TurboIEG.com

Continuous change

دفتر :

اساسيات الدوائر الكهربائية

Circuit

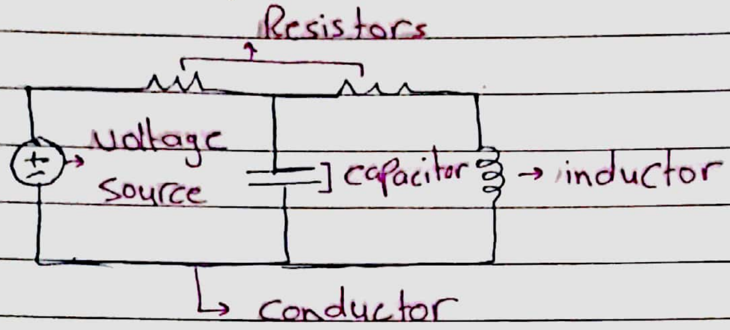
للطالبة : راما خضير

اللجنة الأكاديمية لقسم الهندسة الصناعية

2023

Circuit
1/3

ooo Basic component and electrical circuit :-



ooo Unit and scale :-

↳ any measurable quantity can be describe by number and unit. 3 meter
num ↲ ↳ unit.

* length → meter "m"
* mass → kilogram "kg"
* time → second "s"
* current → Amper "A"
* temp → kelvin "k"
* Work → Joule "J"
* power → watt "W"
* Voltage → Volt "V"

ooo Prefixes :- البادئات

* 10^{-18} → atto "a"
* 10^{-15} → femto "f"
* 10^{-12} → Pico "P"
* 10^{-9} → nano "n"
* 10^{-6} → micro "μ"
* 10^{-3} → ~~millim~~ milli "m"
* 10^{-2} → centi "c"

Ex : ① 0.000006 m = 6 μm = $6 * 10^{-6}$ m
② 6 mF = $6 * 10^{-3}$ F
③ 7 PF = ~~7~~ $10^{-12} * 7$ F

* Prefixes :-

* 10^{-12} :- tera "T" * 10^{6} : Mega " M "
* 10^{9} : Giga " G " * 10^{3} → kilo " k "

Ex :- ① 10 kN → $10 * 10^{3}$ N
② 5 MΩ → $5 * 10^{6}$ Ω

ooo Charge :-

* type of charge $\xrightarrow{}$ + :- Proton $+1.602 * 10^{-19}$ C
  $\xrightarrow{}$ − :- electron $-1.602 * 10^{-19}$ C

* Unit of charge :- Couloumb " C "

* Charge → DC → Q (+)
  ↳ AC → q (+)

ooo Current :-

↳ time rate of flow of electrical charge through a conductor or circuit element

* $i = \frac{dq}{dt}$ → i = I = current

* unit = Amper = A = $\frac{C}{S}$

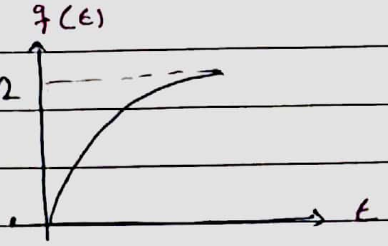
* $\int_{t_0}^{t} i . dt = \int_{t_0}^{t} dq$

$$Q(t) - Q(t_0) = \int_{t_0}^{t} i(t) . dt \quad **$$

Ex:- let $q(t) = \begin{cases} 0, & t < 0 \\ 2-2e^{-100t}, & t > 0 \end{cases}$

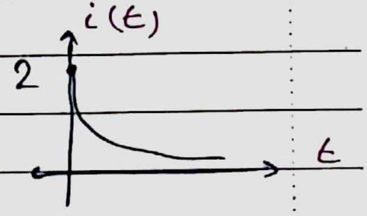
Plot $q(t)$, $i(t)$

Sol:- graph $q(t) \rightarrow$



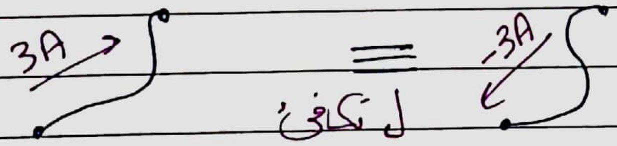
graph $i(t)$:-

① $i(t) = \begin{cases} 0, & t < 0 \\ 200e^{-100t}, & t > 0 \end{cases}$ ②



~ . ~ . ~ . ~ - ~ .

* Current is a vector quantity [magnitude, direction]



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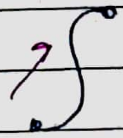
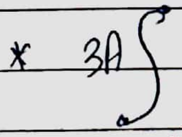


not current

*



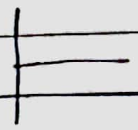
not current

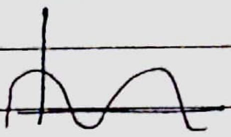
لازم يكون
اتجاه ومقدار

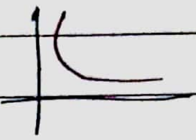
* type of current :-

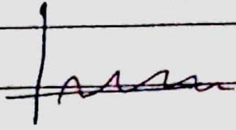
1 DC 2 AC 3 exp 4 damping

ثابت









1/3

ooo Voltage :

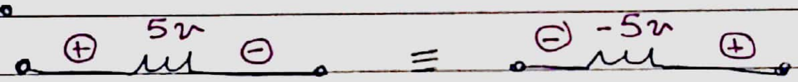
is a measure of work required to move charge through element

* Unit = Volt = V = $\mathcal{V}$

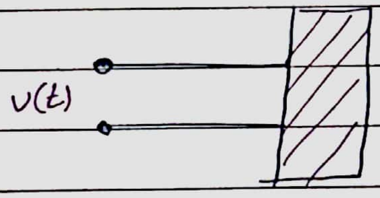
** Note :

Voltage can exist between pair of electrical terminal whether a current is flowing or not.

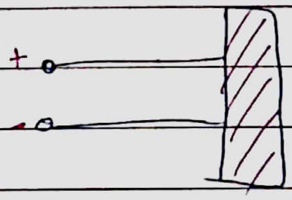
→ Voltage is a vector quantity → magnitude
↳ Polarity ±



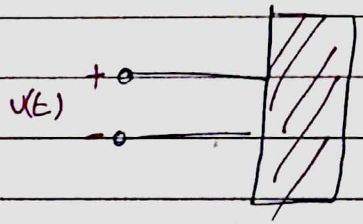
* Voltage :



✗ not voltage



✗ not voltage



Voltage ✓

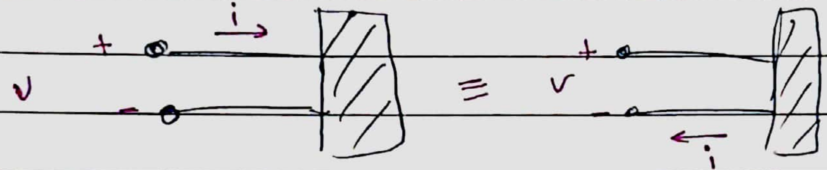
1/3

∞ Power :-

* Unit = Watts
* $P = VI$
watt = Volt * Amper

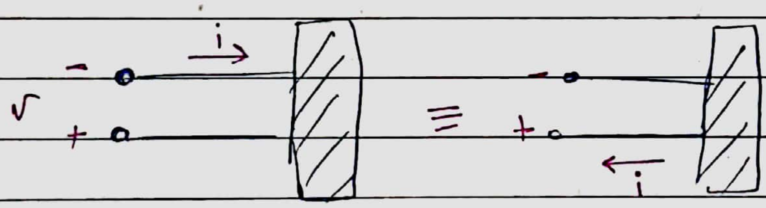
** Passiv sign convention :-

① if +ve current etering +ve terminal of element then power is Absorbed



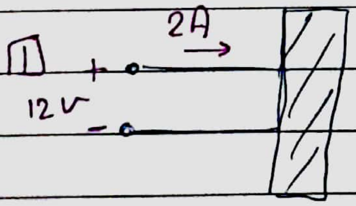
≡ Absorbed

② if + ve current entering in - ve terminal of element then thepower is Supplied.

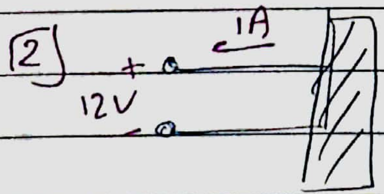


≡ Supplied

↳ Ex :- Find Power :-



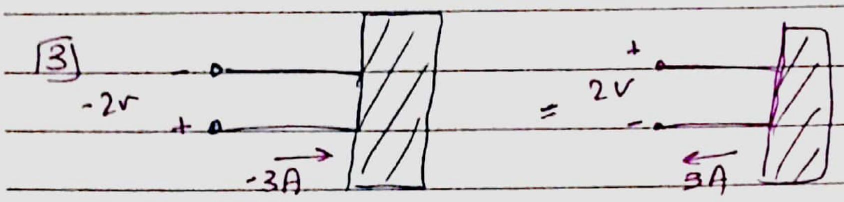
$P = VI = 2 * 12 = 24$ w Absorbed



$P = VI = 12$ w supplied

1/3

$\boxed{3}$



$P = VI \cdot 2 * 3 = 6 W$ Absorbed

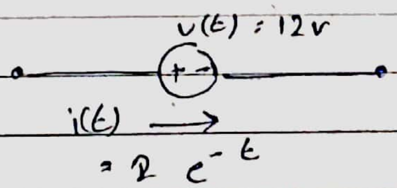
** Note :- $P_{absorbed} = -P_{supplied}$.

Energy :-

$$* \; w(t) = \int_{t_1}^{t_2} P(t) \, dt$$

$$P(t) = v(t) * i(t)$$

ex :-



Find $w(t)$ between $0 \leq t \leq \infty$?

Sol :- $P(t) = v(t) * I(t) = 24 e^{-t}$ watt

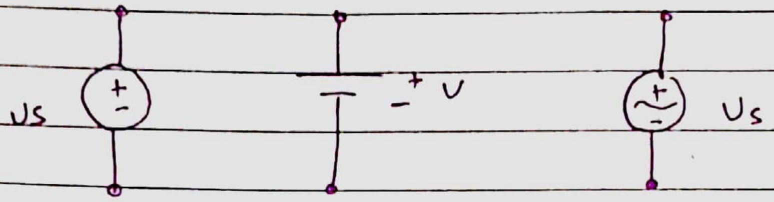
$$w(t) = \int_{0}^{\infty} 24 e^{-t} \, dt = 24 \; J.$$

Sources :-

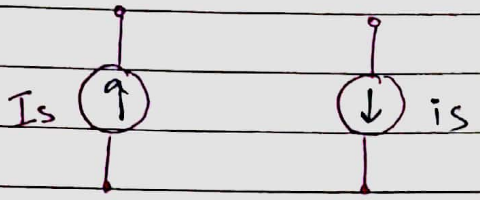
- voltage
  - dep
  - Indep
- current
  - dep
  - indep

3/3

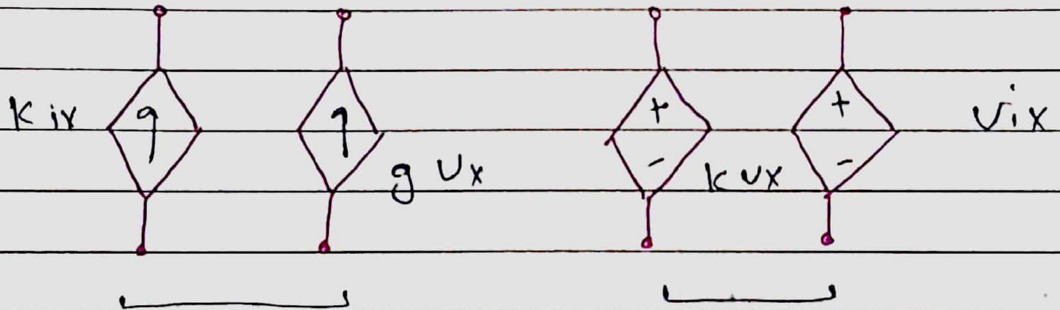
* Indep voltage source :-



* Indep. current source :-



* dependent voltage and current sources :-

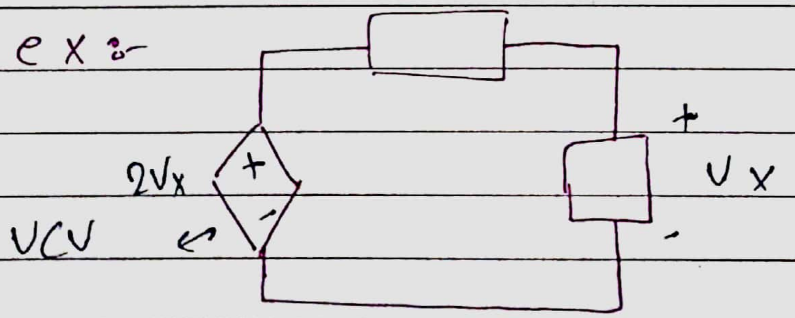


current　　　　voltage

CCC　　VCC　　VCV　　CCV

current control　current　voltage

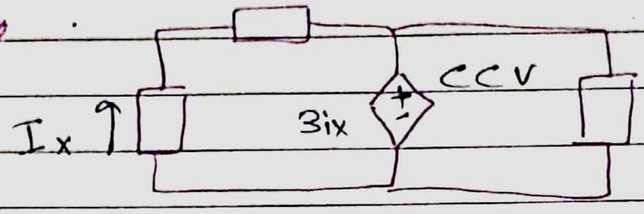
ex :-



$\rightarrow Vx = 1, 2, 3$

$\rightarrow 2Vx = 2, 4, 6$

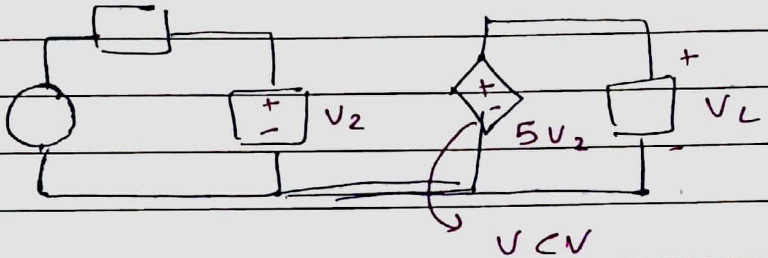
Ex :- let .



$i_x = 1, 2, 3$

$3i_x = 3, 6, 9$

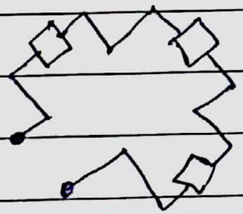
Ex :- let $V_2 = 3V$ find V_L ?



Sol :- $3 * 5 = 15V_2$

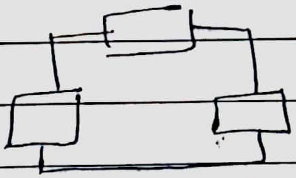
$V_2 = V_L \rightarrow U_L = 15$

000 Network + circuit :-



network.

open path.

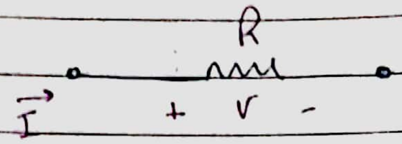


circuit.

close path

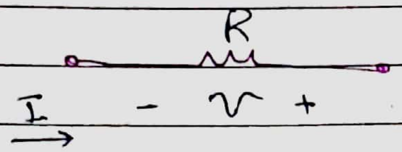
3/3

°°° ohm Law :-



R:- resistor ≡ Ω ≡ ohm
V: voltag = v
I :- current ≡ A

** $\boxed{\oplus\ v = RI}$

(*)


→ $\boxed{\ominus\ v = RI}$

↳ R, L, C → passive element
↳ Sources → active element.

(*) Power ≡ $\boxed{P = vI}$ ①

$P = RI * I = \boxed{I^2 R}$ ②

↳ $P = vI$

$V \cdot \frac{V}{R} = \boxed{\frac{V^2}{R}}$ ③ ☺ ٣ قوانين للقوة

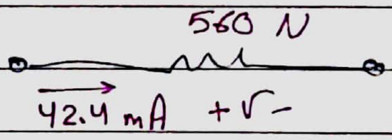
°°° Conductance :-

→ $G = 1/R$

→ Unit → mho

→ $P = vI = v^2 G = \frac{I^2}{G}$

ex: Find Power ?



sol:- $P = vI$

$v = RI = 560 * 42.4 * 10^{-3} = 23.7\ v$

↳ $P = 23.7 * 42.4m = 1.005\ w$ →

chapter 3

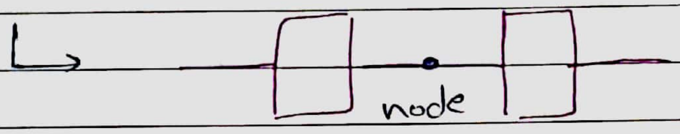
3/3

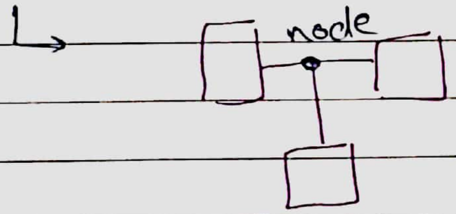
method 2:- $P = I^2R = (42.4 * 10^{-3})^2 * 560 = 1.005w$

((* دائماً المقاومات absorbed))

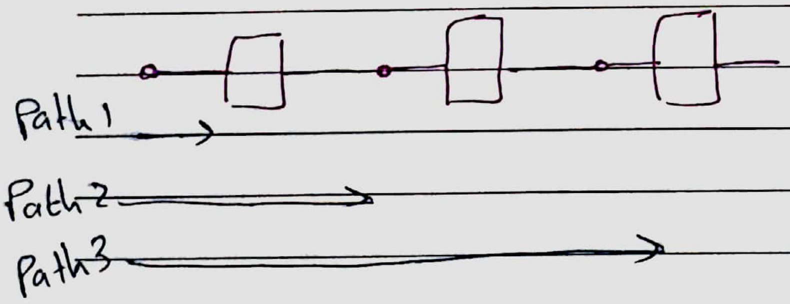
Chapter 3 :- Voltage and current Laws :-

1 node :- a point at which two or more element have a common connection

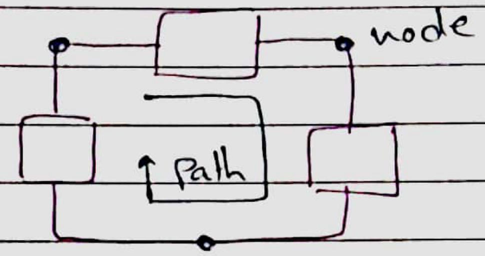




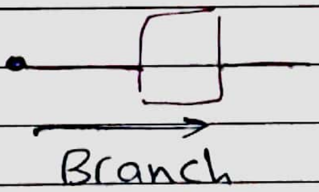
2 path :- a set of node and element that we pass through with out passing through a node more than once



③ Loop :- if the node at which we started is the same as anode on which we end



④ Branch :- consist of one node and one element. «Path حالة خاصة من ال»



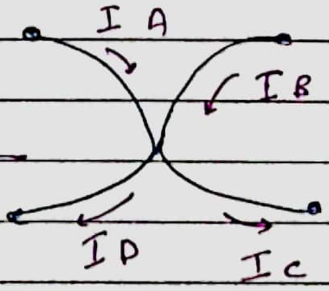
~ . ~ . ~ . ~ . ~

ooo kirchhoff's current law :- (KCL)

مقدار + اتجاه

→ the algebric sum of current entering any node is Zero

$$\hookrightarrow \boxed{\sum_{node} I = 0}$$



التيارات الداخلة = التيارات الخارجة ←

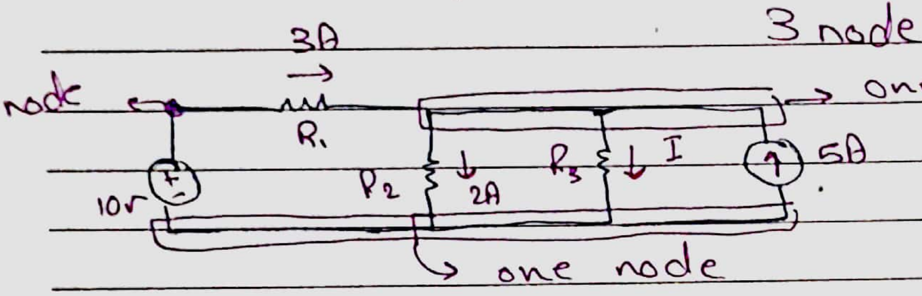
① ✓ $I_A + I_B - I_C - I_D = 0$

② ✓ $-I_A - I_B + I_C + I_D = 0$

دائماً افرض التيارات الخارجة - التيارات الداخلة ☺

Five Apple

ex: find I ?

