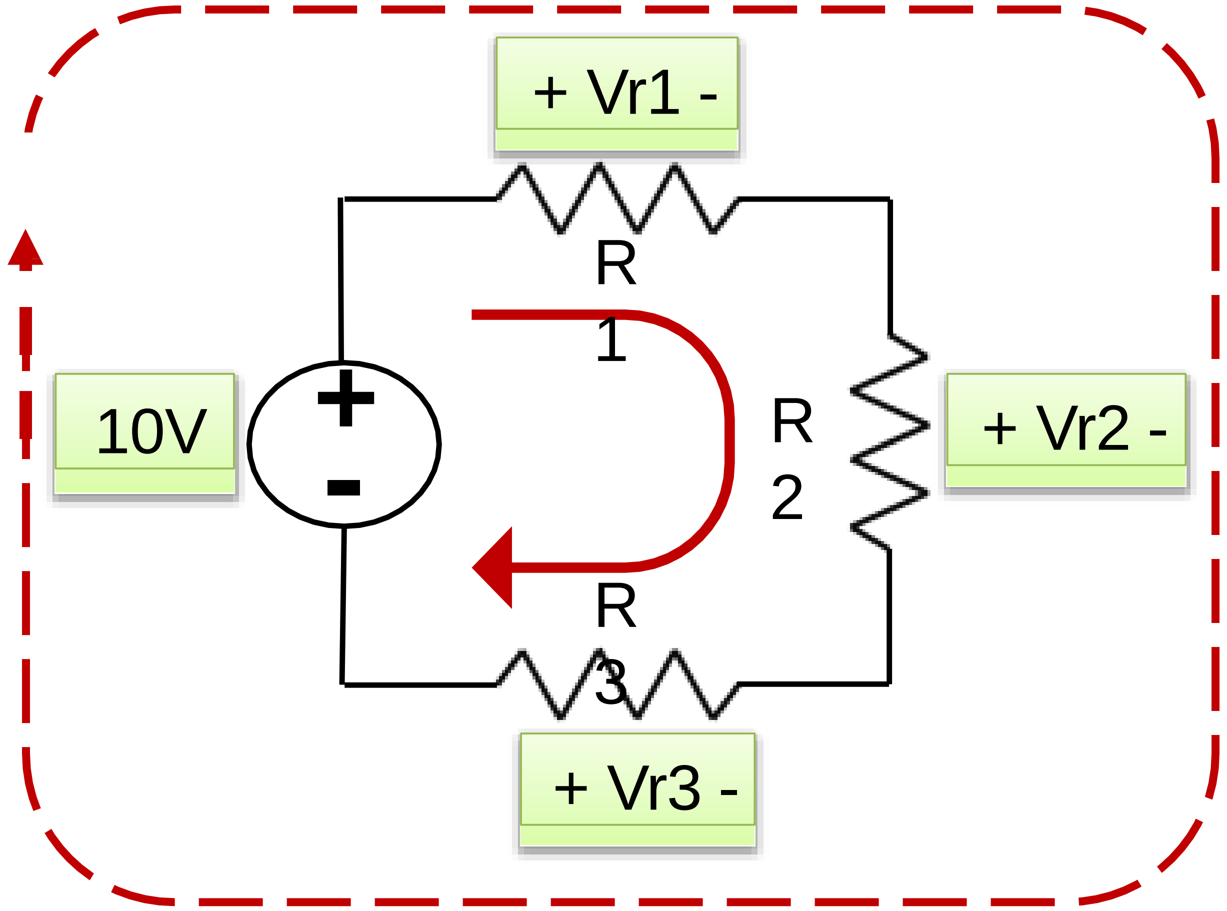
- Note that a current direction must have been assumed. The assumed current creates a voltage across each resistor and fixes the position of the “+” and “-” signs so that the passive sign con-vention is obeyed.

- The assumed current direction and polarity of the voltage across each resistor must be in agreement with the passive sign convention for KVL analysis to work.

