1

ε

Symbols and Abbreviations:

Quantity	Symbol	unit	units
1. Resistance	R	ohm	Ω
2. Capacitance	C	farad	F, μF
3. Inductance	L	henry	H
4. Impedance	Z	ohm	Ω
5. Resistivity	ρ	ohm meter ~~Simens per meter~~	Ωm
6. Conductivity	σ	Simens per meter	S/m
7. Admitance	Y	simens	S
8. Current	I	ampére	A, mA,
9. potential	V	volt	V, mV, K
10. Frequency	f	hertz	Hz, KHz,
11. power	P	Watt	W, Kw, M
12. Energy	W	joule, watt hour	J, W.h
13. Force	F	Newton	N
14. Efficiency	η	unitless	

Abbreviations for Multiples and Submultiples

T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
K	Kilo	10^{3}
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}

International System of Units

The IS of U known as (SI)

The (SI) ~~haves~~ has six fundamental unit

Quantity	symbol	unit	Abbreviation
(1) Length	L	metre	m
(2) mass	m	Kilogram	Kg
(3) time	t	second	S
(4) Electric Current	I	ampere	A
(5) temperature	T	Kelvin	K
(6) luminous intensity	Em	Candela	Cd

Electric circuit and its elements:

An elec circuit or elec.network is an a collection of electrical element interconnected in some specified way so that a closed path is available for the current to flow. The two terminals a and b of a source of elec. energy are connected by wires to resistor, inductors, capacitors or other solid state devices.

Resistance: is the first circuit element used to represent energy dissipation as heat or radiant energy. (circuit symbol)

Inductance: is the second circuit element used to represent the energy stored in a magnetic field and measured in henrys.

Capacitance: is the third circuit element used to represent charge storage and consequently, energy stored in elec. field and is measured in farad.

②

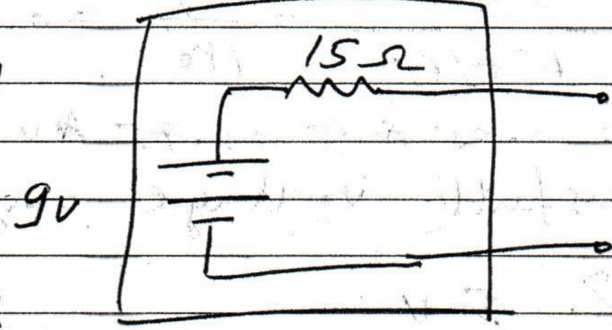
EXp

Calculate the downing of energy in the voltage source of the folowing cases: if the battery has 9V and internal resistace of 15 Ω

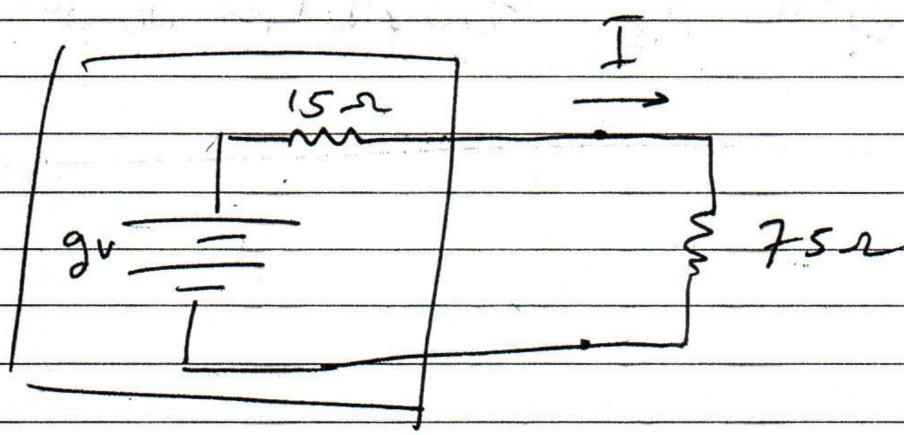
1. before the Load
2. if put the Load $R_L = 75\,\Omega$
3. " " " " $R_L = 165\,\Omega$

①

if not Load that means the current its zero and dowon of the voltage its zero.



②



we can calculate the current used by ~~lows~~ ohms low

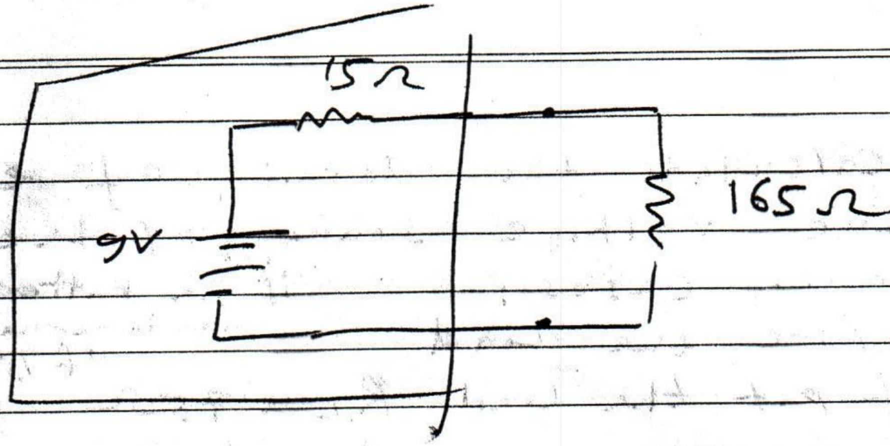
$$I = \frac{V}{R} = \frac{9}{15+75} = \frac{9}{90} = 0.1\ A$$

The dowon of the Voltage:

$$V = IR = 15 \times 0.1 = 1.5\ V$$

That means ~~we can~~ the active usfuly of from this source not 9V, its 7.5V

③



$$I = \frac{V}{R} = \frac{9}{15+165} = \frac{9}{180} = 0.05\ A$$

$$V = IR = 0.05 * 15 = 0.75\ V$$

the usfully voltage only

$8.25\ V$

في حالة عدم اعطاء قيمة R_s نعتبرها صفر

Ohms Law:

The ratio of the potential difference (V) between the ends of a conductor to the current (I) flowing between them is constant, provided the temperature do not change i.e.

$$\frac{V}{I} = \text{constant} = R$$

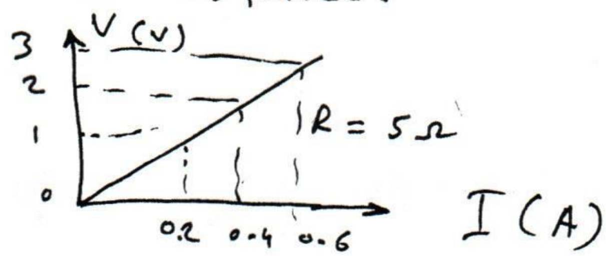
where R is the resistance of the conductor between the two points. If the voltage between points A and B is V volt and current flowing is I ampere, then V/I will be constant and equal to R.

The following points may be noted about ohms Law:

1. Ohms law is true for metal conductors at constant temp., if the temp. change, ohms law is not applicable.
2. Ohms law is true for d.c circuit. It is not in general valid for a.c circuits.
3. Ohms Law can be expressed in three for forms:

   $I = V/R$ $\quad V = IR \quad$ $R = V/I$

4. If ohms Law is expressed graphically (taking Voltage along Y- axis and current along X- axis) of the graph will give the resistance.

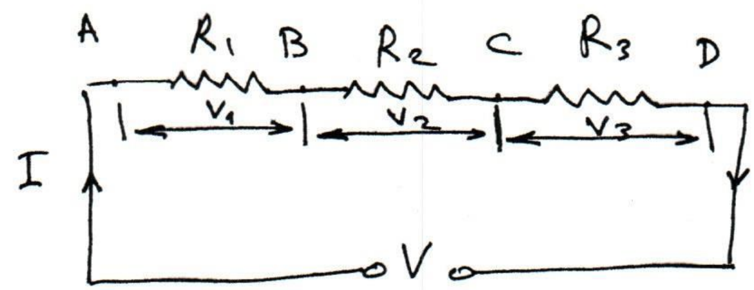


Resistances in Series:

When some conductors having resistances R_1, R_2 and R_3 etc. are joined end on end as in the following figure, they are said to be connected in series. It can be proved that the equivalent resistance or total resistance between points A and D is equal to the some of the three individual resistances.

It should be remembered that:

1. Current is the same through all the three conductors.
2. Voltage drop across each is different due to its resistance and is given by ohms law.
3. Sum of the three voltage drops is equal to the voltage applied across the three conductors.



$$V = V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3$$

Compen-sation

$$V = IR$$

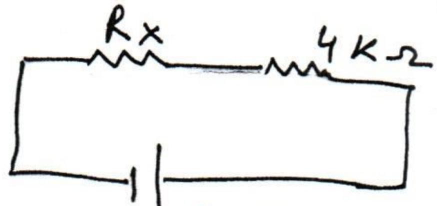
$$IR = IR_1 + IR_2 + IR_3$$

$$R = R_1 + R_2 + R_3$$

4

Exp.

① Find the value of R_X who make the total current of circuit is $4\,mA$



Sol

total Resistance → $R_T = \frac{V_s}{I_s} = \frac{20}{4mA} = 5\,K\Omega$

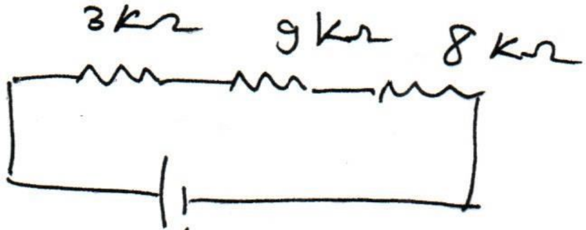
$R_T = R_1 + R_2$

$5K = 4K\Omega + R_X$

$\therefore R_X = 1\,K\Omega$

Exp

find the total resistance, total current and voltag each resistance for the following circuit ?



Sol.

$R_T = R_1 + R_2 + R_3$

$= 3 + 9 + 8 = 20\,K\Omega$

$I_t = \frac{V_s}{R_T} = \frac{40V}{20\,K\Omega} = 2\,mA$

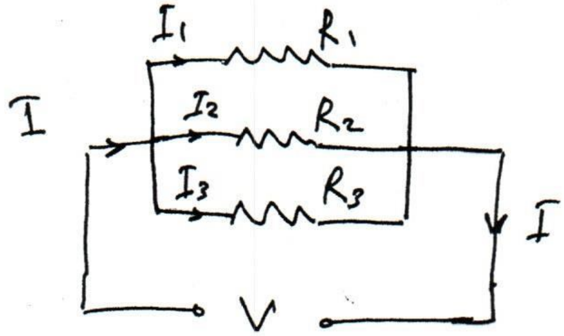
$V_{3K\Omega} = IR = 2 \times 10^{-3} \times 3 \times 10^{3} = 6\,V$

$V_{9K\Omega} = IR = 2 \times 10^{-3} \times 9 \times 10^{3} = 18\,V$

$V_{8K\Omega} = IR = 2 \times 10^{-3} \times 8 \times 10^{3} = 16\,V$

Resistances in Parrallel :

Three resistances, as joined in the following figure are said to be connected in parallel. In this case
① potential drop across all resistances is the same
② current in each resistor is different. ~~and~~
③ the total current is the sum of three separate current.



$$I = I_1 + I_2 + I_3$$

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

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

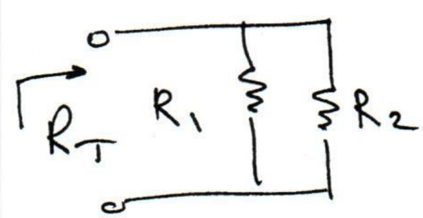
$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \quad \text{or} \quad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

or

$$\boxed{R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}}$$

when connect two resistors (only) in parralle the value of total resistance will be equal

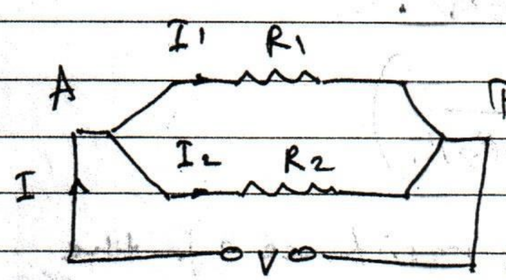
$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$



(5)

~~Q.8.~~ Division of current in parallel Circuits:

in the following fig. two resistances are ~~joinde~~ joined in parallel across a voltage V. The current each branch, as given by ohms Law, is



$I_1 = V/R_1$ and $I_2 = V/R_2$

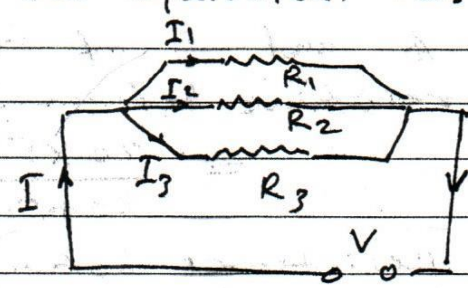
$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$

$I = I_1 + I_2 \Rightarrow I_2 = I - I_1$

$$\frac{I_1}{I - I_1} = \frac{R_2}{R_1} \Rightarrow I_1 R_1 = R_2 (I - I_1)$$

$$I_1 = I \cdot \frac{R_2}{R_1 + R_2} \quad \text{and} \quad I_2 = I \cdot \frac{R_1}{R_1 + R_2}$$

Take the case of three resistors in parallel connected across a voltage V. The total current $I = I_1 + I_2 + I_3$. Let the equivalent resistance be R. Then



$V = IR$

$V = I_1 R_1 \qquad IR = I_1 R_1$

$$\frac{I}{I_1} = \frac{R_1}{R} \quad \text{or} \quad I_1 = IR/R_1 \quad \text{—— (1)}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

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

From $\rightarrow$ ①

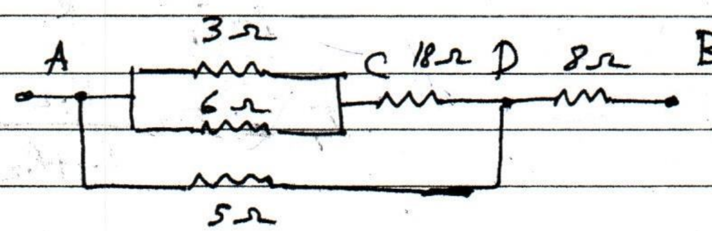
$$I_1 = I\left(\frac{R_2R_3}{R_1R_2+R_2R_3+R_3R_1}\right)$$

Similarly $I_2 = I\left(\frac{R_1R_3}{R_1R_2+R_2R_3+R_3R_1}\right)$ and

$$I_3 = I\left(\frac{R_1R_2}{R_1R_2+R_2R_3+R_3R_1}\right)$$

Exp. Calculate the effective resistance of the following combination of resistances and the voltage drop across each resistance when a potential drop of (60 V) is applied between points A and B

Sol



Resistance between A and C

$$= \frac{6\times3}{6+3} = 2\ \Omega$$

Resistance of branch ACD

$$= 18+2 = 20\ \Omega$$

Now there are two parallel paths between points A and D of resistance $(20\ \Omega)$ and $(5\ \Omega)$

Hence, resistance between A and D

$$= \frac{20\times5}{20+5} = 4\ \Omega$$

$\therefore$ Resistance between A and B $= 4+8 = 12\ \Omega$

total current $= 60/12 = 5\ A$

Current through $5\ \Omega$ resistor $= 5\times\frac{20}{25} = 4\ A$ $\left(I_{(5\Omega)} = I_t \times \frac{R_1}{R_1+R_2}\right)$

" in branch ACD $= 5\times\frac{5}{25} = 1\ A$

P.D. across $3\ \Omega$ and $6\ \Omega$ resistors $= 1\times2 = 2\ V$

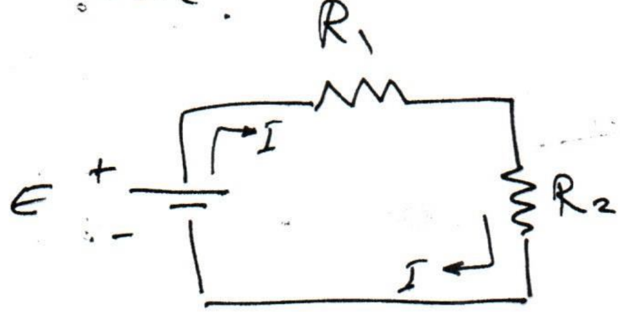
" " $18\ \Omega$ resistor $= 18\times1 = 18\ V$

" " $5\ \Omega$ " $= 5\times4 = 20\ V$

" " $8\ \Omega$ " $= 8\times5 = 40\ V$

Voltage division law

The following figure as shown two series resistance:



we can write this relantion ship:

$$R_t = R_1 + R_2$$

$$E = I \cdot R_t = I \times (R_1 + R_2)$$

$$I = \frac{E}{R_1 + R_2}$$

Compensation in values of current we obtain

$$V_1 = I \cdot R_1 = E \times \frac{R_1}{R_1 + R_2}$$

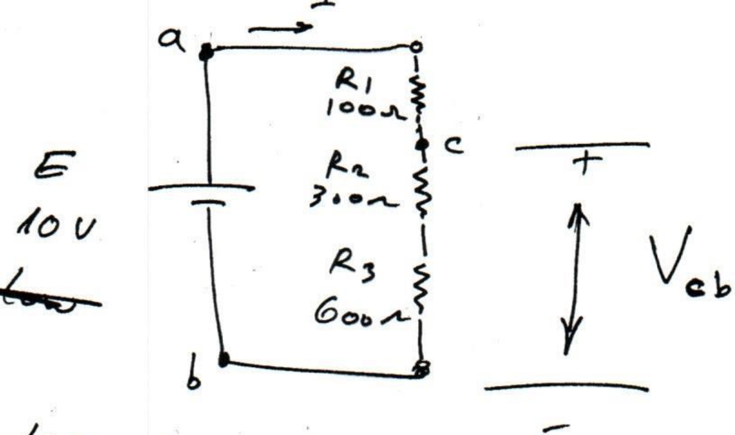
$$V_2 = I \cdot R_2 = E \times \frac{R_2}{R_1 + R_2}$$

This relantion ships acts the relation volta division in the electric circuits when contanis of series resistances.

Exp.

Calculate the total current and the voltage on the leads of each resistance and the voltag between c, b for the following electric circu

Sol



① we solute this Exp. using ~~kahms law~~ Ohm's law :

- $R_t = R_1 + R_2 + R_3 = 100 + 300 + 600 = 1000\ \Omega$

$$I_t = \frac{E(V)}{R_t} = \frac{10}{1000} = 0.01\ A = 10\ mA$$

$V_1 = I R_1 = 0.01 \times 100 = 1V$

$V_2 = I R_2 = 0.01 \times 300 = 3V$

$V_3 = I R_3 = 0.01 \times 600 = 6V$

$\therefore E = V_1 + V_2 + V_3 = 10V$

- $V_{cb} = I \times (R_2 + R_3) = 0.01 \times (300 + 600) = 9V$

② Sol. exp using Voltag division Laws :

$$V_1 = E \times \frac{R_1}{R_1 + R_2 + R_3} = 10 \times \frac{100}{1000} = 1V$$

$$V_2 = E \times \frac{R_2}{R_1 + R_2 + R_3} = 10 \times \frac{300}{1000} = 3V$$

$$V_3 = E \times \frac{R_3}{R_1 + R_2 + R_3} = 10 \times \frac{600}{1000} = 6V$$

$$V_{cb} = E \times \frac{R_2 + R_3}{R_1 + R_2 + R_3} = 10 \times \frac{900}{1000} = 9V$$ //

Atomic Theory

All materials consist of very small atoms, the atom consist of two ~~p~~ general parts:

① It has a hard central core known as nucleus. It contains two types of particles; one is known a proton and carries positive charge, the other is neutron which is electrically neutral.

② Revolving round.

Coulomb Law:

The fundamental unit for charg its Coulum

$$F = K \frac{Q_1 Q_2}{r^2}$$

F - the force between charges, its unit (N)

$Q_1 Q_2$ - The charges, its unit (C) $[Q = 1.6 \times 10^{-19}$ C

~~m~~ r - The distance between the two charges, its unit (m)

K - Coulumb constant and equal $9 \times 10^{9}\ m^2 N/C^2$

Exp. If was the attraction force between two charges 100N, Now how much beco the force between them if multiply the distance between them?

Sol first case:

$$F_1 = K \frac{q_1 q_2}{r_1^2} = 100$$

second case:

$$F_2 = K \frac{q_1 q_2}{(2r_1)^2}$$

by dividing $\frac{F_1}{F_2}$ we obtaine:

$$\frac{F_1}{F_2} = \frac{\cancel{K} \frac{\cancel{q_1 q_2}}{r_1^2}}{\cancel{K} \frac{\cancel{q_1 q_2}}{(2r_1)^2}} = \frac{4\cancel{r_1^2}}{\cancel{r_1^2}} = \underline{4}$$

Thats mean the force in second case its $(\frac{1}{4})$ from Value of first force.

$$\therefore \quad F_2 = \frac{1}{4} F_1 = \frac{1}{4} * 100 = 25N$$

we see the force decreased when the distance its increased.

Classification of materials (The force will be decreased by increasing of distance)

1. Conductors
2. Dielectric
3. Semi-conductors

Electrical current:

The el. current has known the beam of electr. in the conductor and its unit Ampere (A). and we can to define the elec. current as the average of charge changing cross unit of time:

$$I = \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt} \quad (1c/s).$$

Types of current:

① Direct current
② Alternative current

The density of current (J)

$$J = \frac{I}{S} \quad A/mm^2$$

The electro-motiv force (emf):

The ~~charge~~ power who very importent to curry the charge between two Nodes and its symbol (V) 6 unit volt.

$$V = \frac{P}{I} \qquad P = V * I$$

$$1V = \frac{1\,Watt}{1\,ampere}$$

The relation ship between the resistance, lenght of conductor and ~~a~~area of section.

$$R = \rho \frac{l}{A}$$

R - resistance (Ω)

l - conductor lenght (m)

A - area of section for conductor (m^2)

ρ - Resistivity ($\Omega . m$)

Exp.

Conductor of copalt cilinder his lenght 50km and the ~~[illegible]~~ Radius of section its 2mm. Calculate the resistance of this conductor if you know the quality resistance of copalt its $2.7 * 10^{-8}$ $\Omega . m$

Sol/

$$A = \pi r^2$$

$$= \pi (2 \times 10^{-3})^2 = 1.26 \times 10^{-5} m^2$$

$$R = \rho \frac{l}{A}$$

$$= 2.7 \times 10^{-8} \frac{50 \times 10^{3}}{1.26 \times 10^{-5}} = 107 \Omega$$

The due of temperature on the resistance

$$R_1 = R_o\left(1+\alpha\left(T_1 - T_o\right)\right)$$

R_1 – The value of resistance on finally temp – T_1 (Ω)

R_o – The value of resistance on primary temp T_o (Ω)

T_1 – The finally temperature (C°)

T_o – The primary temp. (C°)

α – The quality temperature for the material ($1/{}^\circ C$)

Exp.

