SETSQUARE ACADEMY

Degree Engineering
(Mumbai University)

F.E. Semester - I

Previous Year Paper Solutions

(December 2007 - May 2016)

Basic Electrical Engineering

Common for all Branches

Chapter 1: D.C. CIRCUITS

Theory Questions

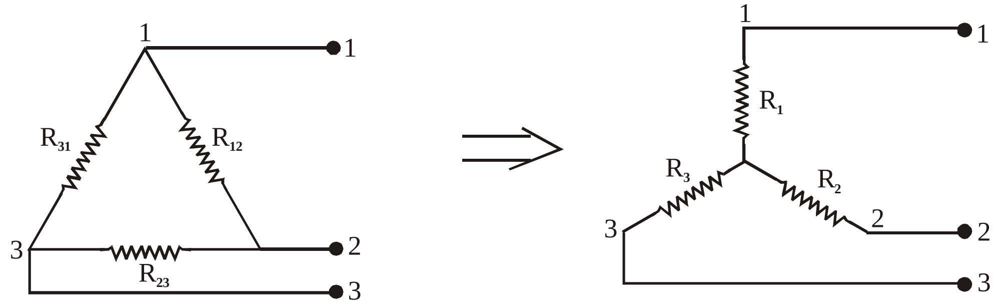
(1) Derive the expression for star -delta and vice-versa conversion of three resistances. **[M-11][6]**

Solution:-

With the help of $\curlywedge \rightarrow \Delta$ and $\Delta \rightarrow \curlywedge$ conversions, we can simplify the given resistive network into series-parallel combination and hence can find a single equivalent resistance.

Case I: $\Delta \rightarrow \curlywedge$ conversions:

Consider the 3 resistors R_{12}, R_{23} and R_{31} connected in Δ as shown in Fig. (a). It is required to replace them by 3 resistors R_1, R_2 and R_3 connected in $\curlywedge$ as shown in Fig. (b).



(a) (b)

(I) From fig. (a), resistance between terminals 1 and 2 $= R_{12} \| (R_{23} + R_{31})$

$$= \frac{R_{12}(R_{23}+R_{31})}{R_{12}+R_{23}+R_{31}} \quad \text{....(1)}$$

(II) From fig. (b), resistance between terminals 1 and 2 $= R_1 + R_2$ ....(2)

(III) $\because$ two networks are electrically equal $\therefore$ (1) = (2)

$$\therefore \quad R_1 + R_2 = \frac{R_{12}(R_{23}+R_{31})}{R_{12}+R_{23}+R_{31}} \quad \text{.....(3)}$$

Similarly, $$R_2 + R_3 = \frac{R_{23}(R_{31}+R_{12})}{R_{12}+R_{23}+R_{31}} \quad \text{.....(4)}$$

and $$R_3 + R_1 = \frac{R_{31}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} \quad \text{.....(5)}$$

(IV) (3) – (4) + (5) $\therefore$ we get

$$R_1 = \frac{R_{12}\times R_{31}}{R_{12}+R_{23}+R_{31}} \quad \text{.....(6)}$$

Similarly, $$R_2 = \frac{R_{23}\times R_{12}}{R_{12}+R_{23}+R_{31}} \quad \text{.....(7)}$$

and $$R_3 = \frac{R_{31}\times R_{23}}{R_{12}+R_{23}+R_{31}} \quad \text{.....(8)}$$

These are the required expressions for $\Delta \rightarrow \curlywedge$ conversions.

Case II: $\curlywedge \rightarrow \Delta$ conversions:

(V) (6) ÷ (7) $\therefore \dfrac{R_1}{R_2} = \dfrac{R_{31}}{R_{23}}$ $\therefore R_{31} = \dfrac{R_1 R_{23}}{R_2}$

(VI) (6) ÷ (8) $\therefore \dfrac{R_1}{R_3} = \dfrac{R_{12}}{R_{23}}$ $\therefore R_{12} = \dfrac{R_1 R_{23}}{R_3}$

(VII) Substituting values of R_{31} and R_{12} in equation (6), we get,

$$R_1 = \frac{\left(\dfrac{R_1 R_{23}}{R_3}\right)\left(\dfrac{R_1 R_{23}}{R_2}\right)}{\left(\dfrac{R_1 R_{23}}{R_3}\right) + R_{23} + \left(\dfrac{R_1 R_{23}}{R_2}\right)}$$

$\therefore$ After re-arranging and simplifying we get:

$$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1}$$ similarly,

$$R_{31} = R_3 + R_1 + \frac{R_3 R_1}{R_2}$$ and

$$R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3}$$

These are the required expressions for the $\curlywedge \rightarrow \Delta$ conversion.

(2) Write short note on : Superposition theorem. **[D-09][5]**

Solution:-

It can be stated as 'In a linear network containing more than one active source (i.e. the constant emf and the constant current source), the resultant current in any branch is the algebric sum of the currents that would be produced by each source acting alone, all the other sources being replaced by their respective internal resistances'.

The constant emf sources are replaced by their internal resistances if given or simply with zero resistances i.e. short circuiut if their internal resistances are not given.

The constant current sources are replaced by infinite resistances i.e. open circuits.

A linear network is one whose parameters are constant i.e. they do not change with current and voltage. In other words, it obeys the Ohm's law i.e. the relation between voltage & current is linear.

Advantages:

(i) Current through a particular branch can be found easily.

(ii) Can be used for circuits with constant voltage as well constant current sources.

Disadvantages:

(i) If currents through all branches are required then this method is lengthy.

(ii) The circuit must contain more than 1 source.

(iii) It can be applied only to linear circuit which contain R, L and C. But it cannot be applied to non-linear circuit which contain electronic components.

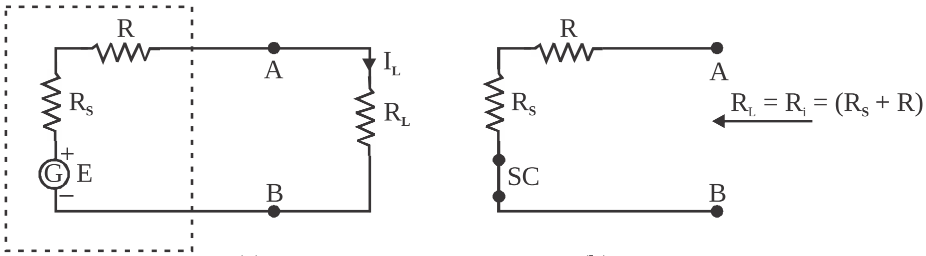
(3) Derive the condition for maximum power transfer through the network.

[D-15][3],[M-13][3],[M-14][3],[D-12][3],[D-08][5]

Solution:-

Maximum Power Transfer Theorem:-

'A resistive load will abstrsact maximum power from a network when the load resistance is equal to the resistance of the network as viewed from the output terminals, with all energy sources removed leaving behind their internal resistances'.



(a) (b)

In Fig. (a), a load resistance R_L is connected across the terminals A and B of a network which consists of a generator G of emf E and internal resistances R_S and R. Represents the resistance of the connecting wires. Let $R_i = R_S + R$ = internal resistance of the network as viewed from A and B, as shown in Fig. (b). According to this theorem, R_L will abstract maximum power from the network when

$$R_L = R_i$$

Proof:

(I) Load current $I_L = \dfrac{E}{R_L + R_i}$.

(II) $\therefore$ Power drawn by the load $P_L = I_L^2 R_L = \dfrac{E^2 R_L}{(R_L + R_i)^2}$ .....(i)

(III) For a given source or circuit, E and R_i are constant, $\therefore$ the power drawn by the load P_L depends upon R_L only.

Thus, for P_L to be maximum, $\dfrac{dP_L}{dR_L} = 0$

$\therefore$ Differentiating equation (i) above and equating to zero, we get

$$\frac{dP_L}{dR_L} = E^2 \frac{(R_L + R_i)^2 \times 1 - R_L[2 \times (R_L + R_i)]}{(R_L + R_i)^4} = 0$$

$E^2 \neq 0$, also the denominator $(R_L + R_i)^4 \neq 0$

$\therefore$ the numerator, $(R_L + R_i)^2 - 2R_L(R_L + R_i) = 0$ or $(R_L + R_i)[(R_L + R_i) - 2R_L] = 0$

$\therefore$ $(R_L + R_i) - 2R_L = 0$ or $(R_i - R_L) = 0$

$\therefore$ $R_L = R_i$ and hence the proof.

(4) State and explain Norton's theorem. **[D-13][3]**

Solution:-

The Norton's theorem as applied to d.c. circuits can be stated as follows:

'Any network having terminals A and B can be replaced by a single source of current I_N in parallel with a single resistance R_N.

(i) The current I_N is the current that would flow through AB when A and B are short circuited (with the proper direction).

(ii) The resistance R_N is the resistance of the network measured between A and B with load, if any, removed and constant voltage sources being replaced by their internal resistances (or simply by zero resistance i.e. short circuit if internal resistances are not given) and constant current sources replaced by ∞ resistance i.e. open circuit.

Thus, according to this theorem, any two terminal network, however complex, can be replaced by a single source of current I_N (with proper direction) called Norton's current source in parallel with a single resistance R_N called Norton's reisitance.

Advantages:

(i) It reduces a complex circuit into a simple circuit of a single current source in parallel with a single resistance.

(ii) Current through a particular branch can be found easily.

(iii) Can be used for circuits having one or more constant voltage as well as constant current sources.

(iv) This theorem is best suited for finding currents through a variable load resistance which takes up several finite values e.g. R_{L_1}, R_{L_2} ....

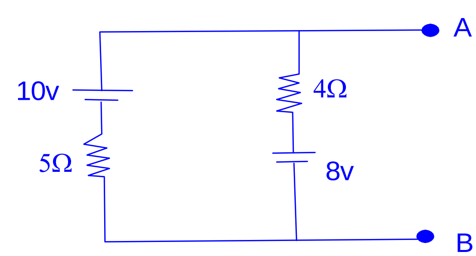
Disadvantage:

If currents through all branches are required then this method is lengthy.

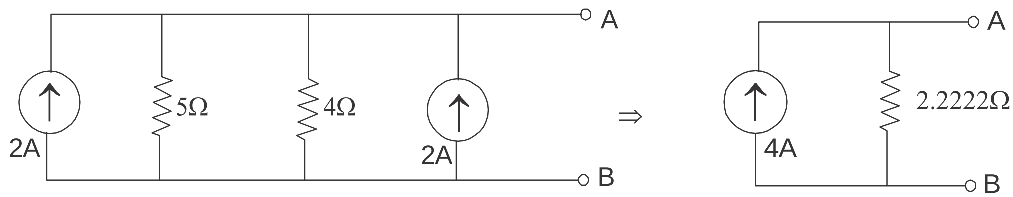
Numerical Problems

Type I : Series & Parallel

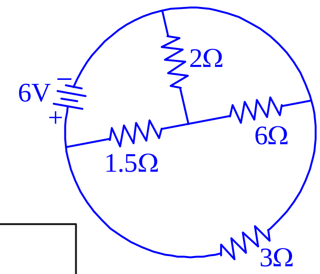
(1) Convert the given circuit into a single current source in parallel with a single resistance between points A and B. **[D-14][3]**



Solution:-

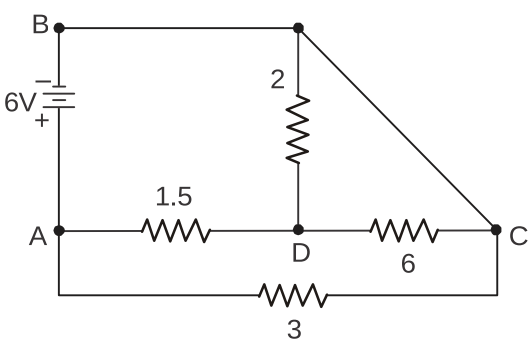


(2) What is the total current supplied by the battery to the circuit shown? **[D-10][5]**

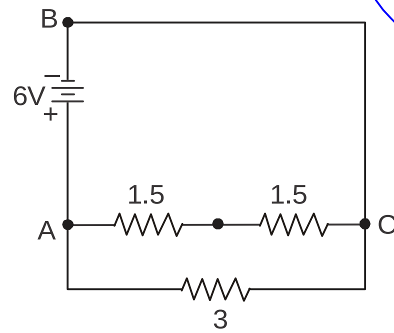


Solution:

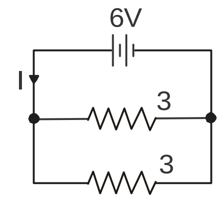
Redraw and simplify the circuit as follows:



(a)



(b)

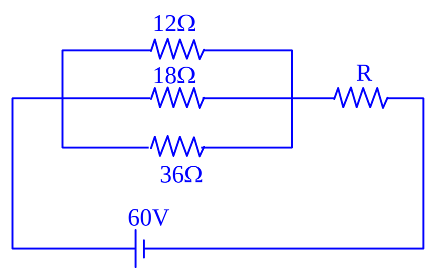


(c)

From Fig. (c), the total resistance is $R_T = 3 \parallel 3 = 1.5\ \Omega$

$\therefore$ Total current supplied by the battery is, $I = \dfrac{6V}{1.5} = 4A$

(3) Find the value of Resistance 'R' when power consumed by the 12Ω resistor in the given circuit is 36 W. **[D-09][5]**



Solution:

As resistor $R_1 = 12\Omega$, $R_2 = 18\Omega$, $R_3 = 36\Omega$ are in parallel so voltage across each resistor is same i.e. 60 V

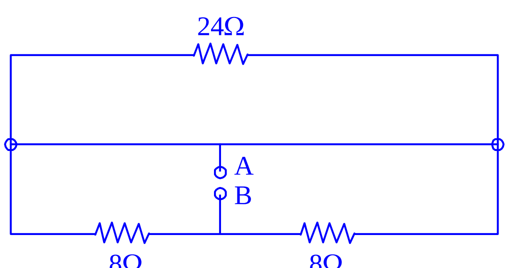
$$I_1 = \frac{V}{R_1} = \frac{60}{12} = 5A, \quad I_2 = \frac{V}{R_2} = \frac{60}{18} = 3.33A, \quad I_3 = \frac{V}{R_3} = \frac{60}{36} = 1.667A$$

As $I = I_1 + I_2 + I_3 = 5 + 3.33 + 1.667 = 9.996\ A$

$$\therefore \text{ The Value of } \quad R = \frac{V}{I} = \frac{60}{9.996} = 6.002 \approx 6\Omega.$$

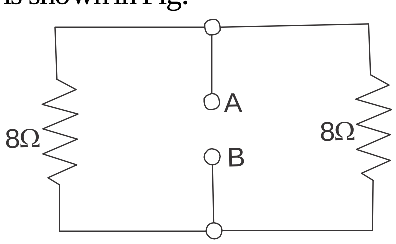
$\therefore$ Hence the value of resistance R is 6 Ω.

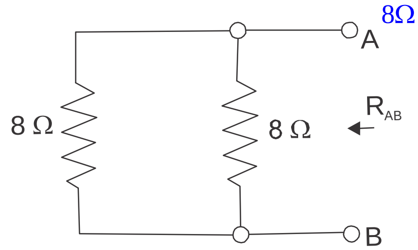
(4) Find R_{AB}. **[M-08][3]**



Solution:

The 24 Ω resistance has been short circuited.
So it will not appear in the circuit. The simplified circuit is shown in Fig.

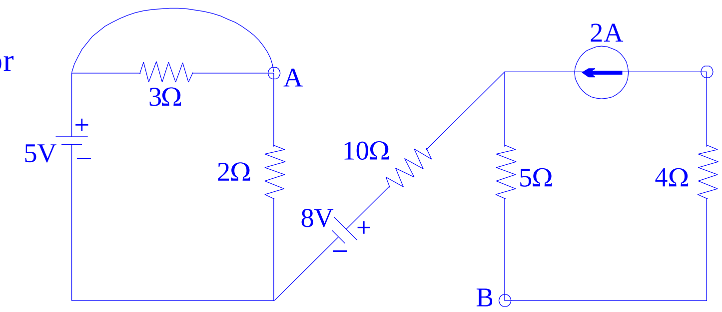




$$\therefore \quad R_{AB} = 8 \| 8 = 4\Omega$$

Type II : KCL KVL

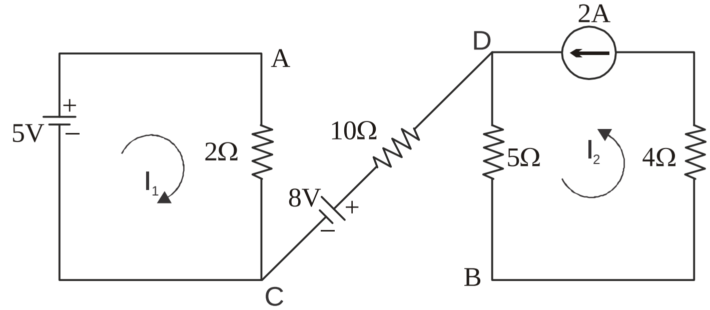
(1) Determine the potential difference V_{AB} for the given network. **[M-14][6]**



Solution:-

$3\,\Omega$ is connected in parallel with a short circuited branch. Hence, $3\,\Omega$ will be redundanted.

$\therefore$



$I_1 = \dfrac{5}{2} = 2.5\,A$ and $I_2 = 2\,A$

Apply KVL to path ABCD,

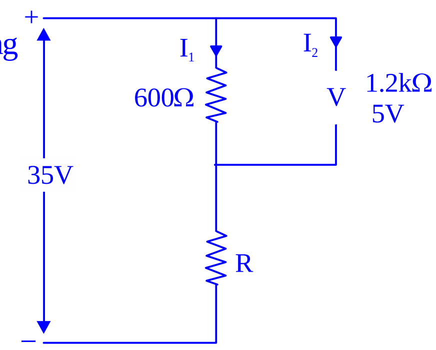
$\therefore V_A - 2I_1 + 8 - 10(0) - 5I_2 - V_B = 0$

$\therefore V_A - V_B = 2I_1 - 8 + 5I_2$

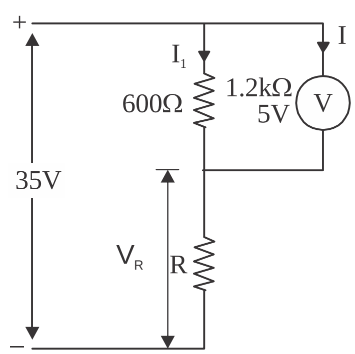
$V_{AB} = 2(2.5) - 8 + (5\,x\,2) = 5 - 8 + 10$

$V_{AB} = 7\,\text{Volt}$

(2) Determine the value of Resistance R as shown in figure using KVL and KCL. **[D-12][6]**



Solution:-



In parallel branch, voltages are same.
Hence voltage across parallel branch = 5V

$\therefore\; V_R + 5 = 35 \;\Rightarrow\; V_R = 30V$

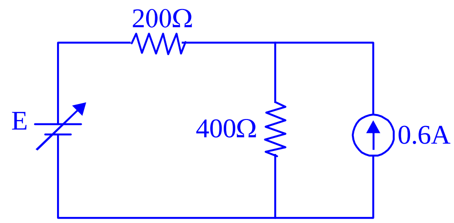
Total resistance in parallel branch = $(600\,\Omega) \| (1.2K\Omega) = 0.4K\Omega$

By using voltage division

$\therefore\; V_R = \dfrac{R}{R+0.4} x35 \;\Rightarrow\; 30 = \dfrac{R}{R+0.4} x35$

$\therefore\; R = 2.4K\Omega$

(3) To what voltage should adjustable source E be set in order to produce a current of 0.3A in 400 ohms resistor. **[M-12][5]**



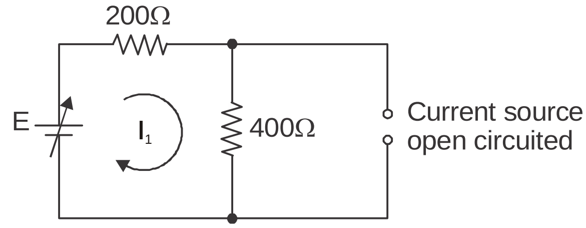
Solution:

Given: $I = 0.3A$

Step 1: Find I_1 due to only voltage source E:

From Fig. (a),

$$I_1 = \frac{E}{200+400} = \frac{E}{600} \text{ Amp.}$$

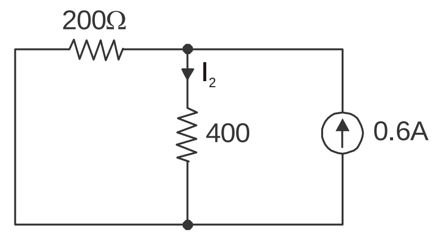


(a)

Step 2: Find I_2 due to only the current source:

From Fig. (b)

$$I_2 = \frac{200}{200+600} \times 0.6 = 0.2 \text{ Amp.}$$



(b)

Step 3: Find E:

By superposition theorem we get,

$$I = I_1 + I_2$$

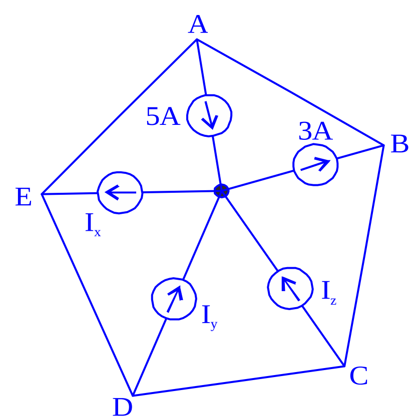
$$\therefore\ 0.3 = \frac{E}{600} + 0.2 \Rightarrow E = 0.1 \times 600 = 60V$$

(4) Find: (i) I_x if $I_y = 2A$ and $I_z = 0$ A

(ii) I_y if $I_x = 2A$ and $I_z = 2I_y$

(iii) I_z if $I_x = I_y = I_z$

[M-10][4]



Solution:

(i) I_x if $I_y = 2A$ and $I_z = 0$ A

By applying the KCL

$$5A + I_z + I_y = I_x + 3A$$

$$\therefore\ 5A + 2A = I_x + 3A$$

$$\therefore\ I_x = 4A$$

(ii) I_y if $I_x = 2A$ and $I_z = 2I_y$

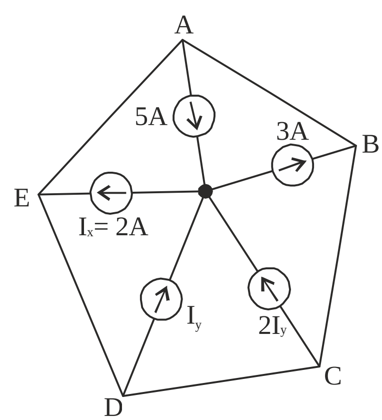
Now by KCL

$$5A + I_y = I_z = I_x + 3A \qquad (\because\ I_z = 2I_y)$$

$$5A + 3I_y = 2A + 3A$$

$$5A + 3I_y = 5A$$

$$\therefore\ I_y = 0$$



(iii) I_z if $I_x = I_y = I_z$

Now By KCL

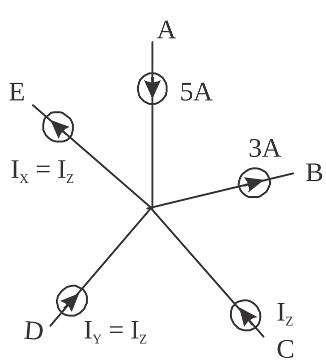
$$5A + I_y + I_z = I_z + 3A$$

$$5A + I_z + I_z = I_z + 3A$$

$$5A + 2I_z = I_z + 3A$$

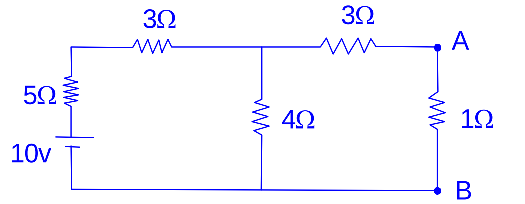
$$2I_z - I_z = 3A - 5A$$

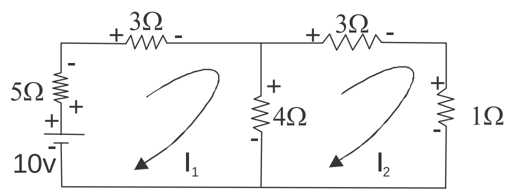
$$\therefore\ I_z = -2A$$



Type III : Mesh Analysis

. (1) Find the current through 1Ω resistance using Mesh Analysis. **[M-15][6]**





Solution:-

Apply KVL to loop (1)

$$10-5I_1-3I_1-4I_1+4I_2=0$$

$$\therefore\ -12I_1+4I_2=-10 \qquad ....(1)$$

Apply KVL to loop (2)

$$-3I_2-I_2-4I_2+4I_1=0$$

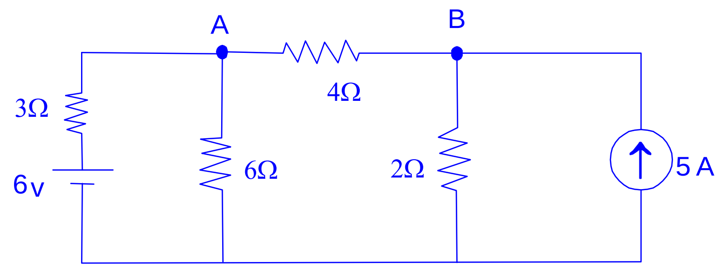
$$\therefore\ -4I_1-8I_2=0 \qquad ....(2)$$

$$I_1=1A, \qquad I_2=0.5A$$

Current through I_W resistances is $\therefore\ I_2=0.5\ A\downarrow$

Type IV : Nodal Analysis

(1) Find the current through 4 Ω. resistance using Nodal analysis. **[D-14][6]**



Solution:-

KCL at (A)

$$\frac{6-V_A}{3}=\frac{V_A}{6}+\frac{V_A-V_B}{4}$$

$$0.75V_A-0.25\,V_B=2 \qquad ......(1)$$

KCL at (B)

$$\frac{V_A-V_B}{4}+5=\frac{V_B}{2}$$

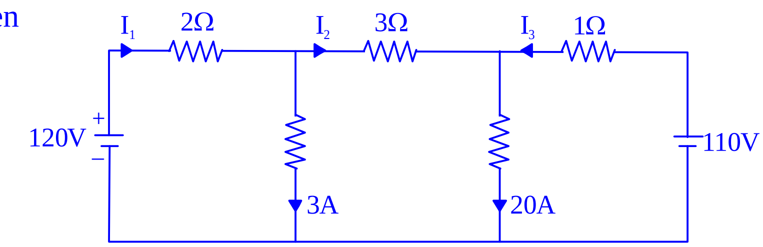
$$-0.25\,V_A+0.75\,V_B=5 \qquad ......(2)$$

Solving (1) and (2)

$$V_A=5.5\,V \qquad V_B=8.5\,V\ =0.75\,A(\leftarrow)$$

$$\therefore\ I_{4\Omega}=\frac{V_A-V_B}{4}=-0.75\,A$$

(2) Find the currents I_1, I_2, I_3 in the given circuit by node voltage method. **[D-13][6]**



Solution:-

Apply KCL at node A.

$$I_1=I_2+3$$

$$\therefore\ \frac{120-V_A}{2}=\frac{V_A-V_B}{3}+3$$

$\therefore 360-3V_A = 2V_A - 2V_B + 18$

$\therefore 5V_A - 2V_B = 342$ ....(i)

Apply KCL at note B,

$$I_2 + I_3 = 20$$

$$\therefore \frac{V_A - V_B}{3} + \frac{110 - V_B}{1} = 20$$

$\therefore V_A - V_B + 330 - 3V_B = 60$

$\therefore V_A - 4V_B = -270$ ....(ii)

Solving equations (i) & (ii) simultaneously,

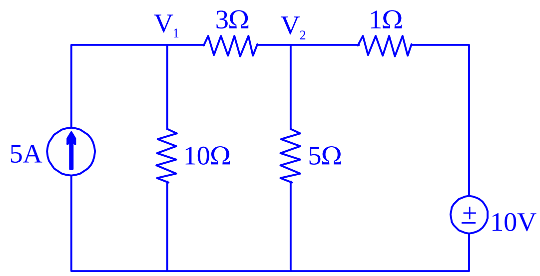
$$V_A = 106\,V \text{ and } V_B = 94\,V$$

Now, $$I_1 = \frac{120 - V_A}{2} = \frac{120-106}{2} = \frac{14}{2} = 7\,\text{Amp}$$

$$I_2 = \frac{V_A - V_B}{3} = \frac{106-94}{3} = \frac{12}{3} = 4\,\text{Amp}$$

$$I_3 = \frac{110 - V_B}{1} = \frac{110-79}{1} = 31\,\text{Amp.}$$

(3) For the network given below find the current through the 3Ω resistor using nodal analysis. **[M-13][6]**



Solution:

Apply KCL at node V_1

$$\therefore 5 = \frac{V_1}{10} + \frac{V_1 - V_2}{3}$$

$\therefore 150 = 3V_1 + 10V_1 - 10V_2$

$\therefore 13V_1 - 10V_2 = 150$ ....(1)

Apply KCL at node V_2

$$\frac{V_2 - V_1}{3} + \frac{V_2}{5} + \frac{V_2 - 10}{1} = 0$$

$\therefore 5V_2 - 5V_1 + 3V_2 + 15V_2 - 150 = 0$

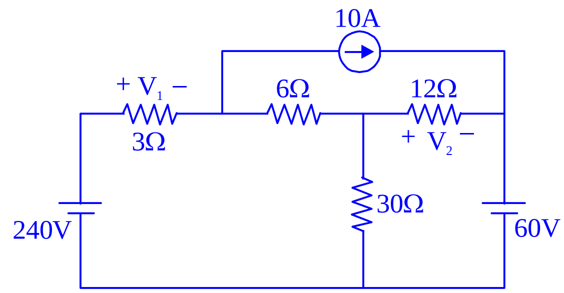
$\therefore -5V_1 + 23V_2 = 150$ ....(2)

$V_1 = 19.88\,V$ and $V_2 = 10.84V$

$$I_{3\Omega} = \frac{V_1 - V_2}{3} = 3.01\,\text{Amp.}(\rightarrow)$$

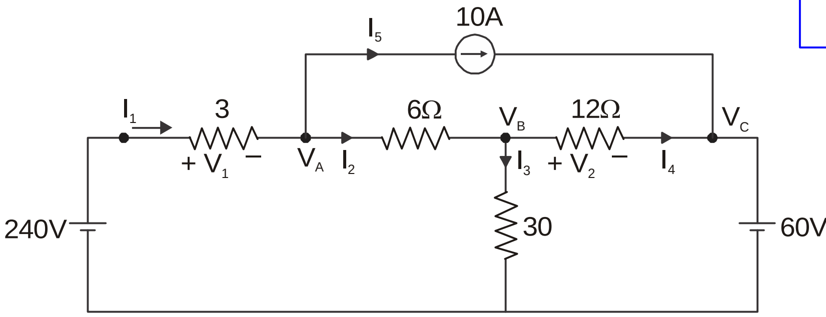
(4) Use Nodal Analysis to determine (i) V_1 and V_2
(ii) Power absorbed across 6 ohms resistor.

[M-12][6]



Solution:

Step 1: Assign the node voltages and branch currents:



Step 2: Write the nodal equations:

Node A: $I_1 = I_2 + I_5$ (But $I_5 = 10A$)

$$\therefore \frac{240 - V_A}{3} = \frac{V_A - V_B}{6} + 10$$

$\therefore\ 6(240 - V_A) = 3(V_A - V_B) + (3 \times 6 \times 10)$

$\therefore\ 1440 - 6V_A = 3V_A - 3V_B + 180$

$\therefore\ 9V_A - 3V_B = 1260$

$\therefore\ 3V_A - V_B = 420$ ...(1)

Node B: $I_2 = I_3 + I_4$

$$\therefore \frac{V_A - V_B}{6} = \frac{V_B}{30} + \frac{V_B - V_C}{12}$$

$$\therefore \frac{V_A - V_B}{6} = \frac{2V_B - 5(V_B - V_C)}{60}$$

$\therefore\ 60\ V_A - 60\ V_B = 12\ V_B + 30\ V_B - 30\ V_C$ (But $V_C = 60$ V)

$60\ V_A - 102\ V_B = -30 \times 60 = -1800$

$\therefore\ 60\ V_A - 102\ V_B = -1800$ ...(2)

Solving (1) and (2)

$V_A = 181.46$ Volts and $V_B = 124.4$ Volts

Step 3: Find V_1 and V_2 :

$\therefore\ V_1 = 240 - V_A = 240 - 181.46 = 58.54$ Volts

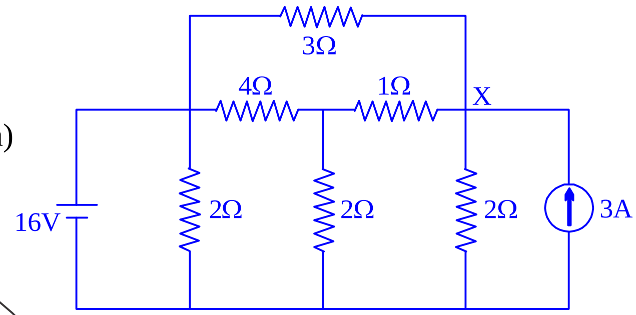
$V_2 = V_B - V_C = 124.4 - 60 = 64.4$ Volts

Step 4: Power absorbed by the 6Ω resistance:

$$P_{6\Omega} = \frac{(V_A - V_B)^2}{6} = \frac{(181.46 - 124.4)^2}{6}$$

$\therefore\ P_{6\Omega} = 30963$ Watt

(5) For the circuit below, using nodal analysis, find voltage at X. **[M-11][8]**



Solution:

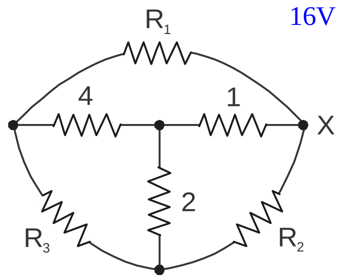
Step 1: Convert star to delta: as shown in fig (a)

$R = (4 \times 1) + (1 \times 2) + (2 \times 4) = 14\Omega$

$$\therefore \ R_1 = \frac{R}{2} = \frac{14}{2} = 7\Omega,$$

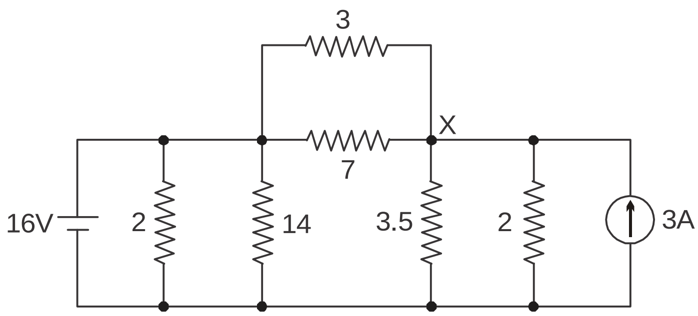
$$R_2 = \frac{R}{4} = \frac{14}{4} = 3.5\Omega$$

$$R_3 = \frac{R}{1} = 14\Omega$$



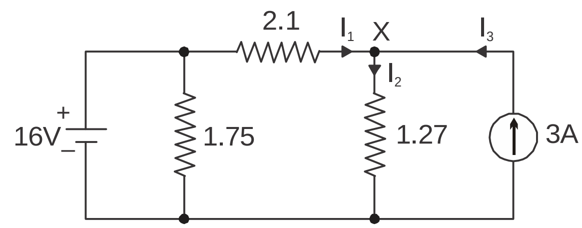
(a)

The given circuit is modified as shown in fig. (b)



(b)

⇒



(c)

Step 2: Find V_X

Apply KCL at node X in Fig. (c)

$I_1 + I_3 = I_2$

$$\therefore \ \frac{16 - V_X}{2.1} + 3 = \frac{V_X}{1.27} \ \Rightarrow \ \frac{(16 - V_X) + (3 \times 2.1)}{2.1} = \frac{V_X}{1.27}$$

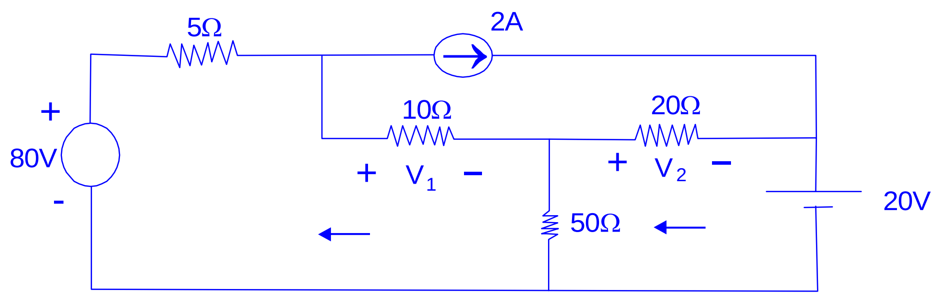
$\therefore \ 1.27(16 - V_X) + (1.27 \times 6.3) = 2.1\ V_X$

$\therefore \ 20.32 - 1.27\ V_X + 8 = 2.1\ V_X$

$\therefore \ 3.37\ V_X = 28.32$

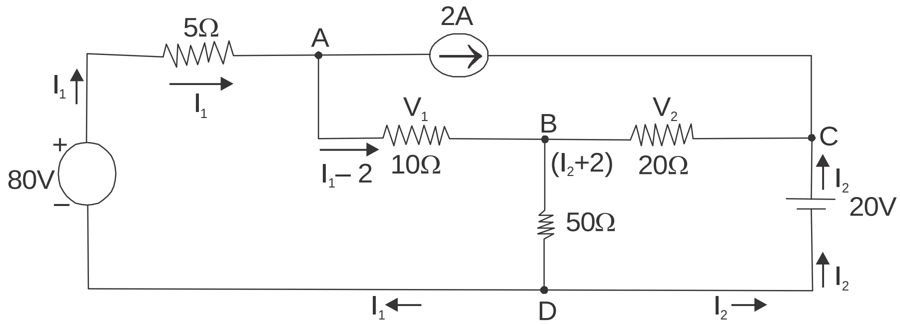
$\therefore \ V_X = 8.4$ Volts.

(6) By using Nodal analysis find V_1 and V_2 **[D-10][8]**



Solution:

Step 1: Mark currents in I_1 and I_2 form two voltage sources and mark currents in all branches applying KCL to node A, B, C and D.



Step 2: Apply voltage loop starting from 80V source through nodes A, B and D.

$$80 = 5I_1 + 10(I_1 - 2) + 50(I_1 + I_2) = 65\ I_1 + 50\ I_2 - 20$$

$$10 = 6.5\ I_1 + 5I_2 \qquad \text{...(1)}$$

Step 3: Apply voltage loop starting from 20 volts source through nodes C, B and D

$$20 = 20(I_2 + 2) + 50(I_1 + I_2) = 50\ I_1 + 70\ I_2 + 40$$

$\therefore$ $-20 = 50\ I_1 + 70\ I_2$

$$-2 = 5I_1 + 7I_2 \qquad \text{...(2)}$$

Solving (1) and (2)

$\therefore$ $I_1 = 3.9\text{A}$ and $I_2 = = -3.07\text{ A}$

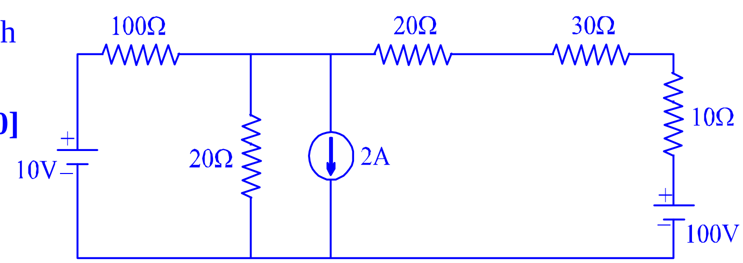
Step 4: Find V_1 and V_2

$$V_1 = 10(I_1 - 2) = 10\ (3.9 - 2) = 19\text{ V}$$

$$V_2 = -20(I_2 + 2) = -20\ (-3.07 + 2) = 21.4\text{ V}$$

(7) Using node analysis find the current through 100Ω resistor in the network shown:

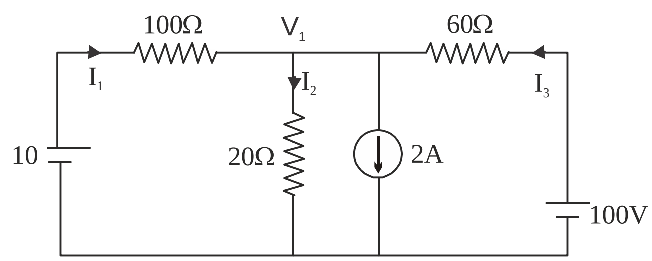
[D-09][10]



Solution:

Apply KCL at node V_1,

$\therefore$ $I_1 + I_3 = I_2 + 2$



$$\frac{10 - V_1}{100} + \frac{100 - V_1}{60} = \frac{V_1}{20} + 2$$

$$\frac{3(10 - V_1) + 5(100 - V_1)}{300} = \frac{V_1 + 40}{20}$$

$$30 - 3V_1 + 500 - 5V_1 = \frac{300}{20}(V_1 + 40)$$

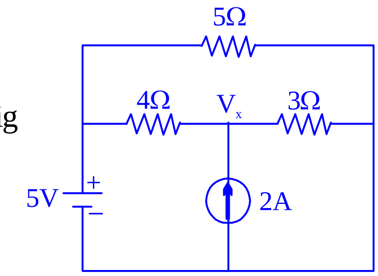
$\therefore$ $-8V_1 + 530 = 15V_1 + 600$

$\therefore$ $V_1 = -3.043\text{V}$

$$\therefore \quad I_1 = \frac{10 - V_1}{100} = \frac{10 + 3.043}{100} = 0.13\text{A}$$

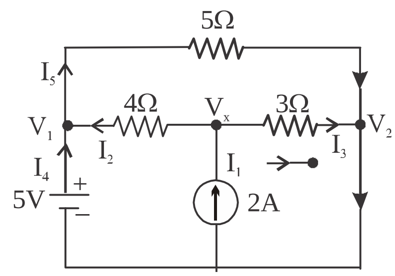
$\therefore$ $I_1 = 0.13\text{A}$

(8) Using nodal analysis, find V_x.**[M-09][4]**



Solution:

Current I_1, I_2, I_3, I_4, I_5, are marked as shown in fig



Node equation at node $\sqrt{x}$ is given by ,

$$I_1 = I_2 + I_3$$

$$2 = \frac{V_x - 5}{4} + \frac{V_x - V_2}{3}$$

$$24 = 3V_x - 15 + 4V_x - 4V_2$$

$$\therefore \quad 7V_x - 4V_2 = 39 \qquad ...(1)$$

Node equation at node $\sqrt{2}$ is given by,

$$I_3 + I_5 = 2$$

$$\frac{V_x - V_2}{3} + \frac{5 - V_2}{5} = 2$$

$$5V_x - 5V_2 + 15 - 3V_2 = 30$$

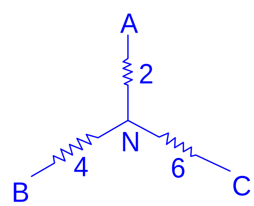
$$5V_x - 8V_2 = 15 \qquad ...(2)$$

Solving Equations (1) and (2) simultaneously,

$$\therefore V_x = 7 \text{ Volt}$$

Type V : Star Delta Transformation

(1) Convert the star circuit into its equivalent delta circuit.**[M-15][3]**



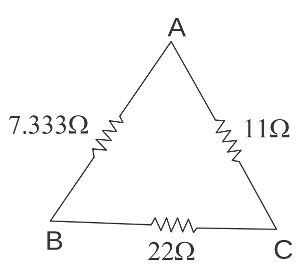
Solution:-

Star to delta conversion

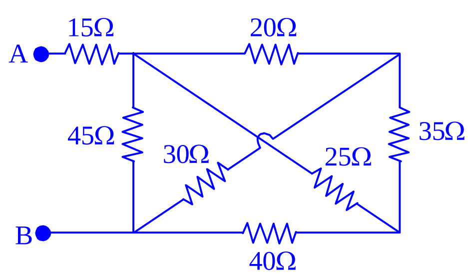
$$R_{AC} = 2 + 6 + \frac{2 \times 6}{4} = 11\Omega$$

$$R_{BC} = 4 + 6 + \frac{4 \times 6}{2} = 22\Omega$$

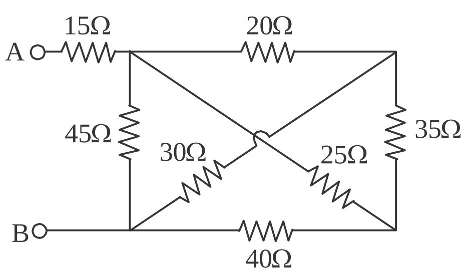
$$R_{AB} = 2 + 4 + \frac{2 \times 4}{6} = 7.333\Omega$$



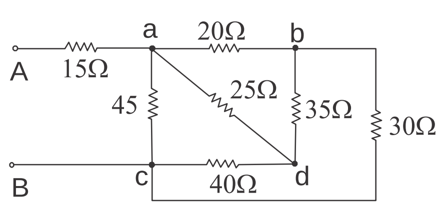
(2) Find a equivalent resistance between A and B **[M-14][7]**



