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D.C. CIRCUITS

VOLTAGE (or) POTENTIAL :-

→ The Amount of workdone to bring a unit positive charge from ∞ to a point is known as absolute potential of that point. we are interested in potential difference (voltage) between two points.

→ If the Energy required to move a charge of Q coulombs from point A to point B is W Joules, the voltage V between A and B is given as

$$\boxed{V = \frac{W}{Q}}$$

→ The unit of voltage is Volt. 1 Volt = 1 Joule/coulomb

Energy :-

→ Capacity to do work is called as Energy. The unit of Energy is Joules

→ If current is entering at +ve terminal of an element, Then The element is absorbing the energy. Vice - Versa.

POWER :-

→ Consider an element having a voltage V across it. A small change in charge Δq is moved through element from the positive terminal to the negative terminal in time Δt. The Energy ΔW absorbed by the element in this process is given as $\Delta W = V \Delta q$.

i.e $\frac{\Delta W}{\Delta t} = V . \frac{\Delta q}{\Delta t}$

$$\Rightarrow \frac{dW}{dt} = \frac{dq}{dt} . V = Vi = P$$

→ The Rate of doing work is known as power.

$$\boxed{P = VI}$$

→ The unit of power is Watt (W).

Electromotive Force :-

→ It is the voltage of the source when nothing is connected to it.

→ Electromotive force (EMF) is not a force. It is a voltage measured in Volts.

→ It is called force because it forces current to flow in a circuit.

Terminal voltage :-

→ The voltage across the terminals of a source is called its terminal voltage.

OHM'S LAW :-

STATEMENT OF OHM'S LAW :-

It states that potential difference between two ends of a conductor is directly proportional to the current flowing through it, provided its temperature and other physical parameters remain unchanged. i.e

$V \propto I$.

$\Rightarrow V = IR$ where R is the constant of proportionality.

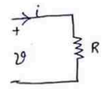
→ R is called Resistance and its unit is ohm (Ω).

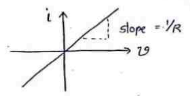
Alternate way :-

$I \propto V$

$\Rightarrow I = GV$ where G is constant of proportionality

→ G is called Conductance of a conductor. It is a Reciprocal of Resistance. SI unit of conductance is Siemens (S).





OHM's LAW in graphical form.

Applications of OHM'S LAW :-

i) $V = IR$, $P = VI = I^2R = V^2/R$. when Two quantities are known, we can Easily Calculate the third quantity by using ohm's law.

Limitation of OHM'S LAW :-

1. This law can't be applied unilateral network. Eg: Network having Diodes etc..
2. ohm's law also not applicable to for Non-linear elements. Eg. Diode, Transistor etc..

POWER AND ENERGY IN RESISTOR :-

→ From ohm's law, $V = IR$.

$$\text{Power} = P = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = V.I. \text{ watt}$$

$$\Rightarrow \boxed{\begin{aligned} P &= VI \text{ watt} \\ &= I^2R \text{ watt} \\ &= V^2/R \text{ watt.} \end{aligned}}$$

→ Energy (I will denote with E or W). is given by

$$P = \frac{dW}{dt} \quad \text{where } W \text{ is work done (Energy).}$$

$$\Rightarrow P.dt = dW$$

$$\Rightarrow \int P.dt = \int dW.$$

$$\Rightarrow W \text{ or } E = \int P.dt \quad J \text{ (or) Joule.}$$

$$\therefore \boxed{E = \int VI.dt = \int I^2R.dt = \int \frac{V^2}{R}.dt.}$$

POWER AND ENERGY IN CAPACITOR :-

→ The property of Material which stores energy in an electric field is known as Capacitence. (C). units are Farad (F)

→ A Capacitence (C) Satisfies a Relation.

$$i = C.\frac{dv}{dt}$$

→ power in a Capacitor $= p = V.i$

$$\Rightarrow p = \frac{dv}{dt}.C.v.$$

$$\Rightarrow \boxed{p = C.V.\frac{dv}{dt}} \text{ Watt.}$$

→ Energy in a Capacitor $= E = \int P.dt.$

$$= \int C.v.\frac{dv}{dt}.dt$$

$$\Rightarrow \boxed{E = \frac{1}{2}Cv^2} \text{ Joule}$$

POWER AND ENERGY IN INDUCTOR :-

→ The property of Material which stores Energy in Magnetic field is known as Inductance. (L). Units are Henry (H)