The value of copalt resistance in the begi of cycle (Temperature $20\ {}^\circ C$) was ($15\ \Omega$) calculate this value when The temp. become ($70\ {}^\circ C$). The quality temp. for copalt $\alpha = 0.004\ C^\circ$

Sol

$$R_1 = R_o\left(1+\alpha\left(T_1 - T_o\right)\right)$$
$$= 15\left(1+0.004\left(70-20\right)\right)$$
$$= 15 \times 1.2 = 18\ \Omega$$

The conductivity :

$(G)\ G = \frac{1}{R} \quad \Omega^{-1} \Rightarrow (G)\ G = \frac{\mathcal{H} * A}{L}$

$\mathcal{H}$ - The quality conductivity

The power :

$P = IV$

$= I^2 R$

$= \frac{V^2}{R}$

The efficiency

$\eta = \frac{P_{out}}{P_{input}} \times 100\%$

unitless

V - Volt drop (V)

I - Current (A)

R - resistance (Ω)

P - Power (W)

The Energy :

$E = P \cdot t$

E - energy (J)

P - power (W)

T - time (s)

Exp// find the energy (dissipation) by cause the working of instrument his power 1800 W to one hour ?

Sol// For measuring the power by unit Joul or watt we must first to convert the time from hour to seconds

$t = 1 \times 60 \times 60 = 3600\ S$

$E = Pt = 1800 \times 3600 = 6480\ kW.s$

OR

$E = Pt = 1.8 \times 1 = 1.8\ Kw.h$

Classification of Elements :

The circuit element can be classified as:

1- Linear element: if the Voltage - current Charach teristic is a straight Line.

2- Nomn Linear element: if the relationship between voltage and current is not a straight lin

3- passive element: is an element containing no sources of energy such as resistance, inductance and capacitance.

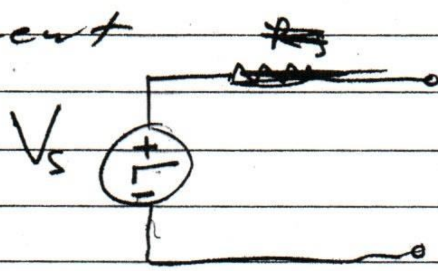
4- Active element: is an elements having interna energy source such as generator, battery

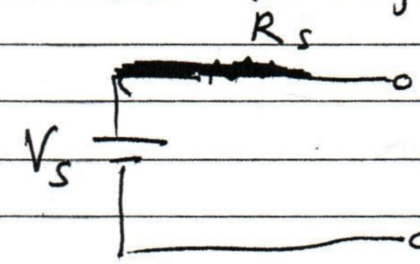
Voltage and Current sources

The two very important sources (active elemen are:

1. independent voltage source
2. independent current source

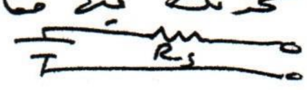
① An independent voltage source is a two termi such as a battery or a generator. The volt is independent of the current through the element



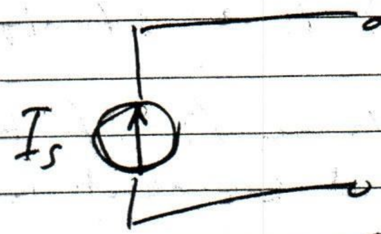


كذلك فيه مقاومة

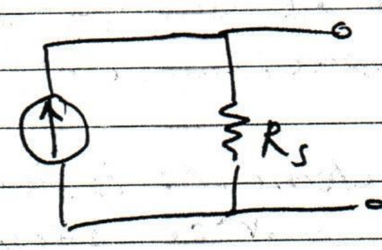
$R_s = 0$



(2) An independent current source is a two termin element through which a current flows. The current is independent of the voltage a cross the element.



يوجد فيها مقاومة داخلية هكذا تكون



كأنها تقترب ∞

Exp

① Change the 300 mH to H

$$300\,mH = \frac{300}{10^3} = 0.3\,H$$

② Chang the 47000 Ω to MΩ

$$47000\,\Omega = \frac{47000}{10^3 \times 10^3} = 0.047\,M\Omega$$

③ Find the total resistance for thee folowing series resistances ?

$R_1 = 30\,K\Omega \quad R_2 = 0.04\,M\Omega \quad R_3 = 5600\,\Omega$

$$R_2 = 0.04\,M\Omega = 0.04 \times 10^3 = 40\,K\Omega$$

$$R_3 = 5600\,\Omega = \frac{5600}{10^3} = 5.6\,K\Omega$$

$$R_1 + R_2 + R_3 = 30K + 40K + 5.6K$$

$$= 75.6\,K\Omega$$

④ Find the total capacitance for thee parallel capacitan

$C_1 = 0.0002\,mF \quad C_2 = 0.1\,\mu F \quad C_3 = 10000\,pF$

$$C_1 = 0.0002\,mF = 0.0002 \times 10^3 = 0.2\,\mu F$$

$$C_3 = 10000\,pF = \frac{10000}{10^3 \times 10^3} = 0.01\,\mu F$$

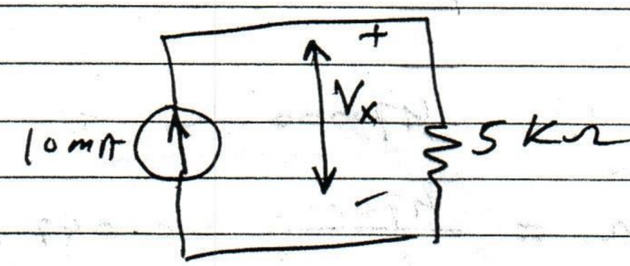
$$C_1 + C_2 + C_3 = 0.2\mu + 0.01\mu + 0.1\mu = 0.31\,\mu F$$

EXP

Calculate the potential between the ideal current sourse (10 mA) if the Load:

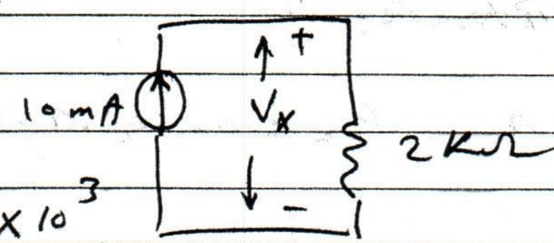
1. $5 K\Omega$
2. $2 K\Omega$

①



$$V_x = IR$$
$$= 10 \times 10^{-3} \times 5 \times 10^{3} = 50 V$$

②

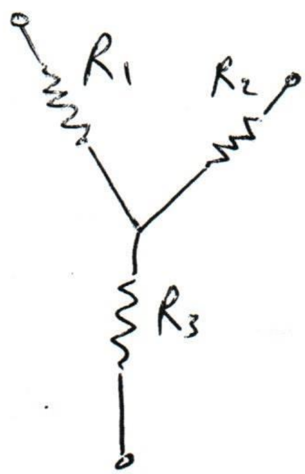


$$V_x = IR$$
$$= 10 \times 10^{-3} \times 2 \times 10^{3}$$
$$= 20 V$$

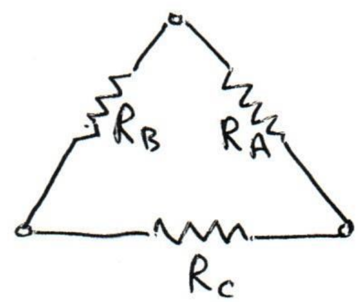
we can see how the potential is changing when ~~we~~, change the load but the current stay without changing

(7) The Convertion laws from delta to star in the electrical circuits.

The following fig. showing three resistances R_A, R_B, R_C connected as delta, and three resistances R_1, R_2, R_3 connected as star.

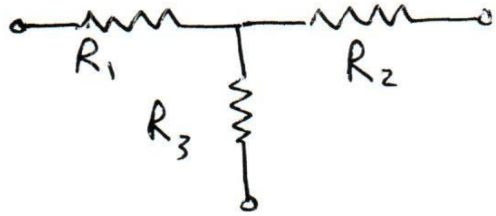


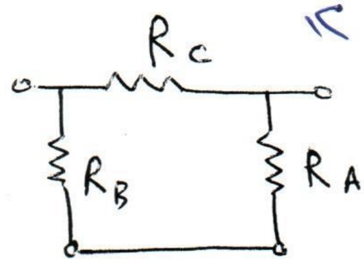
" Y "



" Δ "

We can to simplified these figuers as different figuers:





π

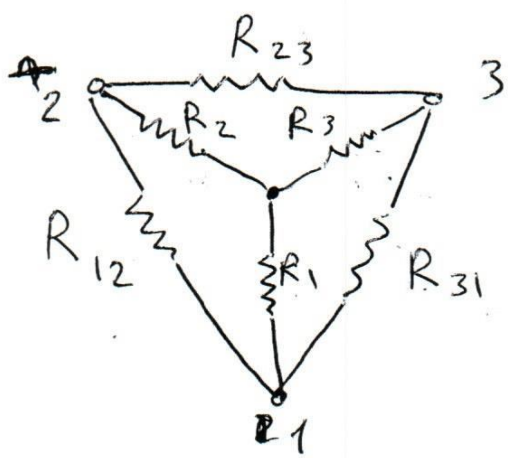
T

Connection T

connection π

① Star/delta Transformation

Easy we can ~~this base~~ simplify this base as :



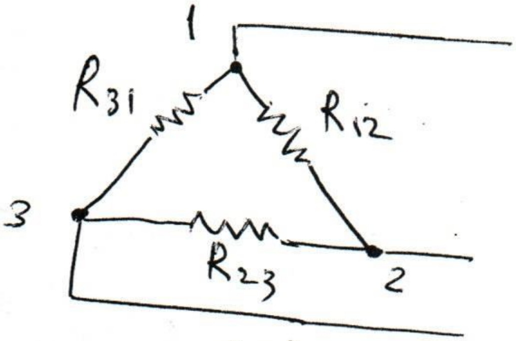
$$R_{31} = \frac{R_2R_3 + R_1R_2 + R_1R_3}{R_2}$$

$$R_{12} = \frac{R_2R_3 + R_1R_2 + R_1R_3}{R_3}$$

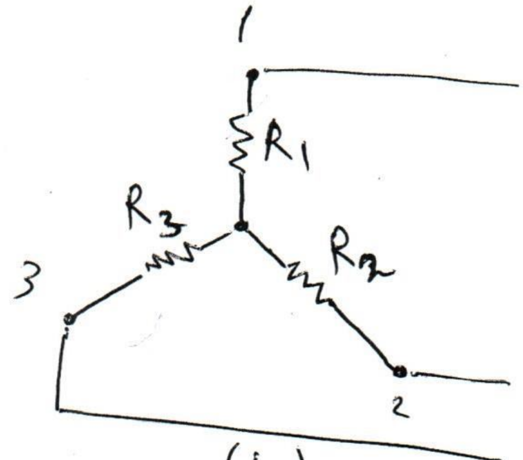
$$R_{23} = \frac{R_2R_3 + R_1R_2 + R_1R_3}{R_1}$$

(2) Delta/star Transformation

If we have complicated networks can be simplified by successively replacing delta meshes by equivalent star systems and vice versa. Suppose we are given three resistances R_{12}, R_{23}, R_{31} connected in delta fasion between terminal 1, 2 and 3 as in the following Fig.(a). So fa as the respective terminals are connected these three resistances can be replaced by the three resistances R_1, R_2 and R_3 connected in star as in Fig.(b).



(a)



(b)

These two arrangements will be electrically equivalent if the resistance as measured between any bair of terminals is the same in both the arrangements. Let us find this condition. First, take delta connection: between terminals 1 and 2, there are two parallel paths; one having

a resistance of R_{12} and other having a resistance of $(R_{23} + R_{31})$.

∴ Resistance between terminals 1 and 2 is:

$$\frac{R_{12} \times (R_{23} + R_{31})}{R_{12} + (R_{23} + R_{31})}$$

Now take the star connection: The resistance between the same terminals 1 and 2 is $(R_1 + R_2$
As terminal resistances have to be the same

$$R_1 + R_2 = \frac{R_{12} \times (R_{23} + R_{31})}{R_{12} + R_{23} + R_{31}} \quad \text{——— (1)}$$

Similarly, for terminals 2 and 3 and terminal 3 and 1, we get:

$$R_2 + R_3 = \frac{R_{23}(R_{31} + R_{12})}{R_{12} + R_{23} + R_{31}} \quad \text{——— (2)}$$

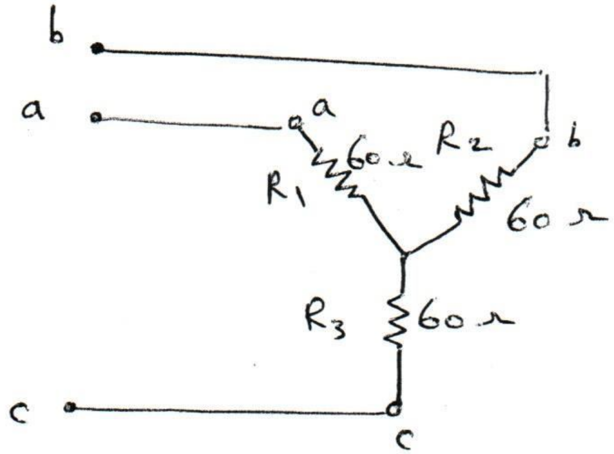
$$R_3 + R_1 = \frac{R_{31}(R_{12} + R_{23})}{R_{12} + R_{23} + R_{31}} \quad \text{——— (3)}$$

Now substracting (2) from (1) and adding the result to (3), we get:

$$R_1 = \frac{R_{12} R_{31}}{R_{12} + R_{23} + R_{31}}; \quad R_2 = \frac{R_{23} R_{12}}{R_{12} + R_{23} + R_{31}}; \quad R_3 = \frac{R_{31} R_{23}}{R_{12} + R_{23} + R_{31}}$$

9

Ex 1 For the following circuit convert the Connection of Star to delta ?



Sol//

$$R_A = \frac{R_1R_2 + R_2R_3 + R_1R_3}{R_1}$$

$$R_A = \frac{60\times60 + 60\times60 + 60\times60}{60} = 180\ \Omega$$

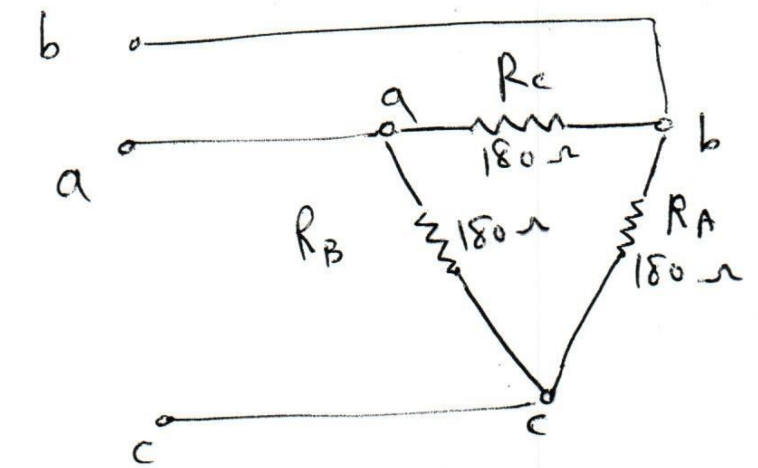
$$R_A = R_B = R_C = 180\ \Omega$$

The ~~connection of~~ resistances of star connection its equal,

∴ we can to calculate the value of resistances in delta connection by direct equation :

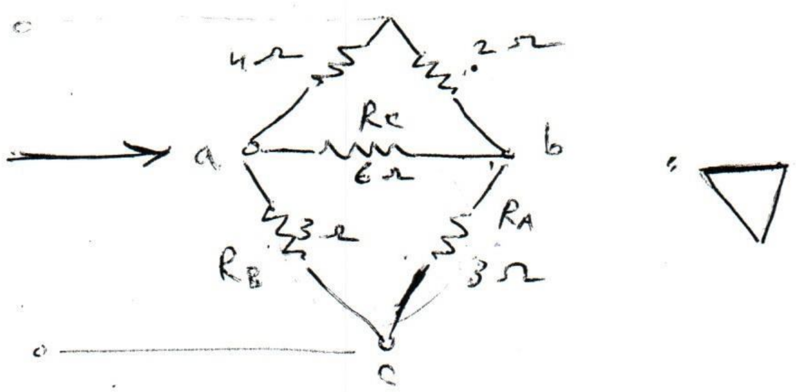
$$R_\Delta = 3\times R_Y = 3\times60 = 180\ \Omega$$

and the equivalent circuit :



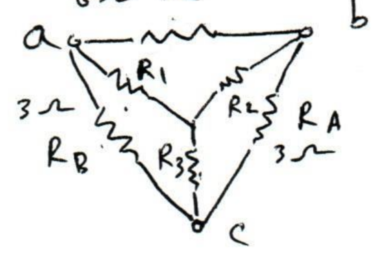
EXP. 2

Calculate the equivalent resistance for the following circuit:



Sol/ Convert the delta connection for resistances (R_A, R_B, R_c) to the star connection.
shown in the circuit has two equal resistances in the delta connection, thats mean we will get two equal resistances in the star connection;

$$R_1 = R_2 = \frac{3 \times 6}{3+3+6} = 1.5\ \Omega$$

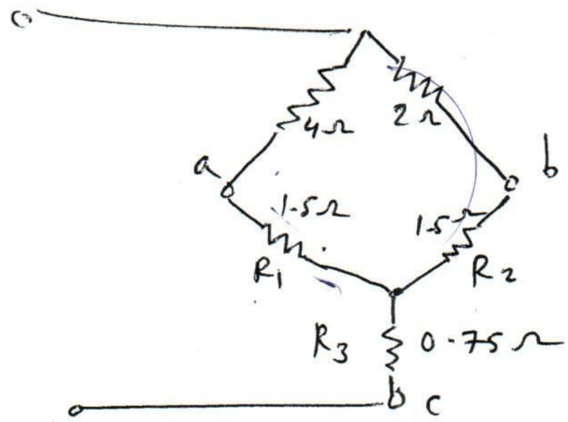


$$R_3 = \frac{3 \times 3}{12} = 0.75\ \Omega$$

— يتبع —

— تكملة حل السؤال —

The electric circuit will be as the following circuit:

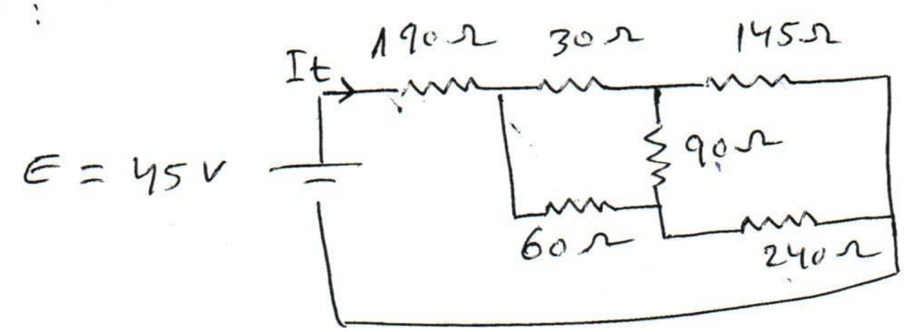


and calculate the equivalent resistance for this circuit from the equation:

$$R_{eq} = 0.75 + \frac{(4+1.5)(2+1.5)}{(4+1.5)+(2+1.5)} = 2.889\,\Omega$$

Exp. 3

Calculate the total current in the following circuit:



Sol//

We can to see more then one methode for finding the total equivalent resistance.

① considerate the resistances (90, 145, 240) are connecta in delta connection and converate to star.

② considerate the resistances (30, 145, 90) and

(60, 90, 240) as star connection and convert to 10
delta connection.

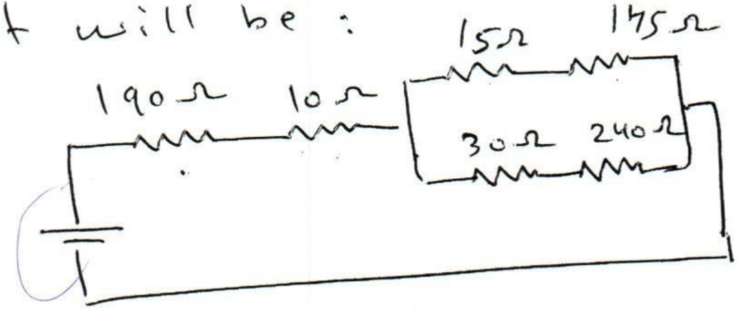
but we take the resistances (60, 30, 90) as delta connection ~~to~~ and convert to star connection:

$$R_A = \frac{30 \times 90}{30+90+60} = 15\,\Omega$$

$$R_B = \frac{90 \times 60}{30+90+60} = 30\,\Omega$$

$$R_C = \frac{30 \times 60}{30+90+60} = 10\,\Omega$$

The circuit will be :

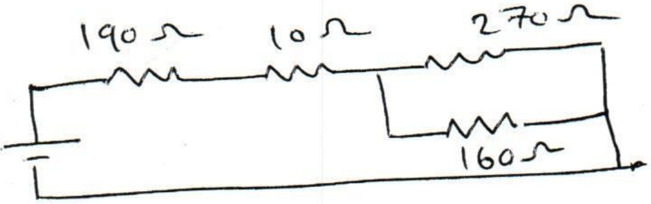


The resistances (15, 145) in series connection and the resistances (30, 240)

$$30+240 = 270\,\Omega$$

$$15+145 = 160\,\Omega$$

and the last resistances in parallel connection



$$270 \,//\, 160 = \frac{270 \times 160}{270+160} = 100\,\Omega$$

The Total equivalent resistance:

$$R_T = R_1 + R_2 + R_3 = 190+10+100 = 300\,\Omega$$

$\therefore$

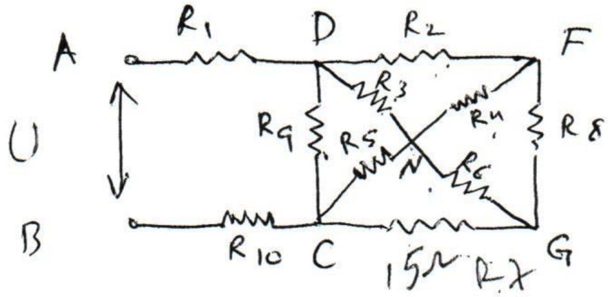
$$I_t = \frac{V_T}{R_T} = \frac{45}{300} = 0.15\ A$$

(11) Exp.4

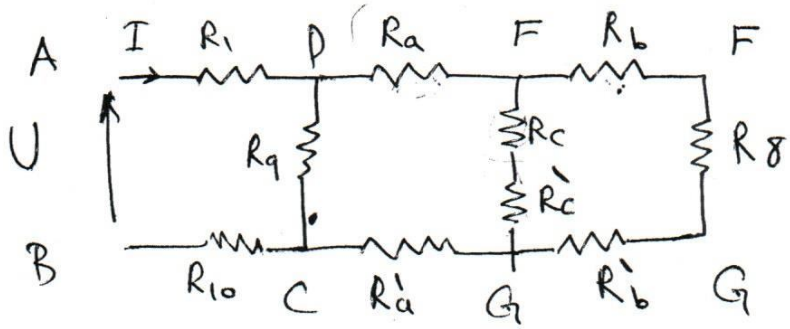
Find the total current for the following circuit:

$R_1 = 6\Omega$, $R_2 = 12\Omega$, $R_3 = 9\Omega$, $R_4 = 6\Omega$, $R_5 = 5\Omega$, $R_6 = 10\Omega$

$R_7 = 15\Omega$, $R_8 = 10\Omega$ $R_9 = 15\Omega$, $U = 57V$, $R_{10} = 15\Omega$



Sol// By converting the delta connection betwen NFDN and NCGN to star connection we get the following circuit:



$$R_a = \frac{R_2 \cdot R_3}{R_4 + R_2 + R_3} = \frac{12 \times 9}{12 + 9 + 6} = 4\Omega$$

$$R_b = \frac{R_2 \cdot R_4}{R_4 + R_2 + R_3} = \frac{12 \times 9}{12 + 9 + 6} = \frac{8}{3} = 2.667\Omega$$

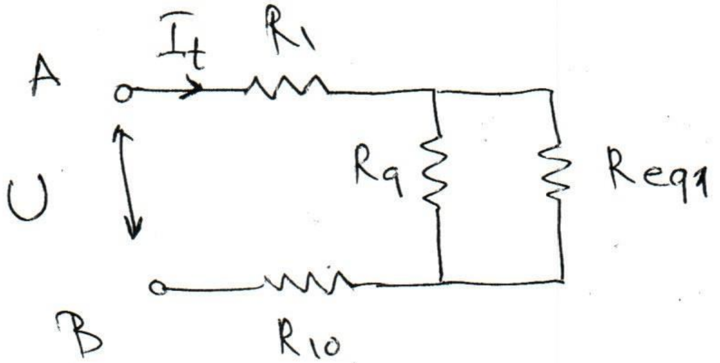
$$R_c = \frac{R_3 \cdot R_4}{R_1 + R_2 + R_3} = \frac{6 \times 9}{12 + 9 + 6} = 2\Omega$$

$$R_a' = \frac{R_5 \cdot R_7}{R_5 + R_7 + R_6} = \frac{15 \times 5}{30} = 2.5\,\Omega$$

$$R_b' = \frac{R_6 \cdot R_7}{R_6 + R_7 + R_5} = \frac{10 \times 15}{30} = 5\,\Omega$$

$$R_c' = \frac{R_5 \cdot R_6}{R_5 + R_6 + R_7} = \frac{5 \times 10}{30} = 1.6667\,\Omega$$

$$R_{eq1} = \frac{(R_b + R_b' + R_8)(R_c + R_c')}{(R_b + R_b' + R_8) + (R_c + R_c')} + (R_a + R_a') = 15\,\Omega$$



$$R_{eq} = R_1 + R_{10} + \frac{(R_9 \cdot R_{eq1})}{R_9 + R_{eq1}} = 28.5\,\Omega$$

$$I_t = \frac{U}{R_{eq}} = \frac{57}{\cancel{28.5}\ 28.5} = 2\,A$$

Kirchhoffs laws

By the middle of the nineteenth century a considerable amount of experience with electric circuits had been gained by the leading men of science of that time. However, it was Gustav robert kirchhoff (1824 - 1887) who published the first systematic formulation of the principles governing the behaviour of electric circuits. He advanced no new experimental facts or concepts but merely rastated familiar principles. His work was embodied in two Laws - a current and a voltage Law - which together are known as kirchhoffs laws. It is upon these laws that electric circuit theory is based. These laws are used (a) in determinging the equivalent resistance of a complicated network of conductors and (b) for calculating the currents flowing in the various conductors. The two-laws can be defined as:

1- Kirchhoffs Current Law (KCL)

It states as follows:

« In any electrical network, the algebraic sum of the currents meeting at a point (or junction) is zero».

