EEE1024: Fundamentals of Electrical and Electronics Engineering

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Passive Elements

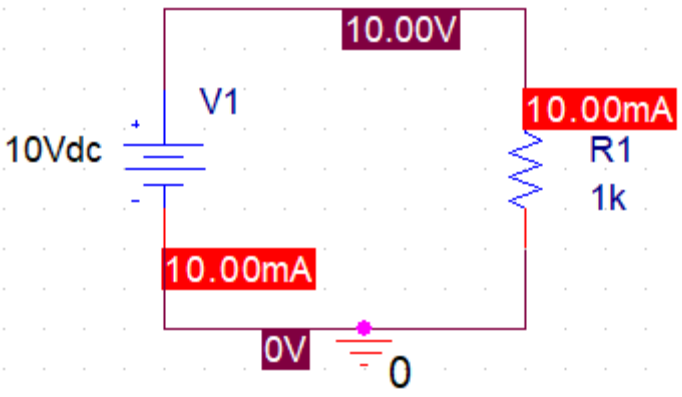
Linear Resistor: 1827 – G. S. Ohm and later Henry Cavendish

"Voltage across conducting materials is proportional to the current flowing through it"

$V \propto I$ $\quad V = IR$ or $R = \frac{V}{I}$ where R is constant of proportionality - resistance

Unit of resistance – ohm "Ω" $\quad 1\Omega = \frac{1V}{1A}$

$\frac{1A}{1V} = 1S$ where S is unit of Conductance 'G' $\quad G = \frac{I}{V} = \frac{1}{R}$



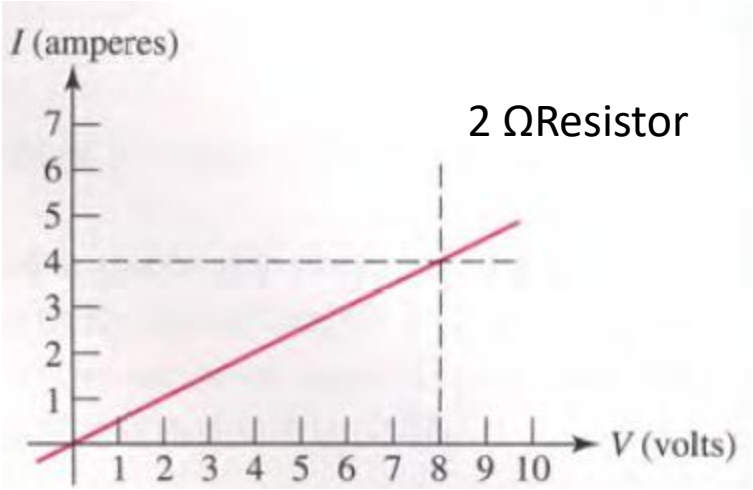
$V = IR$

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

$I = \frac{10}{1 \times 10^3}$

$I = 10^{-2}$ **A**

$I = 10mA$



2 ΩResistor

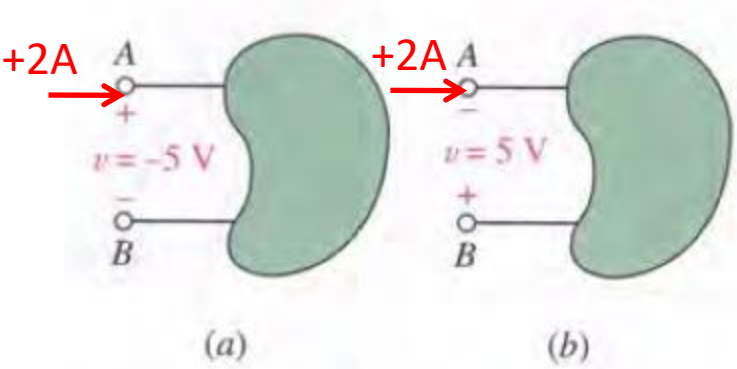
Power

When current flows – from higher potential to lower potential, $V = IR$

– from lower potential to higher potential $V = -IR$

Power absorbed by an element (in a circuit) = product of voltage across it and the current flowing through it.

