ElCoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة ElCoM الاكاديمية

دفتر لمادة:

دوائر كهربائية (١)

من شرح:

د.أشرف العلي

جزيل الشكر للطالب:

عمار أبو الروس

سيركت I

Sir ٢

* Units, Ohm's law, ~~Kirchhoff~~ قانون كيرشوف

Electrical cct :-

- Voltage :- is the work needed to move a charge from one point in the cct. to the other [unit : Volt, Symbol (V)]

- Current :- is the amount of charges that cross certain point in unit time. unit (Amperes) symbol (A)

$I = \frac{\Delta Q}{\Delta t}$

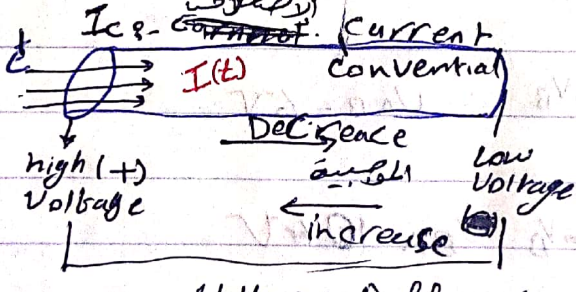
-ve charge $= 1\bar{e} = 1.6 \times 10^{-19}$ C/$\bar{e}$

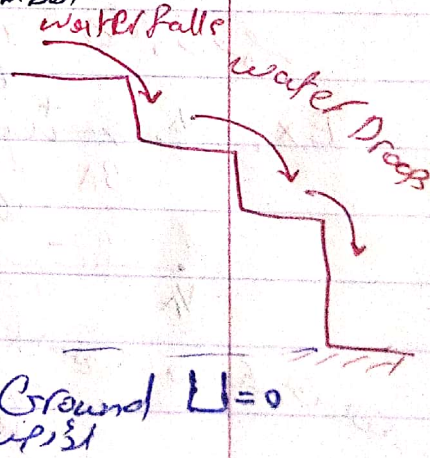
$i(t) = \frac{d\,q(t)}{dt} \Rightarrow q(t) = \int i(t)\,dt$

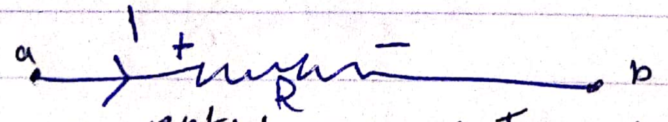
$1\,A = \frac{1\,C}{1\text{ second}} = \frac{\frac{1}{1.6 \times 10^{-19}}\ \bar{e}/c}{1\text{ second}} = \frac{1}{1.6} \times 10^{19}\ \bar{e}/sec$

- Power :- is the energy dissipated by charge in certain load.
  Unit : Watts symbol : W

* Resistor R unit (ohm), symbol Ω





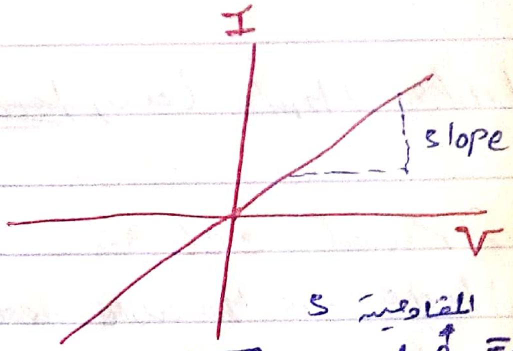


conventional current Technology

$V_a > V_b$. $(V_{ab} = V_a - V_b) > 0$

$(V_{ba} = V_b - V_a) < 0$

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



S المقاومية

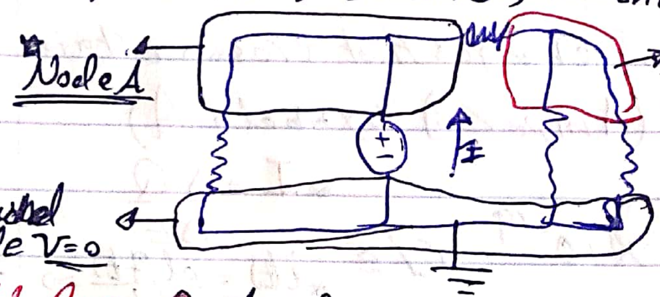
$R = \frac{L\rho}{A} \Rightarrow R = \frac{L}{\sigma A}$

$\rho = \frac{1}{\sigma}$ الموصلية

بنعتبر المقاومة ثابتة

CCt, Definitions:

Loop, Node, Ground, Branch



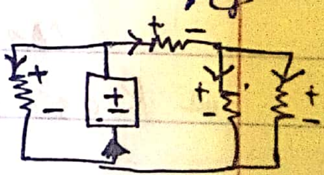
* Ground: is part of cct with zero potential to move charge. (zero Volt)

* Node: Part of cct with same voltage value. جزء من الدارة له نفس الجهد

Node A $\Rightarrow V_A = ??$, Node B $\Rightarrow V_B = ??$

Ground Node $\Rightarrow V_{Ref} = 0$

$V_A > V_B$, $V_A > V_{Ref}$, $V_B > V_{Ref} \Rightarrow V_A > V_B > V_{Ref}$



+ R − V يعني فرق الجهد

$I_c > 0$, لح تكون موجب

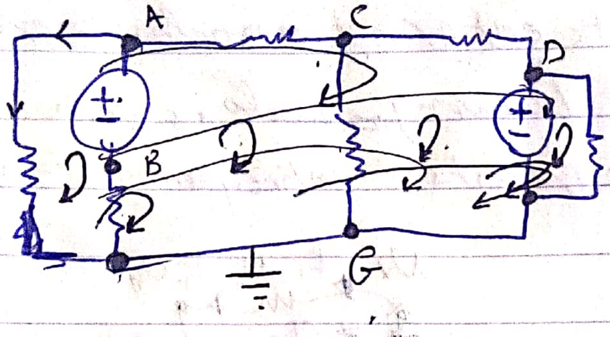
Ex, V_A → 3A, + 2Ω −, 6V, V_B $\therefore V_{AB} = 6V$

V_A, − 2Ω +, 10V, ← 5A, V_B $V_{BA} = 10V$

اذا طلع I سالب بنعكس اتجاه التيار

− R + ، اصنا فرضنا I

Branch:- Part of cct in which the same current flow through it.

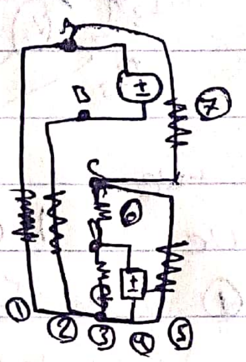


Branch 7 ..

10 loops

4 MESHES

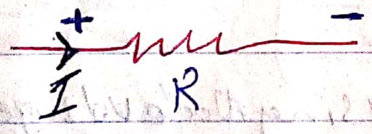
A.



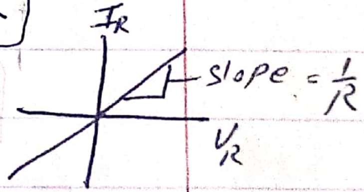
loops:- is a closed Path in a cct.

MESH:- is a loop that has no Loops inside it

Circuits Basics. & KVL laws.



$I = \frac{V}{R} \Rightarrow R = \frac{V}{I} \Rightarrow \boxed{\frac{I}{V} = \frac{1}{R}} \Rightarrow V = I.R$



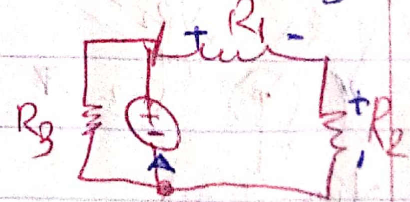
KVL "Kerchhoffs voltage low"

the sum of voltage differences current among loop is zero

$-V_s + V_{R_1} + V_{R_2} = 0$

$-V_{R_3} + V_{R_1} + V_{R_2} = 0$

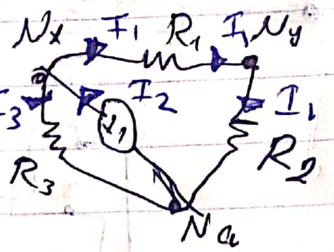
$-V_s + V_{R_3} = 0$



KCL :-

* sum of currents entering a node is zero
* sum of " leaving a node is zero

sum of currents entering a node = sum of current leaving.



KCL @ node Nx

Current entering ⟹ +ve

" Leaving ⟹ -ve

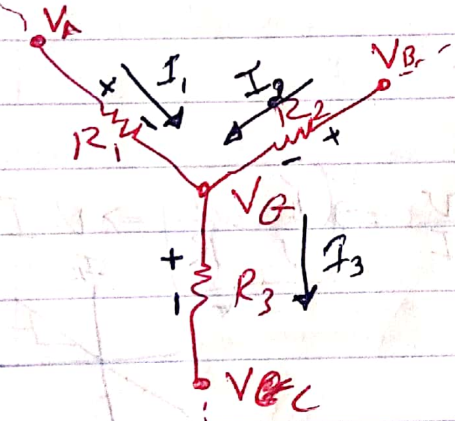
$-I_1 + I_2 - I_3 = 0$ —(1)

KCL @ Ny

$I_1 - I_1 = 0$

KCL @ Na

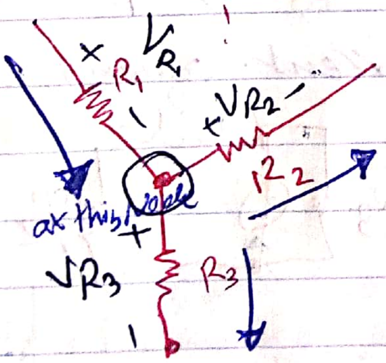
$+I_3 - I_2 + I_1 = 0$



KCL @ VG

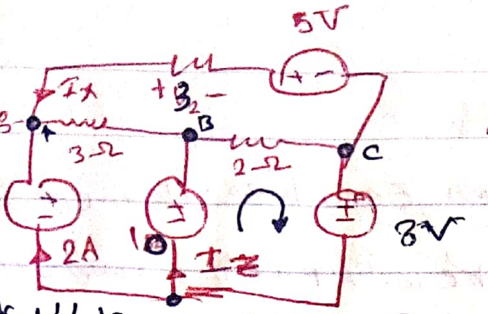
Using Node voltage

$$+\left(I_1 = \frac{V_A - V_G}{R_1}\right) + \left(I_2 = \frac{V_B - V_G}{R_2}\right) - \left(I_3 = \frac{V_G - V_C}{R_3}\right) = 0$$



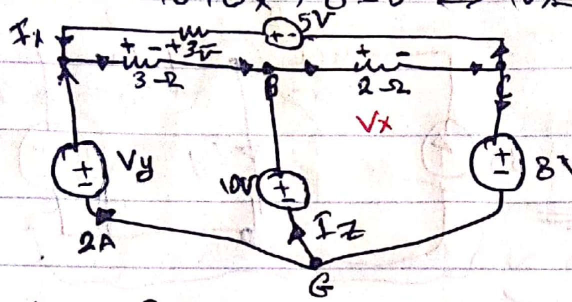
$$\frac{V_{R_1}}{R_1} - \frac{V_{R_2}}{R_2} - \frac{V_{R_3}}{R_3} = 0$$

Ex:-



Find V_x, V_y, I_x, I_z

KVL: $-10+V_x+8=0 \Rightarrow \boxed{V_x=+2} \Rightarrow \boxed{I_z=1\,A}$



حله بالتالي

$+I_x+2A-$

KVL:- $-10+V_x+8=0$ $\underline{V_x=+2}$

Outer loop:- $-V_y-3+5+8=0$ $V_y=10$ volt

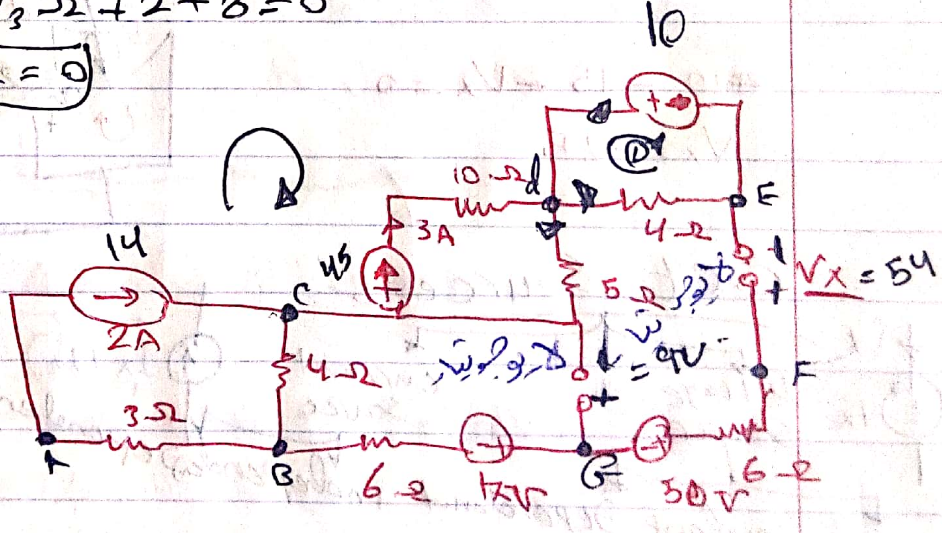
KVL 2 $-V_y+V_{3\Omega}+V_x+8=0$

قوانين الحل :-

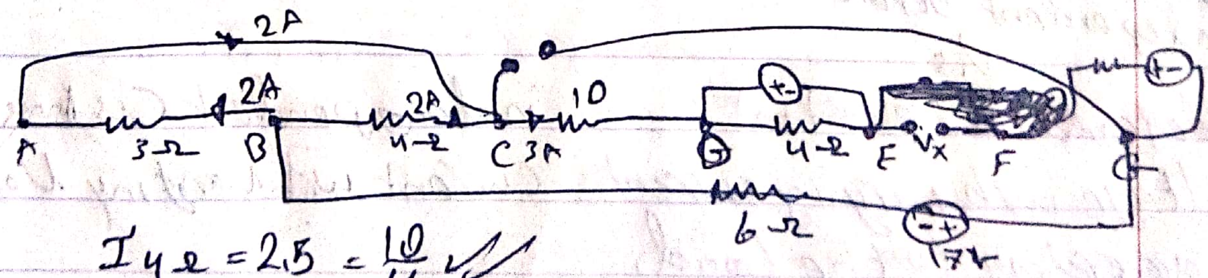
KVL
KCL
Ω law

$-10+V_{3\Omega}+2+8=0$

$\boxed{V_{3\Omega}=0}$



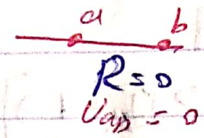
Find V_x



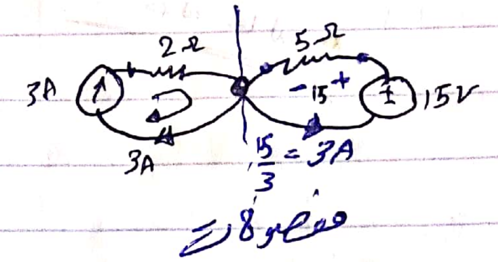
$I_{4\Omega}=2.5=\frac{10}{4}$

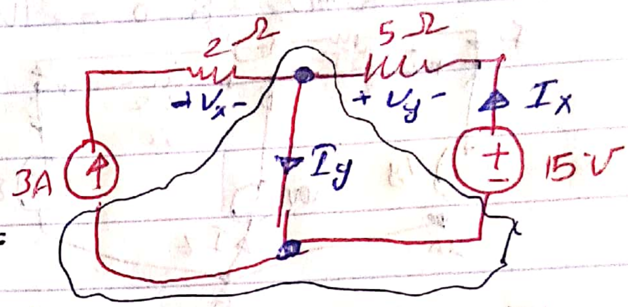
short cct and open cct :-

short cct (S.C) is cct element with Zero Resistance



a and b are within the same node

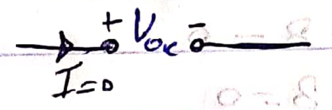


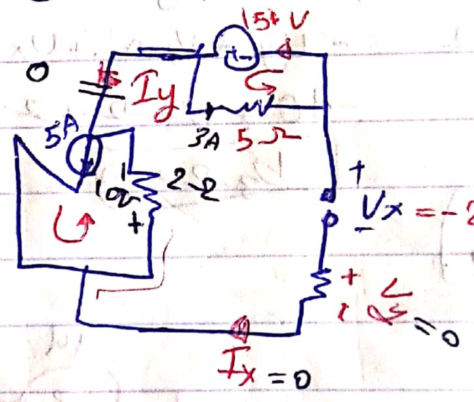


$I_y = 3+3 = 6A$

open cct : (O.C) :-

cct element with infinite Resistance $R=\infty$



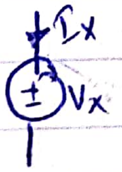


b
p
$25 = V_x$

$10 - 15 - V_x = 0$

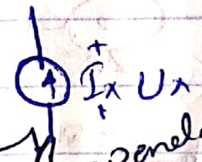
$V_x = -25$

cct Sources :-



Voltage source → independent, Dependent

current source → independent, dependent

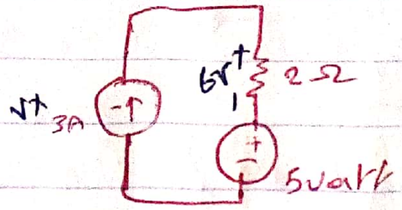


V.S

independent has constant Voltage with varying current according to the Load.

independent C.S has constant current with varying Voltage

Single Loop cct

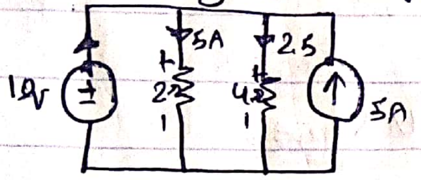


$V_x + 6 + 5 = 0$

$V_x = -11V$

if 2Ω → 3Ω
the voltage will change

Single Node pair

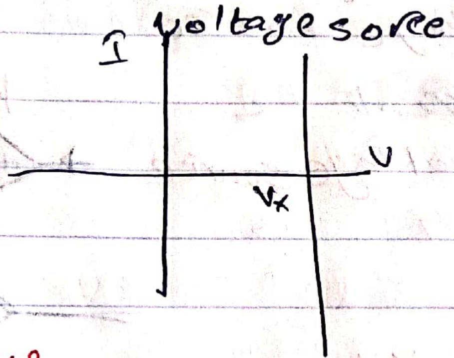


$I_{10} - 5A - 2.5A + 5A = 0$

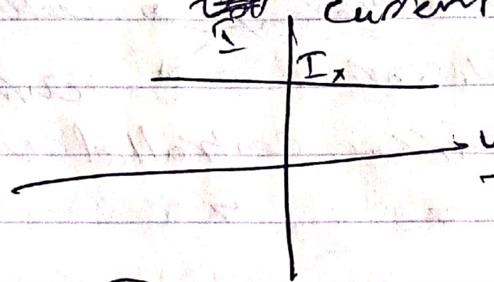
$\boxed{I_{10} = 2.5A}$

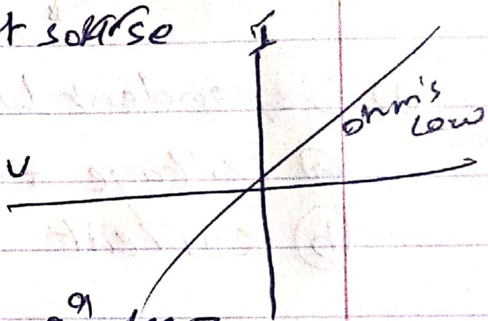
if 2Ω → 4Ω the voltage will change

voltage source



current source

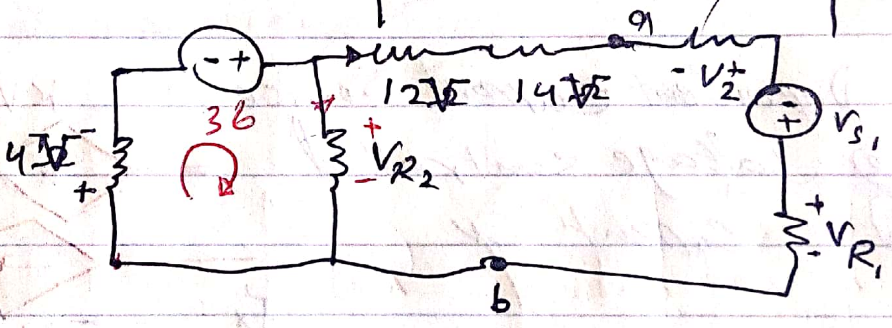




Ex 2

Find V_{R_2}

V_{ab}

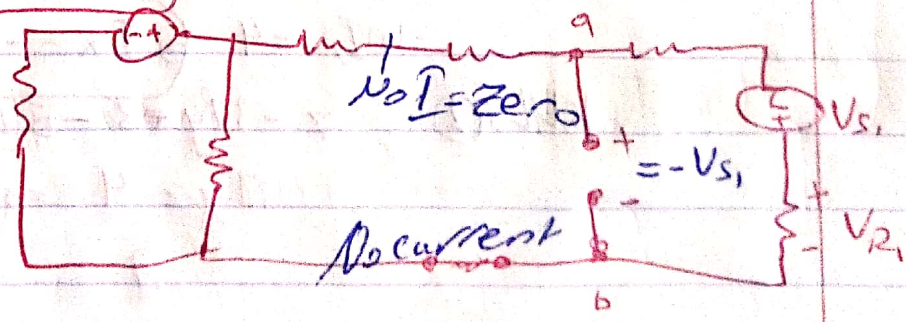


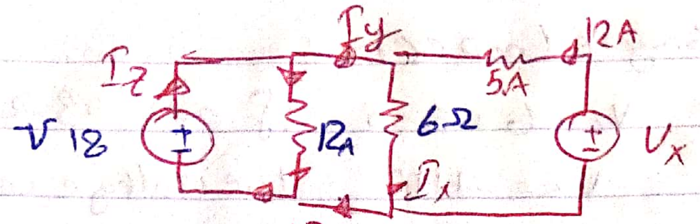
$\cancel{V} = -4 + 36 - V_{R_2} + \cancel{V}$

$\boxed{V_{R_2} = 32V}$

$V_b = \cancel{\quad} -4 + 36 - 12 - 14 + V_a$

$\boxed{V_{ab} = +6 \text{ Volt}}$





$I_x = \frac{18}{6} = 3A$

$12 - I_y - 3 = 0$

$\boxed{I_y = 9A}$

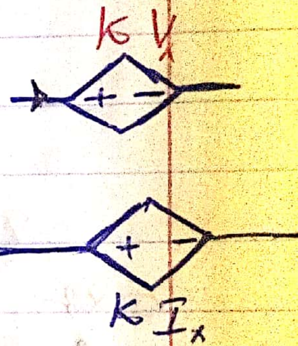
Sources → Independent → V. Source / Current Source

Sources → dependent → voltage source / current source

① Dependent V. Sorous

ⓐ Voltage ~~current~~ Controlled voltage source

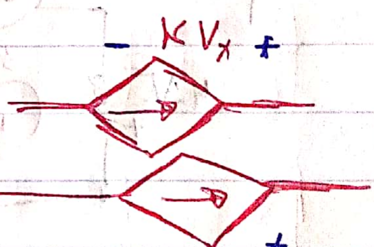
ⓑ current " " " "



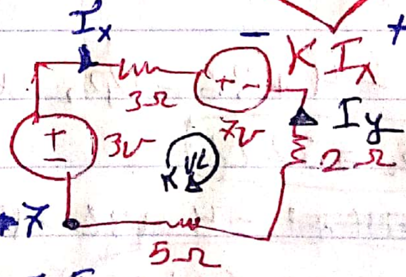
② Dependent current Source

ⓐ voltage controlled

ⓑ Current "



Single loop ckt.