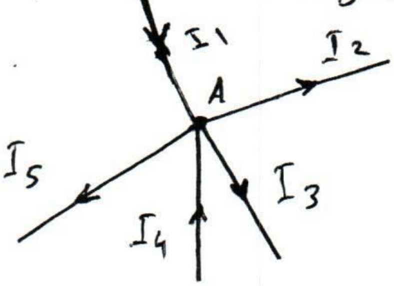
put in another way, it simply means that the total current leaving a junction is equal to the total current entering that junction. It is obviously true because there is no accumulation of charg at the junction of the network.

Consider the case of a few conductors meeting at a point A as in figuere. Some conductors have currents leading to point A, whereas some have current leading away from point A. Assuming the incoming currents to be positive and the outgoing currents negative, we have:

$$I_1 + (-I_2) + (-I_3) + (+I_4) + (-I_5) = 0$$

$$I_1 + I_4 - I_2 - I_3 - I_5 = 0 \quad \text{or} \quad I_1 + I_4 = I_2 + I_3 + I_5$$

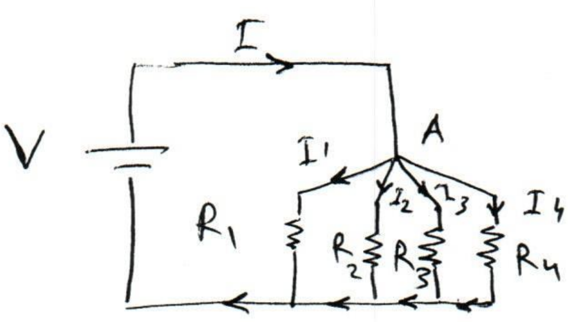
or incoming currents = outgoing currents.



Similarly, in figure for node A:

$$+I + (-I_1) + (-I_2) + (-I_3) + (-I_4) = 0 \quad \text{or} \quad I = I_1 + I_2 + I_3 + I$$

we can express the above conclusion thus: $\sum I = 0$ a a junction

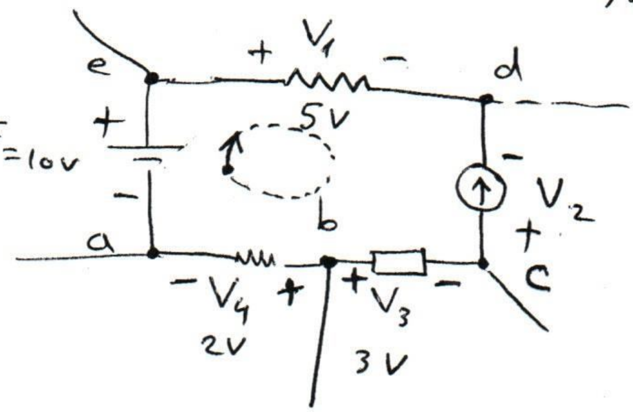


2- Kirchhoffs Voltage Law (KVL)

It states as follows:

« The algebraic sum of the products of currents and resistances is each of the conductors in any closed path (or mesh) in a network plus the algebraic sum of the e.m.fs. in that path is zero.

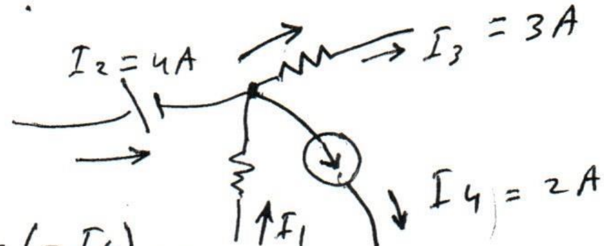
In other owords, $\sum IR + \sum$ ~~em~~ e.m.f. $= 0$ round ames



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

Exp. write the KCL for currents of node shown of the following fig.? Calculate the current $I_1 = ?$

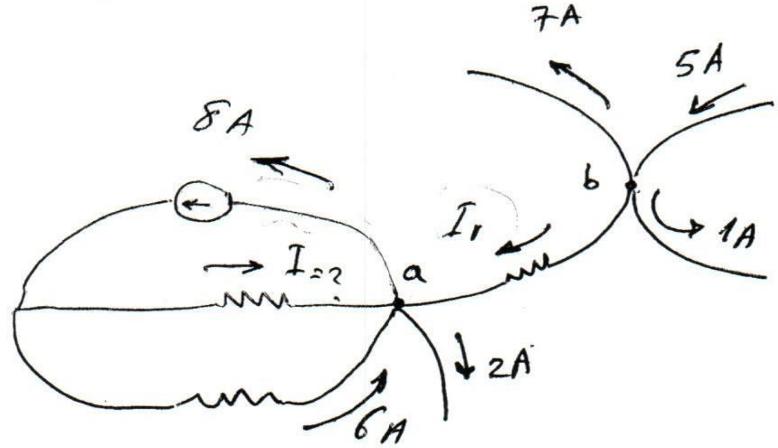
Sol



$$I_1 + I_2 + (-I_3) + (-I_4) = 0$$
$$I_1 + I_2 = I_3 + I_4$$
$$I_1 = I_3 + I_4 - I_2 = 3 + 2 - 4 = \underline{\underline{1A}}$$

Exp.

Calculate the current $I = ?$ for the following Circuit :



Sol

Node b

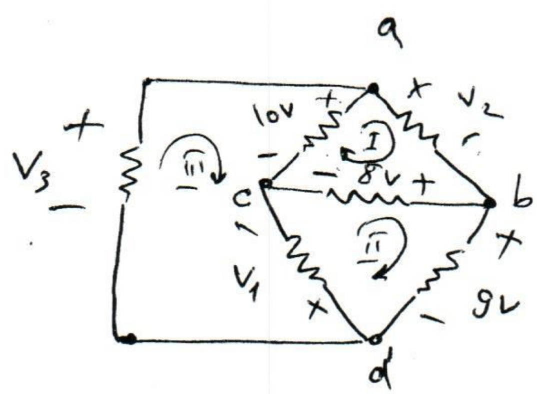
$5 = 7 + 1 + I_1 \Longrightarrow I_1 = 5 - 8 = -3\,A$

Node a

$I + 6 + I_1 = 8 + 2 \Longrightarrow \underline{I} = 10 - 6 - I_1 = 7\,A$

Exp

calculate the Voltages V_1, V_2, V_3 for the following Circuit :



first loop I

$10 - V_2 - 8 = 0 \Longrightarrow V_2 = 10 - 8 = 2V$

second Loop II

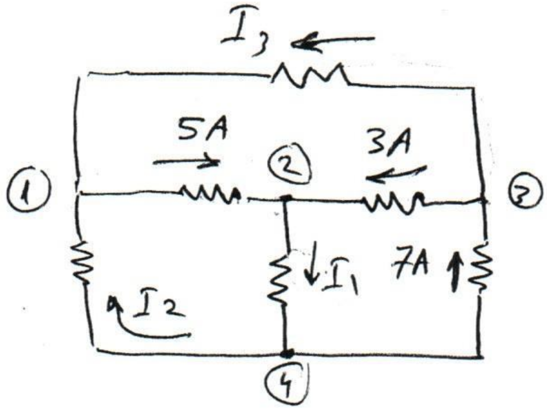
$-V_1 + 8 - 9 = 0 \Longrightarrow V_1 = 8 - 9 = -1\,V$

third Loop III

$V_3 - 10 + V_1 = 0 \Longrightarrow V_3 = 10 - V_1 = 10 - (-1) = 11V$

Exp.

By using Kirchhoffs laws ~~ca~~ calculate the valens of currents I_1, I_2, I_3 for the following circuit:



Sol

In the node 1 has two unknown current and in the nodes 2, 3 has one ~~cur~~ unknown current, at least we will beging in the node 2:

$I_1 = 5+3 = 8A$

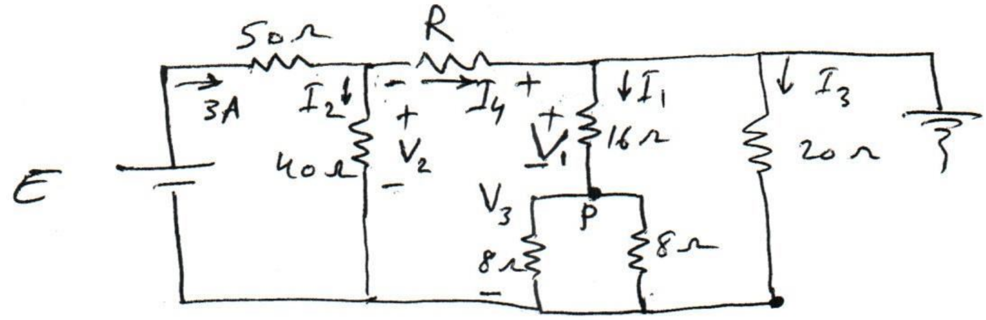
Node 3

$$7 = 3 + I_3 \Rightarrow I_3 = 7-3 = 4A$$

Node 1

$$I_2 + I_3 = 5 \Rightarrow I_2 = 5 - I_3 = 5-4 = 1A$$

Exp. If the voltage of point (P) at the following circuit equal $V_p = -16V$, Calculate each of R, E.



Sol

The voltage of point (P) equal (−16V) :

$\therefore V_1 = 16V$

and the value of current :

$$I_1 = \frac{V_1}{16} = \frac{16}{16} = 1A$$

and the equivalent resistance for the branch who contain the point (P) equal

$$R_{eq1} = 16 + \frac{8 \times 8}{8+8} = 16 + 4 = 20\Omega$$

$$\therefore V_3 = 1 \times R_{eq1} = 1 \times 20 = 20V$$

$$I_3 = \frac{V_3}{20} = \frac{20}{20} = 1A$$

and using the KCL we obtained:

$$I_4 = I_1 + I_3 = 1+1 = 2A$$

$$I_2 + I_4 = 3 \Rightarrow I_2 = 3 - I_4 = 3-2 = 1A$$

$$V_2 = I_2 \times 40 = 1 \times 40 = 40$$

The drop voltage on the leads of resistance R equal :

$$V_R = V_2 - V_3 = 40 - 20 = 20V$$

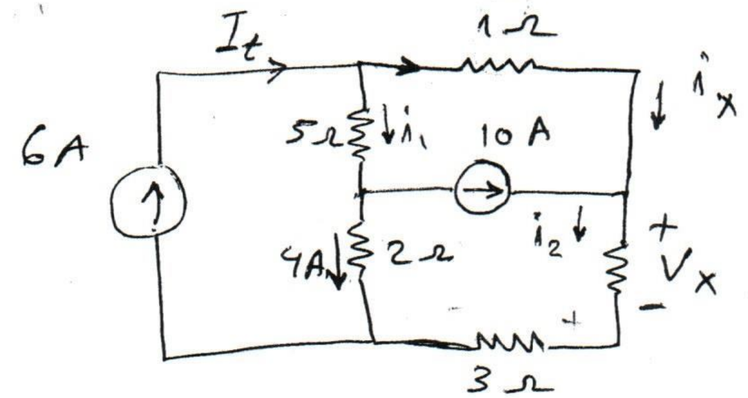
$$\therefore R = \frac{V_R}{I_4} = \frac{20}{2} = 10\Omega$$

by using KVL we obtained :

$$E = 3 \times 50 + V_2 = 150 + 40 = \underline{190V}$$

Exp

(15) Find the value of i_x , V_x in the following circuit ?



Sol

(1) By using KCL we obtained the values of current i_x :

$i_1 = 4 + 10 = 14\ A$

$I_t = i_1 + i_x$

$6 = 14 + i_x \Rightarrow i_x = -8\ A \Rightarrow 10 + (-8) = i_2$

$i_2 = 2\ A$

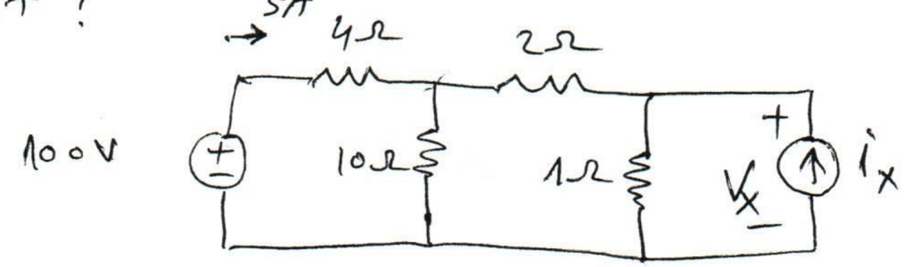
(2) By using KVL we obtained the values of V_x :

$(4 \times 2) + (5 \times 14) - (-8 \times 1) - V_x - (3 \times 2) = 0$

$8 + 70 + 8 - 6 = V_x \Rightarrow V_x = 80\ V$

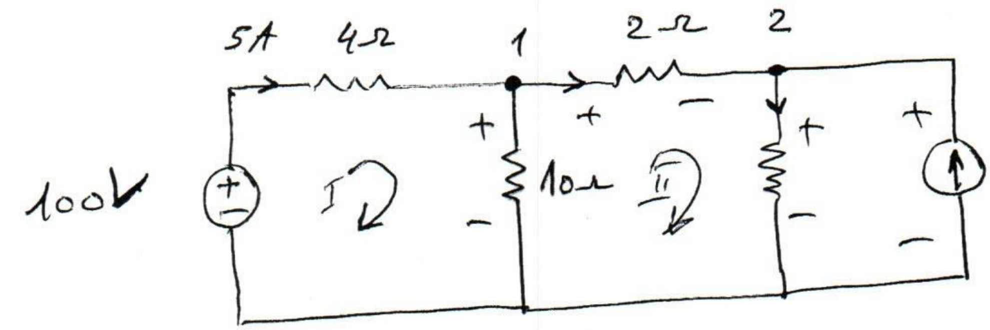
Exp

Find the value of i_x , V_x for the following circuit ?



Sol

C-



$100 - (5 \times 4) - V_{10\Omega} = 0$

$V_{10\Omega} = 100 - 20 = 80\,V$

$I_{10\Omega} = \dfrac{V_{10\Omega}}{10} = \dfrac{80}{10} = 8\,A$

we see the node 1 :

$5 = 8 + I_{2\Omega} \Rightarrow I_{2\Omega} = -3\,A$

$V_{2\Omega} = I_{2\Omega} * R = (-3) * 2 = -6\,V$

By using KVL on the second loop II we obtained ;

$V_{10\Omega} - (-6) - V_{1\Omega} = 0 \Rightarrow 80 + 6 = V_{1\Omega} \Rightarrow V_{1\Omega} = 86\,V$

$I_{1\Omega} = \dfrac{V_{1\Omega}}{1} = 86\,A$

Both of the resistor (1Ω) and the current source (V_x) are Connected in parllel :

$\therefore V_x = V_{1\Omega} = 86\,V$

By using KCL on the node 2 for obtaining the Value of i_x :

$i_{2\Omega} + i_x = i_{1\Omega}$

$-3 + i_x = 86$

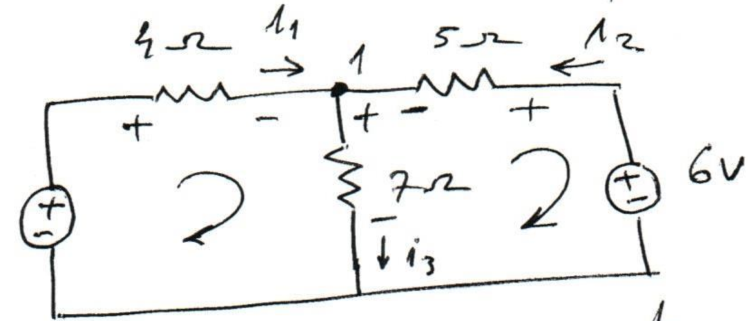
$i_x = 89\,A$

16

Circuit Analysis by Using Kirchhofs laws.

The Kirchhofs current law its active for each Node, and kirchhofs voltage law its active for each Loop in it. we can to analysis electric circuit by considering vector of branch curre by using Kirchhofs laws for obtaining on the number of equation equal to number of unknown currents.

Exp.



By using Kirchhof law for current on the first node 1:

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

$$i_1 + i_2 = i_3 \quad \text{------} \quad (1)$$

By using Kirchhof law for voltage on the both of loops:

$$+5 - V_{4\Omega} - V_{7\Omega} = 0$$

$$5 - 4i_1 - 7i_3 = 0 \quad \text{------} \quad (2)$$

$$V_{7\Omega} + V_{5\Omega} - 6 = 0$$

$$7i_3 + 5i_2 - 6 = 0 \quad \text{------} \quad (3)$$

By subsitution value of i_3 from eq. (1) to eq. (2) and (3) we obtained:

$6-7(i_1+i_2)-5i_2=0$

$6-7i_1-7i_2-5i_2=0$

$-7i_1-12i_2=0$

$7i_1+12i_2=6$ ---------- (4)

$-5+4i_1+7(i_1+i_2)=0$

$-5+4i_1+7i_1+7i_2=0$

$11i_1+7i_2=5$ ---------- (5)

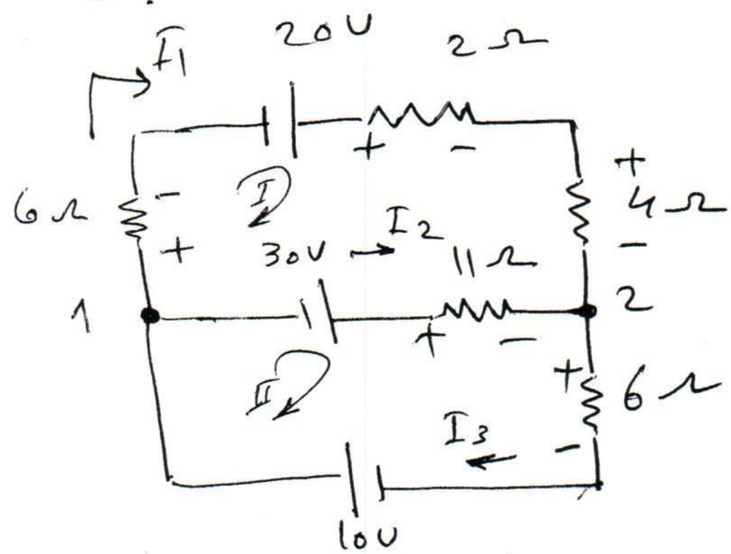
by solving eq. (4) and (5) we obtained:

$i_2=0.37A$ $\qquad$ $i_1=0.22A$

$i_3=i_1+i_2=0.22+0.37=0.59A$

Exp.

In the circuit shown below, determine the direction value of currents in each of the batteries.



— يتبع —

(17)

- تكملة حل السؤال

Sol

$I_3 = I_2 + I_1$ —— ① AT nodes 1, 2

AT loops (I, II)

$20 - 12 I_1 + 11 I_2 - 30 = 0$

$-12 I_1 + 11 I_2 = 10$

$12 I_1 - 11 I_2 = -10$ —— ②

$40V - 11 I_2 - 6 I_3 = 0$

$-11 I_2 - 6 I_3 = -40$

$11 I_2 + 6 I_3 = 40$ —— ③ By subs. (2) and (3) in (1)

$\therefore 12 I_1 - 11 I_2 = -10$

$12 I_1 = -10 + 11 I_2$

$I_1 = \frac{1}{12}(-10 + 11 I_2) \Rightarrow I_1 = \frac{1}{12} \times (11 I_2 - 10)$ —— ④

By subs. (1) in (3)

$11 I_2 + 6 (I_1 + I_2) = 40$

$11 I_2 + 6 I_1 + 6 I_2 = 40$

$6 I_1 + 17 I_2 = 40$ —— ⑤

by subs. (4) in ⑤

$$6 \times \frac{1}{12}(11 I_2 - 10) + 17 I_2 = 40$$

$$5.5 I_2 - 5 + 17 I_2 = 40$$

$$22.5 I_2 = 45 \Longrightarrow I_2 = \frac{45}{22.5} = 2\,A$$

from eq. (4)

$$I_1 = \frac{1}{12} \times (11 \times 2 - 10)$$

$$I_1 = \frac{1}{12}(12) \Longrightarrow I_1 = 1\,A$$

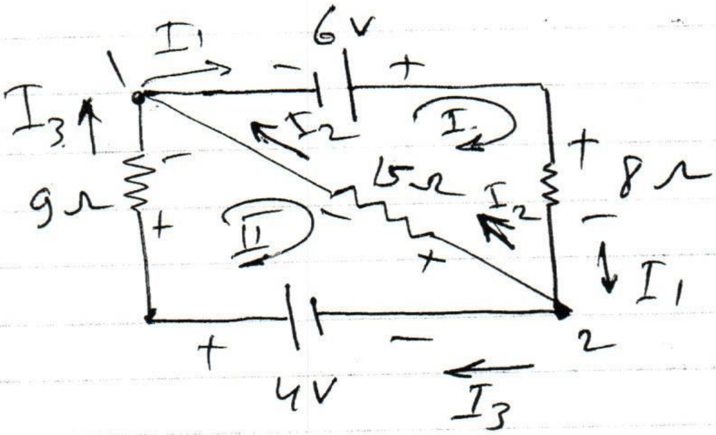
$$I_3 = I_1 + I_2 = 1 + 2 = 3\,A$$

EXP. For the following circuit find the current in each of the three resistances?

