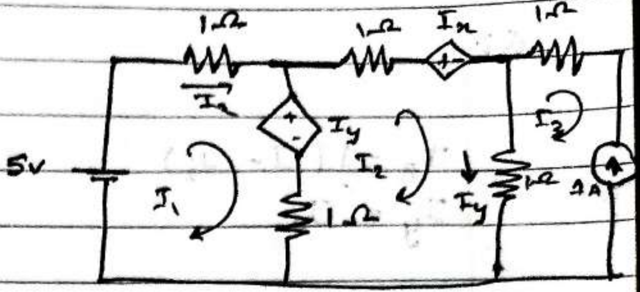
Date : ____________

# DC

Q1.




We get

$I_x = I_1$ ,

$I_y = I_2 - I_3$

$= I_2 + 1$

$I_3 = 1$ A

KVL at loop 1

$\cancel{5 - 1.I_1 - I_y - 1(I_1 - I_2) = 0}$ $\quad$ $5 - I_1 - I_y - 1(I_1 - I_2) = 0$

$\cancel{5 - 2I_1 - I_2 - I_3 + I_2 = 0}$ $\quad$ $5 - 2I_1 - \cancel{I_2} - 1 + \cancel{I_2} = 0$

$\cancel{2I_1 + I_3 =}$ $\quad$ $2I_1 = 4$

$I_1 = 2$ A

$\therefore I_x = 2$ A

KVL at loop 2

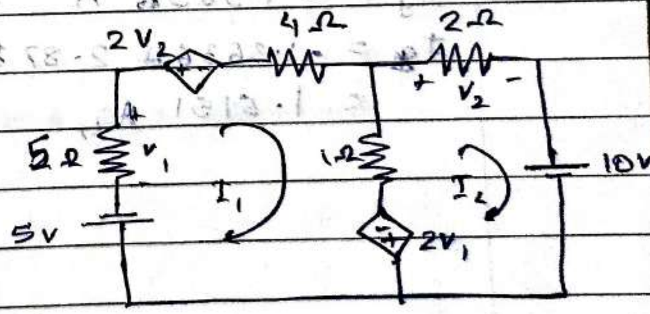
$-1(I_2 - I_1) - I_y - 1(I_2) - I_x - 1(I_2 - I_3) = 0$

$-I_2 + \cancel{I_1} - I_2 - 1 - I_2 - \cancel{I_1} - I_2 + 1 = 0$

$-4I_2 \cancel{-4} = 0$

$I_2 = \cancel{\frac{-1}{4}\text{ A}}$ 0 A

Q2 We get




$\cancel{I_x}$ $v_1 = -5I_1$

$v_2 = 2I_2$

KVL at (1) $-5 - 5(I_1) - 2v_2 - 4I_1 - 1(I_1 - I_2) + 2V_1 = 0$

$-5 - 5I_1 - 2(-5I_1) - 4I_1 - I_1 + I_2 + \cancel{2v_2 = 0}$ $2(2I_2)$

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

$-5 + 5I_2 = 0$

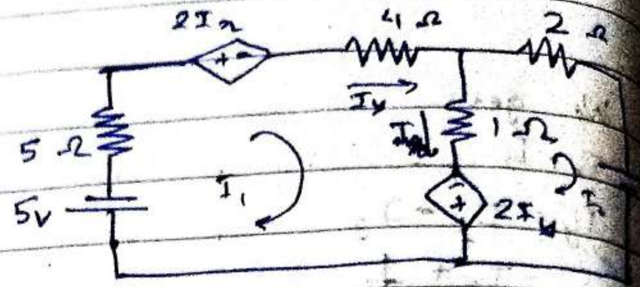
$I_2 = 1$ A

$\therefore \cancel{V_1 = -5(1)}$ $\quad$ $V_2 = 2(1)$

$\cancel{= -5 V}$ $\quad$ $= 2$ V

Date :

Q3.