→ An Inductor Satisfies a Relation,

$$v = L.\frac{di}{dt}$$

→ power in an Inductor $= p = vi$

$$= L.\frac{di}{dt}.i$$

$$\Rightarrow \boxed{p = Li\frac{di}{dt}} \text{ Watt}$$

→ Energy in an Inductor $= E = \int P.dt = \int Li\frac{di}{dt}.dt$

$$\Rightarrow \boxed{E = \frac{1}{2}Li^2} \text{ Joule.}$$

SERIES AND PARALLEL COMBINATION OF R, L, C :-

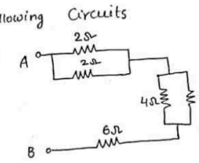
→ when Three Resistances are in parallel. The Equivalent Resistance R_{eq} is given by.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$ where R_1, R_2 and R_3 are given Resistance

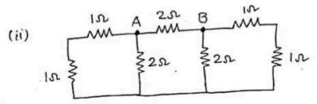
→ when R_1, R_2 and R_3 are in Series. Then $R_{eq} = R_1 + R_2 + R_3$.

Q. Calculate Equivalent Resistance between A and B terminals in the Following Circuits

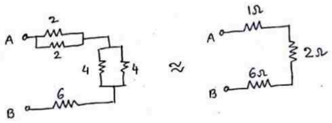
i)



(ii)

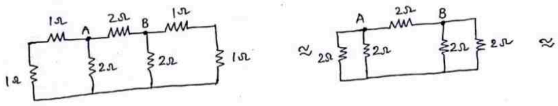


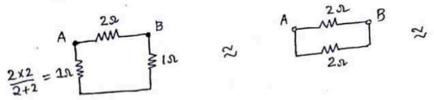
Sol:- i)



$\Rightarrow R_{AB} = 1+2+6 = 9\Omega$

ii)





$R_{AB} = \frac{2 \times 2}{2+2} = 1\Omega$

→ when Three Inductances (L_1, L_2, L_3) are in parallel, The Equivalent Inductance is given by.

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

→ when L_1, L_2, L_3 are in Series. $L_{Eq} = L_1 + L_2 + L_3$ Henry.

→ when Three Capacitors are in parallel. The Equivalent Capacitence C_{eq} is given by

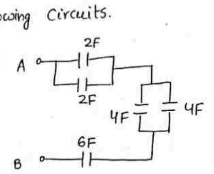
$$C_{Eq} = C_1 + C_2 + C_3$$ where C_1, C_2 and C_3 are given capacitences,

→ when C_1, C_2, and C_3 are in Series. Then

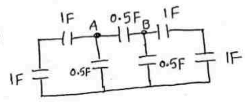
$$\frac{1}{C_{Eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}.$$

Q. Calculate Equivalent Capacitence between A and B terminals in the Following Circuits.

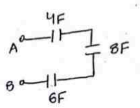
i)



ii)

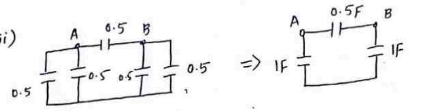


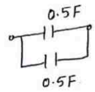
Sol:- i)



$$\Rightarrow C_{AB} = \frac{(4F)\left[\frac{8 \times 6}{8+6}\right]}{4 + \left[\frac{8 \times 6}{8+6}\right]} = \frac{4 \times \frac{48}{14}}{4 + \frac{48}{14}} = 1.84F.$$

ii)

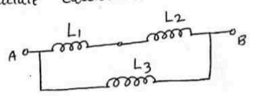




$\Rightarrow C_{AB} = 1F$

Q. Calculate Equivalent inductance b/w A and B terminals.

i)



ii) If $L_1 = 2H$ $L_2 = 4H$. $L_3 = 6H$.

$L_{AB} = ?$

Sol:- i) $$L_{AB} = \frac{L_3(L_1 + L_2)}{L_3 + L_1 + L_2}$$

ii) $$L_{AB} = \frac{6(4+2)}{6+4+2} = 3H$$

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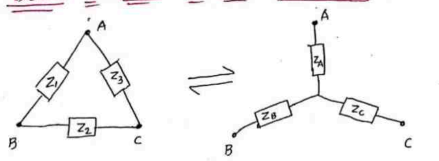
STAR TO DELTA & DELTA TO STAR CONVERSION :- (7)



Delta connection   Star connection.