$I_{8\Omega} = I_1$

$I_{15\Omega} = I_2$

$I_{9\Omega} = I_3$



At node (1) KCL:

$$I_1 = I_2 + I_3 \Longrightarrow I_3 = I_1 - I_2 \quad \text{—— (1)}$$

(18)

For Loop (I) KVL:

$6V - 8I_1 - 15I_2 = 0$

$8I_1 + 15I_2 = 6$ —— (2)

$15I_2 = 6 - 8I_1 \Rightarrow I_2 = \frac{1}{15} \times (6 - 8I_1)$ — (3)

For Loop II KVL

$15I_2 + 4V - 9 \times I_3 = 0$

$15I_2 + 4 - 9I_3 = 0$ —— (4)

by subs. (1) in (4) we obtained;

$15I_2 + 4 - 9(I_1 - I_2) = 0$

$15I_2 - 9I_1 + 9I_2 + 4 = 0$

$24I_2 - 9I_1 + 4 = 0$ —— (5)

by subs. (3) in (5)

$24 \times \frac{1}{15}(6 - 8I_1) - 9I_1 + 4 = 0$

$9.6 - 12.8I_1 - 9I_1 + 4 = 0$

$13.6 - 21.8I_1 = 0$

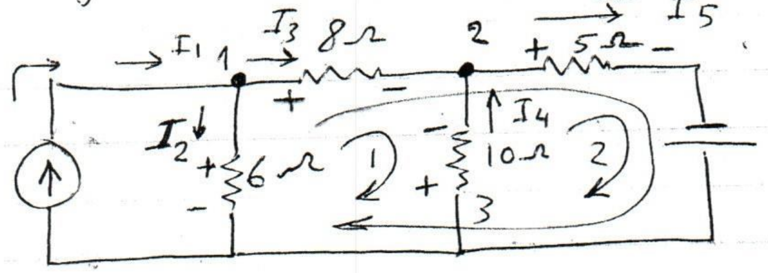
$21.8I_1 = 13.6 \Rightarrow I_1 = 0.6\ A$

$I_2 = \frac{6}{15} - \frac{8 \times 0.6}{15} = 0.4 - 0.32 = 0.08A$

$I_3 = I_1 - I_2$
$= 0.6 - 0.08$
$= 0.52A$

Ex ٣٣

Find the voltage across (8Ω) by using Kirchhoff's Law?



At nodes (1, 2) KCL:

$I_1 = I_2 + I_3$ —— ①

$I_5 = I_3 + I_4$ —— ②

$I_3 = I_5 - I_4$, $I_2 = I_1 - I_3 \Longrightarrow I_2 = 3 - (I_5 - I_4) \Longrightarrow$

$I_2 = 3 - I_5 + I_4$

At Loops (1, 2, 3) KVL:

$6I_2 - 8I_3 + 10I_4 = 0$ —— ③

$-10I_4 - 5I_5 + 10 = 0$

$10I_4 + 5I_5 = 10$ —— ④

$10 + 6I_2 - 8I_3 - 5I_5 = 0$

$-6I_2 + 8I_3 + 5I_5 = 10$ —— ⑤ By subs. I_2 and I_3 in ⑤

$-6(3 - I_5 + I_4) + 8(I_5 - I_4) + 5I_5 = 10$

$-18 + 6I_5 - 6I_4 + 8I_5 - 8I_4 + 5I_5 = 10$

$-14I_4 + 19I_5 = 28$ —— ⑥

19

Now multiply eq. (4) in 19 and eq. (6) in 5 we obtained.

$$10 I_4 + 5 I_5 = 10 \quad — \quad (4) \quad * 19$$

$$-14 I_4 + 19 I_5 = 28 \quad — \quad (6) \quad * 5$$

$\Longrightarrow$

$$\left.\begin{aligned} 190 I_4 + \cancel{95 I_5} &= 190 \\ \pm 70 I_4 \mp \cancel{95 I_5} &= \mp 140 \end{aligned}\right\} \text{By substracting}$$

$-$

$$260 I_4 = 50 \Longrightarrow I_4 = \frac{50}{260} \cong 0.2\,A$$

from eq. (4) $\Longrightarrow$

$$10 I_4 + 5 I_5 = 10 \Longrightarrow 10 * 0.2 + 5 I_5 = 10$$

$$2 + 5 I_5 = 10 \Longrightarrow 5 I_5 = 8 \Longrightarrow I_5 = \frac{8}{5} = 1.6\,A$$

$$I_3 = I_5 - I_4 = 1.6 - 0.2 = 1.4\,A$$

$$V_{8\Omega} = I_3 * R = 1.4 * 8 = 11.2\ V$$

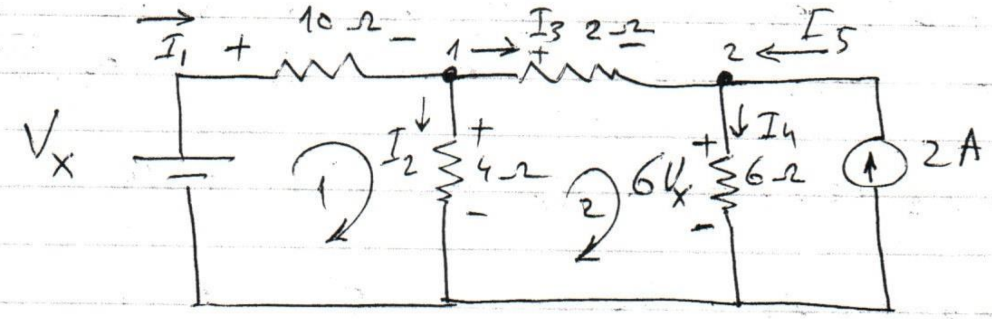
$$I_2 = I_1 - I_3 = 3 - 1.4 = 1.6\,A$$

٢٤

(20)

Exp.

For the circuit shown below, find V_x.



$I_5 = 2A$

$I_4 = \frac{6V_x}{6} = V_x$

$I_4 = V_x$

For nodes (1, 2) KCL

$I_1 = I_2 + I_3$ ——— ①

$I_4 = I_3 + I_5$ ——— ② $\Longrightarrow I_3 = I_4 - I_5 \Longrightarrow \boxed{I_3 = V_x - 2}$

For loops (1, 2) KVL:

$V_x - 10 I_1 - 4 I_2 = 0$

$10 I_1 + 4 I_2 = V_x$ ——— ③

$4 I_2 - 2 I_3 - 6 V_x = 0$

$-4 I_2 + 2 I_3 = -6 V_x$ ——— ④ By subst. ① in ③

$10 (I_2 + I_3) + 4 I_2 = V_x$

$10 I_2 + 10 I_3 + 4 I_2 = V_x$

$14 I_2 + 10 I_3 = V_x$ ——— ⑤

Multiply eq. (4) in $\underline{\underline{14}}$ and eq. (5) in $\underline{\underline{-4}}$ ~~we obta~~ and substracting eq. (5) from eq. (4) we obtain

$$-4 I_2 + 2 I_3 = -6 V_x \text{ —— } (4) \quad * 14$$

$$14 I_2 + 10 I_3 = V_x \text{ —— } (5) \quad * -4$$

$$-\cancel{56 I_2} + 28 I_3 = -84 V_x \text{ —— } (4)$$

$$\pm \cancel{56 I_2} \pm 40 I_3 = \pm 4 V_x \text{ —— } (5)$$

$-$

$$68 I_3 = -80 V_x \text{ —— } (6)$$ by subst. I_3 in (6)

$$68 (V_x - 2) = -80 V_x$$

$$68 V_x - 136 = -80 V_x$$

$$68 V_x + 80 V_x = 136$$

$$148 V_x = 136 \Longrightarrow V_x = \frac{136}{148} = 0.918 \text{ V} = \underline{\underline{I_4}}$$

$$I_3 = 0.918 - 2 = -1.082 \text{ A}$$ by subst. V_x and I_3 in (4)

$$-4 I_2 + 2 * (-1.082) = -6 * (0.918) \Longrightarrow$$

$$-4 I_2 - 2.164 = -5.5$$

$$I_2 = \frac{5.5}{4} = 1.375 \text{ A}$$

$$I_1 = I_2 + I_3 = 1.375 + (-1.082) = \underline{\underline{0.293 \text{ A}}}$$

(21)

من على

Nodal Analysis

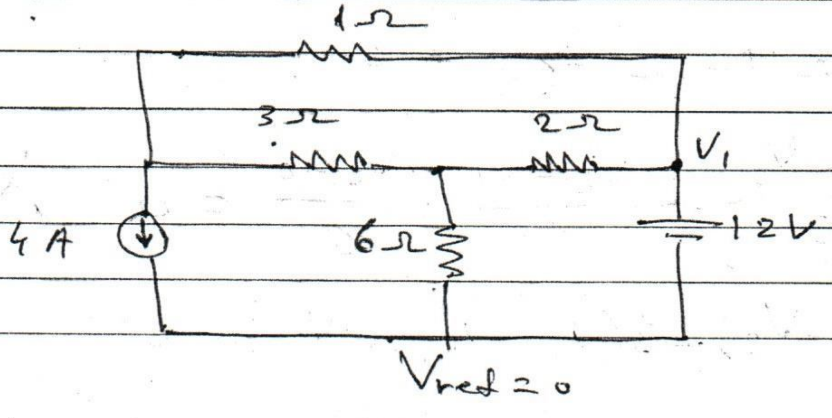
The nodal analysis depends on the first Kirhoffs law in circuit nodes.

~~Pres~~ In work methode must be limit the circui node which contain three(3) branch or more and write symbol for it voltages V_1, V_2, V_3, and consider one of these nodes as refere node $(V_{ref} = 0)$, after that ~~can~~ we must to consider currents vector at each node always out of nodes by using first Kirchh law, and become the sum of currents equal z

and by solve these equestions we obtaine on the unknowns values $(V_1, V_2, \text{———})$ and af this we can to fined circuit currents.

Note: If the voltage source (single) becom between node and reference node that's mea the voltage ~~does~~ node will be known and equ value of this source.

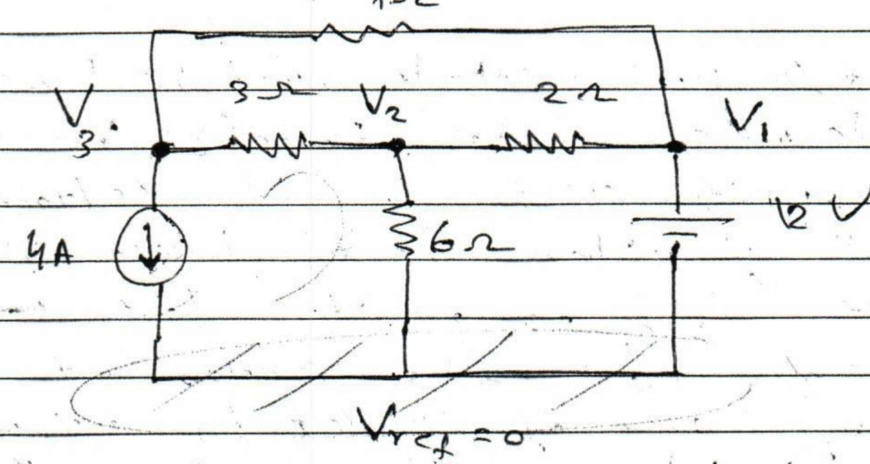
Exp. Fined currents of resistances for the follo circuit?



(7)

Sol/

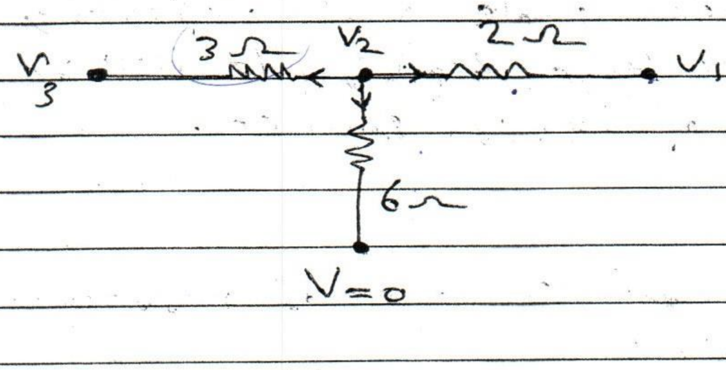
first we must to Limit the circuit nodes which contains on 3 branches, and consider one of them as reference:



We see the voltage source (12V) between the node V_1 and the reference, that's mean the voltag node equal voltage Source;

$$V_1 = 12V$$

Now by using first Kirchhoff's law on second node and consider all of currents out of it;



$$\sum I_{out} = 0$$

$$I_{3\Omega} + I_{2\Omega} + I_{6\Omega} = 0$$

$$\frac{V_2 - V_3}{3} + \frac{V_2 - V_1}{2} + \frac{V_2 - 0}{6} = 0 \quad \times 6$$

$$2(V_2 - V_3) + 3(V_2 - V_1) + V_2 = 0$$

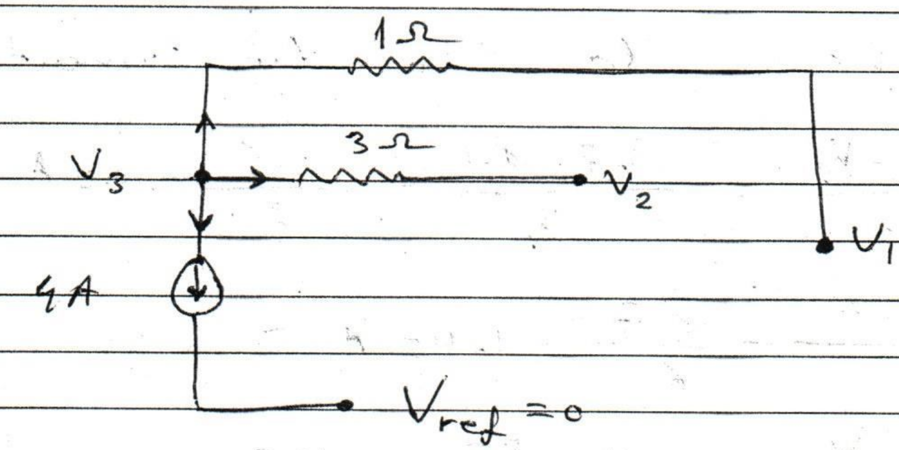
22

CV

$-3V_1 + 6V_2 - 2V_3 = 0$

$-3 \times 12 + 6V_2 - 2V_3 = 0$

$6V_2 - 2V_3 = 36$ ——— (1) $\quad * 4$



$\sum I_{out} = 0$

$I_{1\Omega} + I_{3\Omega} + 4 = 0$

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

$3(V_3 - V_1) + V_3 - V_2 + 12 = 0$

$-3V_1 - V_2 + 4V_3 + 12 = 0$

$(-3 \times 12) - V_2 + 4V_3 + 12 = 0$

$-V_2 + 4V_3 = 24$ ——— (2) $\quad * 2$

$24V_2 - 8V_3 = 144$ ——— (1)

$-2V_2 + 8V_3 = 48$ ——— (2)

$+$

$22V_2 = 192 \Rightarrow V_2 = \frac{192}{22} = 8.7V$

$6 * 8.7 - 2V_3 = 36$

$52.2 - 36 = 2V_3$

$16.2 = 2V_3 \longrightarrow V_3 = \dfrac{16.2}{2} = 8.1\ V$

At least we can to find the currents,

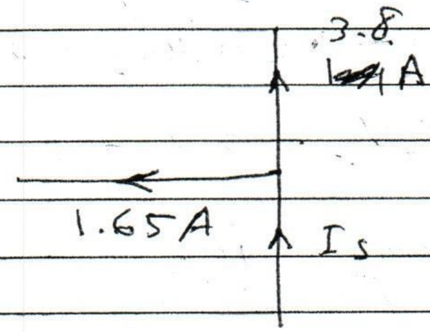
$I_{3\Omega} = \dfrac{V_2 - V_3}{3} = \dfrac{8.7 - 8.1}{3} = \dfrac{0.6}{3} = 0.2\ A$

$I_{6\Omega} = \dfrac{V_2 - 0}{6} = \dfrac{8.7}{6} = 1.45\ A$

$I_{2\Omega} = \dfrac{V_1 - V_2}{2} = \dfrac{12 - 8.7}{2} = \dfrac{3.3}{2} = 1.65\ A$

$I_{1\Omega} = \dfrac{V_1 - V_3}{1} = \dfrac{12 - 8.1}{1} = 3.8\ A$

we must to calculate the source current (12V) which can to calculate from first node:



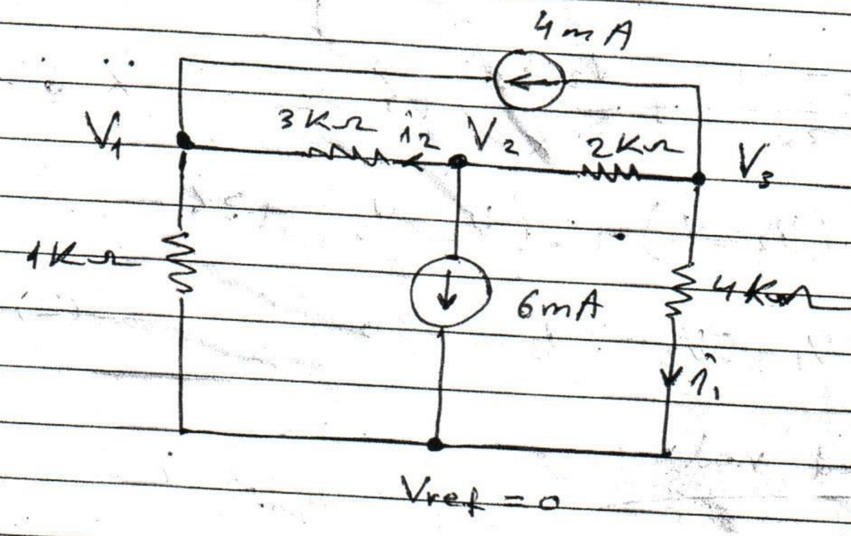
$I_s = I_{2\Omega} + I_{1\Omega}$

$= 1.65 + 3.8$

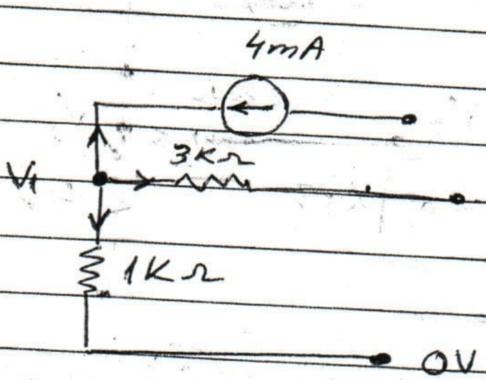
$= 5.45\ A$

CA

EXP. Find i_1, i_2 For the following circuit by using nodel analysis ?



Sol



First node:

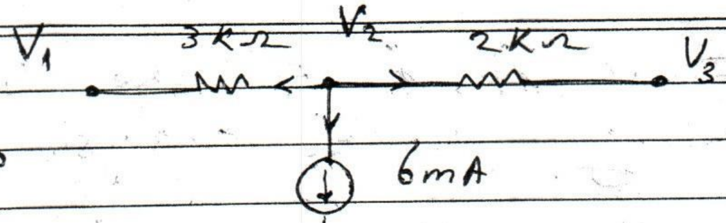
$\sum I_{out} = 0$

$$\left(-4m + \frac{V_1 - V_2}{3K} + \frac{V_1 - 0}{1K} = 0 \right) \times 3K$$

$$-12 + V_1 - V_2 + 3V_1 = 0$$

$$4V_1 - V_2 = 12 \quad \text{—— (1)}$$

seconde node:



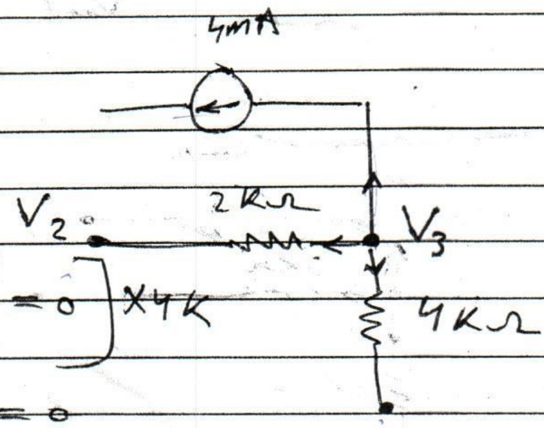
$\sum I_{out} = 0$

$$\left(\frac{V_2 - V_1}{3K} + \frac{V_2 - V_3}{2K} + 6m = 0 \right) \times 6K$$

$$2(V_2 - V_1) + 3(V_2 - V_3) + 36 = 0$$

$$-2V_1 + 5V_2 - 3V_3 = -36 \quad \text{——— (2)}$$

- Third node:



$$\left[4m + \frac{V_3 - V_2}{2K} + \frac{V_3 - 0}{4K} = 0 \right] \times 4K$$

$$16 + 2(V_3 - V_2) + V_3 = 0$$

$$-2V_2 + 3V_3 = -16 \quad \text{——— (3)}$$

- From Eq. (1)

$$4V_1 - V_2 = 12 \Rightarrow 4V_1 = 12 - V_2$$

$$V_1 = 3 - \frac{V_2}{4} \quad \text{——— (4)}$$

by subst. (4) in (2)

$$-6 + \frac{V_2}{2} + 5V_2 - 3V_3 = -36$$

$$\frac{V_2 + 10V_2}{2} - 3V_3 = -30 \quad / \times 2$$

(24)

C9

$11V_2 - 6V_3 = -90$ —— (5) / * 2

$-2V_2 + 3V_3 = -16$ —— (3) / * 11

$22V_2 - 12V_3 = -180$

$+ \quad -22V_2 + 33V_3 = -176$

$21V_3 = -356$

$V_3 = -16.9\ V$

From eq. (5)

$11V_2 + 6 * 16.9 = -90$

$11V_2 = -191.4 \Longrightarrow V_2 = -17.4\ V$

From eq. (4)

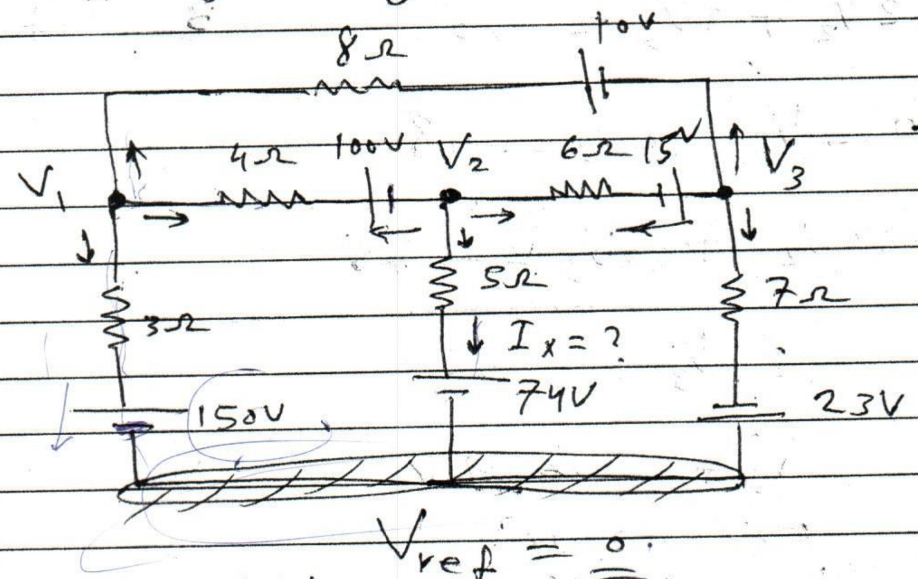
$V_1 = 3 - \frac{V_2}{4} = 3 - \frac{17.4}{4} = 3 - 4.35$
$= -1.35\ \underline{\underline{V}}$

$i_2 = \frac{V_2 - V_1}{3K} = \frac{-17.4 + 1.35}{34} = \frac{-16.05}{43} = -5.35\ mA$

$i_1 = \frac{V_3 - 0}{4K} = \frac{-16.9}{4} = -4.225\ mA$

EXP

Find I_x by using nodal analysis?



