BEE1133 Circuit Analysis

Chapter 1B
Basic Concept

by
Nor Rul Hasma Abdullah
Faculty of Electrical & Electronics Engineering
hasma@ump.edu.my

Chapter Description

Aims

This chapter is aimed to:

1. Explain the Ohm's Law and Kirchhhof's Law to the students
2. Explain the different in between the node, branch and loop
3. Explain the resistive circuit

Expected Outcomes

Student should be able to

1. Explain and solved the question related to Ohm's law and Kirchhof's Law
2. Differentiate the node, branch and loop
3. Recognize the circuit either in series or parallel thus find the equivalent resistance.

References

1. C. Alexander and M. Sadiku, "Fundamentals of Electric Circuits", 4th ed., McGraw-Hill, 2008.
2. J. Nilsson and S. Riedel, "Electric Circuits", 8th ed., Prentice Hall, 2008.

BASIC CONCEPT

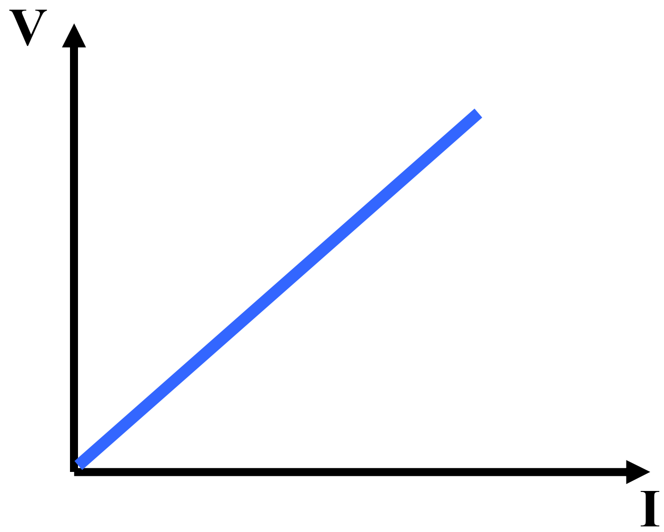
2.1 Ohm's Law and Kirchhoff's Law

2.2 Nodes, branches and loops

2.3 Resistive circuit: Series, parallel circuits and combination circuits

OHM'S LAW

- The voltage, *V* across a resistor is directly proportional to the current, *I* flowing through the resistor.

