Fundamentals of Electrical Engineering

First YEAR

By

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Series and Parallel DC Circuits

Chapter 3

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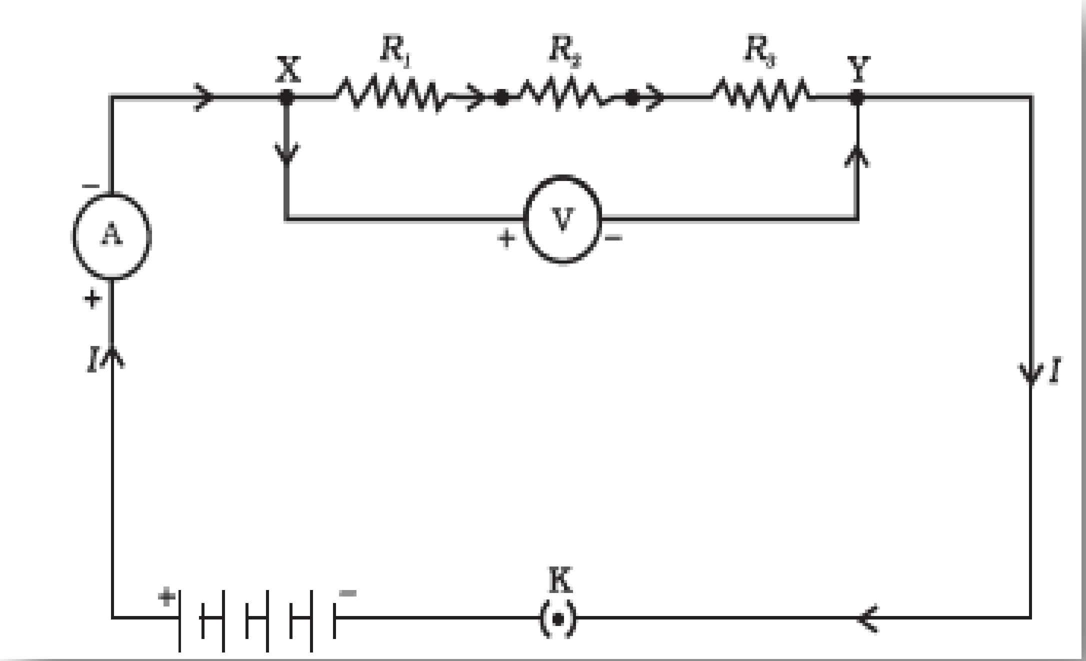
Chapter Content

CH3: Series and Parallel DC Circuits

- Resistors in Series
- Resistors in Parallel
- BRANCHES, NODES, LOOPS, MESHES
- KIRCHHOFF'S VOLTAGE LAW
- Voltage Division

1. Resistors in Series

- The Figure shows an electric circuit in which three resistors having resistances R1,R2 and R3, respectively, are joined end to end. Here the resistors are said to be connected **in series**.



1. Resistors in Series

- The potential difference V is equal to the sum of potential differences V1, V2, and V3.

$$V = V1 + V2 + V3$$

- Applying the Ohm's law to the entire circuit, we have $V = I\,R$
- On applying Ohm's law to the three resistors separately, we further have

$V1 = I\,R1$, $V2 = I\,R2$ and $V3 = I\,R3$.

$I\,R = I\,R1 + I\,R2 + I\,R3$ or $Rs = R1 + R2 + R3$

EX1

How much current will flow through a 2-Ω resistor connected in series with a 4-Ω resistor, and the combination connected across a 12-V source? What is the voltage across each resistor?