Sol AT node (1) KCL;

$$\frac{V_1 - 0 - 150}{3} + \frac{V_1 - V_2 - 100}{4} + \frac{V_1 - V_3 - 10}{8} = 0 \quad * 24$$

$$8V_1 - 1200 + 6V_1 - 6V_2 - 600 + 3V_1 - 3V_3 - 30 = 0$$

$$17V_1 - 6V_2 - 3V_3 = 1830 \text{ —— } (1) \quad * 20 \quad / \quad * 146$$

AT node (2)

$$\frac{V_2 - V_1 + 100}{4} + \frac{V_2 - 0 - 74}{5} + \frac{V_2 - V_3 + 15}{6} = 0 \quad * 120$$

$$30V_2 - 30V_1 + 300 + 24V_2 - 1776 + 20V_2 - 20V_3 + 300 =$$

$$-30V_1 + 74V_2 + 20V_3 = 1176 \text{ —— } (2) \quad * -3$$

AT node (3); $\frac{V_3 - V_1 + 10}{8} + \frac{V_3 - V_2 - 15}{6} + \frac{V_3 - 0 + 23}{7} = 0 \quad * 336$

$$42V_3 - 42V_1 + 420 + 56V_3 - 56V_2 - 840 + 48V_3 + 1104 = 0$$

$$-42V_1 - 56V_2 + 146V_3 = -684 \text{ —— } (3) \quad * -3$$

ب-

$$340V_1 - 120V_2 - 60V_3 = 36600 \quad — (1)$$

$$\mp 90V_1 \pm 222V_2 \pm 60V_3 = \mp 3528 \quad — (2)$$

by substrac.

$$250V_1 + 102V_2 = 40128 \quad — (4) \quad * -1044$$

$$2482V_1 - 876V_2 - 438V_3 = 267180 \quad — (1)$$

$$\mp 126V_1 \mp 168V_2 \pm 438V_3 = \mp 2052 \quad — (3)$$

by subs.

$$2356V_1 - 1044V_2 = 265128 \quad — (5) \quad * 102$$

$$261000V_1 - 106488V_2 = -41893632 \quad — (4)$$

$$\mp 240312V_1 \pm 106488V_2 = \mp 27043056 \quad — (5)$$

substrac.

$$501312V_1 = 68936688$$

$$V_1 = \frac{68936688}{501312} = 137.5 \ V$$ by subst. in (4)

$$250 * 137.5 + 102V_2 = 40128$$

$$102V_2 = 40128 - 34378.135$$

$$102V_2 = 5749.8 \implies V_2 = \frac{5749.8}{102} = 56.37V$$

By subs. V_1 and V_2 in (1)

$$17 * 137.5 - 6 * 56.37 - 3V_3 = 1830$$

$$2337.5 - 338.22 - 3V_3 = 1830$$

$$1999.28 - 3V_3 = 1830$$

$$1999.28 - 1830 = 3V_3$$

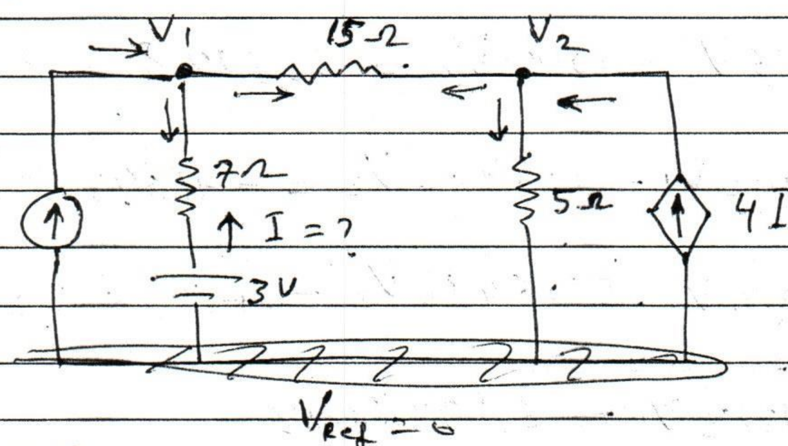
$$9.28 = 3V_3 \Longrightarrow V_3 = \frac{169.28}{3} = 56.4 \text{ V}$$

$$I_X = \frac{V_2 - V_{ref} - 74}{5} = \frac{56.37 - 74}{5} = \frac{-17.63}{5}$$

$$I_X = -3.526 \text{ A}$$

Exp.

For the circuit below, calculate the value of (I) using noded analysis?



Sol. At node (1)

$$\frac{V_1 - V_2}{15} + \frac{V_1 - 0 - 3}{7} = 2$$

$$\frac{V_1 - V_2}{15} + \frac{V_1 - 3}{7} = 2 \quad * 105$$

$$7V_1 - 7V_2 + 15V_1 - 45 = 210$$

$$22V_1 - 7V_2 = 255 \text{ ——— } (1) \quad * 20$$

$$I = -\left(\frac{V_1 - 0 - 3}{7}\right)$$

$$\boxed{I = \frac{3 - V_1}{7}}$$

26

At node: 2

$$\frac{V_2 - V_1}{15} + \frac{V_2 - 0}{5} = 4I \quad * 75$$

$-5V_1 + 20V_2 = 300I$ by sub I in it.

$$-5V_1 + 20V_2 = \cancel{300}^{42.8} * \frac{3-V_1}{\cancel{7}}$$

$-5V_1 + 20V_2 = 128.5 - 42.8V_1$

$+42.8V_1 - 5V_1 + 20V_2 = 128.5$

$37.8V_1 + 20V_2 = 128.5$ —— (2) $* -7$

$440V_1 - 140V_2 = 5100$ —— (1)

$\pm 264.6V_1 \pm 140V_2 = \pm 899.5$ —— (2)

by substracting

$704.6V_1 = 5999.5$

$$V_1 = \frac{5999.5}{704.6} = 8.5\ V$$ by sub. in (1)

$22 * 8.5 - 7 * V_2 = 255$

$187.3 - 7V_2 = 255$

$-7V_2 = 255 - 187.3$

$-7V_2 = 67.6$

$$V_2 = \frac{-67.6}{7} = -9.6\ V$$

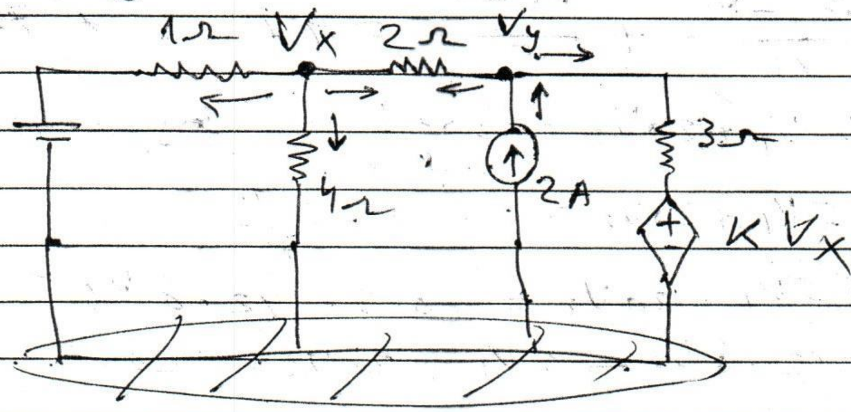
$$I = \frac{3 - V_1}{7} = \frac{3 - 8.5}{7} = \frac{-5.5}{7}$$

$$= -0.785\ A$$

٣١

EXP.

Find the value of (K) which mak $(V_y = 0)$ by using nodle analysis?



At node X: KCL

$$\frac{V_x - 0 - 6}{1} + \frac{V_x - 0}{4} + \frac{V_x - V_y}{2} = 0 \quad V_{ref} = 0$$

$$\frac{V_x - 6}{1} + \frac{V_x}{4} + \frac{V_x - V_y}{2} = 0 \quad \text{—— (1)}$$

When $V_y = 0$

$$V_x - 6 + \frac{V_x}{4} + \frac{V_x - 0}{2} = 0 \quad * 4$$

$$4V_x - 24 + V_x + 2V_x = 0 \quad , \quad 7V_x = 24 \Rightarrow$$

$$V_x = \frac{24}{7} = 3.4\,V$$

AT node y:

$$\frac{V_y - V_x}{2} + \frac{V_y - 0 - KV_x}{3} = 2 \Rightarrow \frac{V_y - V_x}{2} + \frac{V_y - KV_x}{3} =$$

$$-3V_x - 2KV_x = 12 \Rightarrow -3 * 3.4 - 2 * 3.4K = 12$$

$$-10.2 - 6.8K = 12$$

$$-6.8K = 12 + 10.2$$

$$-6.8K = 22.2 \Rightarrow K = \frac{-22.2}{6.8} = -3.2$$

MAXWELL Analysis « Mesh current Loop analysis

By Solving this methode we must to use The Kirchhoffs Voltage law but by using loops current.

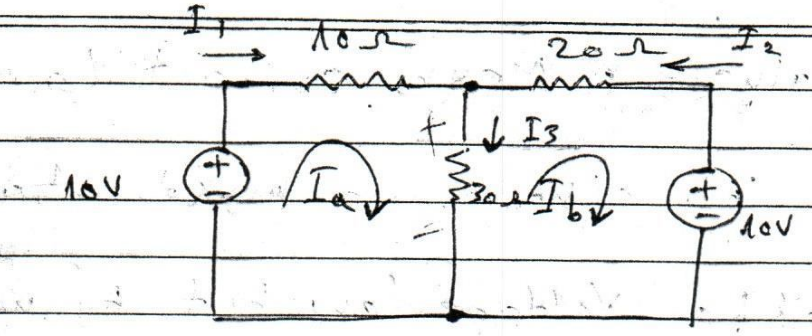
Steps of Solution:

1- Limit number of closed loop.
2- The number of equations = equal number of loop.
3- consider for each loop its current and its vector with clockwise.
4- The current between two loop to solve this case we must to used (Super mesh).

In case Super mesh:

1- we take the due of source.
2- eleminate the source and put in his place open circuit.
3- Consider the current equition for the open loop as a one loop.

Exp Calculate the currents for the following circuit by using currents loop (Maxwell analysis



Sol//

loop a

$\cancel{10 + 10I_a + 30I_a - 30I_b = 0}$ $10 - 10I_a - 30I_a + 30I_b$

$-40I_a + 30I_b = -10$

$-40I_a + 30I_b = -10$ / by dividing eq ÷ 10

$-4I_a + 3I_b = -1$ —— (1) / * 5

Loop b

$-10 + 30I_a - 30I_b - 20I_b = 0$

$30I_a - 50I_b = 10$ / ÷ −10

$-3I_a + 5I_b = -1$ —— (2) / * 3

$-20I_a + 15I_b = -5$ —— (1)

by sub. $+9I_a - 15I_b = +3$ —— (2)

by add.

$11I_a = -2$

$\cancel{29I_a = 8}$ $\Rightarrow$ $I_a = \frac{-2}{11} = \cancel{0.181\,A}$ $\cancel{-0.927}$ A

-0.181 A

from eq (2) find the I_b:

$-3 \times \cancel{0.181}\ -0.181 + 5I_b = -1$

$5I_b = \cancel{0.457}\ \cancel{3.18}\ \cancel{3.181}\ -1.545$

$I_b = -\frac{\cancel{0.457}\ \cancel{3.181}\ 1.545}{5} = \cancel{0.636}$ A $= 0.091$

$I_a = I_1 = \cancel{0.181\,A}\;\cancel{0.727\,A}\; -0.181\,A$

$I_b = -I_2 = -(\cancel{-0.091}) = \cancel{0.091\,A}\;\cancel{-0.6309}\;\cancel{0.636}\; 0.309\,A$

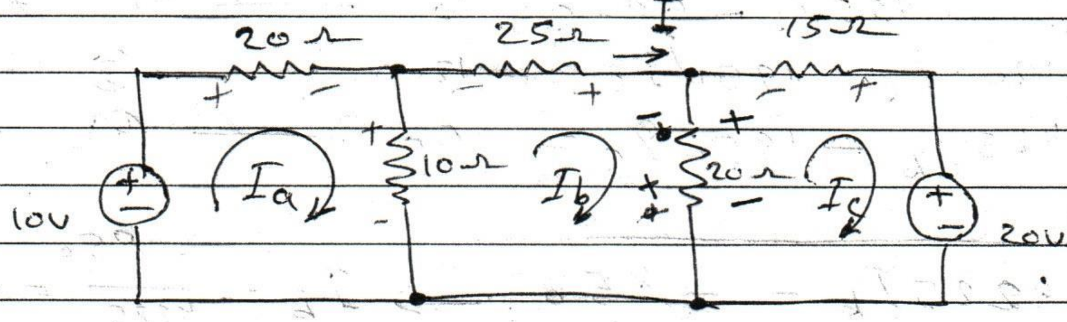
$I_3 = I_a - I_b = \cancel{0.181 - (-0.091) = 0.272\,A}$

$= \cancel{-0.727 - 0.636 = -1.363\,A}$

$-0.181 - 0.309 = -0.49\,A$

Exp.

calculate the Loop currents for the following circuit ?



Sol

Loop a

$$10 - 20 I_a - (I_a - I_b)10 = 0$$

$$-20 I_a - 10 I_a + 10 I_b = -10$$

$$-30 I_a + 10 I_b = -10 \quad / \div -10$$

$$3 I_a - I_b = 1 \quad \text{——} \; (1) \quad * 10$$

Loop b

$$10(I_b - I_a) + 25 I_b + 20(I_b - I_c) = 0$$

$$10 I_b - 10 I_a + 25 I_b + 20 I_b - 20 I_c = 0$$

$$-10 I_a + 55 I_b - 20 I_c = 0 \quad \text{——} \; (2) \quad * 3$$

٣٣

(8)

$$20(I_c - I_b) + 15 I_c = -20$$

$$20 I_c - 20 I_b + 15 I_c = -20$$

$$-20 I_b + 35 I_c = -20 \quad \text{—— (3)} \qquad * 60$$

$$30 I_a - 10 I_b = 10 \quad \text{—— (1)}$$

$$-30 I_a + 165 I_b - 60 I_c = 0 \quad \text{—— (2)}$$

by add.

$$155 I_b - 60 I_c = 10 \quad \text{—— (4)} \qquad * 35$$

$$-1200 I_b + 1950 I_c = -1200 \quad \text{—— (3)}$$

$$5425 I_b - 1950 I_c = 350 \quad \text{—— (4)}$$

by add.

$$4225 I_b = -850 \Longrightarrow I_b = \frac{-850}{4225} = -0.201 A$$

from eq. (3) we can to find I_c :-

$$-20 * -0.201 + 35 I_c = -20$$

$$35 I_c = -24.02 \Longrightarrow I_c = \frac{-24.02}{35} = -0.686 A$$

from eq. (1) we can to find I_a :

$$3 I_a - (-0.201) = 1$$

$$3 I_a = 1 - 0.201 = 0.799 \Longrightarrow I_a = \frac{0.799}{3} = 0.266 A$$

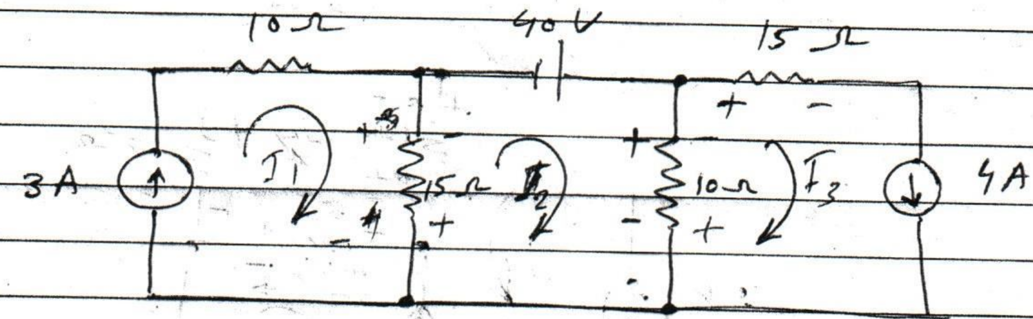
$I_a = 0.266 A$

$I_b = -0.201 A$

$I_c = -0.686 A$

(29)

Exp. Find the power in 40V ? by using Maxwell Analysis (~~Mesh~~ current loop analys



AT loop (1) KVL:

$I_1 = 3A$

AT Loop (2) KVL

$$40 - 10(I_2 - I_3) - 15(I_2 - I_1) = 0$$

$$40 - 10I_2 + 10I_3 - 15I_2 + 15I_1 = 0$$

$$15I_1 - 25I_2 + 10I_3 = -40$$

$$-25I_2 + 10I_3 = -85$$

$$25I_2 - 10I_3 = 85 \quad \text{—— (1)}$$

AT loop (3) KVL:

$I_3 = 4A$

$$25I_2 - 10 * 4 = 85$$

$$25I_2 = 85 + 40 \Longrightarrow 25I_2 = 125$$

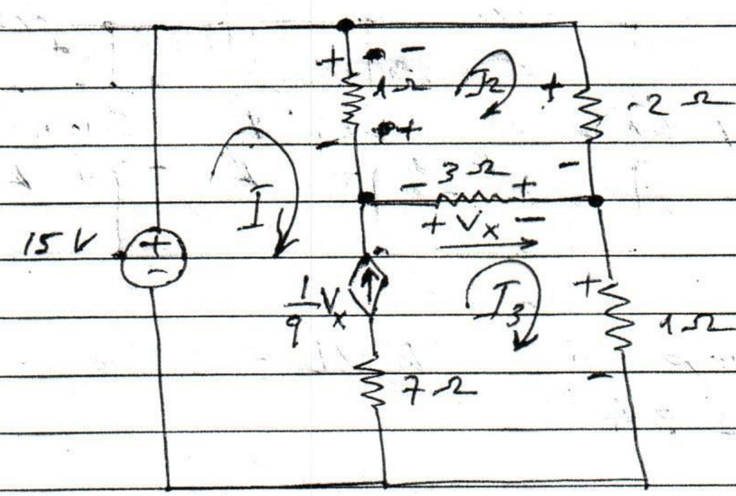
$$I_2 = \frac{125}{25} = 5A$$

power in 40V $= V * I_2$

$= 40 * 5 = 200W$

٣٤

Exp
Find I_1, I_2, I_3 by using mesh-analysis then find V_x ?



Sol

$$I_3 - I_1 = \frac{1}{9} V_x \quad \text{—— (1)}$$

AT super mesh (make current source as open circuit).

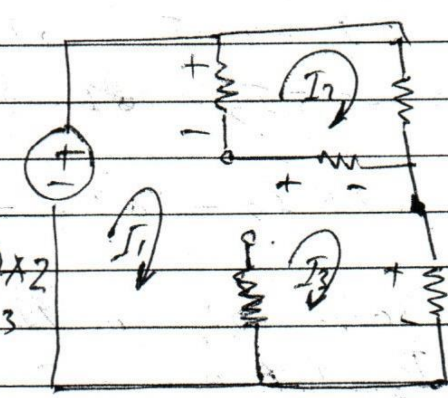
$$+15 - 1\times(I_1 - I_2) - 3(I_3 - I_2) - 1I_3 = 0$$

$$15 - I_1 + I_2 - 3I_3 + 3I_2 - I_3 = 0$$

$$-I_1 + 4I_2 - 4I_3 = -15$$

$$I_1 - 4I_2 + 4I_3 = 15 \quad \text{—— (2)} \times 2$$

$\times -3$



AT loop (2) KVL:

$$-1(I_2 - I_1) - 2I_2 - 3(I_2 - I_3) = 0$$

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

$$I_1 - 6I_2 + 3I_3 = 0$$

$$-I_1 + 6I_2 - 3I_3 = 0 \quad \text{—— (3)} \quad \times 4$$

30

from eq. 1

$$I_3 - I_1 = \frac{1}{\cancel{9}_3} * \cancel{3}^{1} \underbrace{(I_3 - I_2)}_{V_x} \quad * 3$$

$$3I_3 - 3I_1 = I_3 - I_2$$

$$3I_3 - 3I_1 - I_3 + I_2 = 0$$

$$-3I_1 + I_2 + 2I_3 = 0 \quad \text{—— } (4) \qquad * 4$$

$$2I_1 - 8I_2 + \cancel{8I_3} = 30 \quad \text{—— } (2)$$

$$\pm 12I_1 \mp 4I_2 \mp \cancel{8I_3} = 0 \quad \text{—— } (4)$$

by sub.

$$14I_1 - 12I_2 = 30 \quad \text{—— } (5)$$

eq (2) and (3)

$$-3I_1 + 12I_2 - \cancel{12I_3} = -45 \quad \text{—— } (2)$$

$$\pm 4I_1 \mp 24I_2 \pm \cancel{12I_3} = 0 \quad \text{—— } (3)$$

by sub.

$$I_1 - 12I_2 = -45 \quad \text{—— } (6)$$

$I_1 = -45 + 12I_2$ substitude in eq. (5)

$$14 * -45 + 14 * 12I_2 - 12I_2 = 30$$

$$-630 + 156I_2 = 30$$

$$I_2 = \frac{660}{156} = 4.23\text{ A}$$

$$\therefore I_1 = -45 + 12 * 4.23$$

$$= 5.77\text{ A}$$

From eq. (4) we can to find I_3 :

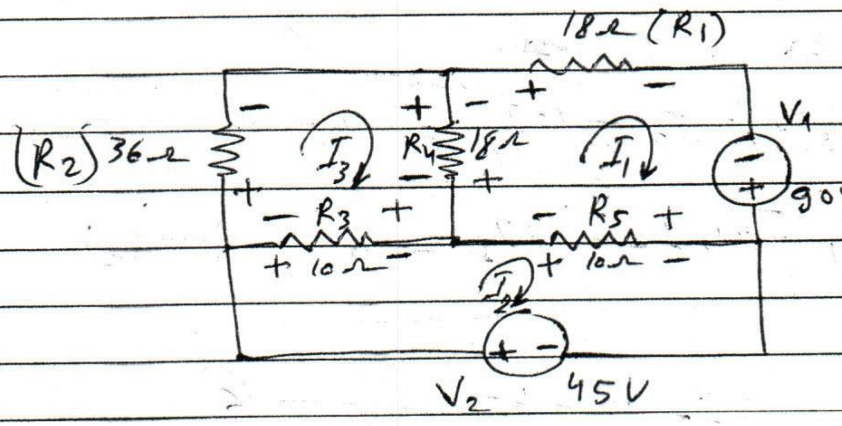
$$-3 * 5.77 + 4.23 = -2 I_3$$

$$-2 I_3 = -13.08 \Longrightarrow I_3 = 6.5\ A$$

$$V_x = 3 * (I_3 - I_2) = 3 * (6.5 - 4.23)$$

$$V_x = 6.81\ V$$

EXP. In the following circuit, find the current in the branch of mesh by using Maxwell analysis ~~or~~ (Loop current analysis)?