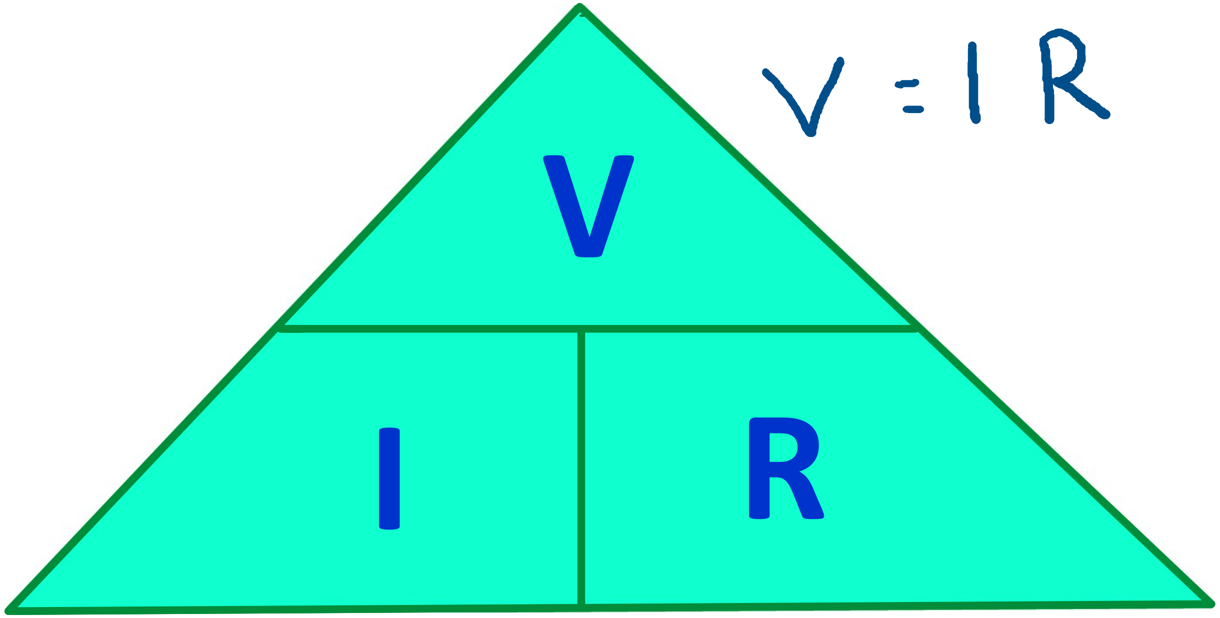


MATHEMATICAL RELATIONSHIP OF *V*, *I*, and *R*

- Formulated with three variables: *V*, *I*, and *R*
- Relationship called Ohm's Law
- Three forms exist:

$$I = \frac{V}{R} \qquad V = IR \qquad R = \frac{V}{I}$$

Ohm's Triangle



$V = IR$

$I = \frac{V}{R}$

$R = \frac{V}{I}$

RELATIONSHIP OF VOLTAGE AND CURRENT

- Voltage and Current Flow
  - What happens if voltage increases or decreases?
    - As voltage increases, current increases.
    - As voltage decreases, current decreases.
- Resistance and Current Flow
  - What happens if resistance increases or decreases?

RELATIONSHIP OF CURRENT TO RESISTANCE*

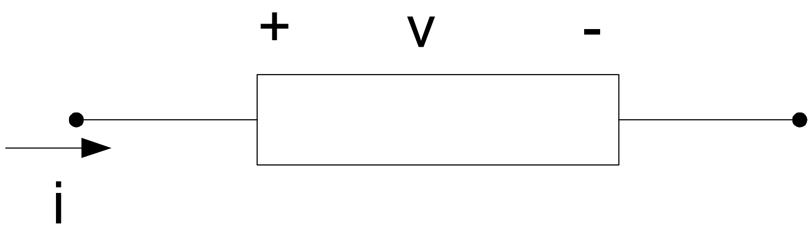
- Indirect Relationship
  - Increase Resistance and Current will decrease
  - Decrease Resistance and Current will increase

* Voltage held constant

POWER AND ENERGY

Defining power as rate of doing work/ the time rate of expending or absorbing energy

$$P = \frac{dW}{dt}$$



where P = power in Watts(W), w is energy in Joules(J),and t is time in seconds(s)

Calculating Energy From Constant Power

- Energy, W is the ability to do work
- If power is independent of time (i.e. a constant value), the equation $P = \frac{dW}{dt}$ becomes

Power = Energy/time

P = W/t (Watt)

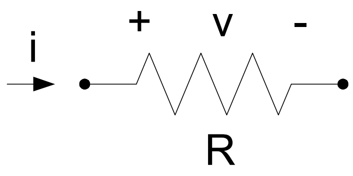
- One watt is the amount of power when one joule of energy used in one second

OHM'S LAW & POWER CALCULATION

2 formulas relating voltage and current

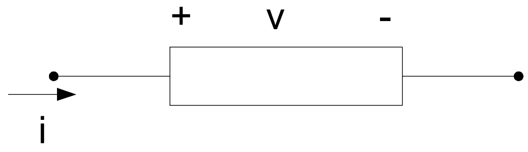
Ohm's Law

A voltage- current relationship of a resistor



$$V = iR$$

The formula of power in relation to voltage and current for any circuit element



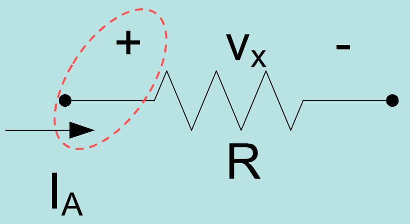
$$P = iV$$

$$P = i^2R$$

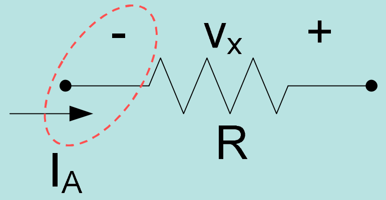
$$P = V^2/R$$

OHM'S LAW & POWER CALCULATION

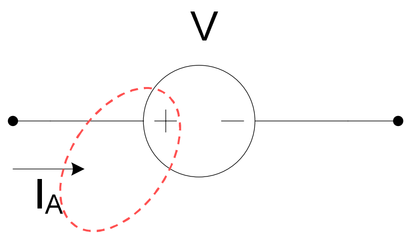
Current enters through +ve terminal	**Current enters through -ve terminal**