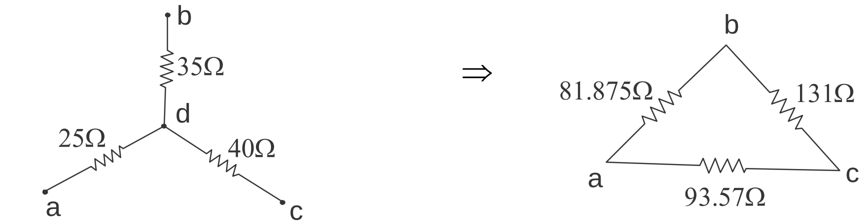
Solution:-

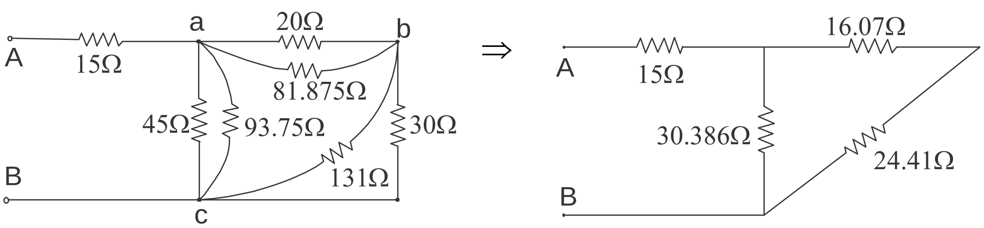


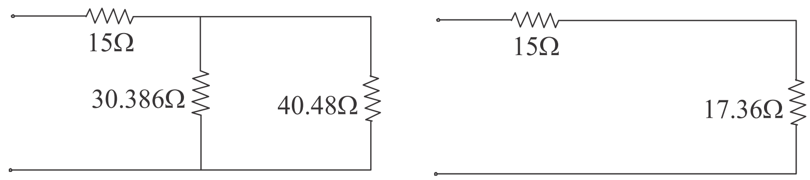
$\Rightarrow$



Star to Delta Transformation:

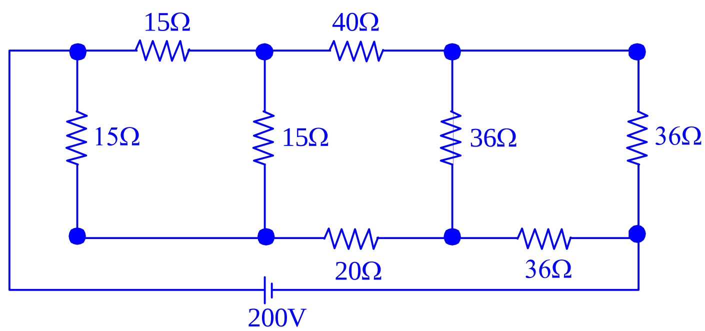






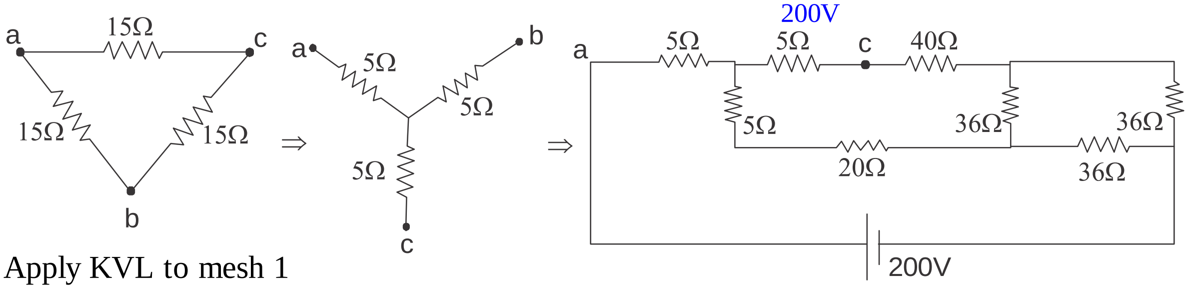
$\therefore\ R_{AB} = 15 + 17.36\ =\ 32.36\Omega$

(3) Determine current through 20Ω resistor in the following circuit. **[D-13][7]**



Solution:-

By Delta to star transformation



Apply KVL to mesh 1

$$-5I_1 - 25(I_1 - I_2) - 36(I_1 - I_3) + 200 = 0$$

$$\therefore\ 66I_1 - 25I_2 - 36I_3 = 200 \qquad ...(1)$$

Apply KVL to mesh 2

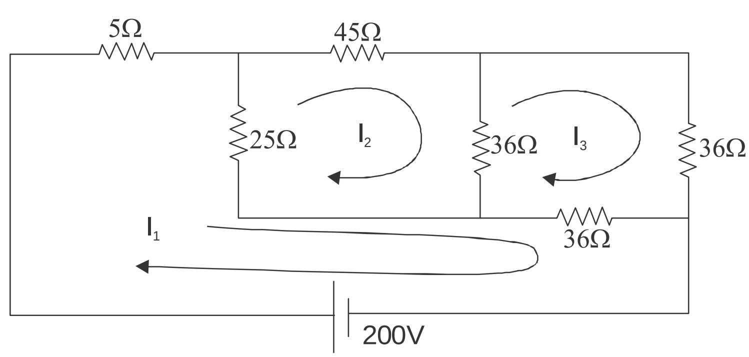
$$-25(I_2 - I_1) - 45(I_2) - 36(I_2 - I_3) = 0$$

$$\therefore\ -25I_1 + 106I_2 - 36I_3 = 0 \qquad ...(2)$$

Apply KVL to mesh 3

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

$$\therefore\ -36I_1 - 36I_2 + 108I_3 = 0 \qquad ...(3)$$



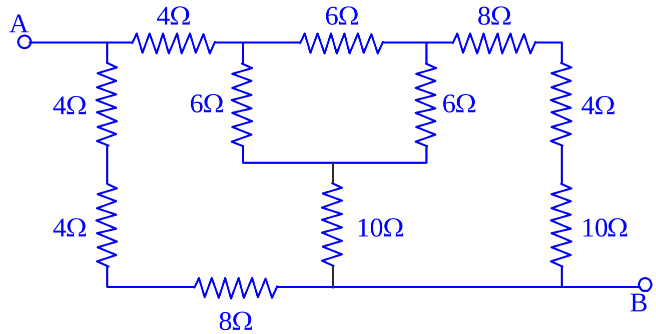
Solving (1), (2) and (3)

$I_1 = 5.07\ \text{Amp}$, $I_2 = 2\ \text{Amp}$ and $I_3 = 2.356\ \text{Amp}$

Current through $20\,\Omega$ resistor, $I_{20\Omega} = I_1 - I_2 = 5.07 - 2$

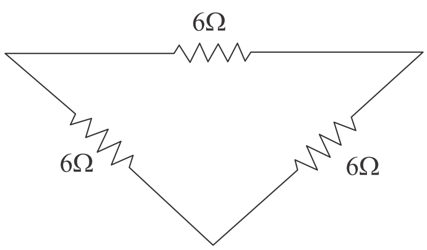
$\therefore\ I_{20\Omega} = 3.07\ \text{Amp}$

(4) For the circuit shown below find the resistance between terminals A and B. **[M-13][7]**

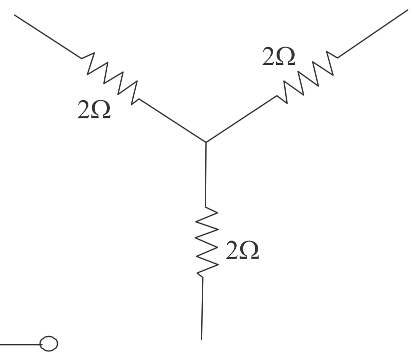


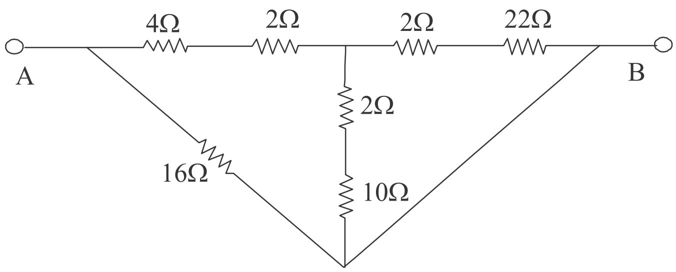
Solution:-

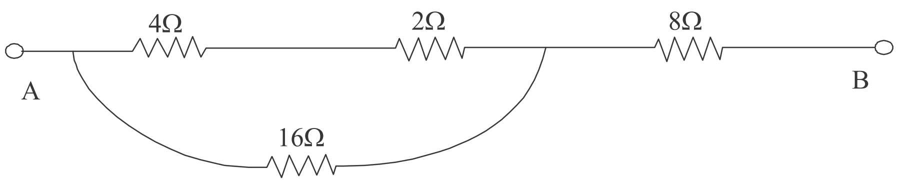
Delta to star conversion



$\Rightarrow$

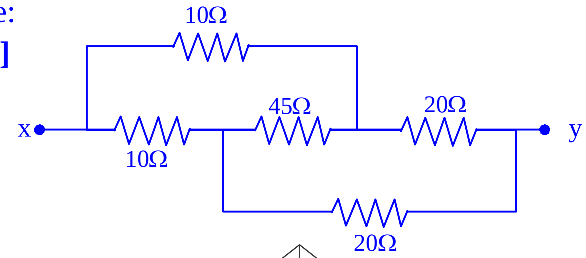




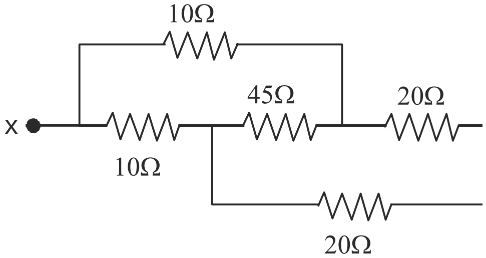


$R_{AB} = 4.36 + 8 = 12.36\ \Omega.$

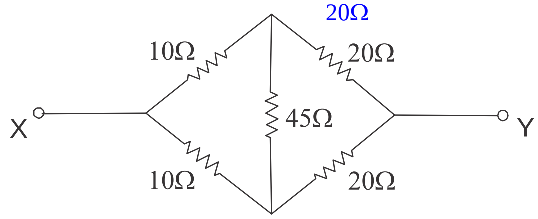
(5) Calculate R_{xy} for the circuit shown in figure: **[D-12][7]**



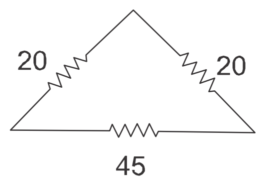
Solution:-



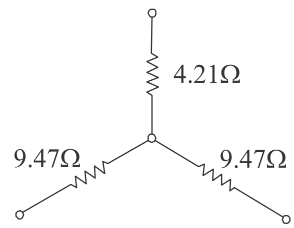
$\Rightarrow$

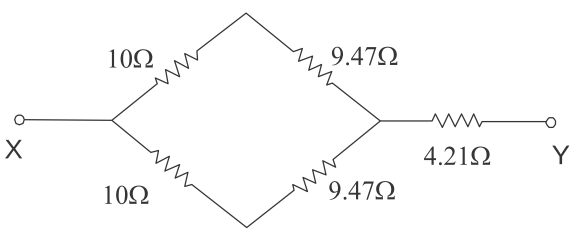


Delta to star conversion

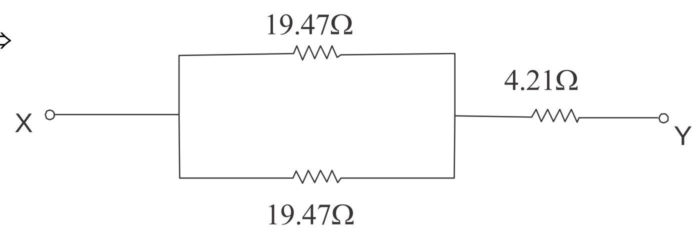


$\Rightarrow$





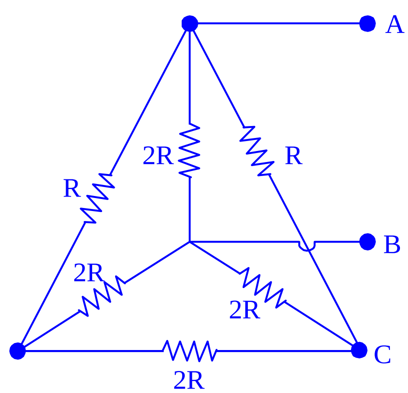
$\Rightarrow$



R_{XY} = 9.735+4.21

R_{XY} = 13.945 Ω

(6) Determine the resistance between A and B in the figure shown. **[D-09][6]**

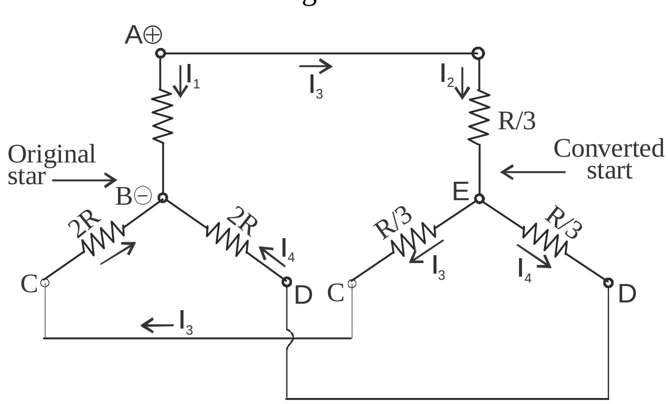


Solution:

Step 1: Convert the outer delta (R × R × R) into star :
Each resistance in the equivalent star is given by,

$$R_{eq} = \frac{R \times R}{R + R + R} = \frac{R^2}{3R} = \frac{R}{3}$$

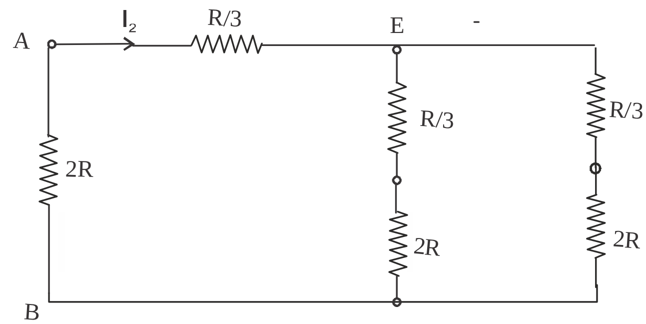
So the simplified circuit is shown in fig.



Note that B and E in Fig. are not connected to each other.
Assuming a source connected between A and B, we get the current division as shown in fig.
Hence equivalent circuit is shown in fig.

$$\therefore\quad R_{AB} = \left\{\frac{R}{3} + \left[\left(\frac{R}{3}+2R\right) \middle\| \left(\frac{R}{3}+2R\right)\right]\right\} \| 2R$$

$$= \left\{\frac{R}{3} + \left[\frac{7R}{3} \middle\| \frac{7R}{3}\right]\right\} \| 2R \quad = \left[\frac{R}{3} + \frac{7R}{6}\right] \| 2R$$



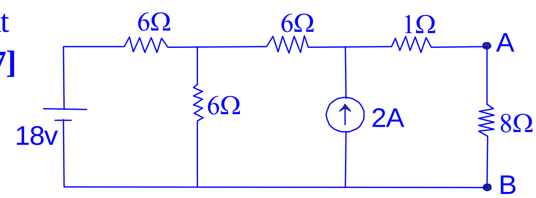
$$R_{AB} = \frac{3R}{2} \| 2R$$

$$\frac{1}{R_{AB}} = \frac{2}{3R} + \frac{1}{2R} = \frac{4R+3R}{6R} = \frac{7R}{6R}$$

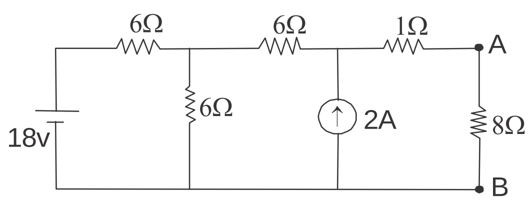
$$R_{AB} = \frac{6}{7} = 0.857\ \Omega$$

Type VI : Source Transformation

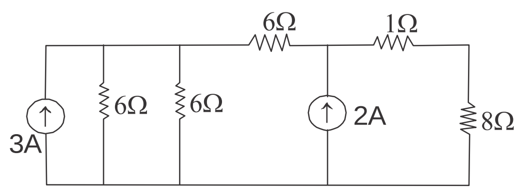
(1) Using source transformation find the current flowing through the 8Ω resistance **[M-15][7]**



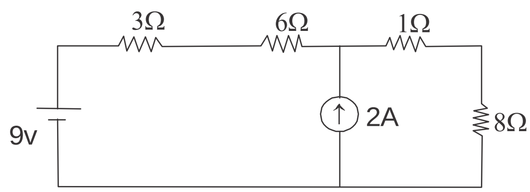
Solution:-



18 V into current source
I =18 / 6 = 3 A

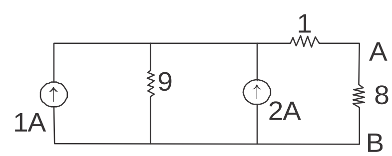


$6 \| 6 = 3\Omega$
3A & 3Ω convertion into voltage source.



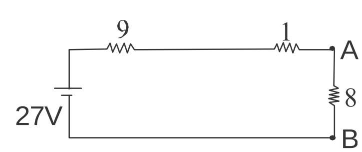
3 & 6 in series
R = 9Ω

9V & 9Ω convert into curent source.
1A + 2A = 3A
3A & 9Ω converting into voltage source

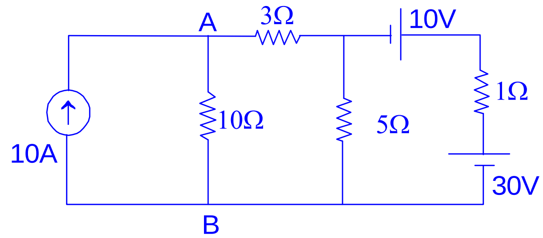


$$I_{8\Omega} = \frac{27}{18}$$

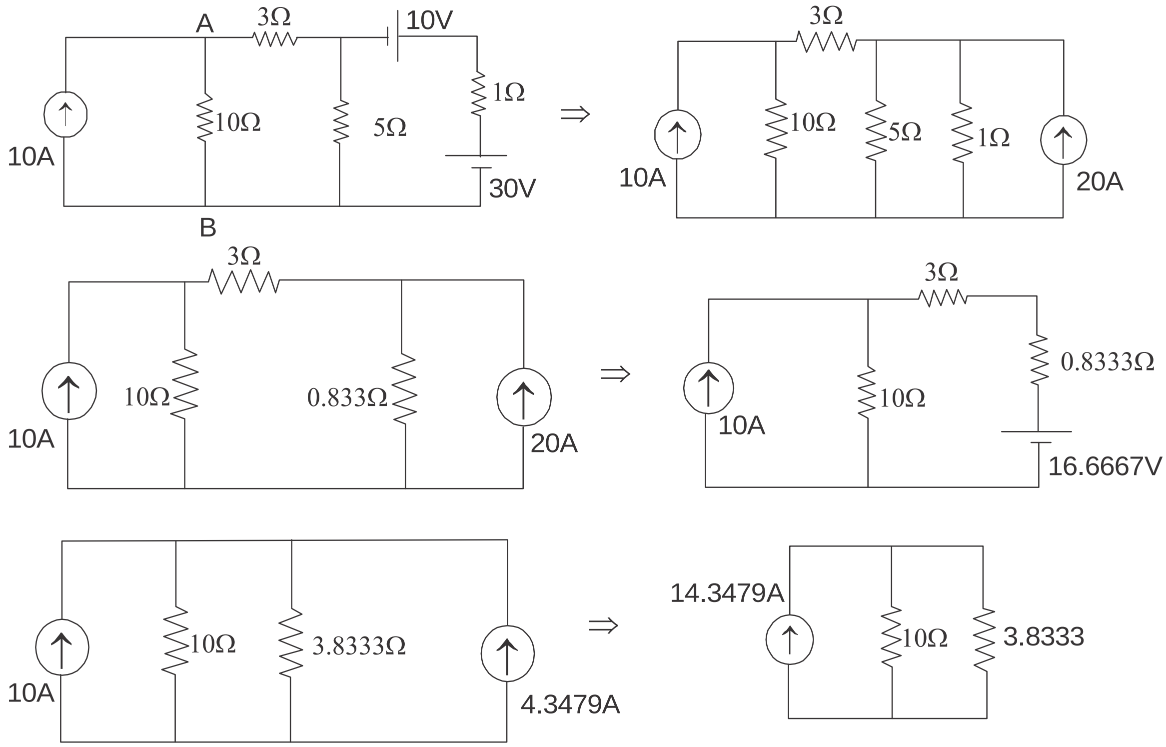
$$I_{8\Omega} = 1.5\ A$$



(2) Using source transformation find the current flowing through the 10 Ω resistance. **[D-14][7]**

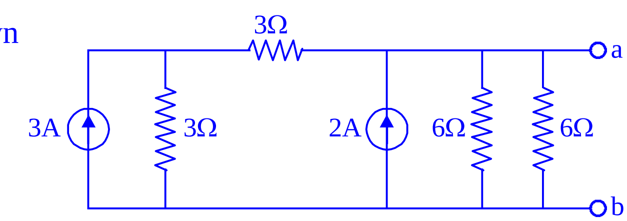


Solution:-

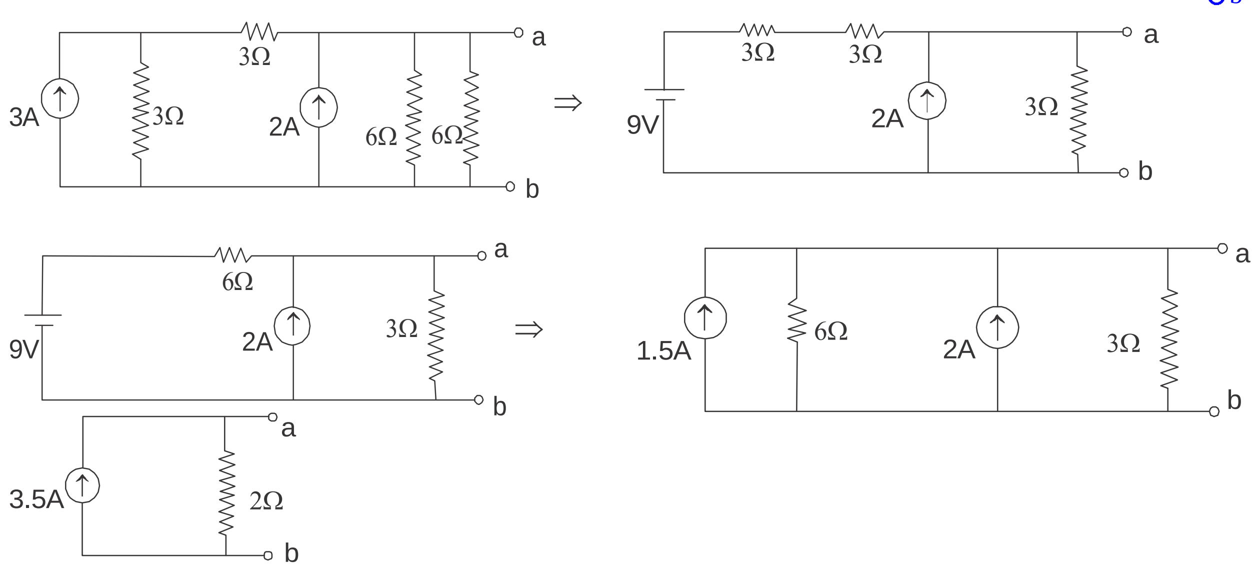


By Current Division Rule, $I_{10\Omega} = \dfrac{3.8333}{13.8333} \times 14.3479 = 3.9759\,A\,(\downarrow)$

