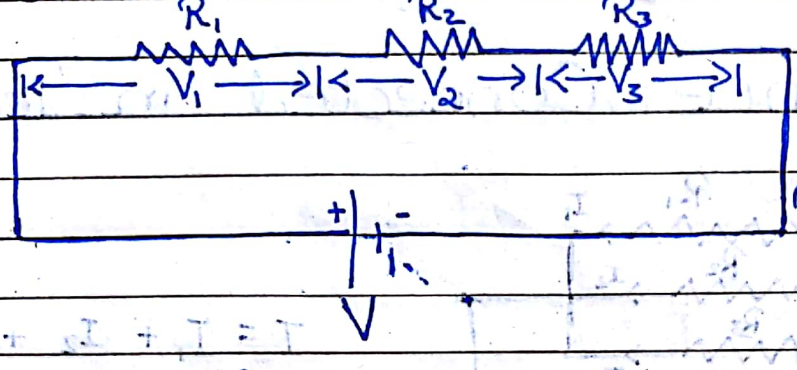
CH: Basics Of Electronics and Electrical Engineering

1. Resistance are connected in series



$V = V_1 + V_2 + V_3$

$R_{eq} = R_1 + R_2 + R_3$

Concept of series circuit:

i] The current flowing in all elements of circuit is same.

ii] Voltage drop across diff elements is depe on value of resistance.

iii] The applied voltage is equal to summissi of voltage drop.

Disadvantages of Series Circuit:

i] If a break occurs at any point in th circuit, no current will flow and the entire circuit becomes useless.

Application

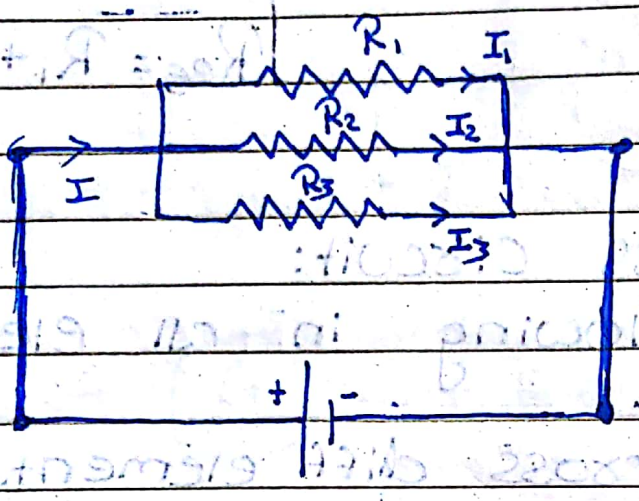
i] For decorative lights

ii] Connecting the regulator with the Fan.

Voltage divider Rule

$$V_n = \frac{V \times R_n}{R_{eq}}$$

Resistance Connected in Parallel



$$I = I_1 + I_2 + I_3$$

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

Concept of parallel circuit:

i] Voltage across all the element is same.

ii] All the elements have diff value of current depending on the value of resistance

iii] The value of total resistance of parallel circuit is always less than the smallest value of resistance.

Advantages

If a break occurs in one of the branch of the circuit, it will have no effect on other branch of the circuit.

- Application:

All domestic connection are run in parallel, so that the working voltage of each equipment is equal to supply voltage.

Current divider rule:

$$I_1 = \frac{I \times R_{eq}}{R_1}$$

$V = I_1 R_1$

$V = I_2 R_2$

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

$$\frac{I_1}{I - I_1} = \frac{R_2}{R_1} \Rightarrow \boxed{I_1 = \frac{R_2}{R_1 + R_2} I}$$

eg: Resistance R is connected in series with parallel circuit consisting of two resistors 12 and 8 Ω. The total power dissipated in the circuit is 280 W. The applied voltage is 44 V. Calculate the value of R.

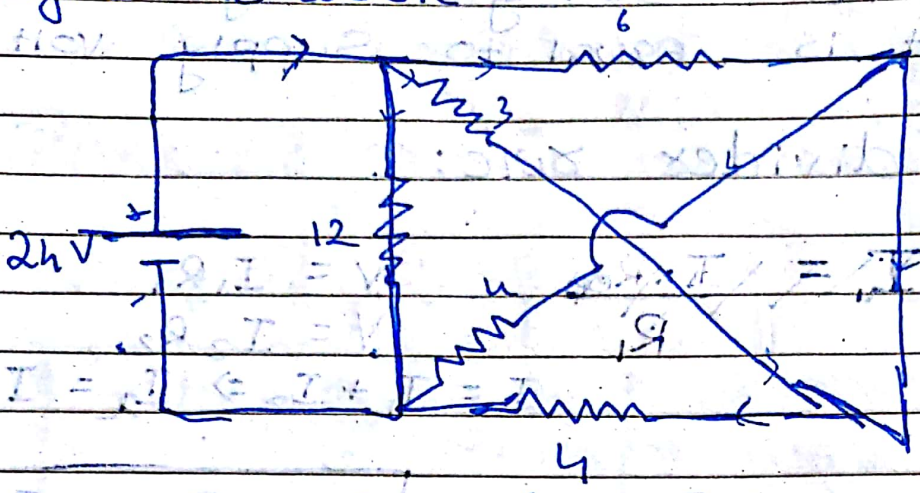
$$R_{eq} = R + \frac{24}{5} \qquad P = \frac{V^2}{R}$$

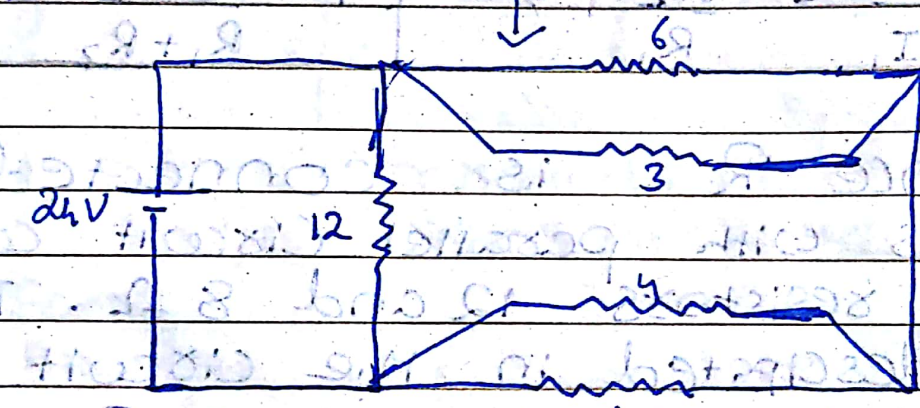
$$280 = \frac{44 \times 44}{R + \frac{24}{5}}$$

$$R + \frac{24}{5} = \frac{22 \times 11}{35}$$

$$R = 2.11$$

eg:- Calculate the value of current supplied by the battery for the given network.