$I_x = 1(I_1 - I_2)$

$I_y = I_1$

KVL at loop 1

$-5 - 5I_1 - 2I_x - 4I_1 - 1(I_1 - I_2) + 2I_y = 0$

$-5I_1 - 2(I_1 - I_2) - 4I_1 - I_1 + I_2 + 2(I_1) = 5$

$-5I_1 - 2I_1 - 4I_1 - I_1 + \cancel{2I_1} + 2I_2 + 3I_2 = 5$

$-10I_1 + 3I_2 = 5$

KVL at loop 2

$-2I_y - 1(I_2 - I_1) - 2I_2 - 10 = 0$

$-2I_1 - I_2 + I_1 - 2I_2 = 10$

$-I_1 - 3I_2 = 10$

$I_1 = -1.3636$ A

$I_2 = -2.8787$ A

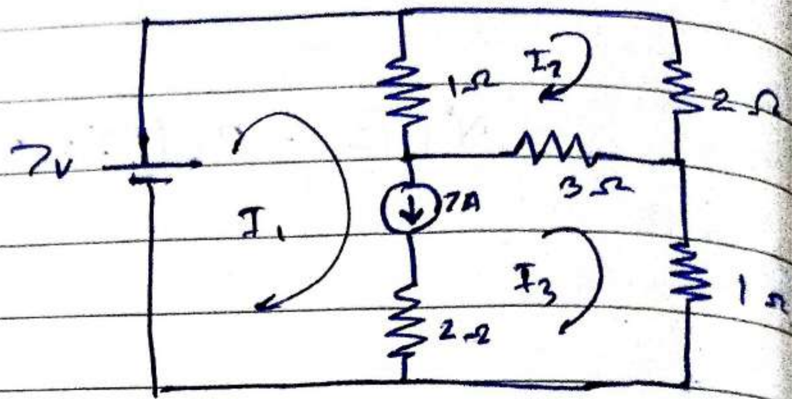
$I_y = -1.3636$ A

$I_x = -1.3636 + 2.8787$

$= 1.5151$ A

Date :

Q2.




KVL loop 2

$\cancel{7-1(I_2-I_1)}$

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

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

$I_1-6I_2+3I_3=0$ $\cancel{2I_1=0}$

$7=I_1-I_3$

Supermesh 1 & 3

$\cancel{7-1(I_2-I_1)-3(I_3-I_2)-I_3=0}$

$\cancel{7-I_2+I_1-3I_3+3I_2-I_3=0}$

$\cancel{7+I_1+2I_2-2I_3=0}$

$I_1+2I_2-2I_3=-7$

$7-1(I_1-I_2)-3(I_3-I_2)-I_3=0$

$7-I_1+I_2-3I_3+3I_2-I_3=0$

$7=I_1+4I_2-4I_3=0$

$I_1-4I_2+4I_3=7$

$I_1=9$ $I_2=2.5$ $I_3=2$ A

Date :

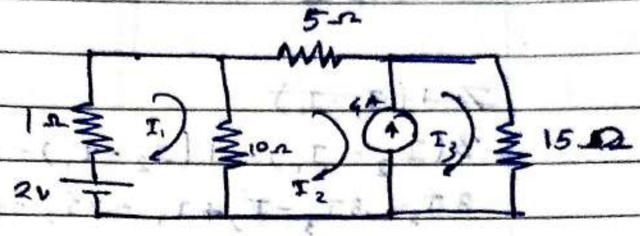
$\boxed{I_4 = 40\ A}$

⊛ Supermesh

$V_x = +\frac{1}{5}(I_2 - I_1)$

$V_1 = -2(I_2 - I_1)$

S1.




KVL in loop 1

$2 - 1(I_1) - 10(I_1 - I_2) = 0$

$-2 = I_1 - 10I_1 + 10I_2$

$-2 = -11I_1 + 10I_2$ —— (1)

4A: $4 = I_3 - I_2$ —— (2)

Supermesh $I_2$ & $I_3$

$-10(I_2 - I_1) - 5I_2 - 15I_3 = 0$

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

$\cancel{5I_2 + 15I_3 = 0}$

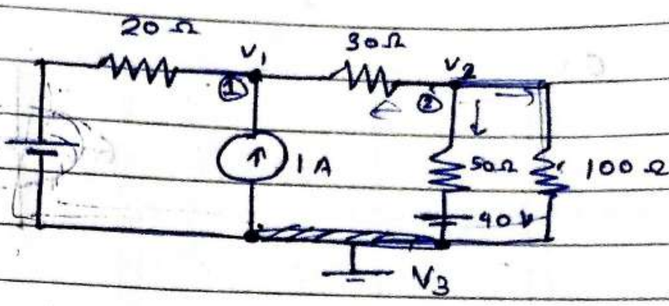
$10I_1 - 15I_2 - 15I_3 = 0$ — (3)