KVL:- $+3 - 3I_x - 7$

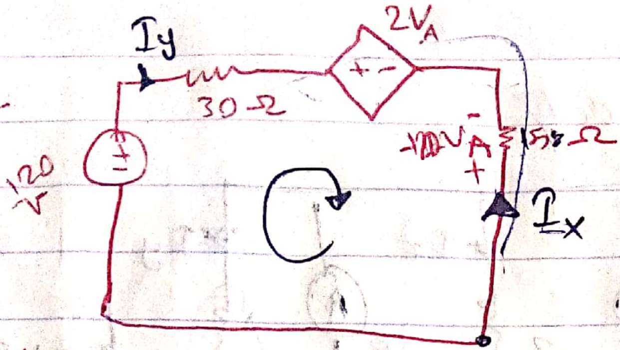
$- 2I_x - 5I_x = 0$

$-10I_x = 4 \Rightarrow \boxed{I_x = -0.4A}$

KVL ②: $7 - 3I_y - 3 - 5I_y - 2I_y = 0$

$10I_y = 4 \Rightarrow \boxed{I_y = 0.4A}$

Ex:-



$\boxed{I_x = \frac{V_A}{15}}$

$I_y = 8A$

Find V_A

$+V_A - 2V_A + 30\,\frac{V_A}{15} + 120 = 0$

$\boxed{V_A = 120\,V}$

$I = \frac{-120}{15} = -8\,A$

Sol I_y:

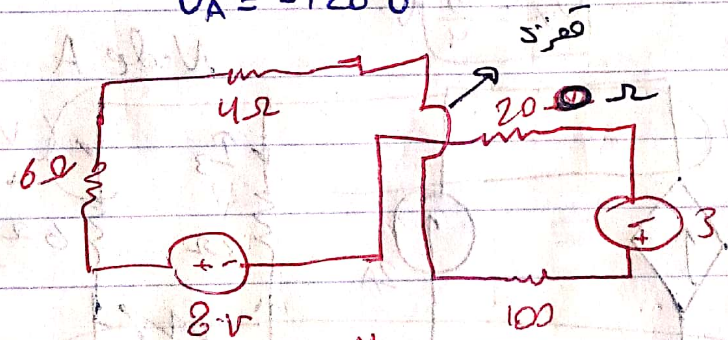
$-120 + 30 I_y + 2V_A + \underbrace{15 I_y}_{-V_A} = 0$

$15 I = -V$

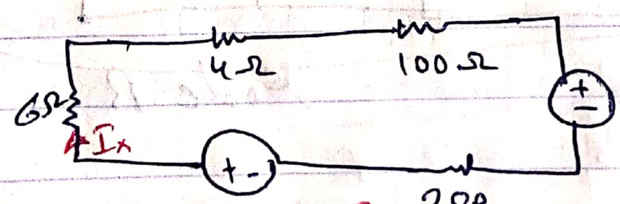
$I_y = 8A$

$V_A = -120\,V$

Ex:

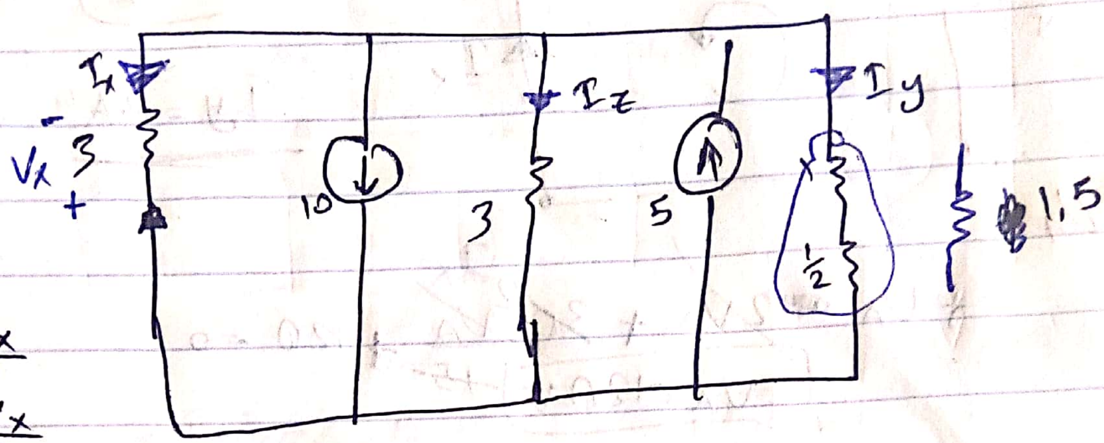


⇓



$60 I_x + 40 I_x + 100 I_x + 3 + 200 I_x - 8 = 0$ — (1)

Single Node pair cct



$I_x = -\frac{V_x}{3}$

$I_z = -\frac{V_x}{3}$

$I_y = -\frac{2V_x}{3}$

KCL

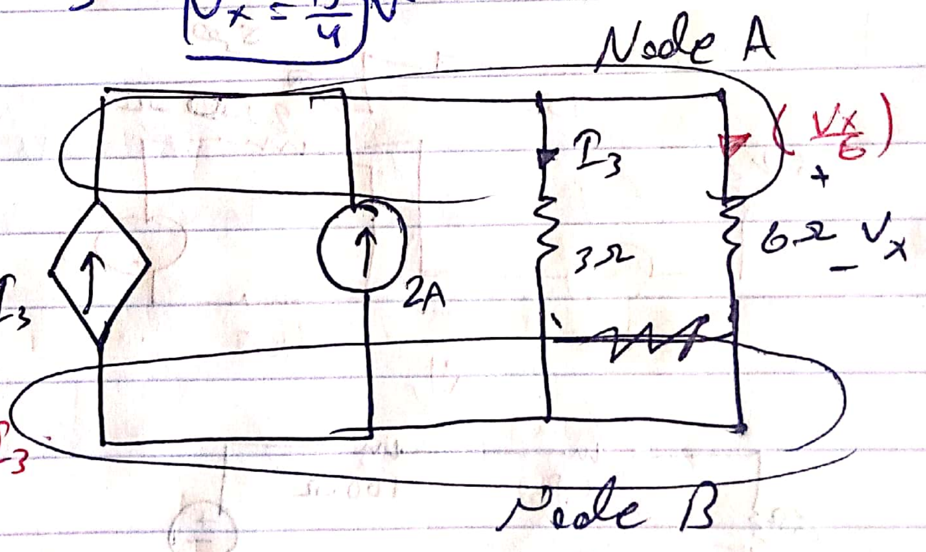
$$-I_x - 10 - I_z - I_y + 5 = 0$$

$$+\frac{V_x}{3} - 10 + \frac{V_x}{3} + \frac{2V_x}{3} + 5 = 0$$

$$\frac{4}{3} V_x = 5$$

$$\boxed{V_x = \frac{15}{4}\ V}$$

Ex:-



Final V_x & I_3

KCL_A :-

$$0.9 I_3 + 2 - I_3 - \frac{V_x}{6} = 0$$

$$I_3 = \frac{V_x}{3}$$

نفس الشئ

KCL_B :-

$$-0.9 I_3 - 2 + I_3 + \frac{V_x}{6} = 0$$

$$-0.9 \frac{V_x}{3} - 2 + \frac{V_x}{3} + \frac{V_x}{6} = 0$$

$$\frac{1.2 V_x}{6} = 2$$

$$\boxed{V_x = 10\ V}$$

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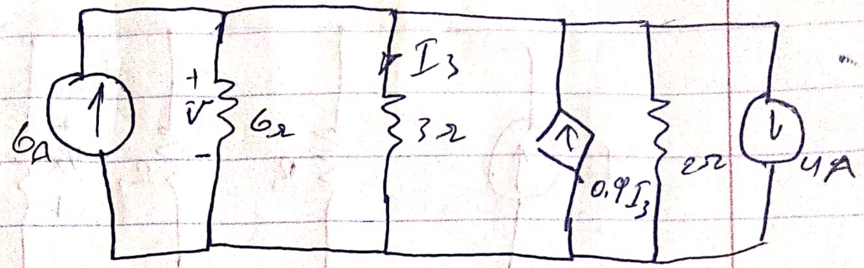
Ex



Find v, I_3

KCL: $+6 - \frac{v}{6} - I_3 + 0.9 I_3 - \frac{v}{2} - 4 = 0$

$\boxed{I_3 = \frac{v}{3}}$

$6 - \frac{v}{6} - \frac{v}{3} + 0.3 \frac{v}{3} - \frac{v}{2} - 4 = 0$

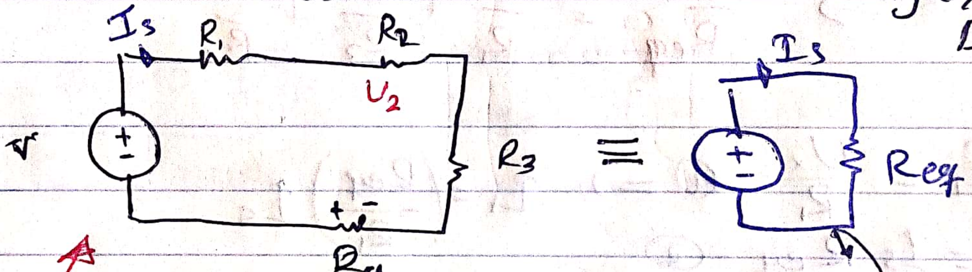
$-v + 0.3v = -2$

$+0.7v = +2$

$\boxed{v = \frac{20}{7} \text{ V}}$ تذكر

$\boxed{I_3 = \frac{20}{21} \text{ A}}$

Parallel and series Resistances and Voltage/Current Divider Rule-



$-V_s + I_s R_1 + I_s R_2 + I_s R_3 + I_s R_4 = 0$

$-V_s + I_s \underbrace{(R_1 + R_2 + R_3 + R_4)}_{R_{eq}} = 0$ —— (1)

$-V_s + I_s (R_{eq}) = 0$

$V_2 = I_s \cdot R_2$ —— (1)

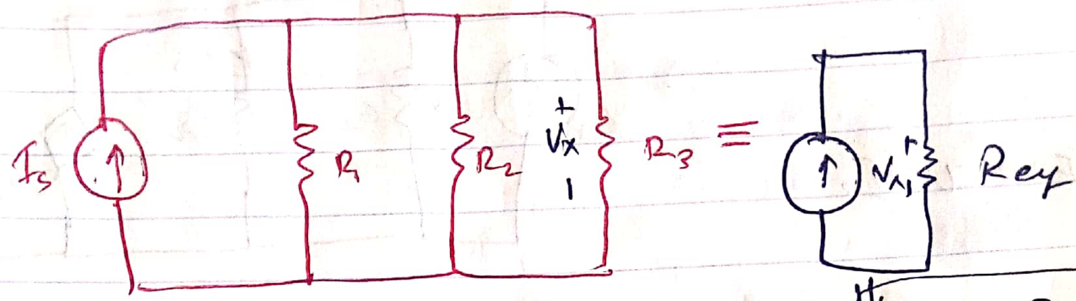
$I_s = \frac{V_s}{R_{eq}}$ —— (2)

$\Longrightarrow \boxed{V_2 = \left(\frac{R_2}{R_{eq}}\right) \cdot V_s}$

Voltage Divider Rule

+ لاحظ ~~[illegible]~~ من السلحفات زي R_4

$V_4 = -\left(\frac{R_4}{R_{eq}}\right) \cdot V_s$



$V_x = I_s \cdot R_{eq}$

kcl:

$$I_s - \frac{U_x}{R_1} - \frac{U_x}{R_2} - \frac{U_x}{R_3} = 0$$

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

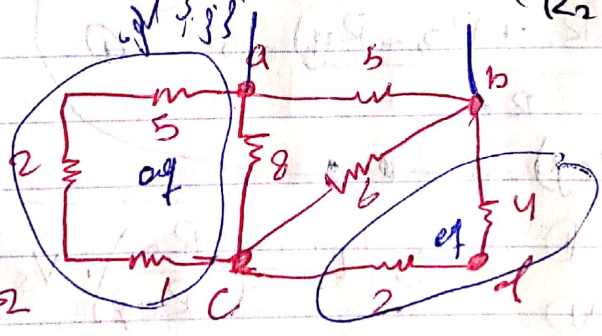
$$U_x = \frac{I_s}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)} \Rightarrow R_{eq} I_s = \frac{I_s}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

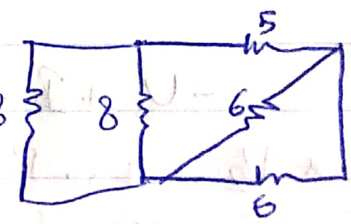
$$\Rightarrow \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$I_1 = \frac{U_x}{R_1} \quad (1) \Rightarrow I_1 = \left(\frac{R_{eq}}{R_1}\right) I_s$$

$$U_x = I_s R_{eq} \quad (2)$$

$$I_2 = \left(\frac{R_{eq}}{R_2}\right) I_s$$

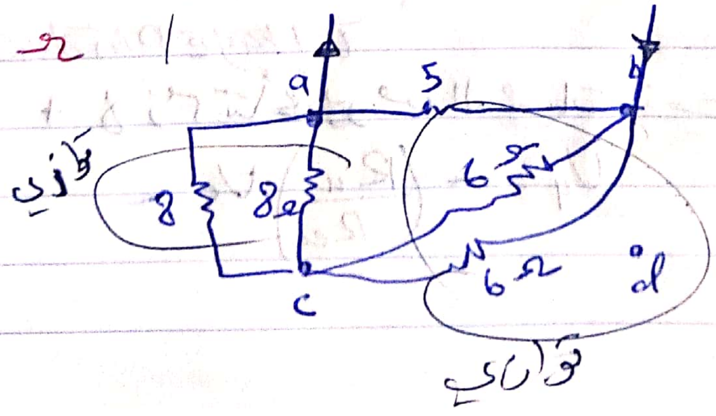




Rab

$R_{ac} = 2.4\ \Omega$

$R_{bc} = \frac{9}{4}\ \Omega$



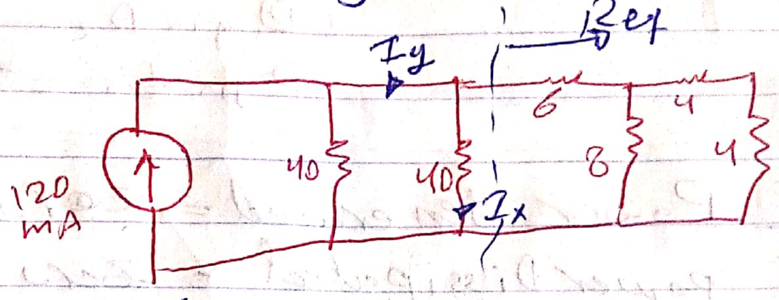
$$R_{ab} = \left[\underbrace{(8//8)}_{5+2+1} + \underbrace{(6//6)}_{4+2}\right] // 13$$

$$= \frac{35}{12}\ \Omega$$

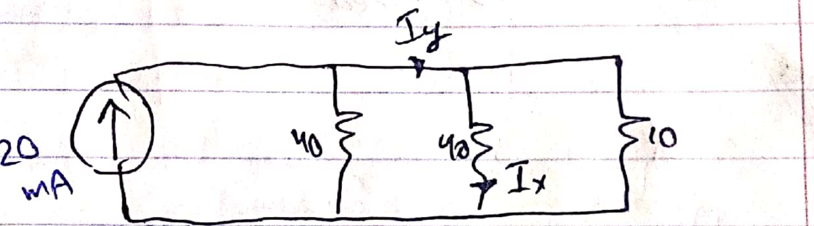
$$R_{AC} = \left[((4+2) // 6) + 3 \right] // 8 // (5+2+1)$$

$$R_{BC} = \left[((5+2+1) // 8) + 3 \right] // (6) // (4+2)$$

Ex



$$R_{eq} = \left[(4+4) // 8 \right] + 6 = 10\ \Omega$$



$$V = \frac{20}{\cancel{3}} \cdot \overset{40}{\cancel{120}} \times 10^{-3}$$

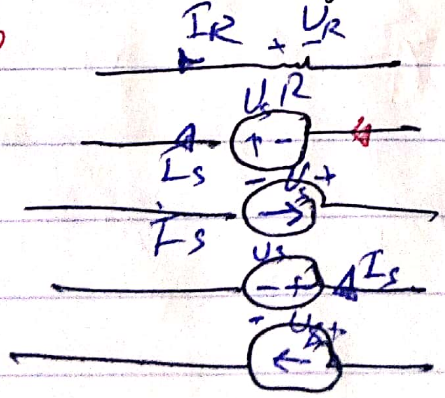
$$\boxed{V = 80 \times 10^{-3}\ V}$$

$$R_{eq_2} = \left[10 // 40 // 40 \right] = \frac{20}{3}$$

$$I_x = 80 \times 10^{-3} \left(\frac{20/3}{40} \right)$$

$$I_y = \frac{20/3}{40} \times 80 \times 10^{-3} + \frac{20/3}{10} \cdot 80 \times 10^{-3}\ A$$

Power Dissipated and Generated



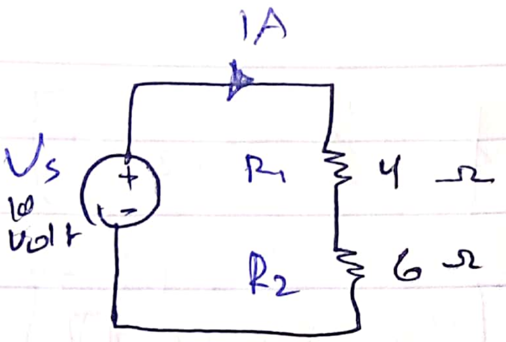
power Dissipated $= I_R \cdot V_A$ (+ve)

Power " $= I_s \cdot (-V_s)$ (−ve)

" " $= I_s(-V_s)$ (−ve)

" " $= I_s \cdot (+V_s)$ (+ve)

" " $I_s \cdot (+V_s) = +ve$



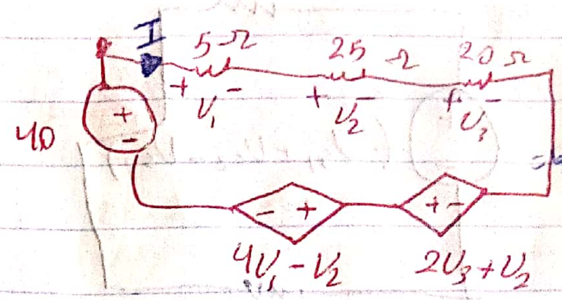
$P_{diss}\ R_1 = +4\ W$
$P_{diss}\ R_2 = +6\ W$ مستهلك
$P_{diss}\ V_s = -10\ W$

$P_{gin}\ R_1 = -4\ W$
$P_{gin}\ R_2 = -6\ W$ متولد
$P_{gin}\ V_s = +10\ W$

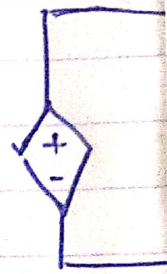
∞ $\sum$ Power generated = zero
$\sum$ power Dissipated = zero
$\sum$ power ginareted $\sum$ Power diss = zero

يوم الثلاثاء (اليوم العلمي) المحاضرة ملغية (25/6)

Ex:- Find power absourbes (consumed, dissipated) at each element



★ بنقدر نحل بصلة للـ O.A
بس لا زم نحلل القولطات زي مهي



KVL:-

$-40 + (2V_3 + V_2) + 4V_1 - V_2 + V_1 + V_2 + V_3 = 0$

$-40 - V_3 - V_2 + 5V_1 = 0$

But :- $V_1 = 5I$, $V_2 = 25I$, $V_3 = 20I$

then $40 = -20I \Rightarrow \boxed{I = -2A}$

$(40 + (2V_3 + V_2) - (4V_1 - V_2)$

Power diss for (40 V) $= (+2)(+40) = +80$ W

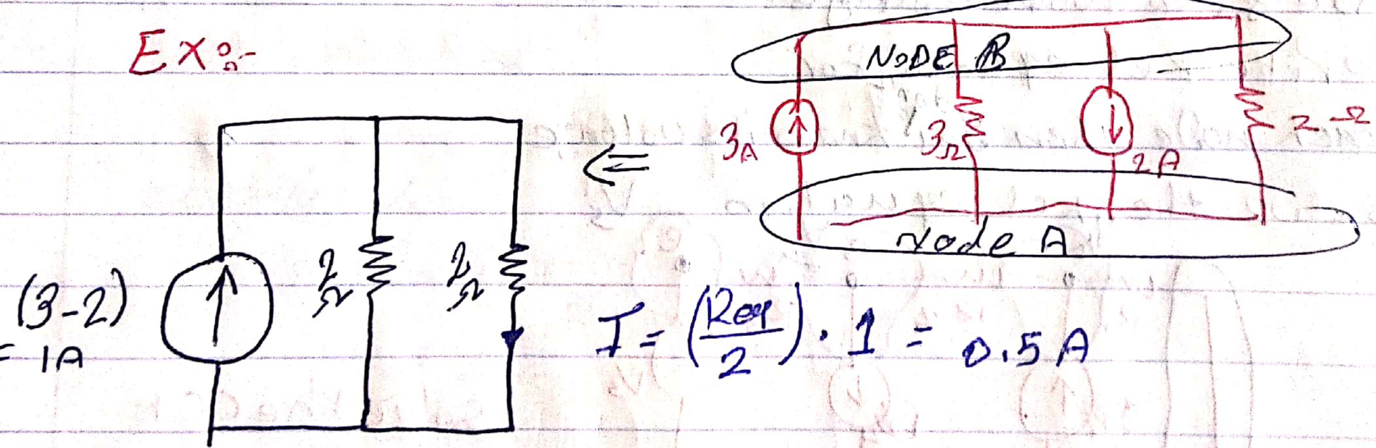
يعني Power genrated (40 V) $= -80$ W

$P_{diss\ (5\Omega)} = I^2 \cdot R = 25$ W

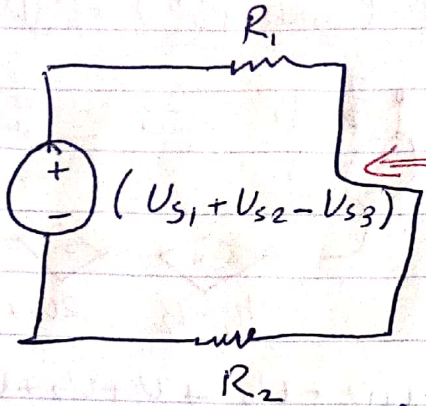
$P_{diss}(2V_3 + V_2) = (+2)(2V_3 + V_2) = 2(\underbrace{2(-20)(-2)}_{-80} + \underbrace{(25)(-2)}_{-50})$

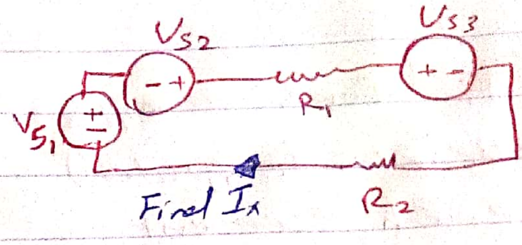
$P_{diss}(2V_3 + V_2) = -260$ W (هذا مولد للطاقة genrated)

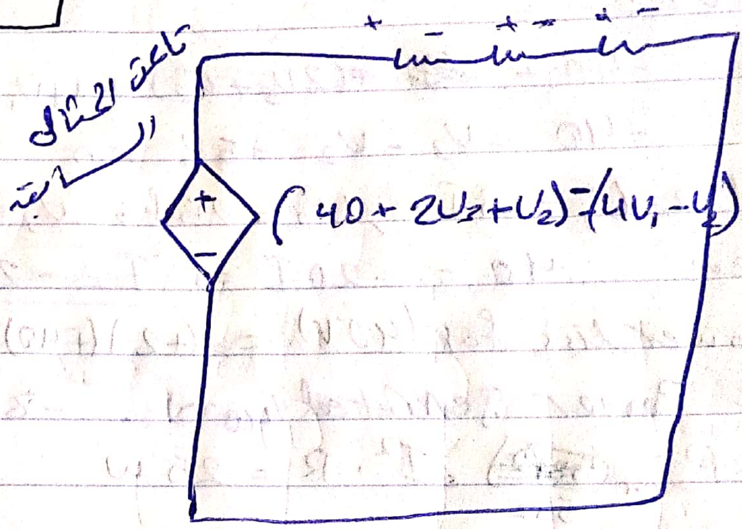
Ex:-



$I = \left(\frac{R_{eq}}{2}\right) \cdot 1 = 0.5A$



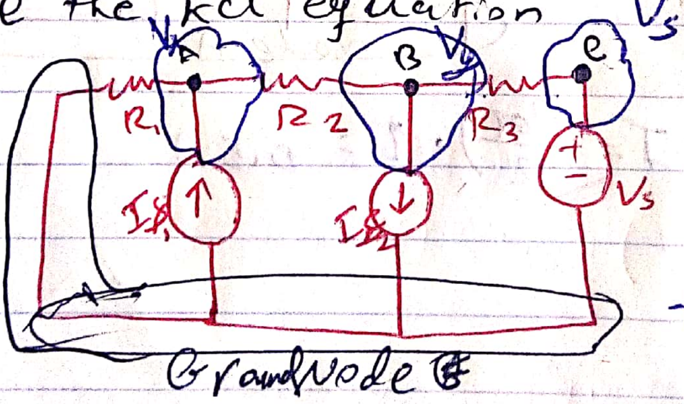




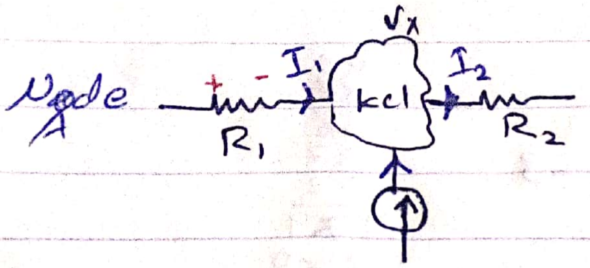
Nodal Analysis

1. Define the Nodes and the Ground Node
2. Define Node Voltage
3. write KCL equasion for each node then you don't know its Voltage
4. Solve the KCL equation

Ex



Solve the CCt to find All current s.



kcl:- $+I_1 + I_{S_1} - I_2 = 0$

① $\boxed{+\left(\frac{0 - V_x}{R_1}\right) + I_{S_1} - \left(\frac{V_x - V_y}{R_2}\right) = 0}$

Should be written using [illegible] variable

① [illegible] $\Longrightarrow$ $\left(-\frac{1}{R_1} - \frac{1}{R_2}\right) V_x + \left(\frac{1}{R_2}\right) V_y = -I_{S_1}$

Node B

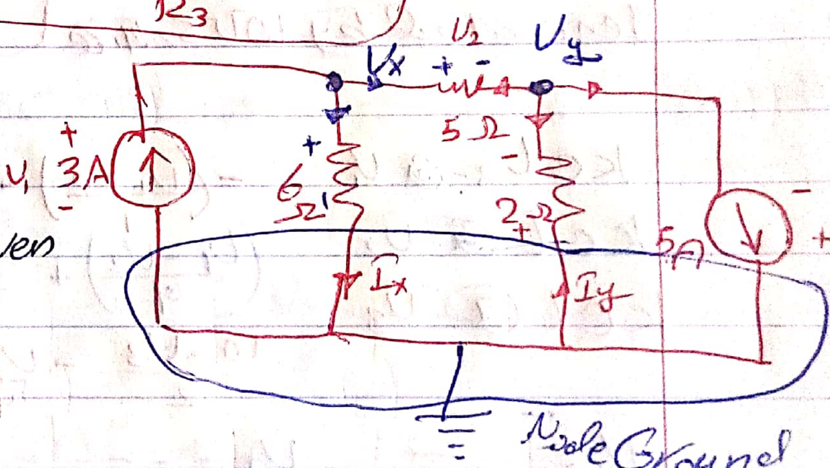
بنقدر نفرض اتجاه التيار، وبينطابق لجميع Nodes

$$-I_2 - I_{S2} + I_3 = 0$$

$$-\left(\frac{V_y - V_x}{R_2}\right) - I_{S2} + \left(\frac{V_S - V_y}{R_3}\right) = 0$$

$$\boxed{\left(-\frac{1}{R_2} - \frac{1}{R_3}\right) V_y + \frac{1}{R_2}(V_x) + \frac{V_S}{R_3} = I_{S2}} \text{ — ②}$$

Ex:-



the Ground should be given or identified.

kcl:- @ V_x

$$+3 - \left(\frac{V_x - 0}{6}\right) - \left(\frac{V_x - V_y}{5}\right) = 0$$

$$\boxed{+3 - \frac{11}{30} V_x + \frac{V_y}{5} = 0} \text{ — ①}$$

kcl:- @ V_x

$$-\left(\frac{V_y - V_x}{5}\right) - 5 - \left(\frac{V_y - 0}{2}\right) = 0$$

$\frac{11}{6}$ * $\boxed{-\frac{7}{10} V_y + \frac{V_x}{5} = 5}$ — ②

$$-\frac{77}{60} V_y + \frac{11}{30} V_x = \frac{55}{6}$$

① + ②

$$-\frac{77}{60}U_y + \frac{U_y}{5} = \frac{55}{6} - 3$$

$$-\frac{\cancel{65}^{13} U_y}{\cancel{60}_{12}} = 37$$

$$U_y = -\frac{444}{13} \, V$$

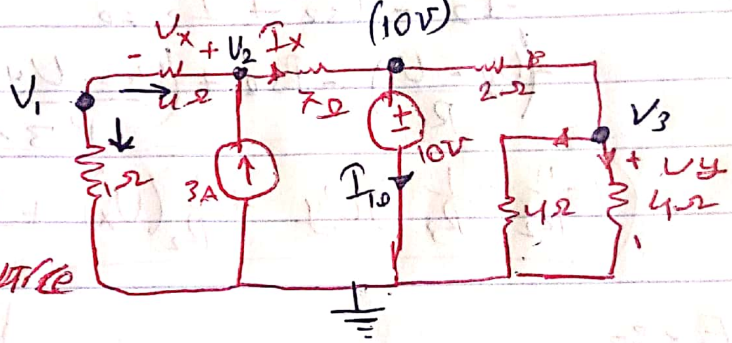
$U_1 = U_x - 0$, $I_x = \frac{U_x - 0}{6}$