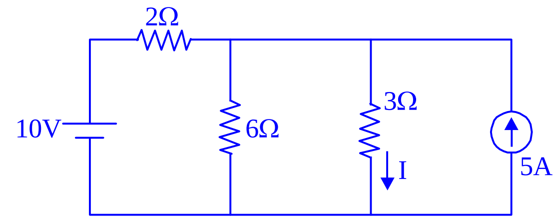
(3) Using source conversion, reduce the circuit shown in figure into single current source in parallel with single resistance. **[M-14][3]**



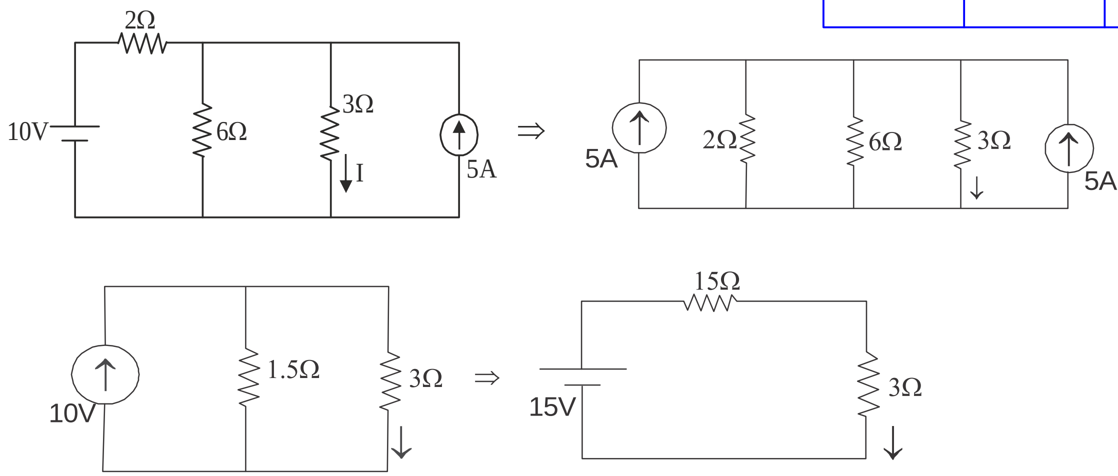
Solution:-



(4) Using source transformation find I. **[D-13][3]**

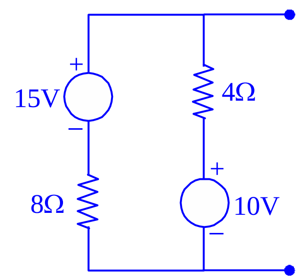


Solution:-

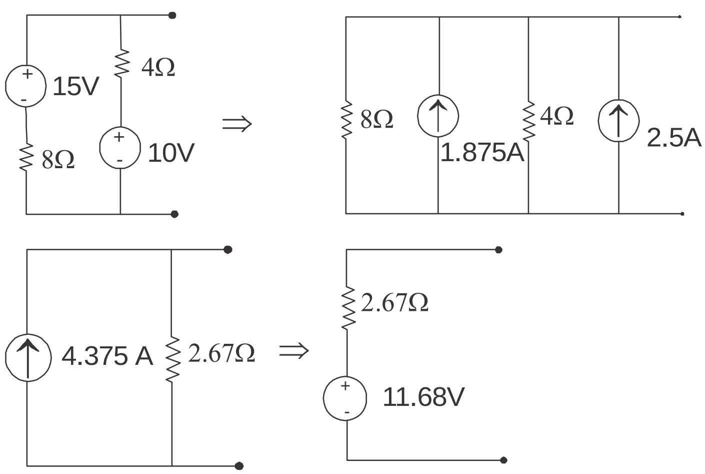


$$I = \frac{15}{1.5+3} = 3.33\,\text{Amp}$$

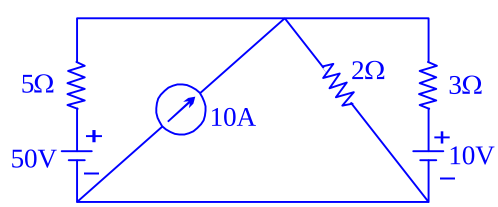
(5) Using source transformation convert the circuit given below to a single voltage source in series with a resistor.**[M-13][3]**



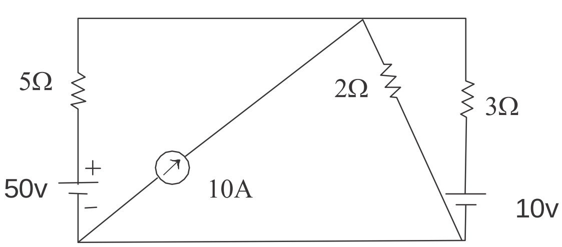
Solution:-

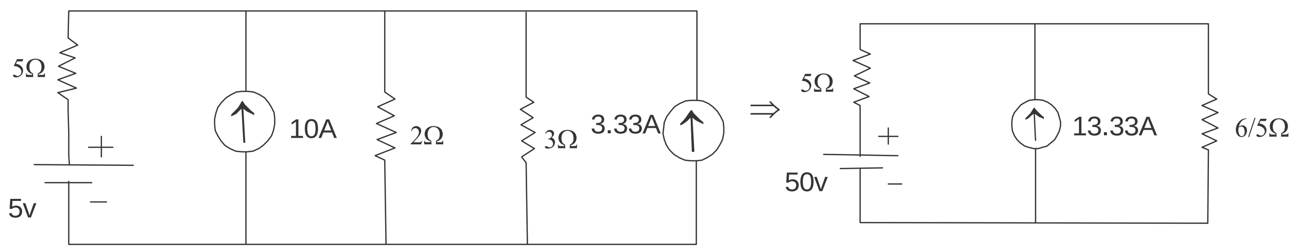


(6) Find the current flowing through 5Ω resistance using source transformation. **[D-12][3]**



Solution:-

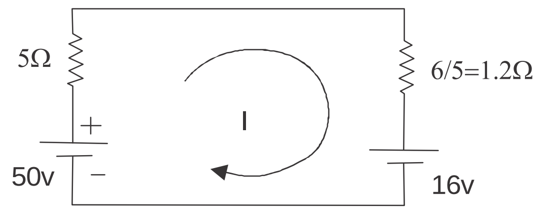




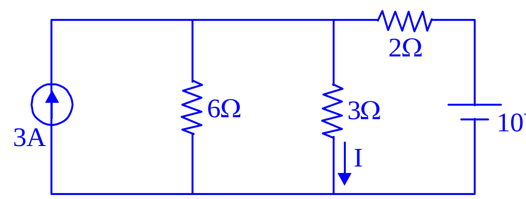
Apply KVL to mesh,

$50 - 5I - 1.2I - 16 = 0 \Rightarrow 6.2I = 34$

$\therefore$ I = 5.48 Amp.

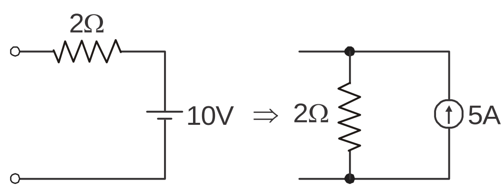


(7) Using source transformation find I. **[M-11][5]**

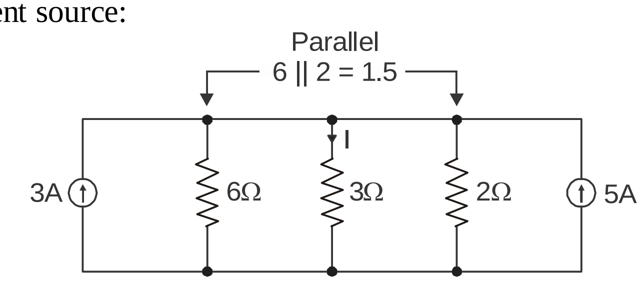


Solution:

Step 1: Convert the voltage source to current source:



(a)

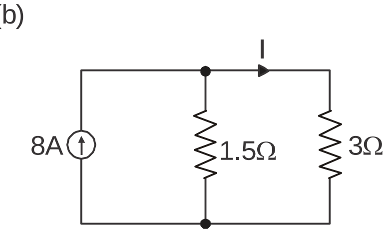


(b)

Step 2: Combine the current source and find I:

$\therefore$ Current through 3Ω resistor, $I = 8 \times \dfrac{1.5}{3+1.5}$

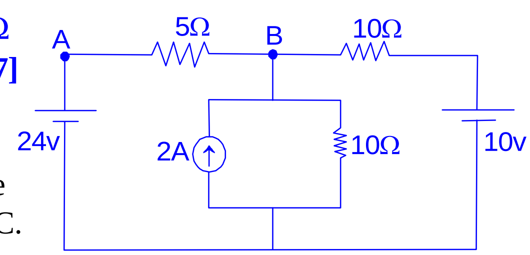
$$= 8 \times \frac{1.5}{4.5} = \frac{8}{3} = 2.67 \text{ Amp.}$$



(c)

Type VII : Superposition Theorem

(1) Find the value of current flowing through the 5 Ω resistance using superposition theorem.**[M-15][7]**



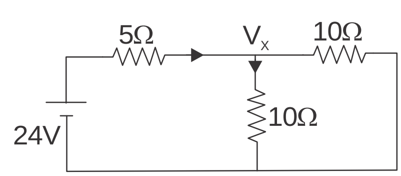
Solution:-

(i) Consider 24V battery acting alone & replace 2A source with O.C. & 10V battery with S.C.

Apply KCL at node X

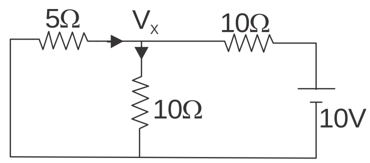
$$\frac{24 - V_X}{5} = \frac{V_X}{10} + \frac{V_X}{10} \Rightarrow \frac{24}{5} = V_X\left[\frac{1}{10} + \frac{1}{10} + \frac{1}{5}\right]$$

$\therefore V_X = 12\,V$



$$\therefore\ I'_{5\Omega}=\frac{24-12}{5}=2.4\,A(\rightarrow)$$

(ii) Consider 10V battery acting alone & replace 24V battery with S.C & 2A source with O.C.
Apply KCL at node X

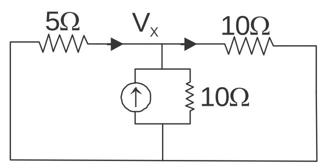


$$\frac{0-V_X}{5}+\frac{10-V_X}{10}=\frac{V_X}{10}\Rightarrow 1=\frac{V_X}{5}+\frac{V_X}{10}+\frac{V_X}{10}$$

$$\therefore\ V_X=2.5V$$

$$\therefore\ I''_{5\Omega}=\frac{0-V_X}{5}=-0.5A(\rightarrow)$$

(iii) Consider 2A source acting alone & replace the battery with S.C.
Apply KCL at X



$$\frac{0-V_X}{5}+2=\frac{V_X}{10}+\frac{V_X}{10}\Rightarrow 2=V_X\left(\frac{1}{10}+\frac{1}{10}+\frac{1}{5}\right)$$

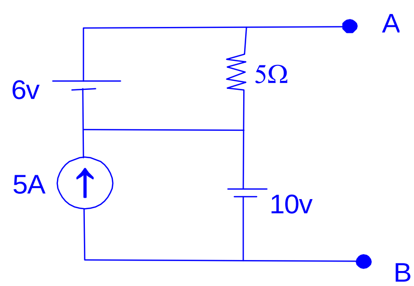
$$\therefore\ V_X=5V$$

$$\therefore\ I'''_{5\Omega}=\frac{0-V_X}{5}=-1A(\rightarrow)$$

$$\therefore\ I_{5\Omega}=I'_{5\Omega}+I''_{5\Omega}+I'''_{5\Omega}=2.4-0.5-1$$

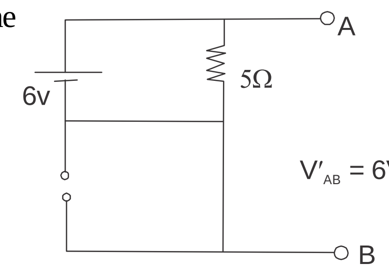
$$I_{5\Omega}=0.9\,A(\rightarrow)$$

(2) Find voltage V_{AB} using super position theorem. **[D-14][3]**



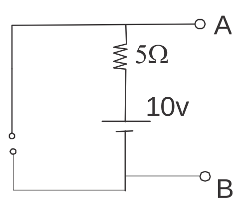
Solution:-

(i) 6V acting alone



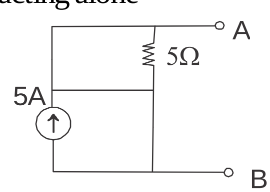
V'_{AB} = 6V

(ii) 10V acting along



5Ω short circuited
V''_{AB} = 10V

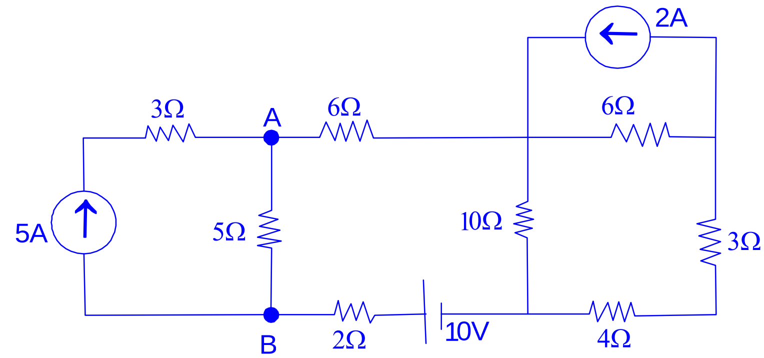
(iii)5A acting alone



V'''_{AB} = 0V

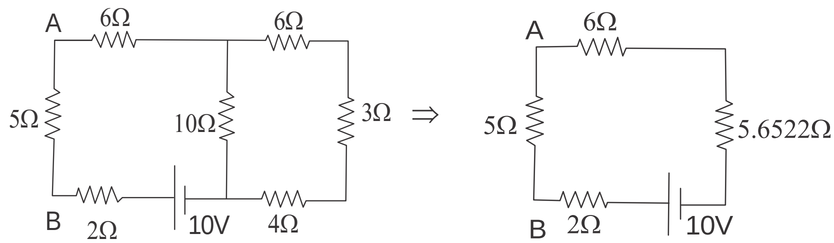
$$\therefore\ V_{AB}=V'_{AB}+V''_{AB}+V'''_{AB}=16\,V$$

(3) Find the value of current flowing through the 5 Ω resistance using Superposition Theorem.**[D-14][7]**



Solution:-

(i) Consider 10V acting alone and replace current sources with OC



$$I'_{5\Omega} = \frac{10}{18.6522} = 0.5361\,A\,(\uparrow)$$

(ii) Consider 2A acting alone and replace 5A source with OC & 10V battery with S.C.

Apply KCL at V_1

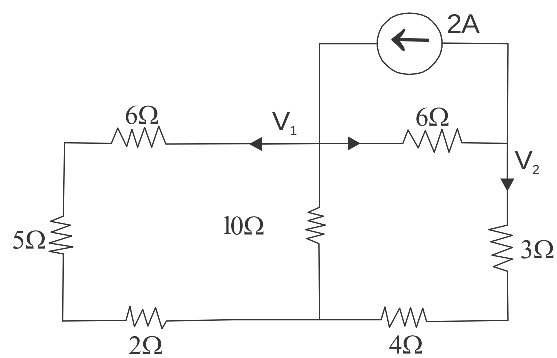
$$2 = \frac{V_1}{10} + \frac{V_1}{13} + \frac{V_1 - V_2}{6}$$

Apply KCL at V_2

$$\frac{V_1 - V_2}{6} = 2 + \frac{V_2}{7}$$

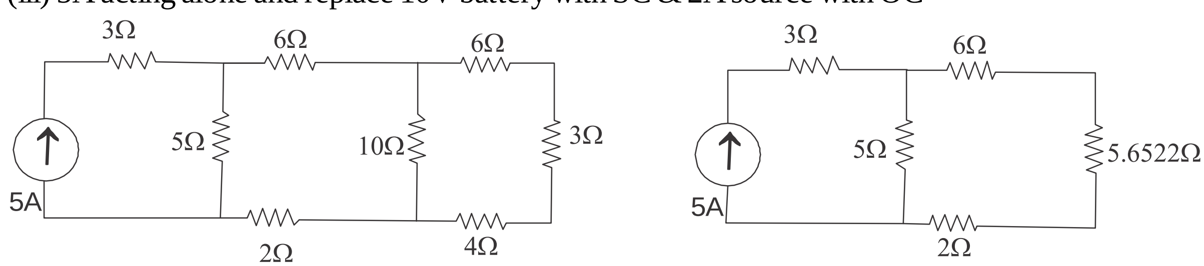
Solving (1) and (2)

$V_1 = 3.6364\,V,$ $V_2 = -4.5035\,V$



$$I''_{5\Omega} = \frac{3.6364}{13} = 0.2797\,A\,(\downarrow)$$

(iii) 5A acting alone and replace 10V battery with SC & 2A source with OC

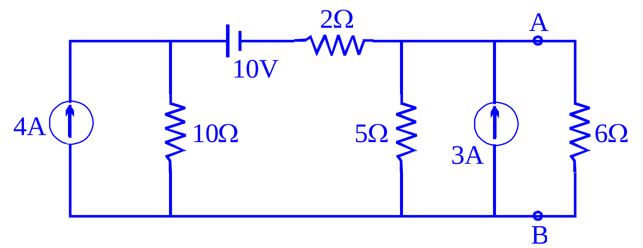


By Current division rule,

$$I'''_{5\Omega} = 5\,x\,\frac{13.6522}{18.6522} = 3.6597\,A\,(\downarrow)$$

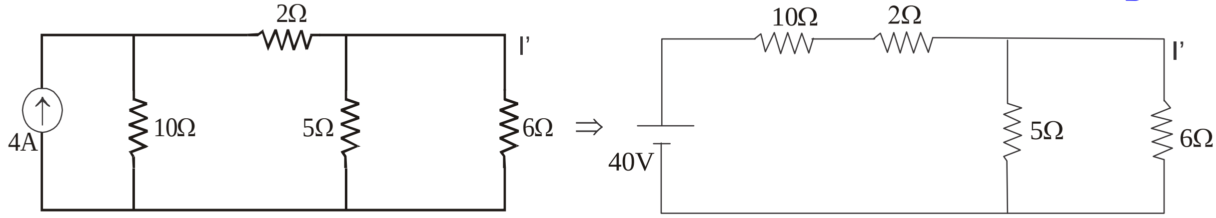
$$\therefore I_{5\Omega} = I''_{5\Omega} + I'''_{5\Omega} - I'_{5\Omega} = 3.4033\,A\,(\downarrow)$$

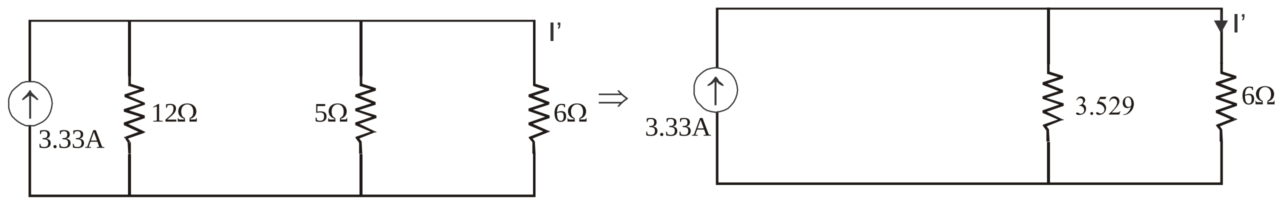
(4) Find the current through 6Ω reisitor using superposition theorem.**[M-14][7]**



Solution:-

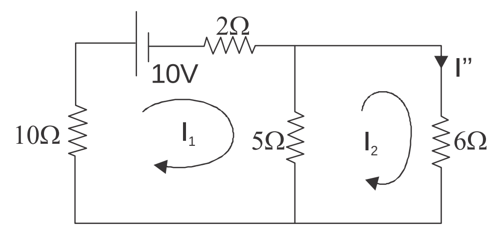
(I) Consider 4A source acting alone and replace 10V bat with SC and 3A source with O.C.





By current division rule, $I' = \dfrac{3.529}{3.529+6} \times 3.33 = 1.233\,\text{Amp.}$

(II) Consider 10V bat acting alone and replace current sources with O.C.



Apply KVL to mesh 1

$\therefore -10I_1 - 10\,2I_1 - 5(I_1 - I_2) = 0$

$\therefore 17I_1 - 5I_2 = -10 \quad ...(1)$

Apply KVL to mesh 2

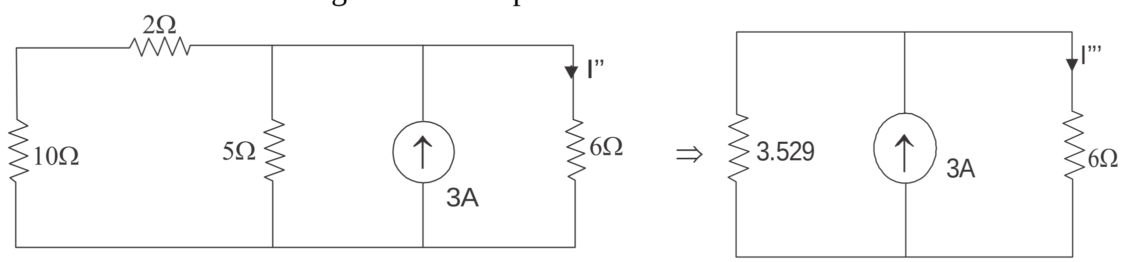
$-5(I_2 - I_1) - 6I_2 = 0 \Rightarrow -5I_1 + 11I_2 = 0 \quad ...(2)$

Solving (1) and (2)

$I_1 = -0.6790\,\text{Amp} \qquad I_2 = -0.3086\,\text{Amp}$

Now, $I'' = I_2 = -0.3086\,\text{Amp}$

Concider 3A source acting alone and replace 4A source with O.C. and 10V bat with S.C.