$-2.3478\ A$ $\quad -2.7826\ A$ $\quad 1.2173\ A$

$I_1 = \cancel{-2.8695\ A}$ $\quad I_2 = \cancel{-2.9565\ A}$ $\quad I_3 = \cancel{1.0434\ A}$

# Nodal

$I_{100} = ?$




KCL at node 1

$$1 = \frac{V_1 - \cancel{V_3} - 60}{20} + \frac{V_1 - V_2}{30}$$

$$1 = \frac{V_1}{20} - \frac{\cancel{60}^{\,3}}{\cancel{20}} + \frac{V_1}{30} - \frac{V_2}{30}$$

$$4 = V_1\left(\frac{1}{20} + \frac{1}{30}\right) - \frac{V_2}{30}$$

KCL at node 2

$$0 = \frac{V_2 - V_1}{30} + \frac{V_2 - \cancel{V_3}}{100} + \frac{V_2 - \cancel{V_3} - 40}{50}$$

$$0.8 = -\frac{1}{30} V_1 + V_2\left(\frac{1}{30} + \frac{1}{100} + \frac{1}{50}\right)$$

$$I_{30\Omega} = \frac{V_1 - V_2}{30} \text{ A } (\rightarrow)$$

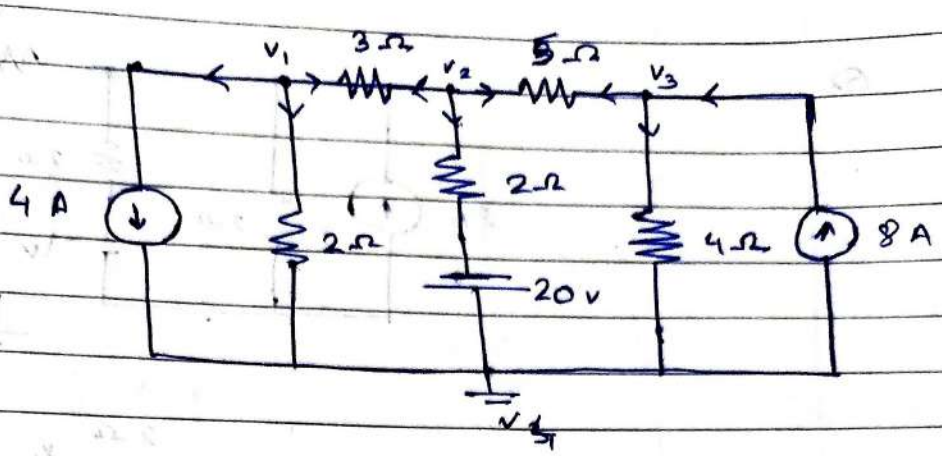
$$I_{100\Omega} = \frac{V_2 - V_3}{100}$$

$$V_{30\Omega} = V_1 - V_2$$

$$V_{100\Omega} = V_2 - V_3$$

Date : ____________

Q2.




