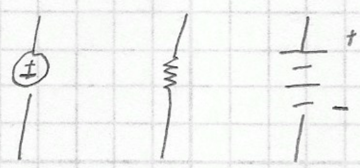
Circuit - a representation of energy gives - (active elements) and energy takers (passive elements) that for a closed path through which current cam flow.

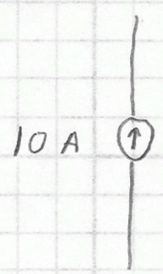
Can be represented schematically and mathematically
* assuption - Ideal world.

1. active elements - provide energy

a. Independent Sources

i voltage source - the value of the voltage between the terminals is know; the amount of current provided is determined by what it is connected to.

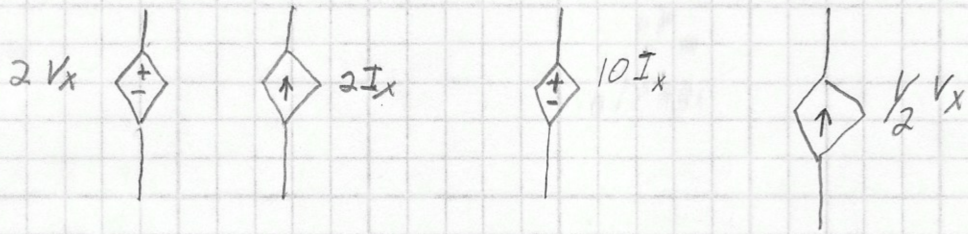




* There is a voltage Associated with current sources!

b. Dependent Sources (controlled sources)

- can be a voltage or current sources)
- can depend on a voltage or current else where in the court

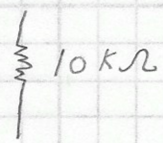


* Will need one extra (constraint) eqn.

2. Passive Elements

a. Resistors

- symbol in signs R

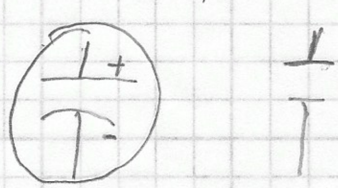


- Units are Ohms (Ω)

b. Capacitors

- symbol in eqns, C

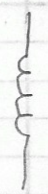
-



- Units are Farads (F)

c. Inductors

- symbol in eqns, L

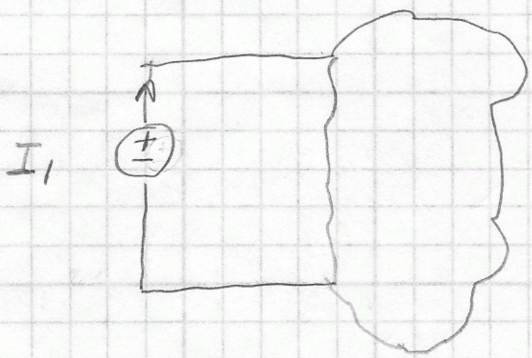


- Units are Hen-rys (H)

<u>Current</u>

- symbol in eqns is i ← time dependent (AC) or I ← constant (DC)

- Defined based on direction positive charges would flow.



Current is the rate of flow of charges

1 Ampere = 1 C/s

A = 1 C/s

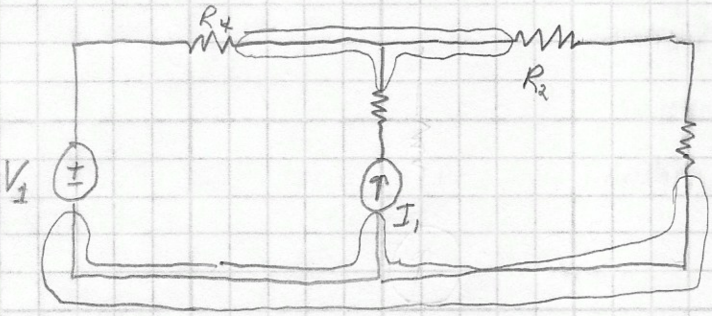
(Amps) A

- If current enters an element at the point of highest voltage and leaves at the point of lowest voltage, that element is passive

Voltage

- better term => potentioal difference
- Voltage is the difference in electric potential energy (per init of charce between two-points
- 1 volt = 1 J/c

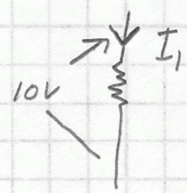
The voltage (potential difference) between two points in a circuit is independent of the path taken between those points.