Sol

Loop I_1 :

$$-18 I_1 + 90 - 10(I_1 - I_2) - 18(I_1 - I_3) = 0$$

$$-18 I_1 - 10 I_1 + 10 I_2 - 18 I_1 + 18 I_3 = -90$$

$$-46 I_1 + 10 I_2 + 18 I_3 = -90$$

$$46 I_1 - 10 I_2 - 18 I_3 = 90 \quad \text{—— (1)} \quad * 10 \,/\, * 46$$

(31)

Loop I_2:

$$45 - 10(I_2 - I_3) - 10(I_2 - I_1) = 0$$

$$-10 I_2 + 10 I_3 - 10 I_2 + 10 I_1 = -45$$

$$10 I_1 - 20 I_2 + 10 I_3 = -45$$

$$-10 I_1 + 20 I_2 - 10 I_3 = 45 \quad \text{——} \quad (2) \qquad * 18$$

Loop I_3:

$$-36 I_3 - 18(I_3 - I_1) - 10(I_3 - I_2) = 0$$

$$-36 I_3 - 18 I_3 + 18 I_1 - 10 I_3 + 10 I_2 = 0$$

$$18 I_1 + 10 I_2 - 64 I_3 = 0$$

$$-18 I_1 - 10 I_2 + 64 I_3 = 0 \quad \text{——} \quad (3) \qquad / * 18$$

$$460 I_1 - 100 I_2 - \cancel{180 I_3} = 900 \quad \text{——} \quad (1)$$

$$\pm 180 I_1 \mp 360 I_2 \pm \cancel{180 I_3} = \mp 810 \quad \text{——} \quad (2)$$

By sub.

$$640 I_1 - 460 I_2 = 90 \quad \text{——} \quad (4) \qquad / * 820$$

$$2944 I_1 - 640 I_2 - \cancel{1152 I_3} = 5760 \quad \text{——} \quad (1)$$

$$-324 I_1 - 180 I_2 + \cancel{1152 I_3} = 0 \quad \text{——} \quad (3)$$

By add.

$$2620 I_1 - 820 I_2 = 5760 \quad \text{——} \quad (5) \qquad / * 460$$

$$524800 I_1 - \cancel{377200 I_2} = 73800 \quad \text{——} \quad (4)$$

$$\mp 1205200 I_1 \pm \cancel{377200 I_2} = \mp 2649600 \quad \text{——} \quad (5)$$

by sub

$$-680400 I_1 = -2575800$$

$$I_1 = 3.785 \text{ A}$$

from eq. (4) we can to find I_2:

$640 * 3.785 - 460 I_2 = 90$

$2422.4 - 90 = 460 I_2 \Longrightarrow$

$I_2 = 5.07\ A$

from eq. (1) we can to find I_3:

$46 * 3.785 - 10 * 5.07 - 18 I_3 = 90$

$174.11 - 50.7 - 90 = 18 I_3$

$33.41 = 18 I_3 \Longrightarrow I_3 = 1.856 A$

$\therefore\ I_{R_1} = I_1 = 3.785\ A$

$I_{R2} = I_3 = 1.856\ A$

$I_{R_4} = I_1 - I_3 = 3.785 - 1.856 = 1.929 A$

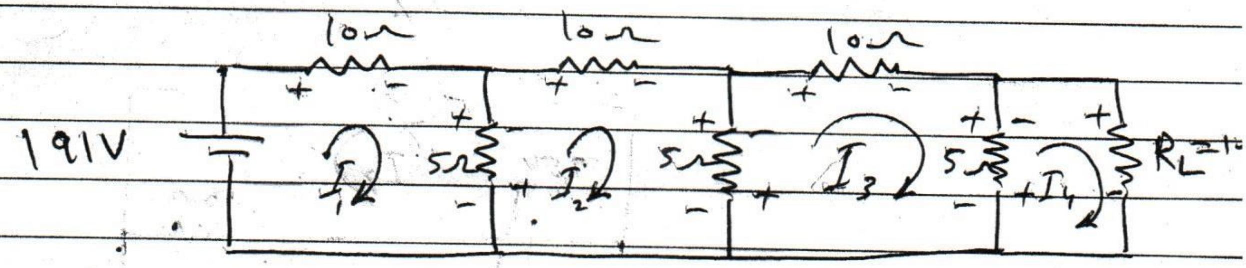
$I_{R_3} = I_2 - I_3 = 5.07 - 1.856 = 3.214\ A$

$I_{R_5} = I_2 - I_1 = 5.07 - 3.785 = 1.285\ A$

32

Exp.

Find the power of $R_L = 1\Omega$ using mesh current (loop current)?



AT Loop (1) KVL:

$191 - 10I_1 - 5(I_1 - I_2) = 0$

$-10I_1 - 5I_1 + 5I_2 = -191$

$15I_1 - 5I_2 = 191$ ——— (1)

AT Loop (2) KVL:

$-5I_2 + 5I_1 - 10I_2 - 5I_2 + 5I_3 = 0$

$5I_1 - 20I_2 + 5I_3 = 0$

$-5I_1 + 20I_2 - 5I_3 = 0$ ——— (2)

AT Loop (3) KVL:

$-5I_3 + 5I_2 - 10I_3 - 5I_3 + 5I_4 = 0$

$5I_2 - 20I_3 + 5I_4 = 0$

$-5I_2 + 20I_3 - 5I_4 = 0$ ——— (3)

AT Loop (4) KVL:

$-5I_4 + 5I_3 - 1I_4 = 0$

$5I_3 - 6I_4 = 0$

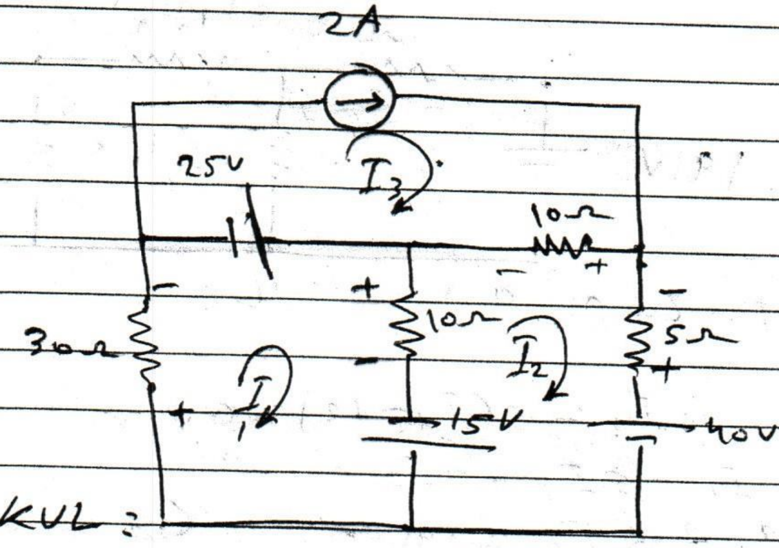
$-5I_3 + 6I_4 = 0$ ——— (4)

By adding (1) and (4), the result substract from (3)

$I_4 = ?$ $\Longrightarrow$ $P_{1\Omega} = I_4^2 * R$

EXP.

Find the current for circuit shown be by usig mesh analysis « Maxwell analysis »



AT Loop (3) KVL:

$I_3 = 2A$ ——— ①

AT Loop (1) KVL:

$-30 I_1 + 25 - 10 I_1 + 10 I_2 + 15 = 0$

$-30 I_1 - 10 I_1 + 10 I_2 + 40 = 0$

$-40 I_1 + 10 I_2 = -40$

$40 I_1 - 10 I_2 = 40$ ——— ②

AT Loop (2) KVL:

$-15 + 10 I_2 - 10 I_1 + 10 I_2 - 10 I_3 + 5 I_2 - 40 = 0$

$-10 I_1 + 25 I_2 - 10 I_3 = 55$

$-10 I_1 + 25 I_2 = 55 + 10 * 2$

$-10 I_1 + 25 I_2 = 75$ ——— ③

by sübstrac eq ③ fm ② we can to find I

$I_1 = (\quad\quad) A$

$I_2 = (\quad\quad) A$

Superposition Theorem

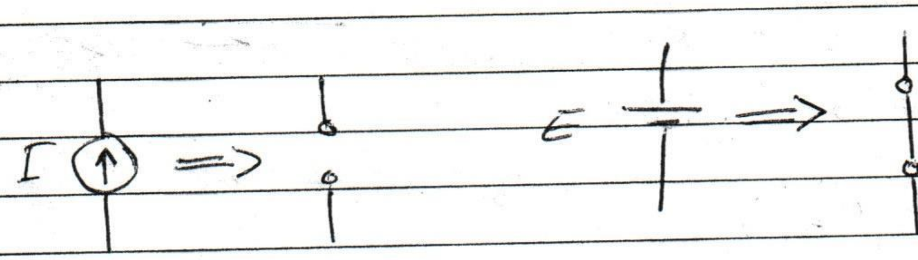
The ST used for Analyses electric circu
ts whitch containe more of voltage source o
current source.

Notes:

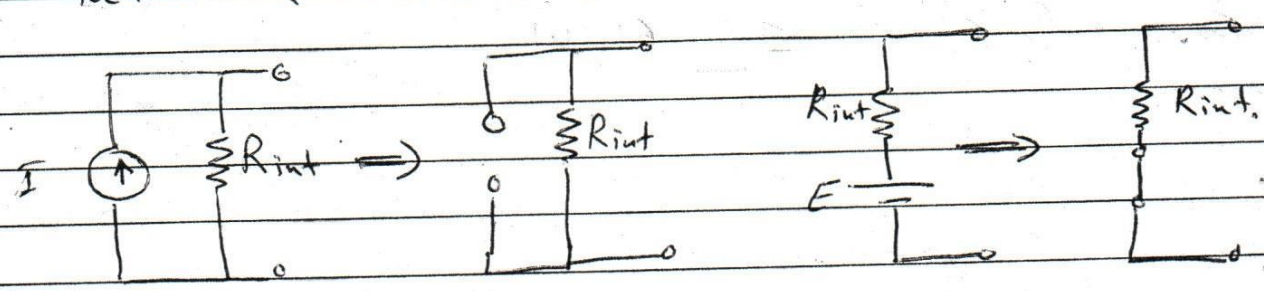
- The current sources compensate b open circuit.
- The voltage sources compensate by short circuits.

~~Sckutibo~~ Solutions steps

1- we take only one source.
2- Find the current or voltage for each source.
3- Add there currents or voltages.

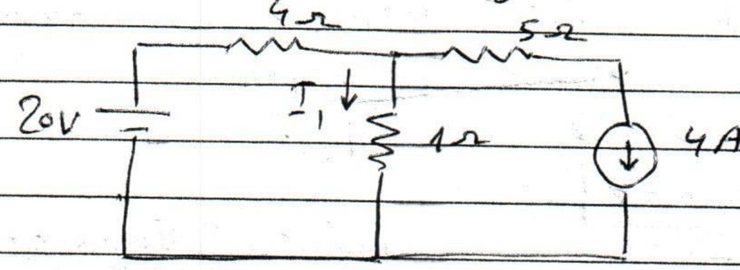


In case the voltage or current source ha internal resistance we will get this:



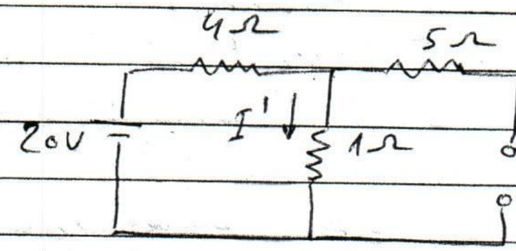
exp.

Find the power in 1Ω by using superposition



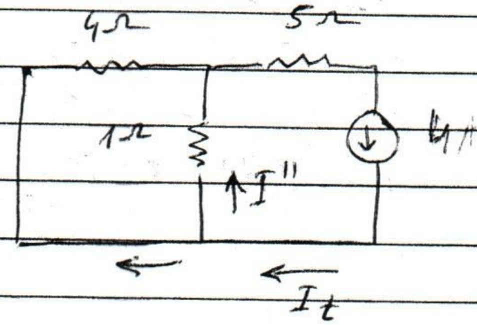
$P_{1\Omega} = I_1^2 * R$

1- effect 20V:



$I' = \frac{20}{4+1} = \frac{20}{5} = 4A$

2- effect 4A:



$I'' = I_t * \frac{4}{4+1}$

$I'' = 4 * \frac{4}{5} = \frac{16}{5} = 3.2A$

$I_1 = 4 - 3.2 = 0.8A$

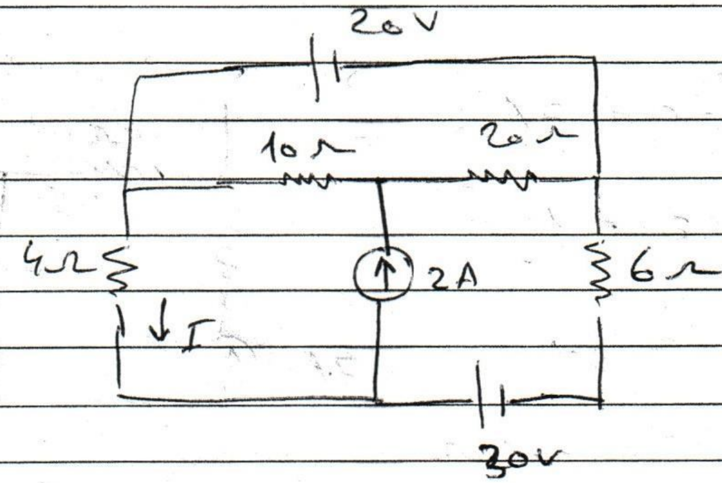
$P_{1\Omega} = I_1^2 * R$

$P_{1\Omega} = (0.8)^2 * 1 = 0.64\ W$

34

exp.

For the circuit find I using superposition theorem ?



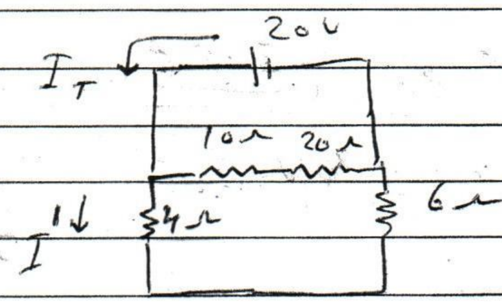
1- effect 20V;

$$R_{eq} = 10 \parallel 30 = 7.5\,\Omega$$

$$I_T = \frac{V}{R_{eq}} = \frac{20}{7.5}$$

$$= 2.666\ A$$

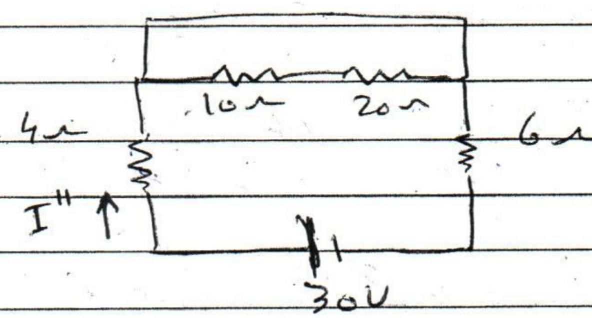
$$I' = 2.666 * \frac{30}{40} = 2A$$



2- effect 30V :

$$I'' = \frac{30}{10} = 3A$$

3- effect 2A :

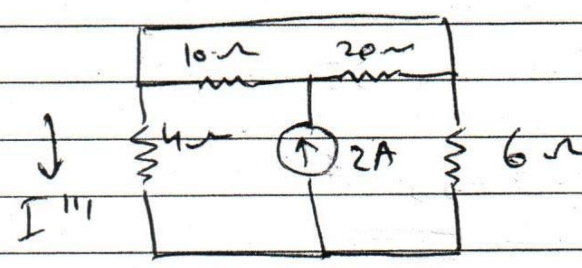


$$I''' = 2 * \frac{6}{10} = 1.2\ A$$

$$I = I' - I'' + I'''$$

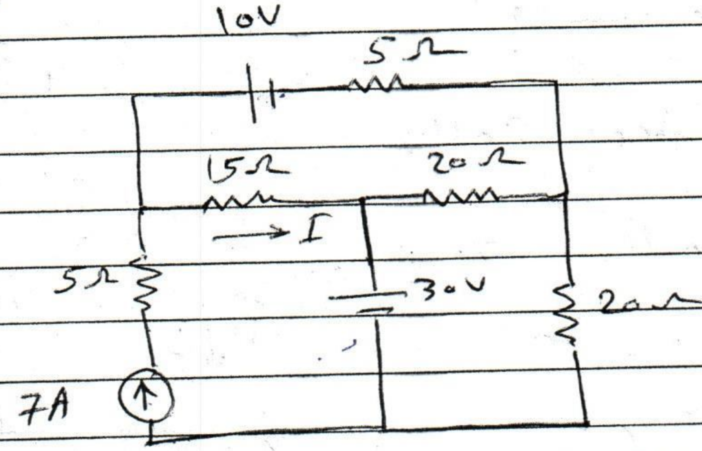
$$= 2 - 3 + 1.2$$

$$= 0.2\ A$$



exp.

Find the current I in this figure by using super-position?



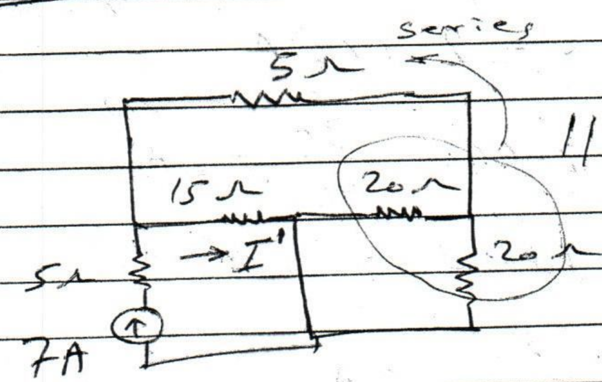
1- effect 7A :

$20 \parallel 20 = 10\,\Omega$

$10 + 5 = 15\,\Omega$

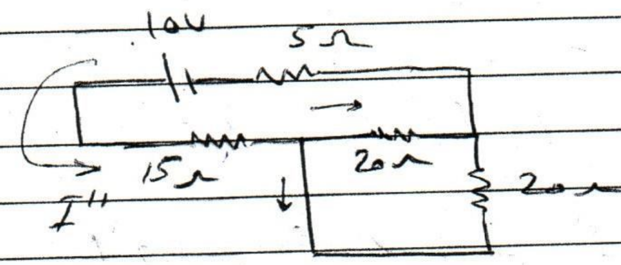
$15 \parallel 15 = 7.5\,\Omega$

$I' = 7 * \frac{15}{30} = \underline{\underline{3.5\,A}}$



2- effect 10V :

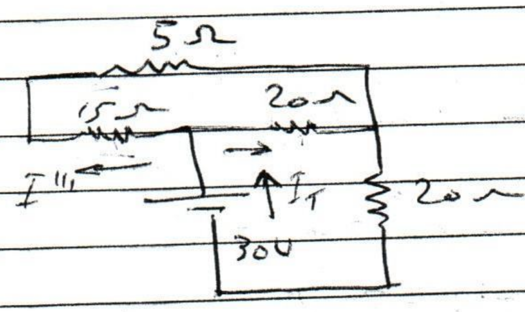
$I'' = \frac{10}{30} = \underline{\underline{0.33\,A}}$



3- effect 30V :

$I_T = \frac{30}{30} = 1A$

$I''' = 1 * \frac{20}{40} = \underline{\underline{0.5\,A}}$

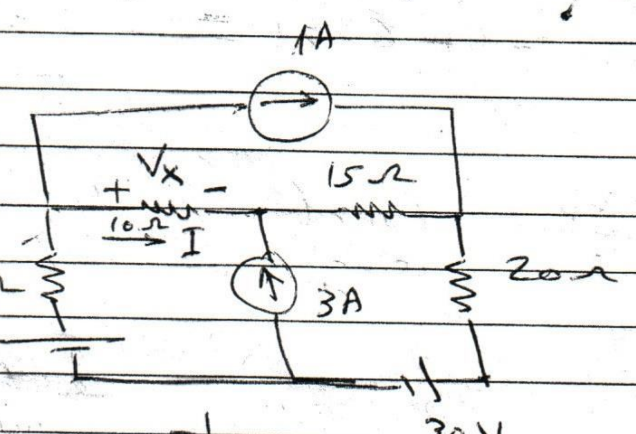


$I = 3.5 + 0.33 - 0.5$

$= \underline{\underline{3.33\,A}}$

35

Exp. For the circuit shown below, find V_x b
using superposition theorem?