→ **Delta to Star conversion :-** (Assume above values of impedences)

$$Z_A = \frac{Z_1 Z_3}{Z_1+Z_2+Z_3} \qquad Z_B = \frac{Z_1 Z_2}{Z_1+Z_2+Z_3} \qquad Z_C = \frac{Z_3 Z_2}{Z_1+Z_2+Z_3}$$

→ **STAR TO DELTA CONVERSION :-**

$$Z_1 = Z_A + Z_B + \frac{Z_A Z_B}{Z_C}$$

$$Z_2 = Z_B + Z_C + \frac{Z_B Z_C}{Z_A}$$

$$Z_3 = Z_A + Z_C + \frac{Z_A Z_C}{Z_B}$$

→ In Case Resistor,

i) **STAR TO DELTA :**

$$R_1 = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$R_2 = R_B + Z_C + \frac{R_B R_C}{R_A}$$

$$R_3 = R_A + R_C + \frac{R_A R_C}{R_B}$$

ii) **DELTA TO STAR :-**

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

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

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

→ In Case of Capacitor,

i) **STAR TO DELTA. :-**

$$\frac{1}{j\omega C_1} = \frac{1}{j\omega}\left[\frac{1}{C_A} + \frac{1}{C_B} + \frac{C_C}{C_A C_B}\right]$$

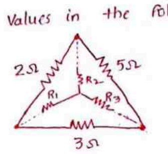
$$\Rightarrow \frac{1}{C_1} = \frac{1}{C_A} + \frac{1}{C_B} + \frac{C_C}{C_A C_B}$$

DELTA TO STAR

$$\frac{1}{C_A} = \frac{1/C_1 \cdot 1/C_3}{\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}}$$

(8)

Q. If Delta connection is converted into star equivalent. Then calculate R_1, R_2, R_3 values in the following network.



Sol:-

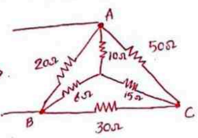
$$R_1 = \frac{2(3)}{2+3+5} = \frac{6}{10} = 0.6\,\Omega$$

$$R_2 = \frac{2(5)}{2+3+5} = \frac{10}{10} = 1\,\Omega$$

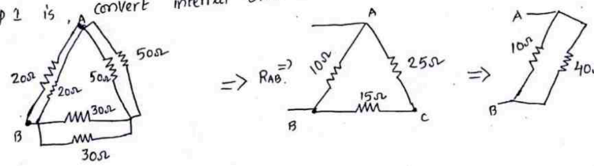
$$R_3 = \frac{3(5)}{2+3+5} = \frac{15}{10} = 1.5\,\Omega$$

Q. Find Equivalent Resistance between A and B terminals in the following Network.

$R_{AB} \Rightarrow$

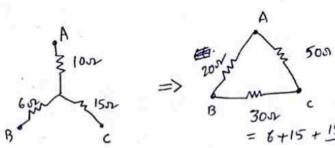


Sol:- Step 1 is convert internal Star into Delta Network.



$$\therefore R_{AB} = \frac{10(40)}{10+40} = \frac{40\cancel{0}}{5\cancel{0}} = 8\,\Omega$$

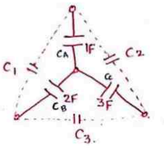
Hint:- convert

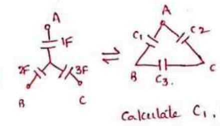


$50\Omega = 10+15+\frac{10(15)}{}$

$= 6+15+\frac{15(6)}{10}$

Q. Convert the following Network into its Delta Equivalent form.



(a) 

Calculate C_1, C_2 and C_3 if both are equivalent CKS.

Sol:-

$$\frac{1}{C_1} = \frac{1}{1} + \frac{1}{2} + \frac{1(1/2)}{1/3} = 1.5 + \frac{3}{2} = 3. \quad \Rightarrow C_1 = \frac{1}{3}F$$

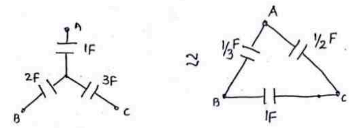
$$\text{IIIly } C_2 = \frac{C_A C_C}{C_A+C_B+C_C} = \frac{1(3)}{1+2+3} = \frac{3}{6} = \frac{1}{2}F.$$

you can obtain above formula after simplifying $\frac{1}{C_2} = \frac{1}{C_A} + \frac{1}{C_C} + \frac{C_B}{C_A C_C}$

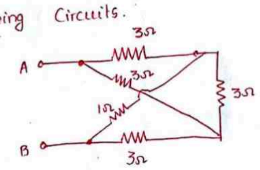
$$\Rightarrow C_2 = \frac{C_A C_C}{C_A+C_B+C_C}$$

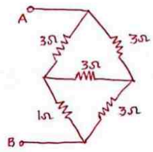
$$\text{IIIly } C_3 = \frac{C_B C_C}{C_A+C_B+C_C} = \frac{6}{1+2+3} = 1F$$

$\therefore$



Q. Calculate Equivalent Resistance between A and B terminals in the following Circuits.

i) 

ii) 

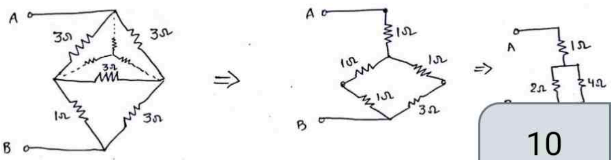
Sol:- i) and ii) Both are Same Circuits.

i) will be converted as (ii). This is the first observation

→ Don't Apply Wheatstone Bridge logic. It is not satisfying.

i.e $3 \times 3 \neq 1 \times 3$.