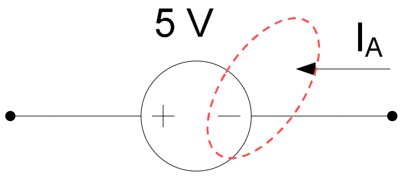
$V_x = +I_AR$
$P = +I_AV$



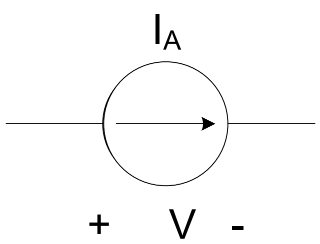
$V_x = -I_AR$
$P = -I_AV$



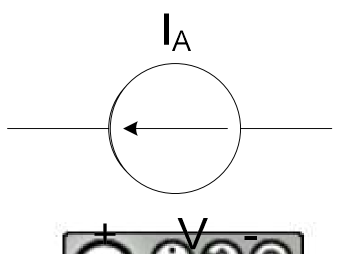
$P = +I_AV$



$P = -I_AV$



$P = +I_AV$



$P = -I_AV$

OHM'S LAW & POWER CALCULATION

Some power can be negative(+ve) / positive(-ve)

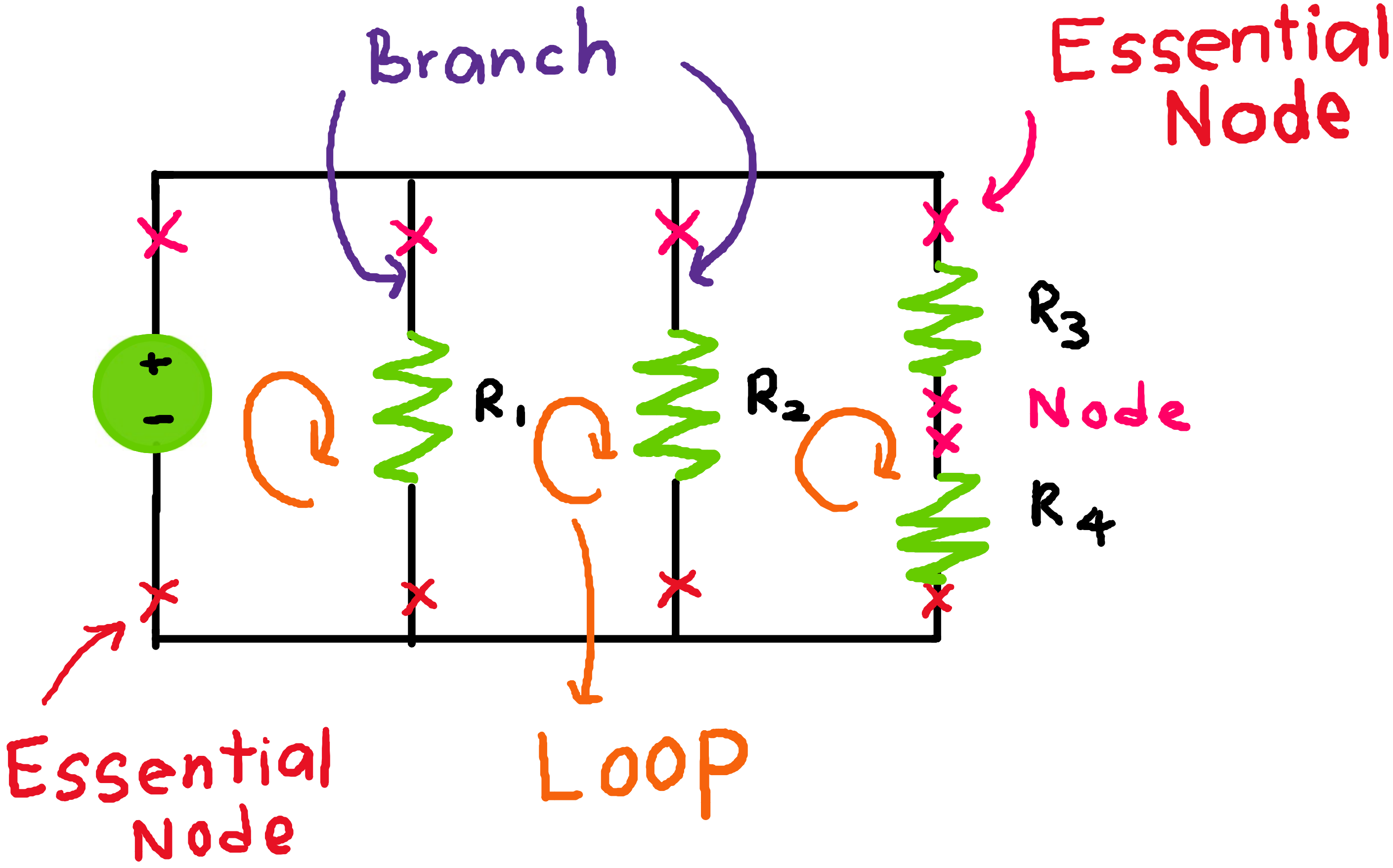
1. +ve power : element is absorbing power