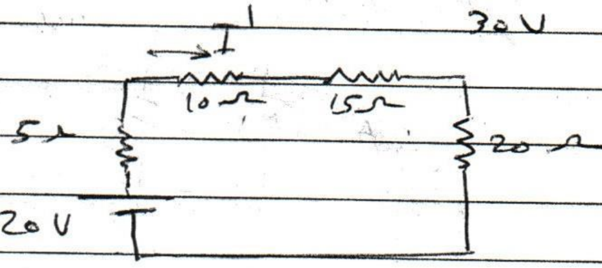


1- effect 20V

$$I' = \frac{20}{50} = 0.4A$$

$$V_{x_1} = 0.4 * 10$$

$$= 4V \ (+)$$

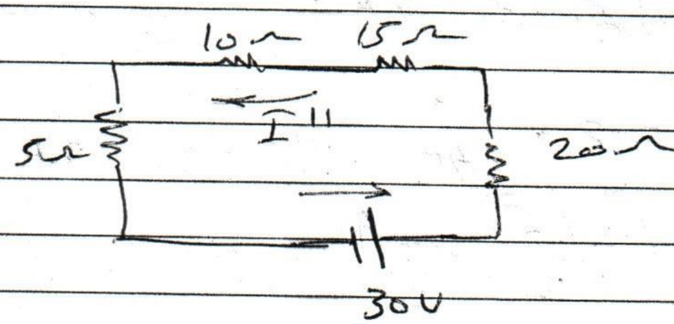


2- effect 30V:

$$I'' = \frac{30}{50} = 0.6 \ A$$

$$V_{x_2} = 0.6 * 10$$

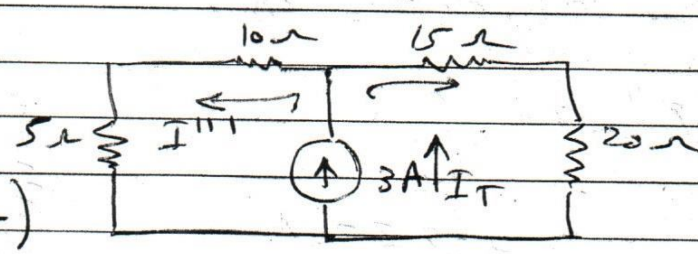
$$= 6V \ (-)$$



3- effect 3A:

$$I''' = 3 * \frac{35}{50} = 2.1A$$

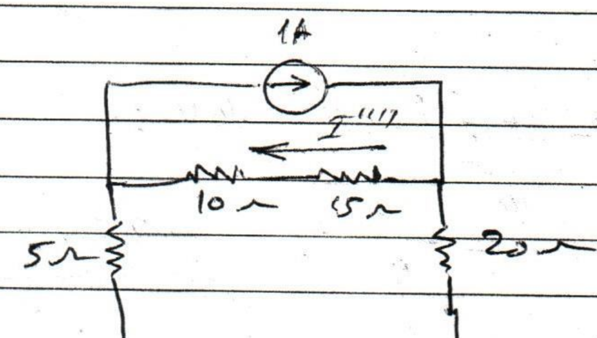
$$V_{x_3} = 2.1 * 10 = 21V \ (-)$$



4- effect 1A:

$$I'''' = 1 * \frac{25}{50} = 0.5 \ A$$

$$V_{x_4} = 0.5 * 10 = 5 \ V(-)$$

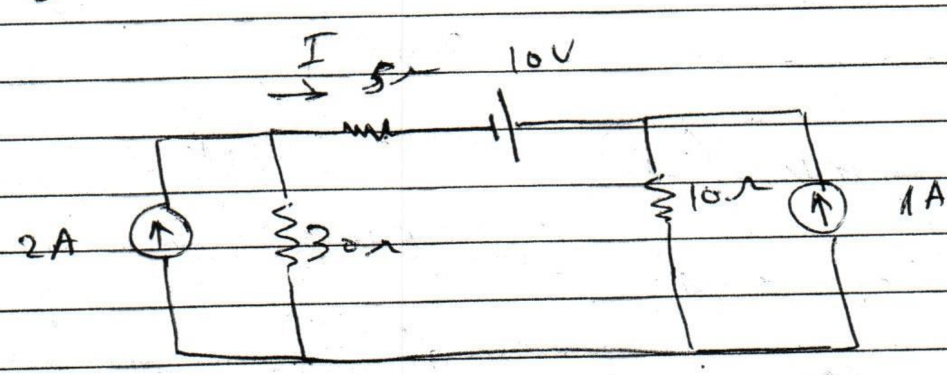


c-

$$V_{x_T} = V_{x_1} + V_{x_2} + V_{x_3} + V_{x_4}$$

$$V_{x_T} = 4 - 6 - 21 - 5 = \underline{\underline{-28\ V}}$$

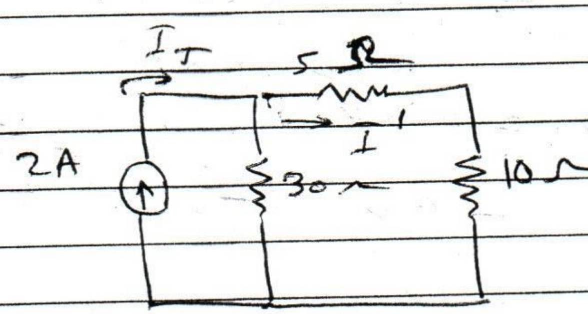
Exp. Find I For the circuit shown befor by using superposition theorem ?



1- effect 2A:

$$I' = 2 * \frac{30}{45}$$

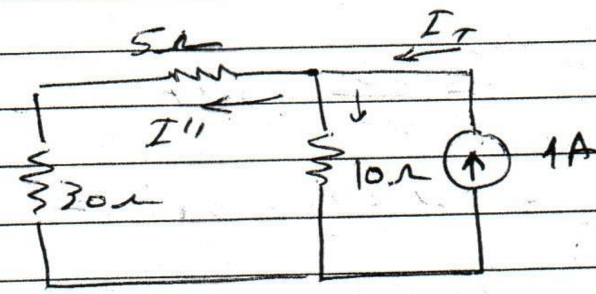
$$= \underline{\underline{1.333\ A}}$$



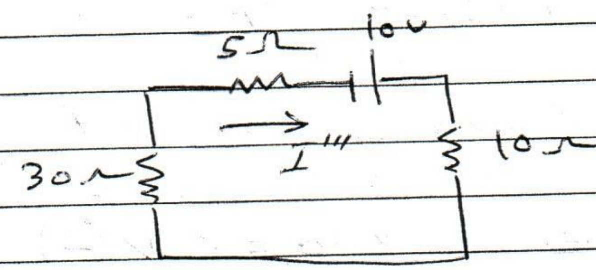
2- effect 1A:

$$I'' = 1 * \frac{10}{45}$$

$$= \underline{\underline{0.222\ A}}$$



3- effect 10V:



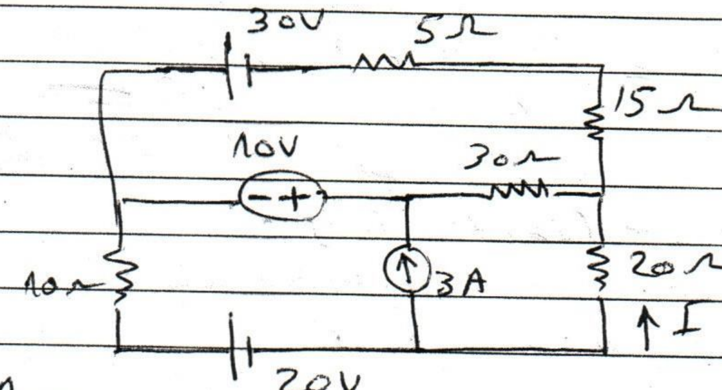
$$I''' = \frac{10}{45} = \underline{\underline{0.222A}}$$

36

$I = 1.333 - 0.222 + 0.222 = \underline{\underline{1.333\ A}}$

Exp:

For the circuit, find current I, by using superposition theorem?



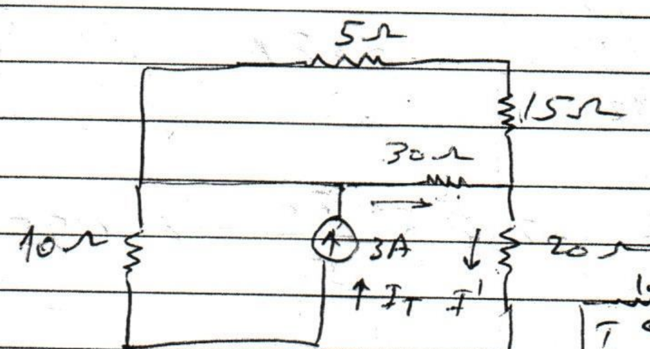
1- effect 3A:

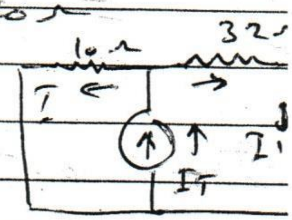
$20 // 30 = 12\,\Omega$

$12\,\Omega + 20 = 32\,\Omega$

$I' = 3 * \frac{10}{42} = 0.714\ A$

2- effect 30V:

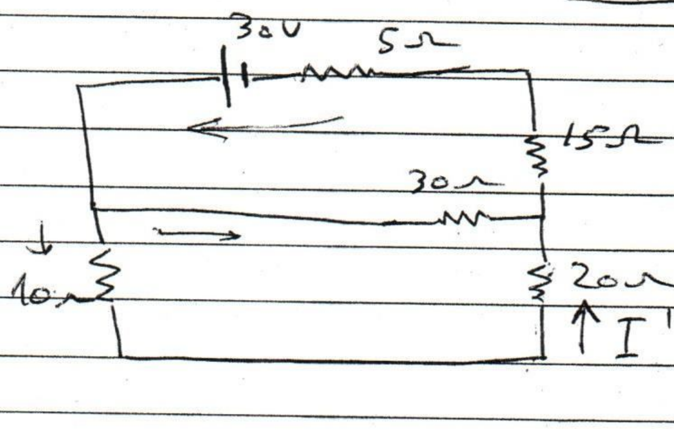




$30 // 30 = 15\,\Omega$

$15 + 15 + 5 = 35\,\Omega$

$I_T = \frac{30}{35} = 0.857 A$



$I'' = 0.857 * \frac{30}{60}$

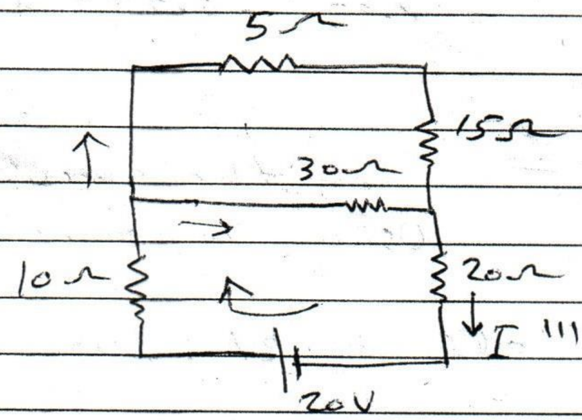
$= 0.428\ A$

3- effect 20V :

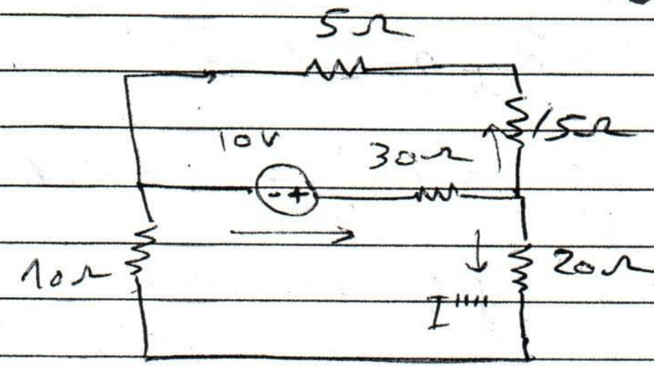
$20 \parallel 30 = 12\,\Omega$

$R_{eq} = 30 + 12 = 42\,\Omega$

$I_T = \dfrac{20}{42} = 0.476\,A = \underline{\underline{I'''}}$



4- effect 10V :



$30 \parallel 20 = 12\,\Omega$

$12 + 30 = 42\,\Omega$

$I_T = \dfrac{10}{42} = 0.238\,A$

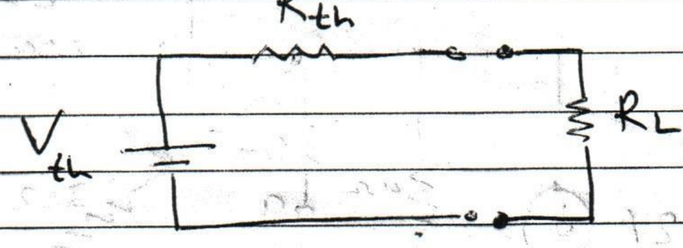
$I'''' = 0.238 * \dfrac{20}{50} = 0.095\,A$

$I = -0.714 + 0.428 - 0.476 - 0.095 = \underline{\underline{-0.856\,A}}$

37

The Thevenin Theorem

The TT can transform any electric circuit to equivalent circuit (Thevinin) :



This Thereme used when the circuit have voltage sources with resistances only.

Solution steps :
take the device who must to calculate him thevinin circuit for him and put in his place A, B. Calculate the equivalent resistance between A, B and this value equal $R_{eq} = R_{th} = R_N$ and calculate the volta,

between A, B, this value equal V_{th} and in the finished drawing the equivalent circuit.

1- take the device and put A, B.
2- Calculate the voltage between A, B (V_{th}).
3- put short circuit between A, B and calcu. the current ($I_{s.c}$), $I_{s.c} = I_N$.
4- we can to calculate the resistance R_{th} =

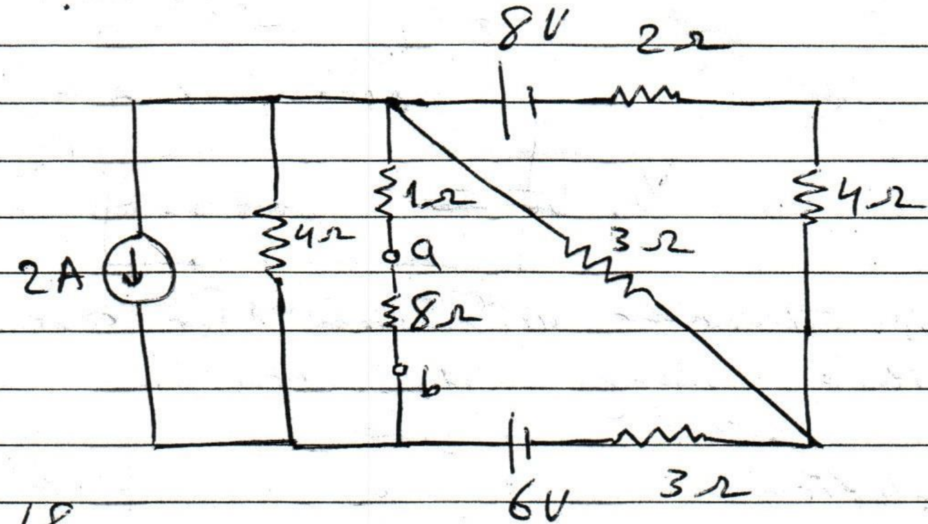
$$R_N = R_{th} = \frac{V_{th}}{I_{s.c}}$$

$$I_{s.c} = \frac{V_{th}}{R_{th} + R_L}$$

ES

~~Exp.~~

Find the power dissipated in $8\,\Omega$ using thevinn theorem?



$$6 // 3 = \frac{18}{9} = 2\,\Omega$$

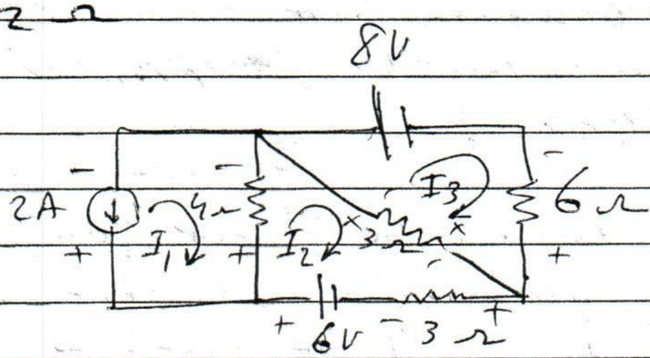
$$2 + 3 = 5\,\Omega$$

$$5 // 4 = \frac{20}{9} = 2.222\,\Omega$$

$$2.222 + 1 = 3.222\,\Omega$$

$$R_{th} = 3.2\,\Omega$$

$$V_{th} = V_{ab} = V_{4\Omega}$$



$$V_{4\Omega} = I * R$$

By using mesh analysis:

AT loop 1 KVL:

$$I_1 = -2A$$

38

AT Loop 2 KVL:

$6 - 3I_2 - 4(I_2 - I_1) - 3(I_2 - I_3) = 0$

$6 - 3I_2 - 4I_2 + 4\underbrace{I_1}_{=-2} - 3I_2 + 3I_3 = 0$

$6 - 6I_2 - 4I_2 + 3I_3 - 8 = 0$

$-10I_2 + 3I_3 = 2$ —— 1

AT Loop 3 KVL:

$-8 + 6I_3 - 3(I_3 - I_2) = 0$

$-8 + 6I_3 - 3I_3 + 3I_2 = 0$

$3I_2 + 3I_3 = 8$ —— 2

By substracting 1 and 2

$-10I_2 + \cancel{3I_3} = 2$

$\mp 3I_2 \mp \cancel{3I_3} = \mp 8$

$-13I_2 = -6 \Longrightarrow I_2 = \frac{-13}{-6} = 2.16\ A$

From eq. 1 we can to find I_3:

$-10 * 2.16 + 3I_3 = 2$

~~(21.6~~ $3I_3 = 2 + 21.6 = 23.6$

$I_3 = \frac{23.6}{3} = 7.86\ A$

$V_{4\Omega} = 4 * (I_2 - I_1) = 4 * (2.16 + 2) = 4 * 4.16 = 16.6$

$\Longrightarrow$

$V_{th} = 16.64\,V$

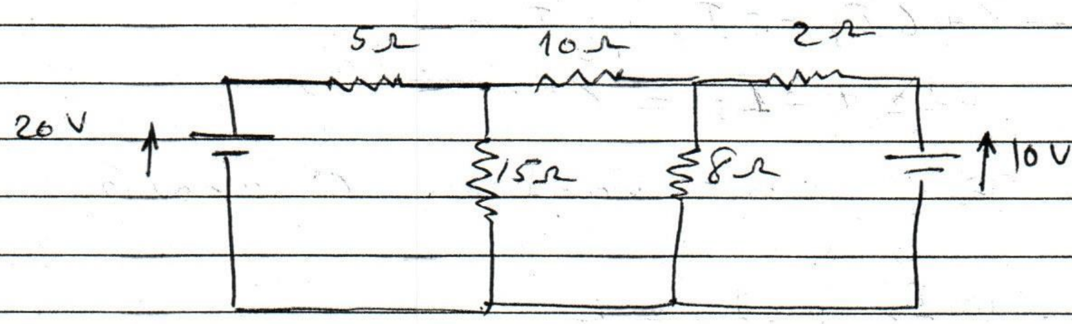
$$I = \frac{V_{th}}{R_{th}+8} = \frac{16.64}{3.2+8} = \frac{16.64}{11.2} = \underline{1.485\,A}$$

$$P_{8\Omega} = I^2 \times R = (1.485)^2 \times 8 = 2.205 \times 8$$

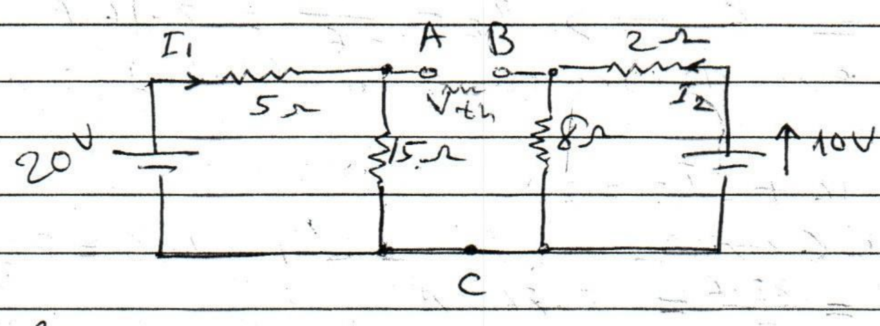
$$P_{8\Omega} = 17.6418\ W.$$

Exp.

Calculate the current in the resistance 10Ω By using thevinin Theorem for the following circuit. ?



When we open the branch ~~which~~ whitch his resistance 10Ω the circuit will be:

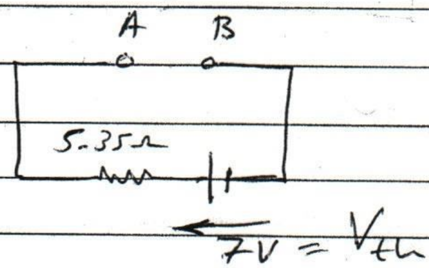


$$I_1 = \frac{20}{5+15} = 1\,A \implies V_{AC} = 1 \times 15 = \underline{15\,V}$$

$$I_2 = \frac{10}{2+8} = 1\,A \implies V_{BC} = 1 \times 8 = \underline{8\,V}$$

∴ $V_{AB} = V_{AC} - V_{BC} = 15 - 8 = 7\,V = V_{th}$

$$R_{eq} = \frac{5\times 15}{5+15} + \frac{8\times 2}{8+2} = 3.75 + 1.6 = 5.35\,\Omega = R_{AB} = R_{th}$$



$$R_{eq} = R_{th} + 10 = 5.35 + 10 = 15.35\,\Omega$$

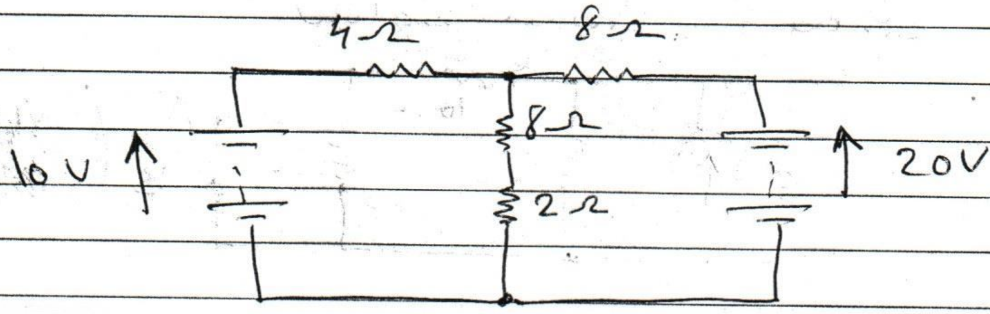
$$I_{th} = \frac{V_{th}}{R_{th}+10} = \frac{7}{15.35} = 0.46\,A$$

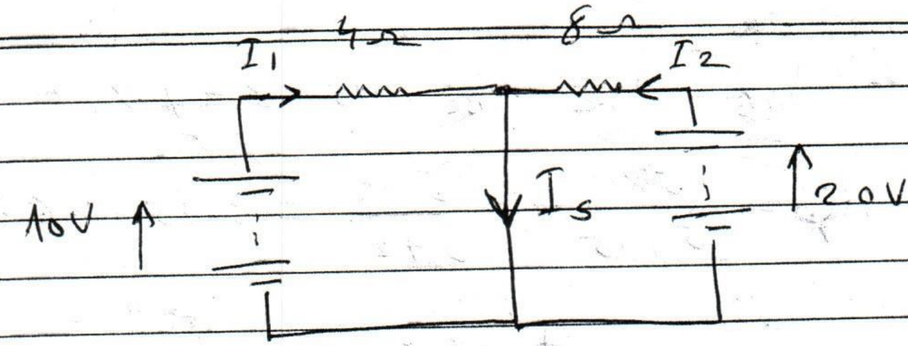
Norton's Theorem

this theorem its same as a thevinin but here we ~~put~~ use the current source ~~replace~~.

Exp

Calculate the voltage drop a cross the resistance (2 Ω) of the following circuit by using norton theorem ?