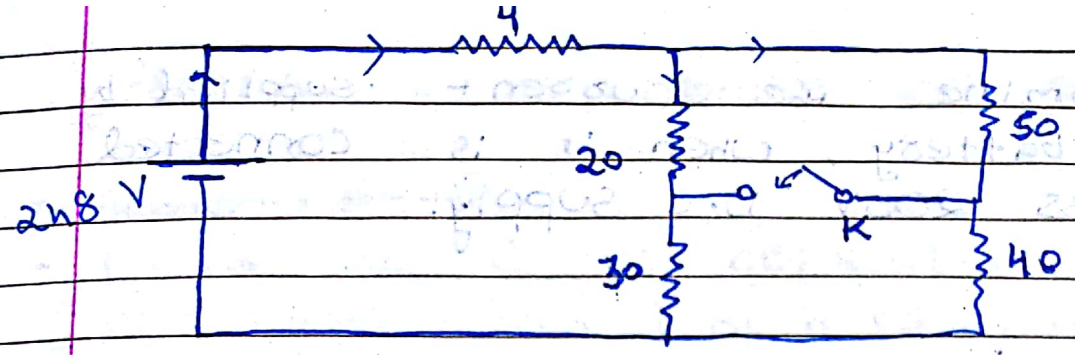




$\Rightarrow R_{eq} = 3$

$V = I R_{eq} + I = \frac{24}{3} = 8\ A$

What is current through switch K when it is closed in the given network.

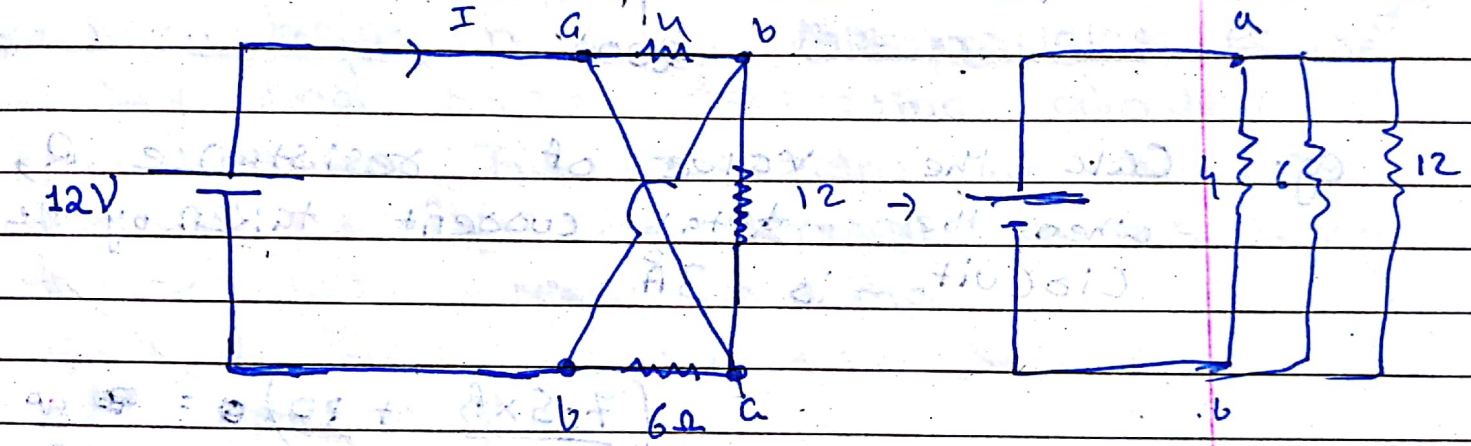


50||20 = 14.28 Ω

30||70 = 17.14 Ω

$I = \frac{35}{35.42} \Rightarrow I = 7.00$ A

Eg: Find the current supplied by the battery for the given network.



$R = 2\Omega$

$I = 6$ A

g: Determine the value of R so that current supplied by battery is 5A.

V → 15 V

$\frac{1}{2} + \frac{1}{3}$

$\frac{r}{10} + \frac{1}{7?}$ $\frac{1}{5}$

$\frac{3 \times 2}{5}$

$\frac{3.7 \times R}{3.7 + R} = 3$

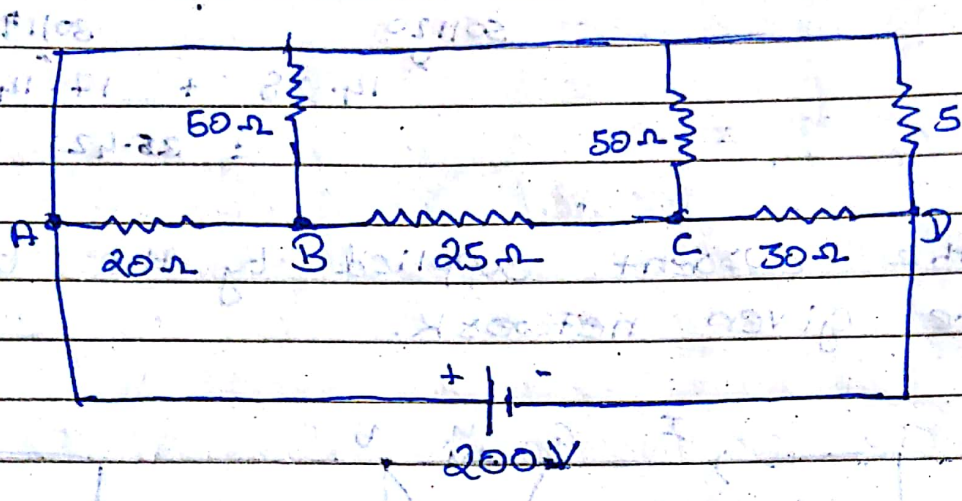
$\frac{6R}{6+R} = 3$

$11.1 = 0.7R$

$3R = 3 \times 6$

$R = 6$

eg:- Determine the current supplied by the battery, when it is connected across 200V D.C supply.



eg: Calc the value of resistance R, when the total current taken by the circuit is 3A

$$\left(\frac{7.5 \times R}{7.5 + R} + \frac{30}{3}\right) = \frac{40}{3}$$

$$\frac{10}{3} = \frac{7.5R}{7.5+R}$$

$$75 + 10R = 22.5R$$

$$12.5R = 75$$

$$R = 6\ \Omega$$

Effect of temperature on resistance

~~= Ratio of P~~

- Ohm's law is not applicable to ~~diode~~ non linear devices, such as diode, transist zener diode etc.

i) of Pure metal:

For pure metals, resistance increases linearly with increase in temperature.