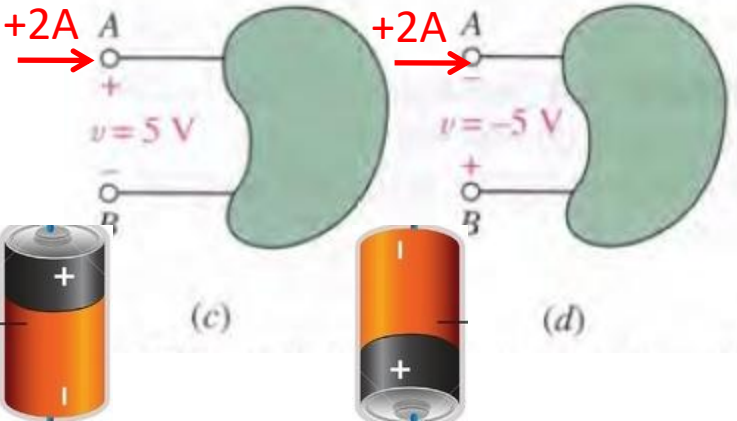
$$P = VI = (IR)I = I^2R$$



Terminal B is 5V +ve w.r.t. A

a) $(-5)(+2) = -10W$???

b) $(+5)(+2) = +10W$



Terminal A is 5V +ve w.r.t. B

c) $(+5)(+2) = +10W$

d) $(+5)(+2) = +10W$

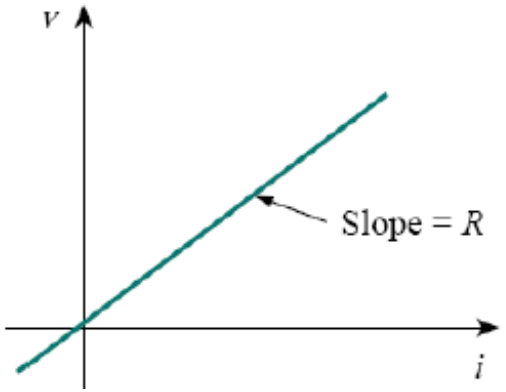
Power – Passive Sign Convention

Negative Power – Object is losing energy or supplying energy to another object! OR
- GENERATING Energy -> It is a Source!

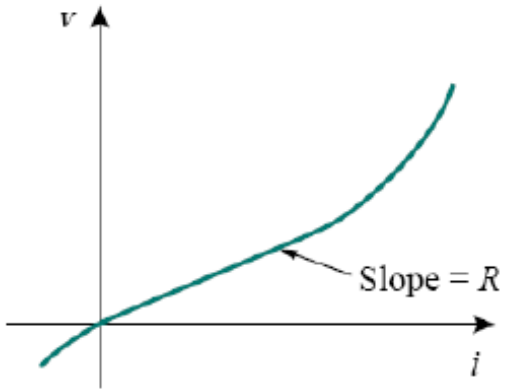
One terminal of an element is *V* volts +ve w.r.t. other, and if current *I* enters the elemer through that terminal, power *P = VI* is absorbed by the element OR Power *P* is delivered to th element (by a source)

Passive Sign Convention – Power absorbed or dissipated is positive!