- The voltages in the loop may be summed in either direction. It makes no difference except to change all the signs in the resulting equation. Mathematically speaking, its as if the KVL equation is multiplied by -1. See the illustration below.

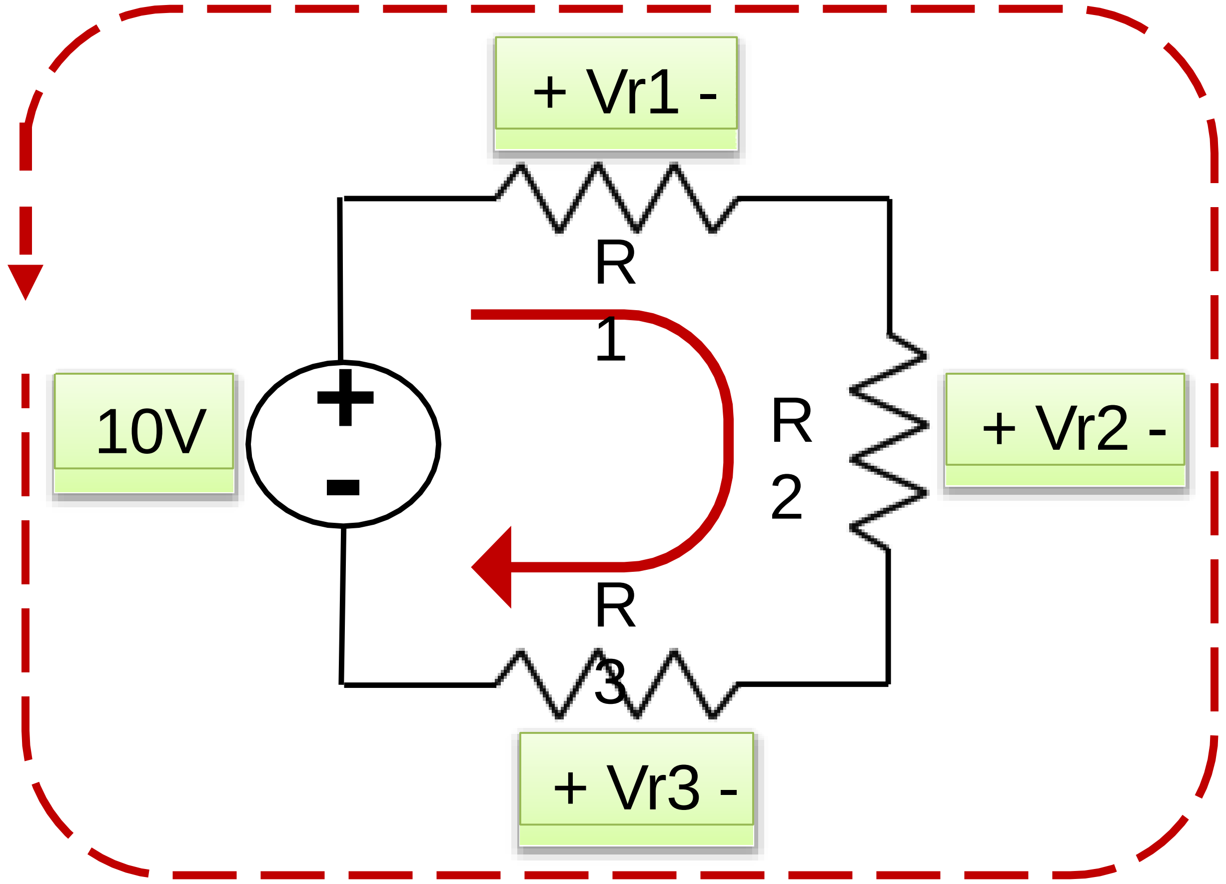
Summation of voltage terms may be done in either direction

