* Power = $I * V$ unit:- watt.

⊕ sign ⟶ the element absorbe power.
⊖ sign ⟶ the elemet general power.

+ Power absorbed = - Power generated.

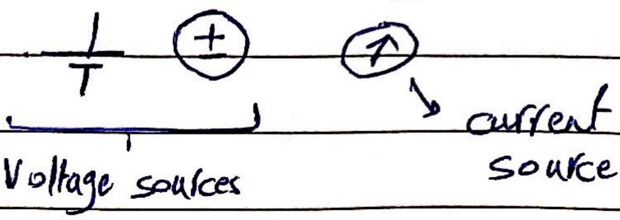
* current should enter through the positive polarity of the voltage.

* $\Sigma P = 0$ ⟶ total power absorbed = total power generated.

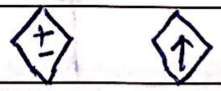
Circuit elements:-
1) active element:- capable of generating energy
2) Passive element:- doesn't generat energy

ex. active elements ⟶ batteries
ex. passive elements ⟶ resistors, capacitors, inductors.

* Current and Voltage sources:-
1- independent ⟶ Completly independent of other circuit elements.



2) dependent $\longrightarrow$ Controlled by another voltage or current



"diamond shape"

$V = IR$

I :- current
R :- resistance
V :- Voltage.

* short circuit $\longrightarrow$ $V = 0$, $R = 0$
* open circuit $\longrightarrow$ $I = 0$

* $P = VI = I^2R = \frac{V^2}{R}$

* number of branches in a circuit = number of element
* Node :- where elements connect together
* Loop :- closed path.

* KCL "Kirchhoff's current law"

ΣI "entering a node" $= 0$

* $I_{in} \longrightarrow$ ⊕ and $I_{out} =$ ⊖
or vice versa.

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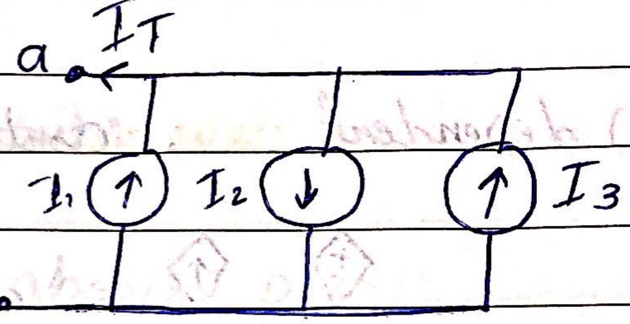
$I_T + I_2 = I_1 + I_3$



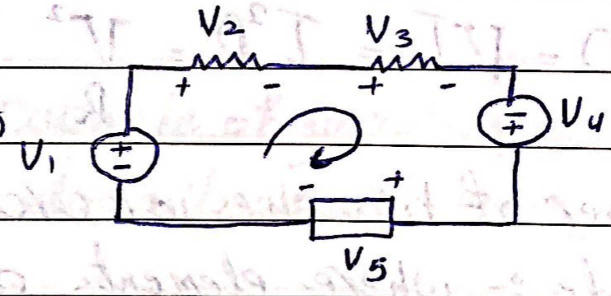
* when the current sources are conneted in parallel

* KVL "Kirchhoff's Voltage law."

$$\Sigma V \text{ "around loop"} = \text{zero}$$

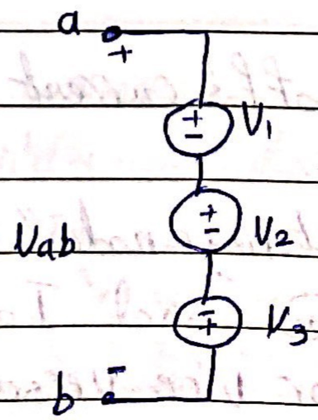
* The sign on each Voltage is the polarity of the terminal encountered first as we travel around the loop

$-V_1 + V_2 + V_3 - V_4 + V_5 = 0$

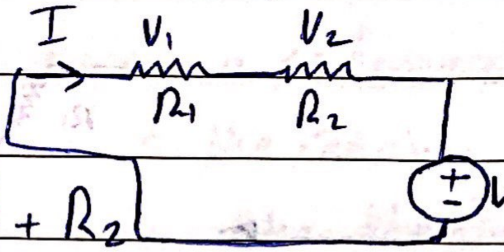


* when the voltage sources are conneted in series, KVL can be applied to obtain the total Voltage source.