2. -ve power : element is supplying, or developing, or delivering power

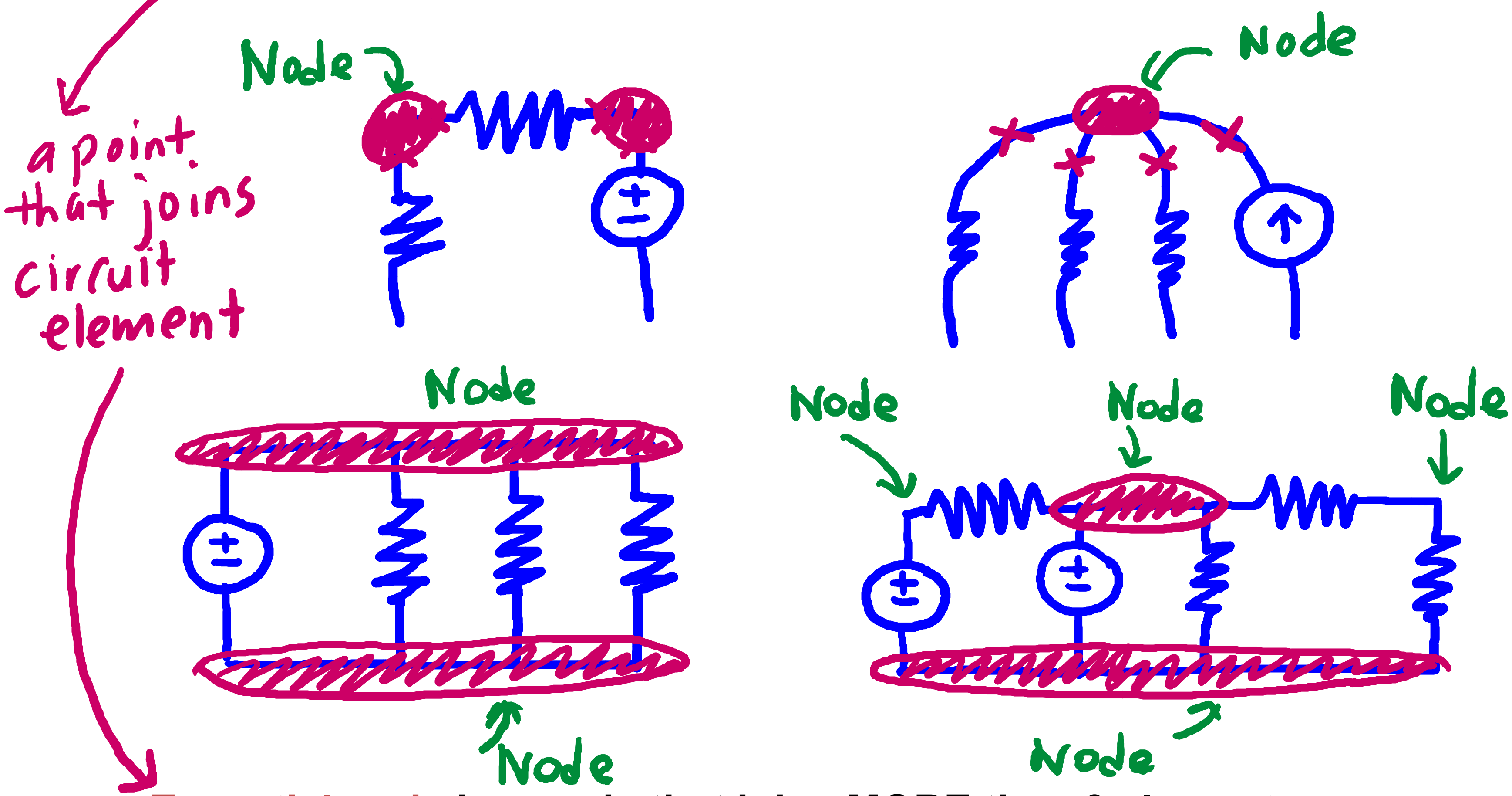
$$P_{absorb} = P_{deliver}$$

$$+P = -P$$

NODE, BRANCH AND LOOP



NODE, BRANCH AND LOOP



<u>Essential node</u> is a node that joins MORE than 2 elements

KIRCHHOFF’S CURRENT LAW (KCL)