Reason: At low temp, the charge particl inside the conductor are almost stationar With increase in temp, this particles equire energy and start oscillating about their mean position. This movement of particle opposes the flow of electron, so resistance increases with increase in temp.

ii) of metal alloy:

For metal alloys, resistance increases with in in temp, but the rate of change of resistan with temp is less compared to pure met

iii] of insulators:

The resistance of insulator decreases wi increase in temp.

Reason: As the temp increases, some e⁻'s ac energy and become free for conduction, he the conductivity increases and resistance decreases with increase in temp.

iv] Of Semiconductor:

Semiconductor materials have -Ve temp coefficent of resistivity; that means that resistance decreases with inc' in temperature.

Reason: As temp increases some valence $e^{\ominus}$'s recieve energy and cross the energy gap and enter into the conduction band, which increases conductivity, so resistance decreases with increase in temp.

Resistance Temperature Co-efficent

$$R_2 = R_1 [1 + \alpha_1 (t_2 - t_1)]$$

$$R_1 = R_2 [1 + \alpha_2 (t_1 - t_2)]$$

$$R_2 = R_2 [1 + \alpha_2 (t_1 - t_2)][1 + \alpha_1 (t_2 - t_1)]$$

$$1 + \alpha_1 \Delta t - \alpha_2 \Delta t - \alpha_1 \alpha_2 (\Delta t)^2 = 1$$

$$\alpha_1 - \alpha_2 - \alpha_1 \alpha_2 \Delta t = 0$$

$$\alpha_1 = \alpha_2 (1 + \alpha_1 \Delta t)$$

$$\alpha_2 = \frac{\alpha_1}{1 + \alpha_1 \Delta t} \qquad \Delta t = t_2 - t_1$$

Eg: At 0°C copper wire has its resistance equal to $4 \times 10^{-3}\ \Omega$ and its temp coeff of resistance equal to $1/234.5$ per °C. Find the value of its resistance and temp coefficient of resistance at 70°C.

$$\alpha_2 = \frac{1}{234.5 + 70} = \frac{1}{304.5}$$

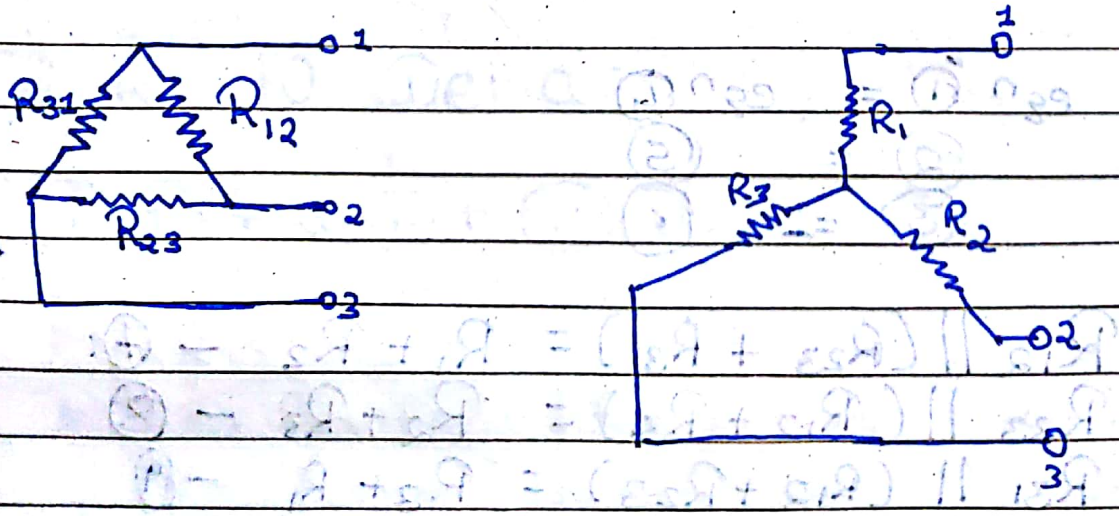
$$R_2 = 4 \times 10^{-3} \left[1 + \frac{1}{234.5} \times 343\right]$$

$$= 5.149 \times 10^{-3}\ \Omega$$

Delta to Star or Star to Delta Transformation

→ When large no of unknown's are there, this method is used.

i) Delta to star:



Resistance between terminal 1 and 2 in delta
$R_{12} \,||\, (R_{23} + R_{31})$ — (1)

Resistance between terminal 2 and 3 in delta
$R_{23} \,||\, (R_{12} + R_{31})$ — (2)

Resistance between terminal 3 and 1 in delta
$R_{31} \,||\, (R_{12} + R_{23})$ — (3)

Resistance between terminal 1 and 2 in star
is $R_1 + R_2$ — (4)

Resistance " " " " 2 and 3 " "
is $R_2 + R_3$ — (5)

Resistance " " " " 3 and 1 " "
is $R_3 + R_1$ — (6)

Delta = Star

$\Rightarrow$ eqn (1) = eqn (4)
(2) = (5)
(3) = (6)

$R_{12} \,||\, (R_{23} + R_{31}) = R_1 + R_2$ — (7)
$R_{23} \,||\, (R_{12} + R_{31}) = R_2 + R_3$ — (8)
$R_{31} \,||\, (R_{12} + R_{23}) = R_3 + R_1$ — (9)

To find R_1 ⇒ ⑦ − ⑧ + ⑨

$$\Rightarrow 2R_1 = [R_{12} \,||\, (R_{23} + R_{31})] - [R_{23} \,||\, (R_{12} + R_{31})] + [R_{31} \,||\, (R_{12} + R_{23})]$$

$$2R_1 = \frac{R_{12}(R_{23} + R_{31})}{R_{12} + R_{23} + R_{31}}$$

$$2R_1 = [R_{12} \cdot R_{23} + R_{31} R_{12} - R_{23} R_{12} - R_{31} \cdot R_{32} + R_{31} \cdot R_{12} + R_{31} \cdot R_{23}] / [R_{12} + R_{23} + R_{31}]$$

$$\boxed{R_1 = R_{31} \cdot R_{12}}$$

$$\boxed{R_1 = \frac{R_{31} \cdot R_{12}}{R_{12} + R_{23} + R_{31}}} \quad - (10)$$

$$R_2 = \frac{R_{32} \cdot R_{21}}{R_{12} + R_{23} + R_{31}} \quad - (11)$$

$$R_3 = \frac{R_{31} \cdot R_{32}}{R_{12} + R_{23} + R_{31}} \quad - (12)$$

STAR TO Delta:

(10)(11) + (11)(12) + (10)(12)

$$\frac{R_{12} \cdot R_{23} \cdot R_{31}}{(R_{12} + R_{23} + R_{31})^2} \left[R_{12} + R_{23} + R_{31} \right]$$