$I_y = \frac{0 - U_y}{2}$ $U_2 = 0 - U_y$

Ex 2:-

الحل المختصر

Find U_x, U_y, I_x, Power generated by 10V source



kcl :- @ U_1 $-\left(\frac{U_1 - 0}{1}\right) - \left(\frac{U_1 - V_2}{4}\right) = 0 \Rightarrow \frac{5U_1}{4} = \frac{U_2}{4}$ — ①

kcl @ U_2 $\left(\frac{U_1 - U_2}{4}\right) + 3 - \left(\frac{U_2 - 10}{7}\right) = 0 \Rightarrow \boxed{-\frac{13}{28}U_2 + \frac{U_1}{4} = -\frac{31}{7}}$ ②

kcl @ U_3 $\frac{10 - U_3}{2} - \frac{U_3}{4} - \frac{U_3}{4} = 0 \Rightarrow \boxed{U_3 = 5\,V}$

$V_1 =$ ____ $U_2 =$ ____ $V_3 =$ ____

$U_x = U_2 - U_1$ $I_x = \frac{U_2 - 10}{7}$ $U_y = V_3 - 0$

Apply kcl @ (10 Volts)

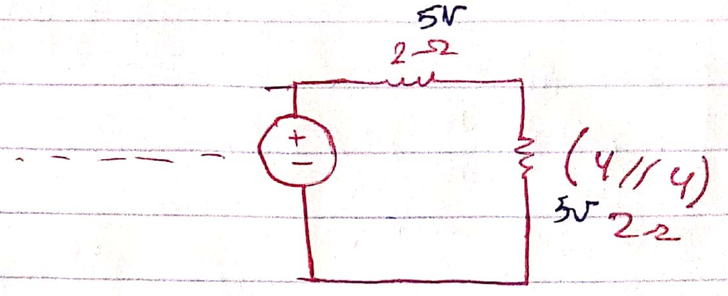
$$\left(\frac{U_2 - 10}{7}\right) - I_{10} - \left(\frac{10 - V_3}{2}\right) = 0$$

$$\Rightarrow I_{10} = \frac{U_2}{7} + \frac{V_3}{2} - \frac{45}{7}$$

$P_{diss} = I_{10}(+10)$ $P_{gin} = -I_{10}(+10)$

$$\boxed{U_1 = \left(\frac{1}{1+4}\right)U_2}$$

الحل البسيط

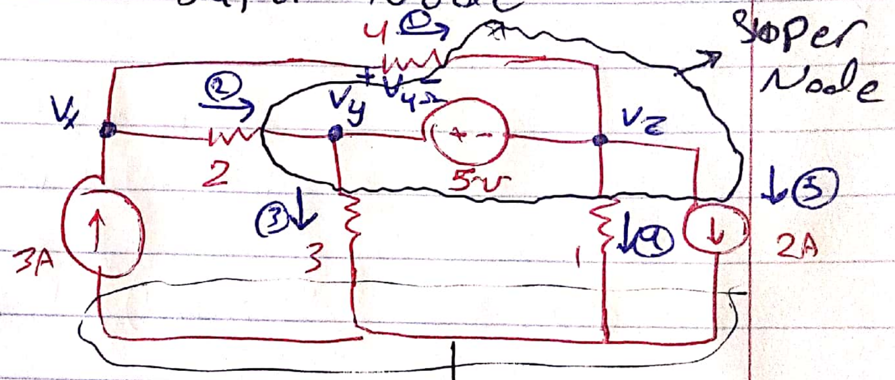


$$V_{2\Omega} = \frac{2}{4}(10) = 5V$$

Ex 8-

Ground بتقدر تحط ★ وين ما بدك بس حاول تحطه عند يكون فيه أقل عدد من المجاهيل

Super-Node



KCL @ Vx:-

$$3 - \left(\frac{V_x - V_y}{2}\right) - \left(\frac{V_x - V_z}{4}\right) = 0 \quad (1)$$

السوبر node هي تجمع لـ اثنين من node لا نستطيع معرفة التيار بينهما (بدلالة الجهود)

KCL @ SuperNode:-

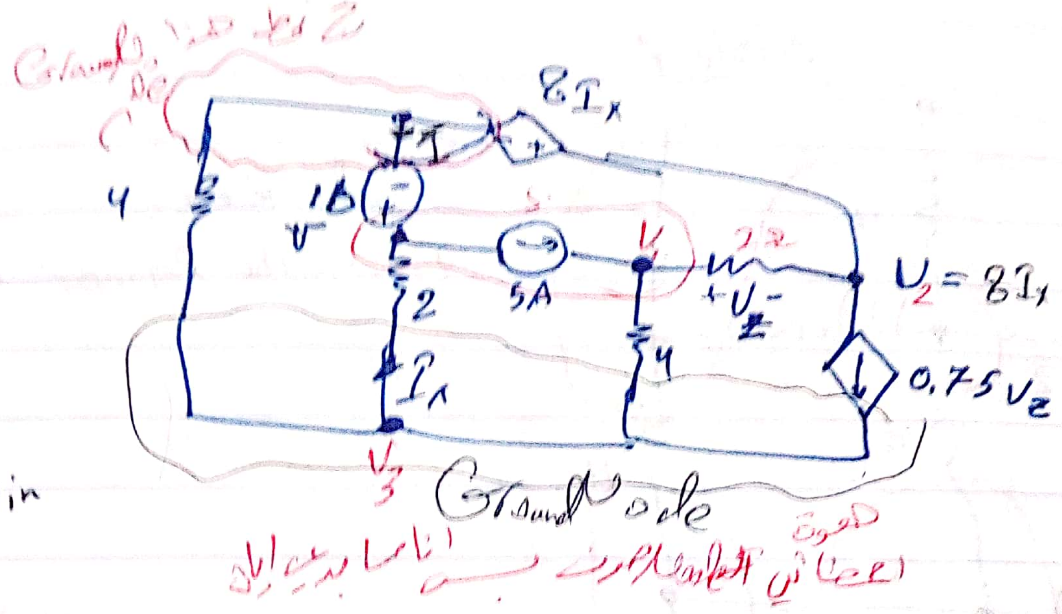
$$\left(\frac{V_x - V_z}{4}\right) + \left(\frac{V_x - V_y}{2}\right) - \frac{V_y}{3} - \frac{V_z}{1} - 2 = 0 \quad (2)$$

Voltage But source eq

$$\boxed{V_y - V_z = 5V} \quad (3)$$

$\Rightarrow$ $V_x =$
$V_y =$
$V_z =$
$V_{4\Omega} =$

كل الحظ نوعين الأول



KCL @ V_3 :-

$$\left(\frac{0-V_3}{4}\right) - \left(\frac{V_3-16}{2}\right) - \left(\frac{V_3-V_1}{4}\right) + 0.75 V_z = 0$$

$$\boxed{V_3 + 8 + \frac{V_1}{4} + 0.75 V_z = 0}$$

$(V_2 - V_3)$

KCL @ V_1

$$5 - \left(\frac{V_1-V_2}{2}\right) - \left(\frac{V_1-V_3}{4}\right) = 0$$

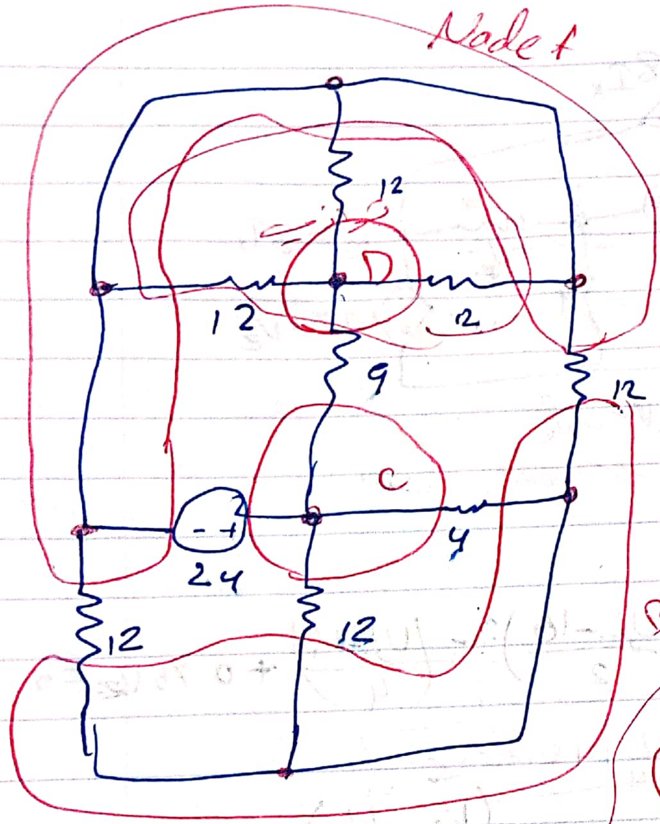
$$\boxed{5 - 0.75 V_1 - 0.5 V_2 - 0.25 V_3 = 0}$$

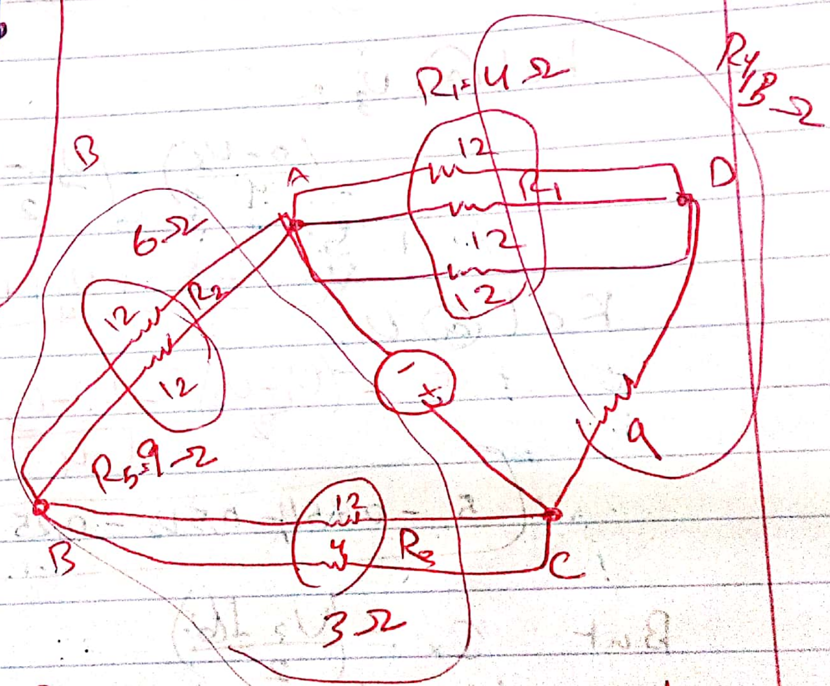
But $I_x = \left(\frac{V_3 - 16}{2}\right)$

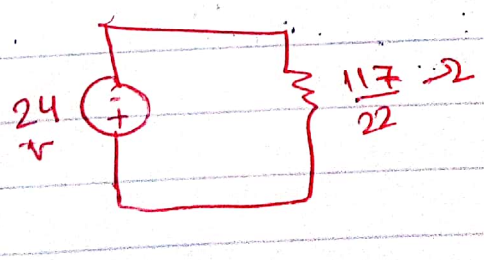
$V_2 = 4(V_3 - 16)$

Find Req

Find the P_g inear by 24V source







$\frac{27}{90}$ $\frac{1}{9} + \frac{1}{13}$ $\frac{22}{117}$

$R_1 = 12 // 12 // 12 = 4\,\Omega$

$R_2 = 12 // 12 = 6\,\Omega$

$R_3 = 12 // 4 = 3\,\Omega$

$R_4 = 4 + 9 = 13\,\Omega$

$R_5 = 6 + 3 = 9\,\Omega$

$R_{eq} = 13 // 9 = \frac{117}{22}\,\Omega$

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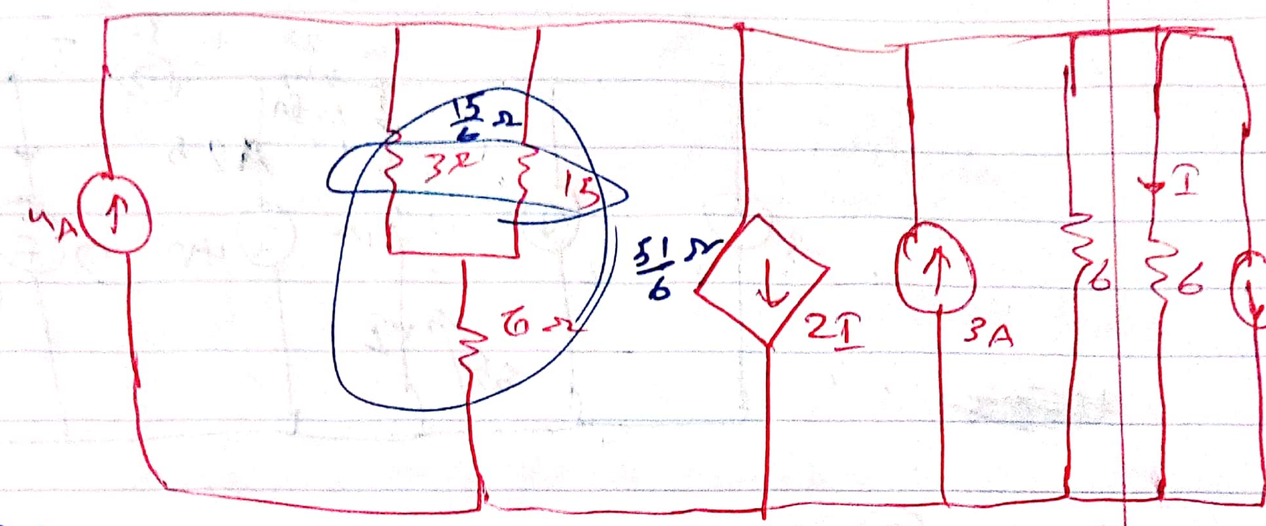
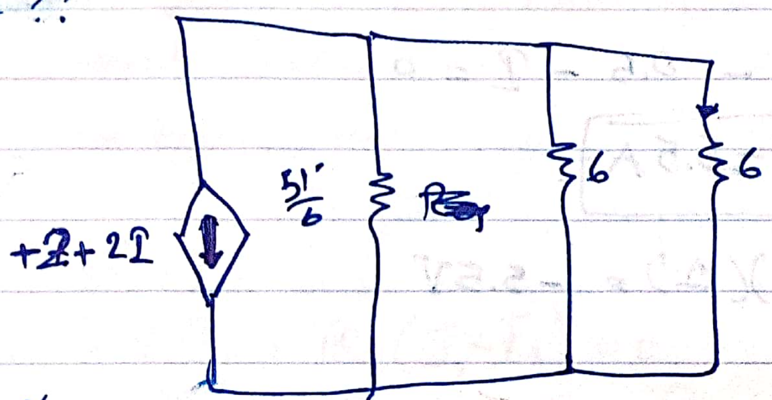
$$\frac{36+15}{51}$$



Find I ??

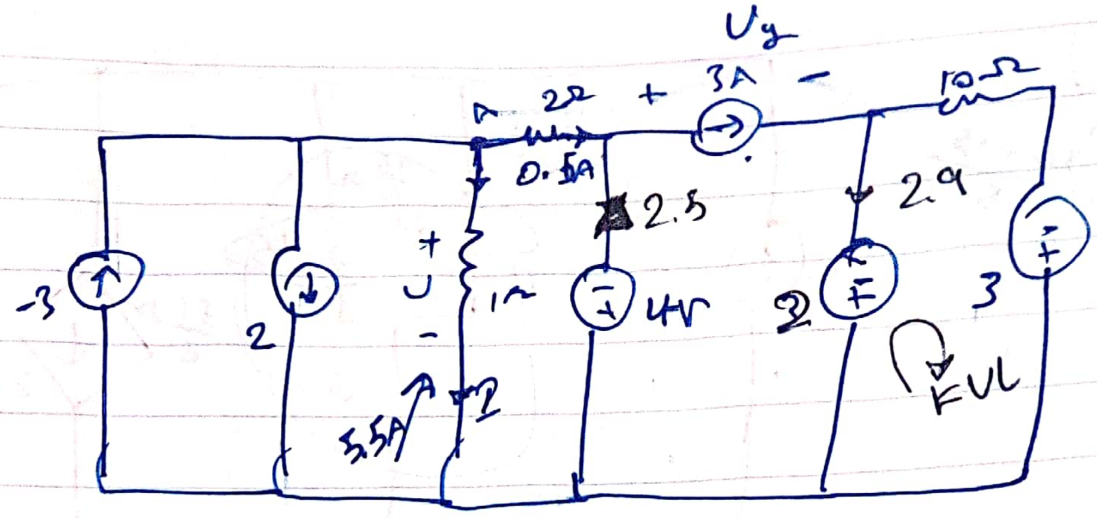


$$\frac{6}{51} + \frac{2}{3}$$

$$\frac{18+51}{153} = \left(\frac{69}{153}\right)$$

$$V = \frac{69}{153}(2+2I)$$

$$\frac{I}{2} = \frac{69}{153}(2+2I) \rightarrow I = ??$$



KCL @ A

$$-3+2-0.5-I=0$$

$$\boxed{I=-5.5A}$$

$$U=-(5.5)(1)=-5.5V$$

KVL $\quad +2-3+10I=0$

$$\boxed{I=0.1}$$

KCL

$$I_{2v}=+3-0.1=2.9$$

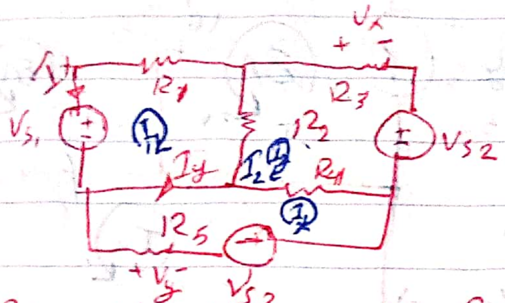
KVL

$$+U_y+4-2=0$$

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

MECH Analysis

Ex



الحل بال: KVL, KCL, current Divider, Voltage Divider, Req

Systematic Methods to solve cct: Nodal, MECH, Superposition

خطوات الحل MECH

1. Define the Meshes and Mesh currents.
2. Apply KVL for MESHES that you don't know it's current value.
3. Solve the KVL eq.

KVL @ MECH I :-

$$-V_{s1} + R_1 I_1 + R_2(I_1 - I_2) = 0$$

$$(R_1 + R_2) I_1 - R_2 I_2 = V_{s1} \quad \text{—— (1)}$$

KVL @ MECH II :-

$$R_2(I_2 - I_1) + R_3 I_2 + V_{s2} + R_4(I_2 - I_3) = 0$$

$$(R_2 + R_3 + R_4) I_2 - R_2 I_1 - R_4 I_3 = -V_{s2} \quad \text{—— (2)}$$

KVL @ MECH III

$$V_{s3} + I_3 R_5 + (I_3 - I_2) R_4 = 0$$

$$(R_5 + R_4) I_3 - I_2 R_4 = -V_{s3} \quad \text{—— (3)}$$

$I_1 = -$ $\quad I_2 = -$ $\quad I_3 = -$

$I_x = I_1 \qquad I_y = I_3 - I_1$

$V_y = -I_3 \cdot R_5$

P_{diss} by $V_{s2} = I_2 V_{s2}$

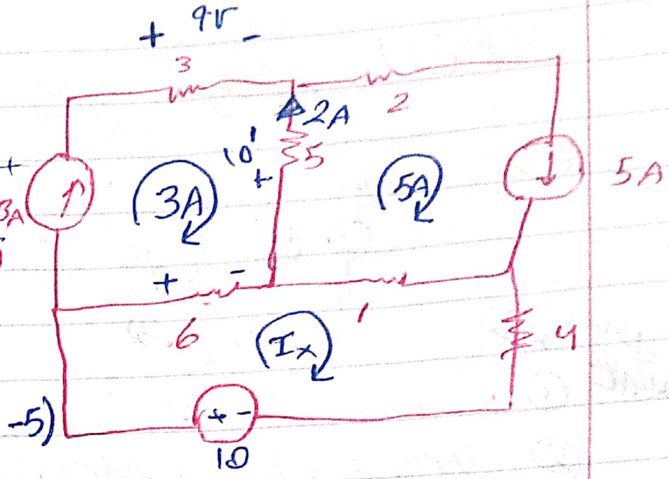
$P_{gin\,by\,V_{s3}} = -I_3 \cdot V_{s3}$

Ex
Find Power generated by 5A

C.S $= -(-V_y \cdot 3)$ V_y

Dissipated by 5A

$=$



KVL @ I_x

$$-28 \quad -5 \quad 33$$

$$-10 + 6(I_x - 3) + 1(I_x - 5) + 4I_x = 0$$

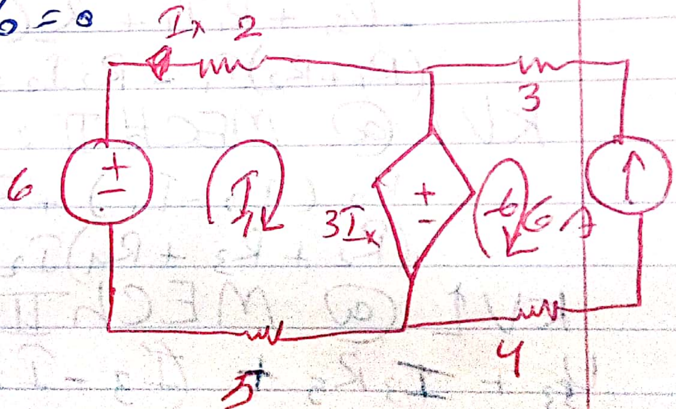
$$11 I_x = +33$$

$$\boxed{I_x = 3A}$$

KVL.

$$-V_y + 9 - 10 - (I_x - 3)6 = 0$$

Ex 8-



$$I_1 = -I_x$$

KVL @ MI

$$-6 + 2I_1 + 3(-I_1) + 5I_1 = 0$$

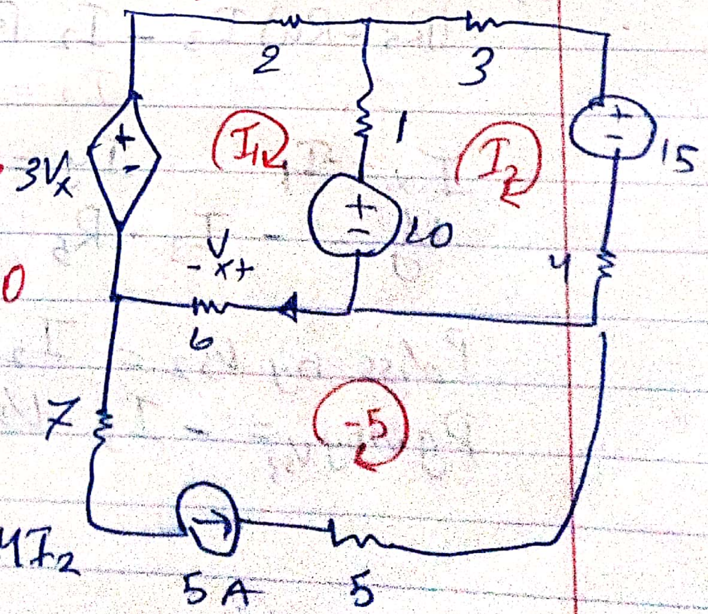
$$4I_1 = 6$$

$$\boxed{I_1 = 1.5\ A}$$

Ex 8-

$V_x =$

$(I_1 + 5)6$



KVL at MI

$$-3((I_1+5)6) + 2I_1 + (I_1 - I_2) + 10 + 6(I_1+5) = 0 \quad \text{---} \quad (1)$$

$$\cancel{+9I_1 + I_2 = 10} \quad (1)$$

KVL @ MII

$$-10 + (I_2 - I_1) + 3I_2 + 15 + 4I_2 = 0 \quad \text{---} \quad (2)$$

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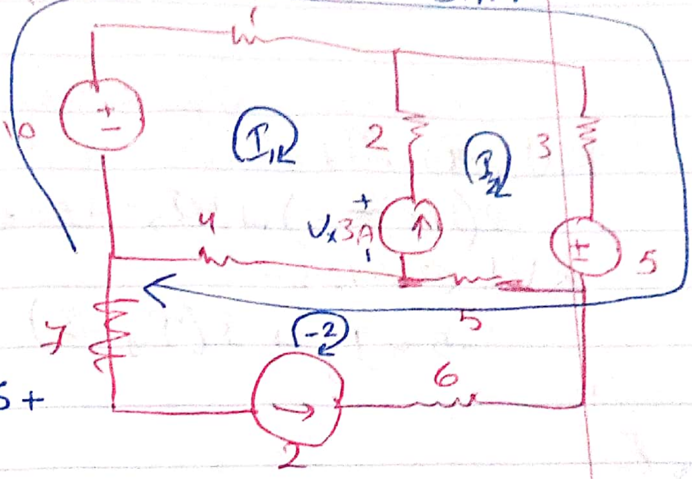
* ملاحظة نقدر نغير محل الأشياء إلى ع الدوائر

S.m

Ex

KVL @ M1 :-

$-10 + I_1 + 2(\overbrace{I_1 - I_2}^{-3A}) + V_x + 4(I_1+2) = 0$ —— ①



KVL @ M2 :-

$-V_x + 2(\overbrace{I_2 - I_1}^{3A}) + 3I_2 + 5 + 5(I_2+2) = 0$ —— ②

Since we have current source between two MESHES (I_1, I_2)

$\boxed{3 = I_2 - I_1}$ —— ③

$I_1 = \text{---}$ $I_2 = \text{---}$

$V_x = \text{---}$

we have Super Mesh (if we have a current source between two meshes)

* لما يكون في مصدر تيار بين مشين

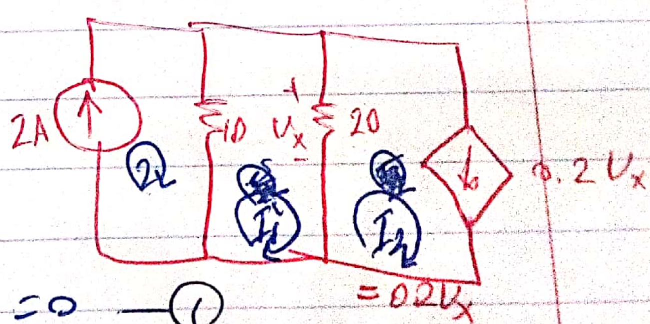
KVL @ S.m

$-10 + I_1 + 3I_2 + 5 + 5(I_2+2) + 4(I_1+2) = 0$ —— ④

ع هي نفس المعادلة جمع معادلة ②+①

$3 = I_2 - I_1$ —— ③

Ex :-



KVL @ M1 :-

$10(I_1 - 2) + 20(I_1 - 0.2V_x) = 0$ —— ①

But $V_x = 10(2 - I_1)$ —— ②

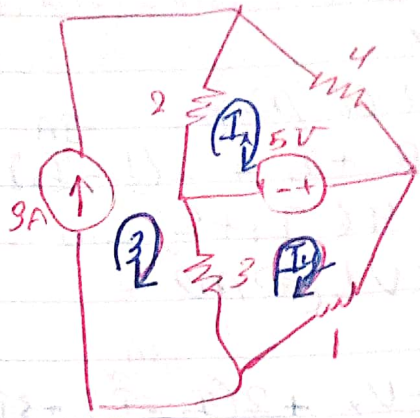
$I_1 = \text{---}$ $V_x = \text{---}$

KVL @ M_1:-

$$2(I_x - 3) + 4I_x + 5 = 0$$

KVL @ M_2:-

$$-5 + I_y + 3(I_y - 3) = 0$$



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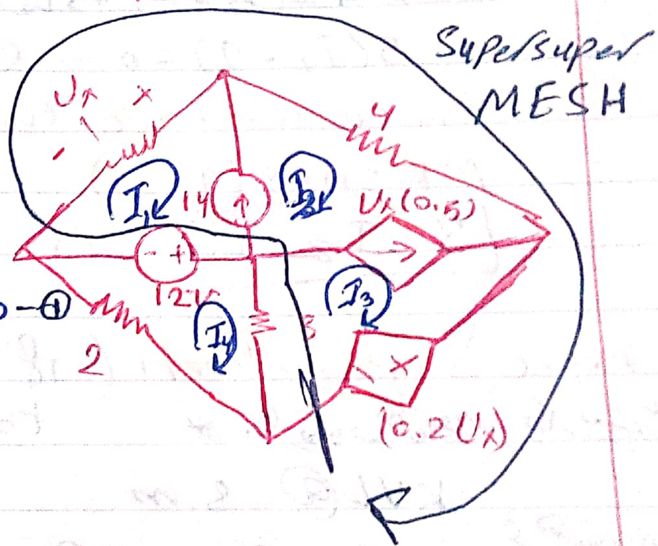


KVL @ super super MESH

$$3(I_3 - I_4) + 12 + I_1(1) + 4I_2 + 0.2U_x = 0 \quad (1)$$

$$I_2 - I_1 = 14 \quad (2)$$

$$I_3 - I_2 = 0.5U_x \quad (3)$$

But $U_x = -I_1(1)$

KVL @ - I_4

$$2I_4 - 12 + 3(I_4 - I_3) = 0 \quad (4)$$

Scanned by CamScanner

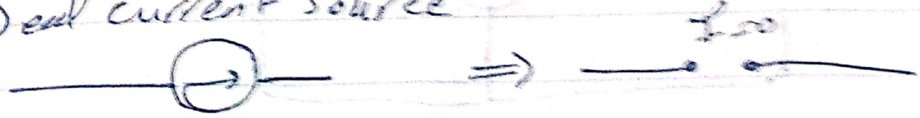
Super position :-

the value of a response (voltage) or current in a cct. is a linear sum of Responses (currents, voltages) each one of them is due to our single active source.