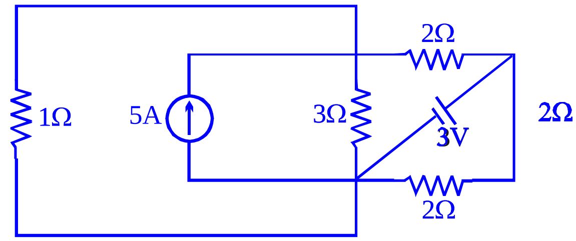
$\therefore I''' = \dfrac{3.529}{6+3.529} \times 3 = 1.11\,\text{Amp.}$

By superposition theorom,

$I_{6\Omega} = I' + I'' + I''' = 1.233 + (-0.3086)$

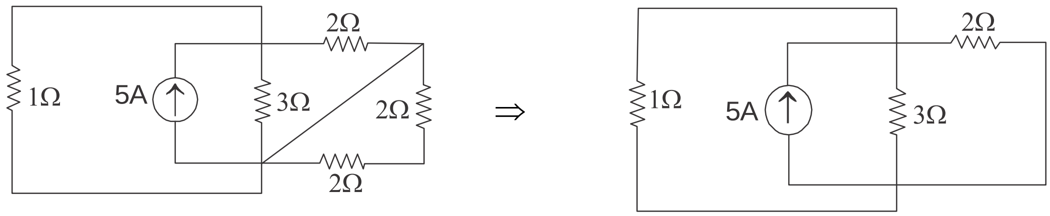
$\therefore \quad I_{6\Omega} = 2.035\ \text{A}$

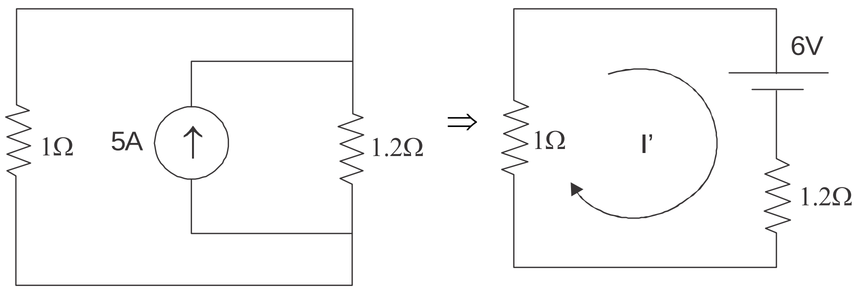
(5) Determine current in 1Ω resistor using superposition theorem. **[D-13][7]**



Solution:-

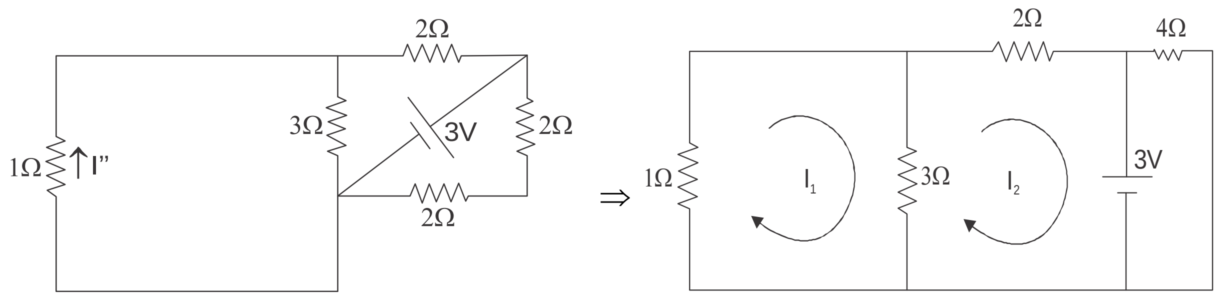
(I) consider 5A source acting & replacing 3V battery with SC.





Current throuugh $1\,\Omega$, $I' = \dfrac{-6}{1+1.2} = -2.727$ Amp.

(II)Consider 3V battery acting alone & replacing 5A current source with O.C.



Since the $4\,\Omega$ Resistance is in parallel with the 3V voltage source, the Resistance of $4\,\Omega$ gets redundant. Hence can be neglected.

Apply KVL to mesh 1

$\therefore -I_1 - 3(I_1 - I_2) = 0 \quad \Rightarrow \quad -4I_1 + 3I_2 = 0 \qquad ....(1)$

Apply KVL to mesh 2

`

$-3(I_2 - I_1) - 2I_2 - 3 = 0 \quad \Rightarrow \quad -3I_1 + 5I_2 = -3 \qquad ....(2)$

Solving (1) & (2)

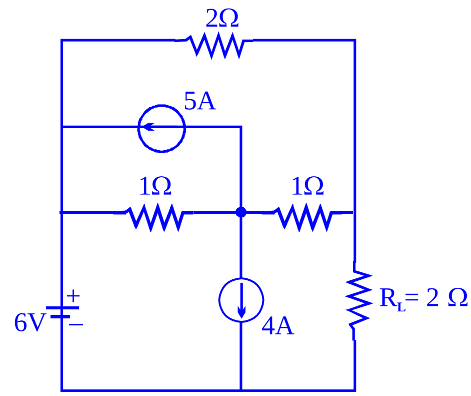
$I_1 = -0.8182$ Amp $\qquad I_2 = -1.09$ Amp

Current through 1Ω is $I" = I_1 = -0.8182$ Amp

By Superposition theorem, current through 1Ω is

$I_{1\Omega} = I' + I" = -2.727 - 0.8182 = -3.5452$ Amp.

(6) Determine current through $R_L = 2\Omega$ in the circuit shown below using superposition theorem **[M-13][7]**



Solution:-

(i) Consider 5A source acting alone & replace 6V battery with S.C. & 4A source with O.C.

$$-I_2' + I_3' = 5$$

Apply KVL to supermesh 2,3

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

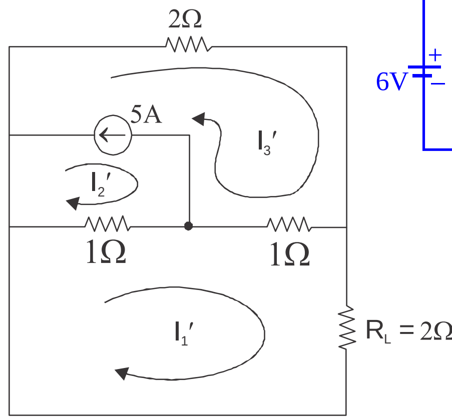
Apply KVL to mesh 1

$$4I_1' - I_2' - I_3' = 0$$

$$I_1' = -0.8333\,A$$

$$I_2' = -4.1667\,A$$

$$I_3' = 0.8333\,A$$



(ii) Consider 4A source acting alone & replace 5A source with O.C. & 6V battery with S.C.

$$-I_1'' + I_2'' = 4$$

Apply KVL to supermesh 1,2

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

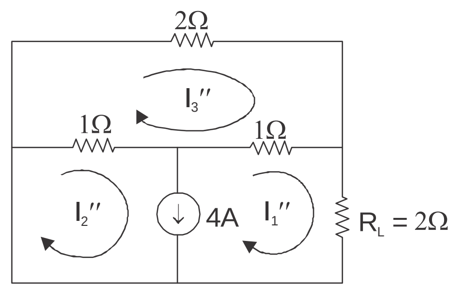
Apply KVL to mesh 3

$$-I_1'' - I_2'' + 4I_3'' = 0$$

$$I_1'' = -0.6667\,A$$

$$I_2'' = 3.33\,A$$

$$I_3'' = 0.6667\,A$$



(iii) Consider 6V source acting alone & replace the current sources with O.C.

Apply KVL to mesh 1

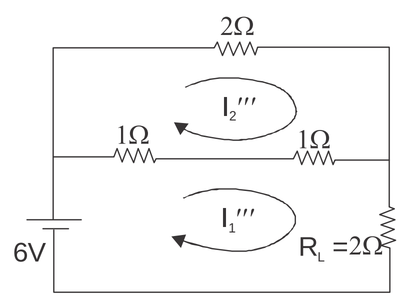
$$4I_1''' - 2I_2''' = 6$$

Apply KVL to mesh 2

$$-2I_1''' + 4I_2''' = 0$$

$$I_1''' = 2\,Amp$$

$$I_2''' = 1\,Amp$$

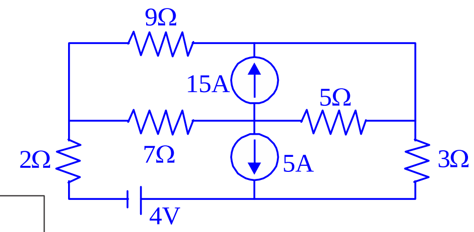


Applying superposition theorem, current thrugh 2Ω is :

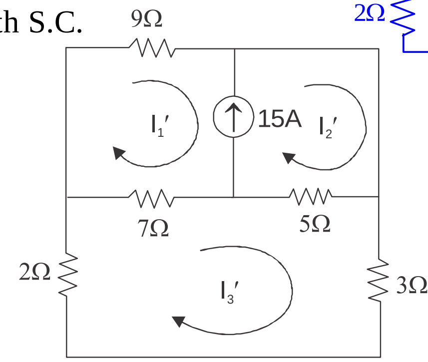
$$I_{2\Omega} = I_1' + I_1'' + I_1''' = -0.8333 + (-0.6667) + 2$$

$$I_{2\Omega} = 0.5\,Amp$$

(7) Find the current through 3Ω resistor using superposition theorem. **[D-12][7]**



Solution:- (I) Consider 15A source acting alone & replace 5A surce with O.C. & 4V battery with S.C.



$-I_1'+I_2'=15$

Apply KVL tomesh 3

$-7I_1'-5I_2'+17I_3'=0$

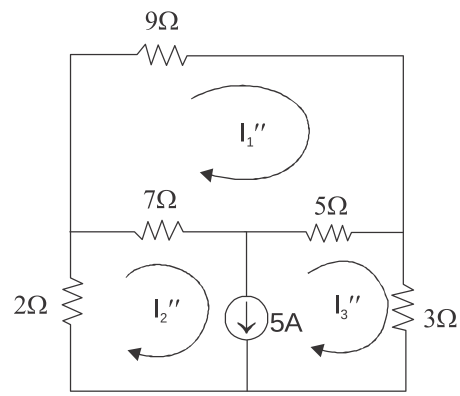
Apply KVL to supermesh 1 & 2

$16I_1'+5I_2'-12I_3'=0$

$I_3'=3.169\,A$

$\therefore I'_{3\Omega}=3.169\,A$

(II)Consider 5A source acting alone & replace 15A surce with O.C. & 4V battery with S.C.



$5A \to ON, 15A \,\&\, 4A \to OFF$

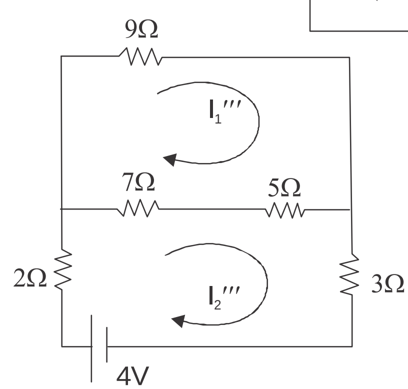
$I_2'' - I_3'' = 5$

$21I_1'' - 7I_2'' - 5I_3'' = 0$

$-12I_1'' + 9I_2'' + 8I_3'' = 0$

$I_3'' = -2.4\,Amp$

(III)Consider 4V battery acting along & replace the current sources with O.C.



$4A \to ON, 5A \,\&\, 15A - OFF$

$21I_1''' - 12I_2''' = 0$

$-12I_1''' + 17I_2''' = 4$

$I_2''' = 0.3944\,Amp$

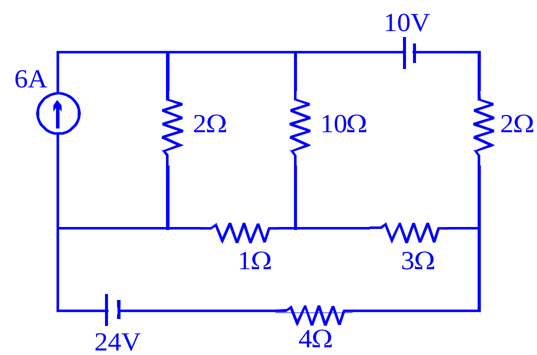
By superposition Theorem

$I_{3\Omega} = I_3' + I_3'' + I_2'''$

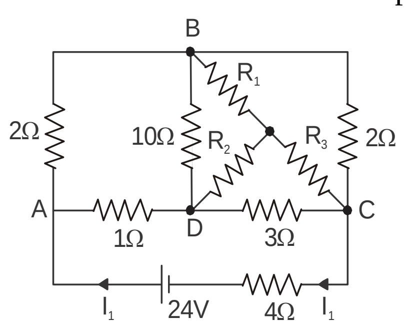
$= 3.169 + (-2.465) + 0.3944$

$= 1.0984\,Amp. \downarrow$

(8) Find the current across 4Ω by superposition theorem. **[D-11][10]**



Solution: Step 1: Find I_1 through 4Ω only due to the 24V source: Convert ΔBDC into star and simplify:

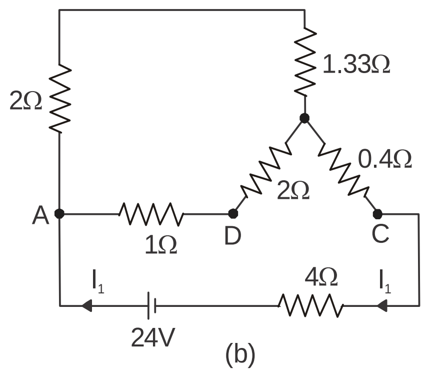


(a)

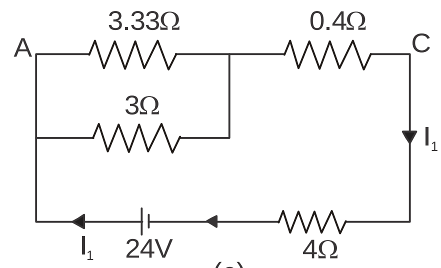
$$R_1 = \frac{10 \times 2}{10+2+3} = 1.33\Omega$$

$$R_2 = \frac{10 \times 3}{15} = 2\Omega$$

$$R_3 = \frac{2 \times 3}{15} = 0.4\Omega$$



(b)



(c)

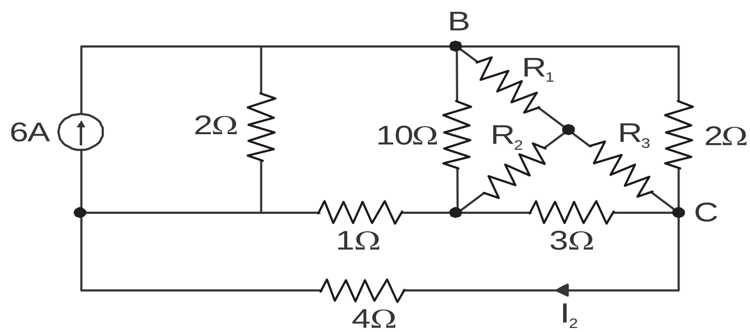
From Fig. (c), the equivalent resistance is given by,

$R_{T1} = 1.58 + 0.4 + 4 = 5.98 \approx 6\Omega$

$$\therefore \quad I_1 = \frac{24V}{6\Omega} = 4\,\text{Amp}\,(\leftarrow) \qquad ...(1)$$

Step 2: Find I_2 through 4Ω only due to 6A source:

Convert 6A source to a voltage source and ΔBDC to star:

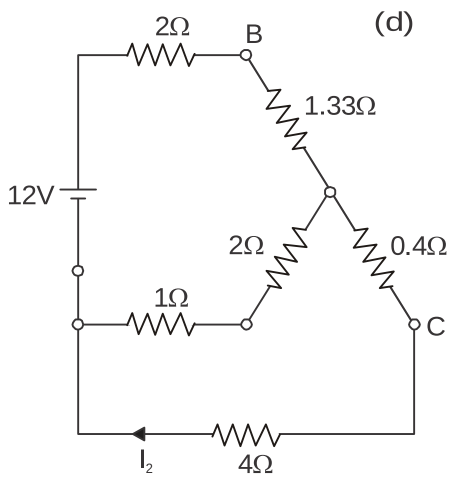


(d)

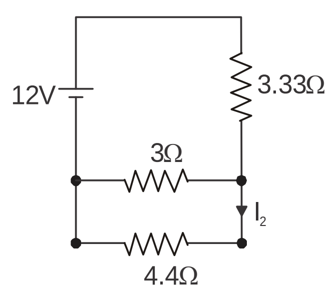
$$R_1 = \frac{10\times 2}{10+2+3} = 1.33\Omega$$

$$R_2 = \frac{10\times 3}{15} = 2\Omega$$

$$R_3 = \frac{2\times 3}{15} = 0.4\,\Omega$$



(e)



(f)

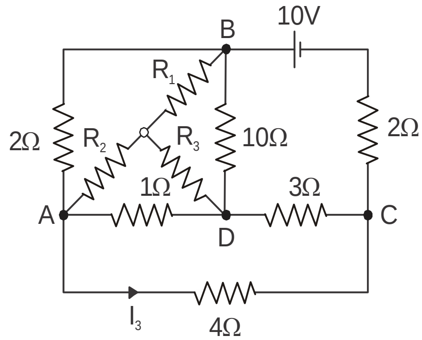
From Fig. (f), the total resistance is given by,

$$R_{T2} = 3.33 + (3\,||\,4.4) = 5.11\ \Omega \ \Rightarrow \ I_{T2} = \frac{12V}{5.11} = 2.35\,A$$

$$\therefore \quad I_2 = \frac{3}{3+4.4}\times 2.35A = 0.95\,\text{Amp.}\ (\leftarrow)$$

Step 3:Find I_3 through 4Ω only due to 10V source:

Convert ΔABD to star:

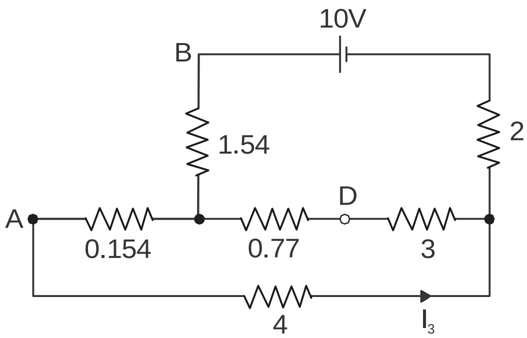


(g)

$$R_1 = \frac{2\times10}{2+1+10} = 1.54\Omega$$

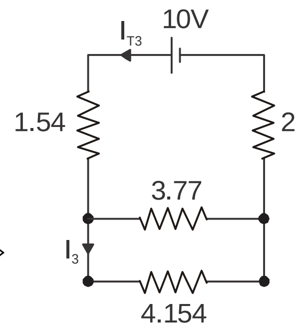
$$R_2 = \frac{2\times1}{13} = 0.154\Omega$$

$$R_3 = \frac{10\times1}{13} = 0.77\Omega$$



(h)

⇒



(i)

From Fig. (i)

R_{T3}= 1.54 + 2 + 1.98 = 5.52Ω ⇒ $I_{T3} = \dfrac{10V}{5.52\Omega} = 1.81$ Amp.

$$\therefore \quad I_3 = \frac{3.77}{3.77+4.154}\times1.81 \text{ Amp} = 0.86 \text{ Amp } (\rightarrow)$$

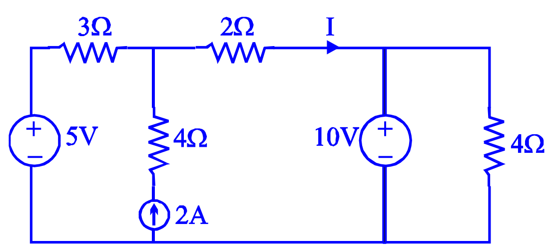
Step 4: Total current through 4Ω resistance:

$I = I_1 + I_2 - I_3 = 4 + 0.95 - 0.86$

∴ I = 4.09 Amp. (←)

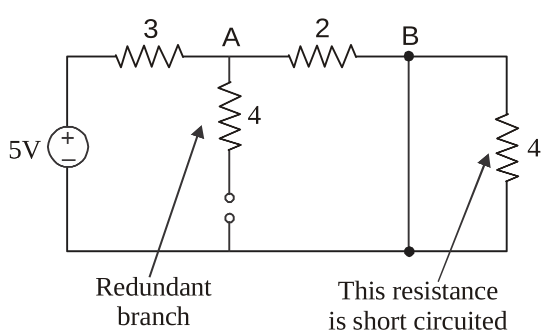
(9) Using superposition principle find I.

[M-11][8]

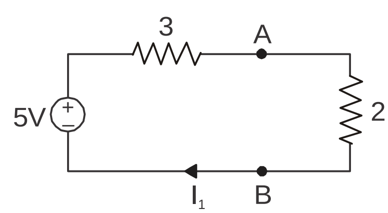


Solution:

Step 1: Current I_1 only due to 5V source

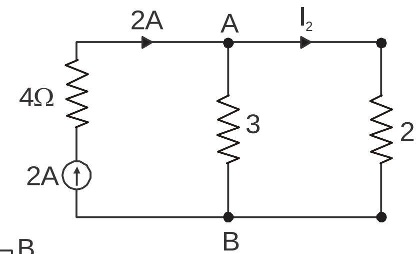


(a)



(b)

From Fig. (b), $I_1 = \dfrac{5}{5} = 1A$ ...(A to B)

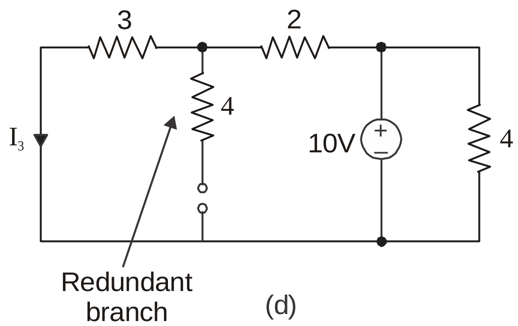


(c)

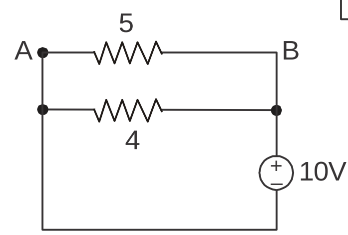
Step 2: Current I_2 only due to 2A source

$$I_2 = \frac{3}{2+3} \times 2A = 1.2\text{ A} \quad \text{...(A + B)}$$

Step 3: Current I_3 only due to 10V source:



(d)



(e)

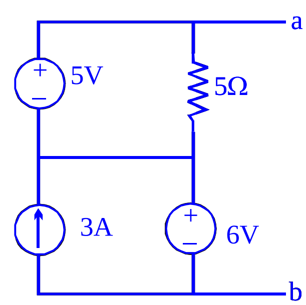
From Fig. (e), $I_3 = \dfrac{10V}{5} = 2A$ ...(B to A)

Step 4: Find I

$I = I_1 + I_2 - I_3 = 1 + 1.2 - 2 = 0.2$ (A to B)

(10) Find V_{ab} for the circuit below using superposition theorem.