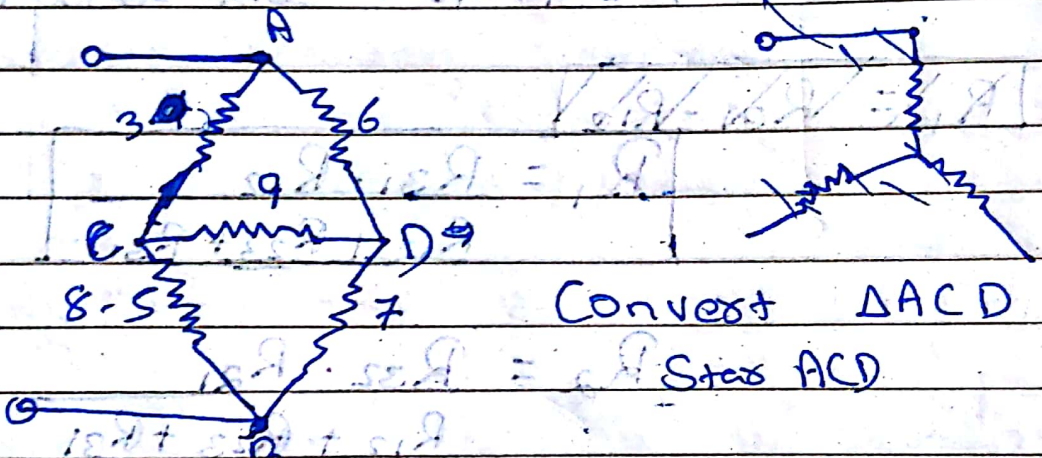
$$\frac{R_{12} \cdot R_{23} \cdot R_{31}}{R_{12} + R_{23} + R_{31}} = \boxed{R_{12} \cdot R_3}$$

$$\Rightarrow \boxed{R_1R_2 + R_2R_3 + R_3R_1 = R_{12} \cdot R_3}$$

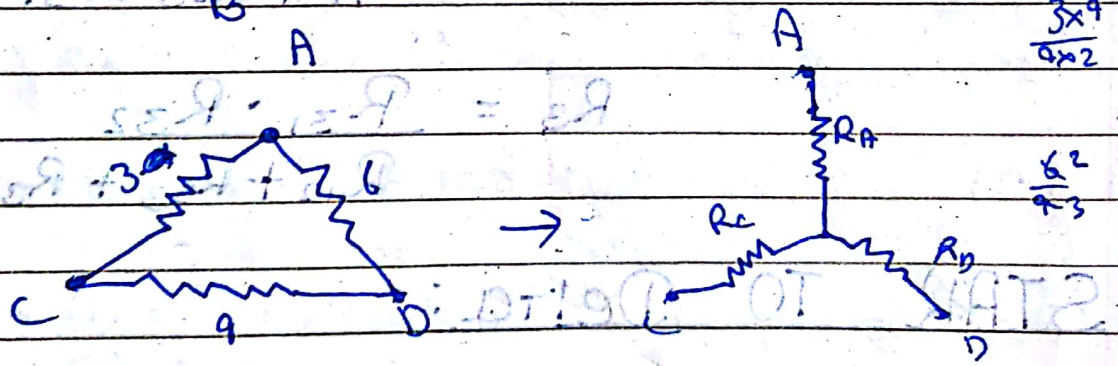
$$\Rightarrow R_1R_2 + R_2R_3 + R_3R_1 = R_{23} \cdot R_1$$

$$R_1R_2 + R_2R_3 + R_3R_1 = R_{31} \cdot R_2$$

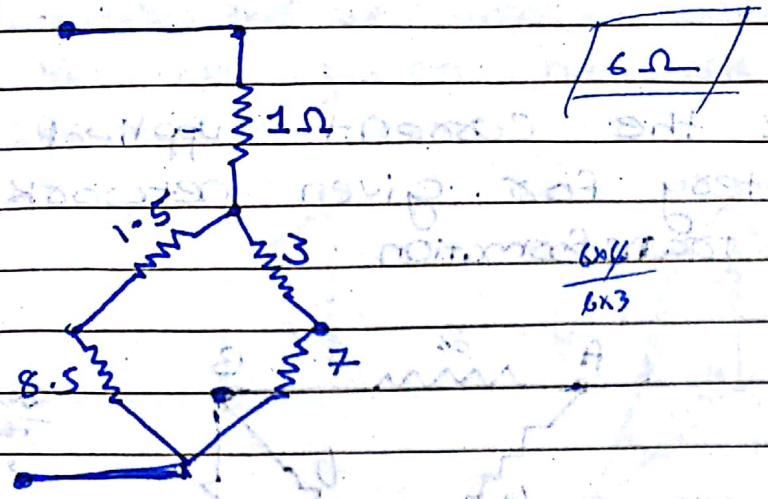
eg: Using delta/star transformation, find the value of equivalent resistance between points A and B for given network.



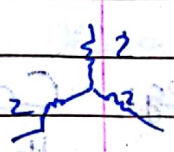
Convert ΔACD to Star ACD



$R_A = 1\ \Omega$ $R_C = 1.5\ \Omega$ $R_D = 3\ \Omega$

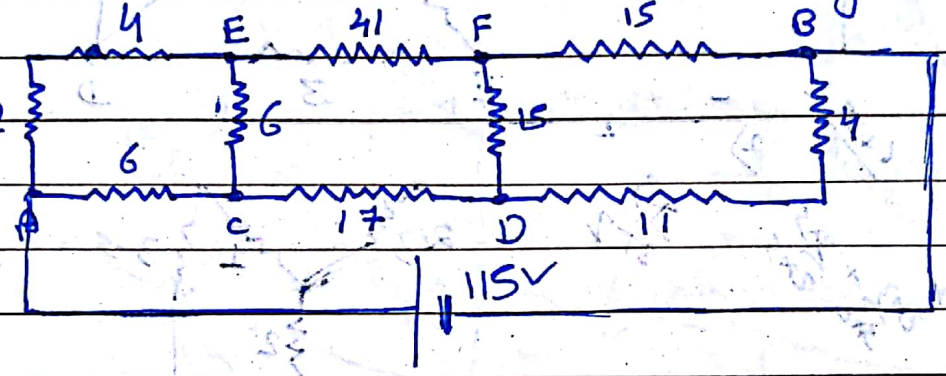


6Ω



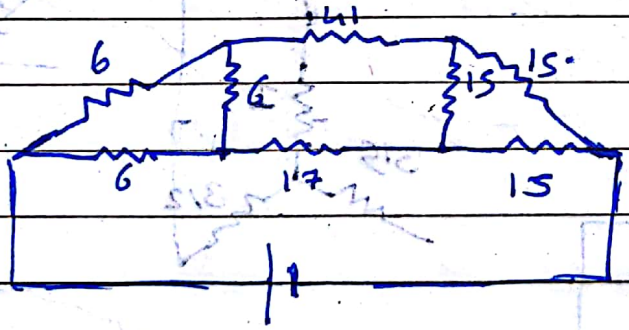
6×6 / 6×3

Eg: Using delta/star transformation, determine the current in 17Ω resistor for the given network