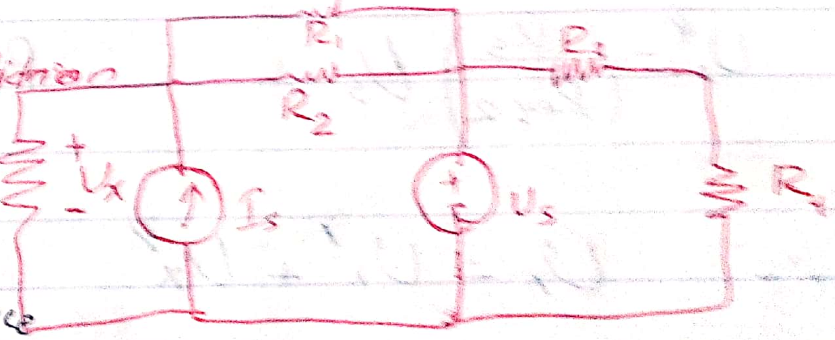
مع الـ source سيكون وباقي كل الـ sources غيرها

Dead voltage source

Dead current source



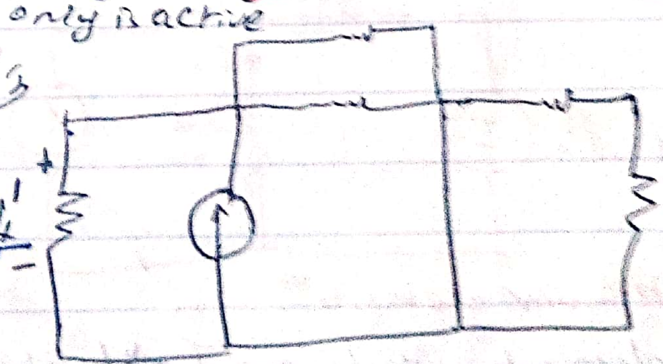
Find V_x using superposition



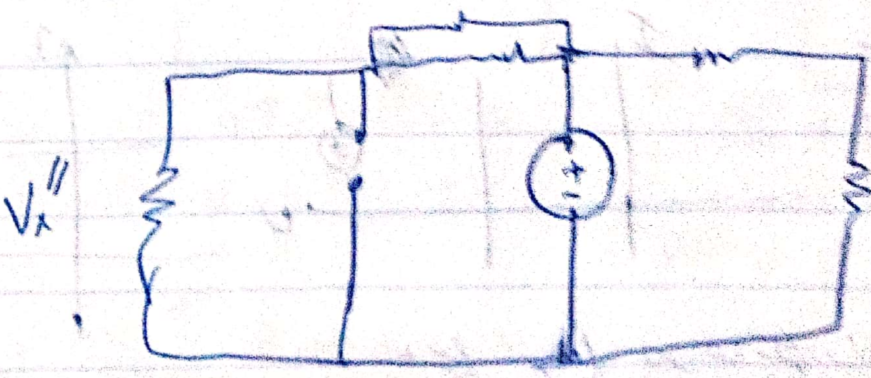
(*) C.S is active only

(∝) Voltage source only is active

(*)

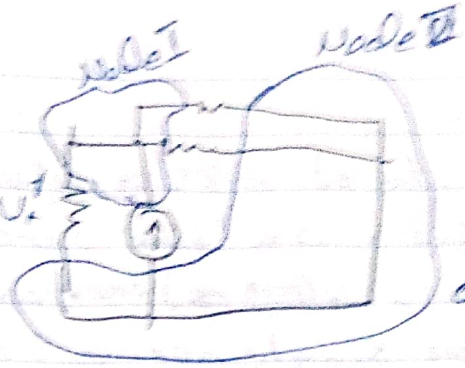


(∝)



الحل

(*)

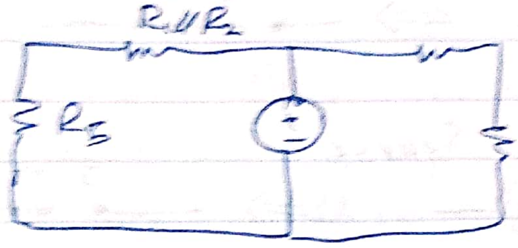


الاربع مقاومات
ع التوازي
ح نستخدم current divider
$R_{eq} = R_5 \parallel R_1 \parallel R_2$

$$V_x'' = I_{R_5} \cdot (R_5) = \frac{R_{eq}}{R_5} \cdot I_s \cdot \cancel{R_5} = R_{eq}\, I_s$$

نفس المقاومات
ع التوازي

(∞)

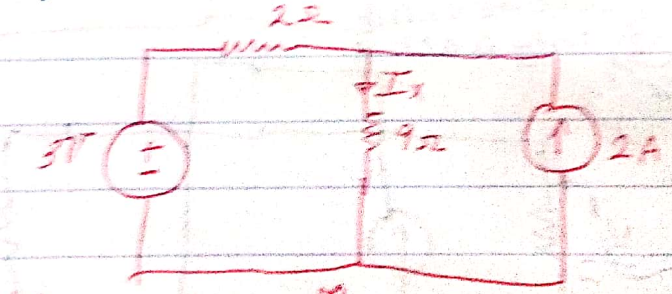


$$V_x'' = \left(\frac{R_5}{R_{eq\,2}}\right) V_s$$

$R_{eq_2} = R_5 - (R_1 \parallel R_2)$

$$\therefore \quad V_x = V_x' + V_x''$$

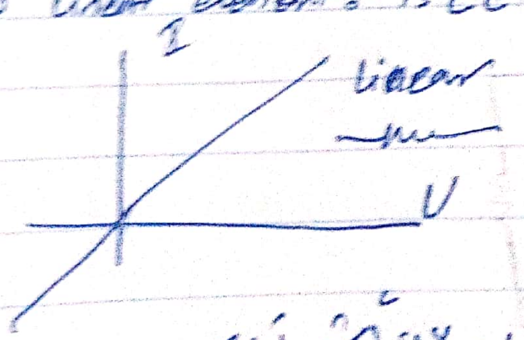
Ex:- Find I_x

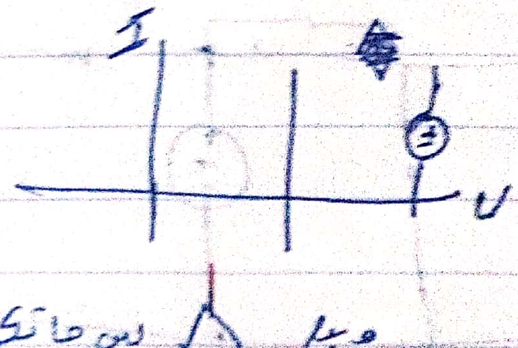


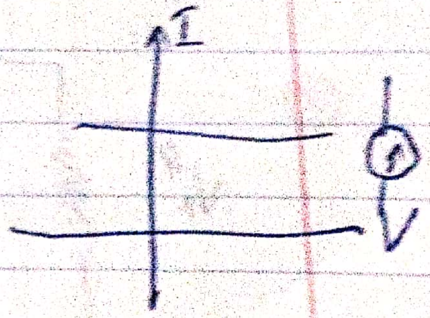
we use superpositon only for linear* cct.

* linear cct:- is a cc with linear element∞

∞ linear element:- is cc element with liner I-V characteristics

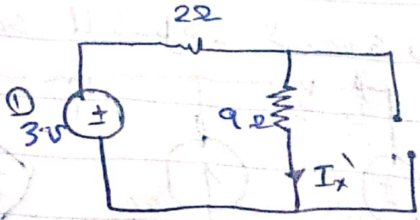






مثلا  بس ما نكتب بدلالة اشو نريد

solve Ex



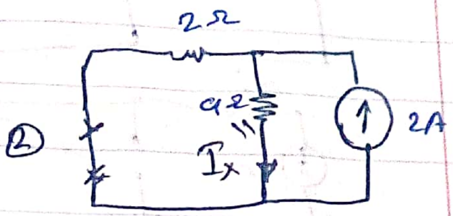
$$I_x' = \frac{3}{11}$$

السـ

$$I_x'' = \left(\frac{2}{11} \cdot 2\right) = \frac{4}{11}$$

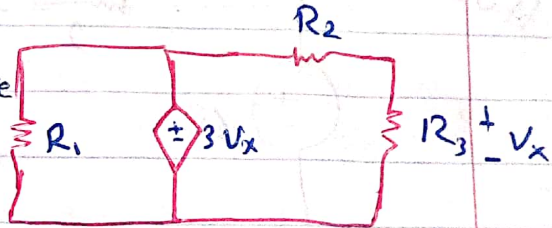
$$or = \left(\frac{R_{eq}}{9}\right) \cdot 2 \qquad R_{eq} = \frac{2(9)}{11}$$

$$I_x = \frac{7}{11} = \frac{4}{11} + \frac{3}{11}$$



Ex : find the current in this cct

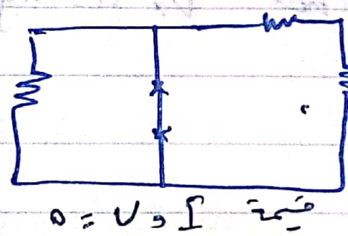
this cct is passive
(Resistive cct)



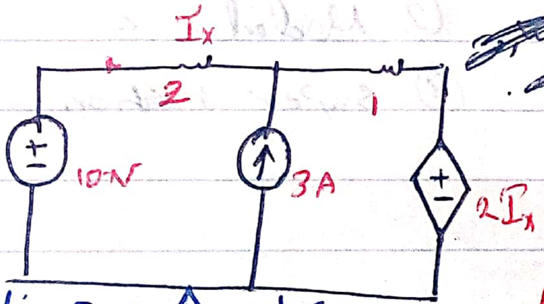
$$V_x = \frac{R_3}{(R_2+R_3)} \, 3V_x \Rightarrow V_x = 0$$

دائرة ميتة)

المكافئ

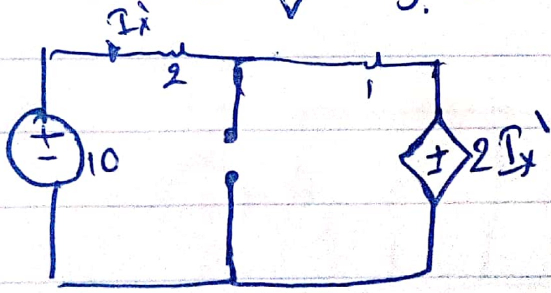


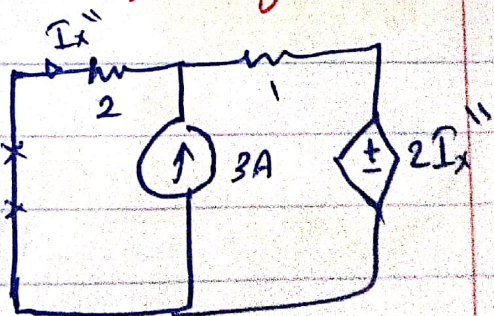
Ex:-



نعتبر ان (±) ميت فلا ~~[illegible]~~ نلغيه

Find I_x using S.P





KVL

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

$$5I_x' = 10 \Rightarrow I_x' = 2A$$

KCL

$$I_x'' + 3 - I_y = 0$$

$$I_y = I_x'' + 3 \quad — ①$$

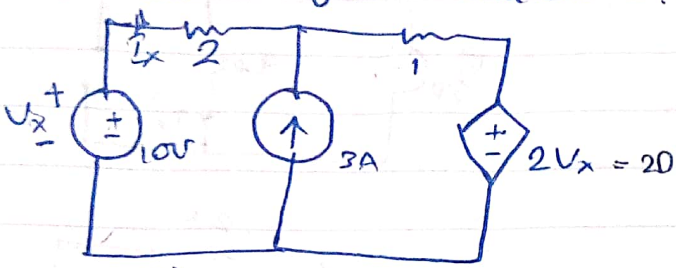
KVL

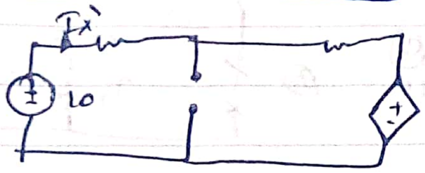
$$2I_x'' + I_x'' + 3 + 2I_x'' = 0$$

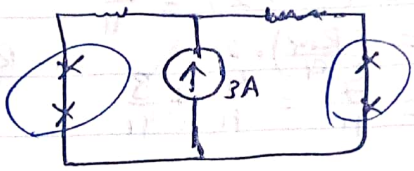
$$I_x'' = -0.6A$$

$$\therefore I_x^* = 2 - 0.6 = 1.4A$$

اذا خط لل (±) متغير ثابت لل soRce لما نقتل هذا ال Source رح نقتل (±) لانو رح يصير زيه

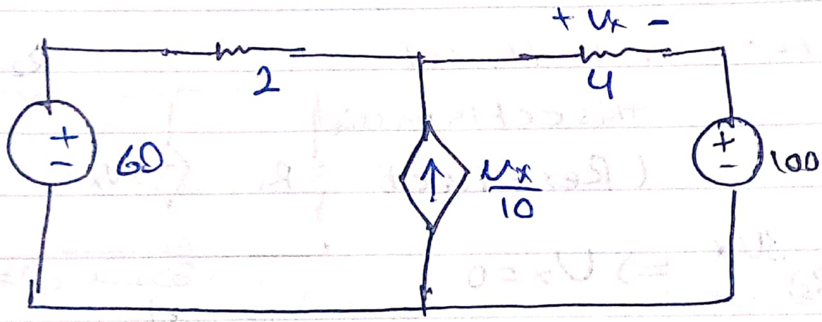






صفر

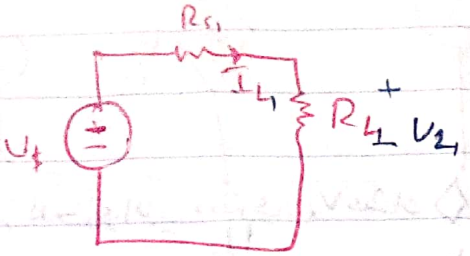
H.W

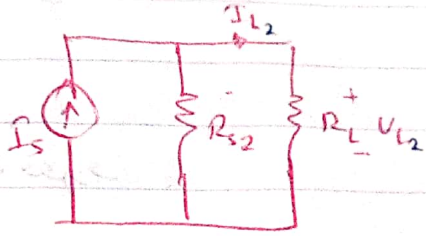


Find V_x using:-

1. Mesh Analysis
2. Nodal "
3. Super Position

Source Teransformation





$$I_{L_1} = \frac{V_s}{R_{s_1} + R_L}$$

$$V_{L_1} = I_L \cdot R_L$$

$$I_{L_2} = \left[\frac{\frac{R_{s_2} \cdot R_L}{R_{s2} + R_L}}{R_L}\right) \cdot I_s$$

$$= \left(\frac{R_{s_2}}{R_{s_2} + R_L}\right) \cdot I_s$$

$$V_{L_2} = \left(\frac{R_{s_2} R_L}{R_{s_2} + R_L}\right) \cdot I_s$$

when we get $I_{L_1} = I_{L_2}$?

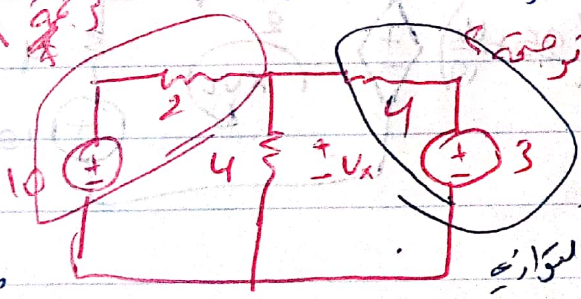
or $V_{L_1} = V_{L_2}$

if $\dfrac{V_s}{R_{s_1} + R_2} = \dfrac{R_{s_2}}{R_{s_2} + R_L}(I_s)$, if $V_s = R_{s_2} \cdot I_s$ and $R_{s_1} = R_{s_2}$

$V_{L_2} = V_{L_1}$ $\quad \dfrac{V_s R_L}{R_s + R_L} \overset{?}{=} \left(\dfrac{R_L R_s}{R_s + R_L}\right) I_s$ if $R_{s_2} = R_{s_1}$, $V_s = R_{s_2} \cdot I_s$

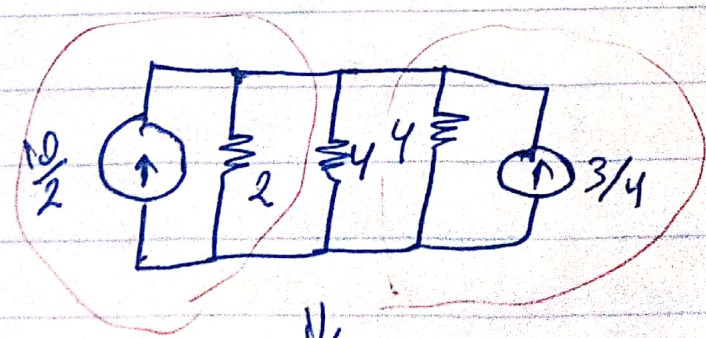
Ex.

use source Transformation to find V_x

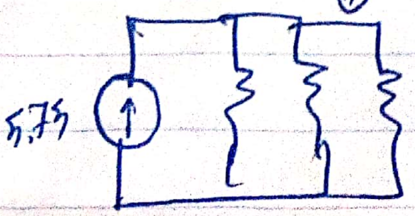


ترجمة 1

ال V يكون voltage مع مقاومة بنترجم لـ current source مع نفس المقاومة ع التوازي



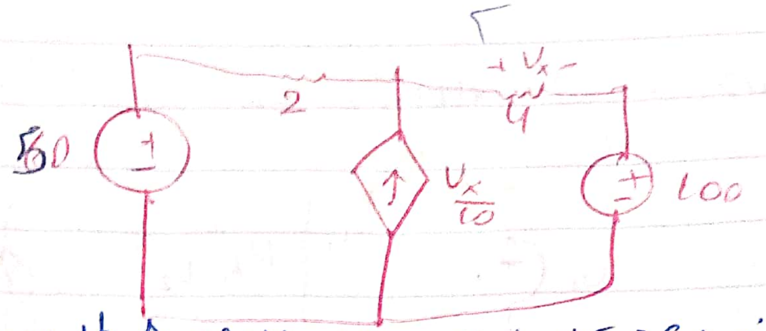
⇓



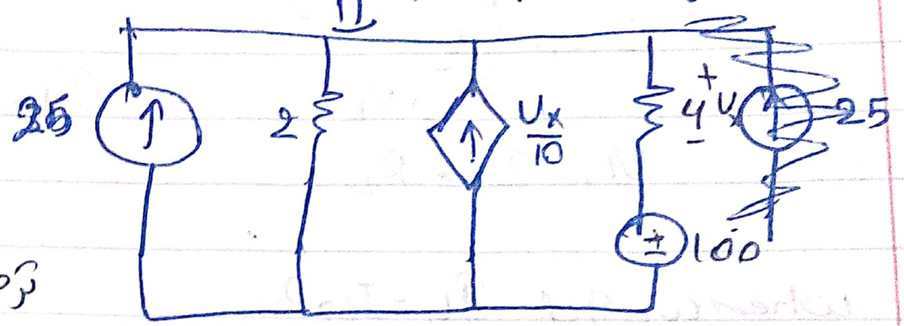
$R_{eq} = 2 \| 4 \| 4 = 1\ \Omega$

$V_x = 5.75\ V$

Using S.T Find V_x

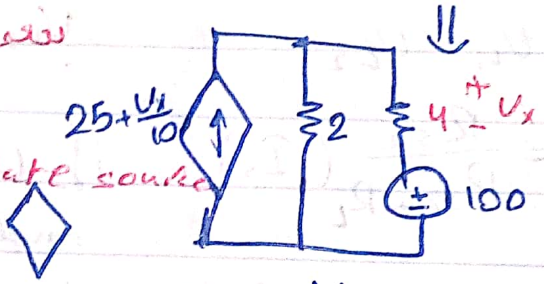


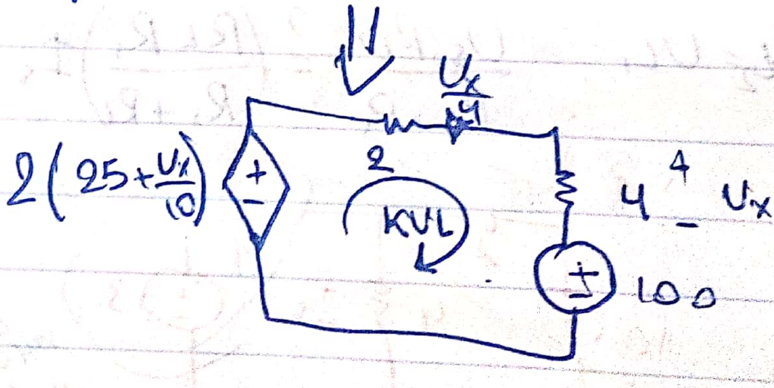
غلط نعمل ترجمة للجزء الذي يحتوي V_x عشان ◇ بطل معروف



ترجمة ©

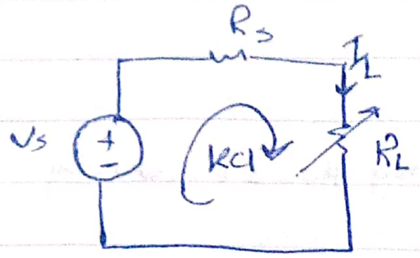
نعمل ترجمة بتحول dependent current
توازي مع سـ ر
توالي مع المقاومة ~~source~~ Voltage source





→ source Transformation

* maximum power Transfer Theory



Find the maximum power dissipated in R_L

$P_L = I_L * V_L = I_L^2 * R_L$

$-V_s + I_L R_s + I_L R_L = 0$

$$\boxed{I_L = \frac{V_s}{R_s + R_L}}$$

$\rightarrow P_L = \frac{V_s^2}{(R_s+R_L)^2} * R_L$ نشتقه بدلالة R_L

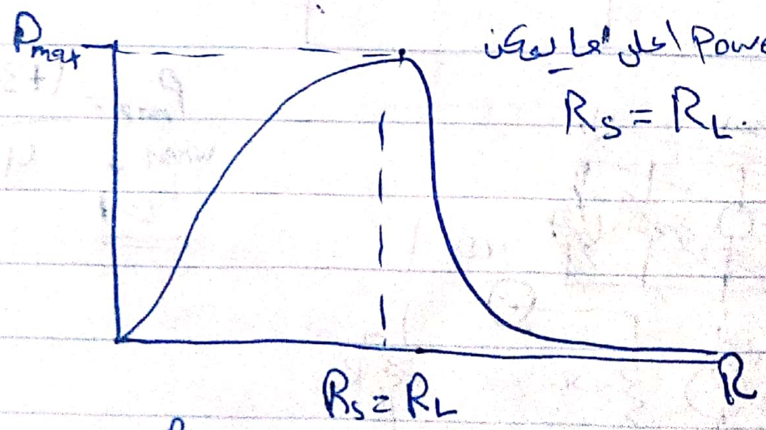
$\Rightarrow \frac{\delta P_L}{\delta R_L} = \frac{V_s^2 (R_s+R_L)^2 - V_s^2 R_L (2)(R_s+R_L)}{(R_s+R_L)^4}$

$\rightarrow \frac{\delta P_L}{\delta R_L} = 0 \rightarrow V_s^2 (R_s+R_L)^2 - V_s^2 R_L (2)(R_s+R_L) = 0$

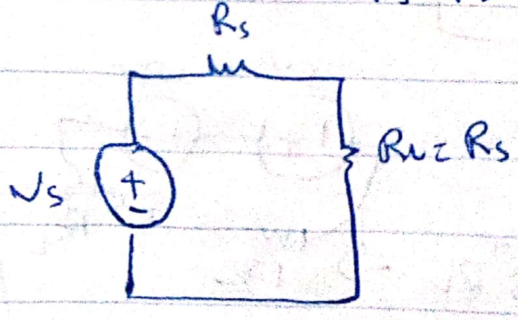
$= (R_s+R_L)^2 - R_L(2)(R_s+R_L) = 0$ ندرس التزايد والتناقص

$(R_s+R_L)^{\cancel{2}} = 2R_L \cancel{(R_s+R_L)}$

$R_s = R_L$



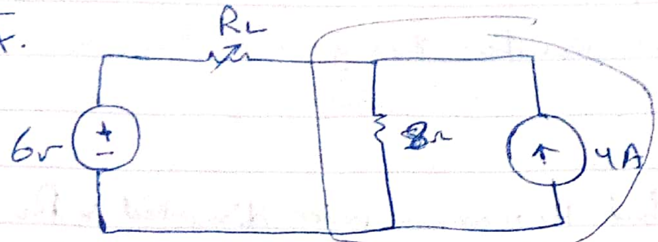
يكون الـPower اعلى ما يمكن عندما $R_s = R_L$



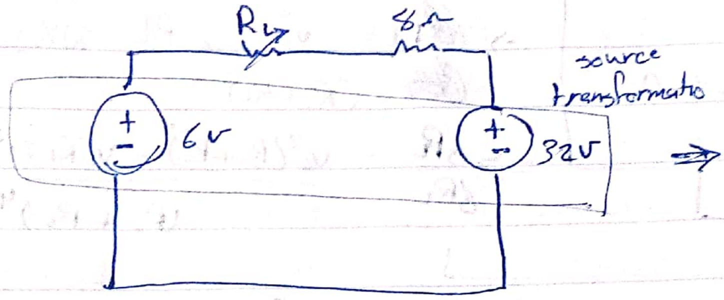
$\Rightarrow I_L = \frac{V_s}{2R_s}$

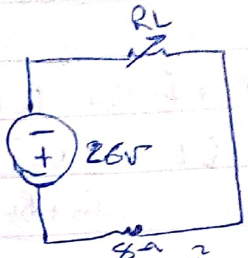
$P_{max} = I_L^2 R_L = \frac{V_s^2}{4R_s^2} R_s = \frac{V_s^2}{4R_s}$

Ex.