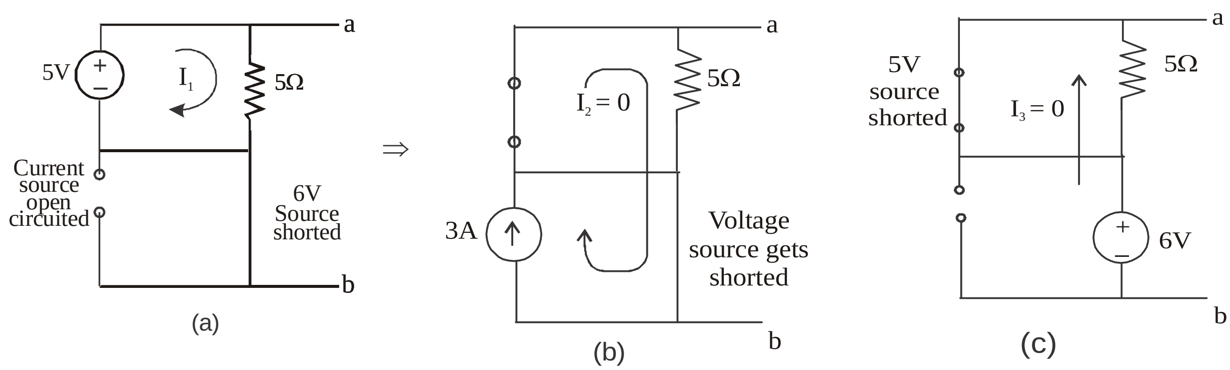
[May 09][4]



Solution:

Step1: Current through 5 Ω due to only 5 V source:

From fig (a). $I_1 = \dfrac{5V}{5\Omega} = 1\text{Amp}$



Step 2 : Current through 5 Ω due to only 3 A source :

From fig (b) $I_2 = 0$

Step 3 : Current due to only 6 V source :

Since there is no return path for I_3 as shown in fig.(c), $I_3 = 0$

Step 4 : Calculation of V_{ab} :

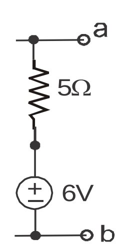
Total current through 5Ω resistance is

$$I = I_1 + I_2 + I_3 = 1 + 0 + 0 = 1 \text{ Amp.}$$

From Fig 2 (d)

$$V_{ab} = (5 \times I) + 6V = (5 \times 1) + 6V$$

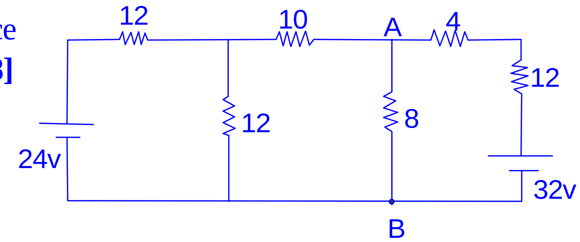
$$\therefore V_{ab} = 11V$$



(d)

Type VIII : Thevenins Theorem

(1) Find the current through 8Ω resistance using Thevenin's theorem **[M-15][8]**



Solution:

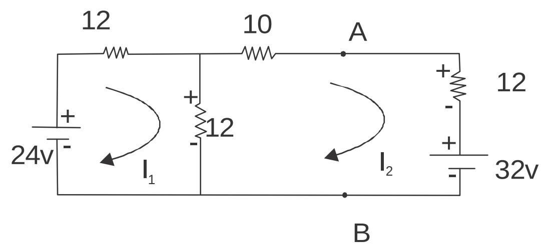
(i) Calculation of V_{TH} :

Open circuit 8Ω

Apply KVL to loop (1)

$$24-12I_1-12I_1+12I_2=0$$

$$-24I_1+12I_2=-24 \qquad ...(1)$$



Apply KVL to loop (2)

$$-10I_2-16I_2-32-12I_2+12I_1=0$$

$$-12I_1-38I_2=32 \qquad ...(2)$$

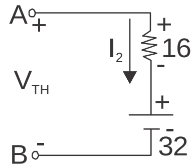
Solving (1) and (2)

$$I_1=0.6875\,A,\ \ I_2=-0.625\,A$$

Apply KVL, $V_{TH}-16I_2-32=0$

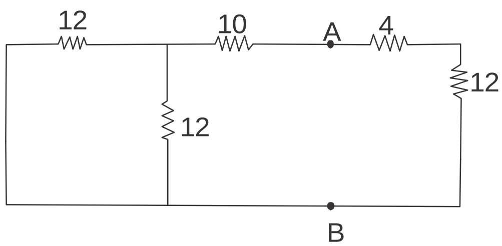
$$\therefore\ V_{TH}=32+16(-0.625)$$

$$\therefore V_{TH}=22\,V\,(A+ve\ w.r.t\ B)$$



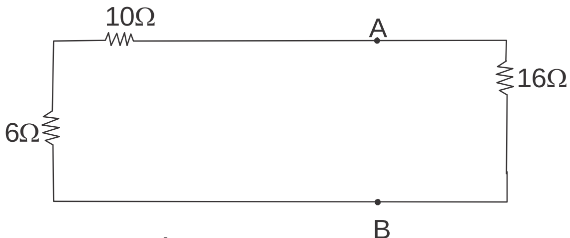
(ii) Calculation of R_{TH} :

Open circuit current source and short circuit voltage source and open circuit R_L

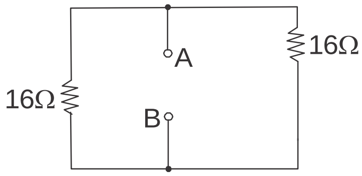


$$12\|12=6\Omega$$

$$4+12=16\Omega$$



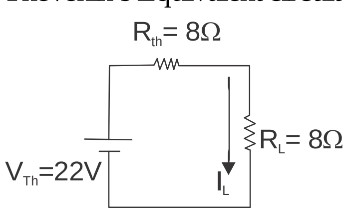
$$10+6=16\Omega$$



$$16\|16=8\Omega$$

$$R_{Th}=8\Omega$$

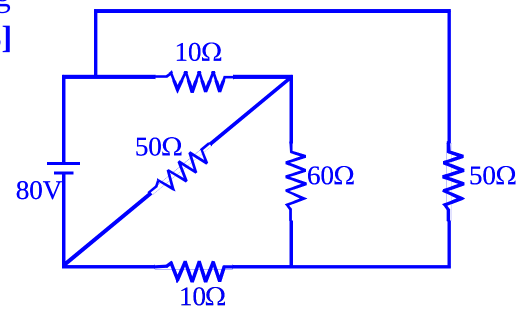
Thevenin's Equivalent circuit :



$$\therefore\ I_L=\frac{V_{Th}}{R_{Th}+R_L}$$

$$I_L=1.375\,\text{Amp}\,(\downarrow)$$

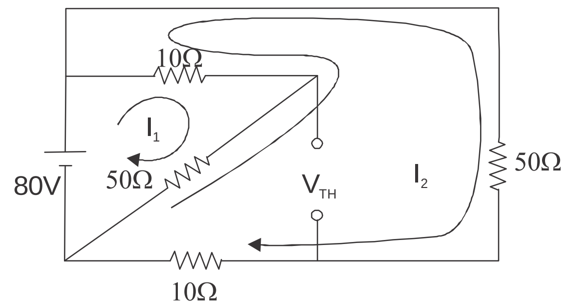
(2) Find the current through 60Ω resistance by using Thevenin's theorem. **[M-14][8]**



Solution:-

Calculation for V_{TH}:

Apply KVL to mesh 1



$$80-10(I_1-I_2)-50(I_1-I_2)=0$$

$$\therefore 60I_1-60I_2=80$$

$$\therefore 3I_1-3I_2=4 \quad \text{...(i)}$$

Apply KVL to mesh 2

$$-10I_2-10(I_2-I_1)-50I_2=0$$

$$\therefore -10I_1+70I_2=0$$

$$\therefore -I_1+7I_2=0 \quad \text{...(ii)}$$

Solving equation (i) & (ii)

$$I_1=1.556\,\text{Amp. and } I_2=0.2222\text{Amp.}$$

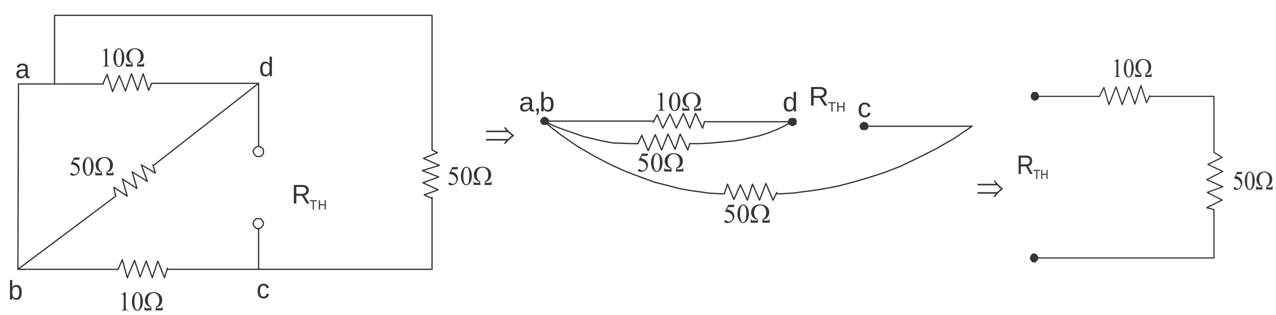
Writing KVL equation for V_{TH}

$$\therefore -50(I_2-I_1)-V_{TH}-10I_2=0$$

$$\therefore V_{TH}=-50I_2+50I_1-10I_2 \;=50I_1-60I_2$$

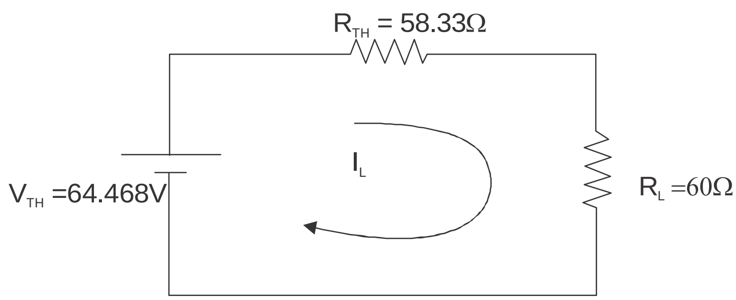
$$V_{TH}=64.468\,\text{volt}$$

Calculation for R_{TH}:



$$R_{TH}=8.33+50 \quad \Rightarrow \quad R_{TH}=58.33\Omega$$

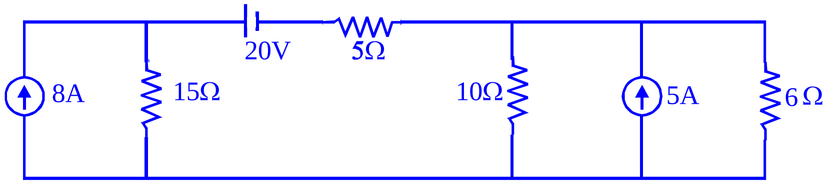
Thervenin's equivalent circuit is,



$$\therefore I_L=\frac{V_{TH}}{R_{TH}+R_L}=\frac{64.468}{60+58.33}$$

$$I_L=0.5448\,\text{Amp.}$$

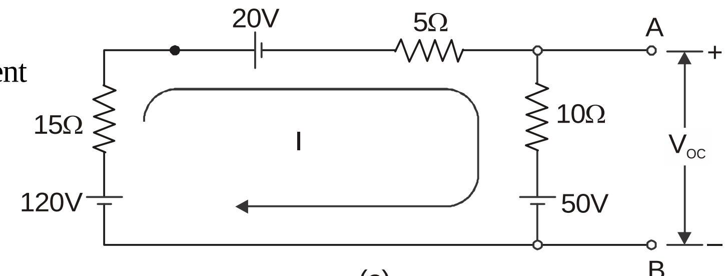
(3) Find the current through 6 ohms resistor using Thevenin's theorem for the given circuit. Verify the same using Superposition Theorem. **[M-12][12]**



Solution: **Part I: Solution using Thevenin's theorem**

Step 1: Find V_{OC}

Convert the 8A and 5A sources into equivalent sources and open circuit the load resistance R_L = 6Ω, redreaw the circuit as shown in Fig. (a).



(a)

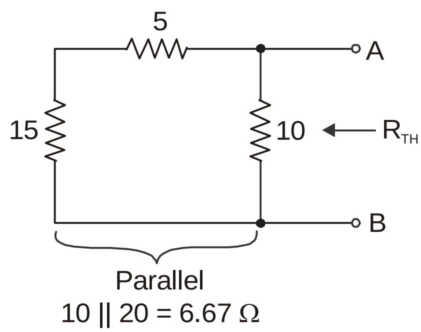
Apply KVL to the loop shown in Fig. (a)

$$120 = (15 + 5 + 10)\ I + 20 + 50$$

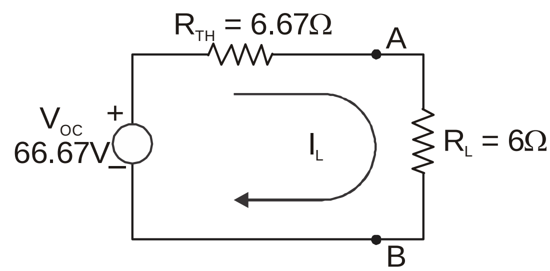
$$\therefore\ I = \frac{120-70}{30} = 1.667 \text{ Amp.}$$

$$\therefore\ V_{OC} = V_{AB} = 50 + (10 \times I) = 50 + (10 \times 1.667) = 66.67 \text{ Volts}$$

Step 2: Find R_{TH}



(b) To find R_{TH}



(c)Thevenin's equivalent circuit

$$R_{TH} = 10 \| 20 = \frac{10 \times 20}{10+20}$$

$$\therefore R_{TH} = 6.67\,\Omega$$

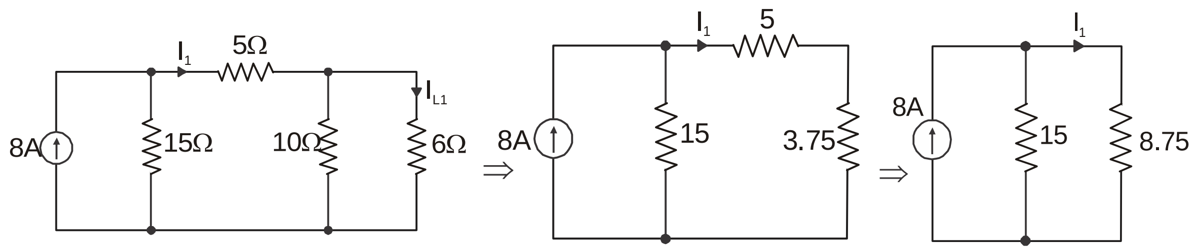
Step 3: Find I_L

From Fig. (c) we get,

$$I_L = \frac{V_{OC}}{R_{TH}+R_L} = \frac{66.67}{6.67+6} = 5.26 \text{ Amp.}$$

Part II: Solution using superposition theorem

Step 1: Find I_{L1} only due to the 8A source:

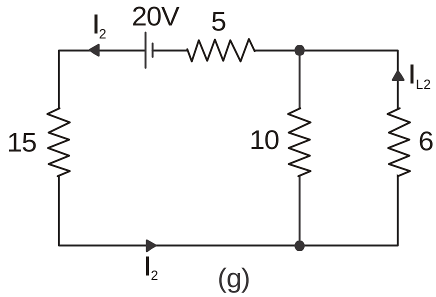


(d) (e) (f)

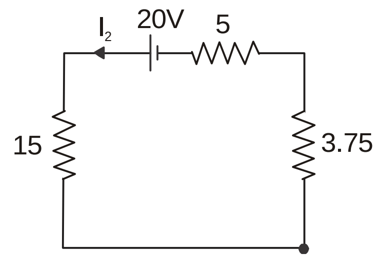
$$\text{From Fig. (f), } I_1 = \frac{15}{15+8.75} \times 8\,A = 5.05 \text{ Amp.}$$

$$\text{From Fig. (d), } I_{L1} = \frac{10}{10+6} \times I_1 = \frac{10}{16} \times 5.05 = 3.16 \text{ Amp.}$$

Step 2: Find I_{L2} only due to the 20V source:



(g)

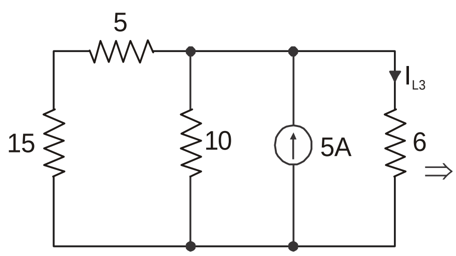


(h)

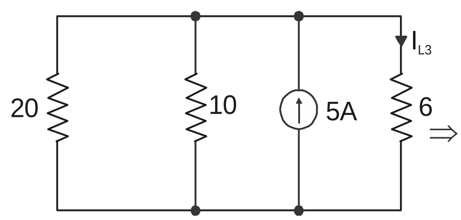
From Fig. (h), $I_2 = \dfrac{20V}{23.75\Omega} = 0.842\ A$

From Fig. (g), $I_{L2} = \dfrac{10}{10+6} \times I_2 = \dfrac{10}{16} \times 0.842 = 0.53\,\text{Amp.}$

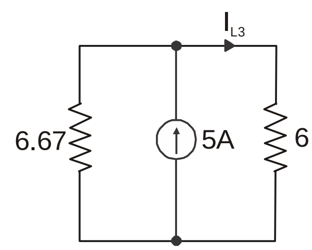
Step 3: Find I_{L3} only due to the 5A source:



(i)



(j)



(k)

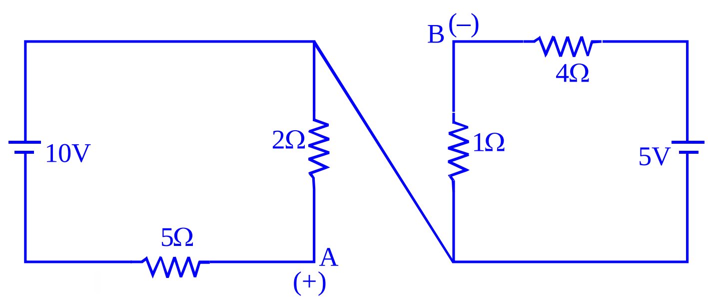
From Fig. (k), $I_{L3} = \dfrac{6.67}{(6.67+6)} \times 5A = 2.63\ \text{Amp.}$

Step 4: Find total current I_L through 6Ω resistance:

Note that I_{L1} and I_{L3} are in the same direction while I_{L2} flows in the opposite direction to them.

$\therefore\ I_L = I_{L1} - I_{L2} + I_{L3} = 3.16 - 0\ 0.53 + 2.63 = 5.26$ Amp.

(4) Obtain Thevenin's equivalent circuit across A and B. **[D-10][8]**



Solution:

Step 1: Find V_{OC}

From fig. (a)

$I_1 = \dfrac{10V}{7\Omega} = 1.43\,A\,,\quad I_2 = \dfrac{5V}{5\Omega} = 1A$

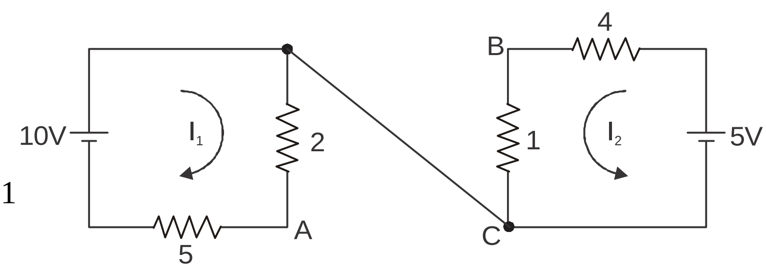
Treat point C as the reference point.

$\therefore\ V_{AC} = -2I_1 = -2 \times 1.43 = -2.86\ V$

And $V_{BC} = +1\ I_2 = +1 \times 1 = +1\ V$

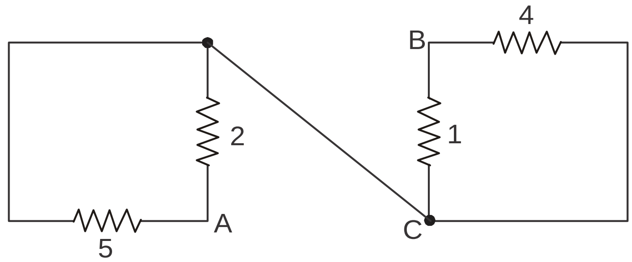
$\therefore\ V_{OC} = V_{AB} = V_{AC} - V_{BC} = -2.86 - 1$

$\therefore\ V_{OC} = -3.86$

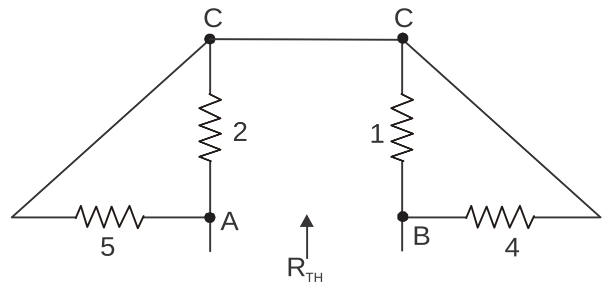


(a)

Step 2: Find R_{TH}

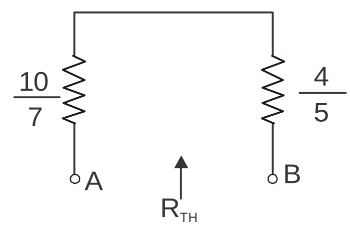


(b)



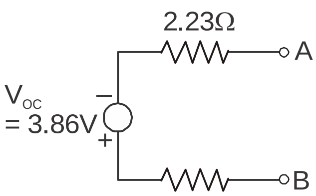
(c)

From fig. (d), $R_{TH} = \frac{10}{7} + \frac{4}{5} = \frac{50+28}{35} = 2.23\Omega$

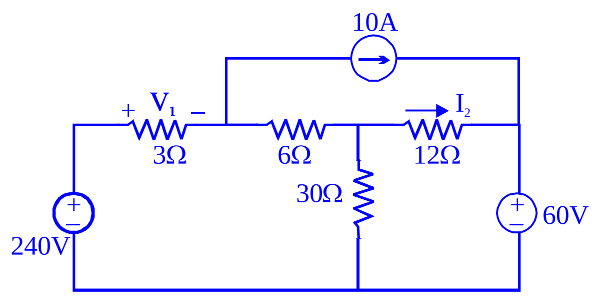


(d)

Step 3: Draw Thevenin's equivalent



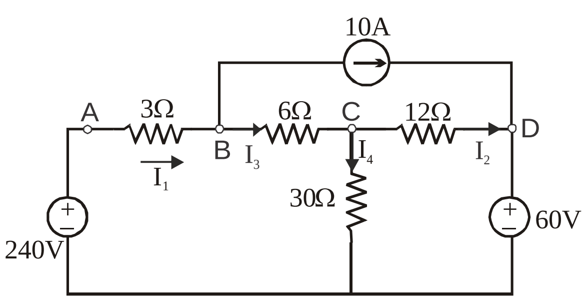
(5) Calculate voltage 'V_1' and 'I_2' by nodal analysis and verify 'I_2' by Thevenin's Theorem for the circuit shown in figure. **[D-08][10]**



Solution:

Part I : Nodal Analysis

Step 1 : The nodes and the branch currents are assigned as shown in Fig.