Linear Resistor

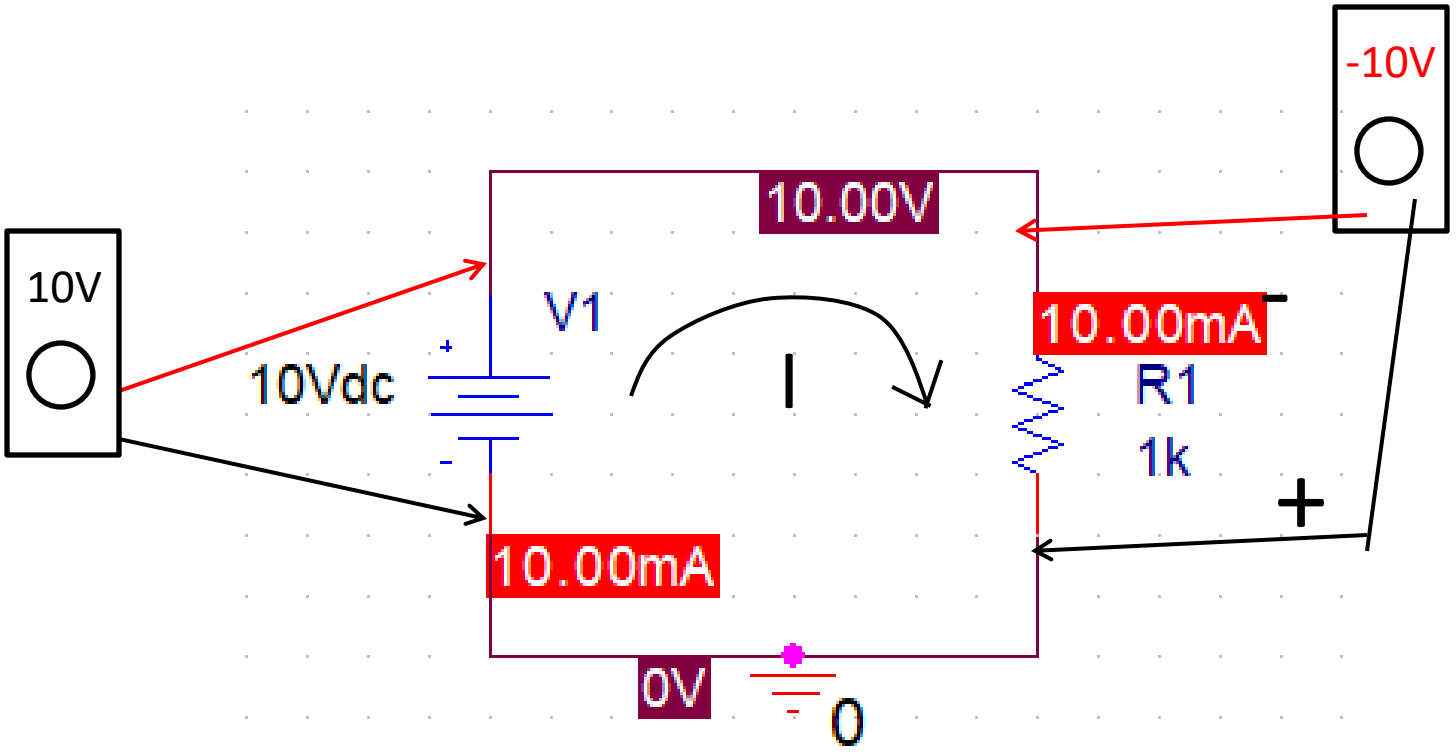


Non-linear Resistor



Non-linear resistor does NOT obey Ohm's law!

Simple Example



V drop across R1 = +10V

SI Prefixes

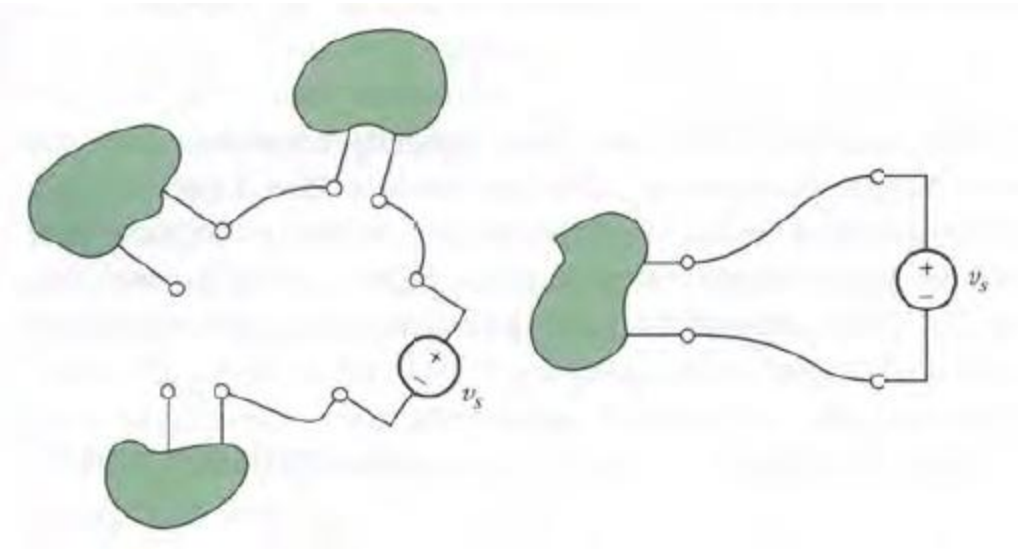
Not highlighted are the ones which are *frequently used*