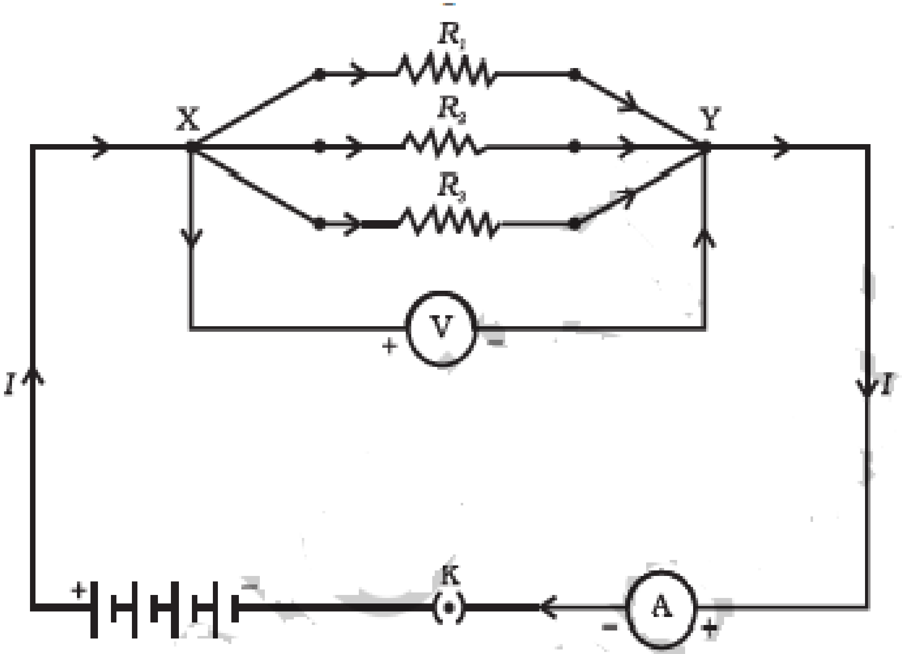
I

$$R_s = R_1 + R_2 = 2 + 4 = 6\,\Omega \qquad I_1 = \frac{V}{R_s} = \frac{12}{6} = 2\text{ A}$$

$$V_1 = I_1 R_1 = 2 \times 2 = 4\text{ V} \quad \text{and} \quad V_2 = 2 \times 4 = 8\text{ V}$$

2. Resistors in Parallel

- The Figure shows a combination of resistors in which three resistors are connected together between points X and Y. Here, the resistors are said to be connected **in parallel**.



2. Resistors in Parallel

- the total current I, is equal to the sum of the separate currents through each branch of the combination. $I = I1 + I2 + I3$
- By applying Ohm's law, we have $I = V/Rp$
- On applying Ohm's law to each resistor, we have $I1 = V/R1$; $I2 = V/R2$; and $I3 = V/R3$.
- we have $V/Rp = V/R1 + V/R2 + V/R3$
- R TOTAL $= 1/Rp = 1/R1 + 1/R2 + 1/R3$
- $Req = (R1*R2) / (R1+R2)$

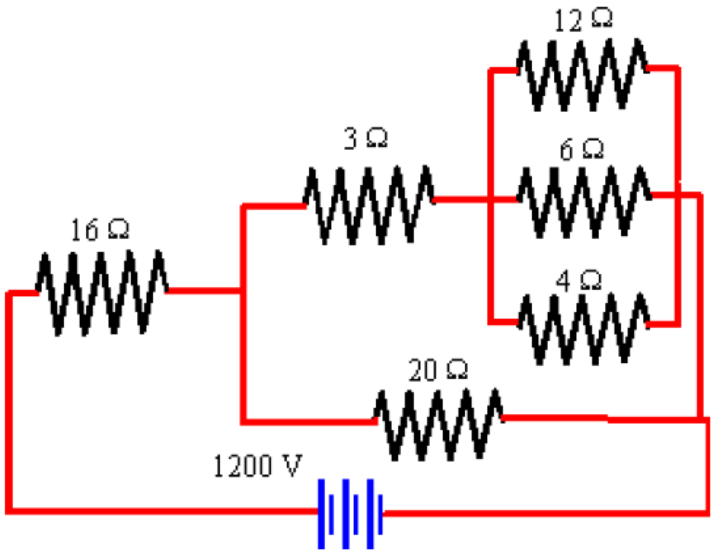
EX2

What is the total resistance of the combination of a 2-Ω and a 4-Ω resistance in parallel? Calculate the current supplied by a 12-V source connected across the combination.

$$\frac{1}{R_p} = \frac{1}{2} + \frac{1}{4} = \frac{3}{4} \quad \text{or} \quad R_p = \tfrac{4}{3}\,\Omega \qquad I = \frac{V}{R_p} = \frac{12}{4/3} = 9\text{ A}$$

