Methods of Analysis:-

① Nodal analysis:- (with no voltage sources) (Determine nodes voltages)

→ to find nodes voltages.
→ put a reference node.
→ apply kcl to every nonreference node.

you'll get a matrix of = $A v = b$.

→ all current sources are in parallel.

nothing in series.

② Nodal analysis with voltage source:- (Determine nodes voltages)

(using the concept of a super node)

→ supernode always gives you the first equation.

→ apply kcl to super node.

→ here you may have current sources + $\boxed{\text{voltage sources}}$.

Then apply ~~kvl with these sources~~ we have no problem with V_s in series ~~with R~~ ← as a single node ← in parallel with resister

③ Mesh analysis (voltage sources in series with other elements)

→ Apply kvl to each mesh in terms of (iR)

to get n equations of $Ai = b$.

④ Mesh analysis with current sources.

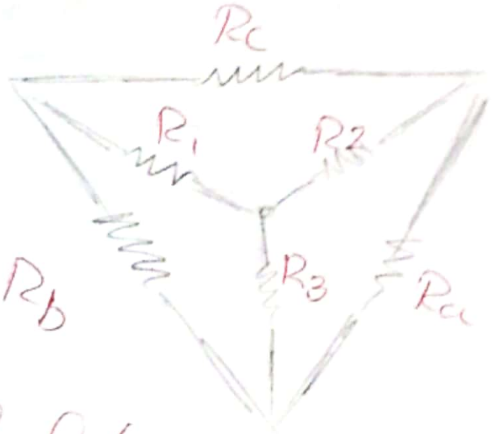
→ A super mesh requires the application of both kvl and kcl.

Gewill be excluded.

① cases:- current source in 1 mesh, we treat the mesh current as that current (take care of directions)

② case:- super mesh → kvl to meshes excluding the branch of supermesh
→ kcl to a node between 2 meshes.

Delta-Wye connections:



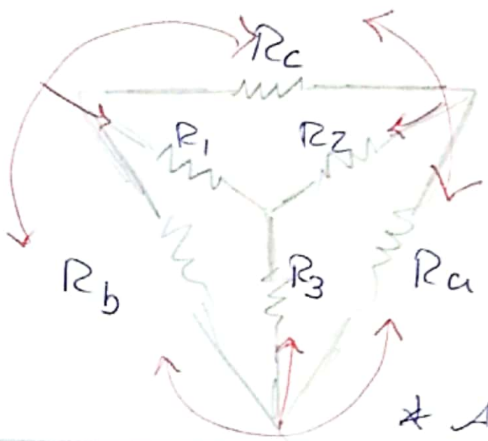
∇-Y conversion:-

① $R_1 = \dfrac{R_b \cdot R_c}{R_a + R_b + R_c}$

② $R_2 = \dfrac{R_a \cdot R_c}{R_a + R_b + R_c}$

③ $R_3 = \dfrac{R_a R_b}{R_a + R_b + R_c}$

So you can find it this way:



* And for a special case:-

A Balanced ∇ connection

$R_a = R_b = R_c = R$

So you have a balanced Y connection:-

$R_1 = R_2 = R_3 = \dfrac{R}{3}$ ✓

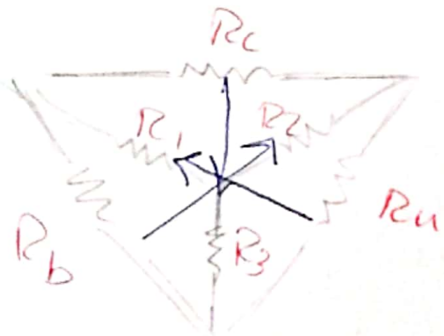
Y-∇ conversion:-

$R_a = \dfrac{R_1R_2 + R_1R_3 + R_2R_3}{R_1}$

$R_b = \dfrac{R_1R_2 + R_1R_3 + R_2R_3}{R_2}$

$R_c = \dfrac{R_1R_2 + R_1R_3 + R_2R_3}{R_3}$

The Trick:-



According to Ohm's law →

$v = \begin{cases} i \cdot R \text{ (through } + \to i) \\ -i \cdot R \text{ (" } - \to i) \end{cases}$ measured for v through a resister

$R = \frac{v}{i}$ Ω

→ $R = \frac{\rho L}{A}$ when we are mentioning the conductor

ρ = resistivity of material.