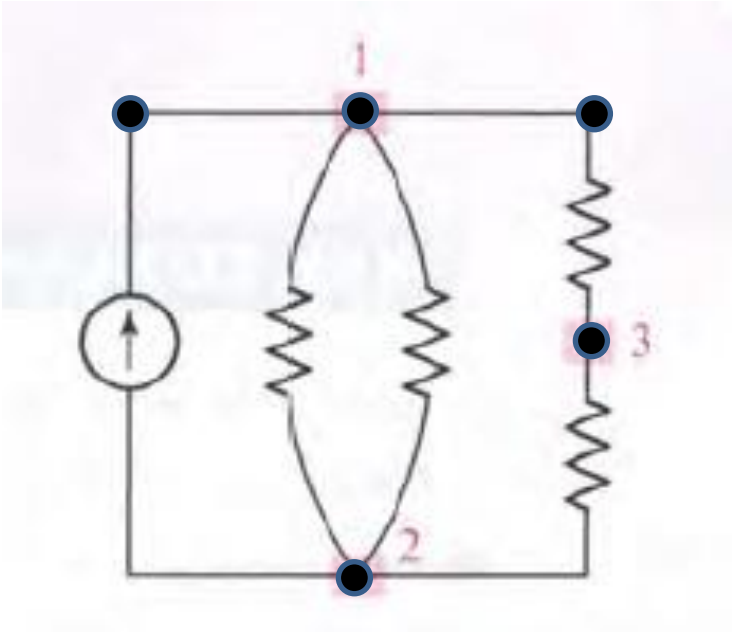
Factor	Name	Symbol	Factor	Name	Symbol
10^{-24}	yocto	y	10^{24}	yotta	Y
10^{-21}	zepto	z	10^{21}	zetta	Z
10^{-18}	atto	a	10^{18}	exa	E
10^{-15}	femto	f	10^{15}	peta	P
10^{-12}	pico	p	10^{12}	tera	T
10^{-9}	nano	n	10^{9}	giga	G
10^{-6}	micro	μ	10^{6}	mega	M
10^{-3}	milli	m	10^{3}	kilo	k
10^{-2}	centi	c	10^{2}	hecto	h
10^{-1}	deci	d	10^{1}	deka	da