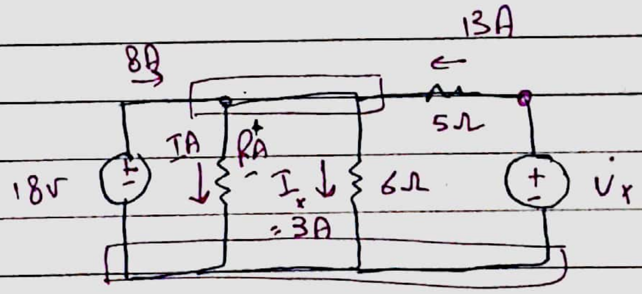


لانه ما في element
بفصل سهم ☺

Using KCl :-

$\rightarrow 3 + 5 = 2 + I \rightarrow I = 6A$

ex:- find R ?



$* \quad + V_A = R_A I_A$

$+ 18 = R_A \, \boxed{I_A} \rightarrow$ using KCl :- $8 + 13 = I_A + 3$

$I_A = 18A$

$\frac{18}{18} = R_A$

$R_A = 1 \, \Omega$

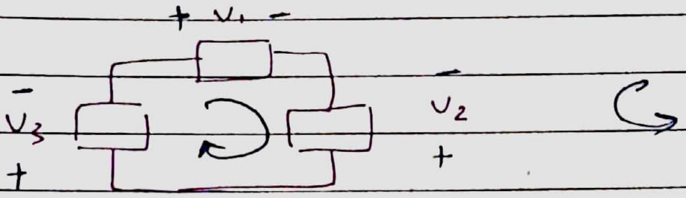
6/13

∘∘∘ Kirchhoffs voltage Law :- «KUL»

↳ the algebraic sum of the voltages around any Loop is Zero

$$\sum_{Loop} V = 0$$

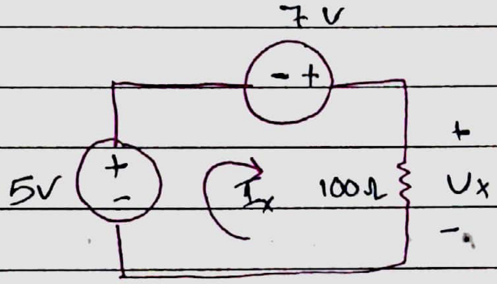
ex :-



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

OR $-V_3 + V_2 - V_1 = 0$

ex :- Find V_x, i_x ?



sol :- ① using the KUL

$-5 - 7 + V_x = 0$

$V_x = 12V$ *

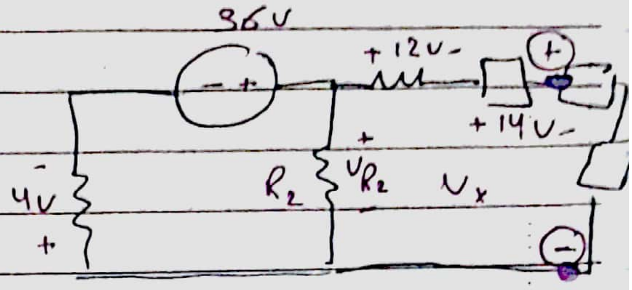
② using the ohm Law :-

$+V_x = R I_x$

$12 = 100 * I_x$

$I_x = 120 mA$ *

Ex: Find V_{R_2}, V_x ?



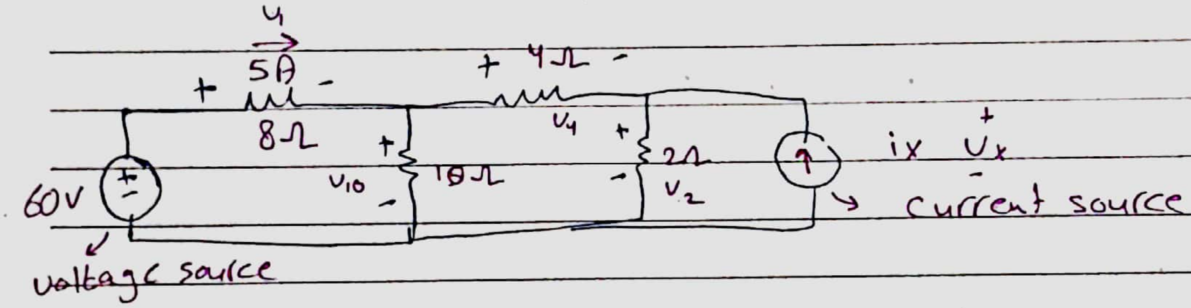
Sol:- ① Using KVL :-

$$4 - 36 + V_{R_2} = 0$$
$$V_{R_2} = 32V$$

② using KVL :-

$$+4 - 36 + 12 + 14 + V_x = 0$$
$$V_x = 6V$$

Ex:- Find V_x, I_x P!



→ ① + $V_1 = 8 * 5 = 40V$

→ ② Using the KVL on loop:-

$$-60 + 40 + V_{10} = 0$$
$$V_{10} = 20v$$

⑤ $V_4 = 4 I_4 = 12V$

⑥ using KVL :-

$$-V_{10} + V_4 + V_2 = 0$$
$$V_2 = 8V$$
$$V_x = 8V$$

→ ③ + $V_{10} = 10 * I_{10} \rightarrow \boxed{I_{10} = 2A}$

KCL

→ ④ Using the ~~KVL~~ on Loop:-

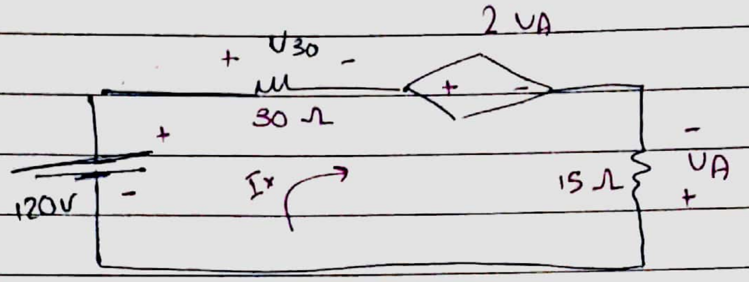
$$5 = I_4 + I_{10}$$
$$I_4 = 3A$$

⑦ $I_2 = \frac{V_2}{2} = 4A$

⑧ $I_4 + I_x = I_2$

$$I_x = 1A$$

Ex :- Find the power on each element :-



Using the KVL :

* $-120 + V_{30} + 2V_A - V_A = 0$

$-120 + 30\underline{I_x + V_A} = 0$

$-120 + 30I_x - 15I_x = 0 \rightarrow I_x = 8A$

* $-V_A = 15I_x \rightarrow \underline{V_A = -15I_x}$

① $P_{120} = VI = 120 * 8 = 960W$ supplied

= - 960 w absorbed.

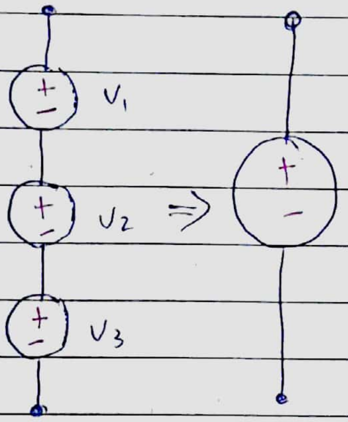
② $P_{30} = I^2R = 8^2 * 30 = 1920$ w absorbed

③ $P_{2VA} = VI = 8 * 2 * -15 * 8 = -1920$ w absorbed.

④ $P_{15} = I^2R = 8^2 * 15 = 960$ w absorbed.

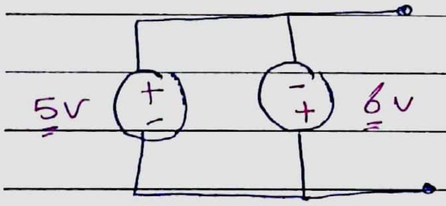
8/13

Series and Parallel connected Sources :-



$V_t = V_1 + V_2 + V_3$

* ((Voltage in Series))

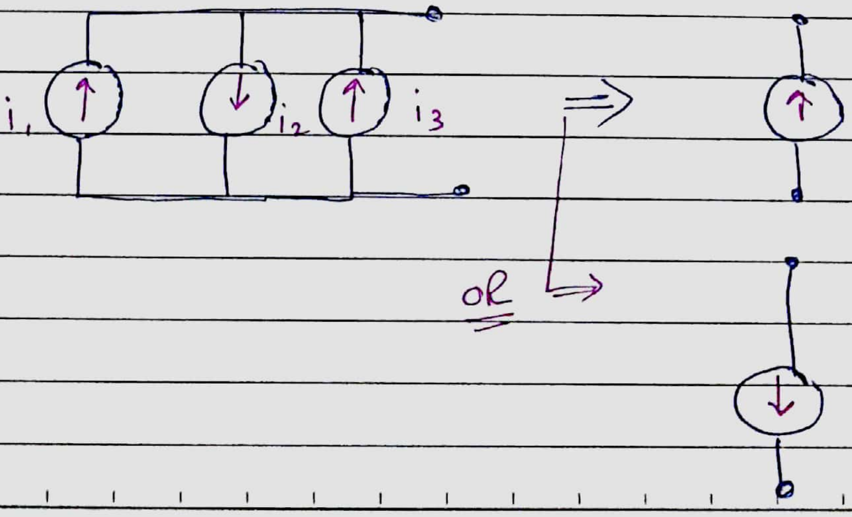


✗

ما بقدر اجمعهم لأنه
الفولتية مختلفة

* ((Voltage in ~~Se~~ Parallel

* current in parallel :-

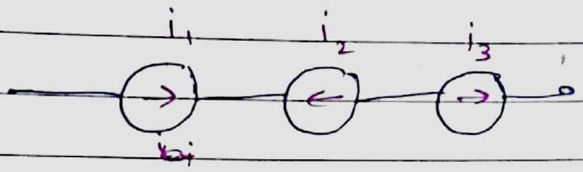


$I_t = i_1 - i_2 + i_3$

$I_t = (-i_1) + i_2 + (-i_3)$

8/13

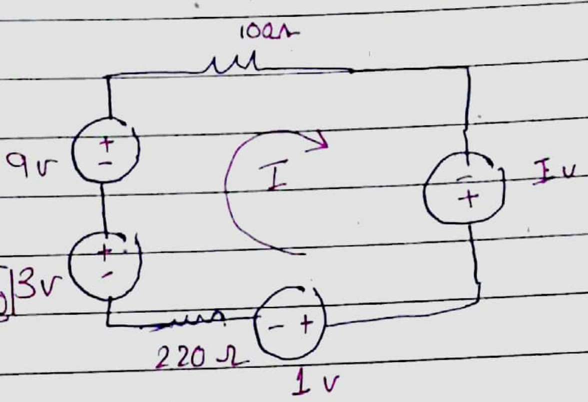
⊛ Current in Series :-



ما بقدر احطهم
بنفس الـ element ✗
لانه التيارات مختلفة ☹

ex : Find I ?

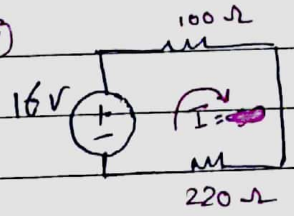
sol :-



$$\boxed{100 I - 5 + 220 I - 3 - 9 = 0}$$

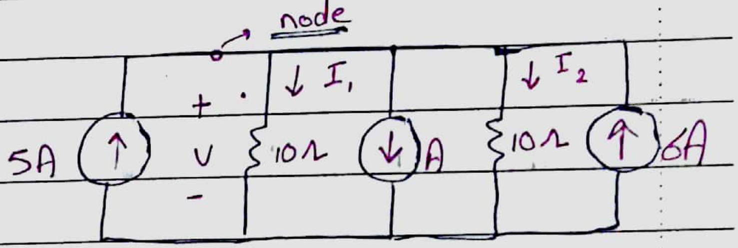
$\to$ $I' = 50 \text{ mA}$

⊛



$$\left.\begin{aligned} 100 I + 220 I - 16 &= 0 \\ I &= 50 \text{ mA} \end{aligned}\right]$$ الطريقة الأسهل

ex :- Find V ?

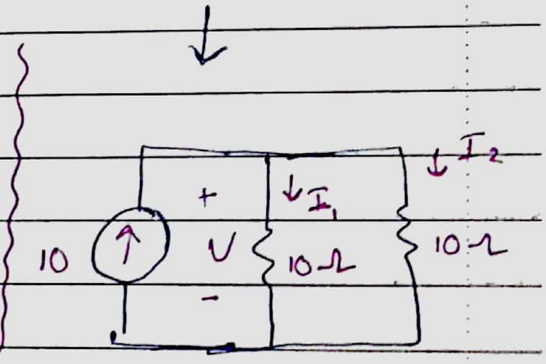


sol :- using KCL :-

$5 + 6 = 1 + I_1 + I_2$

$10 = I_1 + I_2$

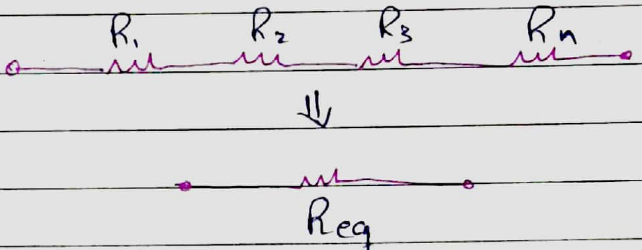
$\frac{V}{10} + \frac{V}{10} \rightarrow V = 50V$



$10 = I_1 + I_2 \rightarrow V = 50V$

8/3

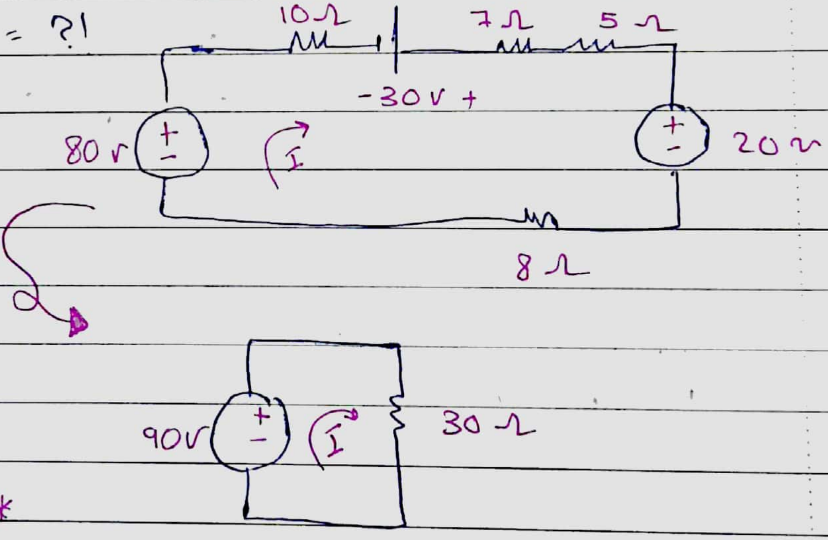
Resistor in series and parallel



$$Req = R_1 + R_2 + R_3 + \dots + R_n$$

→ Resistor in series

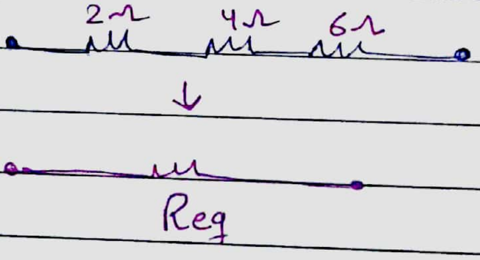
ex:- Find I = ?!



$-90 + 30I = 0$

$I = 3A$ *

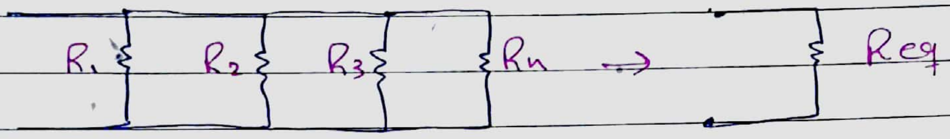
ex:- Find Req ?!