$V_{ab} = V_1 + V_2 - V_3$



Req. in series = the sum of the individual resistance



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

* current division "for resistors in series"

$$V_1 = V \frac{R_1}{R_1+R_2 \cdots}, \quad V_2 = V \frac{R_2}{R_1+R_2 \cdots}$$

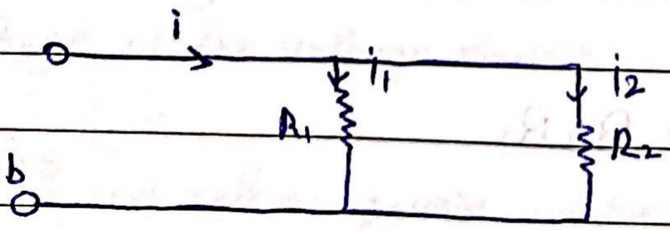
* The larger resistance → the larger voltage drop.

Req in parallel = $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ ------ etc.

* for two resistors in parallel :-

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

* current division "for resistors in parallel"



$$i_1 = i \frac{R_2}{R_1+R_2}, \quad i_2 = i \frac{R_1}{R_1+R_2}$$

NOTEBOOK

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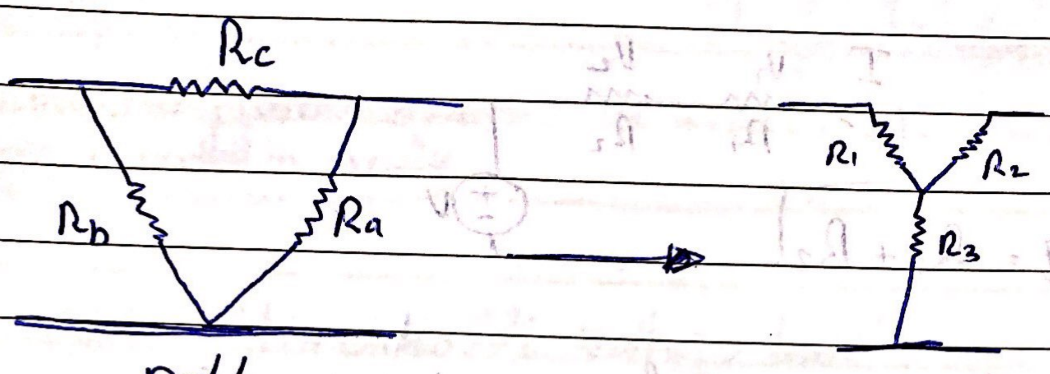
* Delta to wye Conversion :-

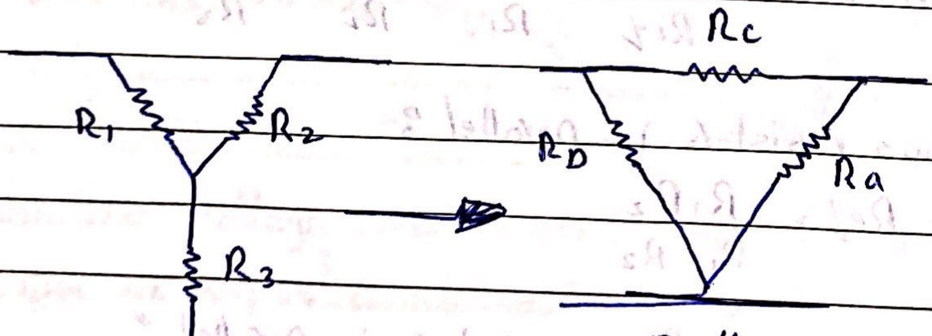


Delta wye

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c} \qquad R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

* wye to delta Conversion.



wye Delta

$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$

$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

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* Nodal analysis → using nodes Voltages

1- select a node as a reference node. Assign Voltages $V_1, V_2 \dots V_{n-1}$. to the remaining $n-1$ nodes.