Nodes, Branches and Loops

Electrical Network: Interconnection of two or more circuit elements

Electrical Circuit ?? It is a network which has at least one **closed path**



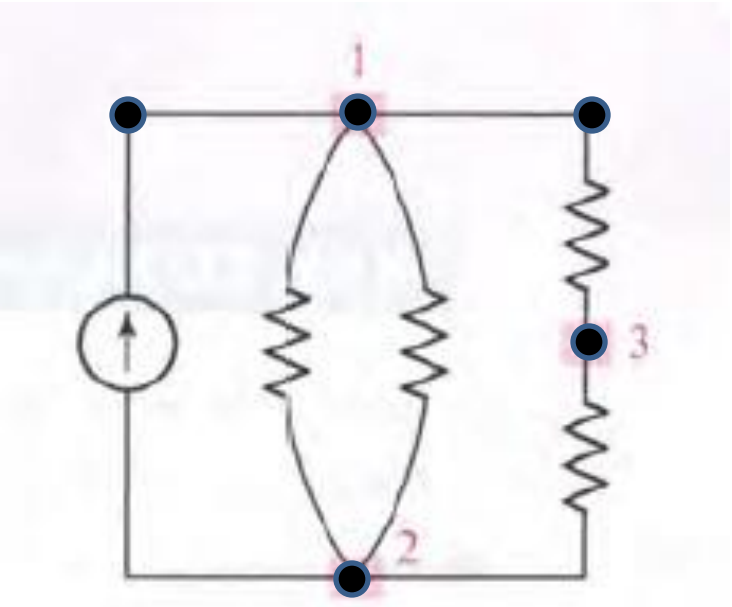


NODE: A point at which two or more elements have a common connection

How many nodes ? 3

PATH: If we start from one node in a network and pass through different elements, as long as no node is encountered more than once, we have defined a *path*.

Nodes, Branches and Loops



PATH: **If we start from one node in a network and pass through different elements, as long as no node is encountered more than once, we have defined a *path*.**

LOOP: If the node that we start is the same as the node we end, then the path is called as a *loop*.

Move from node 2 to node 1, then upper right resistor to node 3 – **path or loop ?**

When will it become a loop ? **End at node 2**

BRANCHES: A single path which is composed of one element and a node at each end of the element.

How many branches in the circuit ? **5**

Kirchhoff's Current and Voltage laws

Gustav Robert Kirchhoff – German Univ. Professor - same time as G. S. Ohm – 2 world famous physical laws

One law (KCL) – Principle of conservation of charge

The total charge of the system has not and will never change.

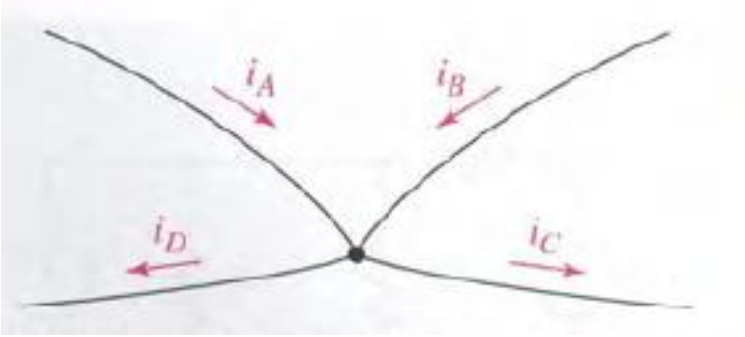
Algebraic sum of currents entering any node is zero

Second law (KVL) – Principle of conservation of energy

Energy is neither created nor destroyed

Algebraic sum of voltages around any closed path is zero

Kirchhoff's Current law (KCL)



Algebraic sum of currents entering any node is zero

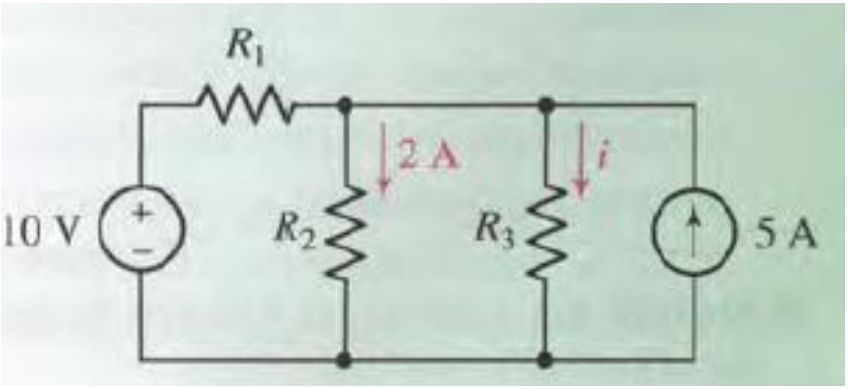
Entering the node $i_A + i_B + (-i_C) + (-i_D) = 0$

Leaving the node $(-i_A) + (-i_B) + i_C + i_D = 0$

$$i_A + i_B = i_C + i_D$$

$$\sum_{n=1}^{N} i_n = 0$$

Example: If the voltage source supplies 3A of current, compute the current through resistor R_3