→ Convert Δ network into star.



10

$$\Rightarrow R_{AB} = 1 + (2 \| 4) = 1 + \frac{2(4)}{2+4} = \frac{7}{3}\Omega$$

→ H/W. Assume Capacitors and practice the above Model.

* THE KIRCHOFF'S LAWS :-

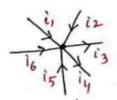
→ Kirchhoff's current Law (KCL)

→ Kirchoff's Voltage Law. (KVL)

1. KIRCHHOFF'S CURRENT LAW (KCL) :-

In a Lumped electric Circuit, For any of its nodes, on that at any time 't', The Algebraic sum of branch currents leaving the node is zero.

$$-i_1 - i_2 + i_3 + i_4 - i_5 - i_6 = 0.$$



$$\Rightarrow i_1 + i_2 + i_5 + i_6 = i_3 + i_4$$

we can also define KCL as,

Sum of entering Currents = Sum of leaving Currents at node.

→ KCL is independent of nature of elements connected to the Node.

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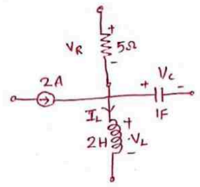
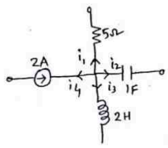
Q. If $V_R = 5V$, $V_c = 4\sin 2t$ then Calculate I_L and V_L in the following Circuit.



Sol:- The given circuit is·



$i_3 = I_L$.

By KCL,

$i_1 + i_2 + i_3 + i_4 = 0$. —①

$\Rightarrow i_1 = -\frac{V_R}{5\Omega} = \frac{5}{5} = -1$

$i_2 = C \cdot \frac{dV_c}{dt} = 1 \cdot \frac{d}{dt}(4\sin 2t) = 8\cos 2t$.

$i_3 = I_L = ?$

$i_4 = -2A$.

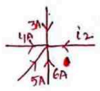
$\therefore$ By KCL,

$-1 + 8\cos 2t + I_L - 2 = 0$.

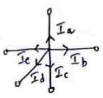
$\Rightarrow \boxed{I_L = 3 - 8\cos 2t}$ Amp.

$V_L = L \cdot \frac{dI_L}{dt} = 2 \cdot \frac{d}{dt}[3 - 8\cos 2t] = \underline{32\sin 2t \ V}$

Q. Calculate i_2 in following Circuit



Sol:-



By KCL,

$I_a + I_b + I_c + I_d + I_e = 0$.

$\Rightarrow -3 - i_2 - 6 - 5 - 4 = 0$

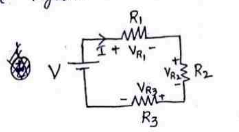
$\Rightarrow \boxed{i_2 = -18\ A}$

Guru govind.

→ KIRCHHOFF'S VOLTAGE LAW :-

In a Lumped electric Circuit, For any of its loops and at any time 't', the Algebric Sum of branch Voltages around (closed) loop is zero.

Eg:

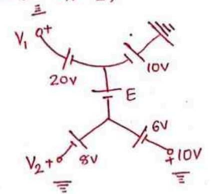


By KVL,

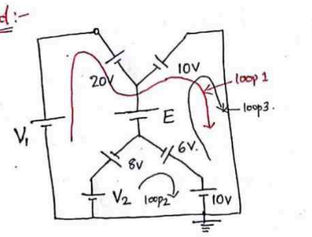
$-V + V_{R_1} + V_{R_2} + V_{R_3} = 0$.

$\Rightarrow V = V_{R_1} + V_{R_2} + V_{R_3}$.

Q. Determine V_1, V_2, E for the following Circuit.



Sol:-



From loop1,

$-V_1 + 20 - 10 = 0 \Rightarrow V_1 = 10V$.

From loop 2,

$-V_2 + 8 - 6 + 10 = 0. \Rightarrow V_2 = 12V$.

From loop3.

$-10 + 6 - E - 10 = 0 \Rightarrow E = -14V$.