Part of Traversal



Resulting KVL Equation: $V_{r1}+V_{r2}+V_{r3}-10=0$

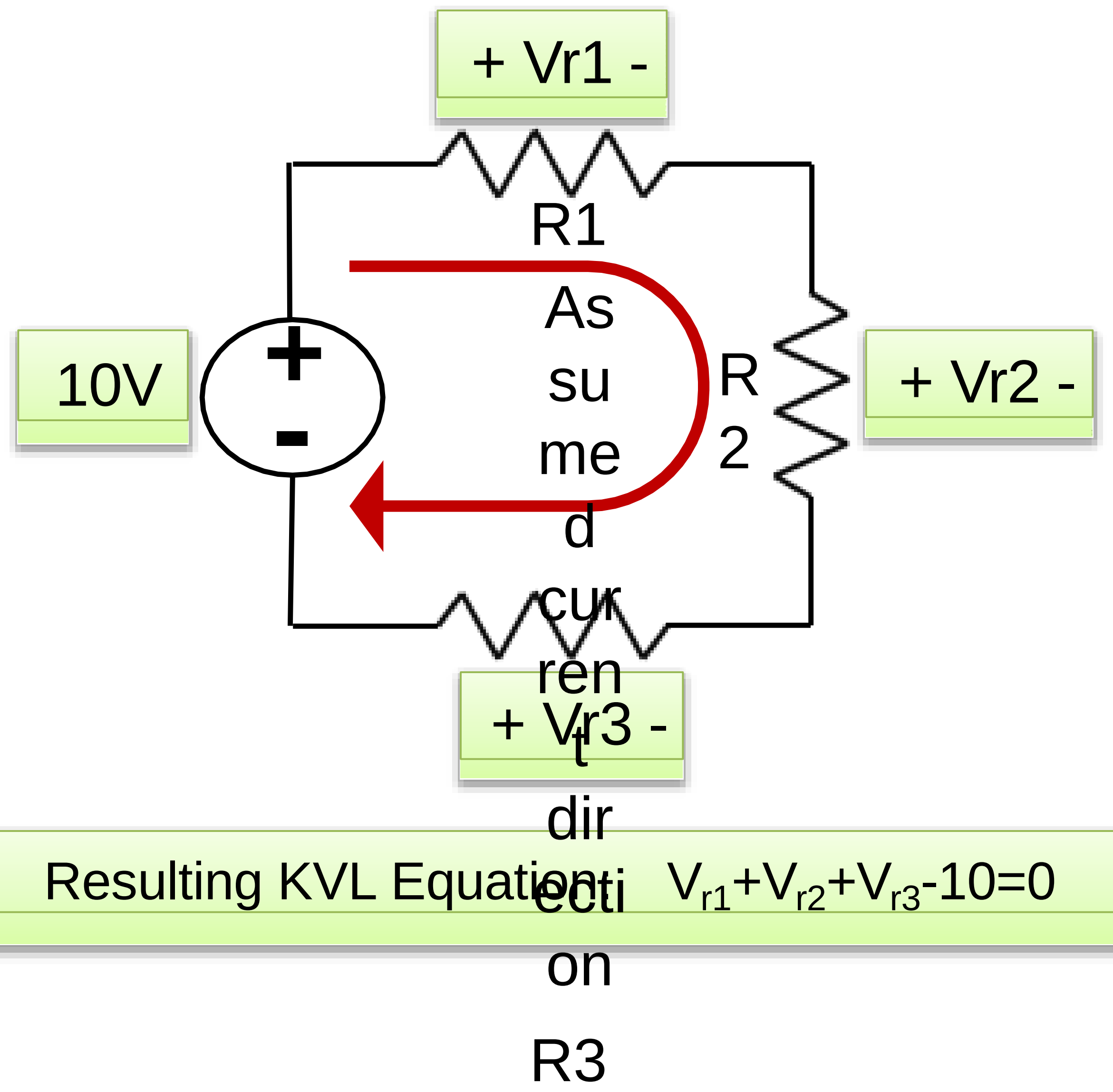