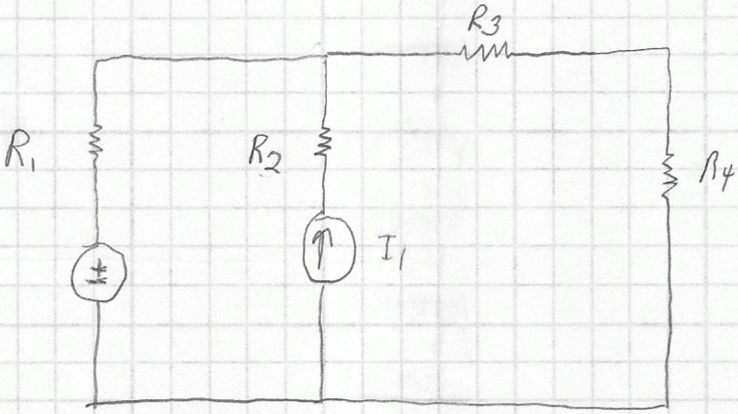
node - a point (wires connecting elements) where 3* or more elements are connected.

- branch - the element(s) that connect two nodes
- mesh - a region of space enclosed by branches.

single - Arrow Notation



Ex:

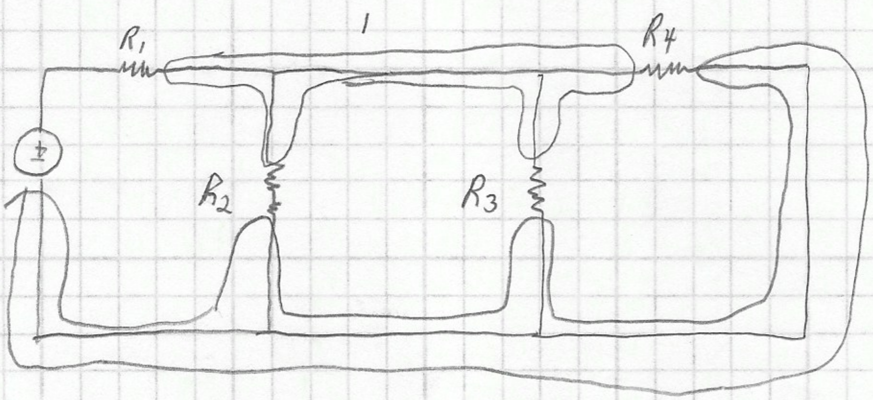


series - elements that are connected "end-to-end" The only node between them is a connection of only 2 elements

* The elements is series share the same current!

parallel - elements and branches, that are connected between the same two nodes.

ex!

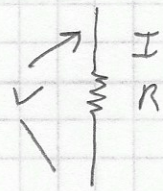


$R_2 \,//\, R_3 \,//\, R_4$

Elements in parallel have the same voltage!

Fundamental Laws of Circuit Analysis

(1.) Ohm's Law $V = IR$



(2.) Kirchhoff's Current Law (KCL)

The total current entering a node must be equal to the total current leaving the node.

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

(3.) Kirchhoff's Voltage Law (KVL)

Around any complete loop (starting & finishing at the same node), the total change in voltage must equal zero.

* $\Delta V = 0$ around closed loop.

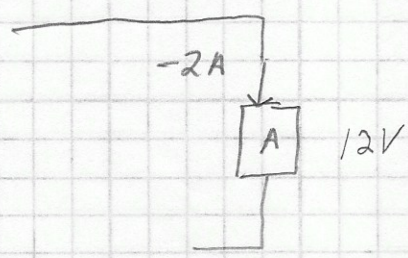
$\Sigma V_{Rise} = \Sigma V_{Drop}$

4. Power Law

$P = IV \quad (= I^2 R = V^2/R$

$= (C/s)(J/C) = J/s = W$

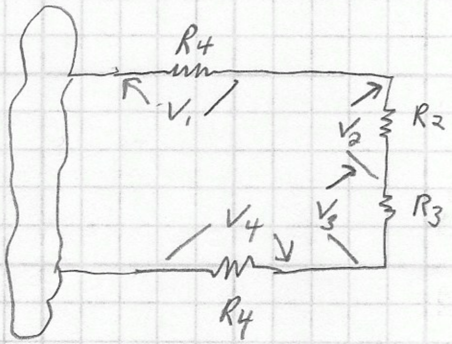
$\Sigma P_{supplied} = \Sigma P_{absorbed}$ for the whole circuit