$Req = 2 + 4 + 6 = 12\ \Omega$

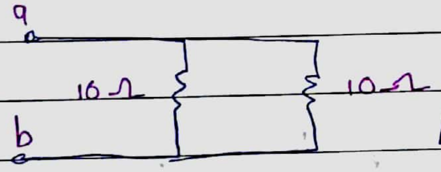
8/3

⊛ Resistor in Parallel :-



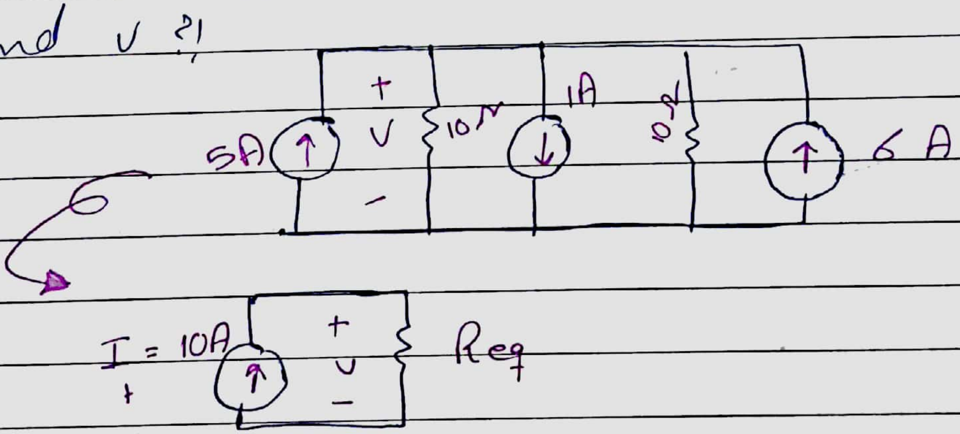
$$\therefore \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$$

ex :- Find Req ?



Sol :- $\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{10} = 5\Omega$

ex :- Find v ?!



$\therefore I_t = 5 - 1 + 6 = 10\,A$

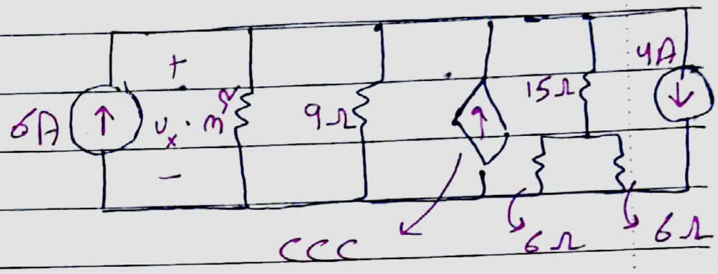
$\therefore R_{eq} = \frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{10} = 5\,\Omega$

8/3

ex: Find the power in the dep. source:

$R_{eq} = [6 \parallel 6] + 15$ ①

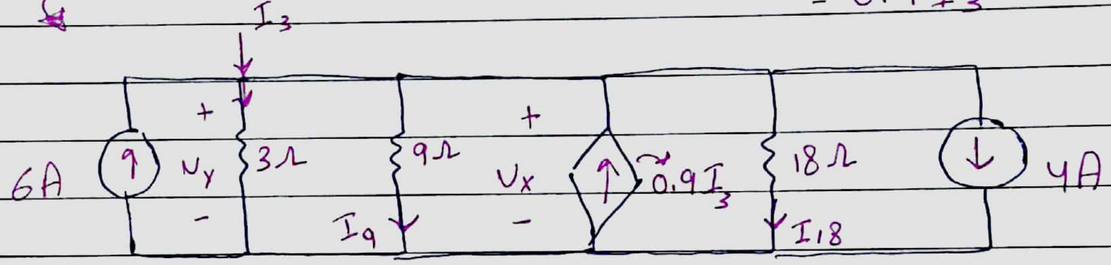
$= 18\ \Omega$



ccc

$= 0.9 I_3$

②



$P_{dep.source} = V I$

$= [V_x * 0.9 I_3] \qquad I_3 = \frac{V_x}{3}$

$P = 0.3 V_x^2$

∴ Using KCL:-

$6 + 0.9 I_3 = I_3 + I_9 + I_{18} + 4$

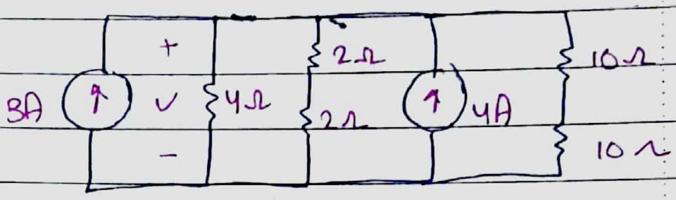
$2 = 0.1 \left[\frac{V_x}{3}\right] + \left[\frac{V_x}{9} + \frac{V_x}{18}\right]$

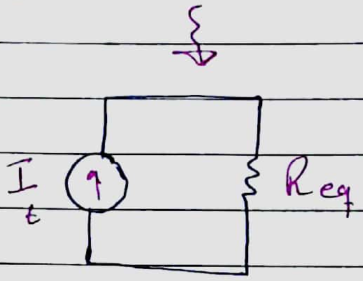
$V_x = 10\ V$

$P = 0.3 V^2 x = 0.3 * (10)^2 = 30\ W$ supplied

8/3

ex :- Find v ?





$I_t = 3 + 4 = 7A$

$R_{eq} = (2+2) // (10+10) // 4$

$4 // 20 // 4$

$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{20} + \frac{1}{4}$

$R_{eq} = 1.818$

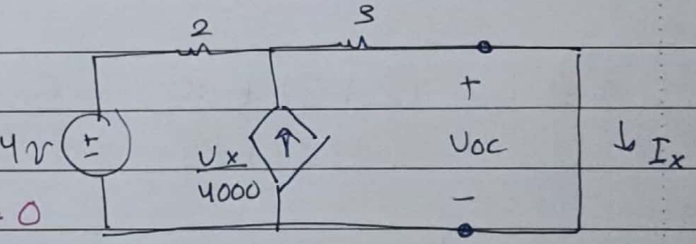
⊛ $V = RI = 1.818 * 7 \approx 14$ volt.

31/3

* case 2:- dep + indep. current and voltage source in the complex network.

* $V_{th} = V_{oc}$
* $I_n = I_{sc}$
* $R_{th} = \frac{V_{oc}}{I_{sc}}$

→ ex:- Find thevenin and Norton :-



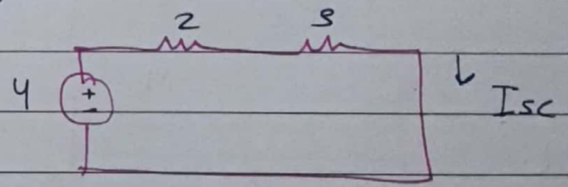
→ sol :-

$V_{oc} = V_x$

$= -4 + 2\left[\frac{-V_x}{4000}\right] + V_x = 0$

$V_x = 8v$ #

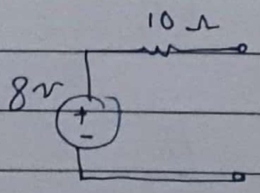
ce →



→ $-4 + 2I_{sc} + 3I_{sc} = 0$

$I_{sc} = 0.8mA$

→ $R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{8}{0.8} = 10\ \Omega$



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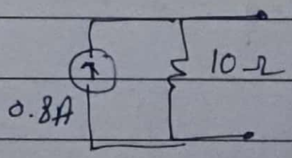


7/4

⊛ Case 3 :-

only dep. source in the complex network.

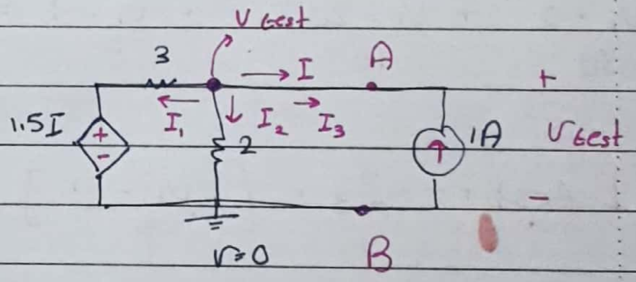
→ Assume :- $I_{test} = 1A$ / $V_{test} = 1V$

→ Find :- $V_{test} = ?!$ / $I_{test} = ?$

$$\underbrace{V_{test} = ?!}_{\downarrow} \qquad \underbrace{I_{test} = ?}_{\downarrow}$$

$R_{Th} = \dfrac{V_{test}}{I_{test}}$ $\qquad R_{th} = \dfrac{V_{test}}{I_{test}}$

ex :- Find thevenin :-



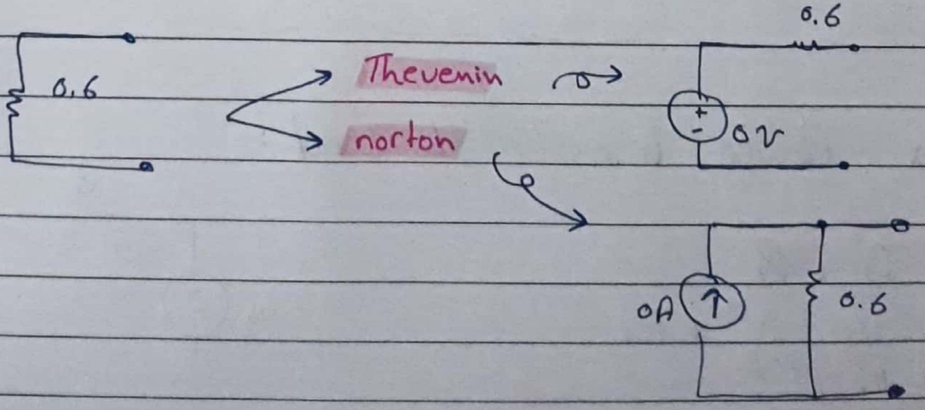
sol :-

$R_{Th} = \dfrac{V_{test}}{I_{test}} = \dfrac{V_{test}}{1}$

$\boxed{I = -1}$ #

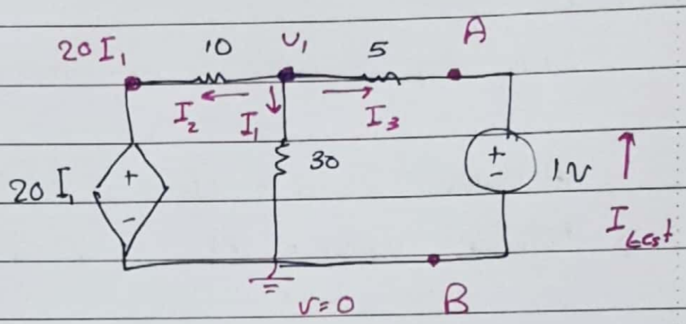
→ $I_1 + I_2 + I_3 = 0$

$\dfrac{V_{test} - 1.5I}{3} + \dfrac{V_{test}}{2} - 1 = 0 \rightsquigarrow V_{test} = 0.6v.$



7/4

ex:- Find thevenin :-



Sol :-

$* R_{th} = \frac{V_{test}}{I_{test}} = \frac{1}{I_{test}}$

$* -I_1 + I_2 + I_3 = 0$

$\frac{V_1 - 0}{30} + \frac{V_1 - 20 I_1}{10} + \frac{V_1 - 1}{5} = 0 \rightsquigarrow V_1 = 30 I_1$

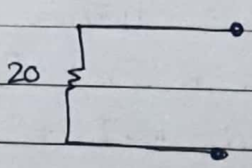
$V_1 = 0.75 V.$

$* I_{test} = -I_3 = \left[\frac{V_1 - 1}{5}\right] = 50 mA$

↳ $R_{th} = \frac{1}{50} = 20 \Omega$

thevenin

norton.



$\circledast$ Max. Power transfer to Load :-

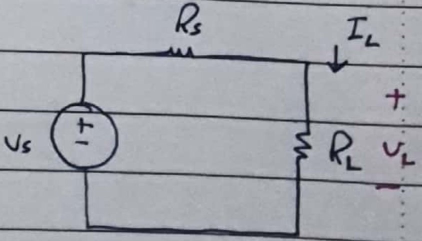
$P = I_L^2 * R_L$

$\left(\frac{V_s}{R_L + R_s}\right)^2 * R_L$

$\rightsquigarrow \frac{dP}{dR_L} = 0 \rightsquigarrow \boxed{R_s = R_L}$ #

↳ max. Power

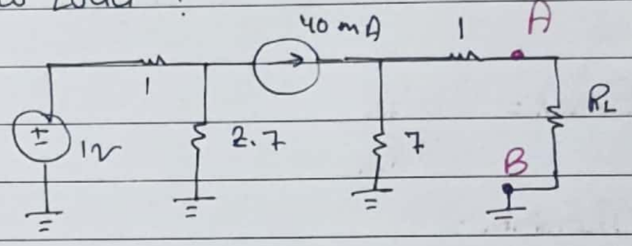
لما يتساووا.



7/4.

$$P_{max} = \frac{v_s^2}{4R_s} = \frac{v_{th}^2}{4R_{th}}$$

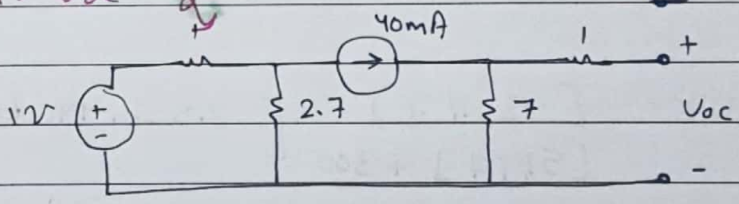
ex:- Find Power max to Load ?



sol :- $P_{max} = \frac{v_{th}^2}{4R_{th}}$

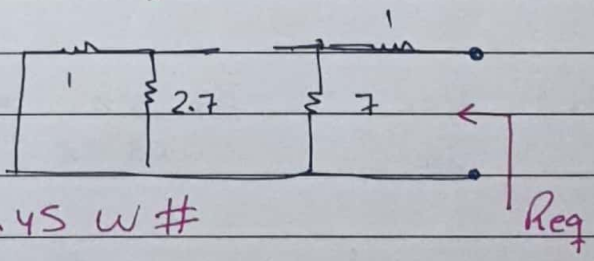
→ ~~threvelixi~~ thevenin :-

$v_{th} = V_{oc}$



$V_{oc} = 7 * 40 = 280\ v$

$R_{th} = R_{eq}$ after killing all source

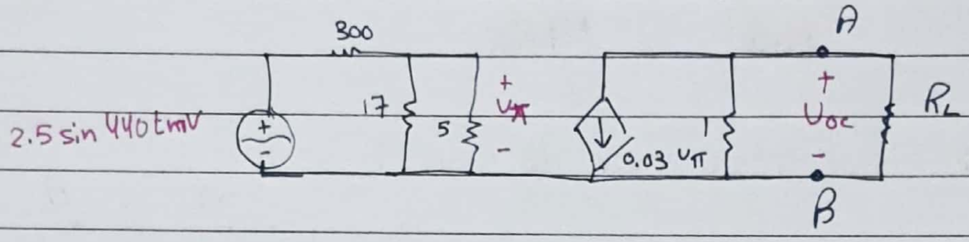


$R_{eq} = 1 + 7 = 8\ \Omega$

$$\therefore P_{max} = \frac{(280)^2}{4(8)} = 2.45\ w\ \#$$

7/4

ex:- Find Max Power transfer:-



$$P_{max} = \frac{V_{th}^2}{4R_{th}}$$

Thevenin :-

$V_{th} = V_{oc}$

$$\hookrightarrow [-0.03 v_\pi][1] = -30 v_\pi$$

$$v_\pi = \frac{[5 \parallel 17]}{[5 \parallel 17] + 300} \left[2.5 \sin 440 t m \right] = \_\_ v$$

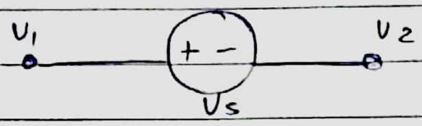
$$I_{sc} = -0.03 v_\pi$$

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{-30 v_\pi}{-0.03 v_\pi} = 1 \Omega$$

$$P_{max} = \frac{v_{th}^2}{4R_{th}} = 1.211 \sin^2 440 t \, \mu W.$$

2013

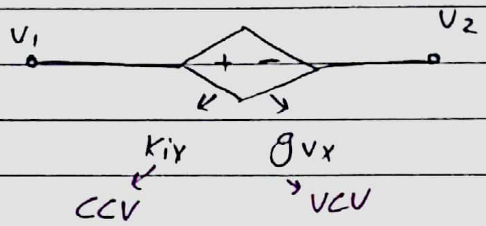
* Super node :-



independent

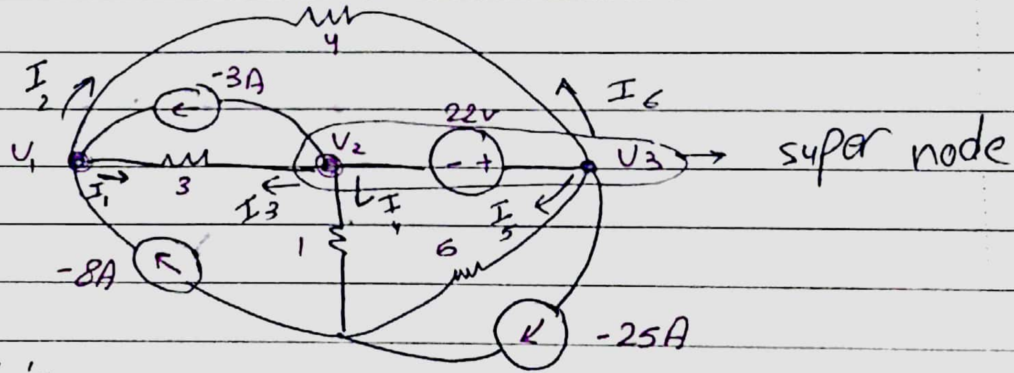
معادلتين

① KCl ② ~~supernode~~ voltage source



dependent

ex:-
Find V_1, V_2, V_3:-



Sol:-

at node 1 :-

$$-3 - 8 = I_1 + I_2$$

$$-11 = \frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{4} \quad --- ①$$

~~at node 2:~~

at node "supenode" :- (node 2 + node 3)

$$-3 + I_3 + I_4 + I_5 + I_6 + (-25) = 0$$

$$-3 + \frac{V_2 - V_1}{3} + \frac{V_2 - 0}{1} + \frac{V_3 - 0}{5} + \frac{V_3 - V_1}{4} - 25 = 0 \; ②$$

$$\rightarrow \; -V_2 + V_3 = 22 \quad --- ③$$

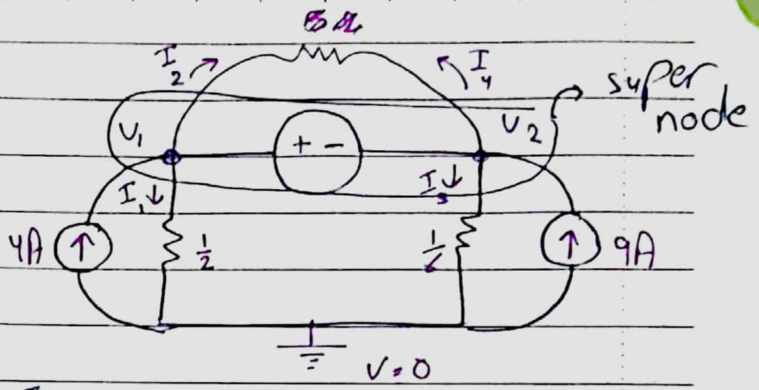
$V_1 = 1.071 V$

$V_2 = \square$ V

$V_3 = \square$ V

2013

ex:- Find V_1, V_2 ?