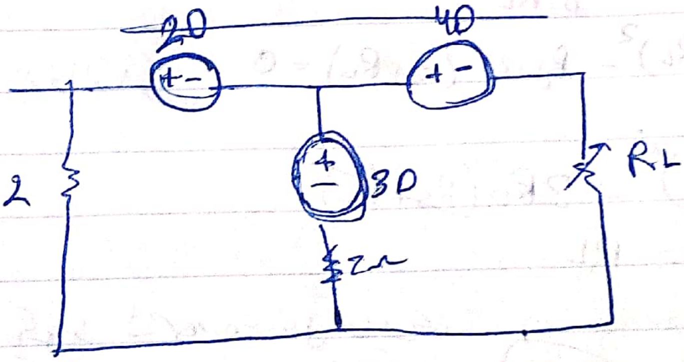
→ Find max power delivered to Rc Assuming than RL is varying Resistance



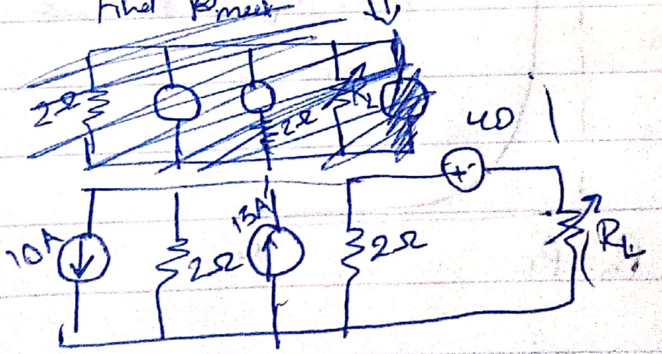


$$P_{max} = \frac{(26)^2}{4(8)} = 21.125\,W$$

Ex.

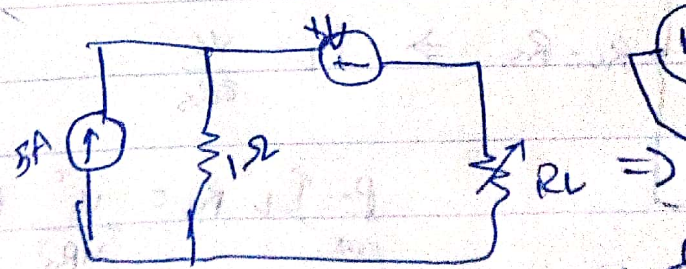


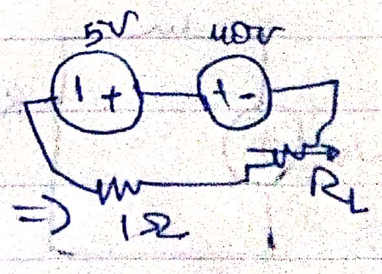
Find P_{max}

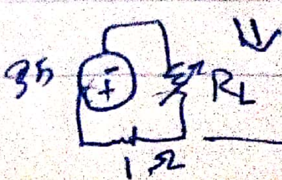


$$P_{max} = \frac{(+35)^2}{4(1)}$$

when $R_L = 1$





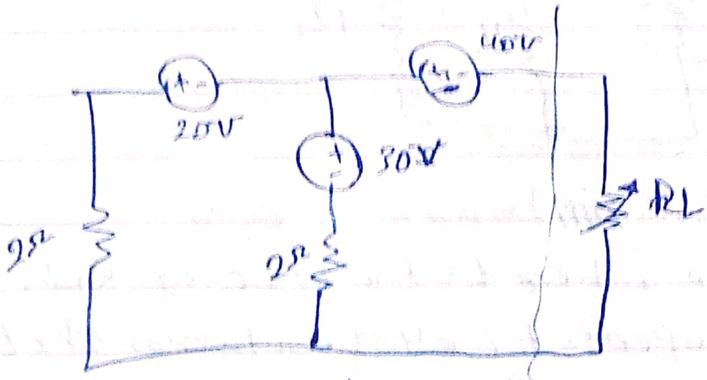


$\boxed{R_L = 1\Omega}$

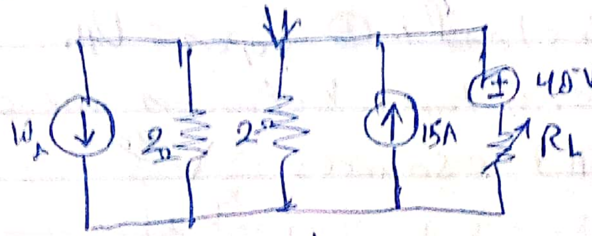
→ Thevinin & Norton Theory :-

* Thevinin Equivallent Theory : any cct can be reduced into a single V.S (V_{thv}) in series with single Resistance (R_{th})

* Norton Theory : any cct can be reduced into a single current source (I_n) in parallel with Resistance (R_n)

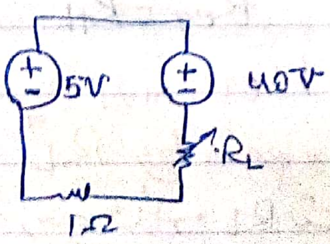


⇓



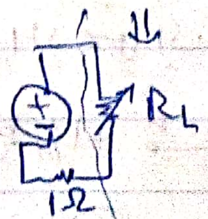
⇓

⇒



⇓

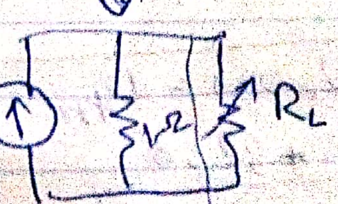
thevinin equivalent ⇒



$V_{th} = -35$ $R_{th} = 1\Omega$

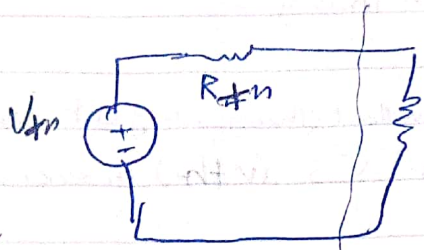
⇓

Norton equivalent ⇒



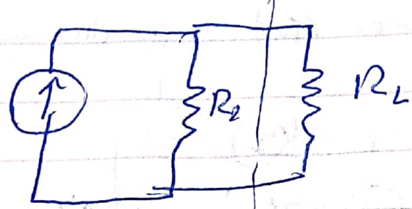
$I_N = \frac{V_{th}}{R_{th}} = -35A$

$R_N = R_{th} = 1\Omega$



$V_{th} = I_N \cdot R_N$

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



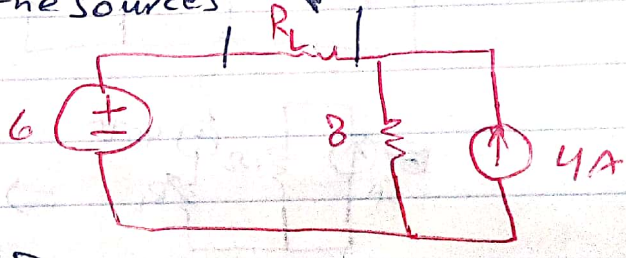
how to find thevinin Equivallent cct.

① Determine where to find the eq. cct.

② Find the open cct voltage between the two Pionts you picleed in ① $V_{open} = V_{th}$

③ Find the eq. Resistance between the same two Points, After you kill the sources

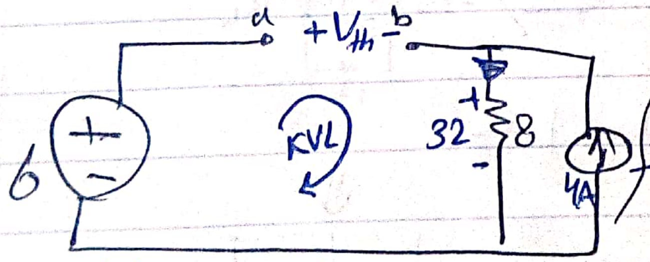
$R_{eq} = R_{th}$

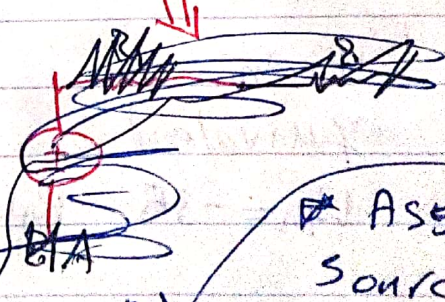


Find thevinin eq cct as seen by RL

جيبتها زي كأنو RL بتتنزع ع الـ

بنشيل الـ شي إلي بدك تشوف منه





$V_{open} = V_{th}$

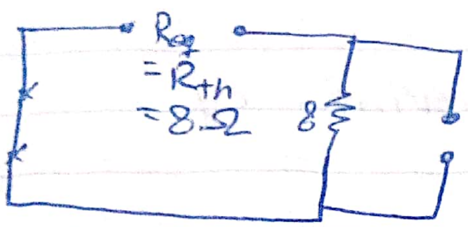
$-6 + V_{th} + 32 = 0$

$\boxed{V_{th} = -26V}$

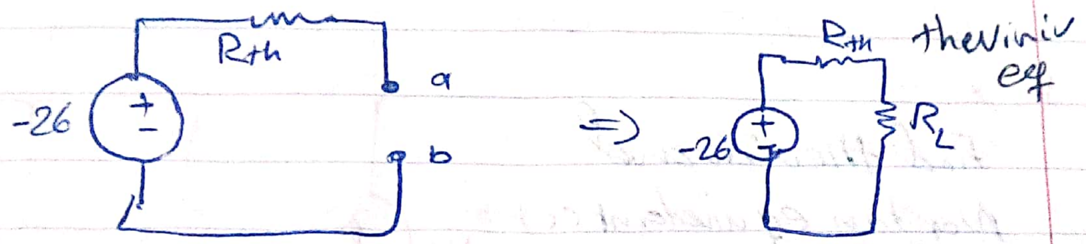
لأنه بتغير الـ V والـ I

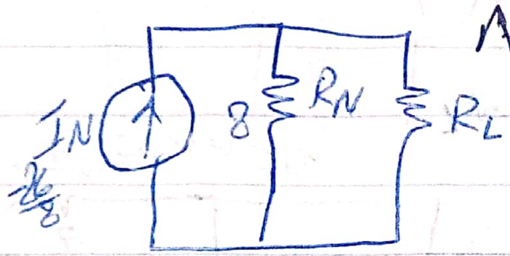
نستخدم الـ

★ Assum Source Transformation ~~should not be used~~ should not be used



$R_{th} = 8$





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

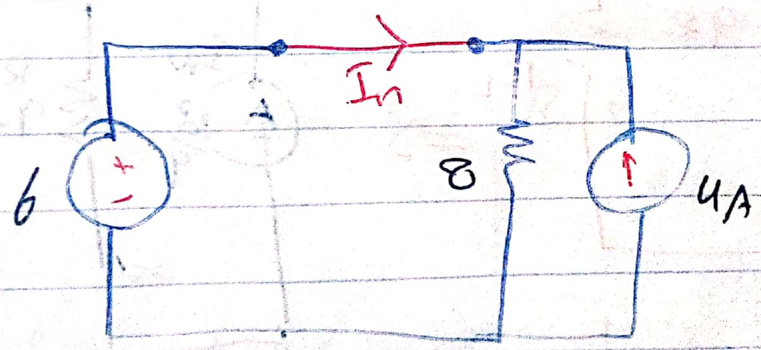
هون نعرف theviniv مقتضى

To find Narton eq.

① determine the two point a, b in which you find the eq cct.

② Find the short cct current between (a, b) $I_{s.c} = I_N$

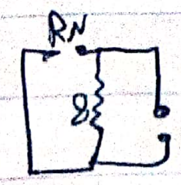
③ Find R_{eq} similar to R_{th} $R_{th} = R_N$

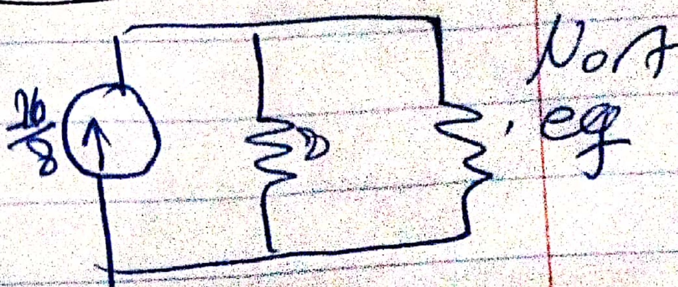


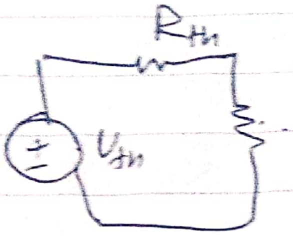
$I_{8\Omega} = \frac{6}{8} = \frac{3}{4}$

$I_n + 4 - \frac{3}{4} = 0 \Rightarrow \boxed{I_n = \frac{-13}{4} A}$

$R_n = R_{th}$



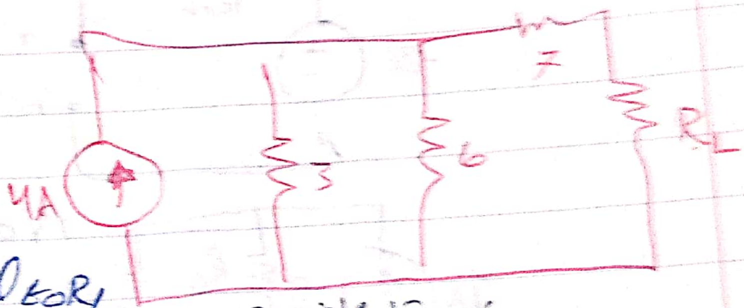




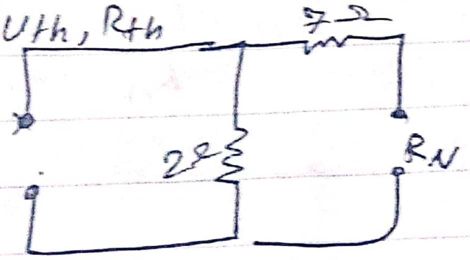
thevinin eq

Ex

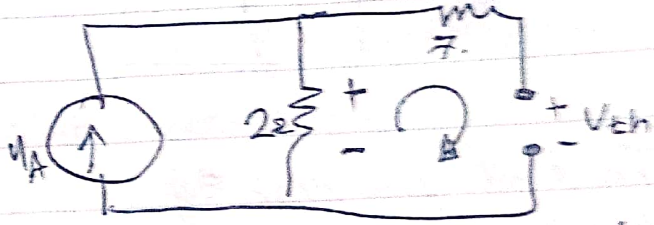
Find thevinin and Norton equivalent cct
- and Find max Power that can be delivered to R_L



to find V_{th}, R_{th}



مش تيار ماشي جوه

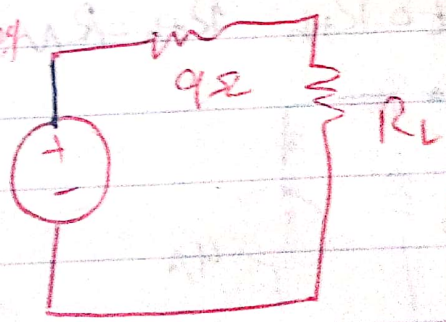


$\boxed{R_N = 9\ \Omega}$

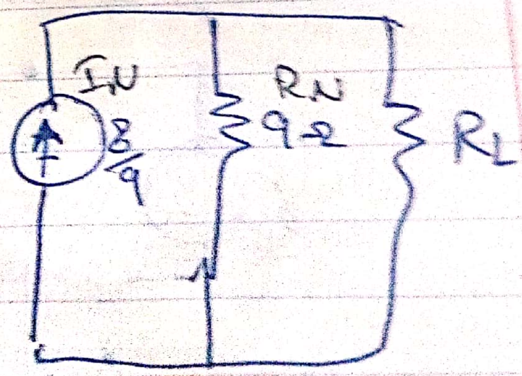
$= (3 \| 6) + 7 = 9\Omega$

$V_{th} = 8V = 2 * 4 =$

thevinin eq cct



$\Rightarrow$

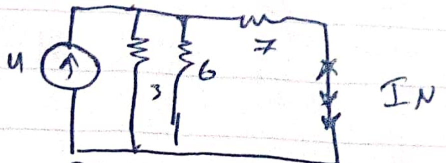


To find R_N, I_N

سؤال واريح دوائر

$R_{eq} = 3 \parallel 6 \parallel 7$
$= \frac{14}{9}$

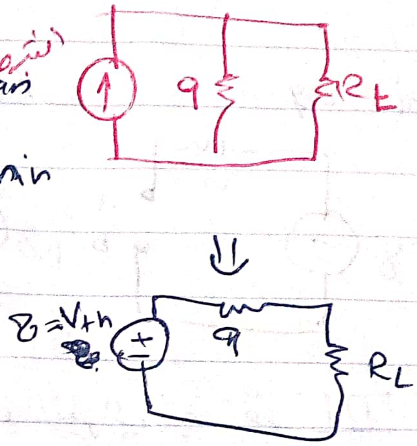
$I_N = I_{7\Omega} = \frac{14/9}{7}(4)$
$= \frac{8}{9} A$



$R_N = R_{th} = 9\,\Omega$

Norton عبارة current source مع مقاومة توازي

thevinin عبارة عن voltage source مع مقاومة على التوالي.



ما هو الفرق ما بين الحالات؟

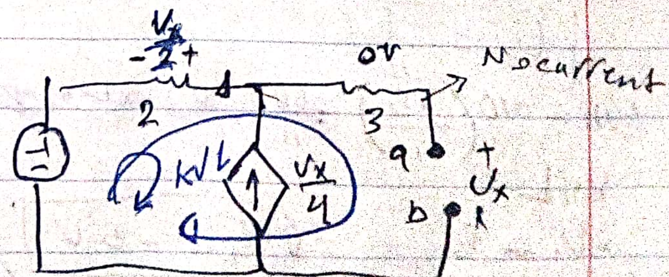
What is δ :-
① Dependent and indepenent
② Dependent δ

A case I :- cct with independent source
case II :- cct with dependent and independent source
case III :- cct, with dependent source only

case I :- $V_{op} = V_{th}$, $R_{eq} = R_{th}$ } $I_N = \frac{V_{th}}{R_{th}}$
أو $I_N = I_{s.c}$ $R_N = R_{th}$

case II

Ex Find thevinin eq as seen by a, b



$V_{th} = V_{o.c} = V_{ab} = V_x$

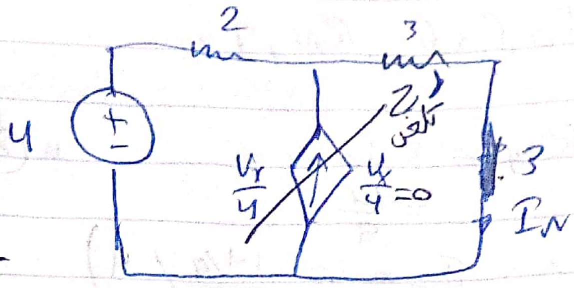
KVL :- $-4 - \frac{V_x}{2} + 0 + V_x = 0$

$\boxed{V_x = 8\,V}$

$R_{th} = R_{eq}$

كيف نجد R_{th} رح نعتبر $\left(R_{th} = \frac{V_{th}}{I_N}\right)$

I_N نجيب

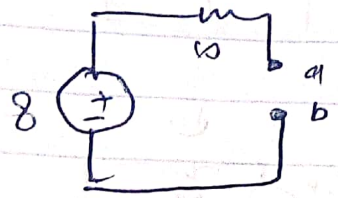


$\therefore \quad R_{th} = \frac{V_{th}}{I_N} = 10\ \Omega$

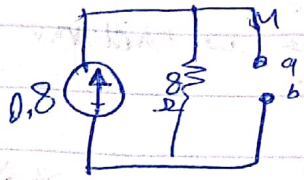
لما عملنا short الـ V_x بتصفر

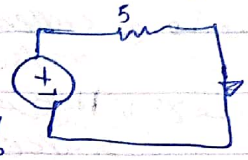
$\Downarrow R_{eq} = 2 + 3$

thevinin eq



Northon eq





$I_N = \frac{4}{5} = 0.8\ A$

* case III : هون لما يكون في dependence بتكون قيمة المتغير إلي فيه صفر عشان مافي اشي يعطيه قيمة (indeped) source

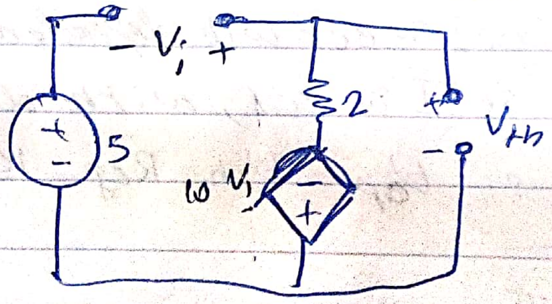
$V_{open} = V_{th} = Zero$

$I_N = Zero$

I short

← مثال case II

Ex



$-5 - V_1 + V_{th} = 0$

$V_{th} = 5 + V_1 \rightarrow (1)$

$V_{th} = -10V_1 \rightarrow (2)$

$\boxed{V_1 = \frac{-5}{11}}$

$V_{th} = -10\left(\frac{-5}{11}\right) = \frac{50}{11}$

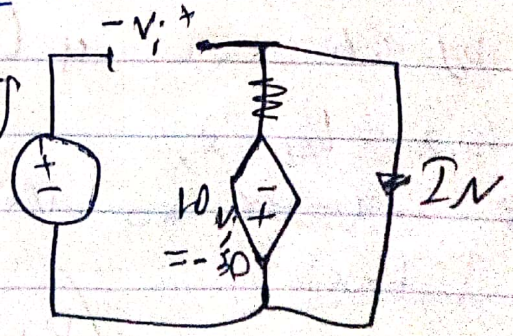
مافي current في الـ مقاومة وقطعها واهمل

KVL

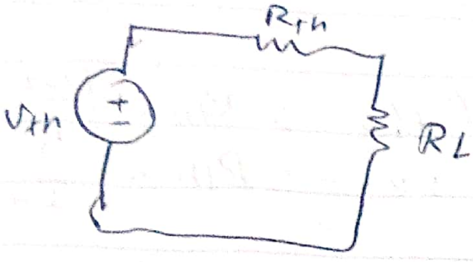
$-V_1 - 5 = 0 \Rightarrow \boxed{V_1 = -5\ V}$

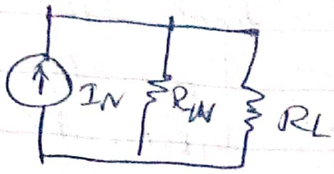
KVL $\quad -50 + 2I_N = 0$

$\boxed{I_N = 25\ A}$



$R_{th} = \frac{\frac{50}{11}}{25} = \frac{2}{11}\ \Omega$

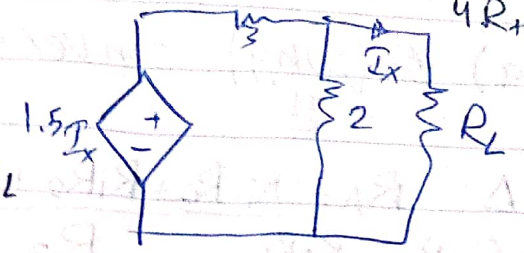




Ex for case III

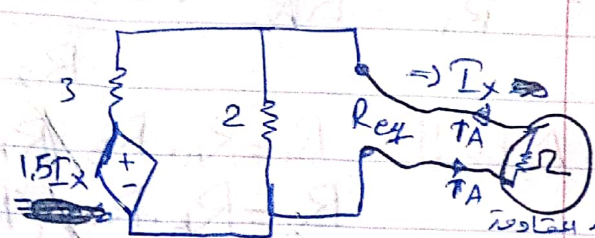
$$P_{max} = \frac{V_{th}^2}{4R_{th}}$$

Find thevinin and Norton as seen by R_L



~~$R_{eq} = (3 \| 2) = \frac{6}{5}$~~

$$R_{th} = \frac{V_x}{1}$$



ما جهد المقاومة

للأوم بطلع المقاومة

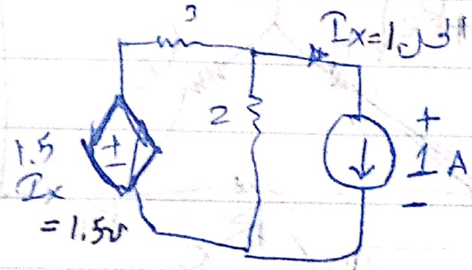
$V_{th} =$

$I_N = 0$

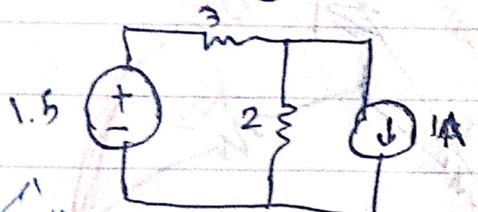
عند اوم ميتر نوعين

واحد بطلع واحد امبير وبحسب فولت

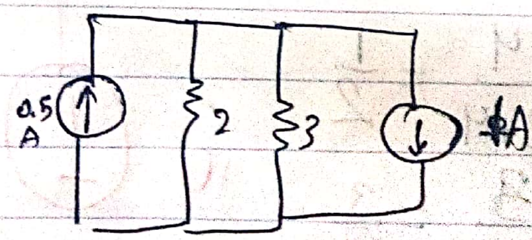
الثاني بعطي جهد قيمه واحد فولت وبطلع التيار