Part of Traversal



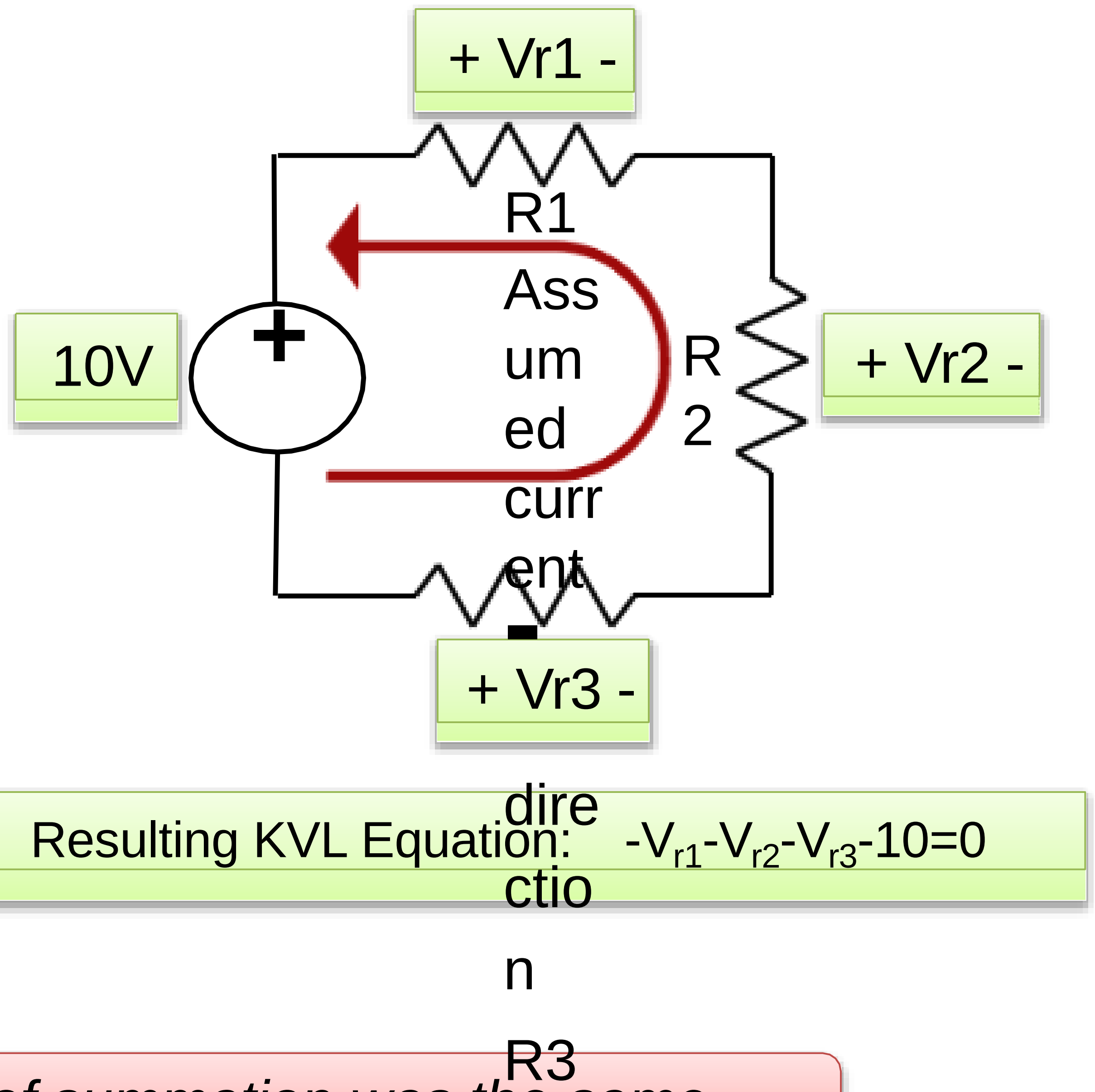
Resulting KVL Equation: $-V_{r1}-V_{r2}-V_{r3}+10=0$