Additional Tools

1. Equivalent Resistance

<u>Resistors in series</u>



$$V_{tot} = V_1 + V_2 + V_3 + V_4$$

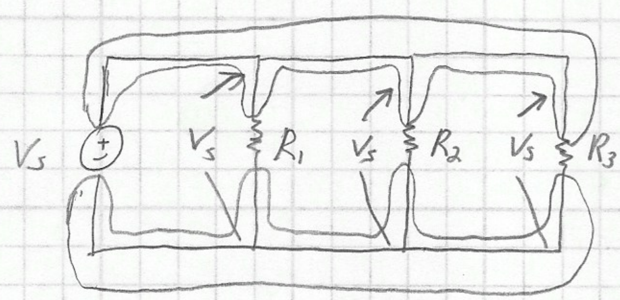
$$= I R_1 + I R_2 + I R_3 + I R_4$$

$$= I \underbrace{(R_1 + R_2 + R_3 + R_4)}$$

$$V_{tot} = I \, R_{eq}$$

$$R_{eq} = \Sigma R_i$$

Resistor in Parallel



KCL: $I_s = I_1 + I_2 + I_3$

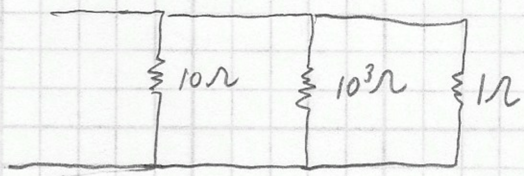
$$I_s = \frac{V_s}{R_1} + \frac{V_s}{R_2} + \frac{V_s}{R_2}$$

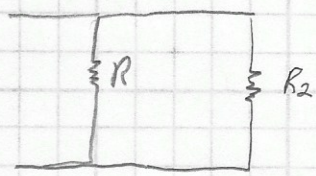
$$I_s = V_s \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)$$

$$\left(\frac{1}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)} \right) I_s = V_s$$

$$R_{eq} I_s = V_s$$

$$\frac{1}{R_{eq}} = \Sigma \frac{1}{R_i}$$





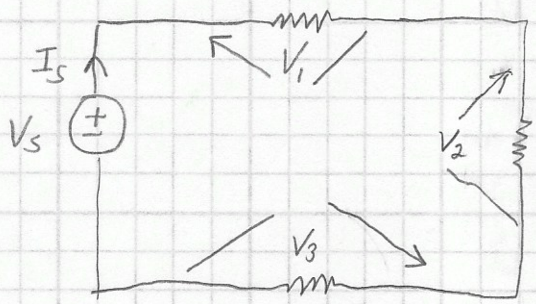
$$\frac{1}{R_{eq}} = \frac{R_2}{R_2 R_1} + \frac{R_1}{R_2 R_1}$$

$$\frac{1}{R_{eq}} = \frac{R_1 + R_2}{R_1 R_2}$$

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{\text{product}}{\text{sum}}$$

2. Voltage Division

- Only works w/ resistor is series!

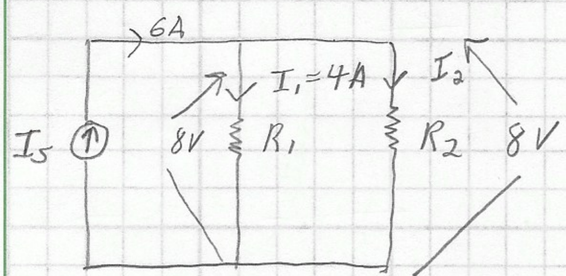


$$\frac{V_2}{V_s} = \frac{I_s R_2}{I_s R_{eq}} = \frac{I_s R_2}{I_s (R_1 + R_2 + R_3)}$$

$$V_2 = \frac{R_2}{R_{eq}} V \qquad V_i = \boxed{\frac{R_i}{R_{eq}} V_s}$$

(3.) Current Division

Only works with resistors in parallel!



$$I_2 = \left(\frac{R_1}{R_1 + R_2}\right) I_s$$

Opposite branch (R_1)

sum of R's ($R_1 + R_2$)

current that is dividing (I_s)

$$I_2 = \left(\frac{2\Omega}{2\Omega + 4\Omega}\right)(6A) = 2A$$

sum of R's

* → current travels through the path of Least resistance.

* Any time you have a controlled source there is one extra equation