$\Downarrow$

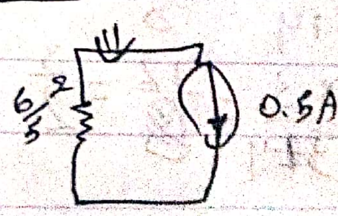


ترجمة $\Rightarrow$

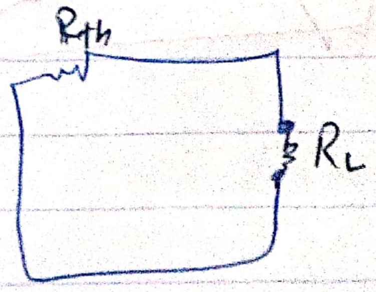


استخدم الي بدك اياه مكانه بوجهد

$$R_{eq} = \frac{1}{0.6} = \frac{10}{6} = \frac{5}{3}\ \Omega$$



الحركة الخاصة



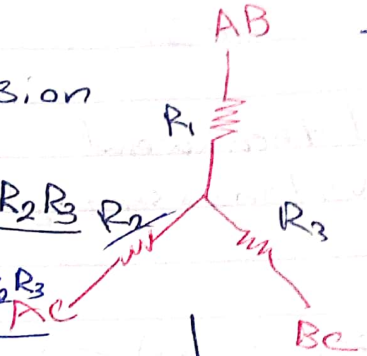
$$V = \frac{6}{5} \cdot 0.5 = 0.6V$$

To find $R_{th} = ??$

بنعمل $I_{test} = 1A \Rightarrow$ Find $V_{\Omega} \Rightarrow R_{th} = \frac{V_{\Omega}}{1}$

او نعمل $V_{test} = 1V \Rightarrow$ Find $I_{\Omega} \Rightarrow R_{th} = \frac{1}{I_{\Omega}}$

* (Delta) to (why) conversion
Δ y



هذا الشكل اسمه y

From Y to Δ

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

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

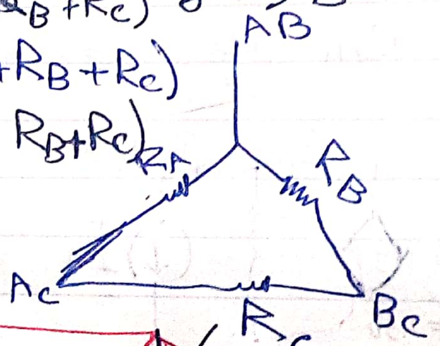
$$R_B = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_2}$$

From Δ to y

$R_1 = R_A \cdot R_B / (R_A + R_B + R_C)$ $y \rightarrow \Delta$

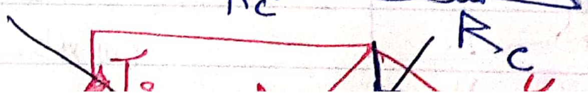
$R_2 = R_A \cdot R_C / (R_A + R_B + R_C)$

$R_3 = R_B R_C / (R_A + R_B + R_C)$



هذا الشكل اسمه Δ

Ex:- Find I_o:-

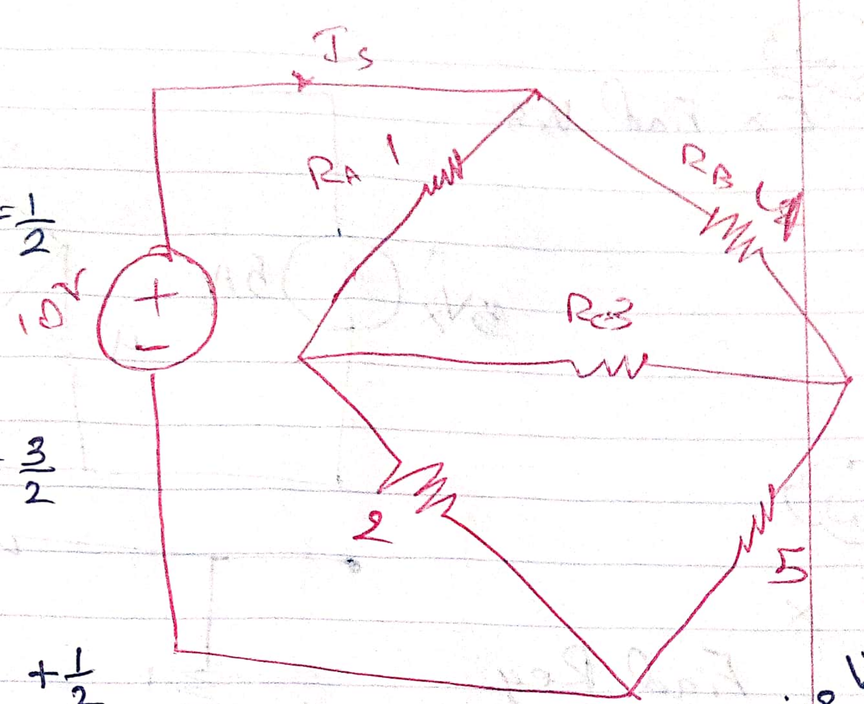


Ex: Find I_s &

$$R_1 = \frac{1*4}{1+3+4} = \frac{4}{8} = \frac{1}{2}$$

$$R_2 = \frac{1*3}{1+3+4} = \frac{3}{8}$$

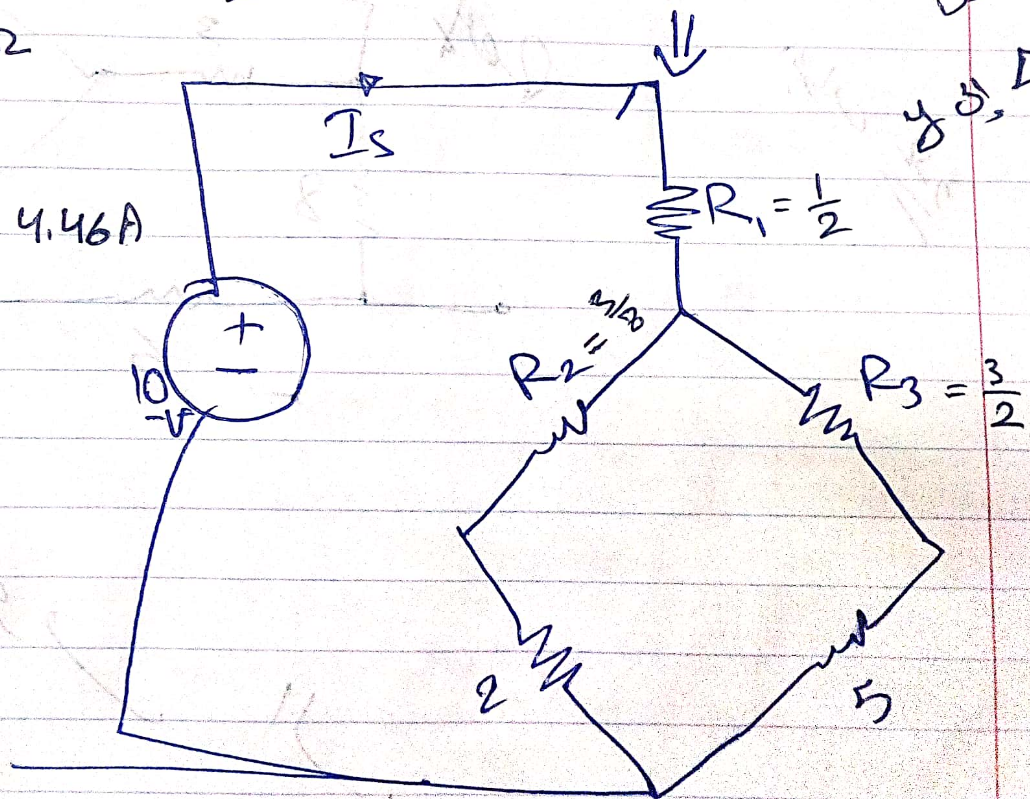
$$R_3 = \frac{3*4}{1+3+4} = \frac{12}{8} = \frac{3}{2}$$



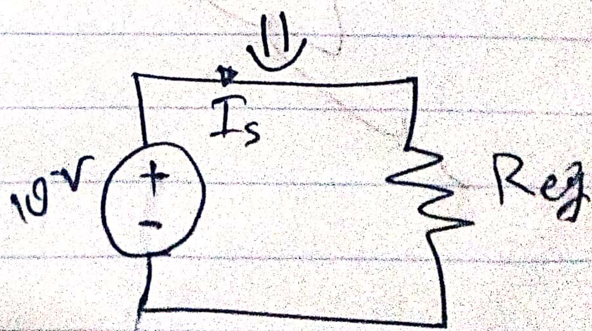
$$R_{eq} = \left(\frac{3}{2} + 5\right) // \left(\frac{3}{8} + 2\right) + \frac{1}{2}$$

$$= 2.239\ \Omega$$

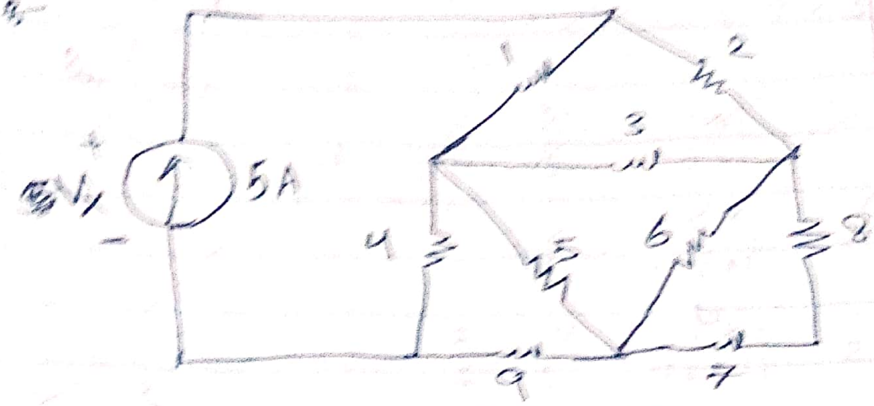
حولناها من
Y لـ D



$$I_s = \frac{10}{2.239} = 4.46A$$

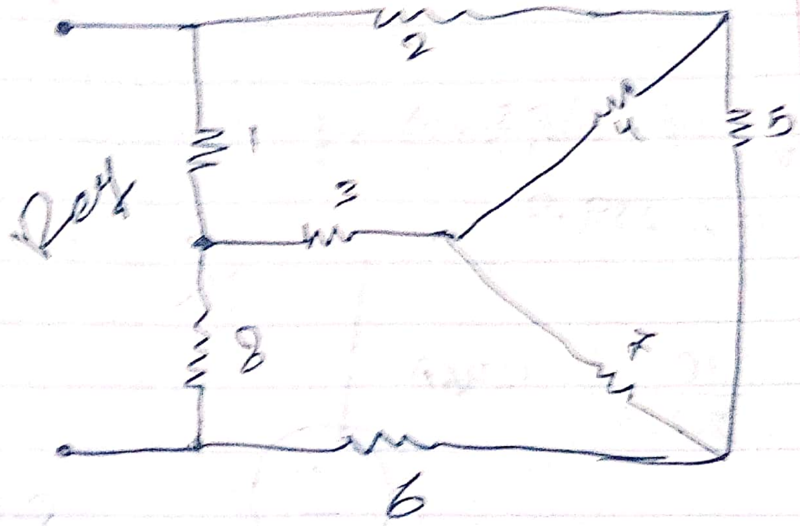


Ex Find V_x



Ex

Find R_{eq}

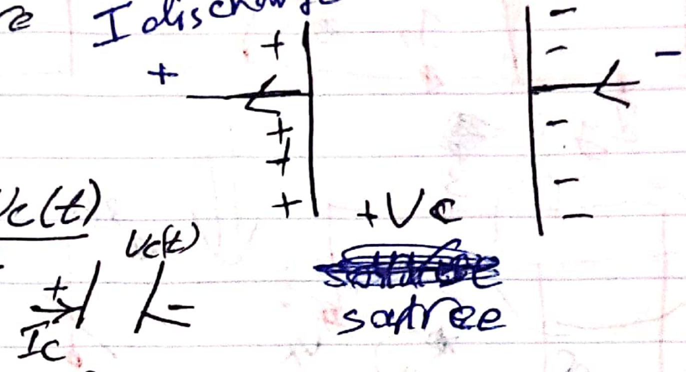


※ final ※

Inductors and Capacitors

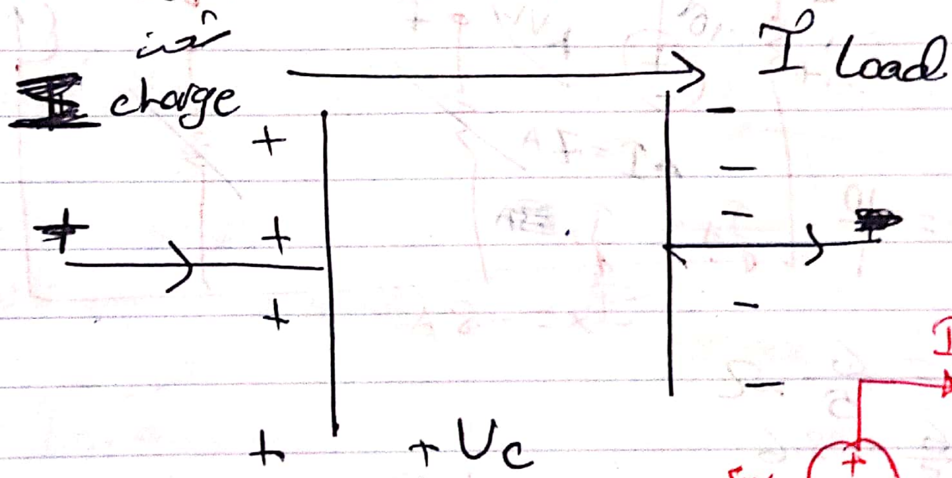
* energy store in elemets (Active elemints)
  Passive elemints (Resistance) (can't store energy)

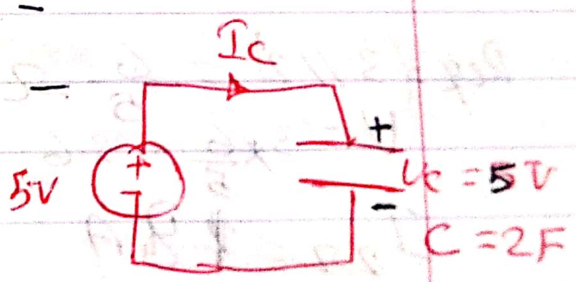
Capacitore I discharge تفريغ



$$I_c(t) = C\frac{d\,V_c(t)}{dt}$$

شحن
charge



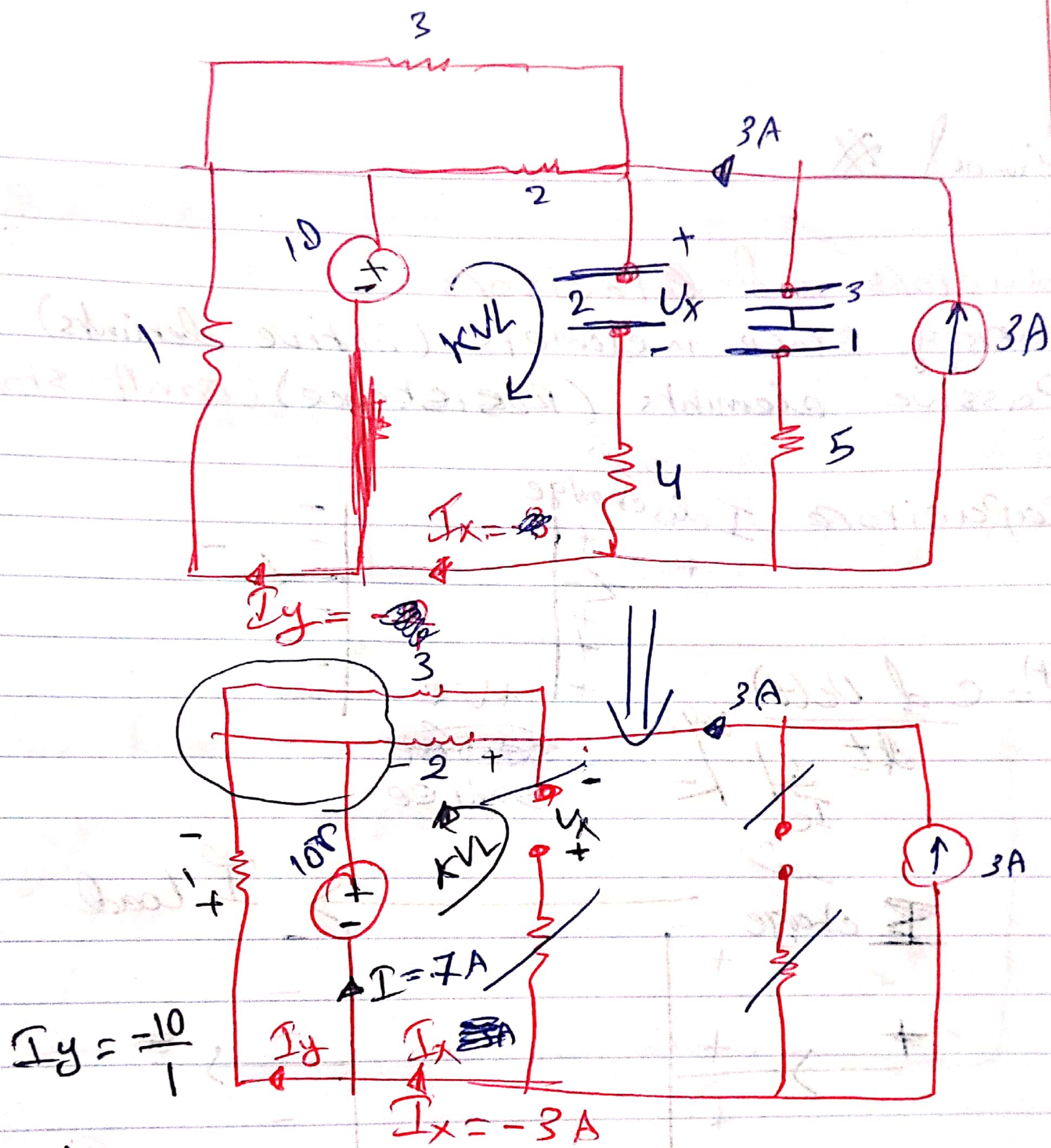


* C ⇒ open cct

* $-5 + V_c = 0$

$$\boxed{V_c = 5V}$$

$$I_c = 2\frac{d(5)}{dt} = \text{zero}$$



$Req = (3 // 2) = \frac{6}{5}\,\Omega$

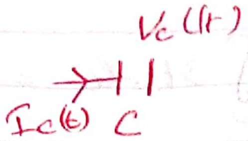
$U = 3 * \frac{6}{5} = 3.6$

$I_{2\Omega} = 1.8\,A$

$+U + 2 * 1.8 + 10 = 0$

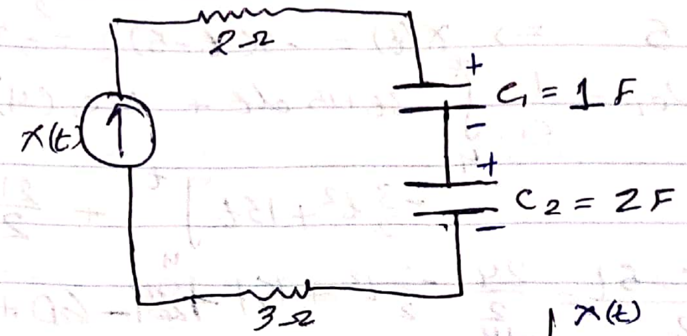
$\boxed{U = -13.6\,V}$

الإمتحان الثلاثاء

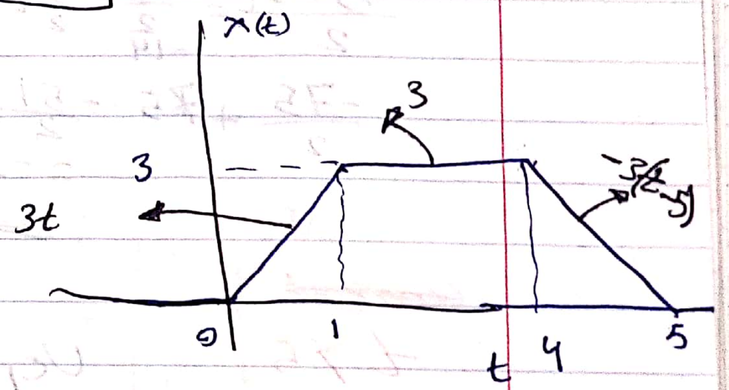


V_c is constant
$I_c = zero$
$$I_c = C \cdot \frac{dV(t)}{dt}$$

Ex:-



Find and plot V_{c_1}, V_{c_2}



$mt + b = f(x)$

$5m + b = 0 \quad (5, 0)$
$4m + b = 3 \quad (4, 3)$
$\boxed{m = -3}$
$b = -15$

$$V_c(t) = \frac{1}{C}\underbrace{\int_{-\infty}^{t} I_c(t)\,dt}_{\text{شحنة}}$$

$x(t) = I_{c_1} = I_{c_2}$

$$V_{c_1} = \frac{1}{C_1}\int_{-\infty}^{t} x(t)\,dt \qquad V_{c_2} = \frac{1}{C_2}\int_{-\infty}^{t} x(t)\,dt$$

$\therefore$
$0 < t < 1 \qquad x(t) = 3t$
$1 < t < 4 \qquad x(t) = 3$
$4 < t < 5 \qquad x(t) = -3(t-5)$

if $t < 0 \quad V_{c_1} = 0, \; V_{c_2} = 0$

if $0 < t < 1 \quad V_{c_1} = \frac{1}{C_1}\int_{-\infty}^{t} 3t\,dt$

$$= \frac{1}{C_1}\left(\underbrace{\int_{-\infty}^{0} 3t\,dt}_{zero} + \int_{0}^{t} 3t\,dt\right) = \frac{1}{C_1}\frac{3}{2}(t^2 - 0) = \frac{3}{2}t^2$$

$$V_{C_2} = \frac{1}{C_2}\int_{-\infty}^{t} 3t\,dt = \int_0^t 3t\,dt = \frac{3}{4}t^2$$

$1 < t < 4$ $\quad x(4) = 3$

$$V_C(t) = \frac{1}{C_1}\int_1^t 3\,dt + V_{C_1}(1) = \frac{3}{2} + 3t\Big]_1^t$$

$$= \frac{3}{2} + 3t - 3 = 3t - \frac{3}{2}$$

$4 < t < 5 \Rightarrow x(t) = -3(t-5) = -3t+15$

$$V_{C_1} = \frac{1}{C_1}\int_4^t -3t+15\,dt + V_{C_1}(4)$$

$$-\frac{3}{2}t^2 + 15t\Big]_4^t + \frac{21}{2}$$

$$\frac{75-51}{2} = \frac{24}{2} = 12 \qquad -\frac{3}{2}t^2 + 15t + 24 - 60 + \frac{21}{2}$$

$$-36 + \frac{21}{2}$$

$$\frac{-75}{2} + 75 - \frac{51}{2} \qquad = -\frac{51}{2}$$

$$= -\frac{3}{2}t^2 + 15t - \frac{51}{2}$$

72, 21, 51, 60, −24, 36

15

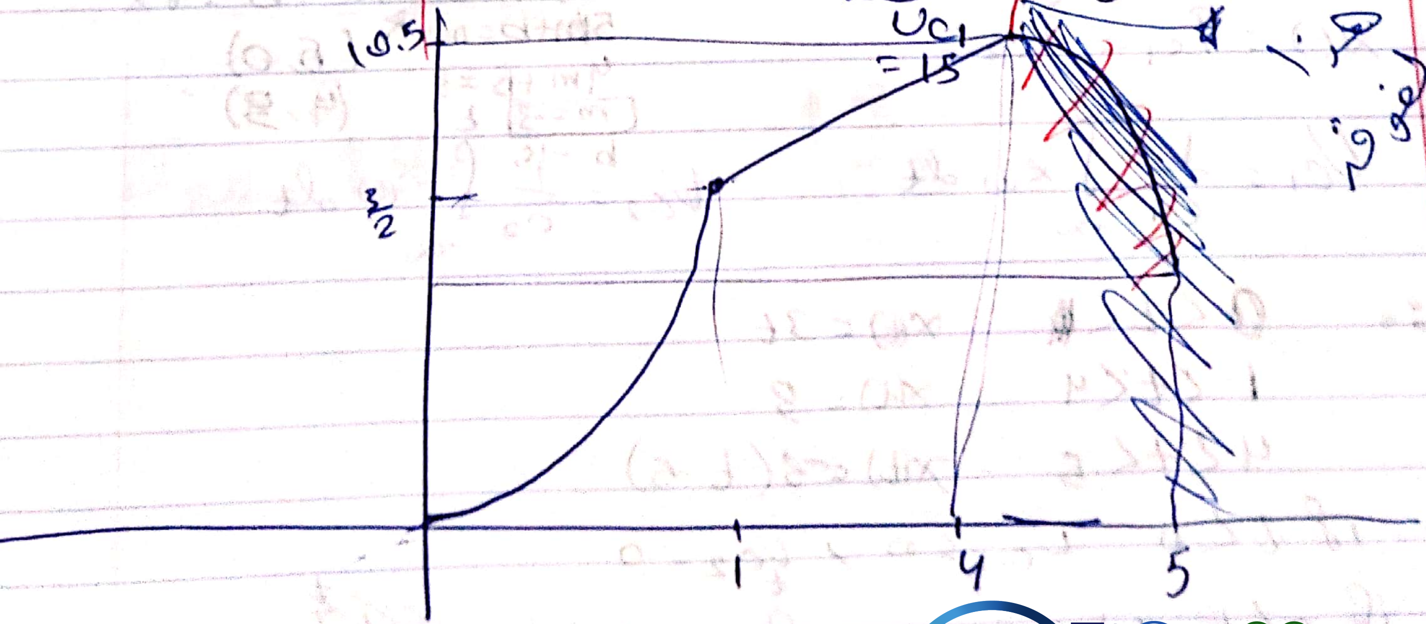
~~Constant~~

$t > 5$

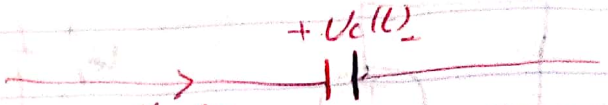
$$V_{C_1} = \frac{1}{C_1}\int_{-\infty}^{5} x(t)\,dt + \int_5^t x(t)\,dt$$

zero

$V_{C_1} = 15$



General rule



$$V_c(t) = \frac{1}{C}\int_{t_0}^{t} I_c(t)\,dt + V_c(t_0)$$

حط نقطة هات

$$V_c(t_0) = \frac{1}{C}\int_{-\infty}^{t_0} I_c(t)\,dt$$

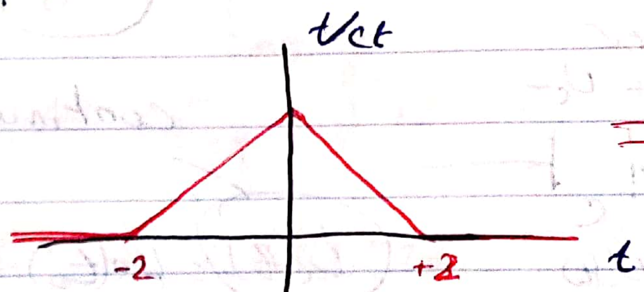
capacitor current is always continuous function