For both summations, the assumed current direction was the same

Assuming the current direction fixes the voltage references



Resulting KVL Equation: $V_{r1}+V_{r2}+V_{r3}-10=0$



Resulting KVL Equation: $-V_{r1}-V_{r2}-V_{r3}-10=0$

For both cases shown, the direction of summation was the same

MESH ANALYSIS

- Analysis using KVL to solve for the currents around each closed loop of the network and hence determine the currents through and voltages across each elements of the network

- Mesh analysis procedure

STEP 1

Assign a distinct current to each closed loop of the network

STEP 2

Apply KVL around each closed loop of the network

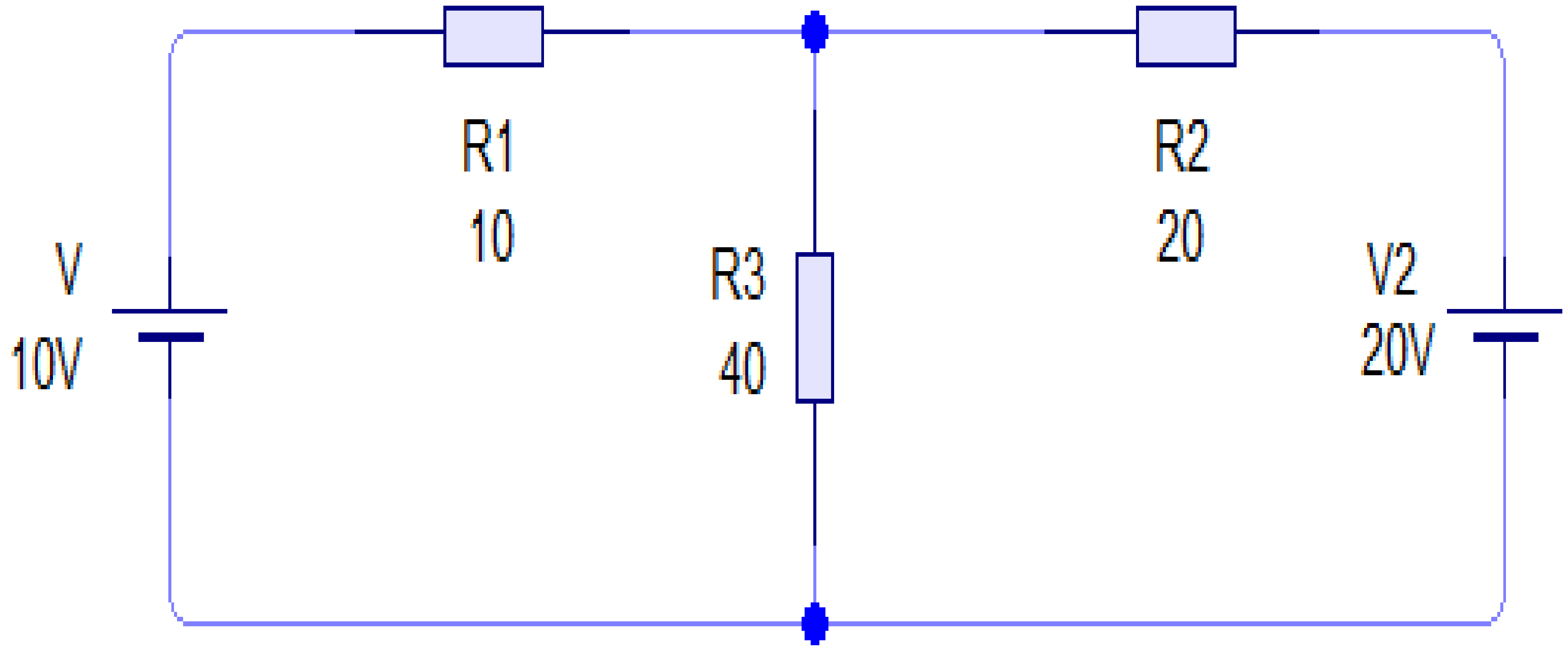
STEP 3

Solve the resulting simultaneous linear equation for the loop currents

EXERCISE

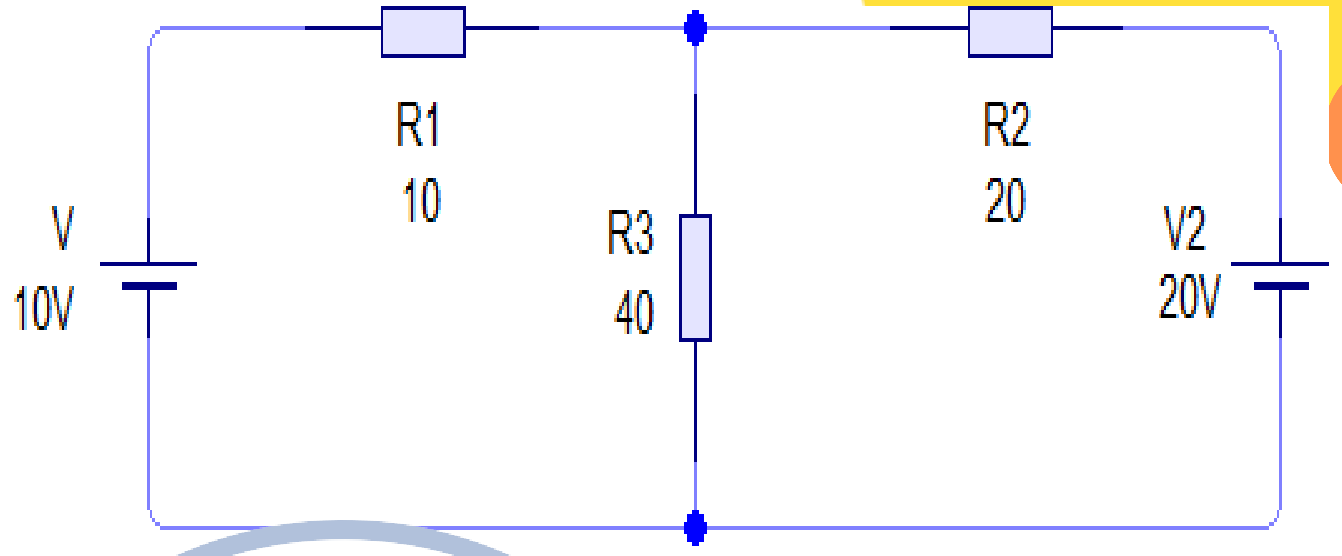
❖ Exercise 1

Find the current flow through each resistor using mesh analysis for the circuit below