Circuits

short $\overset{R}{\uparrow}$ $v = i \cdot R$ $\underset{0}{\downarrow}$

$v = 0$, $R = 0$

→ no element assuming $R = 0$

→ we have short when there is no R connected between a and b

i is not 0 necessarily.

open

→ open terminals so it is as we have a very huge R aproaching ∞

in branch ← → then $i = 0$

but v is not necessarily $= 0$ in this case

$0 \leftarrow i = \frac{v}{R \to \infty}$

The Conductance (عكس المقاومة / الناقلية)

$G = \frac{1}{R}$ → helps to simplify analysis.

Power dissipated by resisters:-

→ resisters will always absorb power
power is always positive in here ✓

→ remember

$p = \mp i \cdot v$

but → $v = \mp i \cdot R$

we say connected in series : sharing same $\underline{i}$

" " " " parallel : " " $\underline{v}$ and connected to same nodes.

Important: ① many voltages connected in series (algebric sum → replace)
② many currents " in parallel (" " → replace)

→ Revise the page of connections in the note book.

kirchhoff's laws

(KCL)

$\Sigma i_{entering} = \Sigma i_{out}$

→ take care of the current source replacement.

$\Sigma \frac{V}{R_{in}} = \Sigma \frac{V}{R_{out}}$

(KVL)

algebric sum of all voltages across a closed path = 0

$\Sigma iR = 0$ $\Sigma v = 0$ Identical.

① Trick (signs) →
moving through (+ term) → + v
" " (- term) → - v

remember → sum of drops = sum of rises

connections:-

Series Resistors :-

→ The current stays the same for them all ✓ (all resistors)

→① Apply (KVL) to determine how it goes ✓ (it gives v_{eq})

→② $R_{eq} = R_1 + R_2 + \dots + R_n$

Then ① $\boxed{i = \frac{v}{R_{eq}}}$

Then ② $v_1 = \pm i.R = \frac{R_1}{R_{eq}} v$

$v_2 = \pm i.R = \frac{R_2}{R_{eq}} v$

Voltage divider rule

Parallel Resistors :-

→ The voltage stays the same for them all ✓ (all resistors)

→ You can apply (KCL) to see more details.

→ $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots + \frac{1}{R_n}$

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

A special case when $N = 2$:-

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

Using Conductance :-

$G_k = \frac{1}{R_k} \rightarrow G_{eq} = \frac{1}{R_{eq}}$

$G_{eq} = G_1 + G_2 + \dots + G_n$

Then we substitute that:-

$$i_k = \frac{\frac{1}{R_k} \cdot i}{\frac{1}{R_{eq}}} = \frac{G_k \cdot i}{G_{eq}}$$

↓

for a branch

The current divider rule

A special case when $N = 2$:-

$$i_1 = \frac{R_2}{R_1 + R_2} \cdot i \qquad i_2 = \frac{R_1}{R_1 + R_2} \cdot i$$

So :-

i_1 is $\propto \frac{1}{R_1}$ and $\propto R_2$

i_2 is $\propto \frac{1}{R_2}$ and $\propto R_1$.

→ See the open and short circuits in the note book ✓

* Chapter 4:

4.2: linearity Property

$$x(t) \longrightarrow \boxed{T} \longrightarrow y(t) = T\{x(t)\}$$

$i(t)$ or $v(t)$ → inputs signals

$i(t)$ or $v(t)$ → outputs signals

$$T\{\alpha_1 x_1(t) + \alpha_2 x_2(t)\} = \alpha_1 T\{x_1(t)\} + \alpha_2 T\{x_2(t)\}.$$

~~if~~

To be a linear system this should be applied

ال input داخل كامل، او حطنا منفصلين، لازم يأدوا لنفس النتيجة

when $y(t) = \beta x(t) + \phi$, its not gonna be linear because of ϕ, it's gonna give a linear equation but not leading to a linear system

Superposition principle

→ to kill a voltage source, replace it with a short circuit.