sol:-

→ at super node:-

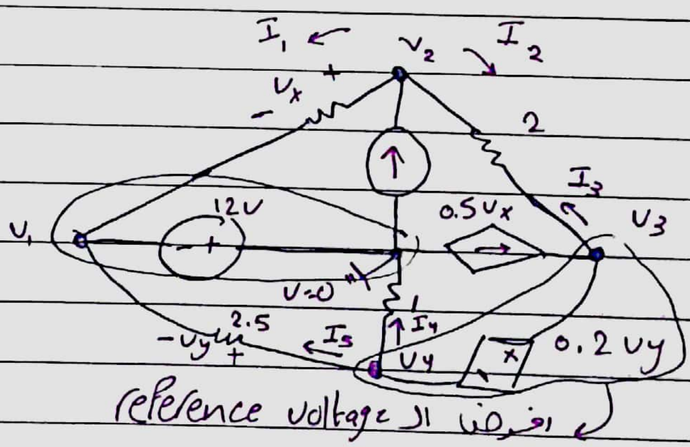
$$4+9 = I_1 + I_2 + I_3 + I_4$$

$$13 = \frac{V_1 - 0}{1/2} + \frac{V_1 - V_2}{1/3} + \frac{V_2 - 0}{1/6} + \frac{V_2 - V_1}{1/3} \quad -- ①$$

$$\rightsquigarrow + V_1 - V_2 = 5 \quad --- ②$$

$$\rightsquigarrow \# \quad V_1 = 5.375\,V \;, \quad V_2 = 375\,mV$$

ex:-



افرض ال reference voltage

((بالطرف لا الأوَّل عند المصدر))

at super node:-

$$-V_1 + 0 = 12$$

$$V_1 = -12\,V \quad --- ①$$

at node 2:-

$$I_1 + I_2 = 14$$

$$\frac{V_2 - V_1}{0.5} + \frac{V_2 - V_3}{2} = 14 \quad --- ②$$

at super node:-

$$0.5\,V_x = I_3 + I_4 + I_5$$

$$0.5\,V_x = \frac{V_3 - V_2}{2} + \frac{V_4 - 0}{1} + \frac{V_4 - V_1}{2.5} \quad ③ \rightarrow \boxed{V_4 - V_3 = 0.2V_y} \quad --- ③$$

→ ~~$-V_4 + V_3$~~

$\rightsquigarrow$ next

2013

$+V_2 - V_1 = V_x$

$+V_4 - V_1 = V_y$

$-V_4 + V_3 = 0.2V_y$

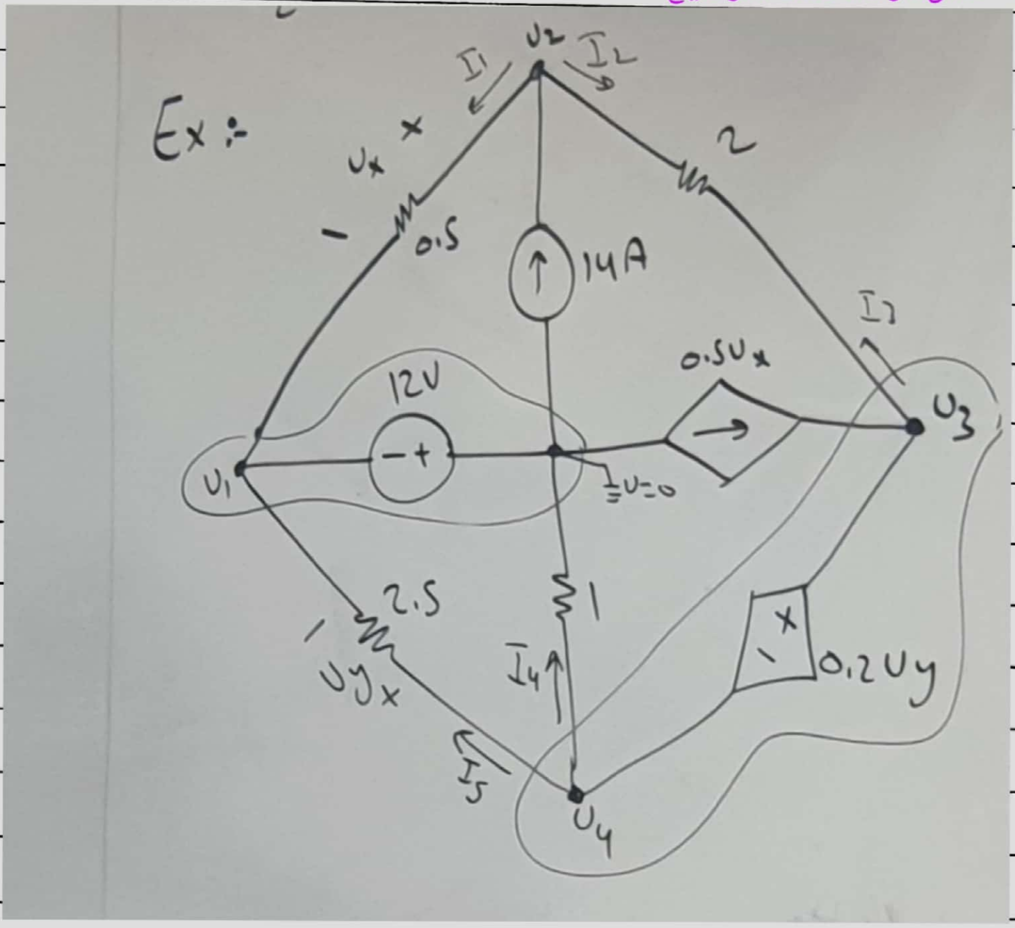
$\rightarrow V_1 = -12V,\ V_2 = -4V,\ V_3 = 0V,\ V_y = -2V$

$V_x = V_2 - V_1 = -4 + 12 = 8V$

$V_y = V_4 - V_1 = -2 + 12 = 10V$

* reference voltage ← بالعادة افرضه رحتي بس لو كانت الدارة معقدة جدا افرضه بالنص #

نفس الرسمه فقط للتوضيح



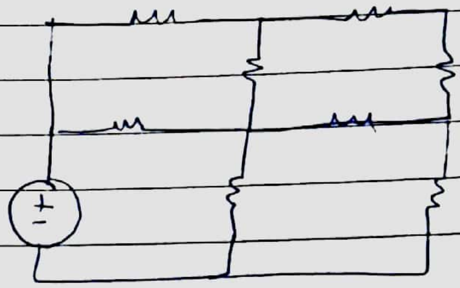
Five Apple

24/3

* mesh - cullent analysis :-

~> mesh analysis is applicable only to planer circuit

* planer circuit *



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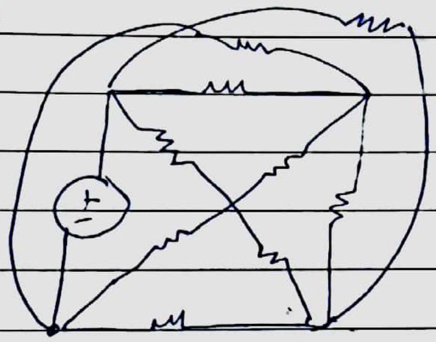
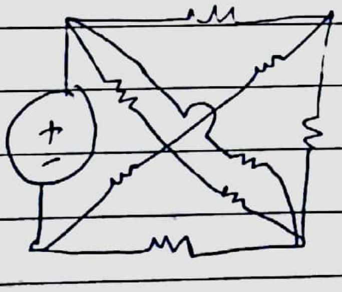


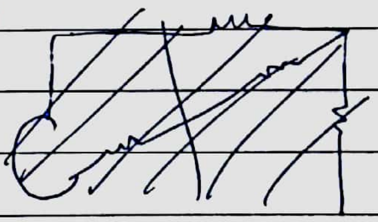
non planer circuit *

*



planer

*



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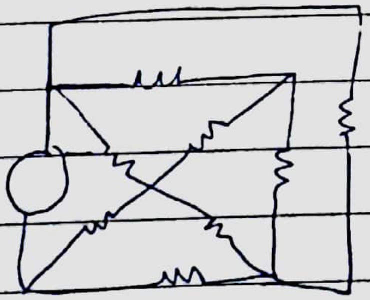


Planer

بالامتحان رح يجي بس

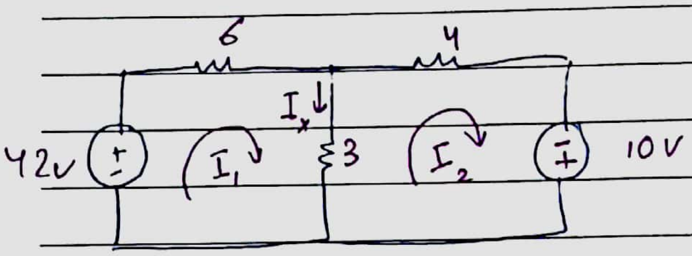
Planer ☺

24/3

* mesh analysis :-

① assume current on each loop.
② apply ~~KVL~~ KUL

* → Find I_1, I_2 ?



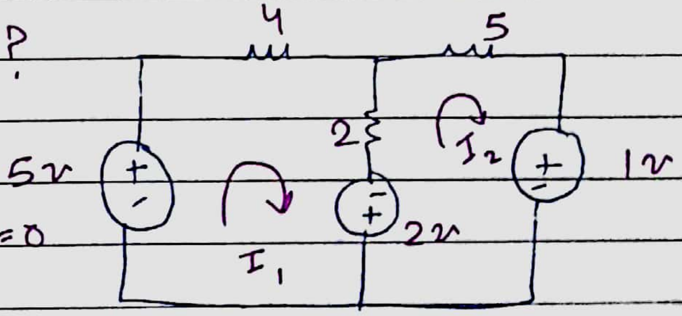
→ $I_x = I_1 - I_2$

at loop 1 :- $-42 + 6I_1 + 3I_x = 0$ ---①

at loop 2 :- $-3I_x + 4I_2 - 10 = 0$ ---②

→ $I_1 = 6A$ $\quad I_2 = 4A$

* → Find I_1, I_2 ?



at loop 1 :-
$-5 + 4I_1 + 2[I_1 - I_2] - 2 = 0$

at loop 2 :- $2 + 2[I_2 - I_1] + 5I_2 + 1 = 0$

→ $I_1 = 1.132\ A$ $\quad I_2 = -0.1053A.$

24/3

* $P_{2\Omega} = I_x^2 (2)$

$(I_1 - I_2)^2 * 2 = 2.474$ w absorbed

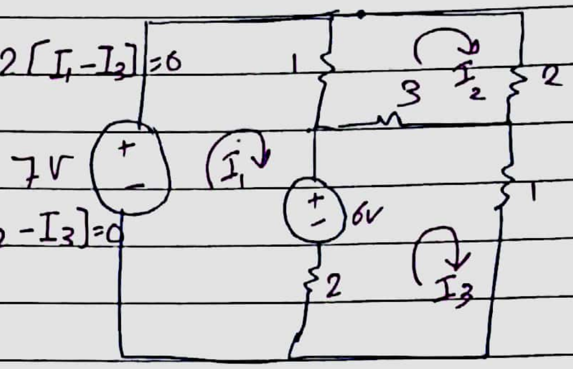
* ex ⟶ Find I_1, I_2, I_3?

at Loop1:-

$-7 + 1[I_1 - I_2] + 6 + 2[I_1 - I_3] = 0$

at Loop 2!-

$[I_2 - I_1] + 2I_2 + 3[I_2 - I_3] = 0$



at loop 3!-

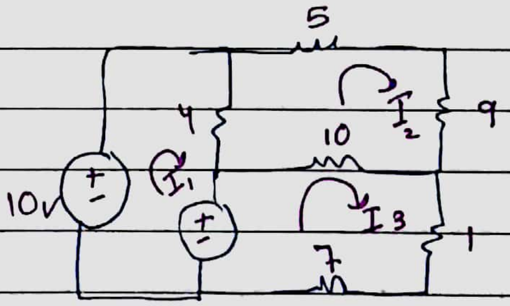
$2[I_3 - I_1] - 6 + 3[I_3 - I_2] + I_3 = 0.$

⟶ $I = 3A$ $I_2 = 2A$ $I_3 = 3A$ #

* ex ⟶ Find I_1, I_2, I_3 ?

at loop1!.

$10 + 4[I_1 - I_2] + 3 = 0$



at loop 2!-

$4[I_2 - I_1] + 5I_2 + 9I_2$

$+ 10[I_2 - I_3] = 0$

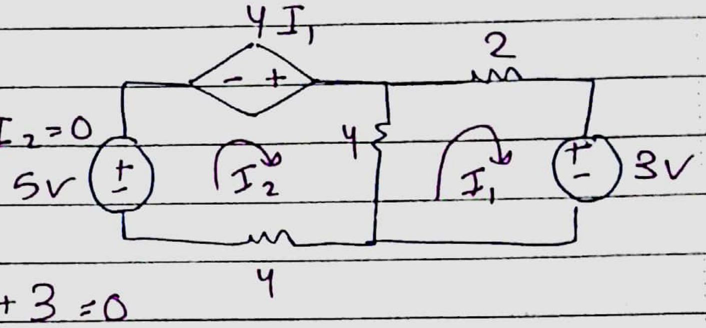
at loop3:-

$-3 + 10[I_3 - I_2] + I_3 + 7I_3 = 0$

⟶ $I_1 = 2.22A$, $I_2 = 470mA$ $I_3 =$ ___ A

24/3

→ Find I_1, I_2 ?



at loop1 :-

$-5+(-4I_1)+4[I_2-I_1]+4I_2=0$

at loop2 :-

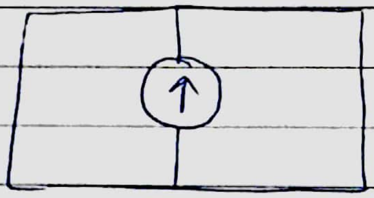
$4[I_1-I_2]+2I_1+3=0$

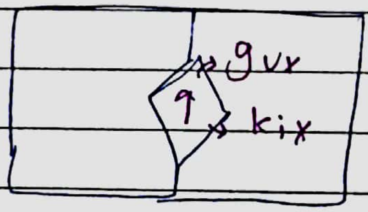
→ $I_1 = -250\ mA$ → $I_2 = 375mA$

Supper Mesh :-

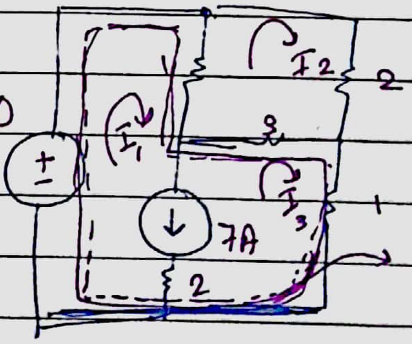
معادلة من KVL

معادلة من التيار نفسه





ex:- Find current :-



يعتبرهم قطعة واحدة.

at supper mesh :-

① $-7+[I_1-I_2]+3[I_3-I_2]+I_3=0$

② $I_1 - I_3 = 7$

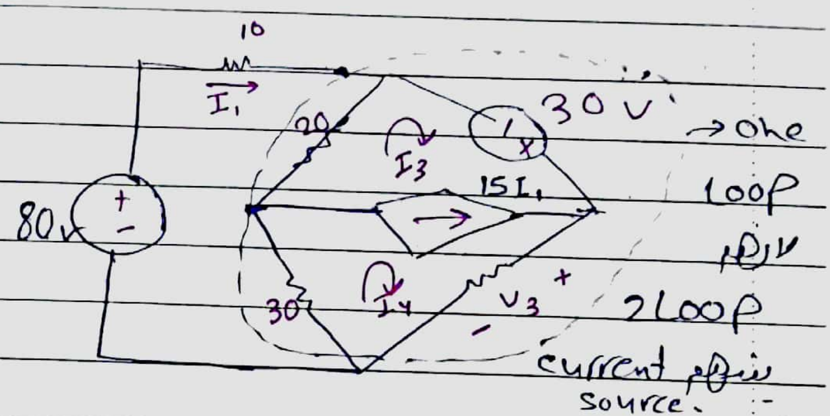
at loop2 :-

$[I_2-I_1]+2I_2+3[I_2-I_3]=0$

→ $I_1 = 9\ A$ → $I_2 = 2.5A$ → $I_3 = 2A$

27/3

Ex :- Find V_3 = ?!



$+V_3 = 40I_4$

$V_3 = 40I_4$

at Loop 1:-

$$-80 + 10I_1 + 20[I_1 - I_3] + 30[I_1 - I_4] = 0 \text{ — } ①$$

at super mesh:-

→ $20[I_3 - I_1] - 30 + 40I_4 + 30[I_4 - I_1] = 0$ --- ②

→ $I_4 - I_3 = 15I_1$ --- ③

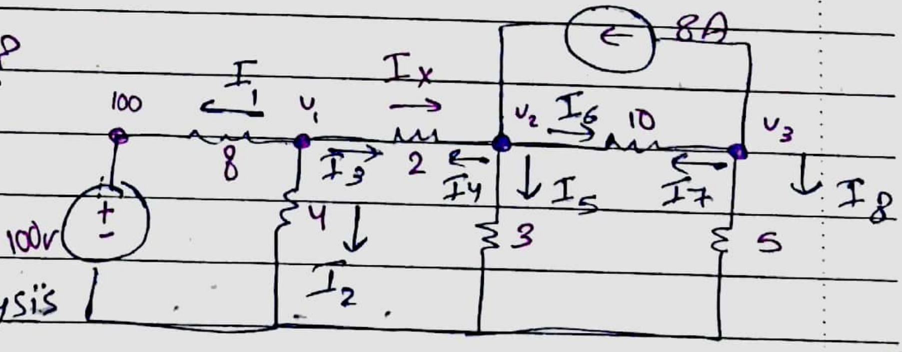
→ Final ans:- $I_1 = 0.584$ A

$I_3 = -6.15$ A

$I_4 = 2.605$ A

$V_3 = 40I_4 = 104.20$ v.

ex :- find I_x ?



sol :-

using nodal analysis

at node 1:- $I_1 + I_2 + I_3 = 0$ → $\boxed{\frac{V_1 - 100}{8} + \frac{V_1 - 0}{4} + \frac{V_1 - V_2}{2} = 0}$ ①

27/3

at node 2 :-

$8 = I_4 + I_5 + I_6$

↳ $8 = \frac{V_2 - V_1}{2} + \frac{V_2 - 0}{3} + \frac{V_2 - V_3}{10}$ -- ②

at node 3 :-

$8 + I_7 + I_8 = 0$

$8 + \frac{V_3 - V_2}{10} + \frac{V_3 - 0}{5} = 0$ --- ③

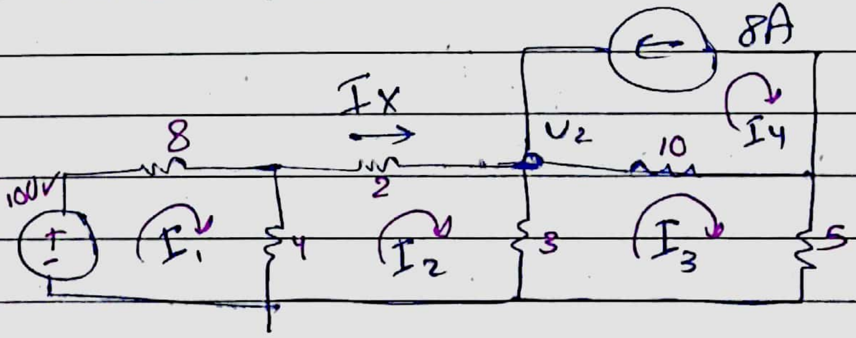
→ Final ans :-

$V_1 = 25,89V$ / $V_2 = 20.31V$ / $V_3 = \square V$ ...