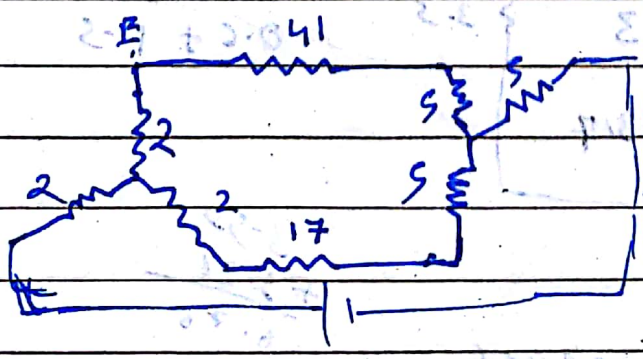
5

15×15 / 15×3



17 + 7

24



48

23

24

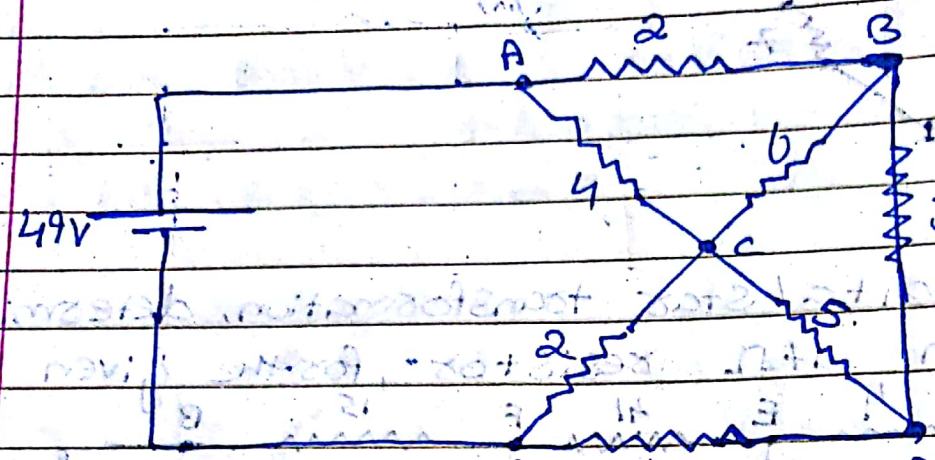
5Ω

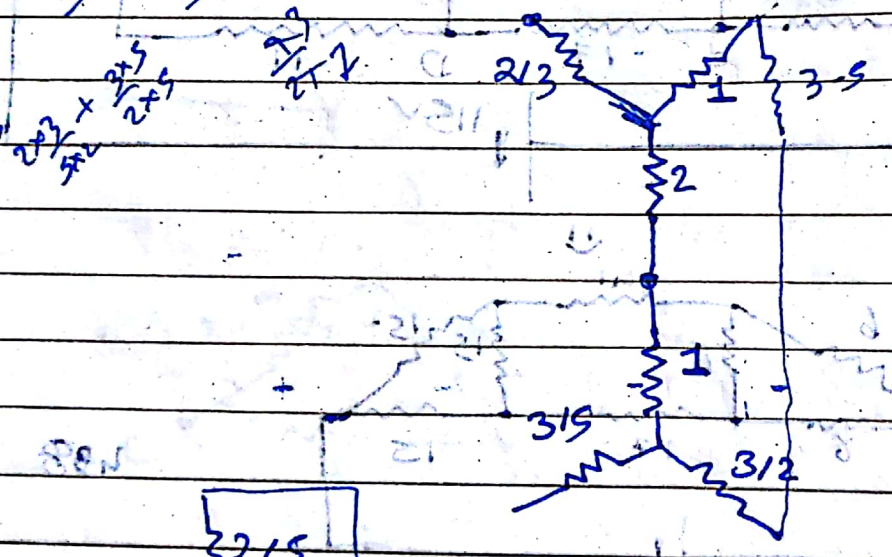
2:1

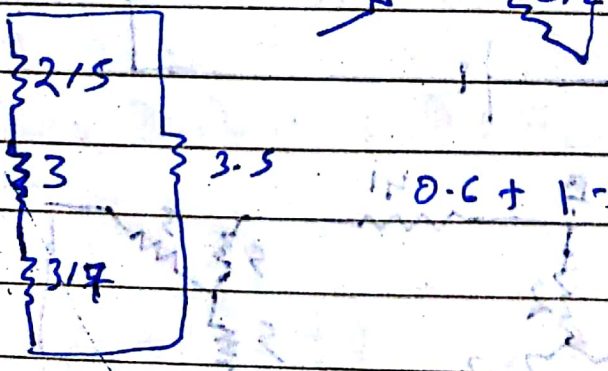
$I = 5\,\Omega$

$\Rightarrow I_{17} = 10/3$

eg: Calculate the current supplied by the battery for given network delta/star transformation