→ to kill a curent source, replace with an open circuit.

Dependent sources are left, because they are controlled by independent ones

Source Transformation:-

voltage source in series with R → current source in parallel with R

$i_{sc} = \frac{V_s}{R}$ (source)

$i_s = i_{sc}$ (source)

$v_s = i_s R$

$i_s = \frac{V_s}{R}$

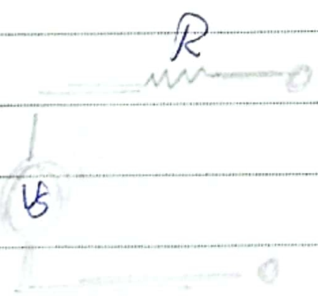
Same for independent sources ✓

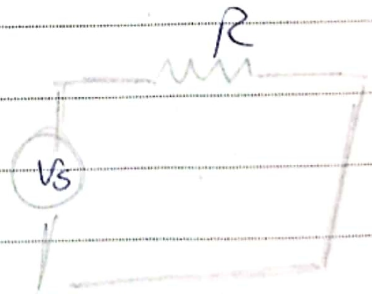
But imagine

→ voltage source presence:-

open circuit

short circuit





$i = 0$

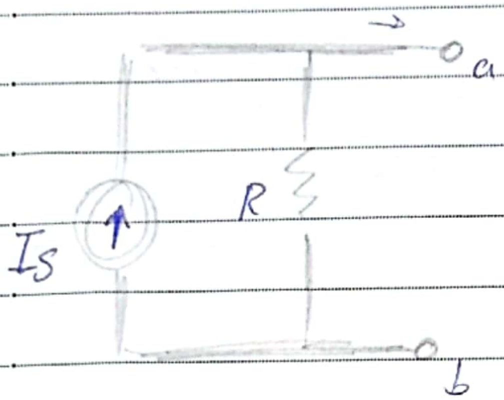
$V_{op} = V_s$

$V_{sh} = V_s$

$i_{sh} = \frac{V_s}{R}$

current source presence :-

open circuit :-

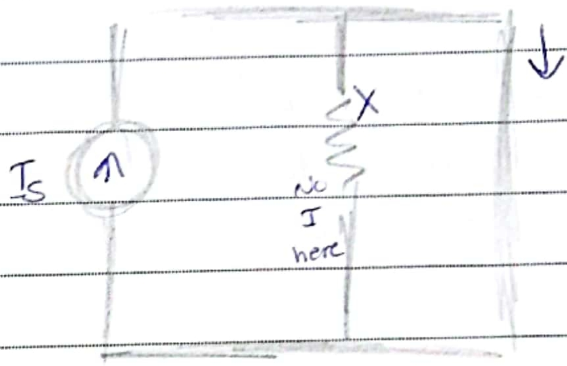


$I_S = \frac{V_S}{R}$

$V_{op} = I_S . R$

$= \frac{V_S}{R} R = V_S$

short circuit :-



$I_{sh} = I_S$

$= \frac{V_S}{R}$

$V_{sh} = V_S$

4.5 Thevenin Theorem

1 case 1 No Independent sources.

case 1 No Independent source

→ disconnect load

you'll have a circuit with open terminals (ab)

→ kill all sources (independent)

* → find R_{th}

→ find V_{th}

→ get back the linear circuit without killing any source.

~~→ $V_{ab} = V_{open} = V_{th}$~~

$V_{ab} = V_{open} = V_{th}$.