* reference node → has the highest number of connections

2- Apply KCl to each of $n-1$, nonreference nodes. Use Ohm's law to express the branch current in terms of node voltages.

3- Solve the resulting simultaneous equations to obtain the unknown node voltages.

* current flows from a highr potential to a lower potential in a resistor.

$$I = \frac{V_{higher} - V_{lower}}{R}$$

* If a voltage source is connected between the reference node and a nonreference node, we simply set the voltage at the non reference node equal to the voltage of the voltage source

* If the voltage source (dependent or independent) is connected between two non-reference nodes, then the two non-reference nodes form one node called supernod.

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* A supernode requires the application of both KCl and KVL

* Mesh analysis → using mesh currents as a circuit variables.

mesh ≡ Loop → closed path.

→ we apply ~~KCl~~ KVL to find unknown currents.

steps:-

1) assign mesh currents $i_1, i_2 ---$ to the n meshes
2) apply KVL to each of the n meshes. Use Ohm's law to express the voltages in terms of the mesh currents
3) solve the resulting n simulataneous equations to get the mesh currents.

* it is conventional to assume that each mesh current flows clockwise.

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dependent
independent.

* when the current source exists only in one mesh, the mesh current is equal to the current source

"مع الاتجاه الاتجاه"

* when a current source exist between two meshes, we create a supermesh, by excluding the current source and any elements connected in series with it.

* A supermesh requires the application of both KVL and KC

* if we have two supermeshes then we put them in one large supermesh.

---

* in superposition we consider one independent source at a time, while all other independent sources are turned off,
* we replace every Voltage source by short circuit "$V = 0$" and every current source by an open circuit '$I = 0$'
* Dependent sources are left intact.

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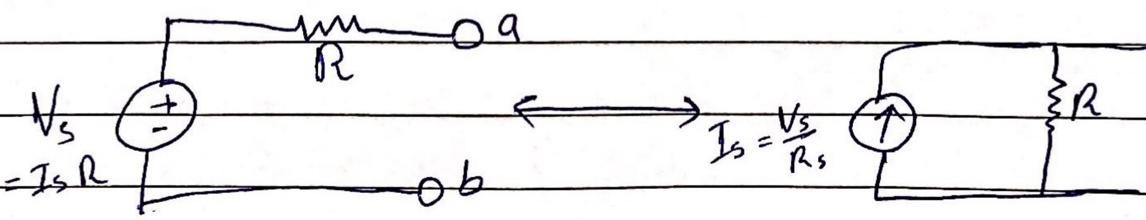
* Source transformation is the process of replacing a Voltage source in series with a resistor by a current source in parallel with a resistor, or vice versa. "dependent and indpendent sources"



* Thevenin's Therom:-

$V_{Th} = V$ "open circuit"