EXERCISE 1

❖ SOLUTION



- Assign a distinct current to each closed loop of the network

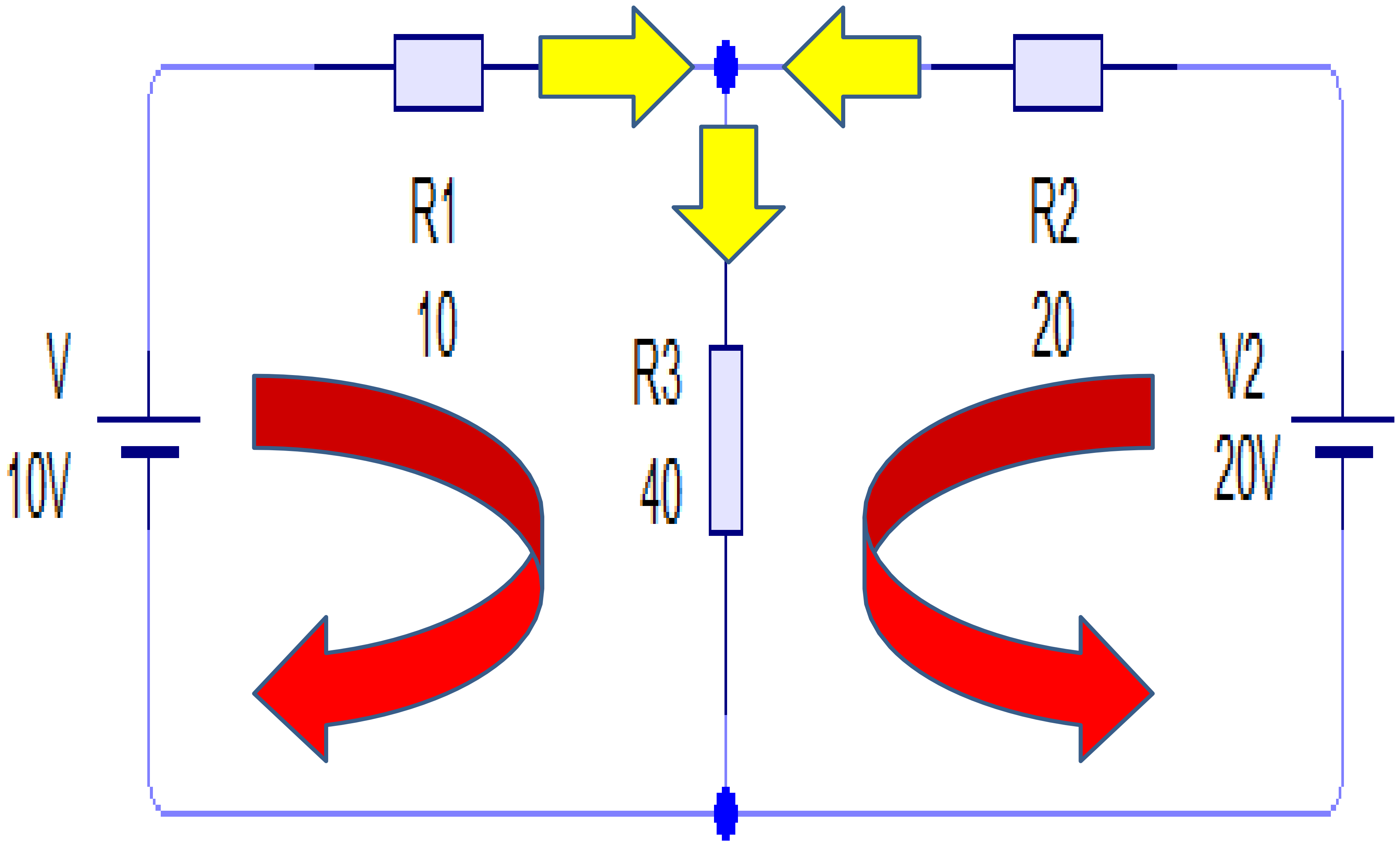
STEP 1

STEP 2

•Apply KVL around each closed loop of the network

- Solve the resulting simultaneous linear equation for the loop currents

STEP 3



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$$Loop1:$$

$$I_1R_1+I_1R_3+I_2R_3=V_1$$

$$10I_1+40I_1+40I_2=10$$

$$50I_1+40I_2=10-----equation1$$

$$Loop2:$$

$$I_2R_2+I_2R_3+I_1R_3=V_2$$

$$20I_2+40I_2+40I_1=20$$

$$40I_1+60I_2=20-----equation2$$

S T E P 2

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STEP 3

Solve equation 1 and equation 2 using Matrix

$$50I_1 + 40I_2 = 10$$

$$40I_1 + 60I_2 = 20$$

Matrixform :

$$\begin{bmatrix} 50 & 40 \\ 40 & 60 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 10 \\ 20 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 50 & 40 \\ 40 & 60 \end{vmatrix} = 3000 - 1600 = 1400$$

$$\Delta I_1 = \begin{vmatrix} 10 & 40 \\ 20 & 60 \end{vmatrix} = 600 - 800 = -200$$

$$\Delta I_2 = \begin{vmatrix} 50 & 10 \\ 40 & 20 \end{vmatrix} = 1000 - 400 = 600$$

$$I_1 = \frac{\Delta I_1}{\Delta} = \frac{-200}{1400} = -0.143A$$

$$I_2 = \frac{\Delta I_2}{\Delta} = \frac{600}{1400} = 0.429A$$

FromKCL :

$$I_3 = I_1 + I_2 = -0.143A + 0.429A = 0.286A$$

EXIT