For Norton theorem :-

→ $i_{ab} = i_{sh} = I_N$

$R_N = R_{th}$

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Chapter 6 summarization:-

§ 6.2 : capacitors

Basic

→ How to find capacitance:-

$C = \frac{q}{V}$ or $C = \frac{\epsilon d}{A}$ (A of one plate)
(q " " ")

c is measured in Farad = 1 columb / volt.

① i through a capacitor:-

$i = C\frac{dv}{dt}$ → you'll find i(t) / function of t until they give you t

② v(t) of capacitor:-

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

Power and Energy:-

* Power

→ $p(t) = i(t) \cdot v(t)$

$p(t) = C\frac{dv(t)}{dt} \cdot v(t)$

* Energy stored in capacitor:

→ $w = \frac{1}{2} C v^2$

convert using $C = \frac{q}{V}$

→ or $w = \frac{1}{2}\frac{q^2}{C}$

→ Series and parallel capacitors:

~~→ Parallel resistors~~

→ Parallel capacitors:

$$C_{eq} = C_1 + C_2 + C_3 + C_4$$

→ they share same voltage.
→ charge is distributed.

→ Series capacitors:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}$$

→ They share same q
→ voltage is disributed.

special.
for $N=2$

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

Inductors:-

Basics:-

→ Inductance: $L = \frac{N^2 \mu A}{l}$

→ voltage:- $v = L\frac{di}{dt}$

→ current $i = \frac{1}{L}\int_{t_0}^{t} v(t)\,dt + i(t_0)$

for special case:-

$t_0 = -\infty \rightarrow i(t_0) = 0$

Then $i(t) = \frac{1}{L}\int_{-\infty}^{t} v(t)\,dt.$

power and energy:-

→ $p = vi = \left(L\frac{di}{dt}\right) i$

→ $w = \frac{1}{2} L i^2$

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Chapter 7:-

first order circuits:-

→ First order differential equation.

RC: circuit of and

RL: " " and

→ from of 1st ODE:

$$\frac{dy(x)}{dx} + p(x)\,y(x) = r(x)$$

or $$y' + p(x)\,y = r(x)$$

2 types of ODE

Homo

$$y' + p(x)\,y = 0$$

NonHomo

$$y' + p(x)\,y = r(x)$$

↳ external force from having v source or i source.

§ Source Free RC circuits

of 1st order Homo ODE.

① $v(0) = V_0$ (Both)

② $w_c(0) = \frac{1}{2} C v_0^2$ (capacitor)

③ $v(t) = v_0 e^{-t/RC} = v_0 e^{-t/\tau}$ (Both) $(t \geq 0)$

④ $\tau = RC$ (General)

τ is the time required for the response to decay to a factor of $1/e$ or 36.8% of its initial value

⑤ power dissipated by the resistor

$$p(t) = \frac{v_0^2}{R} e^{-2t/\tau}$$

⑥ energy absorbed by the resistor

$$w = \frac{1}{2} C v_0^2 (1 - e^{-2t/\tau})$$

⑦ $i(t) = \frac{v_0}{R} e^{-t/\tau}$ (Bot)

Steps to Analyze RC circuits:-

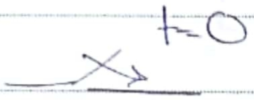
① find $v(0) = V_0$

② find $\tau = RC$

③ find $v(t) = V_0 e^{-t/\tau}$

→ Bold line:- Working with switches while analyzing

: switch is opened at $t=0$



: " " closed at $t=0$

pay attention:-

$t<0$, استخرجي قيم عددية عادي

$t>0$, استخرجي $v(t)$ ، $i(t)$

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The principle is very easy:

→ you should find $V_c(0)$, then if you are given $V_c(0)$, simplify the circuit into a single loop (Free RC), and assume DC conditions.

→ if you have switches:

→ find $V_c(0)$, by assuming that the circuit before closing or openning the switch has been operating for a very long time, and now we are under the DC condition so we can treat (capacitor symbol) as an open circuit

→ once you find so this is $V_c(0)$

→ consider the case of $t>0$

remove the switches, then you end up with RC