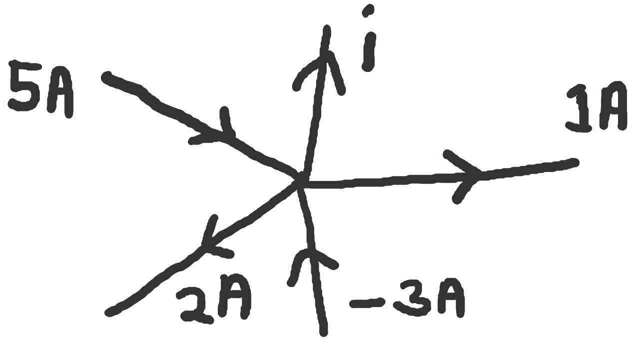
KCL states that the sum of currents at any node equals zero .

$$\sum_{n=1}^{N} i_n = 0 \rightarrow I_{in} = I_{out}$$

where N = number of branches connected to the node

i_n = the nth current entering (or leaving) the node.

KCL



$$I_{in} = I_{out}$$

$5 + (-3) = i + 1 + 2$

$i = 5 - 3 - 1 - 2$

$= -1\ A$

negative sign

opposite direction

Choose

Add the current leaving the node (and subtract the one entering the node)

Therefore, the current should be entering the node

1 node = 1 KCL equation

KIRCHHOFF'S VOLTAGE LAW (KVL)

KVL state that the sum of voltage drops around any closed path is zero

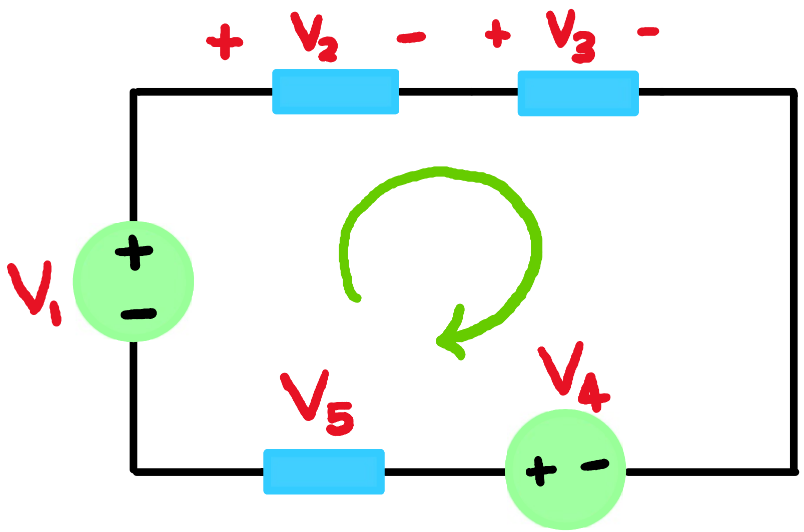
$$\sum_{m=1}^{M} v_m = 0 \quad \longrightarrow \quad V_{in} = V_{out}$$

where M = number of voltages in the loop (or the number of branches in the loop)

