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Series Resistor:

For resistors in series, the total resistance of a series configuration is the sum of the resistance levels.

In eq^n, for any 'N' numbers of resistors,

$$R_T = R_1 + R_2 + \cdots + R_N$$

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In series,

i) Same current flows through the circuit
ii) Resistance is added or, total resistance is greater than the highest value of resistance.
iii) In series, voltage drop is maximum at higher resistance ie, $V \propto R$.
iv) Order of resistor doesn't affect the total resistance.

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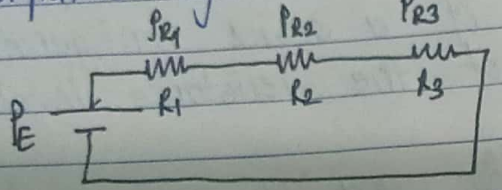
Power distribution in a series Circuit

The power applied by the DC supply must equal to the power dissipates by the resistive elements.



In equation,

$$P_E = P_{R1} + P_{R2} + P_{R3}$$

The power delivered by the supply can be determined by

$$P_E = V \times I_s \quad \text{——} \quad (i)$$

The power dissipated by the resistive elements can be determined by any form.

$$P_1 = V_1 I_1 = I_1^2 R_1 = \frac{V_1^2}{R_1}$$

x) **Note:** In series configuration, the maximum power is delivered to the largest resistor.

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Voltage Source in Series

Voltage source can be connected in series, to increase or decrease the total voltage applied to the system.

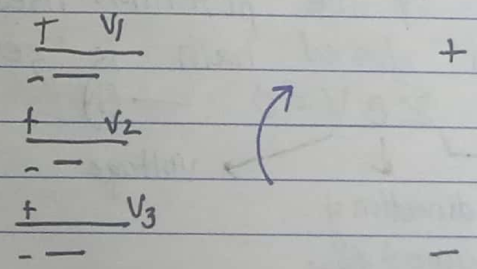
The net voltage is determined by taking the sum of source with same polarity and subtracting the sources with opposite polarity.

The net polarity is the polarity of larger sum.

ie, when current exists from positive polarity, we take +ve sign.

when the current exists from negative polarity, we take −ve sign.

~~The~~ The current direction is the one we suppose.



We suppose a direction with arrow.

$+V_1+V_2+V_3 - V_T = 0$

[∵ In the direction we have supposed, the total voltage goes out from negative side but in individual source, the supposed direction indicates flow from positive side.]

$\therefore V_T = V_1+V_2+V_3$

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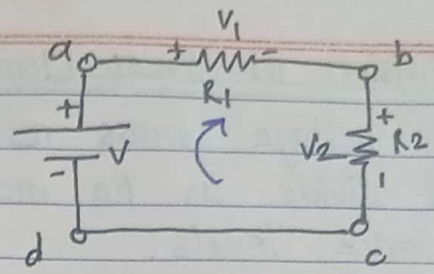
Kirchoff's Voltage Law:

This law is called KVL and was developed by Gustav Kirchoff in the mid 1800s.

The law states that, "the algebraic sum of the potential rises and drops around a closed path is zero.

In symbolic, $\sum_{\circlearrowright} V = 0$ —— (i)

Sum ← Σ, ↓ direction of current flow, → voltage



Now, $\sum_{\circlearrowright} V = 0$

or $+V - V_1 - V_2 = 0$

$\therefore V = V_1 + V_2$.

potential rise (V) — potential drop ($V_1 + V_2$)

Note: the applied voltage of a series DC circuit will equal the sum of voltage drop across the circuit.

KVL can also be written as:

$\sum_{\circlearrowright} V_{rise} = \sum_{\circlearrowright} V_{drop}$.

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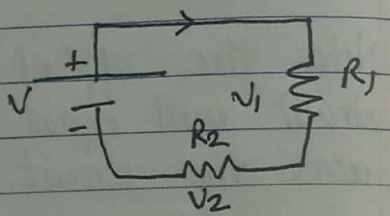
Voltage Division in Series Circuit

The voltage across resistive elements will divide as the magnitude of the resistance levels.

Voltage Divider Rule:

The voltage divider rule permits the determination of voltage across a series resistor without first having to determine the current of the circuit.

Let total resistance be R_T.



$$R_T = R_1 + R_2$$

then, $I_s = I_1 = I_2 = \frac{V}{R_T}$

Applying ohm's law,

$$V_1 = I_1 R_1 = \frac{V_1}{R_T} \times R_1$$

$$V_2 = I_2 R_2 = \frac{V_2}{R_T} \times R_2.$$

Hence, $V_x = V \times \frac{R_x}{R_T}$

ie, Voltage divider rule states that, "the voltage across a resistor in a series is equal to the value of that resistor times the total applied voltage divided by total resistance of the series configuration.

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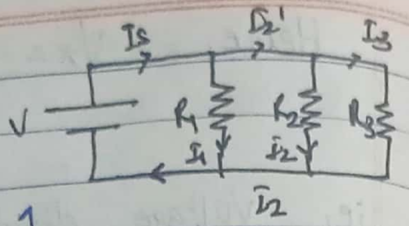
Parallel Resistor

In general, the voltage is always the same across the parallel elements.

Note: If the two elements are in parallel, the voltage across them must be same. However, if the voltage across two neighbouring elements is the same, the two elements may/ may not be in parallel.

So, total resistance ~~(RT) =~~



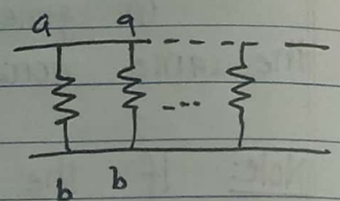
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

In terms of conductance,

$$G_T = G_1 + G_2 + G_3 + \dots +$$

Two elements, branches or circuits are in parallel if they have two points in common.

Total resistance for N number of resistors



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N}$$

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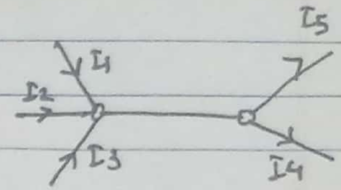
Kirchoff's Current Law:

The algebraic sum of the currents entering and leaving a junction of a network is zero.



OR,

The sum of the currents entering a junction of a network must be equal to the sum of the current leaving the same junction.

$$\Sigma I_{in} = \Sigma I_{out}$$

or, $I_1 + I_2 + I_3 = I_4 + I_5$

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Power Distribution in Parallel Circuit:

$$P_E = P_{R1} + P_{R2} + P_{R3}$$

or, $I_S \times V = I_1 \times V_1 + I_2 \times V_2 + I_3 \times V_3$

or, $I_S^2 \times R_T = I_1^2 \times R_1 + I_2^2 \times R_2 + I_3^2 \times R_3$

or, $\frac{E^2}{R_T} = \frac{V_1^2}{R_1} + \frac{V_2^2}{R_2} + \frac{V_3^2}{R_3}$