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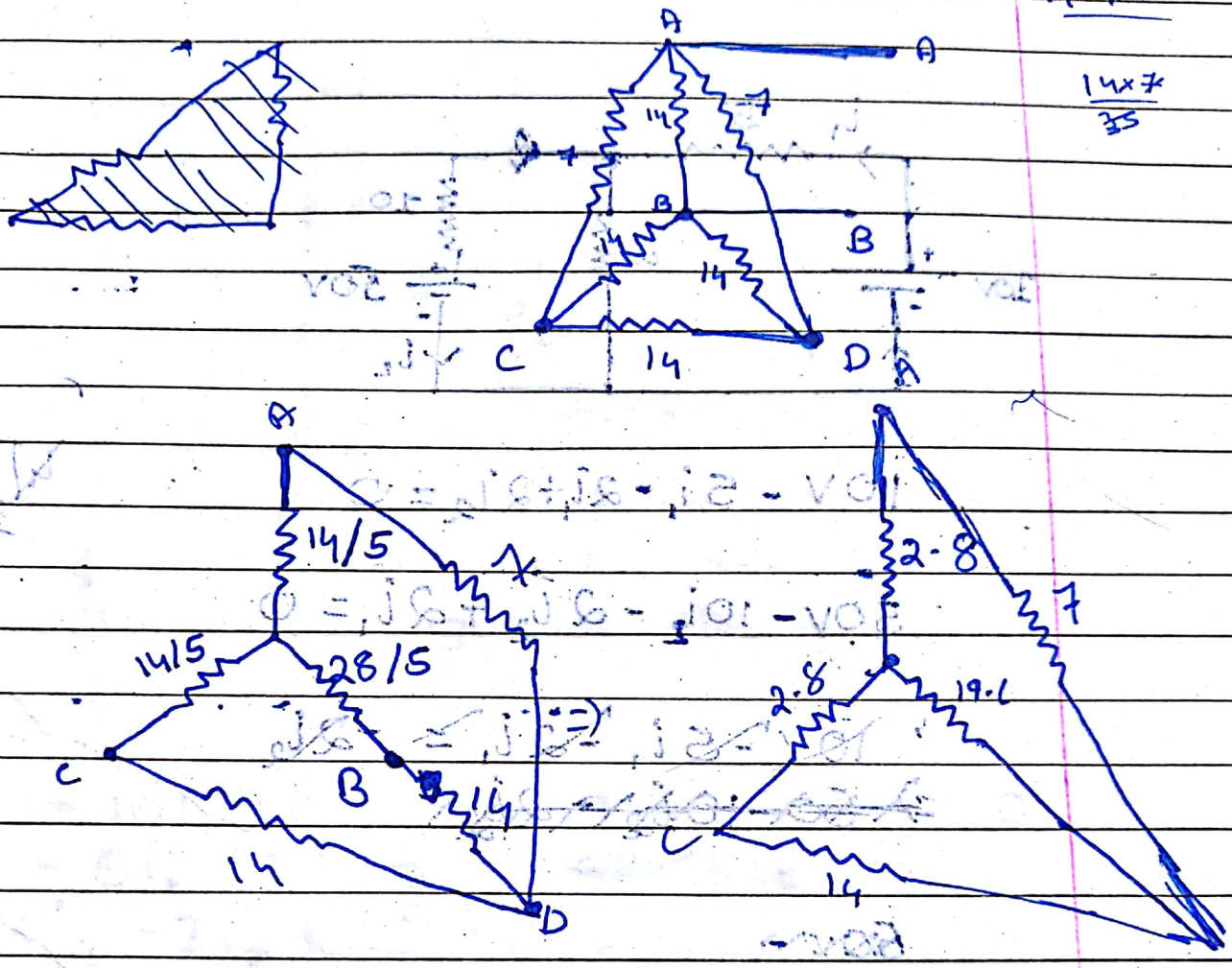
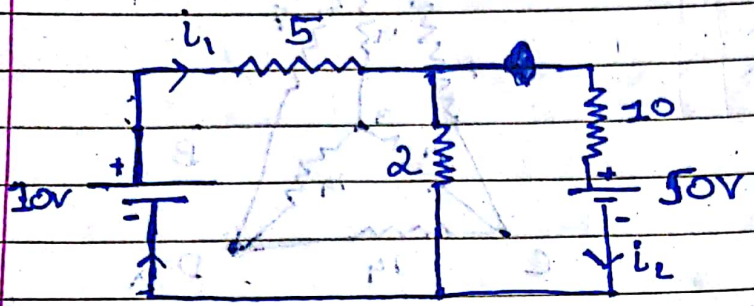
g:- Determine the resistance between terminal A and B for given network using delta/star transformation.



For the given network write the current mesh analysis and determine the current.



$10V - 5i_1 - 2i_1 + 2i_2 = 0$

$50V - 10i_2 - 2i_2 + 2i_1 = 0$

~~$10V - 5i_1 - 2i_1 = -2i_2$~~

~~$\Rightarrow 50 - 10i_2 + 2i_2$~~

~~50V~~

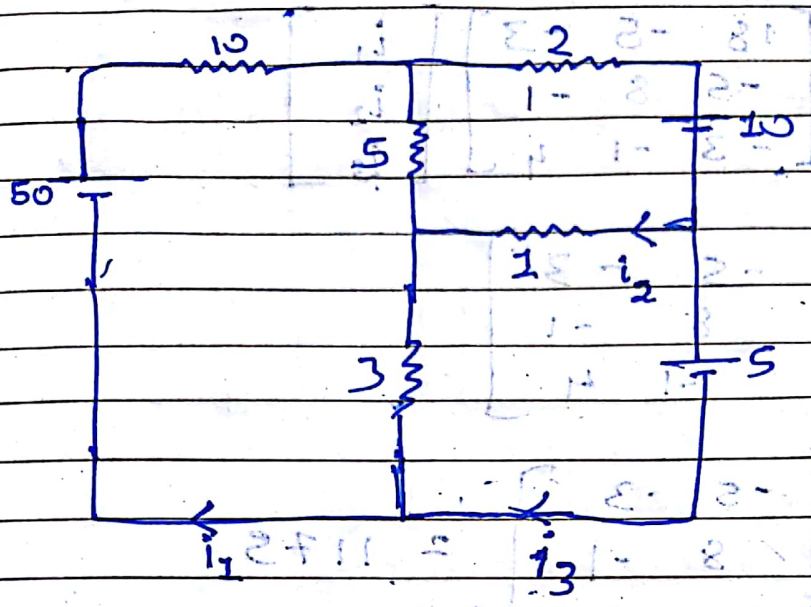
$\Rightarrow 50 + 50 - 25i_1 - 10i_1 + 10 - 5i_1 - 2i_1 + 2i_1 = 0$

$110 - 40i_1 = 0 \Rightarrow i_1 =$

$\Rightarrow i_1 = 0.25A$

$i_2 = -4.125A$

Determine the mesh current i_1, i_2 and i_3 per given network.



$$50 - 10i_1 - 5i_1 + 5i_2 - 3i_1 + 3i_3 = 0$$
$$10 - i_2 - 5i_1 + 5i_2 - 2i_2 + i_3 = 0$$
$$5 - i_3 + i_2 - 3i_3 + 3i_1 = 0$$

$$\Rightarrow 50 - 18i_1 + 5i_2 + 3i_3 = 0$$
$$10 + 2i_2 - 5i_1 + i_3 = 0$$
$$5 - 4i_3 + i_2 + 3i_1 = 0$$

$$50 - 18i_1 + 5i_2 + 3i_3 = 0$$
$$10 - 5i_1 + 2i_2 + i_3 = 0$$
$$5 + 3i_1 + i_2 - 4i_3 = 0$$

$$65 - 20i_1 + 8i_2 = 0$$
$$45 - 17i_1 + 9i_2 = 0$$
$$20 - 3i_1 - i_2 = 0 \qquad 160 - 24i_1 - 8i_2 = 0$$