node 1

$$-4 = \frac{V_1 - V_4}{2} + \frac{V_1 - V_2}{3}$$

$V_4 = 0$

$$-24 = 3V_1 - 3V_4 + 2V_1 - 2V_2$$

$$-24 = 5V_1 - 2V_2 \cancel{- 3V_4} \quad -① $$

node 2

$$0 = \frac{V_2 - V_1}{3} + \frac{V_2 + 20}{2} + \frac{V_2 - V_3}{5}$$

$$\cancel{0 =}\ 0 = 10V_2 - 10V_1 + 15V_2 + 300 + 6V_2 - 6V_3$$

$$10V_1 - 16V_2 + 6V_3 = 300$$

$$10V_1 - 16V_2 + 6V_3\ 300$$

$$\cancel{5V_1 - 8V_2 + 3V_3\ 150} \quad 5V_1 - 8V_2 + 6V_3 = 300 \quad -②$$

node 3

$$8 = \frac{V_3}{4} + \frac{V_3 - V_2}{5}$$

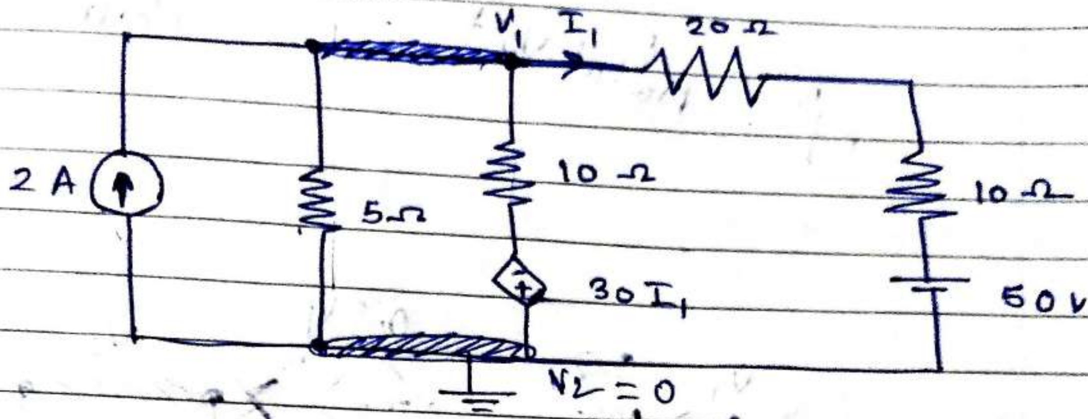
$$160 = 2V_3 - V_2 \quad — ③$$

$V_1 = 16\ V \quad V_2 = 52\ V \quad V_3 = 106\ V$

Nodal

Date :

Q $V_{5\Omega}$




$$\boxed{I_1 = \frac{V_1 - V_2 - 50}{30}}$$

KCL at $V_1$

$$2 = \frac{V_1 - \cancel{V_2}}{5} + \frac{V_1 - \cancel{V_2} + 30 I_1}{10} + \frac{V_1 - \cancel{V_2} - 50}{30}$$

$$2 = \frac{V_1}{5} + \frac{V_1}{10} + \cancel{3}\left(\frac{V_1 - \cancel{V_2} - 50}{\cancel{30}\ 10}\right) + \frac{V_1}{30} - \frac{5\cancel{0}}{3\cancel{0}}$$

$$2 = \frac{V_1}{5} + \frac{V_1}{10} + \frac{V_1}{10} - 5 + \frac{V_1}{30} - \frac{5}{3}$$

$$2 + 5 + \frac{5}{3} = V_1\left(\frac{1}{5} + \frac{1}{10} + \frac{1}{10} + \frac{1}{30}\right)$$

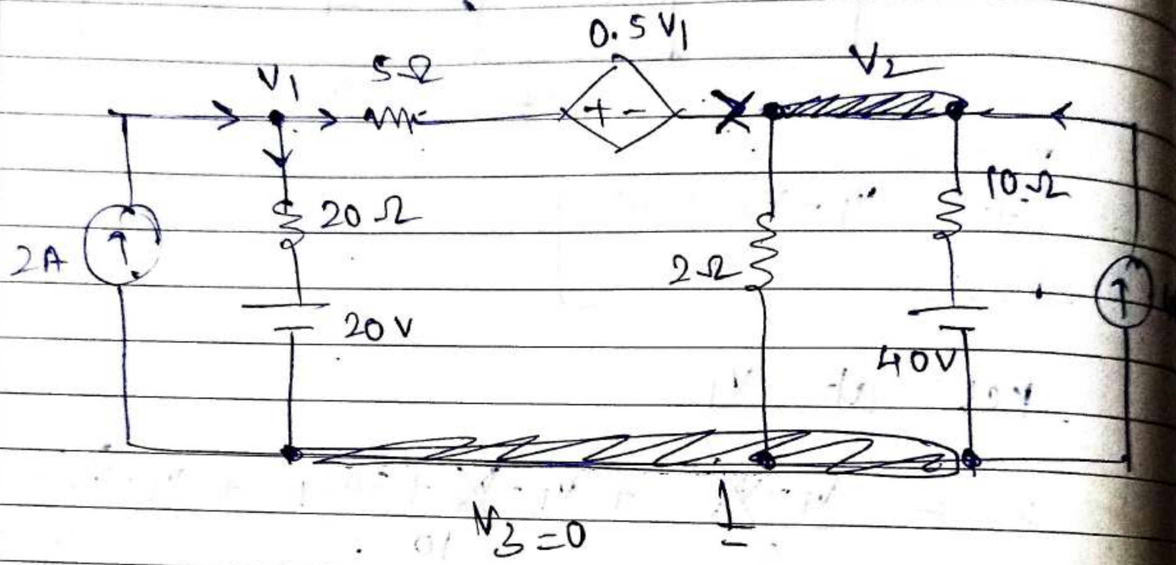
$V_1 =$

$V_{5\Omega}$ $V_1 - V_2$

Mesh
↓
loop current
(our)