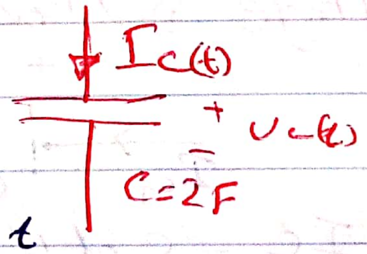
$$I_c(t_0^-) = I_c(t_0) = I_c(t_0^+)$$

من اليسار ... من اليمين

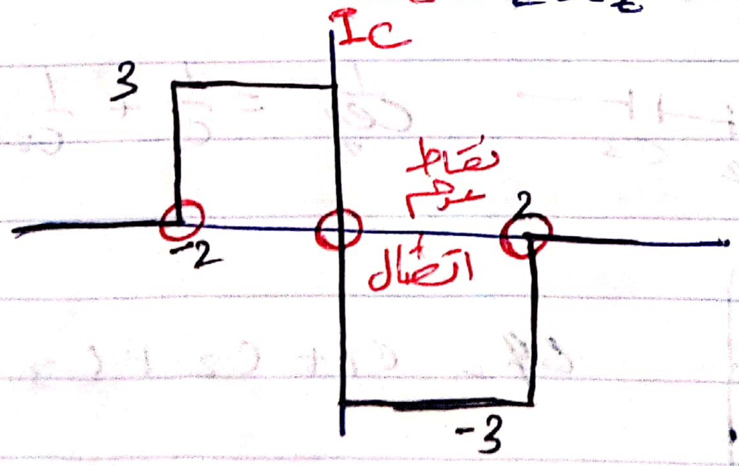
$$I_c(t) = C\,\dot{V}_c(t)$$

Ex :-

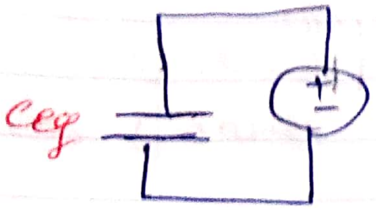


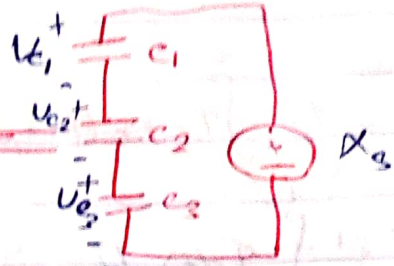


$I_c = 2\,V_c'$



Eq uivallent capacitance





from series capacitor

$$\frac{1}{c_{eq}} = \frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3} + \dots$$

f/o Parallel capaciter

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

KVL

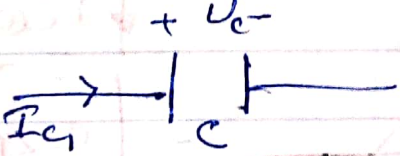
$$+v_{c_1} + v_{c_2} + v_{c_3} - x_s = 0$$

$$x_s = \frac{1}{c_1}\int I_c\,dt + \frac{1}{c_2}\int I_c\,dt + \frac{1}{c_3}\int I_c\,dt$$

$$x_s = \left(\frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3}\right)\int I_c\,dt$$

$$x_s = \frac{1}{c_{eq}}\int I_c\,dt$$

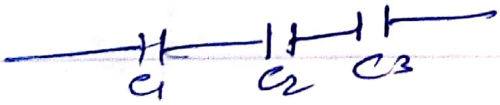
* Can we apply current and voltage Divider



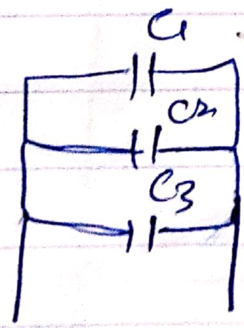
$$I_c = c\frac{d\,v_c(t)}{dt}$$

continuous in time

$$v_c(t) = v_c(t_0) + \frac{1}{c}\int_{t_0}^{t} I(t)\,dt$$

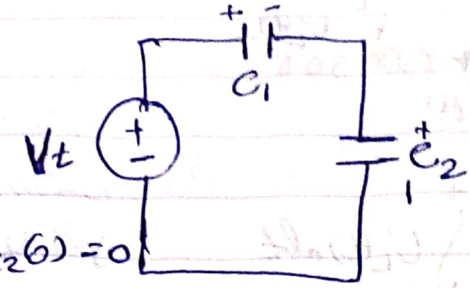


$$\frac{1}{c_{eq}} = \frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3}$$



$$c_{eq} = c_1 + c_2 + c_3$$

Ex :-



$U_{C_1}(0)=U_{C_2}(0)=0$

$U_{C_1}(t) = \overset{zero}{\cancel{U_{C_1}(0)}} + \frac{1}{C_1}\int_0^t I_c(t)\,dt$

$U_{C_2}(t) = \overset{zero}{\cancel{U_{C_2}(0)}} + \frac{1}{C_2}\int_0^t I_c(t)\,dt$

KVL :-

$-U(t) + \frac{1}{C_1}\int_0^t I_c(t)\,dt + \frac{1}{C_2}\int_0^t I_c(t)\,dt = 0$

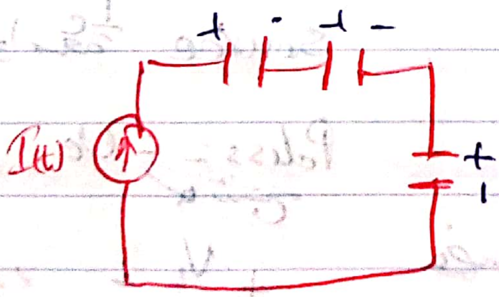
$U(t) = \underbrace{\left(\frac{1}{C_1}+\frac{1}{C_2}\right)}_{\frac{1}{C_{eq}}}\int_0^t I_c(t)\,dt$

$U(t) = \frac{1}{C_{eq}} \cdot \int_0^t I_c(t)\,dt \Rightarrow \int_0^t I_c(t)\,dt = U(t)\, C_{eq}$

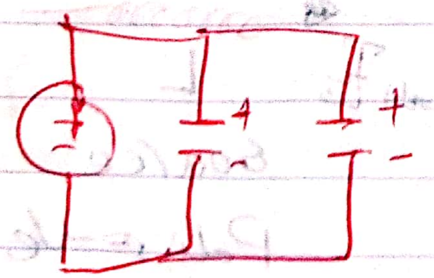
$U_c(t) = \frac{1}{C_1} * U(t)\, C_{eq} = \frac{C_{eq}}{C_1} U(t)$ (Voltage divider)

وهنالك الأمر

V . يكونوا توازيه current source

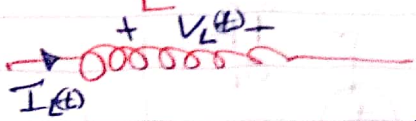


هون بتطلع الفولتية
بسهولة



هون بطلع التيار
بسهولة

المحث



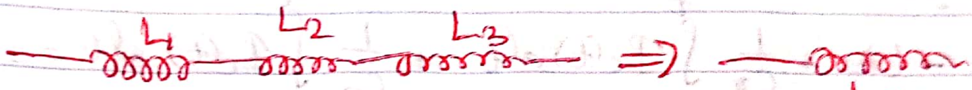
يعامل زي المواسع + نفس طريقة الحل

$$V_L(t) = L\,\frac{dI_L(t)}{dt}$$

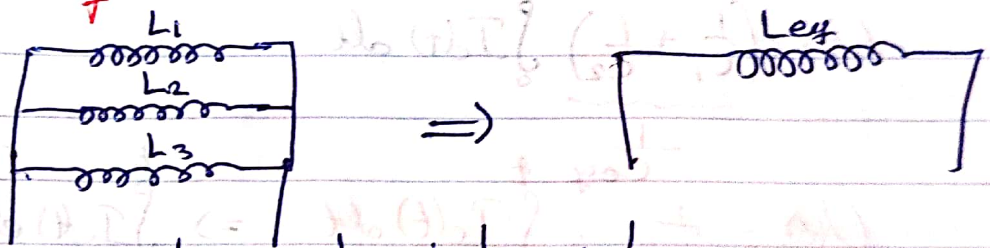
$$I_L(t) = I_L(t_0) + \frac{1}{L}\int_{t_0}^{t} V_L(t)\,dt$$

رسمة راح تكون متصلة (continuous) مع الزمن

لما يكون عليها تيار .
خارجي يتكون بتشحن
كأنها بطارية لما ينفصل .
التيار الخارجي بتحول
المحث زي كأنه
source فبيصير يطلع
~~بحسب~~ تيار

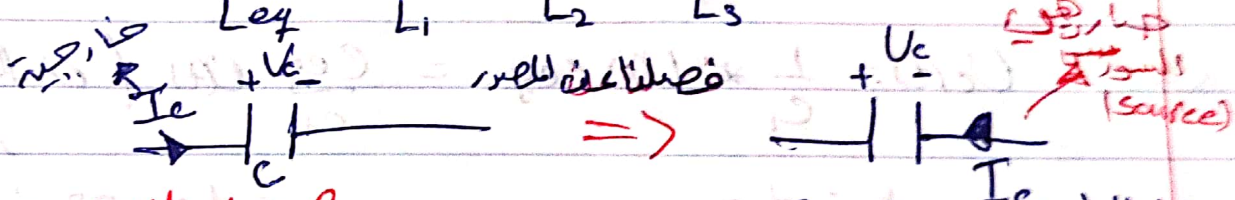


$$L_{eq} = L_1 + L_2 + L_3$$



$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

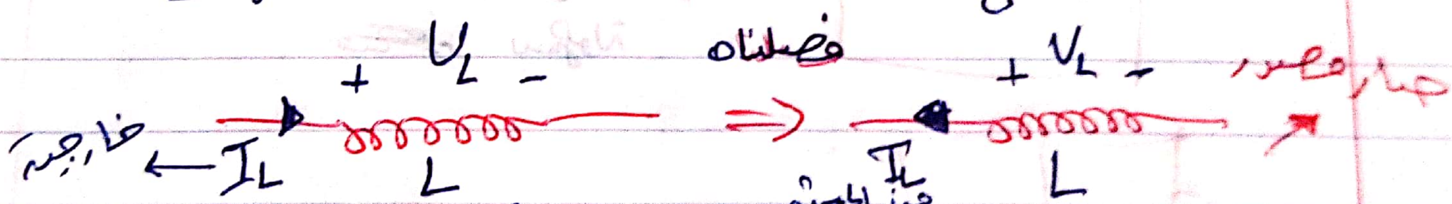
Note



with load — source

$P_{diss} = +V_c$ تستهلك

$P_{diss} = -V_c$ تنتج



load — source

$P_{diss} = +V_c$ — $P_{diss} = -V_c$

For capacitor $\quad P = I_c \cdot V_c = C\dot{V}_c(t) \cdot V_c(t)$

$$= C\frac{dV_c(t)}{dt} \cdot V_c(t)$$

الطاقة الداخلية Energy

$$W_c(t) = \int_{t_0}^{t} P(t)\,dt = \int_{t_0}^{t} C\frac{dV_c(t)}{dt} \cdot V_c(t)\,dt$$

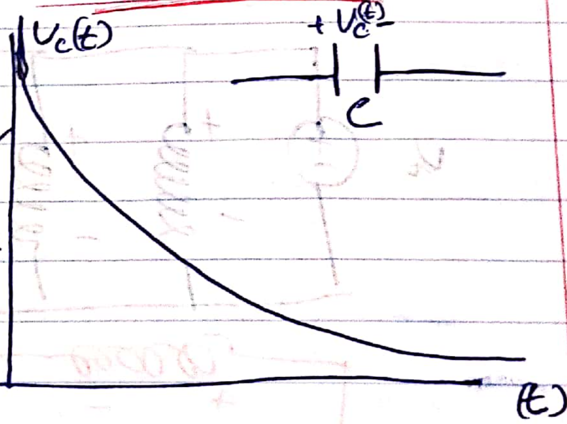
$$= \int_{t_0}^{t} C\,V_c(t)\,dV_c(t)$$

$$C \cdot \frac{(V_c(t))^2}{2}\Bigg|_{t_0}^{t} = \frac{1}{2}C(V_c(t))^2 - \underbrace{\frac{1}{2}C(V_c(t_0))^2}_{W(t_0)}$$

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

If the initial energy $= 0$ $\quad W_c(t) = \frac{1}{2}C\,V_c^2(t)$

(EX) Find the total Energy stored inside the capacitor



Sol: $\quad W_c(t) = \int_{t_0}^{t} P(t)\,dt = \int_{t_0}^{\infty} P(t)\,dt$

$$= W_c(\infty) = \frac{1}{2}C(V_c(\infty))^2 = \text{zero}$$

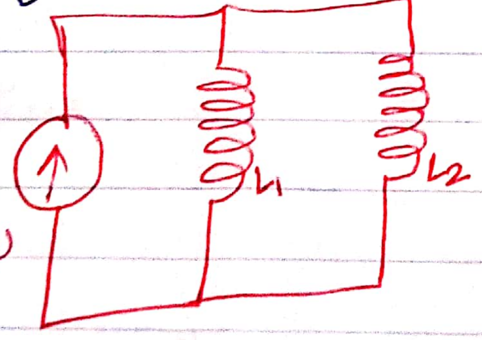
لأن الرسم تذهب إلى الصفر

فقس الحوار 2

$$W_L = \frac{1}{2}L(I(t))^2 - W_L(t_0)$$

Assuming that $W_L(t_0) = 0$ then $W_L = \frac{1}{2}L(I(t))^2$

Ex



$I_{L_1}(0) = I_{L_2}(0)$
$= \text{zero}$

$$I_{L_1} = \frac{1}{L_1}\int_0^t V_{L_1}(t)\,dt + \cancel{I_{L_1}(0)}^{\text{zero}}$$

$$I_{L_2} = \frac{1}{L_2}\int_0^t V_{L_2}(t)\,dt + \cancel{I_{L_2}(0)}^{\text{zero}}$$

KCL $\quad I(t) - I_{L_1} - I_{L_2} = 0$

$$U_{L_1}(t) = U_{L_2}(t) = U_L(t)$$

$$I(t) = \frac{1}{L_1}\int_0^t U_L(t)\,dt + \frac{1}{L_2}\int_0^t U_L(t)\,dt$$

$$I(t) = \underbrace{\left(\frac{1}{L_1} + \frac{1}{L_2}\right)}_{} \int_0^t U_L(t)\,dt$$

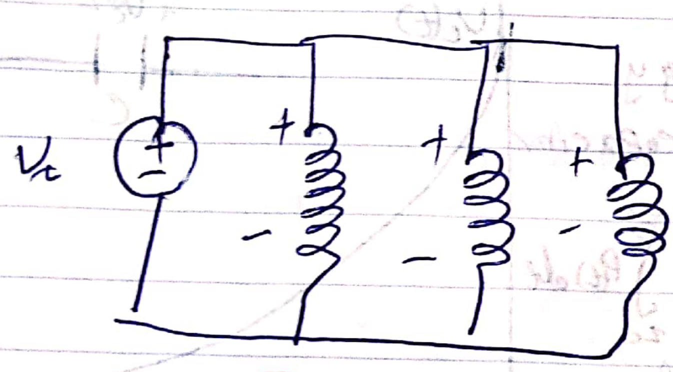
$$I(t) = \frac{1}{L_{eq}} \int_0^t U_L(t)\,dt \Rightarrow \int_0^t U_L(t)\,dt = I(t)\,L_{eq}$$

$$I_{L_1} = \frac{1}{L_1} \cdot L_{eq} \int_0^t \dot{I}(t)\,dt = \frac{L_{eq}}{L_1} I(t)$$ (current divider)

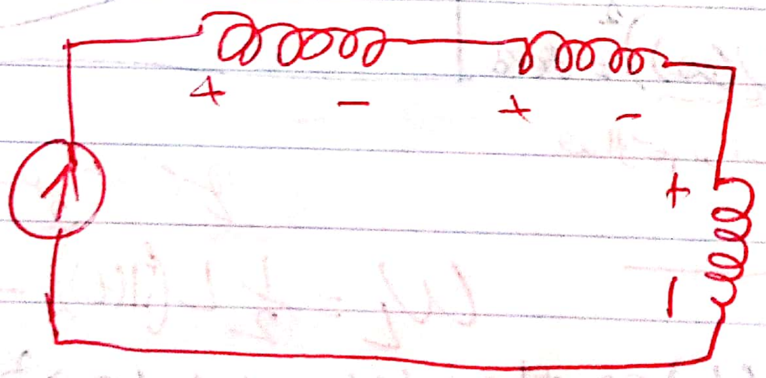
$$U_L(t) = L_{eq}\,\dot{I}(t)$$

$$I(0) = 0\,A$$

$$\int_0^t U_L(t)\,dt = \int_0^t L_{eq}\,\dot{I}(t)\,dt = L_{eq}\,(I(t) - \underbrace{I(0)}_{zero})$$



الجهد ثابت
التيار منه



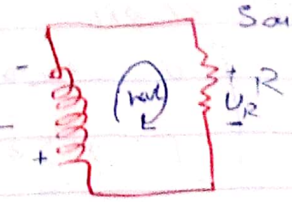
التيار ثابت
الجهد منه

Source free RC and RL cct

Source free RL cct.

$+V_L + V_R = 0$

$L \frac{dI(x)}{dx} + R(i(x)) = 0$



بنعتبر المحث اداة هو بطلع التيار، زي المصدر وعادي يطلع مجهود او تيارات.

$L\, i'(x) + R\, i(x) =$ FODE

$i(t) = A \cdot e^{-tR/L}$ $\tau = L/R$:- time constant

$i(t) = A\, e^{-t/\tau}$

To find A we need initial conditions $i(0) = ?? = A = I_0$

$i(t) = I_{(0)}\, e^{-t/\tau}$ $I(0^-) = I(0) = I(0^+)$ continuously

Plot

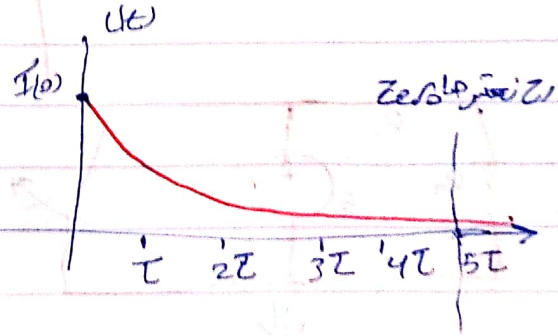
$I(\tau) = I_{(0)} e^{-1} = 0.87 I_0$

$I(2\tau) = I_0 e^{-2} = 0.94 I_0$

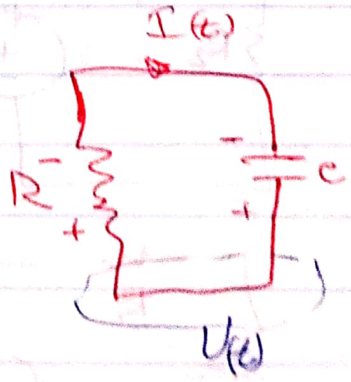
$I(3\tau) = I_0 e^{-3} = 0.96 I_{(0)}$

$I(4\tau) = I_0 e^{-4} = 0.98 I_{(0)}$

$I(5\tau) = I_0 e^{-5} = 0.99 I_{(0)}$



Source free RC cct



KVL

$+(I(t) \cdot R) - \frac{1}{C}\int_{-\infty}^{t} I(t)\, dt$ نشتق

$\dot{I} R - \frac{1}{C} I(t) = 0$ FODE

$I(t) =$

بالنسبة لـ U الأساسي

KCL :- $+\frac{U(t)}{R} + U_t' \cdot C = 0$ FoDE

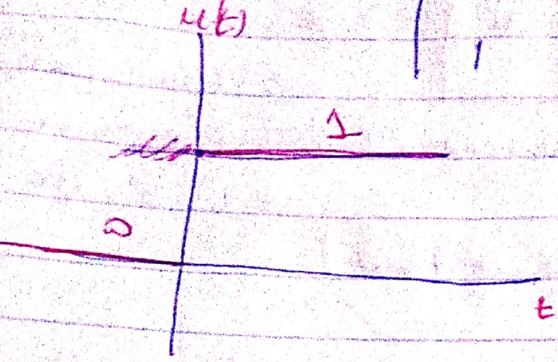
$U(t) = U_0\, e^{-t/\tau}$ $\tau = RC$ time constant

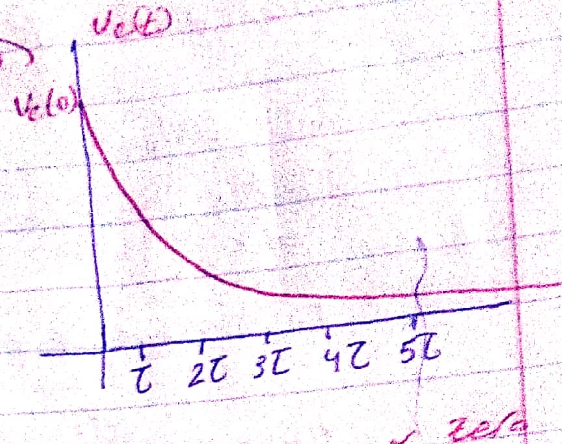
$U_c(0) = U_0$

Scanned by CamScanner

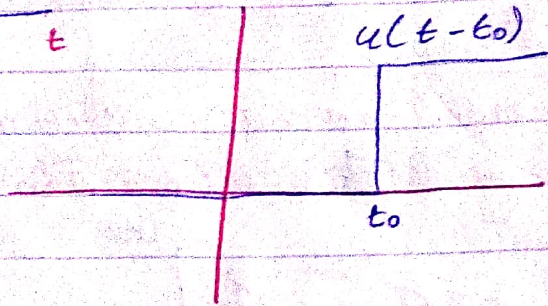
unit step function

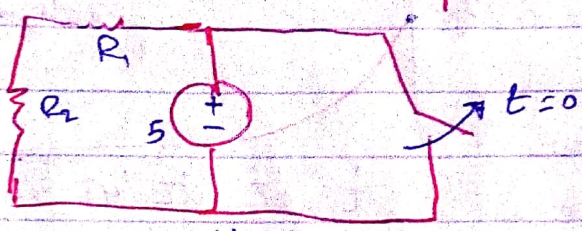
$$u(t) = \begin{cases} 0 & t<0 \\ 1 & t>0 \end{cases}$$