Step 2 : Calculation of V_B and V_C :

Applying KCL at node B,

$$I_1 = 10 + I_3$$

$$\therefore \frac{V_A - V_B}{3} = 10 + \frac{V_B - V_C}{6} \Rightarrow \frac{240 - V_B}{3} = 10 + \frac{V_B - V_C}{6} \qquad (\because V_A = 240V)$$

$$\therefore 480 - 2V_B = V_B - V_C + 60 \Rightarrow 3V_B - V_C = 420 \qquad (1)$$

Applying KCL at Node C,

$$I_3 = I_2 + I_4$$

$$\frac{V_B - V_C}{6} = \frac{V_C - V_D}{12} + \frac{V_C}{30} \Rightarrow \frac{V_B - V_C}{6} = \frac{V_C - 60}{12} + \frac{V_C}{30} \qquad (\because V_D = 60V)$$

$$\therefore 10V_B - 10V_C = 7V_C - 300 \Rightarrow 10V_B - 17V_C = -300 \qquad (2)$$

From Equation (1) and (2)

$$\therefore V_B = 181.46 \text{ volts} \qquad \therefore V_C = 124.4 \text{ volts}$$

Step 3 : Cacuation of V_1 and I_2 :

$$V_1 = V_A - V_B = 240 - 181.46 = 58.54V$$

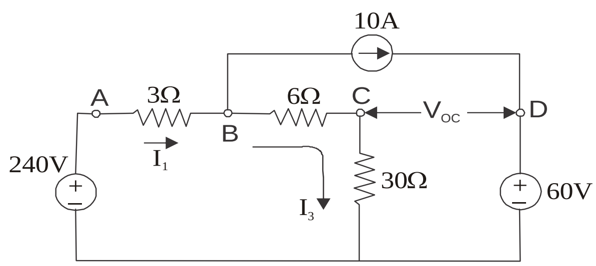
$$I_2 = \frac{V_C - V_D}{12} = \frac{124.4 - 60}{12} = 5.37A$$

Part II : Thevenin's theorem

Assuming the 12 Ω resistance is the load.

Step 1 : Calculation of V_{OC}

Applying KCL at B



(a)

$$I_1 = 10 + I_3$$

$$\therefore \frac{240 - V_B}{3} = 10 + \frac{V_B}{36}$$

$$\therefore 2860 - 12V_B = 360 + V_B$$

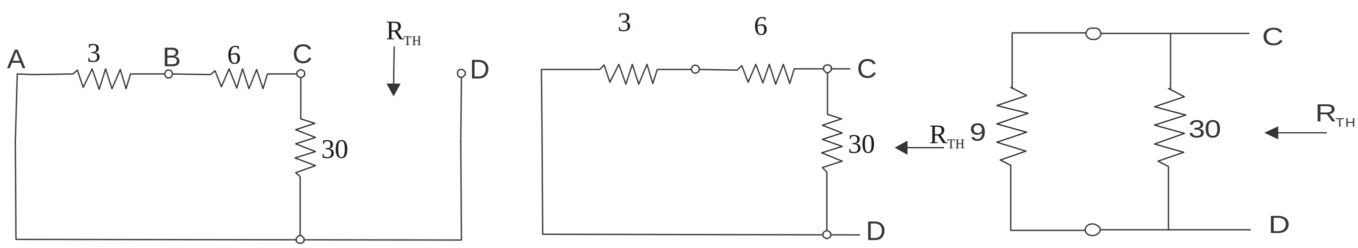
$$\therefore V_B = 193.85V$$

$$\therefore V_C = \frac{30}{30+6} \times V_B = \frac{30}{36} \times 193.85 = 161.54V$$

$$\therefore V_{OC} = V_C - V_D = 161.54 - 60 = 101.54V$$

Step 2 : Calculation of R_{TH} :

$$R_{TH} = 9 \,||\, 30 = \frac{9x30}{39} = 6.92\Omega$$



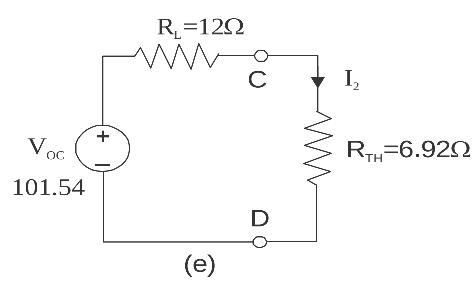
(b) (c) (d)

Step 3 : Calculation of I_2

From Fig. (e),

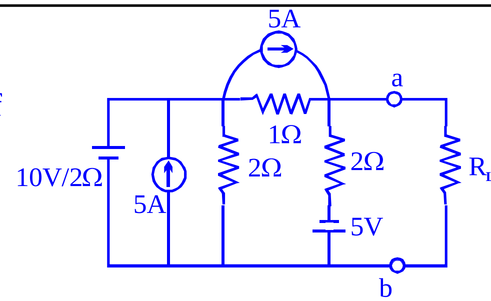
$$I_2 = \frac{V_{OC}}{R_{TH} + R_L} = \frac{101.54}{6.92 + 12}$$

$$\therefore I_2 = 5.37 \text{ Amp}$$



(e)

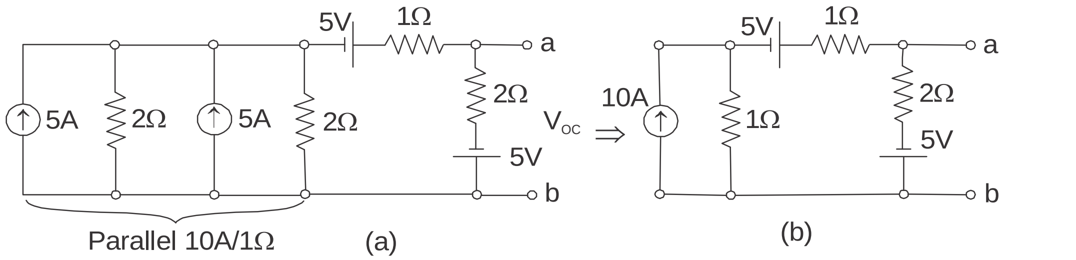
(6) For given circuit find the Thevenin's equivalent circuit across a-b and hence find the current through load of 10Ω. Verify the same with superposition theorem. **[D-07[12]**



Solution:

Step 1 : To find V_{OC}

Converting the $10V/2\,\Omega$ source into a current source of 5A and $2\,\Omega$ and converting the current source of $5A/1\,\Omega$ into a voltage source of 5V and $1\,\Omega$ as shown in fig. (a).

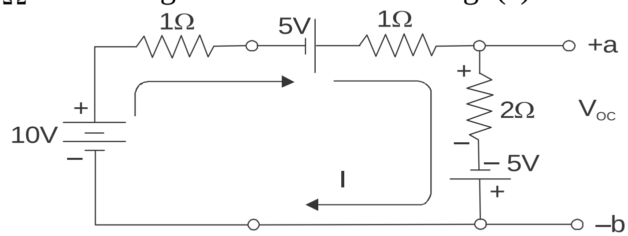


(a) (b)

Converting the current source of $10A/1\,\Omega$ to a voltage source as shown in fig. (c)

$$I=\frac{(10+5+5)}{4\Omega}=5A$$

$$V_{OC}=2I-5=2\,x\,5-5=5V$$

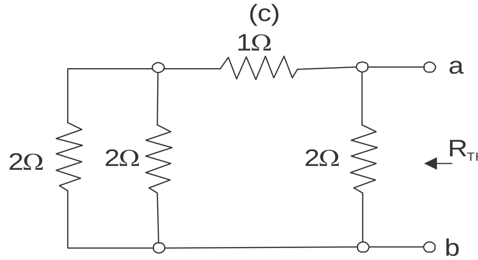


(c)

Step 2 : To find R_{TH}

$$R_{TH}=\left[(2\,||\,2)+1\right]||\,2$$

$$=\left[2\,||\,2\right]=1\Omega$$



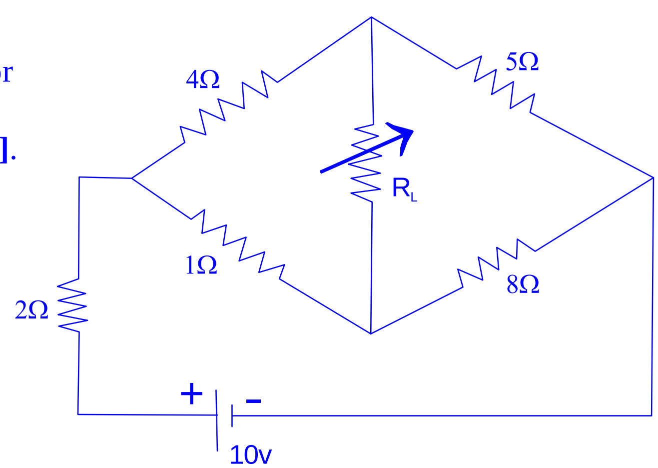
(d)

Step 3 : To find I_L

$$I_L=\frac{V_{OC}}{R_{TH}+R_L}=\frac{5}{1+10}=0.4545\,A$$

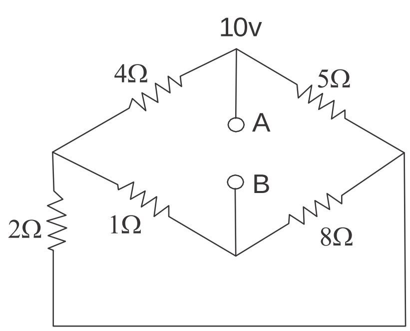
Type IX : Maximum Power Transfer Theorem

(1) For the given circuit find the value of R_L for maximum power transfer and calculate the maximum power absorbed by R_L **[D-14][8]**.

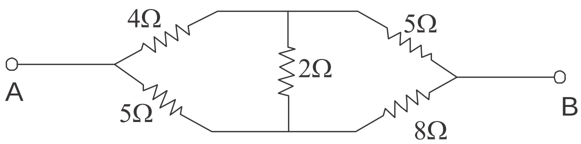


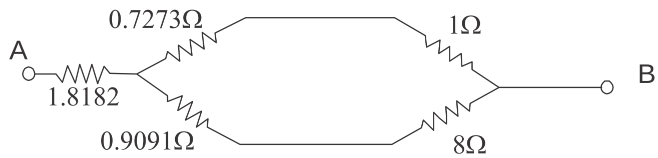
Solution:-

(I) Calculation of R_{TH}: Open circuit R_L



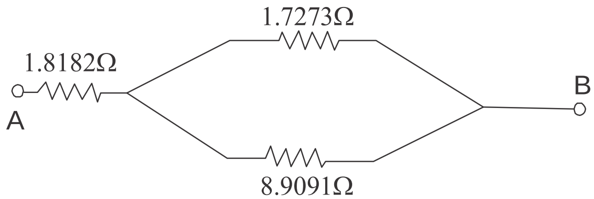
Redrawing the circuit





$$R_{TH} = R_L = 1.8182 + (1.7273 \| 8.9091)$$

$$R_L = 3.265\Omega$$



(II) Calculation of V_{TH} : Open circuit R_L

$$I = \frac{10}{6.5} = 1.5385\,A$$

Current Division Rule

$$I_1 = 0.76928\,A \qquad I_2 = 0.76923\,A$$

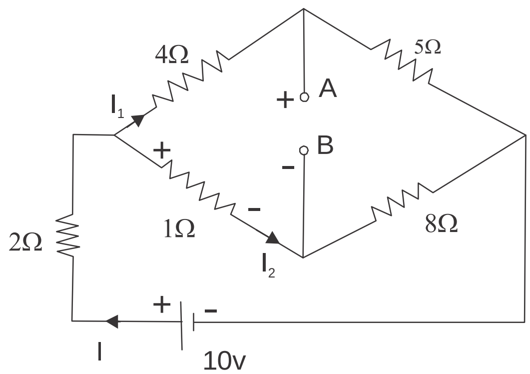
By applying KVL to loop,

$$-4I_1 - V_{TH} + 1 \times I_2 = 0$$

$$\therefore\ E = V_{TH} = 0.76923 - 4 \times 0.76923$$

$$V_{TH} = -2.3077\,V$$

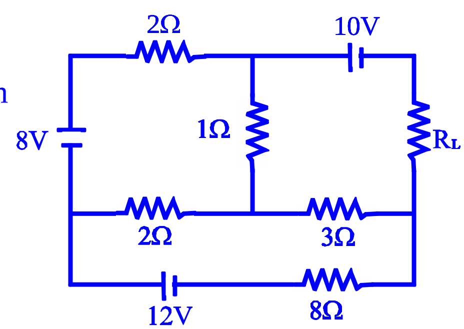
$$\therefore\ V_{TH} = 2.3077\,V \quad (B \text{ position w.r.t. } A)$$



(III) Maximum Power absorbed by R_L

$$P_{L\max} = \frac{E^2}{4R_L} = \frac{(2.3077)^2}{4 \times 3.265} = 0.41\,W$$

(2) For the given circuit find the value of 'R_L' so the maximum power dissipated in it. Also find P_{max}. **[D-13][8]**



Solution:-

Theremin's equivalent circuit is shown in figure

$$\therefore\ I_3 = 0$$

Apply KVL to mesh 1.

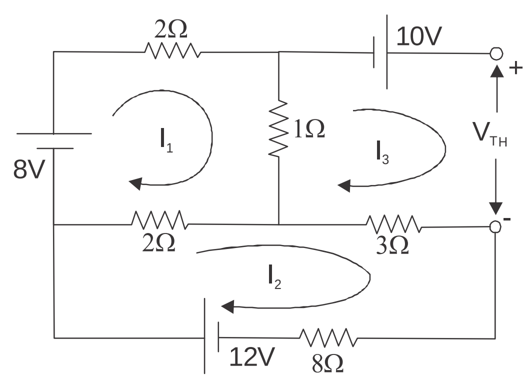
$$8 - 2I_1 - 1(I_1 - I_3) - 2(I_1 - I_2) = 0$$

$$5I_1 - 2I_2 = 8 \qquad .....(1)$$

Apply KVL to mesh 2.

$$12 - 2(I_2 - I_1) - 3(I_2 - I_3) - 8I_2 = 0$$

$$-2I_1 + 13I_2 = 12 \qquad ....(2)$$



Solving (1) and (2)

$$\therefore\ I_1 = 2.098\,\text{Amp and } I_2 = 1.246\,\text{Amp}$$

Writing KVL Equation for V_{TH}

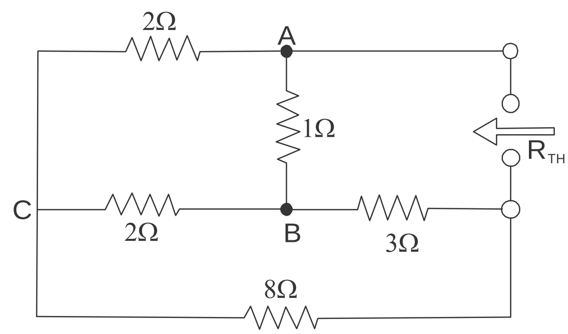
$$10 - V_{TH} - 3(I_3 - I_2) - 1(I_3 - I_1) = 0$$

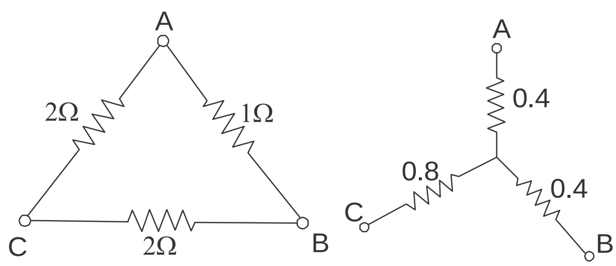
$$\therefore\ V_{TH} = 10 - 3(-I_2) - 1(-I_1) = 10 + 3I_2 + I_1$$

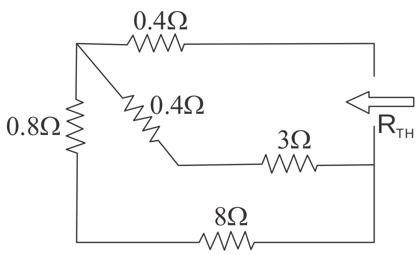
$$V_{TH} = 15.836\ \text{volt}$$

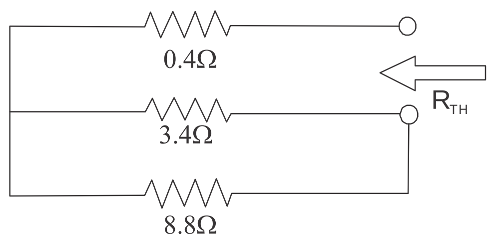
For $R_{TH,}$ short all voltage sources

Delta to star transformation

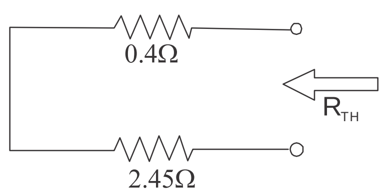








$$R_{TH} = 0.4 + 2.45 \Rightarrow R_{TH} = 2.85\Omega$$

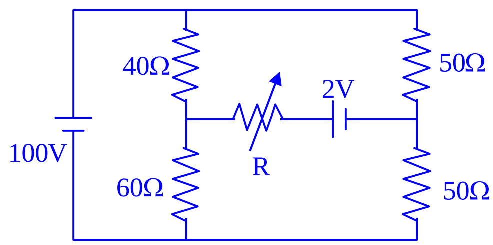


For Maximum Power Transfer

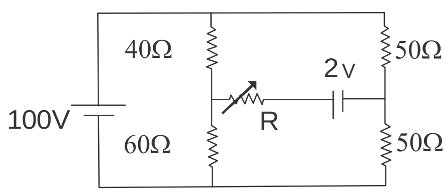
$$R_L = R_{TH} \Rightarrow R_L = 2.85\Omega$$

$$\therefore P_{max} = \frac{V_{TH}^2}{4R_{TH}} = \frac{15.836^2}{4 \times 2.85} = 21.98\ \text{watt}$$

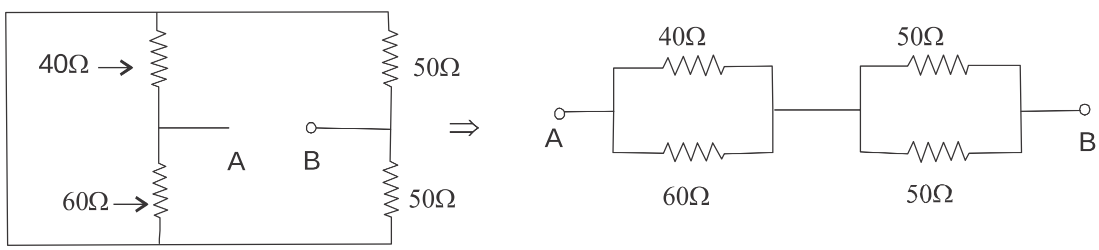
(3) Determine the value of R for maximum power transfer. Also find the magnitude maximum power transferred. **[D-12][8]**



Solution:-



For maximum power, R = R_{equi}



$R_{equi} = 24 + 25 = 49\,\Omega$

$\therefore R = 49\Omega$

Calculation of V_{TH}

KVL to mesh 1 : $100I_1 - 100I_2 = 100$

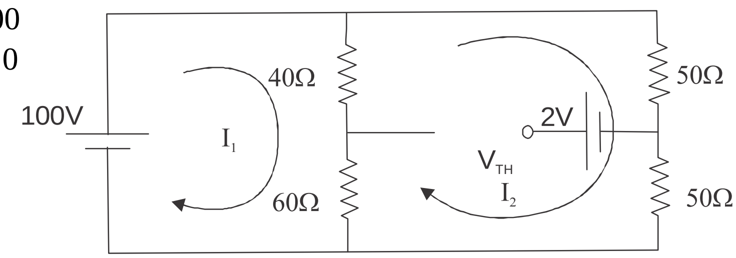
KVL to mesh 2 : $-100I_1 + 200I_2 = 0$

$I_1 = 2$ Amp; $I_2 = 1$ Amp

$V_{TH} - 40(I_2 - I_1) - 50I_2 + 2 = 0$

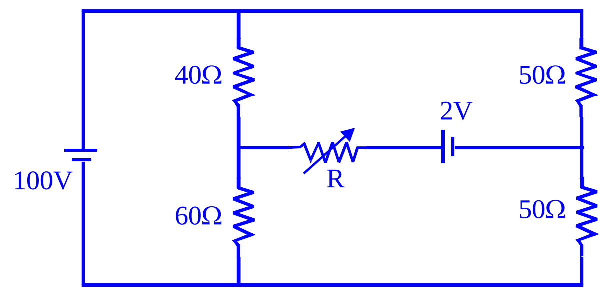
$\therefore V_{TH} = 40(I_2 - I_1) + 50I_2 - 2$

$\therefore V_{TH} = 8V$



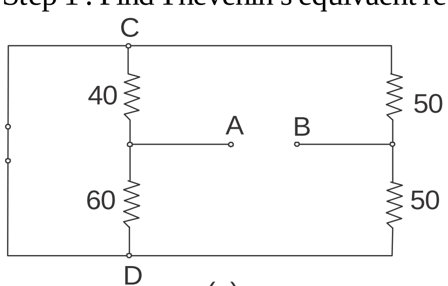
$$\therefore P_{max} = \frac{V_{TH}^2}{4R_{TH}} = \frac{8^2}{4 \text{ x } 49} = 0.32 \text{ watt}$$

(4) Determine the value of R for maximum power transfer. Also find magnitude of maximum power transferred. **[M-08][10]**

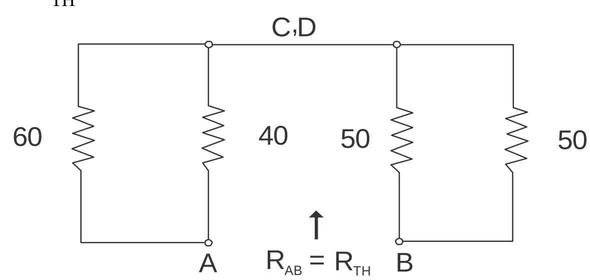


Solution :

Step 1 : Find Thevenin's equivaent resistance R_{TH} :



(a)



(b)

From Fig. (b), $R_{AB} = R_{TH} = (60 \,||\, 40) + (50 \,||\, 50)$

$= 24 + 25$

$\therefore R_{TH} = 49\Omega$

The value of R for the transfer of maximum power is 49 Ω,

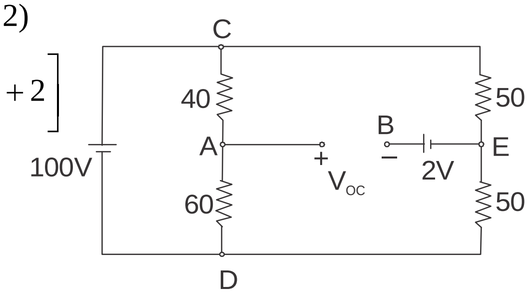
$\therefore R = R_{TH} = 49\Omega$

Step 2 : Find V_{OC} :

$V_{OC} = V_{AB} = V_{AD} - V_{BD} = V_{AD} - (V_{ED} + 2)$

$$= \frac{60}{40+60} \text{ x } 100 - \left[\frac{50}{50+50} \text{x} 100 + 2\right]$$

$\therefore V_{OC} = 60 - (50 + 2) = 8V$

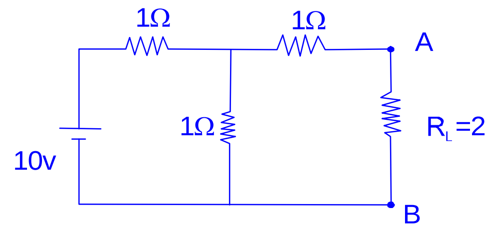


Step 3 : Find P_{Lmax} :

$$P_{Lmax} = \frac{V_{OC}^2}{4R} = \frac{(8)^2}{4 \text{ x } 49} = 0.3265 \text{ W}$$

Type X: Nortons Theorem

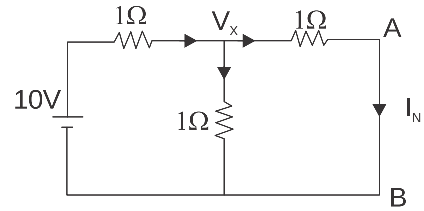
(1) For the given circuit find the Norton equivalent between points A and B. **[M-15][3]**



Solution:-

(i) Calculation of I_N : Short circuit R_L

Apply KCL at V_X,



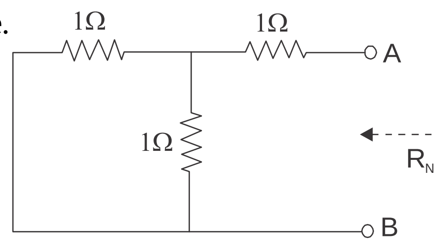
$$\frac{10-V_X}{1}=\frac{V_X}{1}+\frac{V_X}{1}$$

$$\therefore 10=3V_X \Rightarrow V_X=3.333V$$

$$\therefore I_N=\frac{V_X}{1}=3.3333A\ (A\text{ to }B)$$

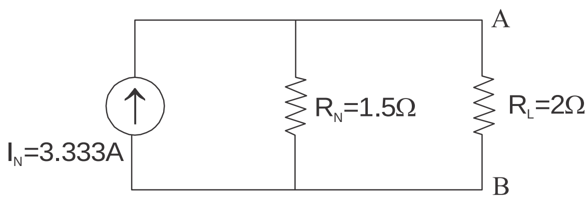
(ii) Calculation of R_N

Open circuit current source & short circuit Voltage source.