$I_x = \frac{V_1 - V_2}{2} = 2,79 A$

(الذيل - الرأس)

Method 2 :- Using mesh analysis.



at loop 1 :- $-100 + 8I_1 + 4[I_1 - I_2] = 0$ -- ①

27/3

at loop 2:- $4[I_2 - I_1] + 2I_2 + 3[I_2 - I_3] = 0$ .. ②

at loop 3:- $3[I_3 - I_2] + 10[I_3 - I_4] + 5I_3 = 0$ .. ③

→ Final ans :- $I_4 = -8$ // $I_x = 2,79A$ / $I_1 = 0A$ ...
$I_2 = 2.79A$ / $I_3 = 0A$

→ * لو طالب فولتية ← استخدم nodal
+ لو طالب تيار ← استخدم mesh.

first

Second (CH5+CH6

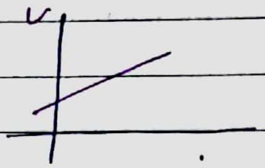
CH5
27/3

* CH5:-

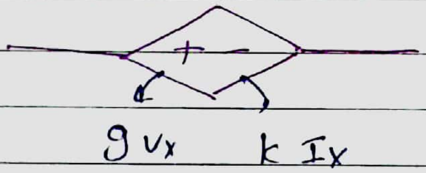
① Linear. element and Linear circuit

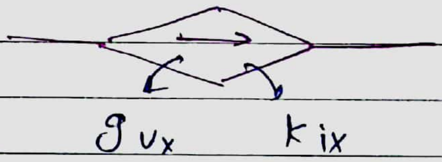
ⓐ linear element:- element that has Linear voltage - current relation

$v(t) = R\,i(t)$



ⓑ linear dep source:- is dep. voltage or current ~~voltage~~ source whose out put current or voltage is ~~Proportional to~~ First power of current or voltage. ↳ Proportional to.





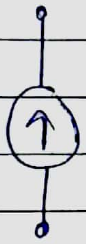
ⓒ linear circuit:- the circuit that composed of: ① indp. source ② dep. linear source
③ linear. element

⊛ Super Position:- the response in a linear circuit having more than one indp. source can be obtained by adding the responses caused by the seperat indep source acting alone.

27/3

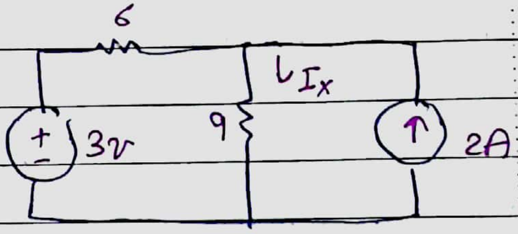
→  Ø V =  S.C

لو بدي اقتل الفولتية رح تصير short circuit.

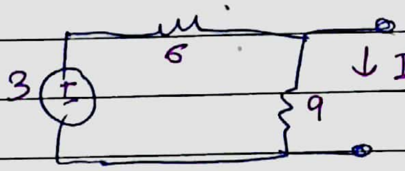
→  Ø A =  O.C "open circuit"

ex :- Find I_x using supper position :-

$I_{x\,tot} = I_x \downarrow_{3v} + I_x \downarrow_{2A}$



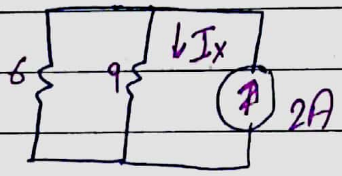
→ *$I_x \downarrow_{3v}$ $\overset{o}{\underset{o}{\rightarrow}}$



$-3 + 6I_x + 9I_x = 0$

$I_x = 0.2A.$

→ $I_x \downarrow_{2A}$ 8-



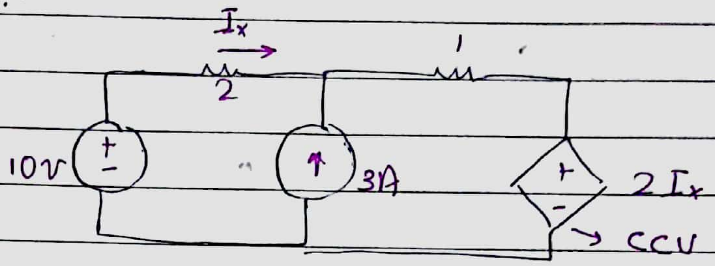
$$I_x = \frac{\frac{1}{9}}{\frac{1}{6}+\frac{1}{9}} * [2] = 0.8A$$

→ $I_{x\,tot} = 0.2 + 0.8 = 1A$

29/3

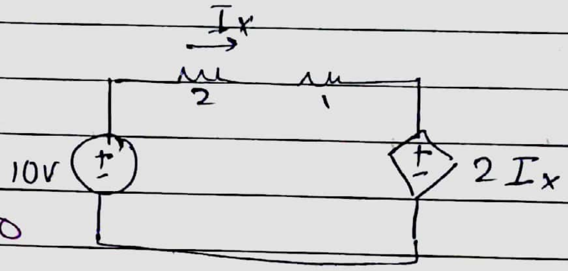
* Super Position :-

ex → Find I_x ?



Sol:- $I_x\downarrow_{tot} = I_x\downarrow_{10v} + I_x\downarrow_{3A}$

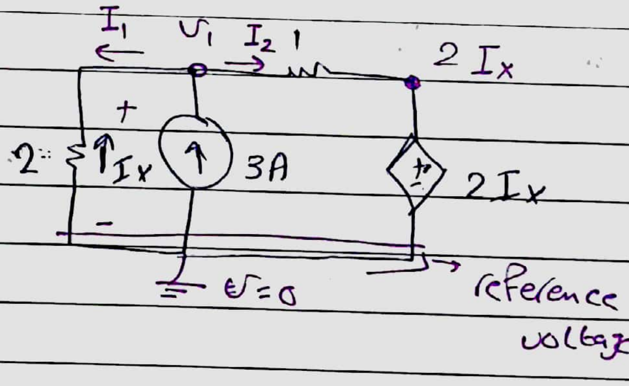
→ $I_x\downarrow_{10v} =$



$-10 + 2I_x + 1I_x + 2I_x = 0$

$I_x = 2A$

→ $I_x\downarrow_{3A} =$



nodal analysis

$3 = I_1 + I_2$

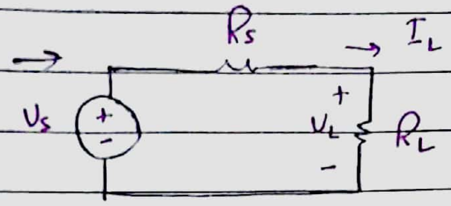
$3 = \frac{v_1 - 0}{2} + \frac{v_1 - 2I_x}{1}$

→ $-v_1 = 2I_x$

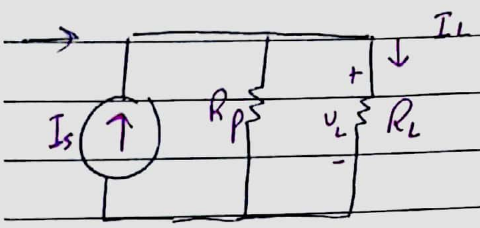
→ Final ans :- $I_x = -6.6A$ / $I_x\downarrow_{tot} = 1.4\ A$

29/3

⊛ Source transformation:- (source ⇄ current / voltage)



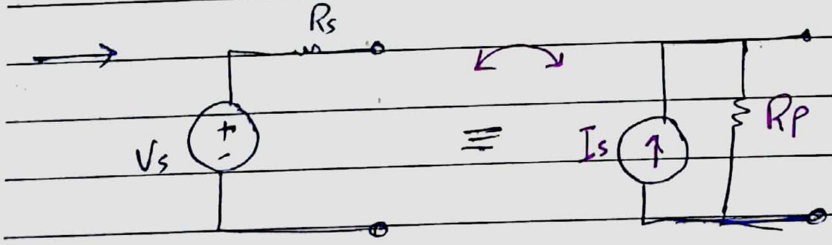
$$V_L = V_s - R_s I_L$$



$$I_L = I_s - \frac{V_L}{R_P}$$

$$* \; V_L = \frac{R_L}{R_L + R_s} [V_s]$$

$$* \; V_L = I_L R_L$$
$$= \frac{1/R_L}{1/R_L + 1/R_P} [R_L][I_s]$$



بنقدر نحول
لاي شكل بس
عن طريق قوانين

① $R_s = R_P$

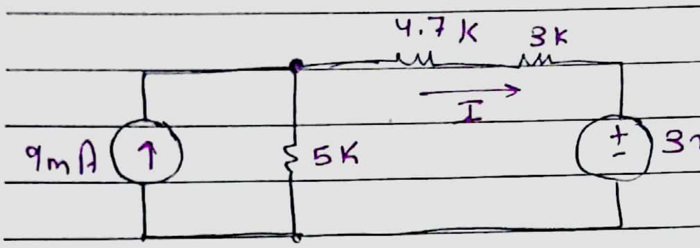
② $V_s = I_s R_P$ = ohm's law.

③ $I_s = V_s / R_s$ = ohm's law

29/3

ex :- Find I ?

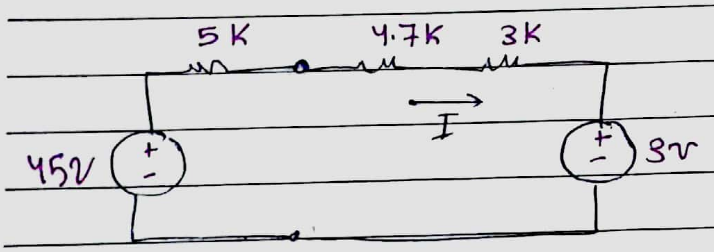
k → 10^3 / m → 10^{-3}



نحولها الى

1 Loop

عن طريق القوانين .



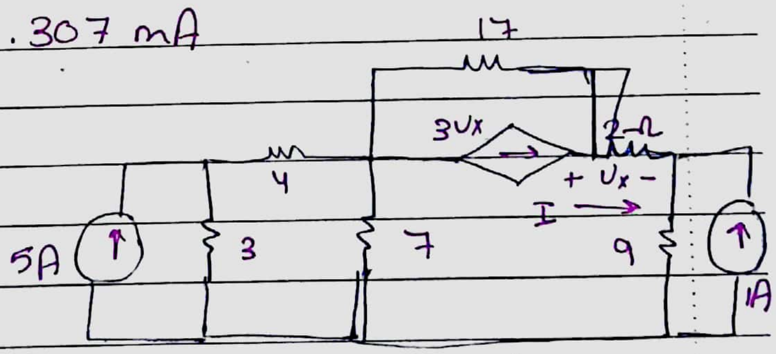
① $R_s = R_p = 5K$

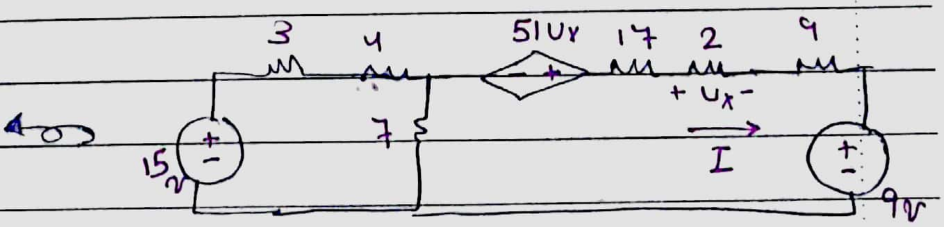
② $V_s = I_s R_p = 5k * 9m = 45V.$

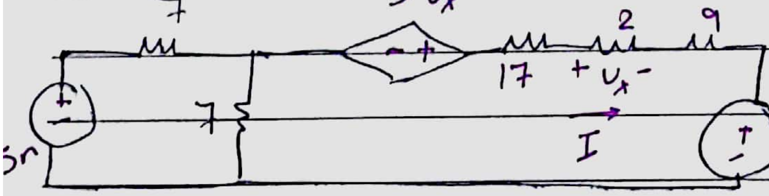
using KVL :- $-45 + 5kI + 4.7kI + 3kI + 3 = 0$

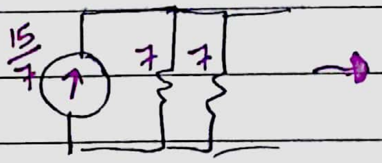
$\rightarrow I = 3.307 \, mA$

ex :- Find I, U_x ?

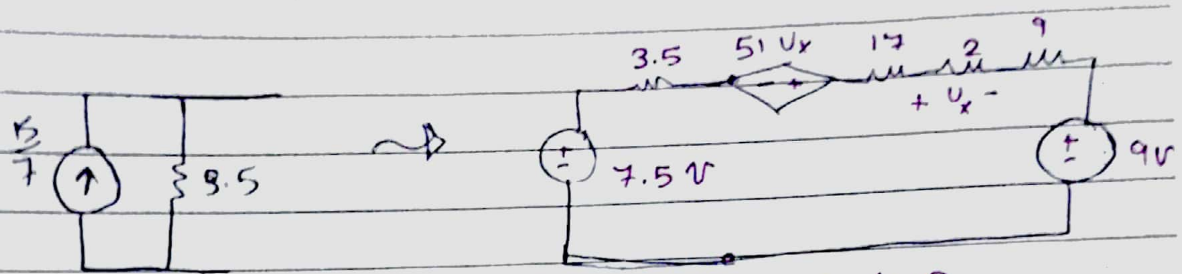








29/3



one Loop.

Using KVL:-

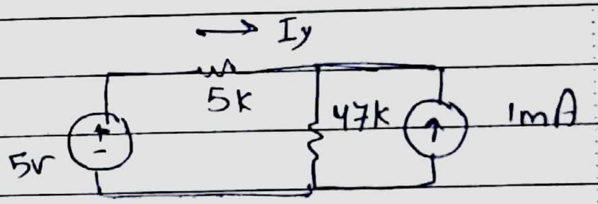
→ $-7.5 + 3.5 \times I - 51 U_x + 17 I + 2I + 9 I + 9 = 0$

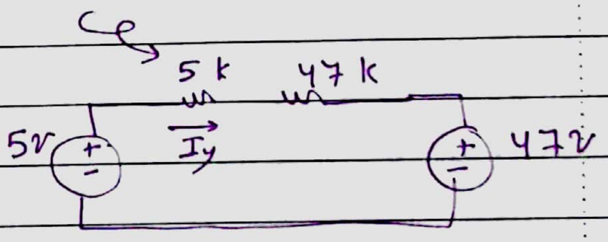
~ $U_x = 2I$

→ Final. ans:- $I = 21.28$ mA

$V_x = 42.2$ mV.

ex:- Find I_y?



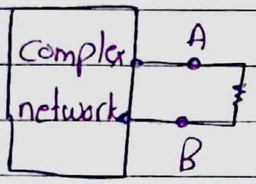


$-5 + 5k I_y + 47k I_y + 47 = 0$

$I_y =$ — A

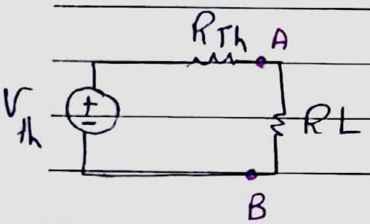
31/3

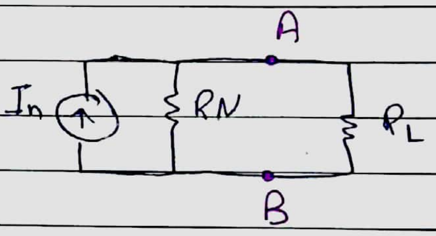
* Thevenin and Norton Equivalent :-



~ Thevenin

~ Norton





⊛ Using Source transformation :-

① $R_{th} = R_V$

② $I_N R_N = V_{Th}$

③ $I_N = \frac{V_{th}}{R_{th}}$

التحويل من notron
الى thevenin
والعكس

case one :- Only Independent current and voltage sources

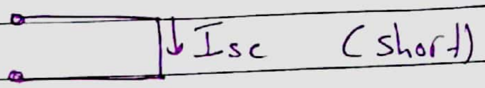
→ $V_{th} = V_{oc}$

(open)

→ R_{th} = Req after killing all sources

31/3

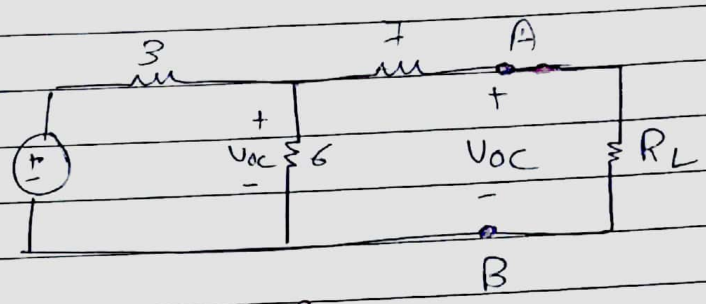
→ $I_n = I_{sc}$



→ $R_{th} = R_N$

ex':-

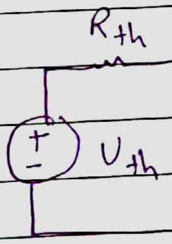
Find thevenin ?