$$u(t-t_0) = \begin{cases} 0 & t<t_0 \\ 1 & t>t_0 \end{cases}$$

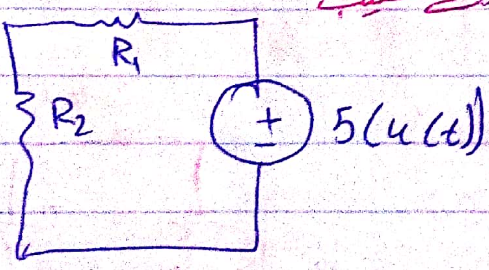




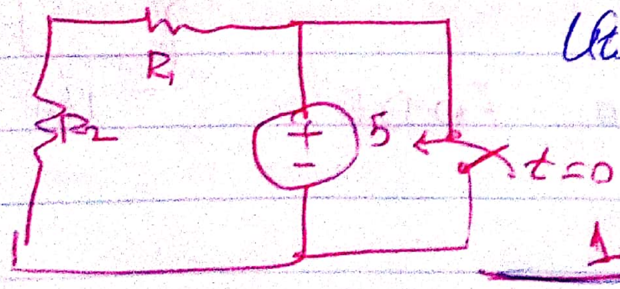
switch opens @ t=0

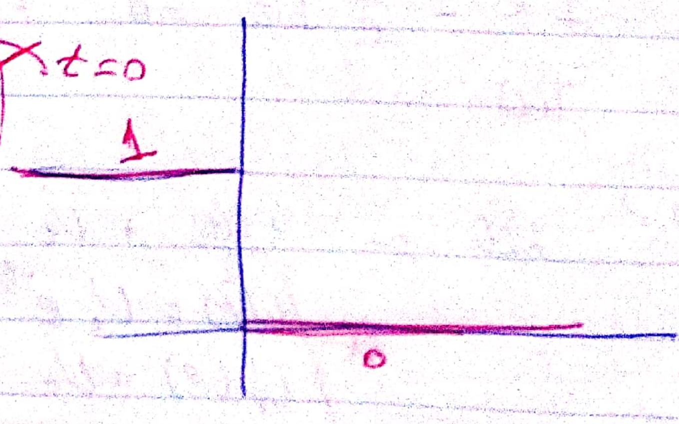
جولنا المفتاح لـ يونت ستيب

u.s.f

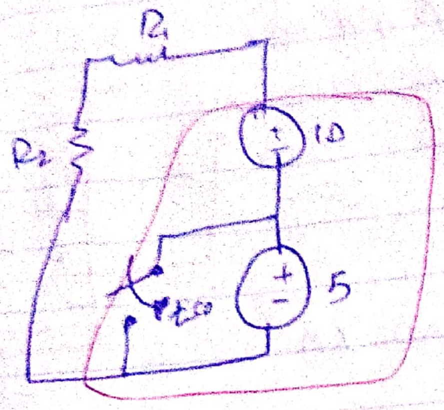


$v(t) = 5\,u(-t)$ ح تعكس السيجنال





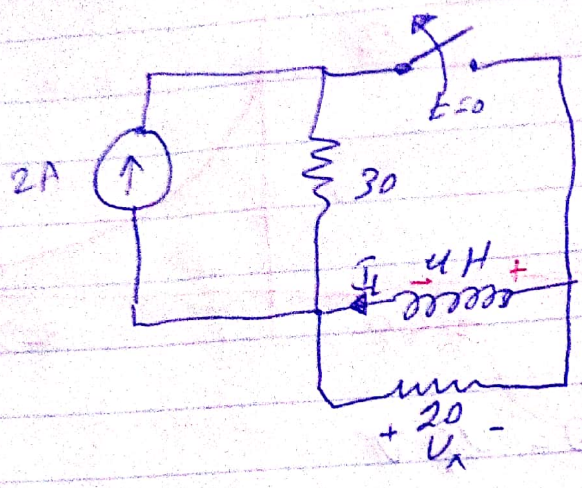
u



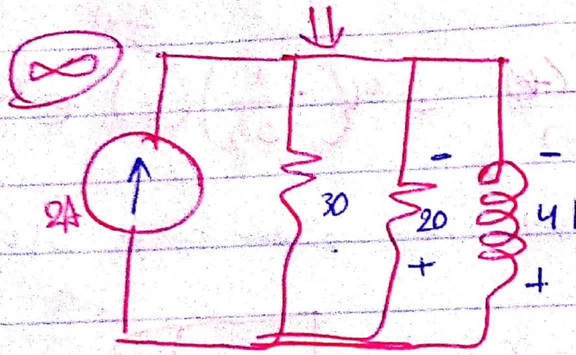
$i(t) = 10 + 5u(-t)$

دائما موجودة

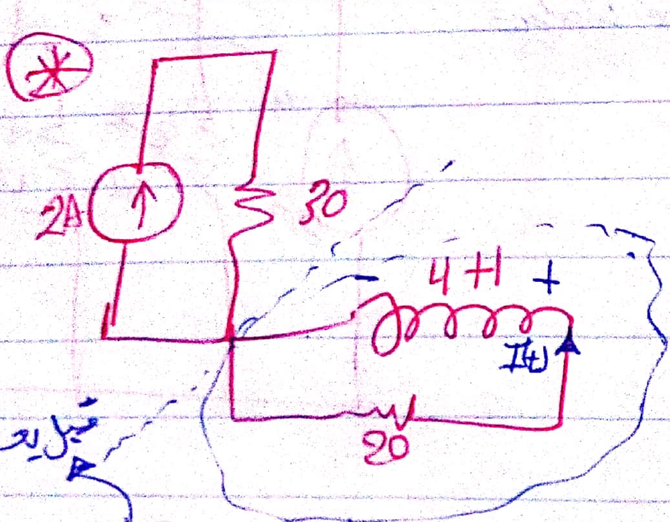
Ex3-



* sketch the cct for $t<0$ and $t>0$



$t<0$



source free RL cct

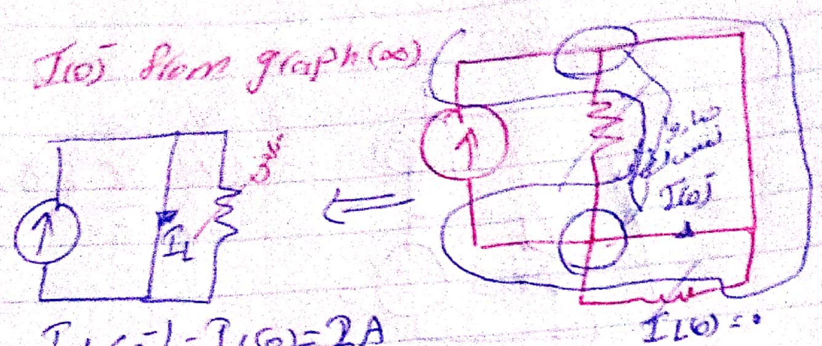
$I(t) = I(0)\,e^{-t/\tau}$

$\tau = \frac{L}{R} = \frac{4}{20} = \frac{1}{5} = 0.2$ sec

قبل يعني

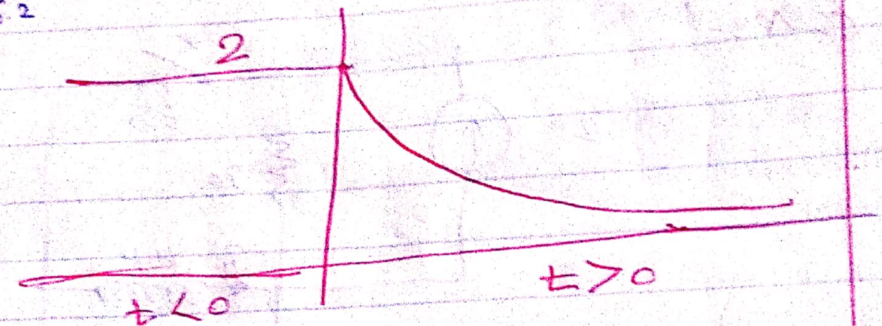
$I(0) = I(0^-) = I(0^+)$

We Find $I(0^-)$ from graph (∞)



$I_L(0^-) = I_L(0) = 2A$

$I(t) = 2e^{-t/0.2}$

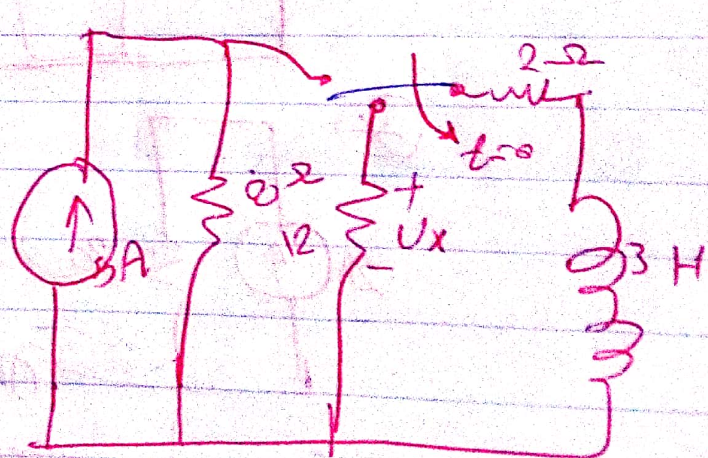


$V_x = \underset{I(t)}{2} \cdot 20 = 40\,V$

$V_L = L\,\dfrac{dI_L(t)}{dt} = 4\left(-\dfrac{1}{0.2}\right)\overset{I(0)}{(2)}\,e^{-t/0.2}$

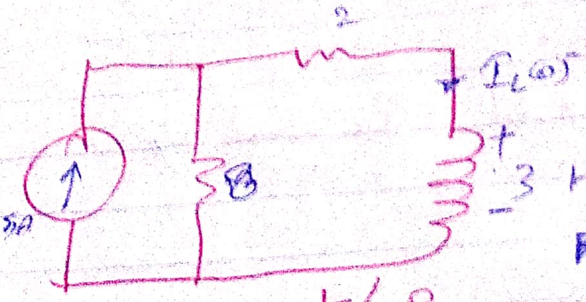
بعد إيجاد متولية الحعث بنقدر نحولو إلي $(t-+)$ ونعمل بحول

Find V_x for all time value

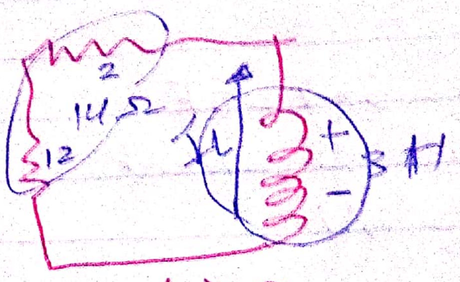


[illegible]
current divider

$I_L(0^-) = \frac{(2 // 8)}{2} \cdot 5 = 4A$



$t < 0$



$t > 0$

* $I_L(t) = 4 e^{-t/\tau}$
$t > 0$
$V_x = I_L(t) \cdot R = 48 e^{-t/\tau}$

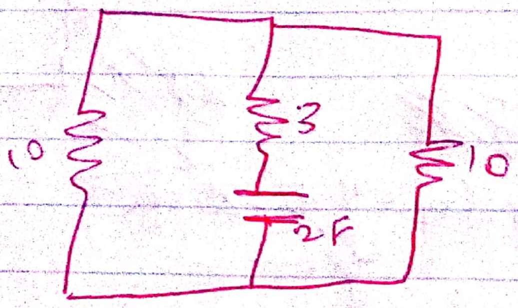
$I_L(t) = I(0) e^{-t/\tau}$

$\tau = \frac{L}{R_{eq}} = \frac{3}{14}$ sec

$I(0) = I(0^-) = 4A$ //

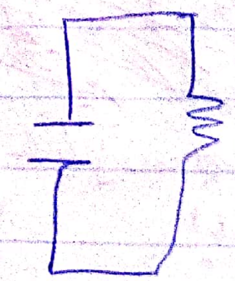
* Source free RL cct :-
Source free RC cct.

$V_c(t) = V_c(0) e^{-t/\tau}$ $\tau = R.C$



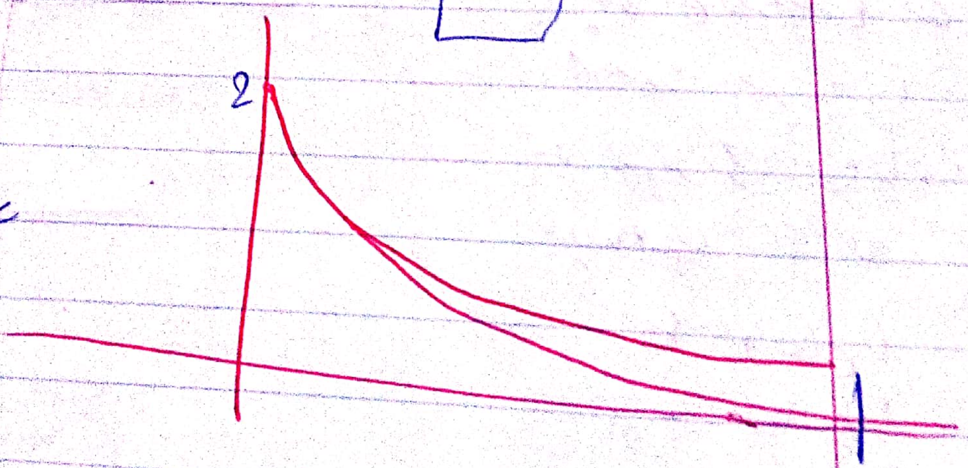
$V_c(t) = 2 e^{-t/\tau}$

C_{eq} R_{eq} ⟹



$R_{eq} = (10 // 10) + 3$
8

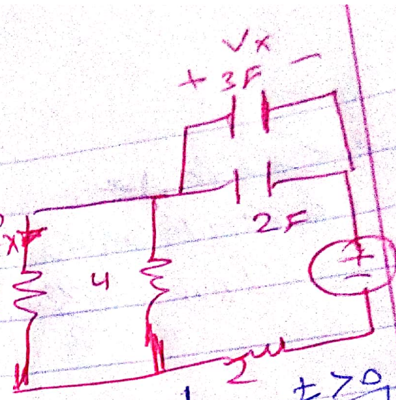
is $V_c(0) = 2V$
Find $V_c(t)$
$\tau = 8 \cdot 2 = 16$ sec



5τ
[illegible]

swich

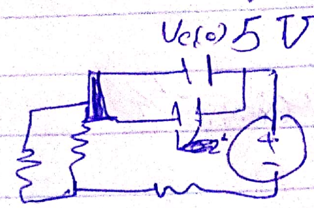
Ex:- Find I_x and V_x

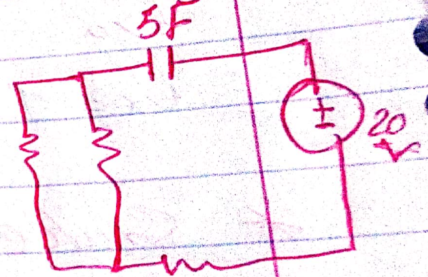


$C_{eq} = 3+2 = 5F$

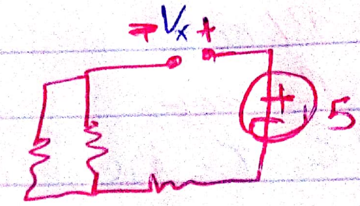
KVL: No current

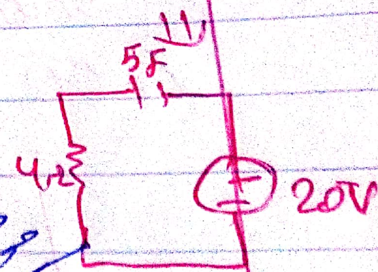
$V_x = 5V$





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





مو موجود
جديد

* Driven Response (step.
(RC)

~~$V_c(t) = V_c(\infty)[1 - e^{-t/\tau}] = V_c(0) - V_c(0)e^{-t/\tau}$~~

$= 5 - 5e^{-t/\tau}$

$\tau = R_{eq} \cdot C_{eq} = 4 \cdot 5 = 20$ sec

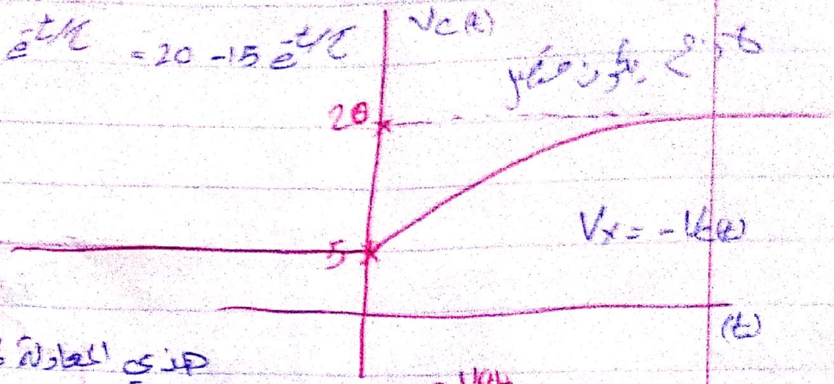
Driven Response (step Response)

$\boxed{V_c(t) = V_c(0) + V_{c0}[1 - e^{-t/\tau}]}$

$V_c(t) = V_c(\infty) + [V_c(0) - V_c(\infty)] e^{-t/\tau}$] general

General

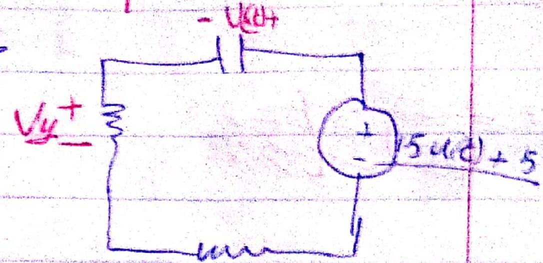
$V_c(t) = 20 + (5 - 20) e^{-t/\tau} = 20 - 15 e^{-t/\tau}$



source مجموع هذي المعادلة طالعلك

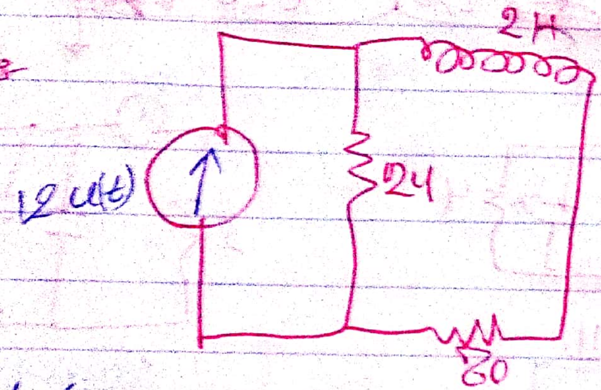
$V_y = [15u(t) + 5 - V_c t]\left(\frac{2}{2+2}\right)$ t للفترة لكل

for all t

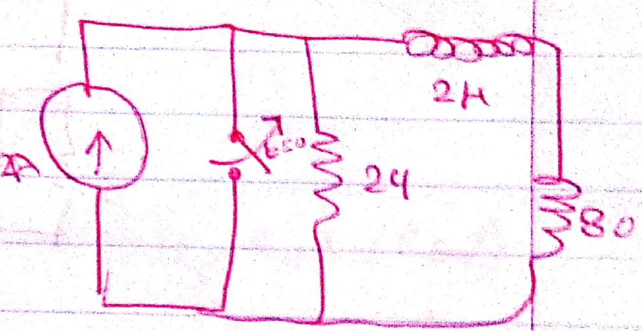


$I_x = \frac{V_y}{4}$ A

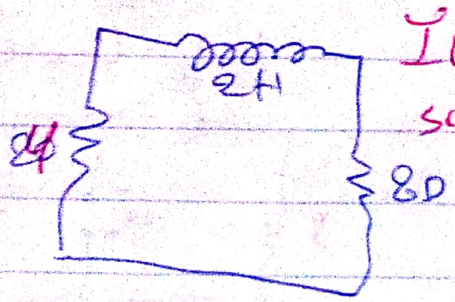
Ex2



OR



t < 0

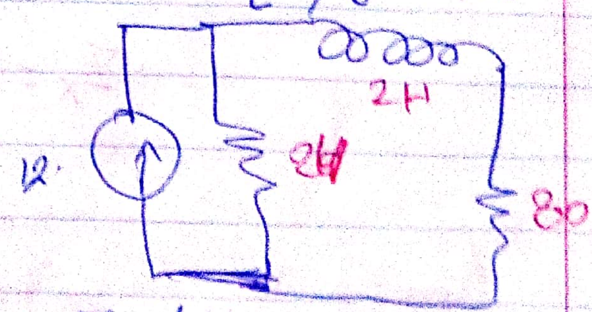


$I_L(0^-) = 0$

source فش

Driven (step Response) RL

t > 0



$I_L(t) = I_L(\infty) + [I_L(0) - I_L(\infty)] e^{-t/\tau}$

$I_L(\infty) = \left(\frac{24}{24+80}\right) \cdot 12$

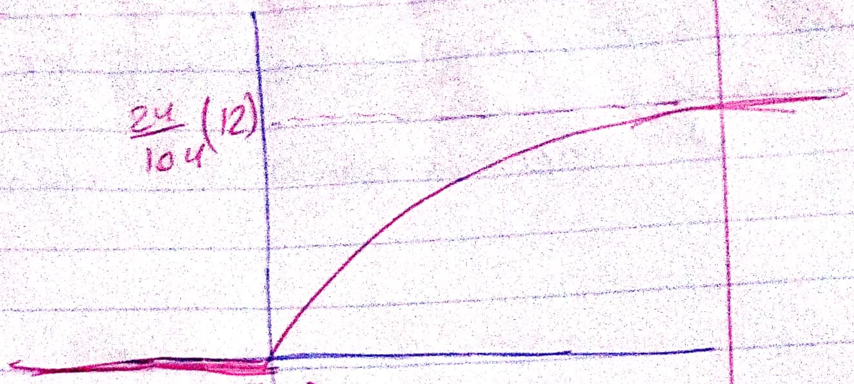
عند $t = \infty$ العنصر الملف يصبح السلك

$R_{eq} = R_{th}$

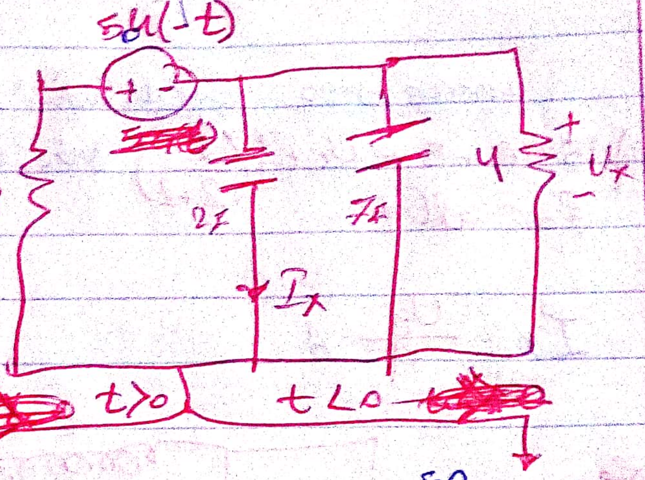
بنطلع Req عن طريق R_{th} بعدما نقفل المصادر كلها

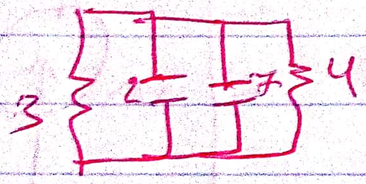
$R_{eq} = 24 \| 80 = \ldots$

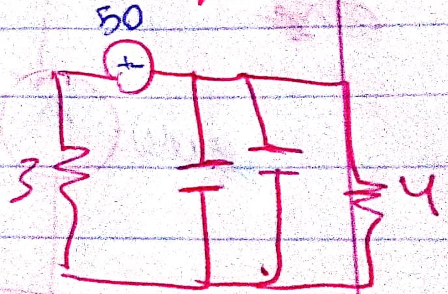
$\tau = \cancel{R_{eq}} \; L / R_{eq}$



Ex

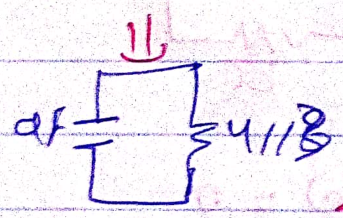




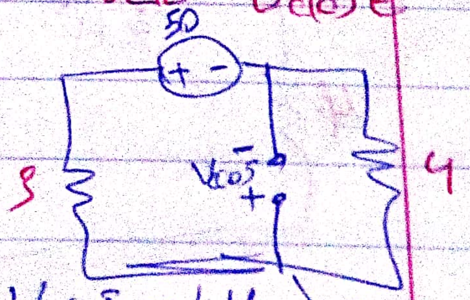


Source free RC cct

$V_c(t) = V_c(0)\, e^{-t/\tau}$



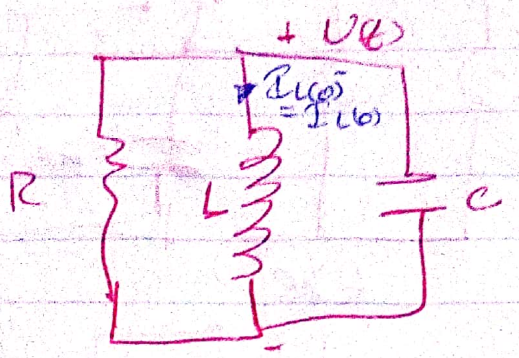
$I_x = V_c(t)\, e$ 2F



$V_c(0) = \left(\frac{4}{4+3}\right) 50$

$\tau = RC = (3 \| 4) \cdot 9$

Source free RLC cct



KCL ⇒ 2nd ODE

$v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$

$v(0) = A_1 + A_2$ —— ①

من الخوارج $\quad v_c(0^-) = v_c(0)$

$$I_L = \frac{1}{L}\int_{-\infty}^{t} v(t)\,dt \Rightarrow I_L(t) = \frac{1}{L}\left[\frac{A_1 e^{s_1 t}}{s_1}\Big|_{-\infty} + \frac{A_2 e^{s_2 t}}{s_2}\right]_{-\infty}^{t}$$

$$= \frac{1}{L}\left(\frac{A_1 e^{s_1 t}}{s} + \frac{A_2 e^{s_2 t}}{s_2}\right) \Rightarrow I_L(0) = \frac{1}{L}\left(\frac{A_1}{s_1} + \frac{A_2}{s_2}\right) \text{ —— ②}$$

$s_1 = -\alpha + \sqrt{\alpha^2 - \omega^2} \qquad s_2 = -\alpha - \sqrt{\alpha^2 - \omega^2}$

$v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$

$\alpha = \frac{1}{2RC} \qquad \omega = \frac{1}{\sqrt{LC}}$

case I $\quad \alpha > \omega \quad$ OVERDAMBED $\quad s_1, s_2$ (Real)

$s_1 = ---,\ s_2 = ---$

case II $\quad \alpha = \omega \quad s = s_1 = s_2 = -\alpha$

$v(t) \quad A(e^{st})$ Critical DAmped

case III $\quad \alpha < \omega$

under DAMBED

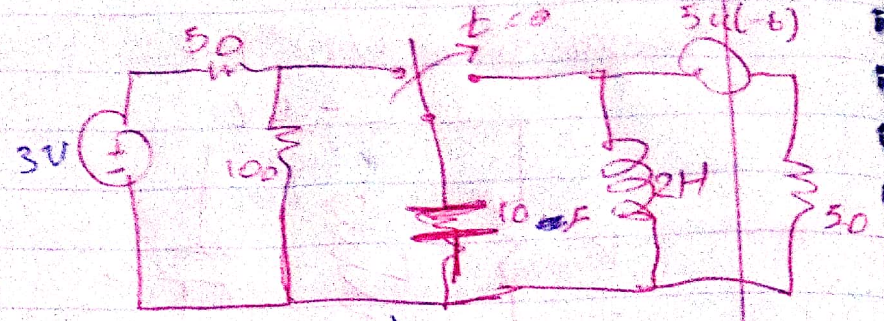
$s_1 = -\alpha + i\sqrt{\omega^2 - \alpha^2}$

$s_1 = -\alpha + i\omega_d$

$s_2 = -\alpha - j\omega_d$

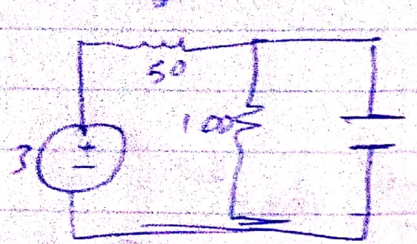
$i = \sqrt{-1}$

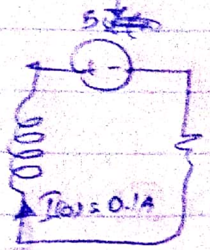
$v(t) = e^{-\alpha t}(B_1 \cos\omega_d t + B_2 \sin\omega_d t) \qquad \omega_d = \sqrt{\omega^2 - \alpha^2}$ (Real)

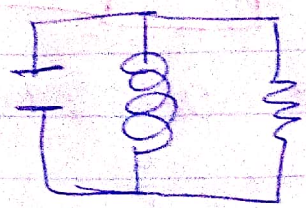


t<0

t>0







$v(0) = \left(\frac{100}{150}\right)3$

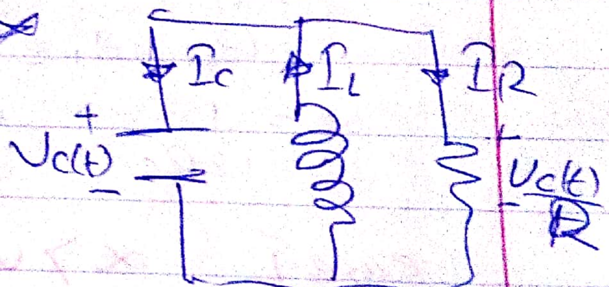
$\alpha = \frac{1}{2 \times 50 \times 10} = \frac{1}{1000} = 0.001$

$\omega = \frac{1}{\sqrt{2 \cdot 10}} = \frac{1}{\sqrt{20}} \approx 0.24$

$V(0) = A_1 \cos 0 + \cancel{A_2 \sin 0}$

$\boxed{V(0) = A_1}$

$V(t) = e^{-\alpha t}\left[A_1 \cos \omega_d t + A_2 \sin \omega_d t\right]$



$I_C = C\frac{dV_t}{dt}$

KCL: $I_C + I_R = I_L$

THE END