$95 - 44i_1 = 0 \Rightarrow i_1 =$

We can solve this by:

$$\begin{bmatrix} 50 \\ -10 \\ -5 \end{bmatrix} = \begin{bmatrix} 18 & -5 & -3 \\ -5 & 8 & -1 \\ -3 & -1 & 4 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 18 & -5 & -3 \\ -5 & 8 & -1 \\ -3 & -1 & 4 \end{bmatrix}$$

$$\Delta_1 = \begin{bmatrix} 50 & -5 & -3 \\ -10 & 8 & -1 \\ -5 & -1 & 4 \end{bmatrix} = 1175$$

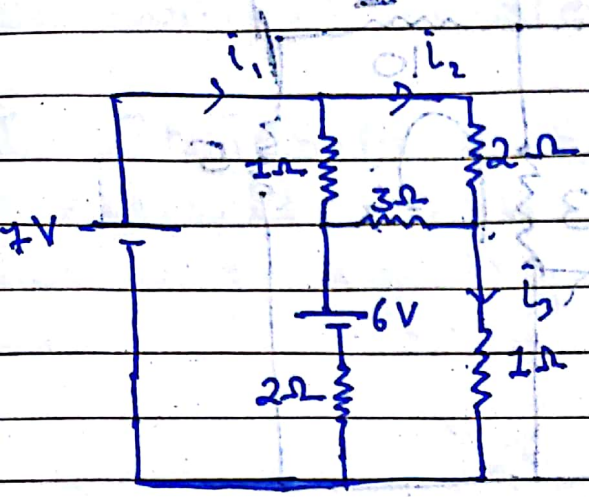
$$\Delta_2 = \begin{bmatrix} 18 & 50 & -3 \\ -5 & -10 & -1 \\ -3 & -5 & 4 \end{bmatrix}$$

$$\Delta_3 = \begin{bmatrix} 18 & -5 & 50 \\ -5 & 8 & -10 \\ -3 & -1 & -5 \end{bmatrix}$$

$$i_1 = \frac{\Delta_1}{\Delta}$$

$$50(-23) - 18(\quad)$$

In given network determine mesh current i_1, i_2, and i_3.



$-2i_2 - 3i_2 + i_2 + i_1 = 0$

$6i_2 = i_1$ $\quad -6i_2 + i_1 + 3i_3 = 0$

$-i_3 - 2i_3 + 6 + 2i_1 - 3i_3 + 3i_2 = 0$

$7 - 1i_1 + i_2 - 6 - 2i_1 + 2i_3 = 0$

$1 - 3i_1 + i_2 + 2i_3 = 0$ $\quad 3 - 9i_1 + 3i_2 + 6i_3 = 0$

$6 + 2i_1 + 3i_2 - 6i_3 = 0$

$9 - 7i_1 + 6i_2 = 0$

$9 - 6i_1 + 3i_3 = 0$

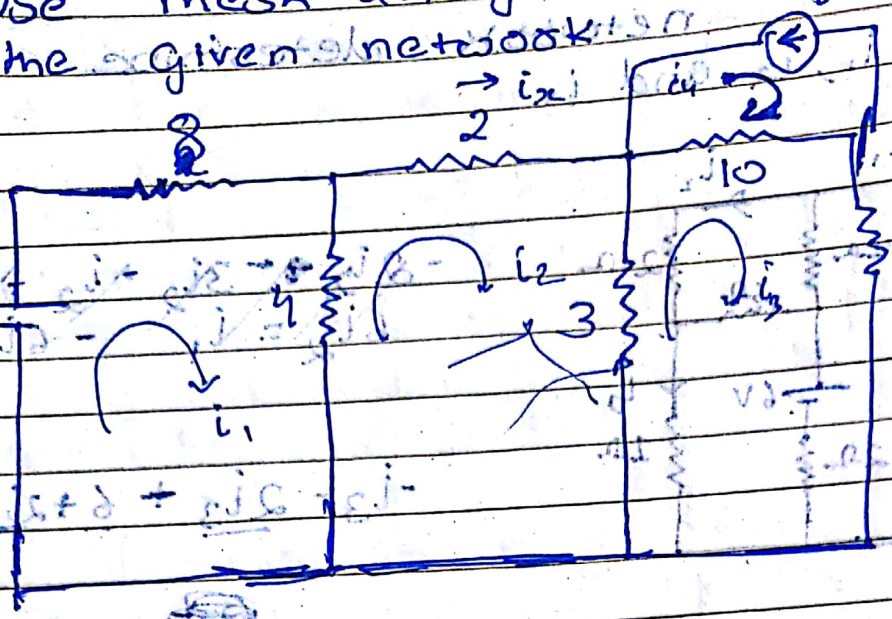
$3 - 2i_1 + i_3 = 0$

$\Rightarrow i_1 = 3A$

$i_2 = 2A$

$i_3 = 3A$

Use mesh analysis to find i_x for the given network.



$$100 - 8i_4 - 4i_1 + 4i_2 = 0$$

$$4i_2 - 4i_1 + 2i_2 + 3i_2 - 3i_3 = 0$$

$$3i_3 - 3i_2 + 10i_3 - 10i_4 + 5i_3 = 0$$

$$100 - 12i_1 + 4i_2 = 0$$

$$9i_2 - 4i_1 - 3i_3 = 0$$

$$18i_3 - 3i_2 + 80 = 0$$

$$27i_2 - 12i_1 - 9i_3 = 0$$

$$100 - 23i_2 + 9i_3 = 0$$

$$80 - 3i_2 + 18i_3 = 0$$

$$200 - 46i_2 + 18i_3 = 0$$

$$120 - 43i_2 = 0$$

$$i_2 = 2.79\text{A}$$

$$i_1 = 9.26\text{A}$$

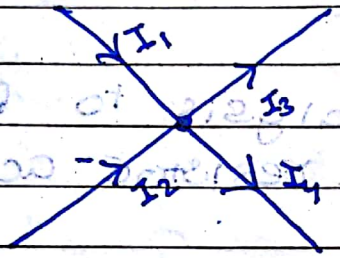
$$i_3 = -3.9\text{A}$$

Kirchhoff's Current Law

- Sum of current entering the node is equal to Sum of current leaving the node.

It States that Sum of Current entering the node must be equal to Sum of Current leaving that node.

$$I_1 + I_2 - I_3 - I_4 = 0$$



Junction: When three or more than three elements are connected at a point it is known as junction.

Node: When two or more than two elements are connected at a point it is known as Node.