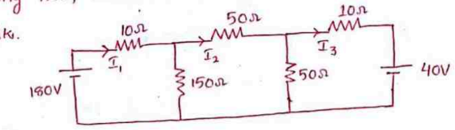
⇒NODAL ANALYSIS & MESH ANALYSIS ;-

KCL + OHM'S LAW → NODAL ANALYSIS

KVL + OHM'S LAW → MESH ANALYSIS.

→ $V = IR$ (OHM'S LAW). power in Resistor $= I^2R = V^2/R = V.I$

(9). By using KVL, Calculate I_1, I_2, I_3 currents in the following network.



After calculating I_1, I_2, I_3. Calculate

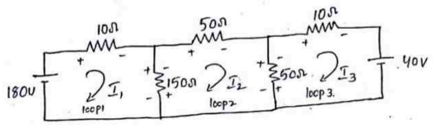
i) power delivered by 180V voltage source

ii) power absorbed by 150Ω Resistor.

iii) power absorbed by 40V voltage source.

iv) Voltage across 150Ω resistor aswell as 50Ω Resistor.

Sol:-



Apply KVL in Loop 1,

$$-180 + 10(I_1) + 150(I_1 - I_2) = 0.$$

$$\Rightarrow \quad 160I_1 - 150I_2 = 180. \quad —(1).$$

Apply KVL in loop 2,

$$50I_2 + 50(I_2 - I_3) + 150(I_2 - I_1) = 0.$$

$$\Rightarrow \quad -150I_1 + 250I_2 - 50I_3 = 0 \quad —(2)$$

Apply KVL in loop 3,

$$10I_3 + 40 + 50(I_3 - I_2) = 0.$$

$$\Rightarrow \quad -50I_2 + 60I_3 = -40 \quad —(3)$$

Solving (1), (2), (3) using Calculator,

$\boxed{I_1 = 3A}$ $\boxed{I_2 = 2A}$ $\boxed{I_3 = 1A.}$

i) power delivered by voltage source 180V $= P_{180V} = V(I_1) = 180(3)$
$= 540\,\text{Watt}$

(ii) Current in 150Ω Resistor $= I_{150\Omega} = I_1 - I_2 = 3 - 2 = 1A.$

$\therefore$ power absorbed by 150Ω Resistor $= P_{150\Omega} = I_{150}^2 R = (1)^2(150)$
$= 150W$

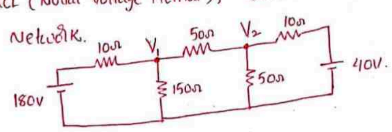
iii) power absorbed by 40V voltage source.

$$P_{40} = V_{40} I_3 = 40(1) = 40W$$

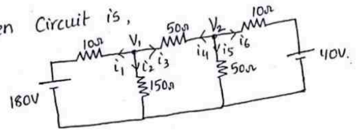
iv). Voltage across 150Ω $= V_{150\Omega} = I_{150\Omega}(150\Omega) = 1(150) = 150V$

Voltage across 50Ω $= V_{50\Omega} = I_{50\Omega}(50\Omega) = I_2(50) = 2(50) = 100V$

(9). By using KCL (Nodal Voltage Method), Calculate V_1 and V_2 in the following network.



Sol:- The given Circuit is,



By applying KCL at node V_1,

$$i_1 + i_2 + i_3 = 0.$$

$$\Rightarrow \quad \frac{V_1 - 180}{10} + \frac{V_1}{150} + \frac{V_1 - V_2}{50} = 0.$$

$$\Rightarrow \quad V_1\left[\frac{1}{10} + \frac{1}{150} + \frac{1}{50}\right] - \frac{V_2}{50} = 18$$

$$\Rightarrow \quad \frac{19}{150}V_1 - \frac{V_2}{50} = 18 \quad —(1).$$

By Applying KCL at node V_2,

$$i_4 + i_5 + i_6 = 0$$

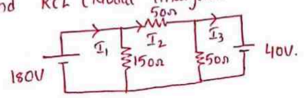
$$\frac{V_2 - V_1}{50} + \frac{V_2}{50} + \frac{V_2 - 40}{10} = 0.$$

$$\Rightarrow V_2\left[\frac{1}{50} + \frac{1}{50} + \frac{1}{10}\right] - \frac{V_1}{50} = 4$$

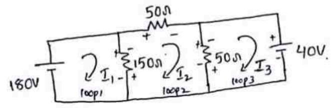
$$\Rightarrow \frac{7}{50}V_2 - \frac{1}{50}V_1 = 4. \quad -(2) \qquad (or) \quad -\frac{1}{50}V_1 + \frac{7}{50}V_2 = 4.$$

$$\boxed{\begin{aligned} V_1 &= 150V \\ V_2 &= 50V. \end{aligned}}$$

(9). Calculate I_1, I_2 and I_3 in the following circuit using KVL (Mesh Analysis) and KCL (Nodal Analysis).