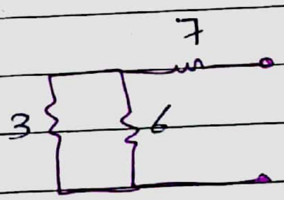
→ sol:- $V_{th} = V_{oc}$

$= [\frac{6}{3+6}][12]$

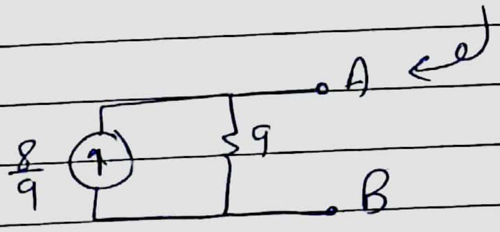
$= 8v$



∴ $R_{eq} = [3 // 6] + 7 = 9\Omega$

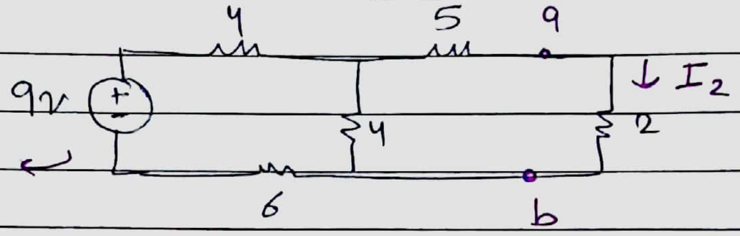


∴ $I_N = I_{sc} = \frac{U_{th}}{R_{th}} = \frac{8}{9} A$



31/3

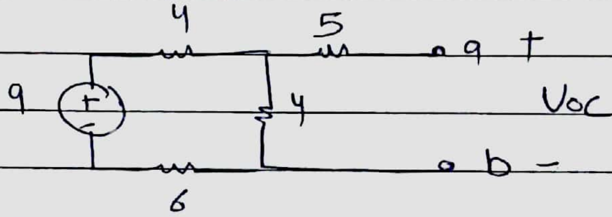
ex:- Find thevenin and $I_2 = ?$



one ind ب تحتوي ع

case 1 اذا

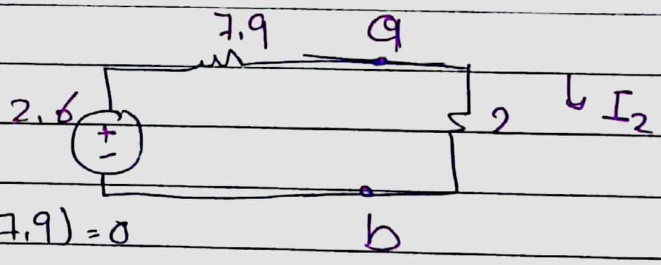
Sol:-



$\rightarrow V_{th} = V_{oc}$

$= \frac{4}{4+4+6} * 9 = 2.6V$

$\rightarrow R_{th} = R_{eq} = \left(\frac{10*4}{10+4}\right) + 5 = 7.9$

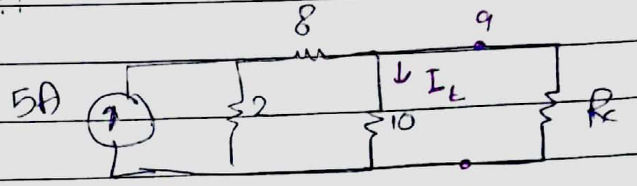


$-2.6 + 7.9(I_2) + 2(7.9) = 0$

$I_2 = 0.26 A$

31/3

Find thevenin ?!



sol :-

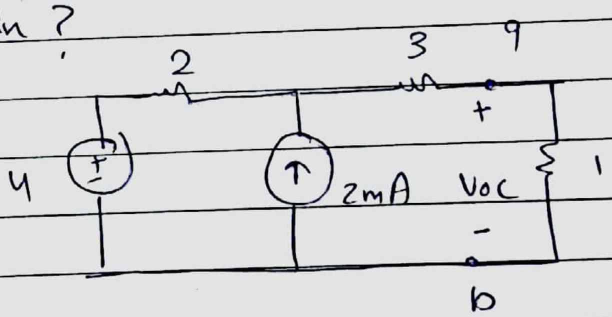
$V_{th} = V_{oc}$

$= 10\, I_L$

$= 10 \left[\left(\frac{1/12}{1/12 + 1/2} \right) * 5 \right] = 5v$

$R_{th} = \frac{(2+8) * 10}{(2+8)+10} = 5\Omega$

ex :- Find thevenin ?



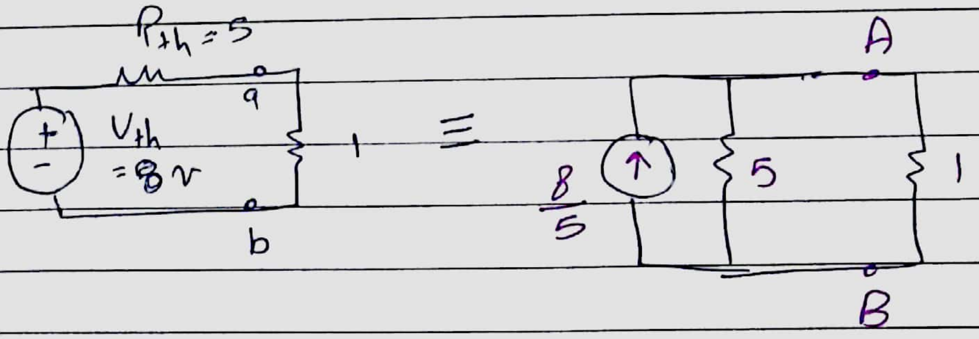
sol:-

$V_{th} = V_{oc}$

$-4 + (2 * -2) + 3 * 0 + V_{oc}$

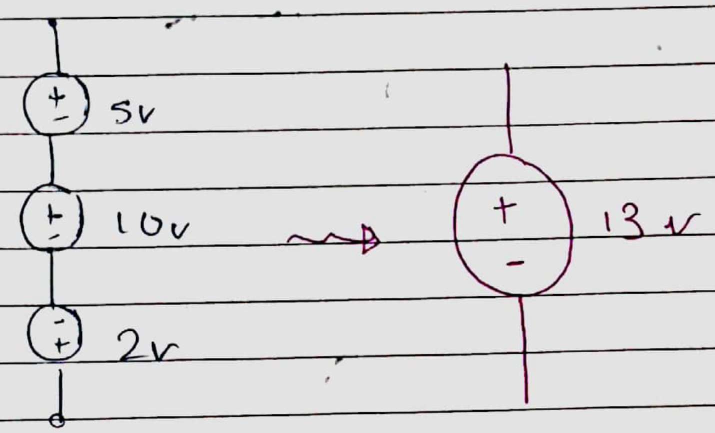
$V_{oc} = 8v.$

$R_{th} \rightarrow R_{eq} - 2 + 3 = 5\,\Omega$

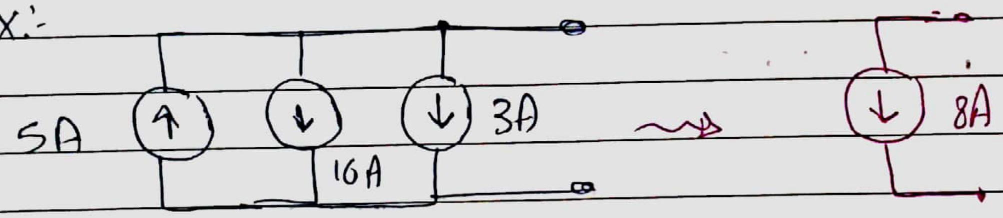


13/3

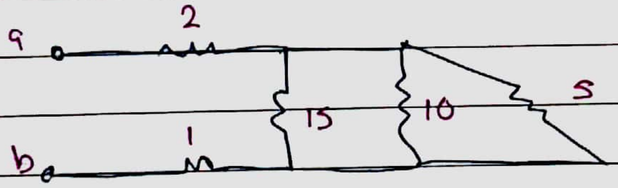
ex :-



ex:-



ex:- Find R_{eq} between a, b ?



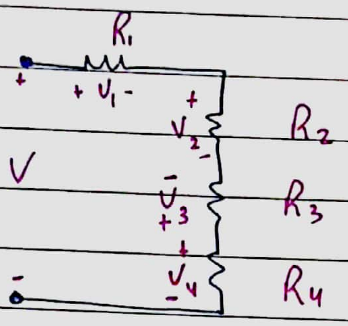
$$R_{eq} = (5 \parallel 10 \parallel 15) + 2 + 1$$

$$= \left[\frac{1}{5} + \frac{1}{10} + \frac{1}{15}\right]^{-1} + 2 + 1$$

$$= \square \ \Omega$$

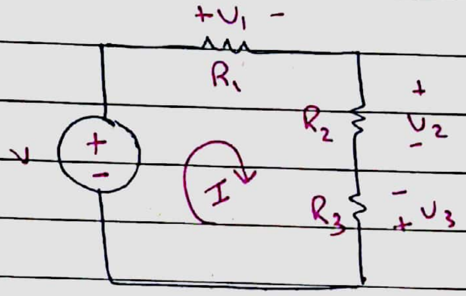
∘∘∘ Voltage and current division :-

↳ Voltage division :-



$$\rightsquigarrow V_n = \left[\frac{R_n}{R_1+R_2+\dots+R_n}\right] * V$$

ex :-



بدل كل هاي
العلبة السخم

$V_3 = -R_3 I$

$$\rightsquigarrow -V + V_1 + V_2 - V_3 = 0$$

$$-V + R_1 I + R_2 I - [-R_3 I] = 0$$

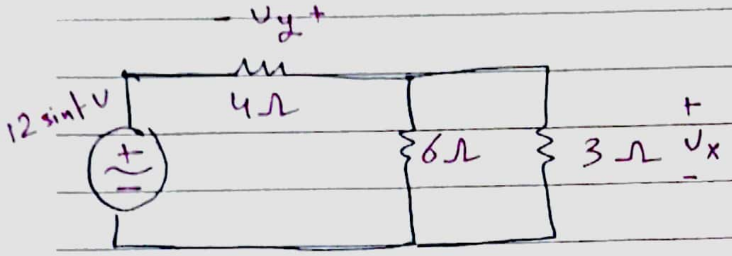
$$I = \frac{V}{R_1+R_2+R_3}$$

$$V_1 = R_1 I_1 = R_1 \left[\frac{V}{R_1+R_2+R_3}\right]$$

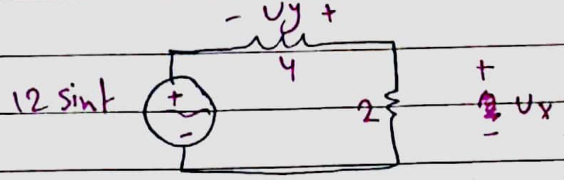
$$V_3 = -R_3 I = -R_3 \left[\frac{V}{R_1+R_2+R_3}\right]$$

13/3

ex:- Find v_x, v_y ?



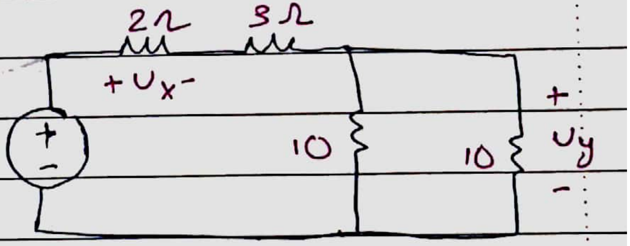
sol : R_{eq} $3 \parallel 6 = 2\Omega$



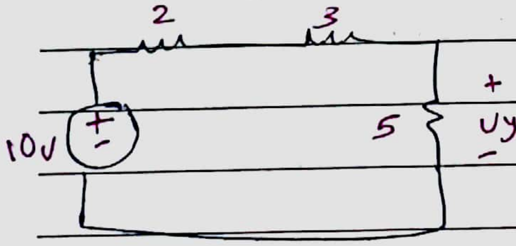
$$U_x = \frac{2}{4+2} * 12 \sin t = 4 \sin t \ V$$

$$v_y = \frac{4}{4+2} * -12 \sin t = -8 \sin t \ V$$

ex:- Find v_x, v_y ?



$R_{eq} = 10 \parallel 10 = 5\Omega$ sol



$$\rightarrow v_y = \frac{5}{5+2+3} * 10v = 5v$$

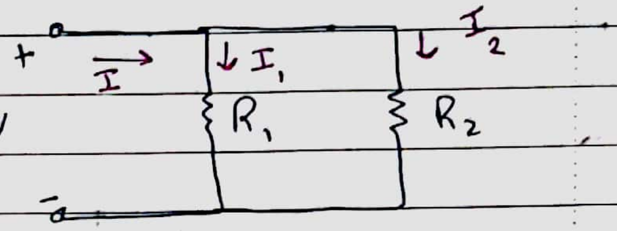
$$U_x = \frac{2}{10} * 10 = 2V$$

13/3

⟶ Current division :-

↳ « R = in Parallel »

$$I_n = \left[\frac{1/R_n}{1/R_1 + 1/R_1 + \dots}\right] * I$$



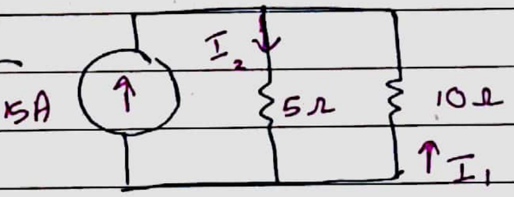
لو التيار بالعكس اضرب ← -1 *

$$I_1 = \left[\frac{1/R_1}{1/R_1 + 1/R_2}\right] * I \quad ; \quad I_2 = \left[\frac{1/R_2}{1/R_1 + 1/R_2}\right] * I$$

ex :- Find I_1 ; I_2 = ?!

$$I_1 = \left[\frac{1/10}{1/10 + 1/15}\right] * \ominus 15$$

sol ⟵



$$I_2 = \left[\frac{1/5}{1/5 + 1/10}\right] * 15$$

⟶ method 2 :-

الأصول

$R_{eq} = 5 // 10$

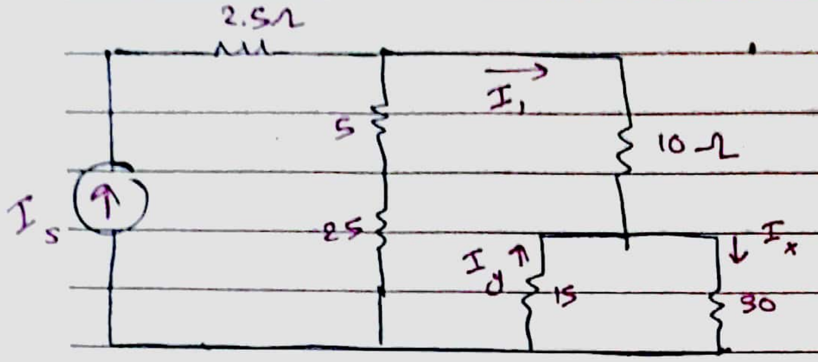
$V = 15 * (5 // 10)$

$$I_1 = \frac{(15)(5//10)}{5}$$

$$I_2 = \frac{-15 * (5 //10)}{10} \#$$

13/3

ex: Find I_x, I_y if $I_1 = 100mA$

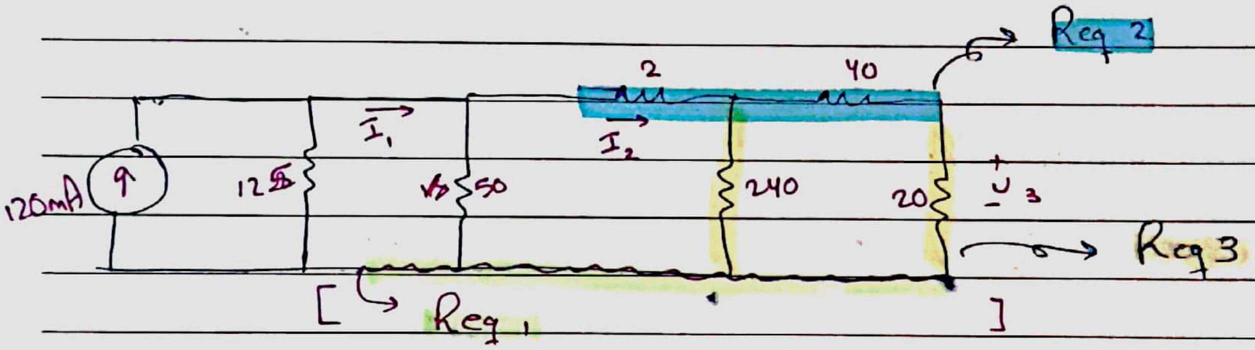


sol → $I_x = \left[\frac{1/30}{1/30+1/15}\right] * 100mA = 33.33 mA$

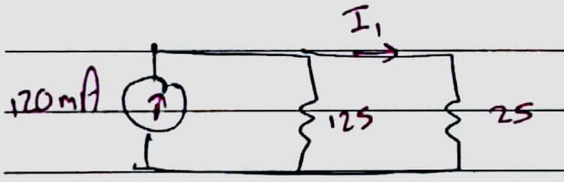
$I_y = \left[\frac{1/15}{1/15+1/30}\right] * -0.1 = -72.77 mA$

لـ تأكد من الرقم بالسن

ex:- Find I_1, I_2, ~~V~~ V_3 ?



→ $Req_1 = [[[20+40) // 240] + 2] // 50 = 25Ω$

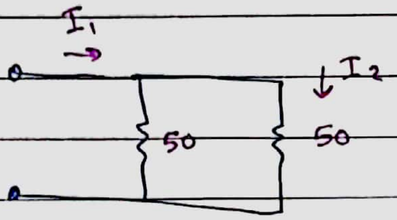


→ $I_1 = \left[\frac{1/25}{1/25+1/125}\right] * 120mA$

$= 100mA$

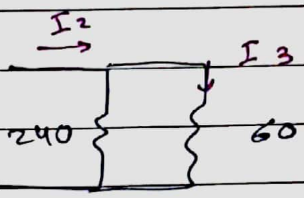
13/3

$R_{eq2} = [[20+40] \parallel 240] + 2 = 50\,\Omega$



$$I_2 = \left[\frac{1/50}{1/50+1/50}\right] * 100\,mA$$
$$= 50\,mA$$

$R_{eq3} = 20+40 = 60$



$$I_3 = \left[\frac{1/60}{1/60+1/240}\right] * 50\,mA$$
$$= 40\,mA$$

$V_3 = 20 * 40\,mA = 0.8$ volt

15/3

CH 4

* Solving equations :-

A) $a_1 X_1 = b_1$

B) $a_{11} X_1 + a_{12} X_2 = b_1$

$a_{21} X_1 + a_{22} X_2 = b_2$

C) $a_{11} X_1 + a_{12} X_2 + a_{13} X_3 = b_1$

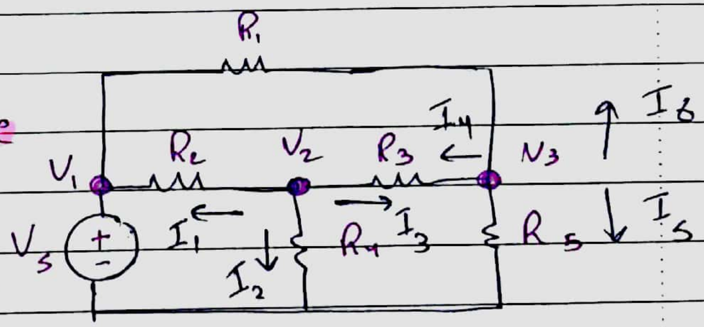
$a_{21} X_1 + a_{22} X_2 + a_{23} X_3 = b_2$

$a_{31} X_1 + a_{32} X_2 + a_{33} X_3 = b_3$

~ . ~ . ~ . ~ . ~ . ~ .