Assignment

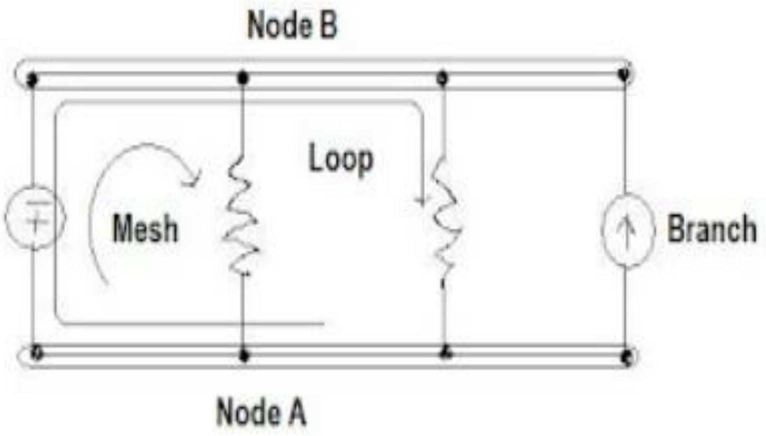
➢ Find the equivalent resistance of the circuit shown below



3. BRANCHES, NODES, LOOPS, MESHES

- a **branch** of a circuit is applied to a group of components that carry the same current,
- A **node** is a connection point between two or more branches.
- A **loop** is any simple closed path in a circuit.
- A **mesh** is a loop that does not have a closed path in its interior.