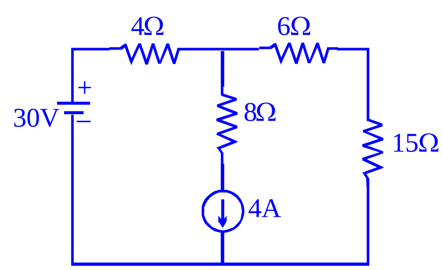


$$R_N=(1\|1)+1=1.5\Omega$$

(iii) Norton's equivalent circuit :



(2) Using Norton's theorem, calculate the current flowing through 15Ω load resistor in the given circuit. **[M-13][8]**



Solution:-

To find I_N:

Apply KVL to mesh 1

$$12I_1-8I_2=30$$

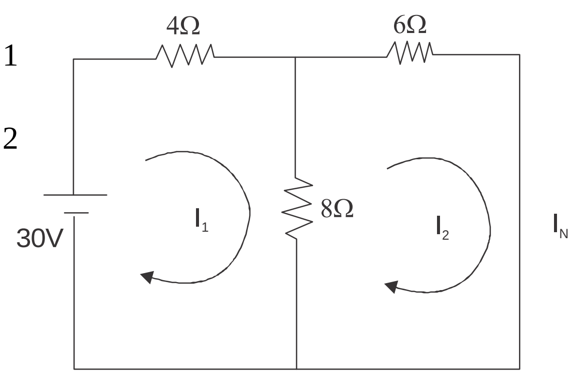
Apply KVL to mesh 2

$$-8I_1+14I_2=0$$

$$\therefore I_1=4.04\text{ Amp}$$

$$I_2=2.31\text{ Amp}$$

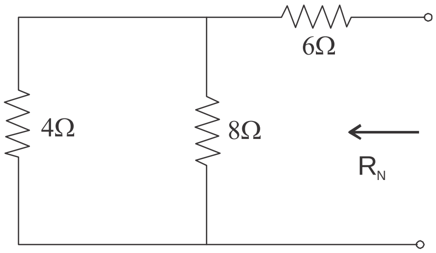
$$\therefore I_N=I_2=2.31\text{ Amp}$$

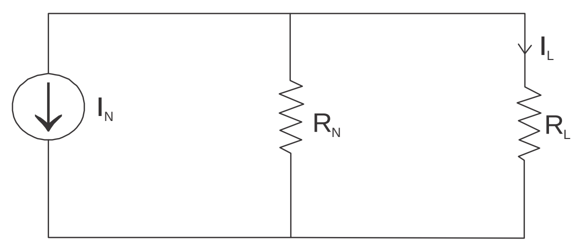


To find R_N:

$$\therefore R_N=8.67\Omega$$

$$\therefore R_L=15\Omega$$

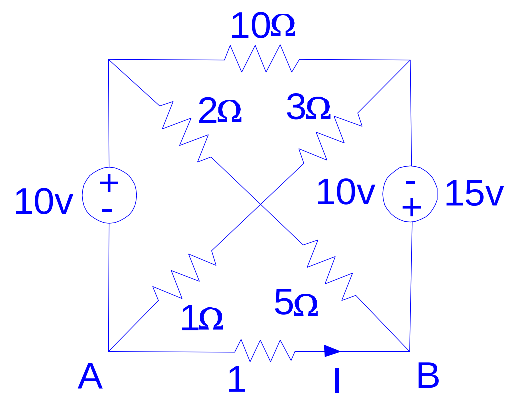




$$I_L=\frac{I_N R_N}{R_N+R_L}$$

$$\therefore I_L=0.8461\text{ Amp}$$

(3) Using Norton's Theorem find I. **[M-11][8]**



Solution:

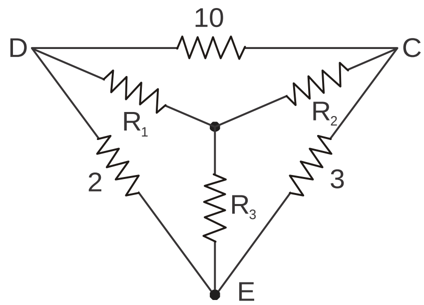
Convert the deltas into starts:

1. ΔDCE to star:

$$R_1 = \frac{10\times 2}{15} = 1.33\Omega$$

$$R_2 = \frac{10\times 3}{15} = 2\Omega$$

$$R_3 = \frac{2\times 3}{15} = 0.4\Omega$$



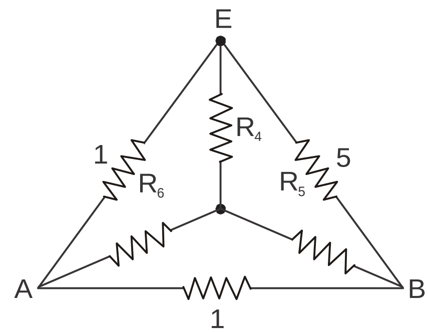
(a)

2. ΔAEB to star:

$$R_4 = \frac{1\times 5}{7} = 0.72\Omega$$

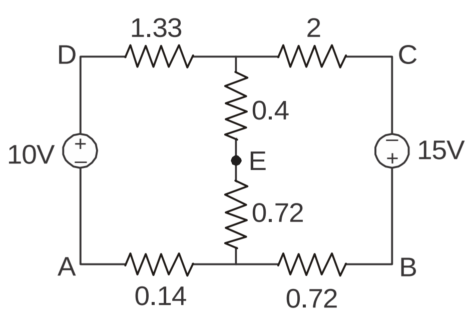
$$R_6 = \frac{1\times 1}{7} = 0.14\Omega$$

$$R_5 = \frac{1\times 5}{7} = 0.72\Omega$$

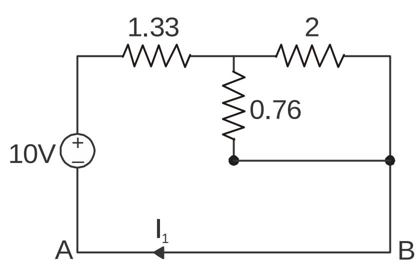


(b)

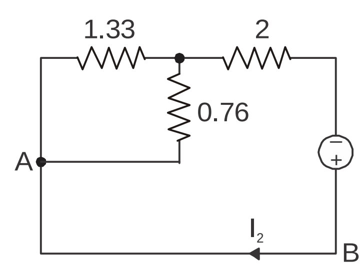
Redraw the simplified circuit:



(c)



(d)



(e)

Find I_{sc}:

We will apply superposition theorem to the simplified circuit of Fig. (c) to calculate I_{sc}.

From Fig. (d) we get

Total resistance $R_1 = 1.33 + (2 \parallel 0.76) = 0.55\Omega$

$$\therefore\ I_1 = \frac{10}{0.55} = 18.16\text{A}$$

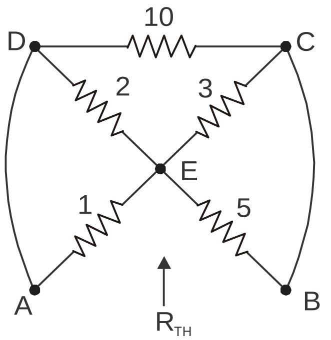
From Fig. (e) we get

Total resistance $R_2 = 2 + (1.33 \parallel 0.76) = 0.48\Omega$

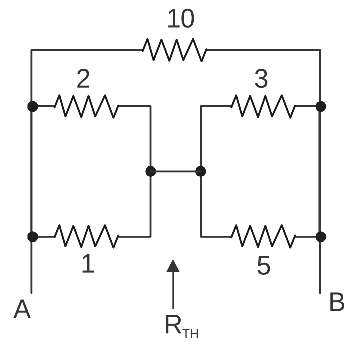
$$\therefore\ I_2 = \frac{15}{0.48} = 31.25\text{A}$$

$$\therefore\ I_{SC} = I_1 + I_2 = 18.16 + 31.25 = 49.14\text{ A}$$

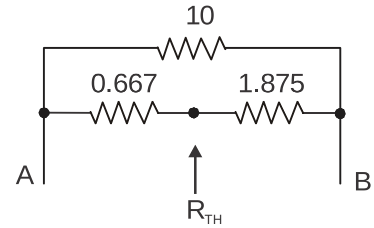
Find R_{TH}:



(f)



(g)



(h)

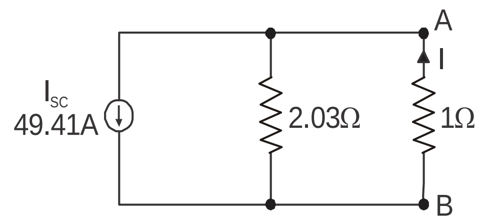
From Fig. (h) we get

$R_{TH} = 10 \parallel (0.0667 + 1.875) = 2.03\Omega$

Find I:

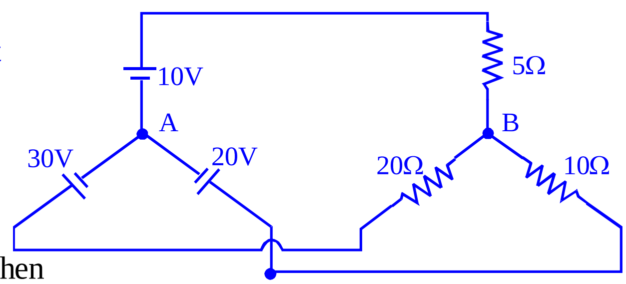
$$I = \frac{2.03}{(2.03+1)} \times 49.41$$

$$\therefore \; I = 33.1\,A\,(\text{from B to A})$$



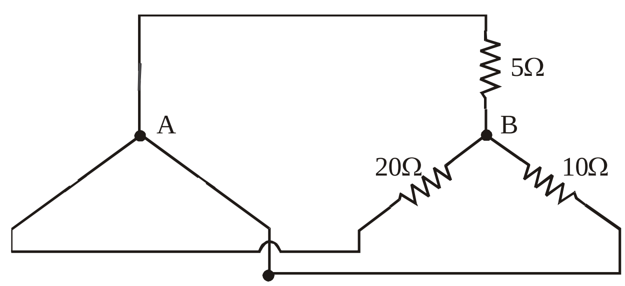
Norton's equivalent

(4) Using Norton theorem, find the current which would flow in a 25Ω resistance connected between points 'A' and 'B' **[M-10][10]**



Solution:

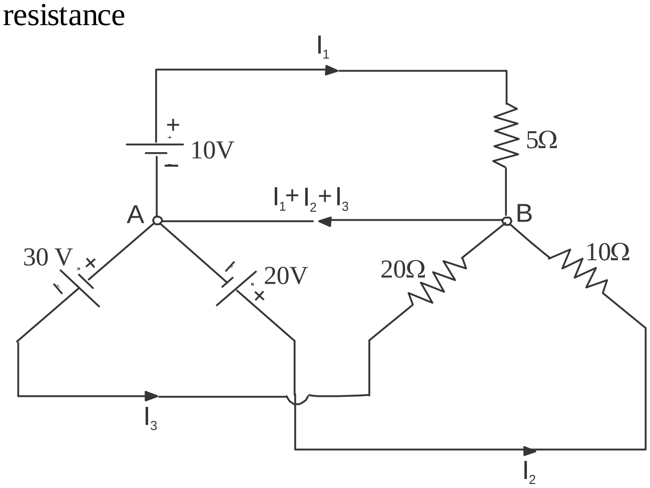
The equivalent resistance of network when viewed from terminals A and B, keeping all the voltage short circuite fig.



$$R_A = 5 \| 10 \| 20$$

$$= \frac{1}{\frac{1}{5}+\frac{1}{10}+\frac{1}{20}} = \frac{20}{7}\Omega$$

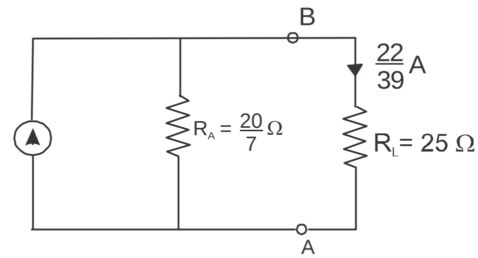
Short circuited current i.e. the current in zero resistance conductor connected across terminals AB fig



$$I_{sc} = I_1 + I_2 + I_3 = \frac{10}{5} + \frac{20}{10} + \frac{30}{20}$$

$$I_{sc} = 5.5\ A$$

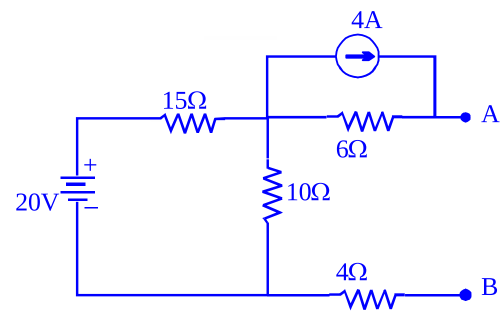
Current through a resistance of 25 Ω connected between points B and A,



$$I = \frac{I_{sc}}{R_A + R_L} \times R_A = \frac{5.5 \times \frac{20}{7}}{\frac{20}{7} + 25}$$

$$\therefore \quad I = \frac{22}{39}\,A$$

(5) Find the Nortons equivalent circuit for the active linear network shown: **[D-09][10]**



Solution:-

Step 1 : Find I_{sc}

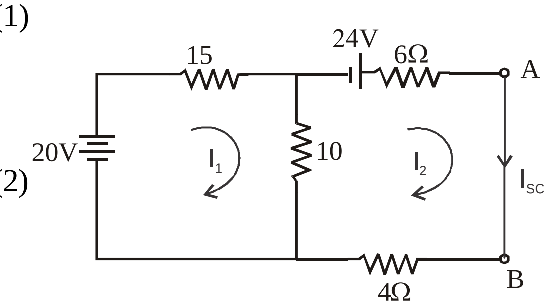
Convert the 4 A source into a voltage source

Apply KVL

$$15I_1 + 10\,(I_1 - I_2) = 20$$

$$25I_1 - 10\,I_2 = 20 \qquad ...(1)$$

Apply KVL to loop 2



$$6\,I_2 + 4\,I_2 + 10\,(I_2 - I_1) = 24$$

$$20\,I_2 - 10\,I_1 = 24$$

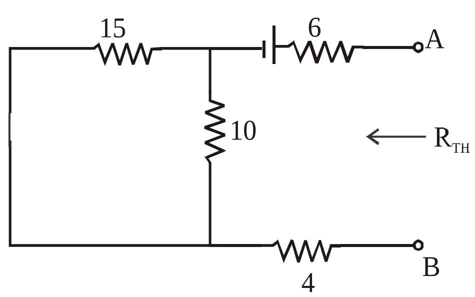
$$\therefore \quad -10\,I_1 + 20\,I_2 = 24 \qquad ...(2)$$

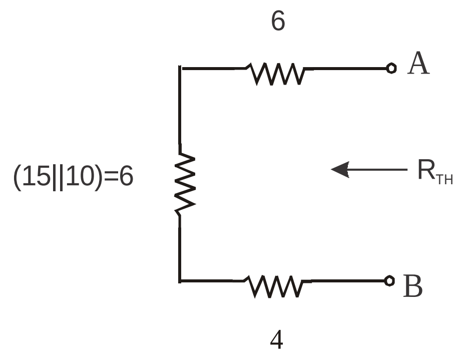
Solving equation (1) by (2) to get

$$\therefore \quad I_1 = 1.6\text{ A and } I_2 = 2A$$

$$\therefore \quad I_{sc} = I_2 = 2A$$

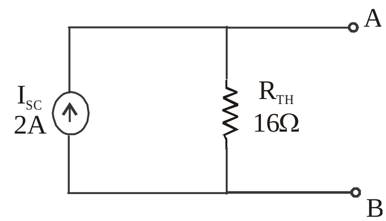
Step 2 : Find R_{TH}



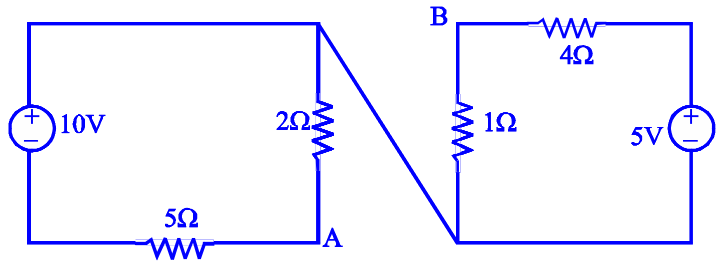


$$\therefore \quad R_{TH} = 6 + 6 + 4 = 16\Omega$$

Step 3 : Draw Norton's equivalent circuit

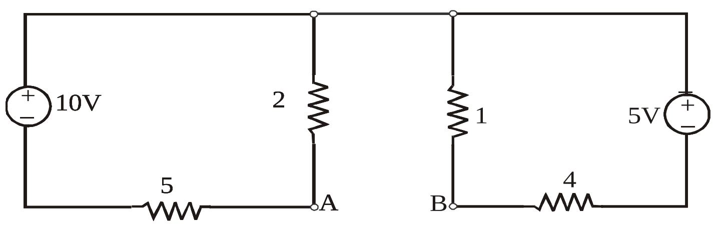


(6) Obtain Norton's equivalent circuit across A and B as shown in figure. **[D-08][8]**

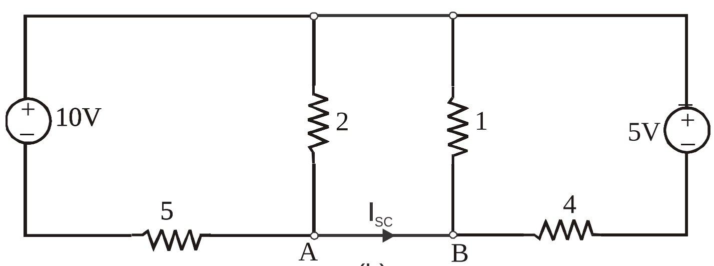


Solution:-

Step 1: Calculation of I_{SC} :
Short circuit points A and B

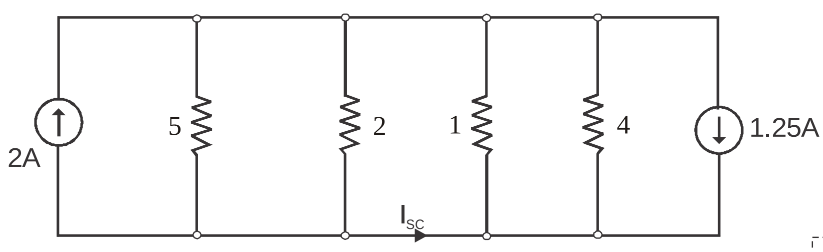


(a)



(b)

Converting the voltage sources into current source and redrawn as shown in fig. (c) and then converting the current source to voltage source as shown in Fig. (d)

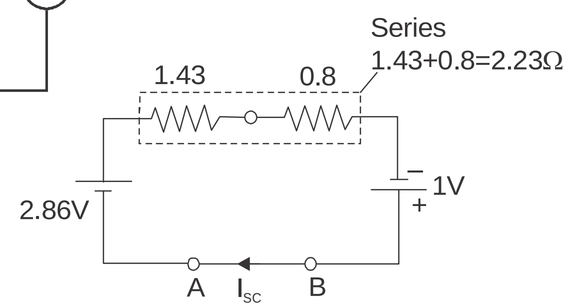


(c)

From fig (d)

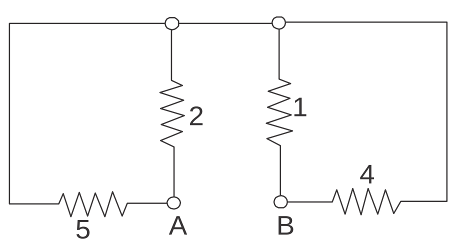
$$2.86 = 2.23 I_{SC} - 1$$

$$\therefore I_{SC} = \frac{3.86}{2.23} = 1.73\,A$$

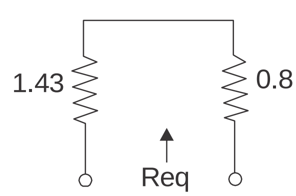


(d)

Step 2 : Calculation of R_{eq}
Form Fig. (a) draw the equivalent circuit of Fig. (e) to calculate R_{eq}

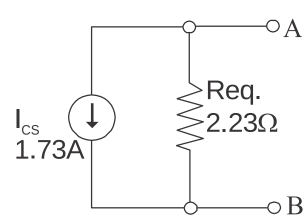


(e)



(f)

Step 3 : Norton's equivaent circuit :
Fig. (g) shows Norton's equivalent circuit



(g)

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