Sol:- i) KVL:



Apply KVL in loop 1,

$$-180 + 150(I_1 - I_2) = 0.$$

$$\Rightarrow 150I_1 - 150I_2 = 180 \quad -(1).$$

Apply KVL in loop 2,

$$50I_2 + 50(I_2 - I_3) + 150(I_2 - I_1) = 0.$$

$$\Rightarrow -150I_1 + 250I_2 - 50I_3 = 0 \quad -(2)$$

Apply KVL in loop 3,

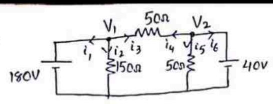
$$50(I_3 - I_2) + 40 = 0.$$

$$\Rightarrow 50I_2 - 50I_3 = 40 \quad -(3)$$

Solving (1), (2), (3)

$$I_1 = 4A \qquad I_2 = 2.8A \qquad I_3 = 2A$$

ii) KCL,



$V_1 = 180V$, $V_2 = 40V$.

Apply KCL at node V_1,

$$i_1 + i_2 + i_3 = 0.$$

$$\Rightarrow i_1 + \frac{V_1}{150} + \frac{V_1 - V_2}{50} = 0.$$

$$\Rightarrow i_1 = -\frac{V_1}{150} - \left(\frac{V_1 - V_2}{50}\right) = \frac{-180}{150} - \frac{140}{50} = -4A$$

$$\therefore I_1 = -i_1 = 4A$$

Apply KCL at node V_2,

$$i_4 + i_5 + i_6 = 0.$$

$$\frac{V_2 - V_1}{50} + \frac{V_2}{50} + i_6 = 0.$$

$$\Rightarrow i_6 = \frac{V_1 - V_2}{50} - \frac{V_2}{50} = \frac{180 - 40}{50} - \frac{40}{50} = 2A$$

$$I_3 = i_6 = 2A.$$

$$I_2 = \frac{V_1 - V_2}{50} = \frac{180 - 40}{50} = \frac{140}{50} = 2.8A$$

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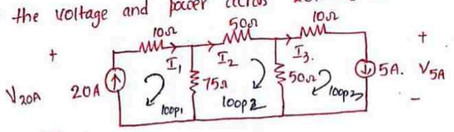
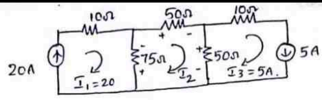
(10). Calculate I_1, I_2, I_3 in the following network. After calculating, find the voltage and power across 20A and 5A current sources.



Sol:- i) KVL, By looking at the circuit, we can easily say.

$$I_1 = 20A \qquad I_3 = 5A.$$



At loop2, By KVL,

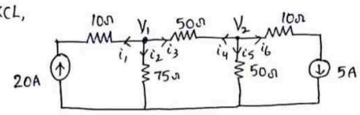
$$50I_2 + 75(I_2 - I_1) + 50(I_2 - I_3) = 0.$$

$$\Rightarrow 175I_2 = 75I_1 + 50I_3.$$
$$= 75(20) + 50(5).$$

$$\Rightarrow I_2 = \frac{1500+250}{175} = \underline{10A}$$

$\therefore$ $\boxed{I_1 = 20A}$ $\boxed{I_2 = 10A}$ $\boxed{I_3 = 5A}$

ii) By KCL,



$i_1 = -20A$; $i_6 = 5A$.

Apply KCL at Node V_1,

$$i_1 + i_2 + i_3 = 0.$$

$$\Rightarrow -20 + \frac{V_1}{75} + \frac{V_1 - V_2}{50} = 0.$$

$$\Rightarrow V_1\left[\frac{1}{75} + \frac{1}{50}\right] - \frac{V_2}{50} = 20 \quad -①$$

Apply Kcl at Node V_2,

$$i_4 + i_5 + i_6 = 0.$$

$$\frac{V_2 - V_1}{50} + \frac{V_2}{50} + 5 = 0.$$

$$\Rightarrow -\frac{V_1}{50} + V_2\left[\frac{1}{50} + \frac{1}{50}\right] = -5 \quad -②.$$

Solving ① & ②.