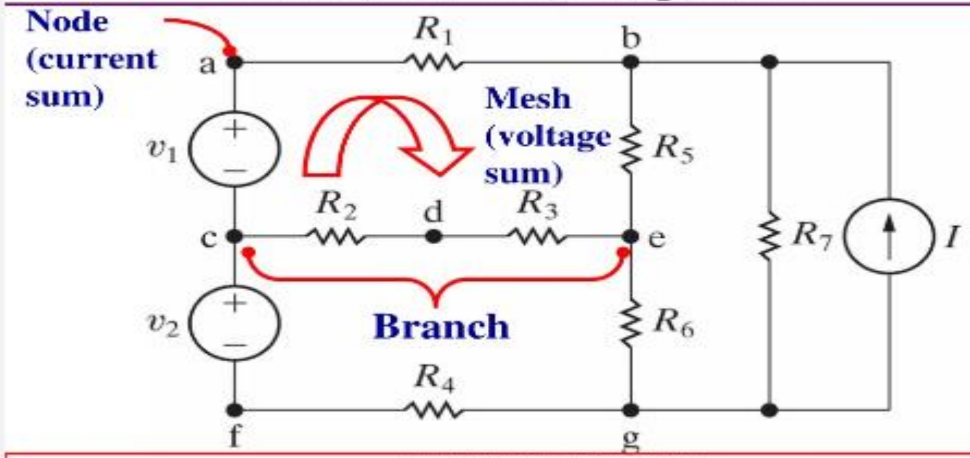
No components are inside mesh



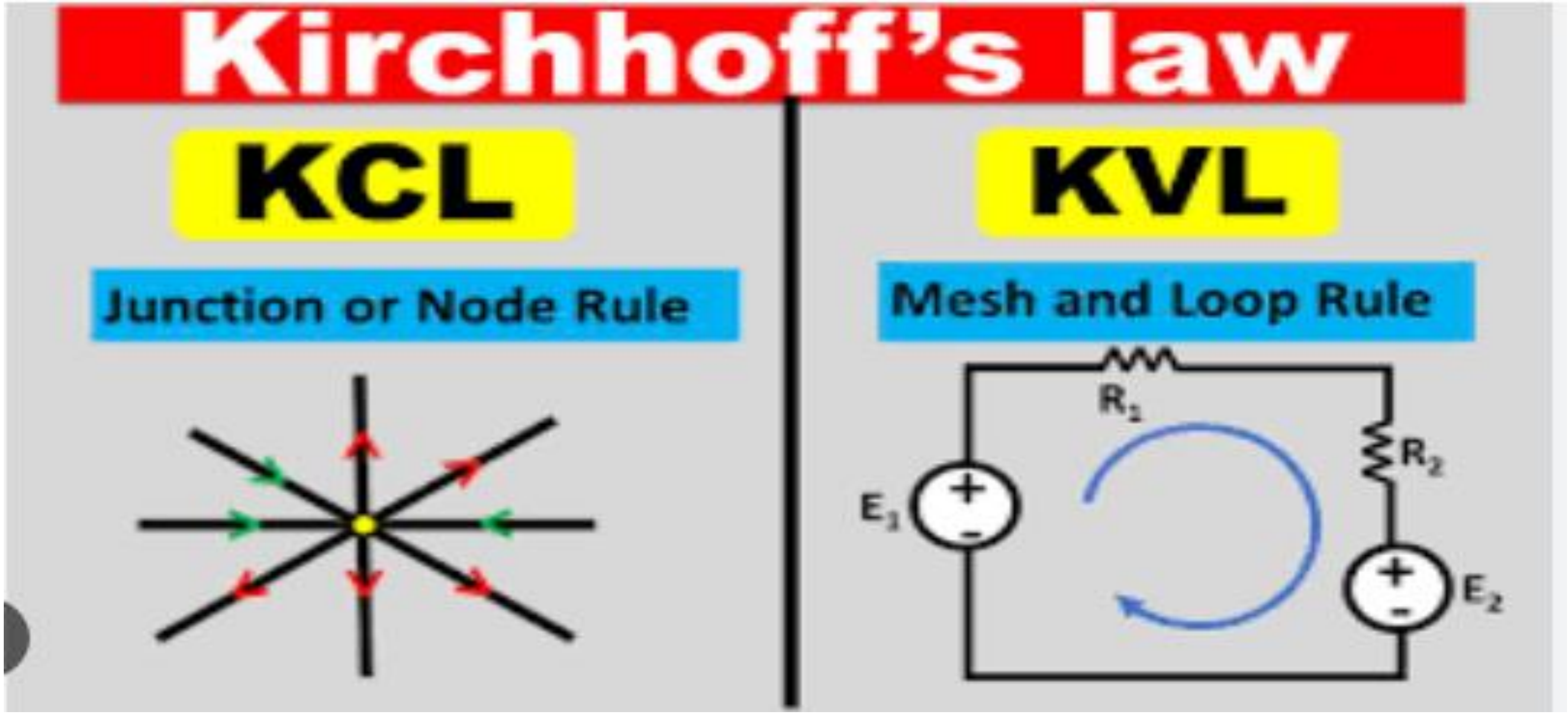
3. BRANCHES, NODES, LOOPS, MESHES,

Node, Branch, Loop, Mesh

1



Node: A point where two or more circuit elements join
Mesh: A loop that does not enclose any other loops
Branch: A circuit path that contains two nodes
Loop: A path with starting node=last node; can contain many meshes


Kirchhoff's law
KCL
Junction or Node Rule
KVL
Mesh and Loop Rule
R1
R2
E1
E2

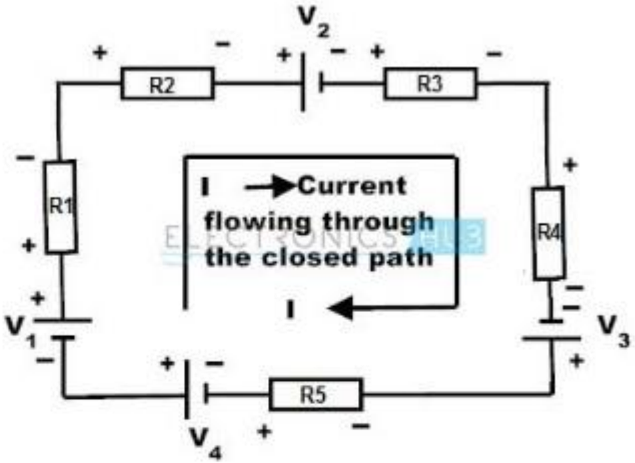
3. KIRCHHOFF'S VOLTAGE LAW

- Kirchhoff's Voltage law, abbreviated KVL, has three equivalent versions: At any instant around a loop, in either a clockwise or counterclockwise direction

✓ The algebraic sum of the voltage drops is zero.

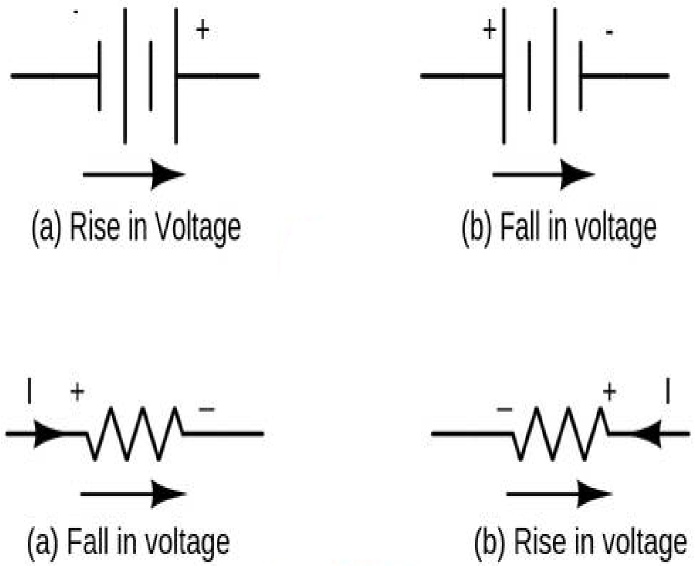
✓ The algebraic sum of the voltage rises is zero.