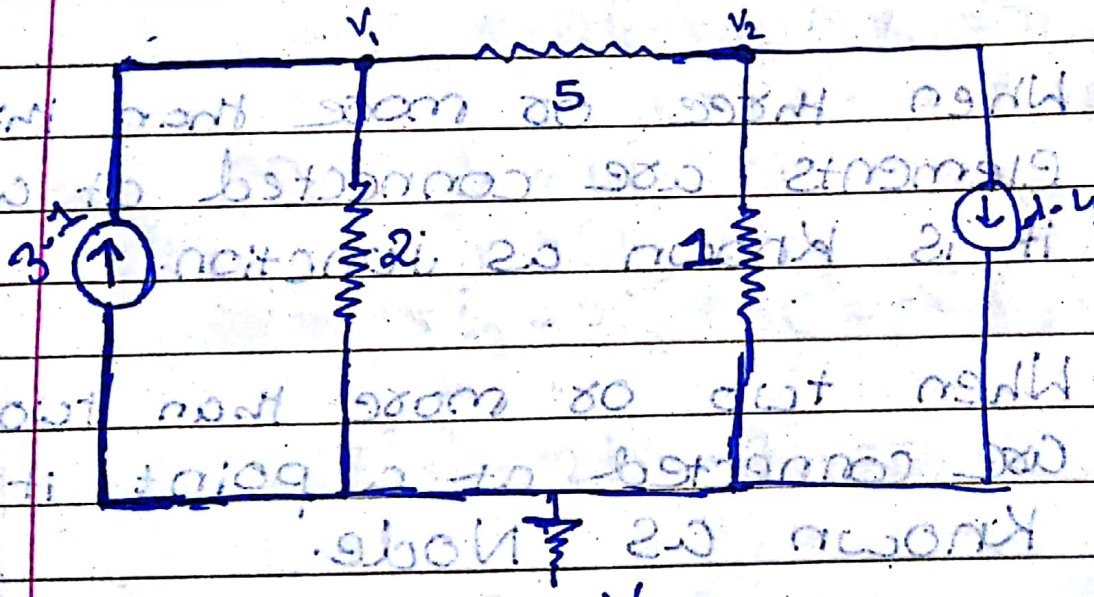
All the Junctions can be called as Node but all the Nodes cannot be called as Junction.

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

Steps to solve the eq by node analysis

i) Make sure the given network is planar network.
ii) Identify the no of nodes in given circuit.
iii) Write eqn for each and every node.
iv) Solve all the eqn to get the value of node voltages.

Q- Use nodal analysis to find voltage across 5 ohm resistor across given network.



$$\text{current} = \frac{V}{R}$$

$$3.1 = \frac{V_1}{2} + \frac{V_1 - V_2}{5} = I$$

$$1.4 = \frac{V_2}{1} + \frac{V_2 - V_1}{5}$$

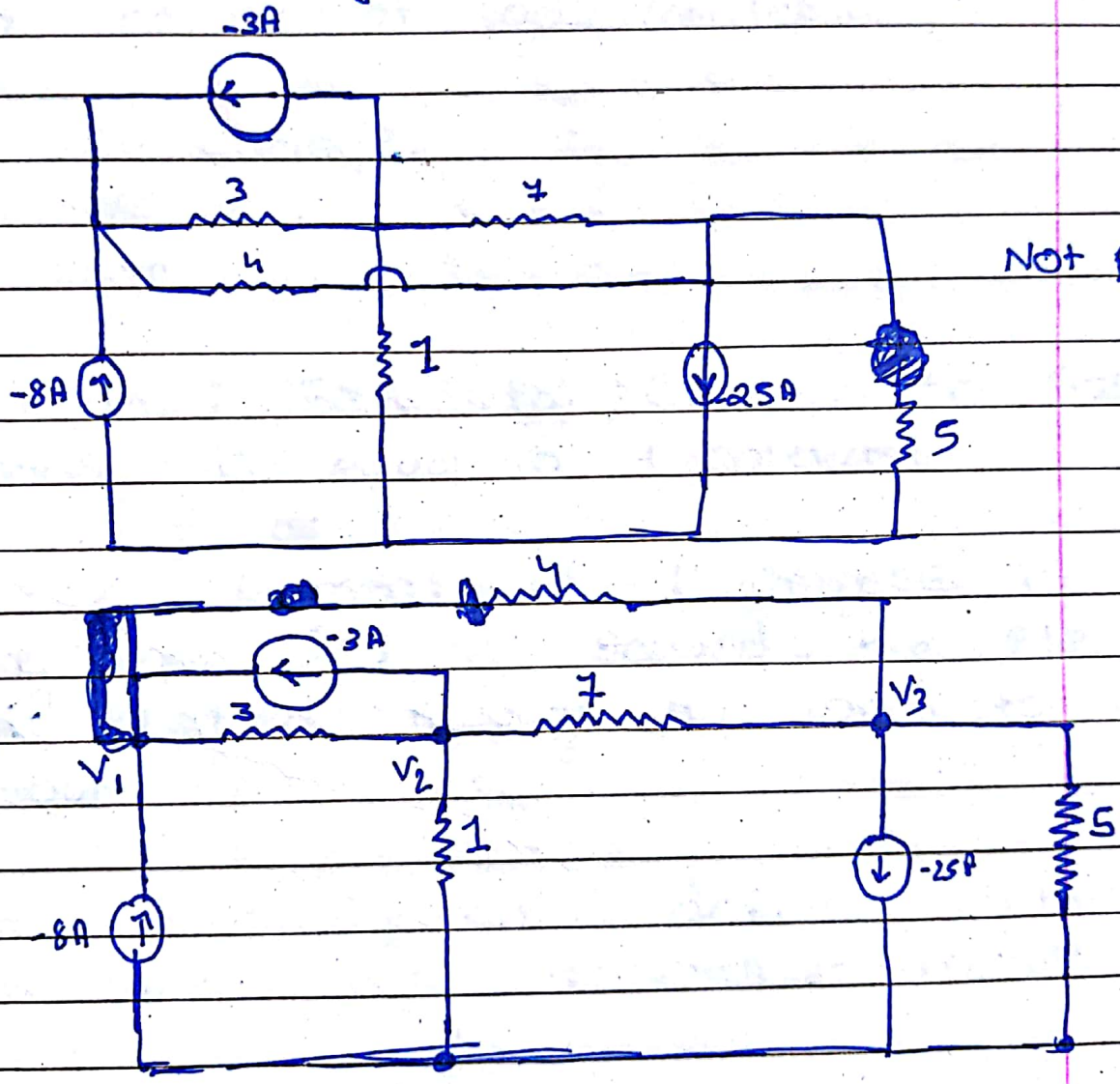
$31 = 5V_1 + 2V_1 - 2V_2 \Rightarrow 31 = 7V_1 - 2V_2$

$7 = 5V_2 + V_2 - V_1 \Rightarrow 14 = 12V_2 - 2V_1$

$17 = 14V_2$

$V_2 = 17$

Find the node voltages in the given circuit using node analysis.



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

$-(-3) = \frac{V_2}{1} + \frac{V_2 - V_1}{3} = \frac{V_2 - V_3}{7}$