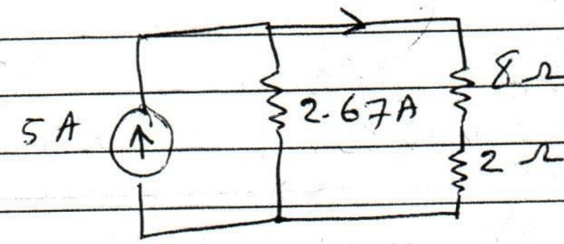


$$I_1 = \frac{10}{4} = 2.5\,A$$

$$I_2 = \frac{20}{8} = 2.5\,A$$

$$I_s = I_1 + I_2 = 5\,A$$

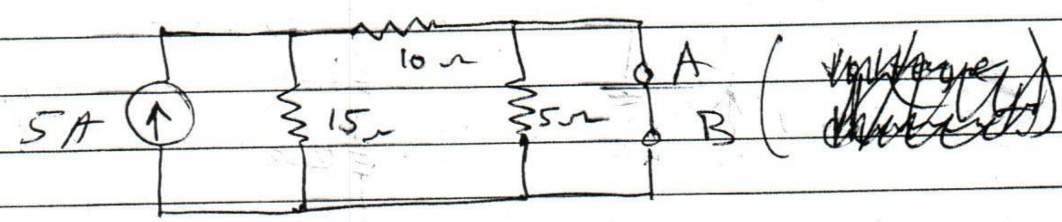
$$R_N = \frac{4\times 8}{4+8} = 2.67\,\Omega$$



$$I = \frac{2.67}{2.67+10} \times 5 = 1.06\,A$$

$$V = 1.06 \times 2 = \underline{\underline{2.12}}\ V$$

Exp:
Find Norton equivalent cicuit for the circuit shown below

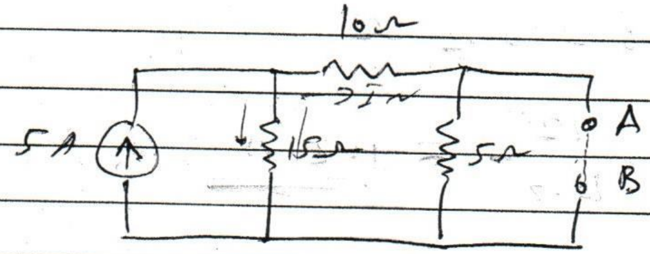


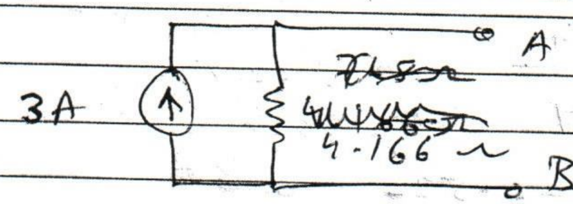
40

$R_N \; \frac{25*5}{30} = 4.166\ \Omega$

$R_N = \cancel{\frac{25*15}{25+15}} = \cancel{4.166}\ \Omega$

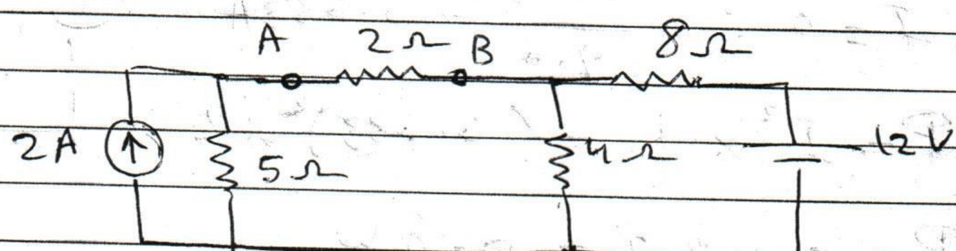
$I_N = 5 * \frac{15}{15+10} = 3A$





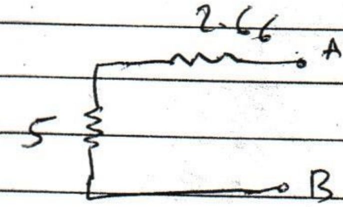
Ex.

Calculate the power dissipated in (2 Ω) using Norton's theorem ?



$R_{th} = R_N$ ~~= Req~~

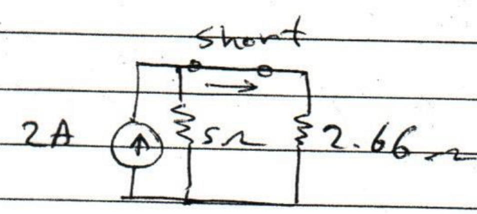
$8 // 4 = \frac{32}{12} = 2.66\ \Omega$



$2.66 + 5 = 7.6\ \Omega$

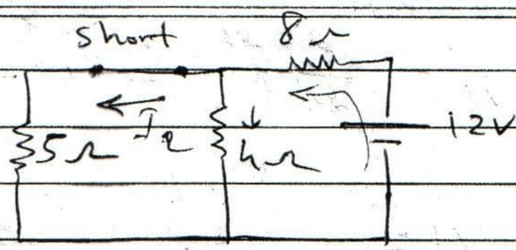
By using superposition theorem

① effect 2A ⇒



$I_1 = 2 * \frac{5}{7.6} = 1.315\ A$

② effect 12V



$5 // 4 = \frac{20}{9} = 2.2 \Omega$

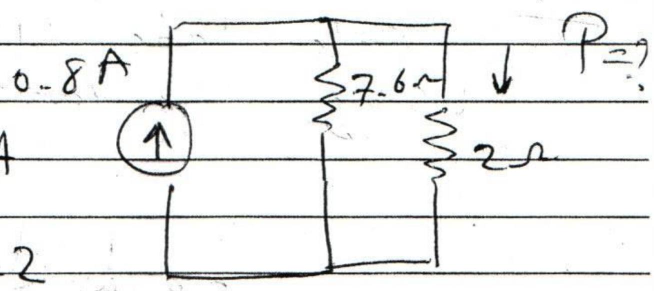
$2.2 + 8 = 10.2\ \Omega = R_{eq}$

$I_T = \frac{12}{10.2} = \underline{1.2\ A}$

$I_2 = 1.2 * \frac{4}{9} = 0.522\ A$

$I_{s.c} = 1.315 - 0.522 = 0.8\ A$

$I_N = 0.8\ A$



$I = 0.8 * \frac{7.6}{9.6} = 0.633\ A$

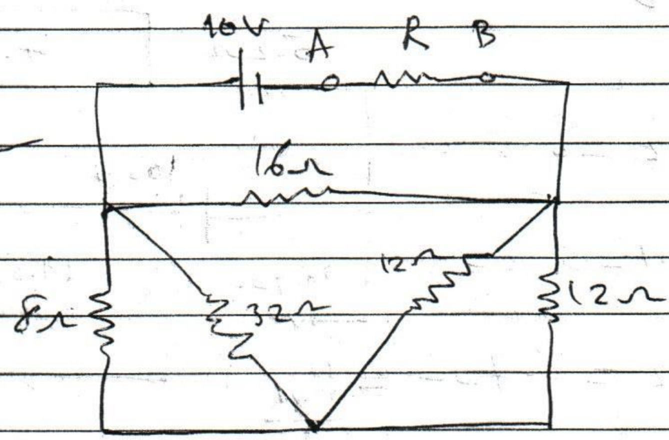
$P = I^2 * R = (0.633)^2 * 2$

$P = 0.4 * 2 = \underline{0.8\ W}$

o}

EXP.

Find maximum power in R ?
by using thevinin theorem.



AT maximum power

$R_L = R_{th} = R_N$

$R_{th} = ?$

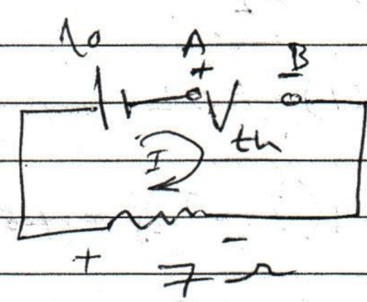
$12 \,//\, 12 = 6\,\Omega$

$8 \,//\, 32 = 6.4\,\Omega$

$6 + 6.4 = 12.4\,\Omega$

$12.4 \,//\, 16 = 7\,\Omega$

$R_{th} = 7\,\Omega$



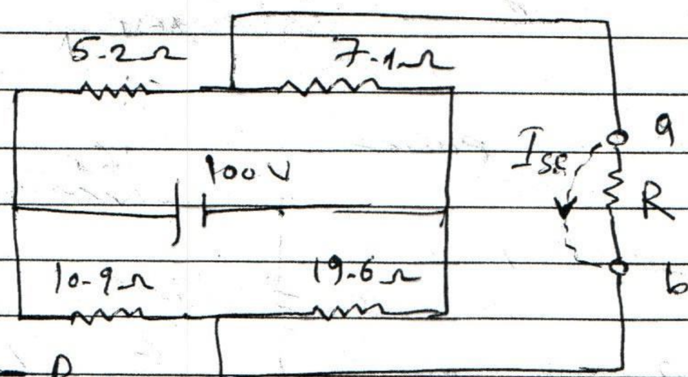
$7I - 10 - V_{th} = 0$ ($I = 0$ open circuit)

$V_{th} = \underline{\underline{-10\ V}}$

$$P_{max} = \frac{(V_{th})^2}{4R_{th}} = \frac{(-10)^2}{4*7} = \frac{100}{28} = 3.6 \text{ WATT}$$

Exp.

Find the maximum power transfer in R_L using Norton theorem?

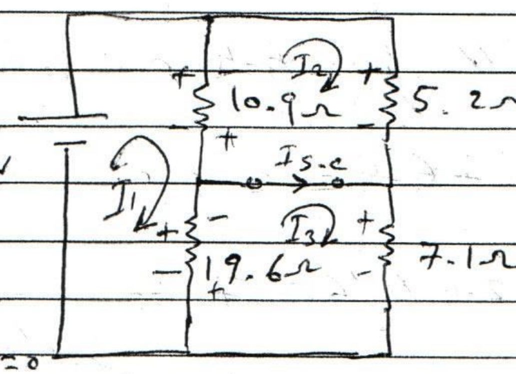


$10.9 // 5.2 = 3.5\,\Omega$

$19.6 // 7.1 = 5.2\,\Omega$

$3.5 + 5.2 = 8.7\,\Omega = \underline{R_N}$

$$I_T = \frac{100}{8.7} = 11.5\,A$$



$I_{s.c} = I_3 - I_2$

AT loop (1) KVL:

$100 - 10.9(I_1 - I_2) - 19.6(I_1 - I_3) = 0$

$30.5 I_1 - 10.9 I_2 - 19.6 I_3 = 100$ —— (1)

AT loop (2) KVL:

$-5.2 I_2 - 10.9(I_2 - I_1) = 0$

$10.9 I_1 - 16.1 I_2 = 0$ —— (2) $*$ 138.84

AT loop (3) KVL:

$-7.1 I_3 - 19.6(I_3 - I_1) = 0$

$19.6 I_1 - 26.7 I_3 = 0$ —— (3)

L3

By adding (2) and (3) ;

$10.9 I_1 - 16.1 I_2 = 0$ —— (2)

$19.6 I_1 - 26.7 I_3 = 0$ —— (3) * 7.1

+

$30.5 I_1 - 16.1 I_2 - 26.7 I_3 = 0$ —— (4)

~~by substitution in (2)~~

by substracting (1) and (4)

$\cancel{30.5 I_1} - 10.9 I_2 - 19.6 I_3 = 100$ —— (1)

$\mp \cancel{30.5 I_1} \pm 16.1 I_2 \pm 26.7 I_3 = 0$ —— (4)

sub.

$5.2 I_2 + 7.1 I_3 = 100$ —— (5) * 26.7

By add. (3) and (5)

$138.84 I_2 + \cancel{189.57 I_3} = 2670$ —— (5)

$139.16 I_1 - \cancel{189.57 I_3} = 0$ —— (3)

+

$139.16 I_1 + 138.84 I_2 = 2670$ —— (6) * 16.1

by add. (2) and (6) we get:

$2240.476 I_1 + \cancel{2235.324 I_2} = 4298.7$ —— (6)

$1513.356 I_1 - \cancel{2235.324 I_2} = 0$ —— (2)

+

$3753.832 I_1 = 42987$

$$I_1 = \frac{42987}{3753.832} = 11.45\ A$$

By substitude in (2)

$$10.9 * 11.45 - 16.1\ I_2 = 0$$

$$124.82 = 16.1\ I_2 \Longrightarrow I_2 = \frac{124.82}{16.1} = 7.75\ A$$

$\Longrightarrow$ from eq. (1)

$$30.5 * 11.45 - 10.9 * 7.75 - 19.6\ I_3 = 100$$

$$349.225 - 84.475 - 19.6\ I_3 = 100$$

$$264.75 - 100 = 19.6\ I_3$$

$$I_3 = \frac{164.75}{19.6} = 8.405\ A$$

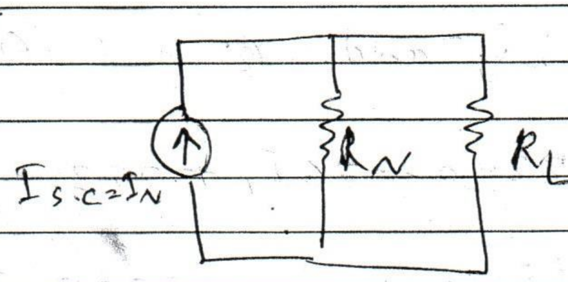
$$I_{s.c} = I_3 - I_1 = 8.405 - 11.45 = -3.044\ A$$

$R_L = R_N = R_{th}$ at max. power

$$V_{th} = I_N * R_N = -3.044 * 8.7 = -26.48\ V$$

$$P_{max} = \frac{(V_{th})^2}{4 R_{th}} = \frac{701.338}{4 * 8.7}$$

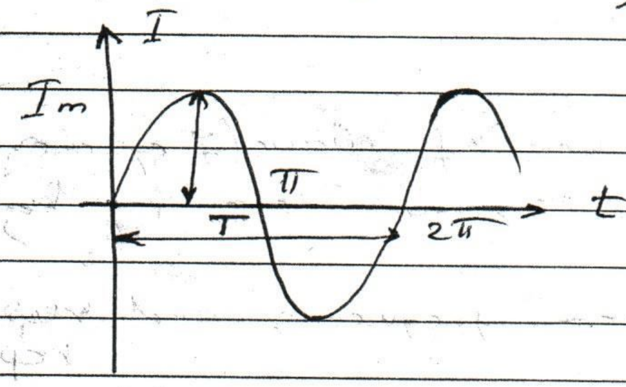
$$= 20.153\ \text{WAtt}$$



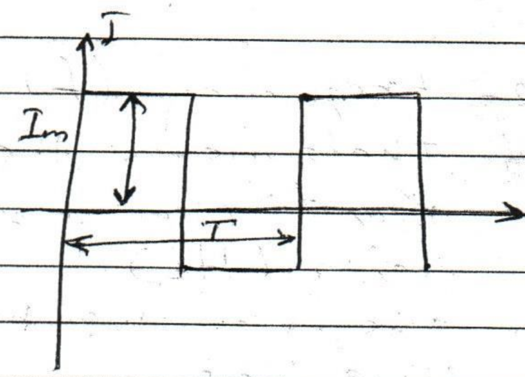
Generation of alternating current, Sinusidal Current

Alternating current (AC) ; its a current ~~who~~ whitch have a variable value and vec relativity with time.

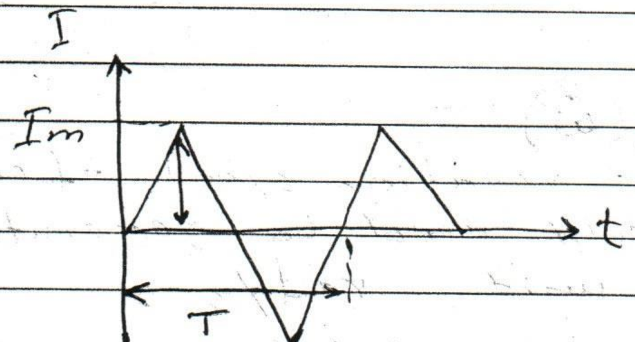
The AC current can act as a wave The wave can be ~~sinusoidal~~ sin wave , square, Sawtuth and triangle as the following



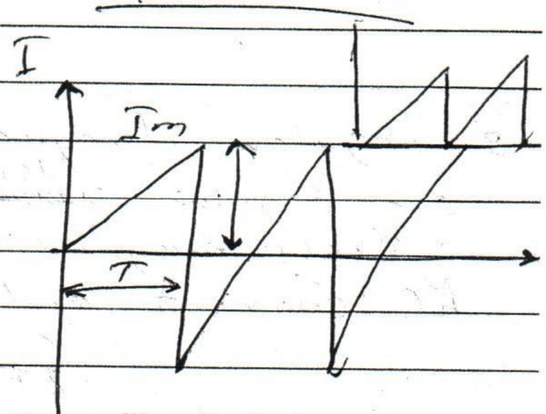
Sin wave



Squar wave



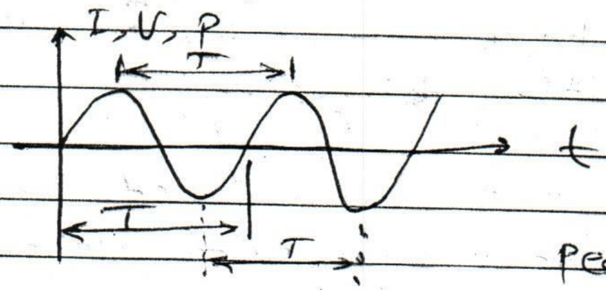
~~Sawtuth~~ triangler wave



Saw tuth wave

The wave may be current , voltage and Power.

1- Period time (T)
The time whitch very important for finishing complet one wav cycle of waves and measuring by Second (s)



peak to peak

2- Frequency (f)
Thats mean the number of wave (frequency) reapiting in time unit, and measuring by Hertz (Hz).
The relanship between frequency and ~~repiting~~ repeating time its:

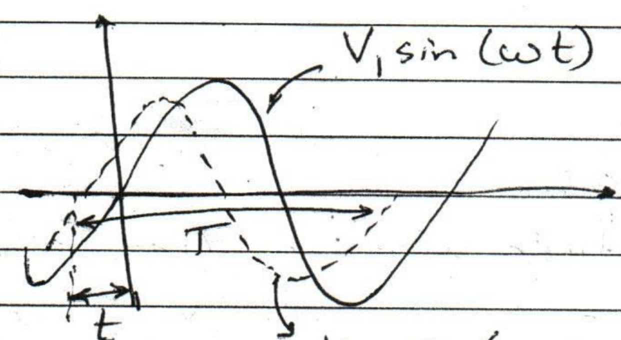
$$f = \frac{1}{T} \quad - \text{Hz} \left(\frac{1}{s} \text{ or } s^{-1}\right)$$

3- Angular frequency (ω)
Or Angular ~~speed~~ Velocity its rotation speed of coil a cross magnetic field used to generation AC current and his unit rad/s :

$$\omega = 2\pi f = \frac{2\pi}{T}$$

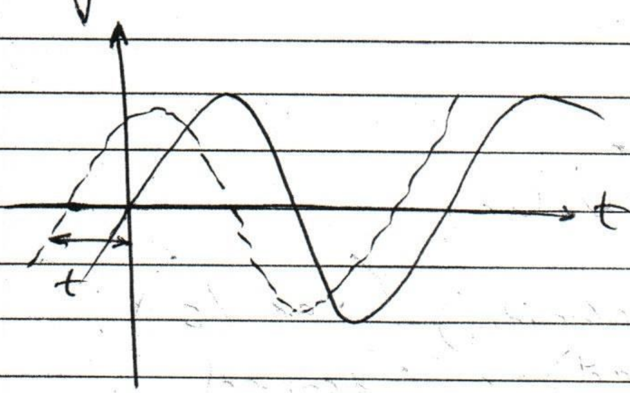
4- Phase shift (ϕ), thats meaning is a value of signal moving from the original place and measured by (rad) or (degree).

how to meaure the ϕ :

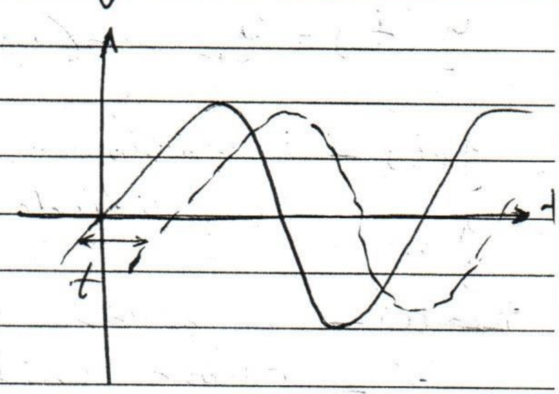


$$\phi = \mp \frac{t}{T} \times 360^\circ$$

if the signal its (Lead) over the original signal thats mean the phase shift must be positive but when the signal its (Lag) over the original signal, the phase shift must be negative.

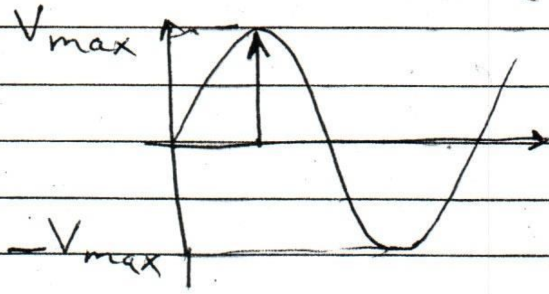


Lead signal
(phase shift positiv)



Lag signal
(phase shift negat

5- Amplitude or maximum Value :
that mean max peak which the wave can state in the peak (V_p)



6- peak-to-peak Value
that mean the amplitude measure from the peak-to-peak :

$$V_{p-p} = 2V_p$$

7- Instantaneous Value :
the Value of wave in the limiting time.

The general mathematic equation for the Sin wave its :

$$y(t) = y_m \sin(\omega t + \phi)$$

$y(t)$ - Instantaneous Value
y_m - Amplitude (max Value)
~~Ang~~ ω - angular speed (velocity) (rad/s)
ϕ - phase shift (rad) or (° degree)

NoTe : when calculating of Instantaneose Value must convert (ϕ) to unit rad :

$$\phi_{rad} = \phi^\circ \times \frac{\pi}{180^\circ}$$

45

Effective Value (root mean square Value)

dissipation power cause by AC current across resistance for limit time equal dissipation power cause by DC current across the same resistance for same time.

Give by math. relaunship:

$$y_{rms} = \sqrt{\frac{1}{T}\int_0^T (y^2(t))\,dt} \qquad \boxed{V_{rms} = \sqrt{\frac{1}{T}\int_0^T (V^2(t))\,dt}}$$

For Sine wave:

$$V(t) = V_p \sin(\omega t) \quad , \quad I(t) = I_m * \sin\omega t$$

$V_p \rightarrow V_{max}$

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T V_p^2 \sin^2(\omega t)\,dt}$$

$$= V_p\sqrt{\frac{1}{T}\int_0^T \frac{1-\cos(2\omega t)}{2}\,dt}$$

$$= V_p\sqrt{\frac{1}{2T}\left[T-0\right]} = \frac{V_p}{\sqrt{2}}$$

V_{max}

$$\boxed{I_{rms} = \sqrt{\frac{1}{T}\int_0^T i^2(t)\,dt}}$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

0 .

Average Value $\underline{\underline{V_{av}}}$

$$V_{av} = \frac{1}{T}\int_0^T V(t)\,dt$$

For sine wave (Voltage)

$$V_{av} = \frac{V_{max}}{\pi}$$

(current)

$$I_{av} = \frac{1}{T}\int_0^T i(t)\,dt \Rightarrow I_{av} = \frac{2 I_{max}}{\pi}$$

~~Avr DC current~~

$$\boxed{\sin\theta = \cos\left(\theta - \frac{\pi}{2}\right) \qquad \cos\theta = \sin\left(\theta + \frac{\pi}{2}\right)}$$

Form Factor (K_F)

Thats mean relativly between the effective and average value:

$$(F.F)\ K_F = \frac{V_{rms}}{V_{av}}$$

Peak Factor (K_P) (K_{max})

$$K_P = \frac{V_{max}}{V_{rms}}$$