✓ The algebraic sum of the voltage drops equals the algebraic sum of the voltage rises.



3. KIRCHHOFF'S VOLTAGE LAW

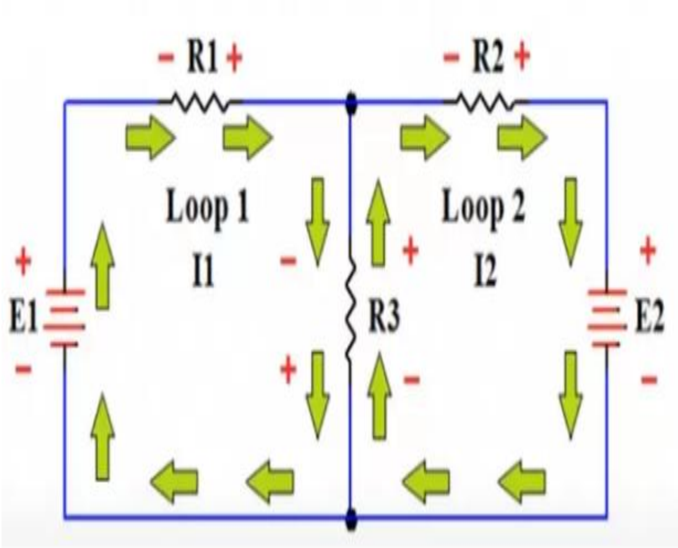
- **Resistance:**
- The potential drop is negative when passing through the resistance in the same direction as the current flow because the potential decreases.
- However, if the resistance is traversed in the opposite direction to the current flow, the potential increases, resulting in a positive voltage drop.



3. KIRCHHOFF'S VOLTAGE LAW

- There are six general steps are required to perform a loop or mesh circuit analysis on a resistive DC network.

1. Identify and assign arbitrarily a direction to the loop currents in the circuit.
2. Mark the polarity of the elements in each loop in terms of our assumed current direction.
3. Create the Kirchhoff's Voltage Law (KVL) equation for each loop in terms of the specified loop direction.
4. Use Ohm's law. to specify the unknown KVL voltages in each loop equation in terms of current and resistance.

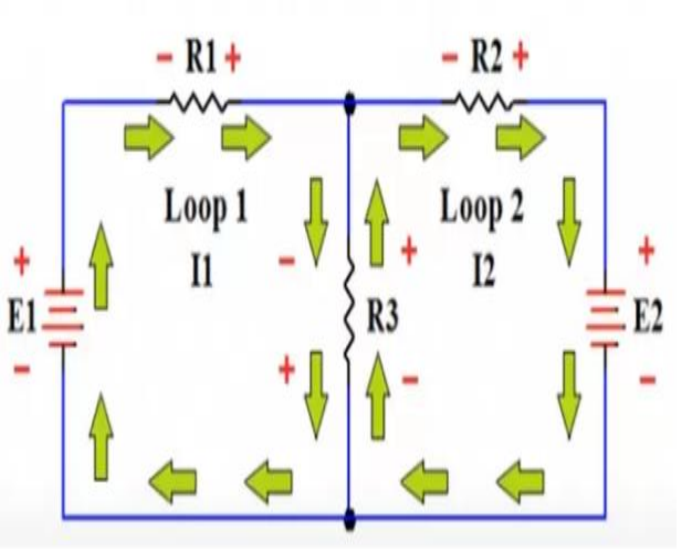


3. KIRCHHOFF'S VOLTAGE LAW

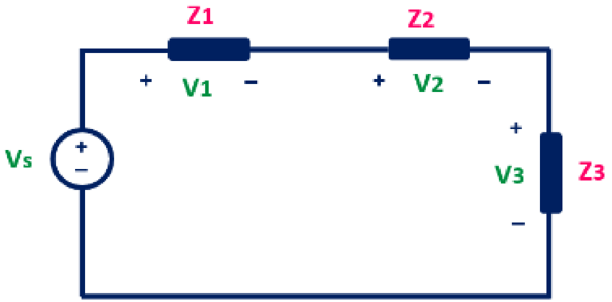
- There are six general steps are required to perform a loop or mesh circuit analysis on a resistive DC network.