CH 4 :- Node and Mesh analysis :-

* node analysis



→ steps :-

① assume reference voltage

② assume voltage on each node

③ assume current entering each Resistor

④ apply KCL

⇝ at node 1 :- $-0 + V_1 = V_s$

$\rightarrow \boxed{V_1 = U_s}$ ---- ①

⇝ at node 2 :- $I_1 + I_2 + I_3 = 0$

$$\boxed{\frac{U_2 - U_1}{R_2} + \frac{U_2 - 0}{R_4} + \frac{U_2 - U_3}{R_3} = 0}$$ — ②

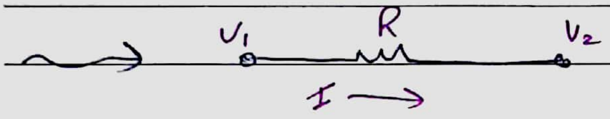
→ cont...

15/3

at node 3 :-

$$I_4 + I_5 + I_6 = 0$$

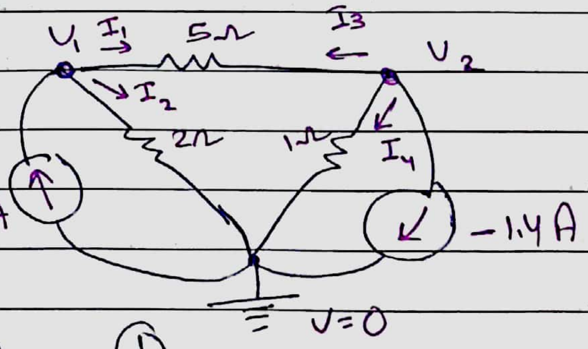
$$\boxed{\frac{V_3 - V_2}{R_3} + \frac{V_3 - 0}{R_5} + \frac{V_3 - V_1}{R_1} = 0} \quad \ldots ③$$



$$\therefore I = \frac{V_1 - V_2}{R}$$

$$\therefore I = \frac{V_2 - V_1}{R}$$

ex:- Find V_1, V_2 ?



→ at node 1 :-

$$3.1 = I_1 + I_2$$

$$3.1 = \frac{V_1 - V_2}{5} + \frac{V_1 - 0}{2} \quad \ldots ①$$

→ at node 2 :-

$$-1.4 + I_3 + I_4 = 0$$

$$1.4 = \frac{V_2 - V_1}{5} + \frac{V_2 - 0}{1} \quad \ldots ②$$

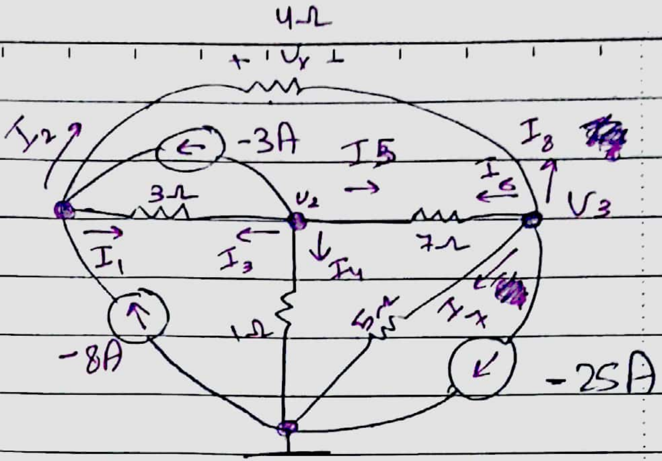
$V_1 = 5v$

$V_2 = 2v$

$I_1 = \frac{V_1 - V_2}{5} = \frac{3}{5} A$

15/3

Ex!-



at node 1:-

$$-3-8 = I_1 + I_2$$

$$-11 = \frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{4} \quad ①$$

at node 2:-

$$-3 + I_3 + I_4 + I_5 = 0$$

$$3 = \frac{V_2 - V_1}{3} + \frac{V_2 - 0}{1} + \frac{V_2 - V_3}{7} \quad -- ②$$

at node 3:-

$$-25 + I_6 + I_7 + I_2 = 0$$

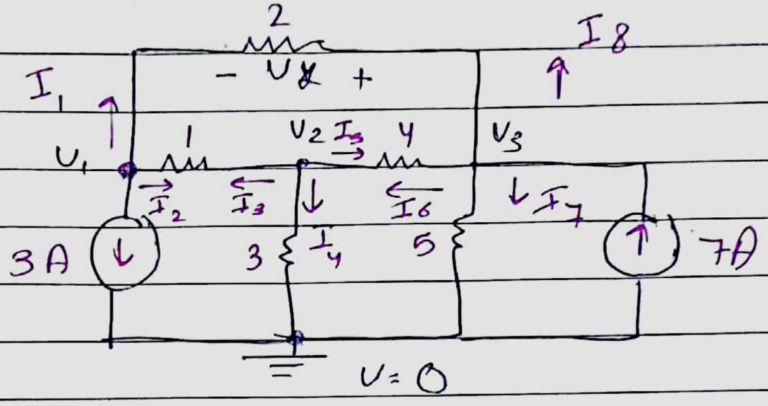
$$25 = \frac{V_3 - V_2}{7} + \frac{V_3 - 0}{5} + \frac{V_3 - V_1}{4} \quad -- ③$$

$\rightsquigarrow$ $V_1 = 5.412\ V$
$V_2 = 7.738\ V$
$V_3 = 46.32\ V$

$V_x = V_1 - V_3$ #

15/3

ex:- Find V_1, V_2, V_3 P



at node ①:-

$$I_1 + I_2 + 3 = 0$$

$$3 + \frac{V_1 - V_2}{1} + \frac{V_1 - V_3}{2} = 0 \quad --- ①$$

at node ②:-

$$I_3 + I_4 + I_5 = 0$$

$$\frac{V_2 - V_1}{1} + \frac{V_2 - 0}{3} + \frac{V_2 - V_3}{4} = 0 \quad -- ②$$

at node ③:-

$$7 = I_6 + I_7 + I_8$$

$$7 = \frac{V_3 - V_2}{4} + \frac{V_3 - 0}{5} + \frac{V_3 - V_1}{2} \quad --- ③$$

$\rightarrow$ $V_1 = 5.235\,V$ / $V_2 = 5.12\,V$ / $V_3 = 11.217\,V$

$V_y = -V_1 + V_3$ #

10/4

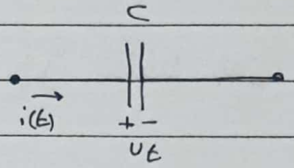
CH7

* Capacitor and Inductors:-

↳ Both the inductors and capacitor are passive element that are capable of sorting and deliviring [illegible] amount of energy.
finite

⊛ Capacitor

unit = Farad.



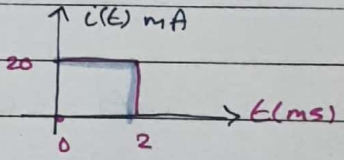
i [illegible] =

$$\longrightarrow \quad i(t) = C \frac{dv(t)}{dt}$$

$$i(t)\,dt = C\,dv(t) \rightsquigarrow \int_{t_0}^{t} dv(t) = \frac{1}{C}\int_{t_0}^{t} i(t).dt$$

$$* \; v(t) - v(t_0) = \frac{1}{C}\int_{t_0}^{t} i(t).dt.$$

ex:- Find $v(t)$ if $C = 5\mu F$



$$\longrightarrow \quad i(t) = \begin{cases} 0 , & -\infty \le t \le 0 \\ 20 * 10^{-3} , & 0 \le t \le 2 \\ 0 , & 2 \le t \le \infty \end{cases}$$

Let $v(-\infty) = 0$

① $v(t) - v(-\infty) = \frac{1}{5\mu}\int_{-\infty}^{0} 0.\,dt \rightarrow v(t) = 0$ #

② $v(t) - v(0) = \frac{1}{5}\int_{0}^{t} 20 * 10^{-3}\,dt \rightarrow v(t) = 4000t$ #

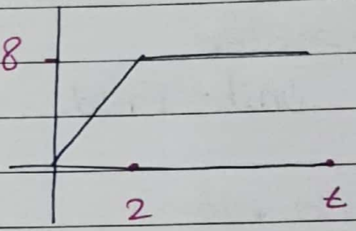
③ $v(t) - v(2) = \frac{1}{6}\int_{2}^{t} 0.\,dt \rightarrow v(t) = 8$ #

~>

10/4.

$$v(t) = \begin{cases} 0 & , -\infty \le t \le 0 \\ 4000t & , 0 \le t \le 2 \\ 8 & , 2 \le t \le \infty \end{cases}$$ #

← لاحظ رح يضل مضغط بالقوة



⊛ Power :-

$$P = VI$$
$$= V\left[C\frac{dv(t)}{dt}\right]$$

⊛ Energy :-

$$w(t) = \int_{t_0}^{t} P(t) . dt$$

$$w(t) = C\int_{t_0}^{t} v(t) . dv(t)$$

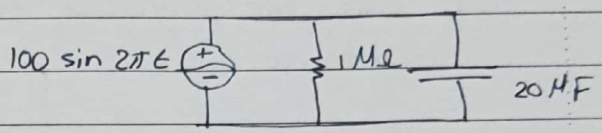
$$= C\left[\frac{v^2(t)}{2}\right]_{t_0}^{t}$$

$$\frac{1}{2}C\left[v^2(t) - v^2(t_0)\right] \rightsquigarrow \text{let } v(t_0) = 0$$

$$\rightsquigarrow w_c(t) = \frac{1}{2}Cv^2(t)$$

10/4

ex :- Find $w_c(t)$, $t = \frac{1}{4}s$, $w_R(t)$ $0 \le t \le 0.5$



① $w_c(t) = \frac{1}{2} c v^2$

$= \frac{1}{2} [20 * 10^{-6}] [100 \sin 2\pi (\frac{1}{4})]^2$

$= 100 \text{ mJ}$

② $w_R(t) = \int_0^{0.5} p(t) \cdot dt = \int_0^{0.5} \frac{[100 \sin 2\pi t]}{1 * 10^6} dt$

$= 2.5 \text{ mJ}$

⊛ Characteristic of Ideal capacitor :

1 there is no current through capacitor if a voltage cross it is not changing with time capacitor is open circuit

$i(t) = c \frac{dv(t)}{d(t)}$

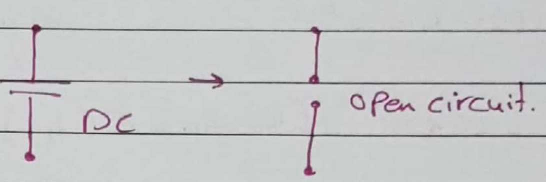
2 Finite amount of energy can be stored in a capacitor even if the circuit is Zero such that voltage is constant $W_c(t) = \frac{1}{2} v^2(t)$

3 It's impossible to change the voltage a cross capacitor in Finit time

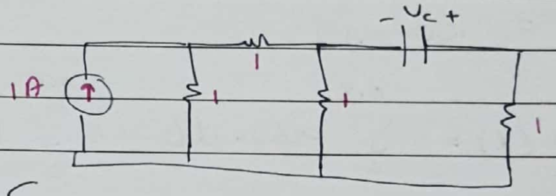
$V_c(0^+) = V_c(0^-)$

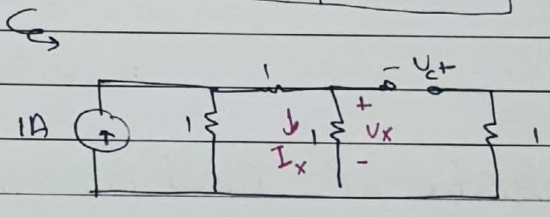
10/4

[4] Capacitor never dissipates energy but only sort it, although this is true in mathmatical model it is not true for physical model due to finit amount of resistance



ex:- Find $V_c(t)$?





$-V_x - V_c = 0$

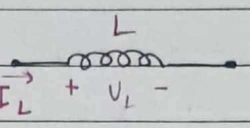
$\rightsquigarrow V_x = 1 I_x$

$1\left[\frac{1/2}{1/2+1/2}\right][1] = \frac{1}{3} v.$

$\rightarrow V_c = -V_x = -\frac{1}{3} v$

12/4

⇝ **Inductors** :-



•• Unit :- **henries.**

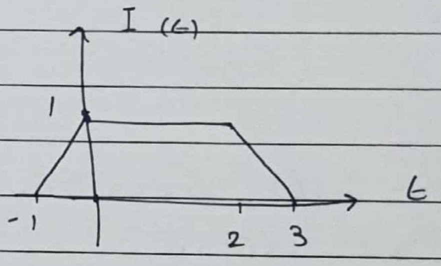
•• $v(t) = L\dfrac{dI(t)}{dt}$

→ $v(t) * dt = L\, dI(t)$

$$\int_{t_0}^{t} d\,I(t) = \int_{t_0}^{t} \frac{1}{L}\, v(t)\, dt.$$

$$* \quad I(t) - I(t_0) = \frac{1}{L}\int_{t_0}^{t} v(t)\,dt$$

ex:- Find $v(t)$ for $L = 3H$



sol:-

$$I(t) = \begin{cases} 0 & , -\infty \le t \le -1 \\ 1 & , 0 \le t \le 2 \\ 0 & , 3 \le t \le \infty \end{cases}$$

$* \quad y - y_1 = m(x - x_1)$ معادلة الخط المستقيم

$I - I_0 = m(t - t_0)$

$\begin{bmatrix} -1 \rightarrow 1 \\ 2 \rightarrow 3 \end{bmatrix}$ لايجاد الاقتران بين

→ $(-1, 0)$ $(0, 1)$

$I - 0 = 1(t + 1)$

$I = t + 1$

→ $(2, 1)$ $(3, 0)$

$I - 0 = (-1)(t - 3) \Rightarrow I = -t + 3$

$$I(t) = \begin{cases} 0 & , \infty \le t \le -1 \\ t+1 & , -1 \le t \le 0 \\ 1 & , 0 \le t \le 2 \\ -t+3 & , 2 \le t \le 3 \\ 0 & , 3 \le t \le \infty \end{cases}$$

→ $v(t) = L\dfrac{dI(t)}{dt} = 3\dfrac{dI(t)}{dt}$

$$\frac{dI(t)}{dt} = \begin{cases} \cancel{0 \quad -\infty \le t \le -1} \\ \cancel{1} \\ \cancel{0 \quad -1 \le t \le 0} \\ \cancel{-1 \quad 0 \le} \\ 0 \end{cases} \quad \longrightarrow$$

12/4

$$\frac{dI_t}{dt} = \begin{cases} 0 & -\infty \le t \le -1 \\ 1 & -1 \le t \le 0 \\ 0 & 0 \le t \le 2 \\ -1 & 2 \le t \le 3 \\ 0 & 3 \le t \le \infty \end{cases}$$

$$v(t) = \begin{cases} 0 & \_\_\_ \\ 3 & \_\_\_ \\ 0 & \_\_\_ \\ -3 & \_\_\_ \\ 0 & \_\_\_ \end{cases}$$

ex:- $v(t) = 6\cos 5t u$, $L = 2H$, $I(-\frac{\pi}{2}) = 1A$

Find $I(t)$?

$$\rightarrow I(t) - I(-\tfrac{\pi}{2}) = \frac{1}{2}\int_{-\frac{\pi}{2}}^{t} 6\cos 5t \, . \, dt$$

$$I(t) = 0.6 \sin 5t + 1.6 .$$

(*) **Power** :- $VI \sim I\left[\frac{L\,dI(t)}{dt}\right]$

(*) **energy** :- $w_L(t) = \int_{t_0}^{t} P_L(t)\,dt = \int_{t_0}^{t} I\left[\frac{L\,dI(t)}{dt}\right]$

$$= L\int_{t_0}^{t} I\,dI(t) = L\left.\frac{I^2_{(t)}}{2}\right|_{t_0}^{t}$$

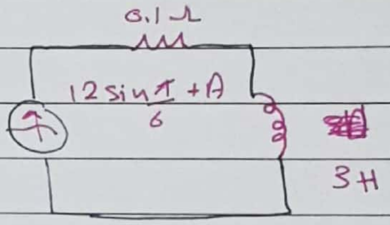
$$= \frac{1}{2}L\left[I(t)^2 - I(t_0)^2\right]$$

→

12/4

Let $I(t_0) = \text{zero} \rightarrow W(t) = \frac{1}{2} L I^2$ #

ex:- Find $w_L(t)\big|_{t=3s}$, $w_R(t)\big|_{0 \le t \le 6}$



sol:- ① $W_L(t) = \frac{1}{2} L\, I(t)^2$

$= \frac{1}{2} [3] [12 \sin \frac{\pi}{6} t]^2$

at $t = 3$

$W = 216\ J$

② $W_R(t) = \int_0^6 [12 \sin \frac{\pi}{6} t]^2 [0.1]\, dt = 43.2\ J$

* * *

⊛ Characteristic of Ideal inductor :-

① There is no voltage across inductor if ~~the~~ current through it isn't changing with time inductor short circuit to DC

$\rightarrow v(t) = L \frac{d I(t)}{dt}$

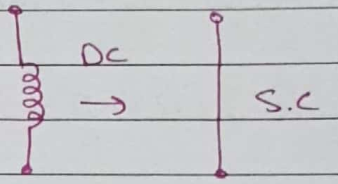
② Finite amount of energy can be stored In inductor even if the voltage is Zero such that current is constant

$\rightarrow W_L(t) = \frac{1}{2} L I^2(t)$

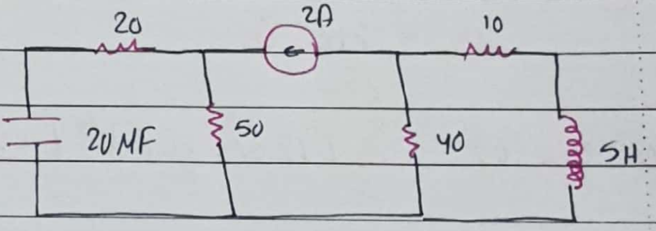
12/4

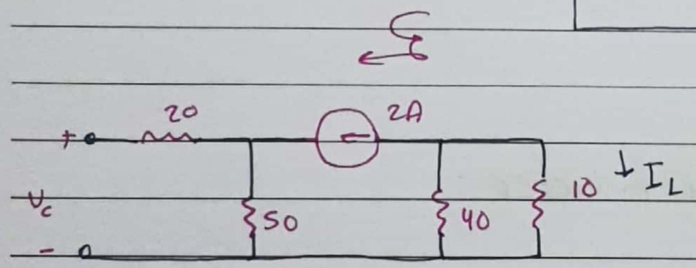
③ $I_L(0^{+}) = I_L(0^{-})$

④ the inductor never dissipute energy but only stor it although this is true For math. model it is not true For physical Model due to internal resistance



ex:- Find $W_L(t) = W_c(t)$





① $W_c(t) = \frac{1}{2} C v_t^{2}$

$v(t) = 50(2) = 100$

$W_c(t) = \frac{1}{2}[20*10^{-6}][100]^{2}$

$= 0.1\,J$

② $W_L(t) = \frac{1}{2} L I_L^{2}(t)$

$I_L = \left[\frac{1/10}{1/10 + 1/40}\right][-2] = -1.6A$

$W_L(t) = \frac{1}{2}[5][-1.6]^{2} = 6.4\,J$

15/5

* General ohm Law :-

$$V = Z I$$

$Z \rightarrow$ impedance (ohm)