v_m = the *m*th voltage

KVL

We can apply LOOP = CLOCKWISE or ANTI-CLOCKWISE



1 loop = 1 KVL equation

Apply KVL Clockwise

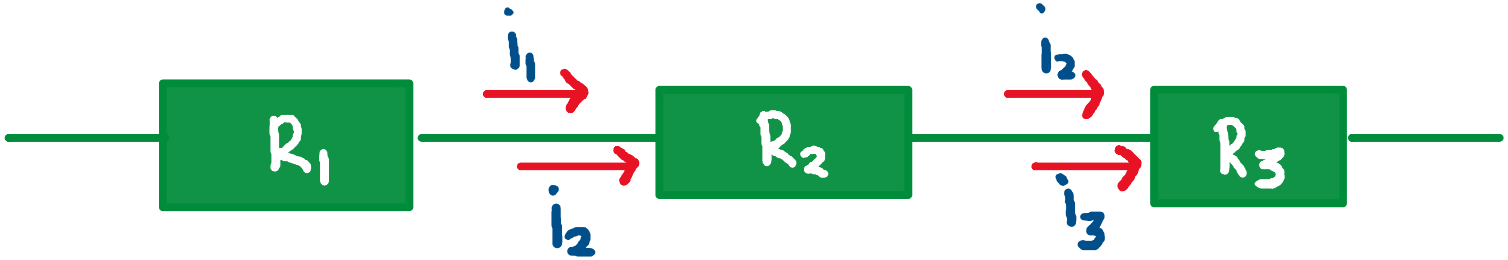
$$-v_1 + v_2 + v_3 - v_4 + v_5 = 0$$

$$v_2 + v_3 + v_5 = v_1 + v_4$$

$$\Sigma\, Voltage\ drop = \Sigma\, Voltage\ rise$$

TRY anticlockwise ....