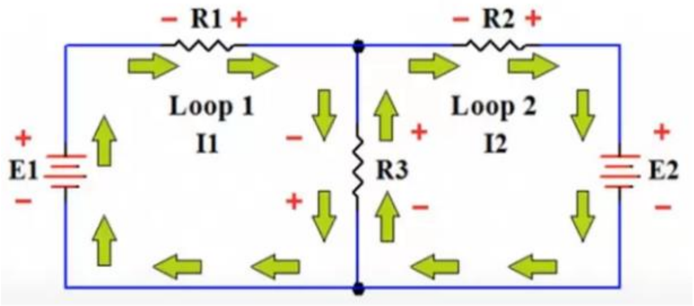
5. Calculate the KVL voltage expressions for each loop in the circuit, use substitution and elimination to solve for the unknown loop currents.

6. Use the loop currents to calculate resistor current and voltage throughout the circuit.



EXAMPLES





That means $Vs + (-V1) + (-V_2) + (-V_3) = 0$

$=> Vs - V_1 - V_2 - V_3 = 0$

$=> Vs = V_1 + V_2 + V_3$

$V_{R1} + V_{R3} + E_1 = 0$

$V_{R2} - E_2 + V_{R3} = 0$

EXAMPLES

- Find V3 and its polarity if the current I in the circuit of the Figure is 0.40 A.

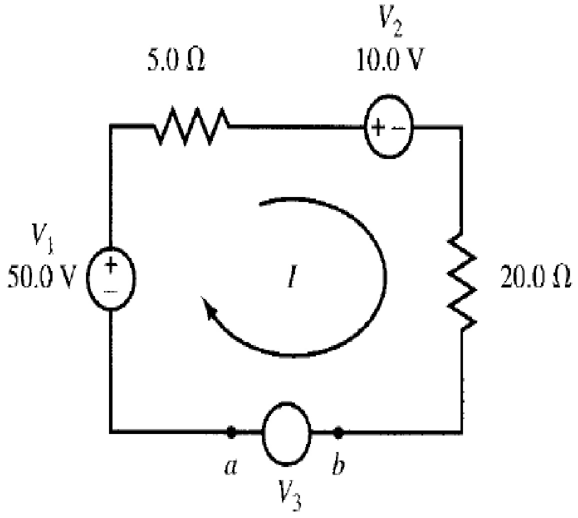
Assume that V_3 has the same polarity as V_1. Applying KVL and starting from the lower left corner,

$$V_1 - I(5.0) - V_2 - I(20.0) + V_3 = 0$$

$$50.0 - 2.0 - 10.0 - 8.0 + V_3 = 0$$

$$V_3 = -30.0\ \text{V}$$

Terminal b is positive with respect to terminal a.



4.Voltage Division

- The voltage division or voltage divider rule applies to resistors in series.
- It gives the voltage across any resistor in terms of the resistances and the total voltage across the series combination-the step of finding the resistor current is eliminated

$$V_2 = \frac{R_2}{R_1 + R_2 + R_3} V_S$$

- By Ohm's law, $V_2 = IR_2$. Also $I = V_S/(R_1+R_2+R_3)$
- In general, for any number of series resistors with a total resistance of R_T and with a voltage of Vs across the series combination, the voltage V_X across one of the resistors R_X is

$$V_X = \frac{R_X}{R_T} V_S$$

EXAMPLES

Two resistors of ohmic values R_1 and R_2 are connected in series, and the combination across a source of voltage V. How is this voltage divided across the resistors?

$$R_s = R_1 + R_2 \qquad I = \frac{V}{R_s} = \frac{V}{R_1 + R_2}$$

$$V_1 = IR_1 = V\frac{R_1}{R_1 + R_2} \qquad V_2 = IR_2 = V\frac{R_2}{R_1 + R_2}$$

EXAMPLES

How much current will flow through a 2-Ω resistor connected in series with a 4-Ω resistor, and the combination connected across a 12-V source? What is the voltage across each resistor?

$$V_1 = V\frac{R_1}{R_1 + R_2} = 12\frac{2}{2+4} = 4\ \text{V} \qquad V_2 = V\frac{R_2}{R_1 + R_2} = 12\frac{4}{2+4} = 8\ \text{V}$$

End of Lecture 3