$I \rightarrow$ current (A)

$V \rightarrow$ voltage (V)

* $Z_R = R$, * $Z_L = jwL$ * $Z_C = \frac{1}{jwL}$

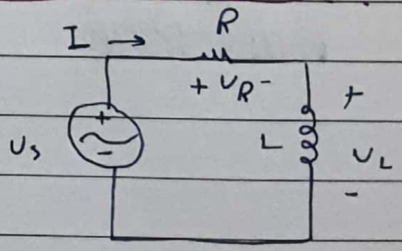
→ KVL :-

$$\sum_{Loop} v(t) = 0 \rightarrow \sum_{Loop} V = Zero$$

&

→ KCl

$$\sum_{node} i(t) = 0 \rightarrow \sum_{node} I = 0$$



$$-U_s + U_R + U_L = Zero$$

$$-U_s + RI + (jwL)I = 0$$

$$I = \frac{U_s}{R + jwL} \quad \#$$

Five Apple

15/5

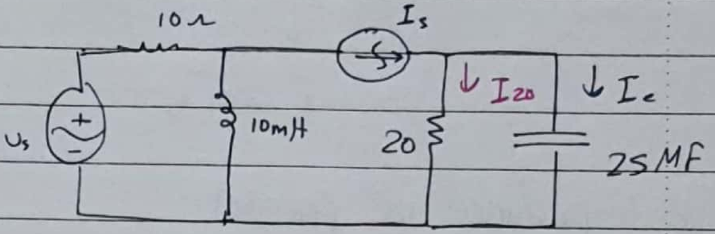
ex :- Let $\omega = 1200$ rad/s , $I_c = 1.2 \angle 28$ A

$I_L = 3 \angle 33$ A Find I_s, V_s, $i_R(t)$

$j\omega L$

$10mH \rightarrow (1200 * 10mH_j)$

$= 12j$

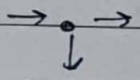


$25\mu F \rightarrow \frac{1}{j\omega c} = \frac{1}{j(1200)(25\mu F)} = -33.33j$

$V_c = (-33.33j)(1.2 \angle 28) = 40 \angle -62$ V.

$I_{20} = \frac{40 \angle -62}{20} = 2 \angle -62$ A

$I_s = I_{20} + I_c = 2.332 \angle -31.04$ A



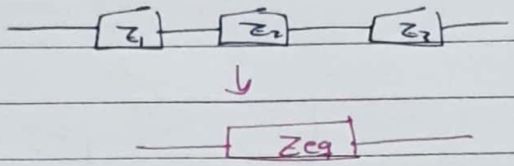
$I_R = I_s + I_L = 3.986 \angle 17.42°$

$i_R(t) = 3.988 \cos(1200t + 17.42)$ A

$\rightarrow -V_s + 10 I_R + 12j[3 \angle 53] = 34.86 \angle 74.55$

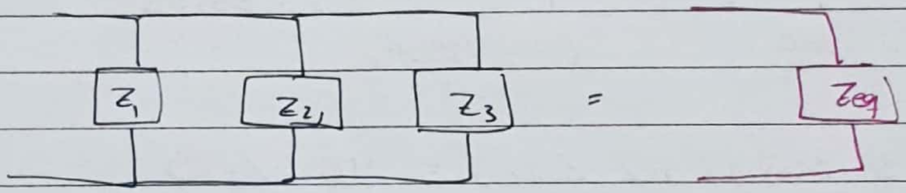
15/5

⊛ Impedance in Series :-



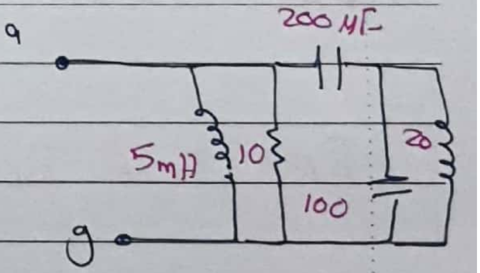
$Z_{eq} = Z_1 + Z_2 + Z_3 \text{--}$

⊛ Impedance in parallel :-



$$\frac{1}{Z_{eq}} = \frac{1}{Z_1} + \frac{1}{Z_2} + \text{---}$$

ex :- Find $Z_{eq} = ?$, $\omega = 1000$ rad/s



5mH → $j\omega L = 5j$

20mH → $j\omega L = 20j$

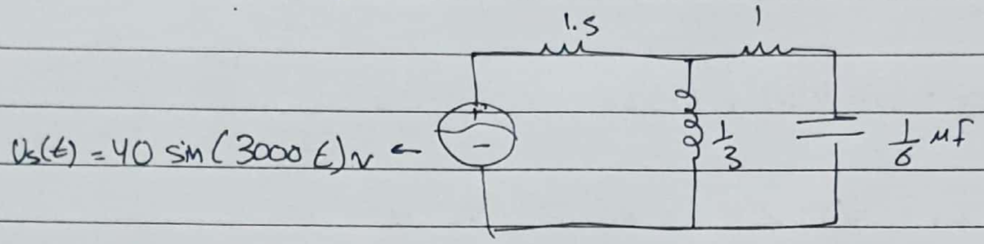
200 μF → $1/j\omega C = -5j$

100 μF → $1/j\omega C = -10j$

$$Z_{eq} = \left[[20j \;//\; -10j] + (-5j) \right] \;//\; 10 \;//\; 5j$$

15/5

ex:- Find $i(t)$ P



$\rightarrow V_s(t) = 40 \sin(3000t)$

$w = 3000$

$V_m = 40$

$= 40 \cos(3000t - 90)$

$\rightarrow V_s = 40 \angle -90 \ v$

$1/3 \rightarrow jwL \rightarrow 1 \ kj$

$1/6 \rightarrow 1/jwL \rightarrow -2 \ kj \ \Omega$

$Z_{eq} = [[[-2kj) + 1k] \parallel 1 kj] + 1.5 \ k$

$= 2.5 \angle 36.87 \ k\Omega$

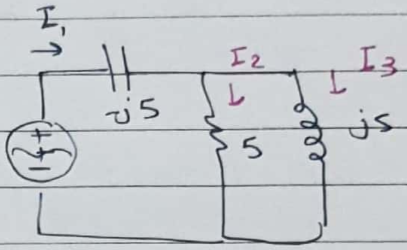
$I = \frac{V_s}{Z_{eq}} = \frac{40 \angle -90}{2.5 \angle 3} = 16 \angle -126.9 \ mA$

$i(t) = 16 \cos(3000t - 126.9) \ mA$

Five Apple

15/5

ex :- Find I_1, I_2, I_3



$Z_{eq} = (j5 \,//\, 5) + (-j5)$

$$I_1 = \frac{100 \angle 0}{Z_{eq}} = 28.28 \angle 45^\circ \text{ A}$$

$$I_2 = \frac{1/5}{1/5 + 1/5j} \left[28.28 \angle 45 \right] = 20 \angle 90^\circ \text{ A}$$

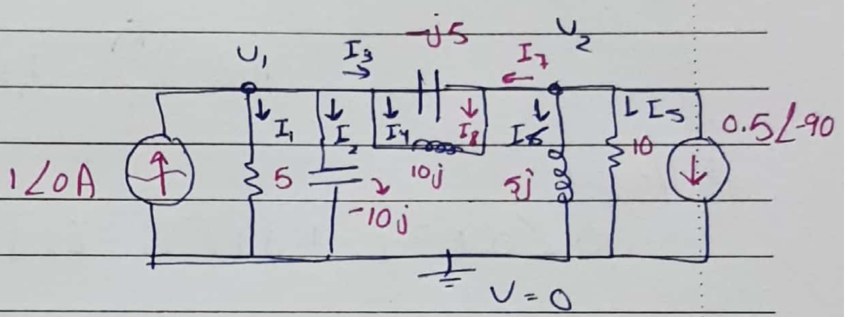
$$I_3 = \frac{1/j5}{1/5 + 1/j5} \left[28.28 \angle 45 \right] = 20 \angle 0 \text{ A}$$

17/5

⊗ nodal analysis :-

① assume reference voltage
② assume voltage on each node
③ assume current entering each Z
④ apply KCl

ex :-



at node 1 :-

$$1\angle 0 = I_1 + I_2 + I_3 + I_4$$

$$1\angle 0 = \frac{V_1}{5} + \frac{V_1}{-j10} + \frac{V_1 - V_2}{-j5} + \frac{V_1 - V_2}{j10} \quad \text{--} ①$$

at node 2 :-

$$0.5\angle -90 + \frac{V_2}{10} + \frac{V_2}{2j} + \frac{V_2 - V_1}{-j5} + \frac{V_2 - V_1}{j10} = 0 \quad \text{--} ②$$

$$\rightsquigarrow V_1 = 2.24\angle -63.4 \quad / \quad V_2 = 4.47\angle 116.6^\circ$$

$$V_1(t) = 2.24\cos(\omega t - 63.4) \quad / \quad V_2(t) = 4.47\cos(\omega t + 116.6^\circ)$$

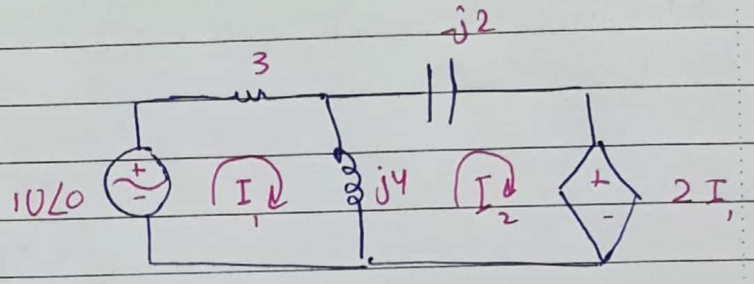
17.5

⑱ mesh analysis

① assume current on each Loop

② apply KVL.

ex :- $w = 10^3$



at loop 1 :-

$$-10\angle 0 + 3I_1 + j4[I_1 - I_2] = 0$$

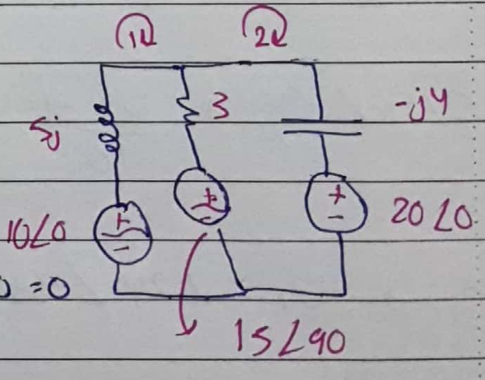
at loop 2 :-

$$j4[I_2 - I_1] - j2 I_2 + 2I_1 = 0$$

→ $I_1 = 1.24 \angle 29.7\ A \sim i(t) = 1.24\cos(10^3 t + 29.7)$

→ $I_2 = 2.77 \angle 56.3 A \sim i(t) = 2.77\cos(10^3 t + 56.3)$

ex :- Find $I_1, I_2 = ?$



at Loop 1 :-

$$-10\angle 0 + 5j I_1 + 3[I_1 - I_2] + 15\angle 90 = 0$$

at Loop 2 :-

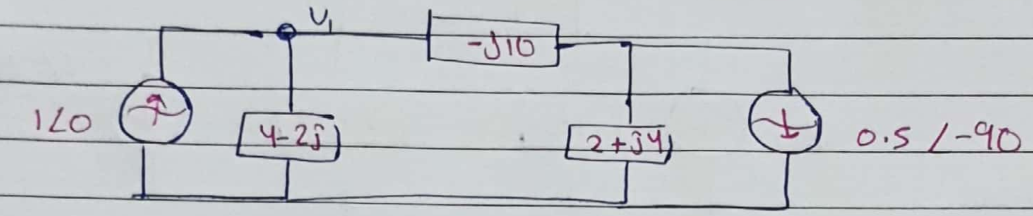
$$-15\angle 90 + 3(I_2 - I_1) - j_4 I_2 + 20\angle 0 = 0$$

→ $I_1 = 4.87 \angle -164.6 A$

$I_2 = 7.17 \angle -144.9 A$

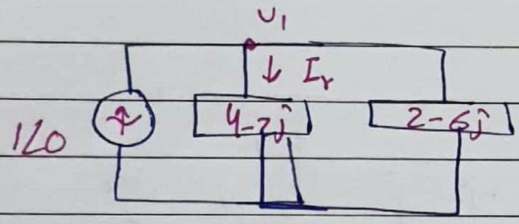
17.5

ex :- Find v_1 ? (superposition)



Using superposition :-

$$V_i = V_{1}\downarrow_{1\angle 0} + V\downarrow_{0.5\angle -90} = \boxed{1-j2} \#$$



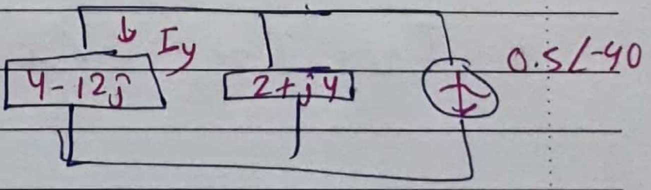
~~$V_1 = (4-2j)$~~

$$V_1 = (4-2j)\, I_x$$

$$= 4-2j * \frac{1/(4-2j)}{(1/4-2j)+(1/2-6j)} \quad [1\angle 0]$$

$$= \boxed{2-j2 \ V}$$

$$\rightsquigarrow V_1\downarrow_{0.5\angle -90} =$$

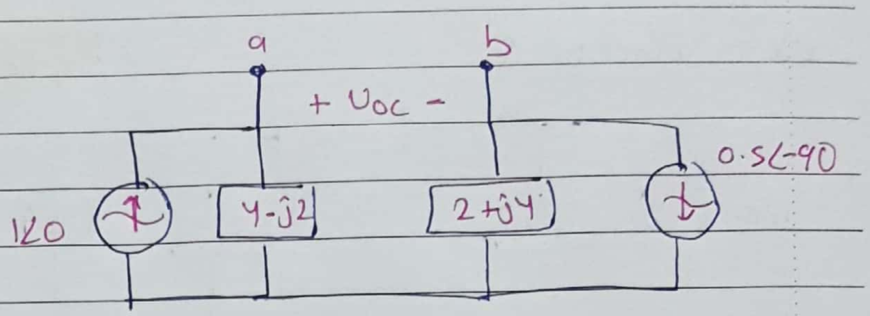


$$V_1 = (4-2j)\, I_y$$

$$V_1 = 4-2j \left[\frac{1/(4-12j)}{1/(4-12j)+(1/2+j4)}\right] [0.5\angle -90] = \boxed{-1}$$

17/5

⊛ Find thevenin

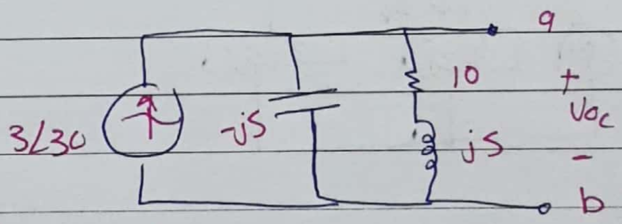


$V_{th} = V_{oc}$

$V_{oc} = (4-j2)(1\angle 0) + (2+j4)(0.5\angle -90) = 6-j3$ v

$Z_{th} = (4-j2) + (2+j4) = 6+j2$

⊛ Find thevenin



* $V_{th} = V_{oc}$

$V_{oc} = [[(10+j5) // -j5] \times 3\angle 30$

$= 16.77 \angle -33.43$ v

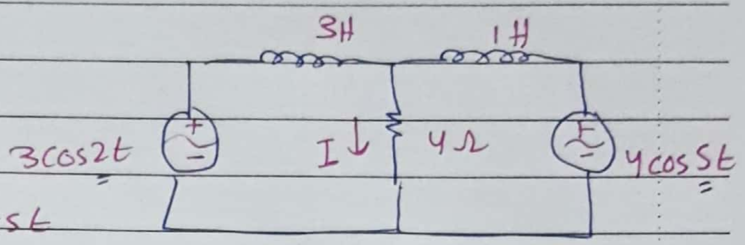
* $Z_{th} = Z_{eq}$ after killing all sources

$(10+j5) // -j5 = 2.5-j5\ \Omega$

* $I_N = I_{sc} = 3\angle 30$ A

17/5

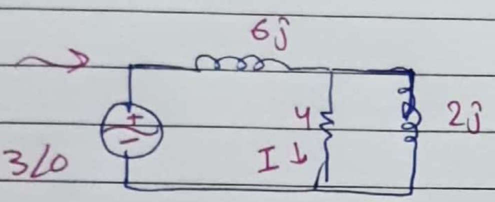
ex:- Find I = ?



$I = I_{3\cos 2t} + I_{4\cos 5t}$

اجباري saper
Position ←

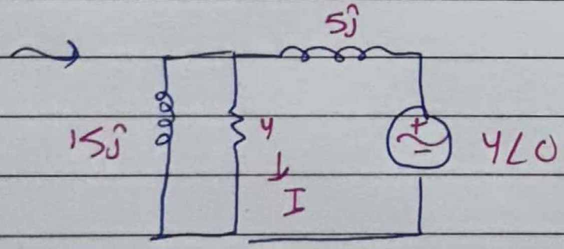
بسبب اختلاف ω



$$I = \frac{V}{4} = \frac{1}{4}\left[\frac{2\hat{j}\,//\,4}{2\hat{j}\,//\,4 + 6\hat{j}}\right][3\angle 0]$$

$$= 175.6\ \angle -20.56\ \text{mA}$$

$i(t) = 175.6\ \cos(2t - 20.56)\ \text{mA}$



$$I = \frac{V}{4} = \frac{1}{4}\left[\frac{4\,//\,15\hat{j}}{4\,//\,15\hat{j} + 5\hat{j}}\right][4\angle 0]$$

$$= 547.1\ \angle -43.15\ \text{mA}$$

$i(t) = 547.1\ \cos(5t - 43.15)\ \text{mA}$

→ $I_{total} = 175.6\cos(2t - 20.56) + 547.1\cos(5t - 43.15)\ \text{mA}$