SERIES-PARALLEL CONNECTIONS



Elements in series carry the same current

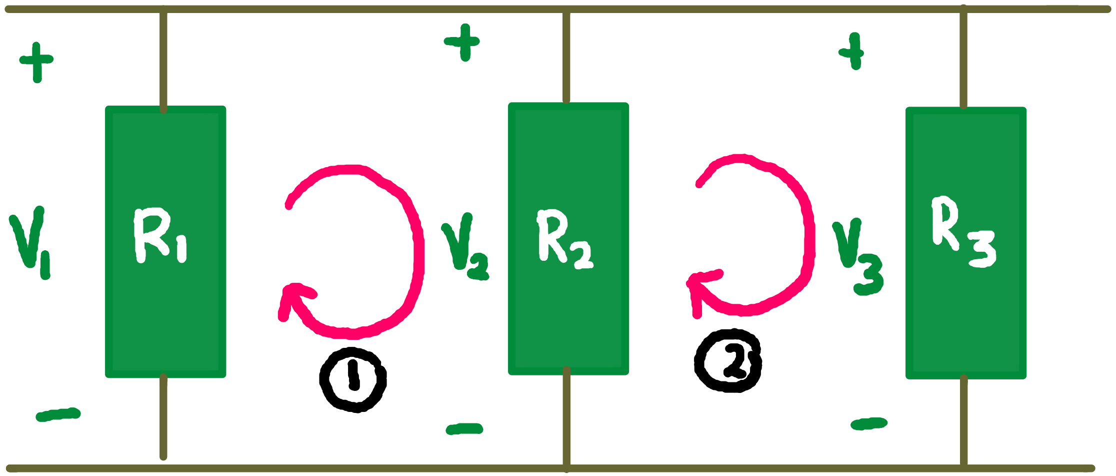
$$i_1 = i_2$$

$$i_2 = i_3$$

Thus,

$$i_1 = i_2 = i_3$$

SERIES-PARALLEL CONNECTIONS



Elements in parallel have the same voltage drop

KVL at Loop 1

$-V_1 + V_2 = 0$

$V_1 = V_2$

KVL at Loop 2

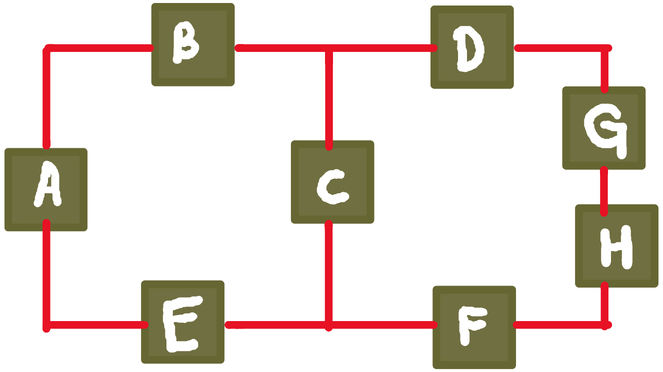
$-V_2 + V_3 = 0$

$V_2 = V_3$

Therefore →

$$V_1 = V_2 = V_3$$

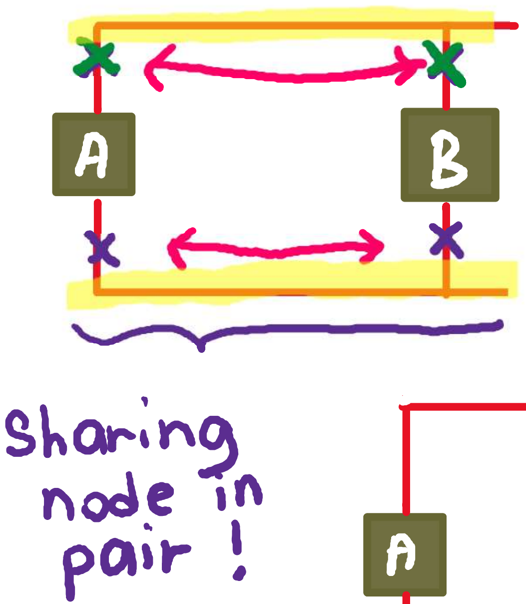
RESISTIVE CIRCUIT: SERIES CONNECTION



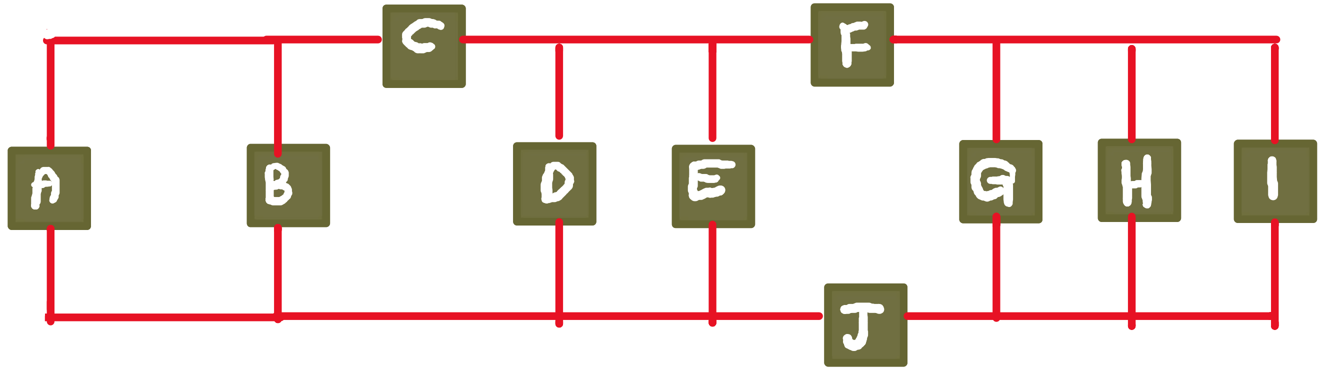
Two elements are considered to be in series if the two elements are joint at a node which meets only the two elements and no other.

Elements in series carry the same current.

RESISTIVE CIRCUIT: PARALLEL CONNECTION AND COMBINITIONS



Elements are connected in parallel if they are connected at a single pair of node



Elements in parallel have the same voltage

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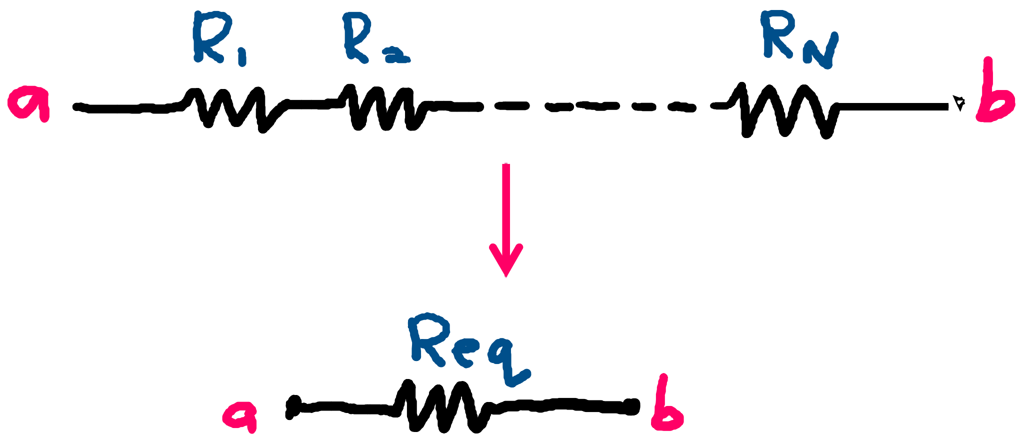
EQUIVALENT RESISTANCE

- The analysis of the circuit uses equivalent resistance as circuit reductions are performed.
- For instance, if a 6-kΩ and a 3-kΩ resistor are in parallel, their equivalent *series* resistance is 2 kΩ.