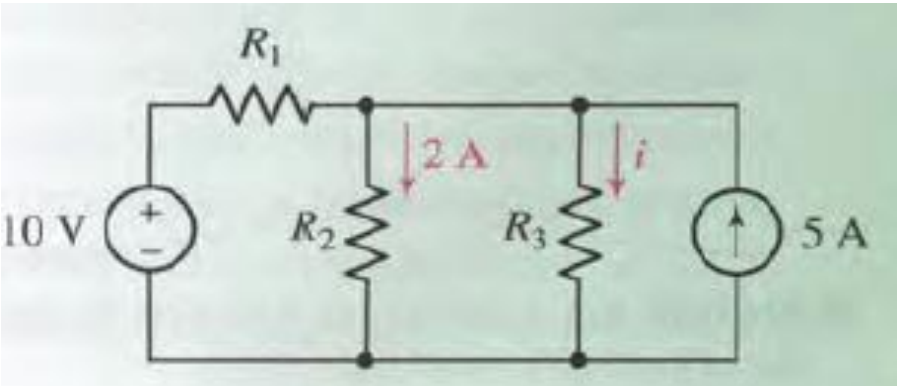


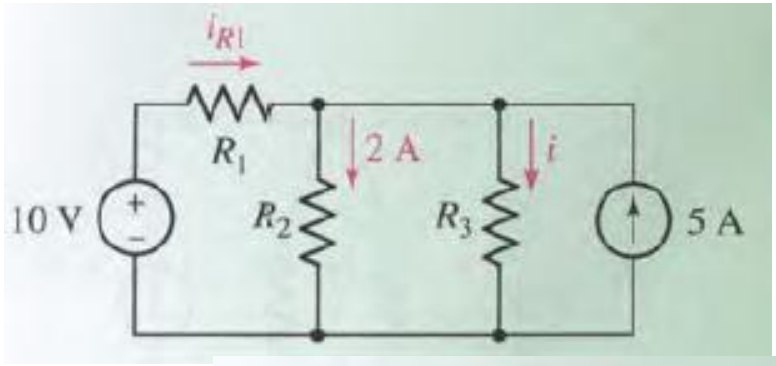
Strategy for such questions

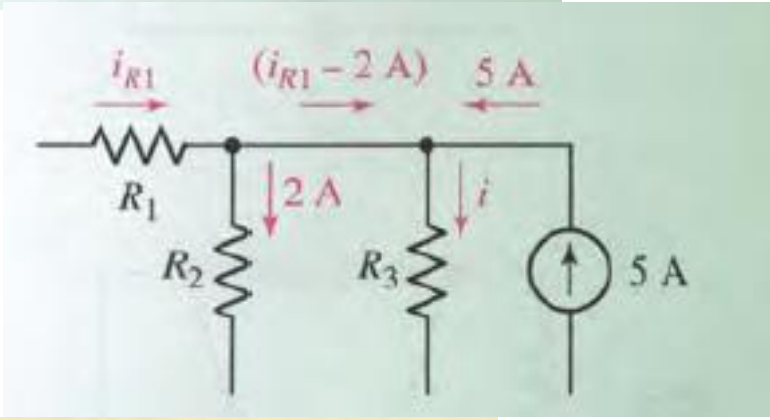
1) Identify goal of the problem
2) Collect known info
3) Devise a plan
4) Construct proper set of equations.

Kirchhoff's Current law (KCL)

Example: If the voltage source supplies 3A of current, compute the current through resistor R_3







1) <u>Identify goal of the problem</u>:
   Labelled 'i' on the figure
2) <u>Collect known info</u>:
   Top node of R_3 connected to 3 branches. Current flowing into this node will have currents from these 3 branches.
3) <u>Devise a plan</u>:
   Label current thr' R1 and write KCL at the top node of R_3
4) <u>Construct proper set of equations</u>:
   Summing up the currents flowing into the node - $i_{R_1} - 2 - i + 5 = 0$

$$i_{R_1} - 2 - i + 5 = 0$$

$$3 - 2 + 5 = i$$

$$i = 6A$$