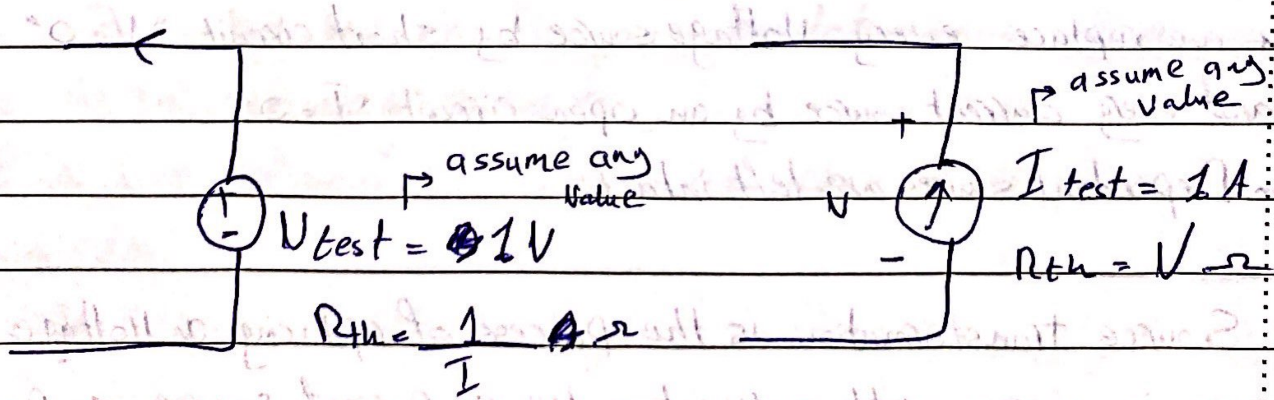
1) If the network has dependent sources and independent source, we turn off all independent sources and find Req

$$R_{th} = \frac{V_{th}}{I_{th}}$$

2) If the circuit has no dependent and has independent sources.
↳ kill all independent sources the find Req

$R_{eq} = R_{th}$

3) If the circuit has only dependent sources:



* Norton's theorem :-

$$R_N = R_{th}$$

$$I_N = \frac{V_{th}}{R_{th}}$$

V_{th} = "V" open circuit

I_N = I "short circuit"

$$R_{Th} = \frac{V_{oc}}{I_{sc}} = R_N$$

---

* Maximum power transfer =

$$P_{max} = \frac{V_{th}^2}{4R_{th}} \quad \boxed{\text{or}} \quad P_{max} = \frac{I_N^2 R_{th}}{4}$$

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* capacitor :- Passive element and linear element.

* V_c cannot change in zero time.

current $I = C \frac{dv}{dt}$

$$V(t) = \frac{1}{C} \int_{t_0}^{t_1} i(\tau)\, d(\tau) + V(t_0)$$

stored energy in capacitor

$$W_c(t) = \frac{1}{2} C \left(V_c^2(t) - V_c^2(t_0)\right) + W_c(t_0)$$

if $w_c(t_0) = 0$, $V_c(t) = 0$

$$W_c(t) = \frac{1}{2} C V_c^2(t)$$

* we replace the capacitor in DC circuits by "open circuit"

* C_{eq} for capacitors in parallel is the sum of the individual capacitances

$$C_{eq} = C_1 + C_2 + C_3 \cdots$$

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in series

* Ceq for capacitors is the reciprocal of the sum of the reciprocals of the individual capacitances

$$C_{eq} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \ldots$$

* for two capacitors $\longrightarrow$ $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$

Inductors $\longrightarrow$ linear and passive elements.

$$V = L \frac{di}{dt} = \text{Slope}$$

$$I = \frac{1}{L} \int_{t_0}^{t} v(\tau)\, d\tau + i(t_0)$$

$$W_L(t) = \frac{1}{2} L \left(i^2(t) - i^2(t_0) \right) + W_L(t_0)$$

$$\text{if } W_L(t_0) = 0 \longrightarrow i_L^2(t_0) = 0$$

$$W_L(t) = \frac{1}{2} L\, i_L^2(t)$$

NOTEBOOK

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* In DC circuits we replce the inductors by short circuit.

* Leq in series $= L_1 + L_2 + L_3 + L_4 \dots$

* leq in parallel $= \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \frac{1}{L_4} \dots$

for two inductors in parallel

$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$$

* $\Delta \to Y$ transformation can be xtended to capacitors and inductors.