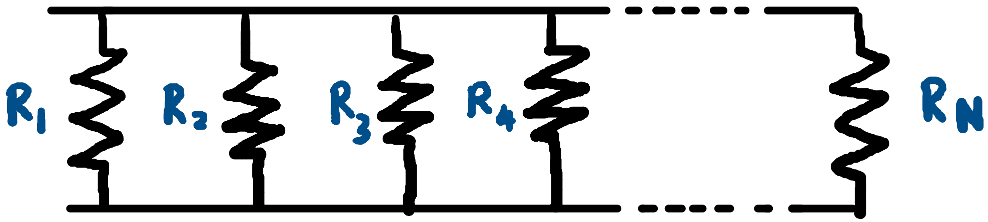
SERIES-PARALLEL EQ. CCT

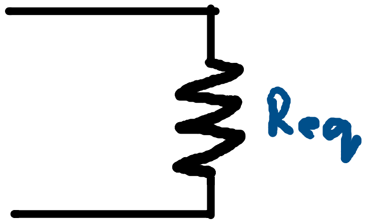


$$R_{eq} = R_1 + R_2 + \ldots\ldots + R_N$$

Where *n* = the number of resistors

SERIES-PARALLEL EQ. CCT





$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \cdots + \frac{1}{R_n}$$

OR

$$R_{eq} = \frac{R_1 + R_2}{R_1 + R_2}$$

please do not write this in your solution.

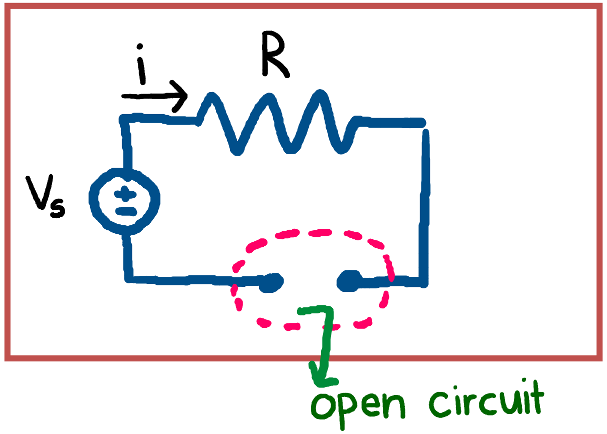
! calculator

$R_1^{-1} + R_2^{-1} + R_3^{-1} + R_4^{-1} + \ldots + R_N^{-1}$

$= answer^{-1}$

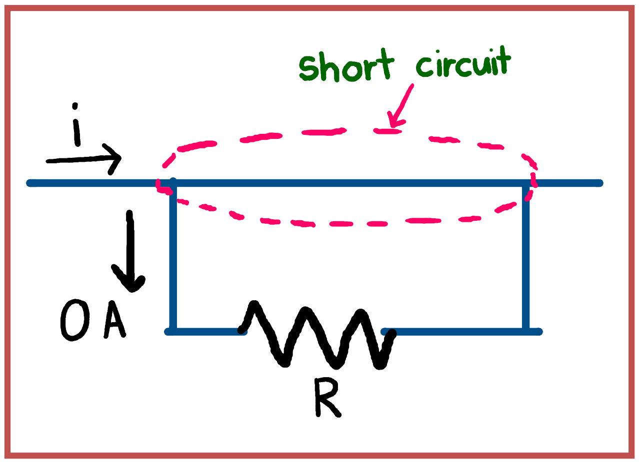
$R_{eq} = R_1 // R_2 // R_3 // \ldots // R_n$

Special Case for R: Short Circuit/Open Circuit



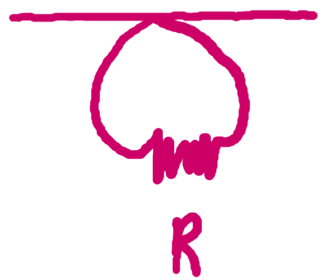
$i = 0, \quad V = V_s$

$R = V/i = V/0 = \infty$



$v = 0,$

$R = 0/i = 0$



Neglect R!

Author Information

Nor Rul Hasma Abdullah (Ph. D)
Senior Lecturer
Email:
hasma@ump.edu.my
Google Scholar:
Nor Rul Hasma
Scopus ID :
35791718100