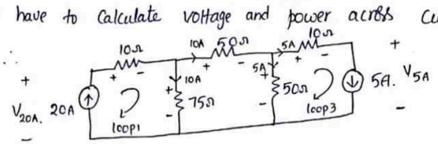
$V_1 = \underline{750V}$ $V_2 = \underline{250V}$

$$I_2 = \frac{V_1 - V_2}{50} = \frac{750 - 250V}{50} = \underline{10A}$$

$$I_1 = -i_1 = 20A.$$

$$I_3 = i_6 = \underline{5A}$$

we have to Calculate voltage and power across Current Sources.



$\rightarrow$ In loop 1, Apply KVL,

$$-V_{20A} + 10(20) + 75(10) = 0.$$

$$\Rightarrow V_{20A} = 950V.$$

i.e voltage across current source 20A $= 950V$.

$\therefore$ power Delivered by 20A Current Source $= P_{20} = V_{20A} \cdot I_{20A}$.
$= 950(20) = \underline{19\,KWatt}$

$\rightarrow$ In loop 3, Apply KVL,

$$+V_{5A} - 50(5) + 5(10) = 0.$$

$$\Rightarrow V_{5A} = 250 - 50 = 200V.$$

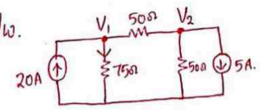
$\therefore$ power absorbed by 5A current Source $= P_5 = V_{5A}(I_{5A}) = 200(5)$
$= \underline{1KW}$

Note:-

Power Delivering Element

Power absorbing element.

Q. H/W.



Calculate V_1, and V_2 and current across 75Ω Resistor.

Ans: $V_1 = \underline{750V}$

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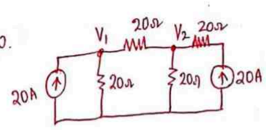
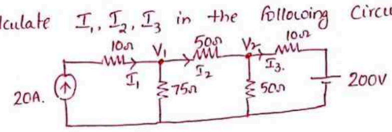
Q H/W.



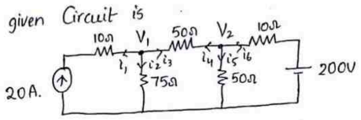
Calculate V_1 and V_2.

Hint: Apply Above procedure. you will get Answer.

Q. Calculate I_1, I_2, I_3 in the following Circuit. (use KCL).



Sol:- The given Circuit is



$i_1 = -20A$.

$\Rightarrow I_1 = -i_1 = 20A$.

Apply KCL at Node V_1,

$i_1 + i_2 + i_3 = 0$.

$\Rightarrow -20 + \frac{V_1}{75} + \frac{V_1 - V_2}{50} = 0$.

$\Rightarrow V_1\left[\frac{1}{75}+\frac{1}{50}\right] - \frac{V_2}{50} = 20$ — (1)

Apply KCL at Node V_2,

$i_4 + i_5 + i_6 = 0$.

$\frac{V_2 - V_1}{50} + \frac{V_2}{50} + \frac{V_2 - 200}{10} = 0$.

$\Rightarrow -\frac{V_1}{50} + V_2\left[\frac{1}{50}+\frac{1}{50}+\frac{1}{10}\right] = 20$. — (2)

Solving (1) and (2). $V_1 = 750V$.
$V_2 = 250V$.

$\therefore I_2 = \frac{V_1 - V_2}{50} = \frac{750-250}{50} = 10A$

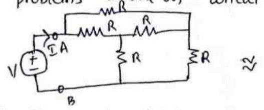
$I_3 = \frac{V_2 - 200}{10} = \frac{50}{10} = 10A$.

$I_1 = -i_1 = 20A$

→ This Completes KVL and KCL Topic. (Exam point of view only)

→ practice problems Based on wheat stone Bridge + KVL + KCL Type.

Eg:-



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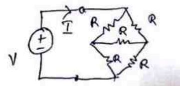
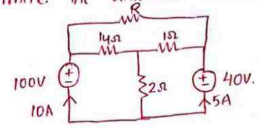


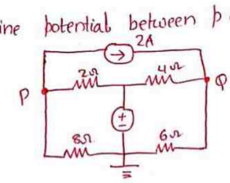
Calculate I

Q. Determine The unknown Resistance. 'R' (KVL & KCL). H/W.



Ans: $R = 12\Omega$

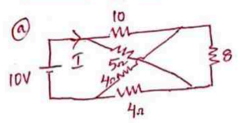
Q. Determine potential between p and Q. in following Circuit.



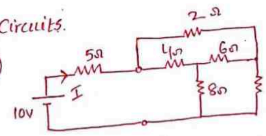
Ans: $V_{PQ} = -6V$.

Q. Calculate I for the following Circuits.

(a)



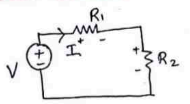
(b)



Hint: Above two are of Bridge Circuits

→ VOLTAGE DIVISION ;-

Eg:



Apply KVL,

$-V + IR_1 + IR_2 = 0$.

$\Rightarrow V = IR_1 + IR_2$

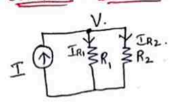
$\Rightarrow I = \frac{V}{R_1+R_2}$

$V_{R_1} = IR_1 = \frac{I.R_1}{R_1+R_2}$

$V_{R_2} = I.R_2/R_1+R_2$

→ CURRENT DIVISION

Eg:



By KCL, $I = I_{R_1} + I_{R_2}$.

$\Rightarrow I = \frac{V}{R_1} + \frac{V}{R_2}$.

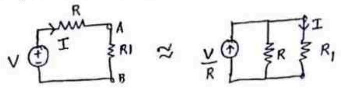
$\Rightarrow V = \frac{I}{\frac{1}{R_1}+\frac{1}{R_2}}$

$\therefore I_{R_1} = \frac{V}{R_1} = \frac{I}{\left(\frac{1}{R_1}+\frac{1}{R_2}\right)R_1} = \frac{I.\cancel{R_1}R_2}{(R_1+R_2).\cancel{R_1}} = \frac{I.R_2}{R_1+R_2}$

Illy $I_{R_2} = I.R_1/R_1+R_2$

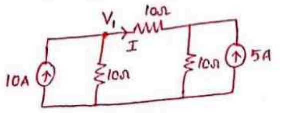
→ SOURCE TRANSFORMATION :-

→ we can Represent Voltage Source in Series with Resistance as Current source with parallel Resistance. Vice-versa.

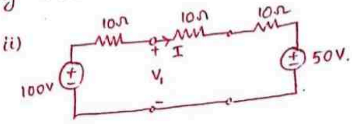


Q. Calculate V_1 and I in the following Circuits.

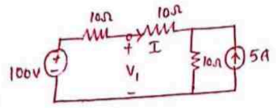
i)



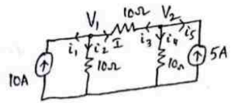
ii)



iii)



Sol:- i) By KCL,



At V_1, $i_1 + i_2 + I = 0$.

$\Rightarrow -10 + \frac{V_1}{10} + \frac{V_1 - V_2}{10} = 0$.

$\Rightarrow 2V_1 - V_2 = 100$ — ①.

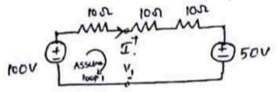
At V_2, $i_3 + i_4 + i_5 = 0$.

$\Rightarrow \frac{V_2 - V_1}{10} + \frac{V_2}{10} - 5 = 0$. $\Rightarrow V_1 - 2V_2 = -50$ — ②.

∴ solving ① & ②. $V_1 = \frac{250}{3}V$. $V_2 = \frac{200}{3}V$. $\boxed{V_1 = \frac{250}{3}V,\ I = 1.67A}$

∴ $I = \frac{V_1 - V_2}{10} = \frac{250 - 200}{3(10)} = 1.67A$

ii) By KVL,



$-100 + 30(I) + 50 = 0$.

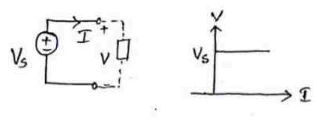
$\Rightarrow \boxed{I = \frac{50}{30} = 1.67A.}$

$-100 + 10(1.67) + V_1 = 0$. $\Rightarrow \boxed{V_1 = \frac{100 - 16.7}{\cancel{\ }} = \frac{250}{3}V.}$

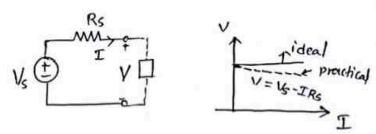
$\Rightarrow V_1 = 83.3V \approx \frac{250}{3}V$.

iii) H/w. $V_1 = \frac{250}{3}V$, $I = 1.67A$ (check it)

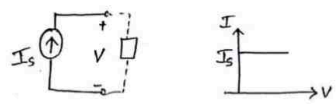
→ IDEAL VOLTAGE SOURCE



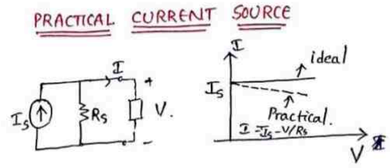
PRACTICAL VOLTAGE SOURCE.



→ IDEAL CURRENT SOURCE



PRACTICAL CURRENT SOURCE



→ DEPENDENT SOURCES :-

→ VCVC
→ VCCS
→ CCVS
→ CCCS

} Not in Syllabus. Basics is Sufficient
Problems Not Required. - GOVIND.