Date :

Nodal
↓
$Eq^{n}$: Nodal volt




KCL at node $V_1$

$$2 = \frac{V_1 - V_3 - 20}{20} + \frac{V_1 - 0.5V_1}{5}$$

$40 = V_1 - V_3 - 20 + 4V_1 - 2V_1$

$60 = \cancel{-2V_1} = 3V_1 \cancel{- V_3}$

$V_1 = 20\ V$

At $V_2$

$$4 = \frac{V_2 - V_1 + 0.5V_1}{5} + \frac{V_2}{2} + \frac{V_2 - 40}{10}$$

$40 = 2V_2 - 2V_1 + V_1 + 5V_2 + V_2 - 40$

$80 = -V_1 + 8V_2$

$V_1 - 8V_2 = -80$

$20 - 8V_2 = -80$

$8V_2 = -100$

$V_2 = -12.5\ V$

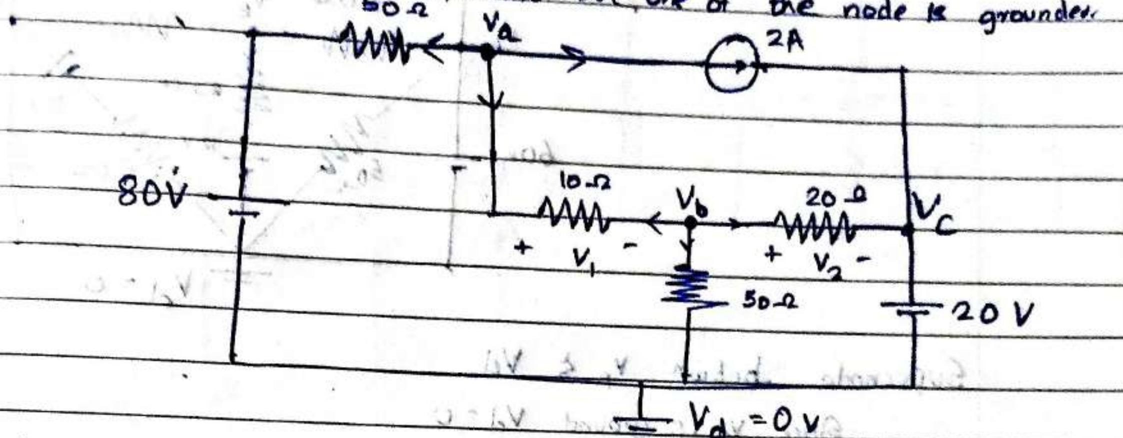
Whenever only single voltage source (no R is series) is present betwn two nodes then its a supernode.

Date :

## Supernode

Type 1

In this type Supernode is present but one of the node is grounded.




Supernode is present between $V_c$ and $V_d$

since $V_d$ is ground ∴ type 1

volt. source eqn

$$20 = V_c - \cancel{V_d}$$

$$\therefore \boxed{V_c = 20}$$

KCL at node $V_a$

$$-2 = \frac{V_a - V_d - 80}{50} + \frac{V_a - V_b}{10}$$

$$-100 = V_a - V_d - 80 + 5V_a - 5V_b$$

$$-20 = 6V_a - 5V_b - \cancel{V_d}$$

KCL at node $V_b$

$$0 = \frac{V_b - V_a}{10} + \frac{V_b}{50} + \frac{V_b - V_c}{20}$$

$$0 = 10V_b - 10V_a + 2V_b + 5V_b - 5V_c$$

$$0 = -10V_a + 17V_b - 5V_c$$

$$0 = -10V_a + 17V_b - 5(20)$$

$$100 = -10V_a + 17V_b$$

$$V_a = 3.07 \text{ V}$$

$$V_b = 7.69 \text{ V}$$

$$V_1 = V_a - V_b$$

$$= 3.07 - 7.69$$

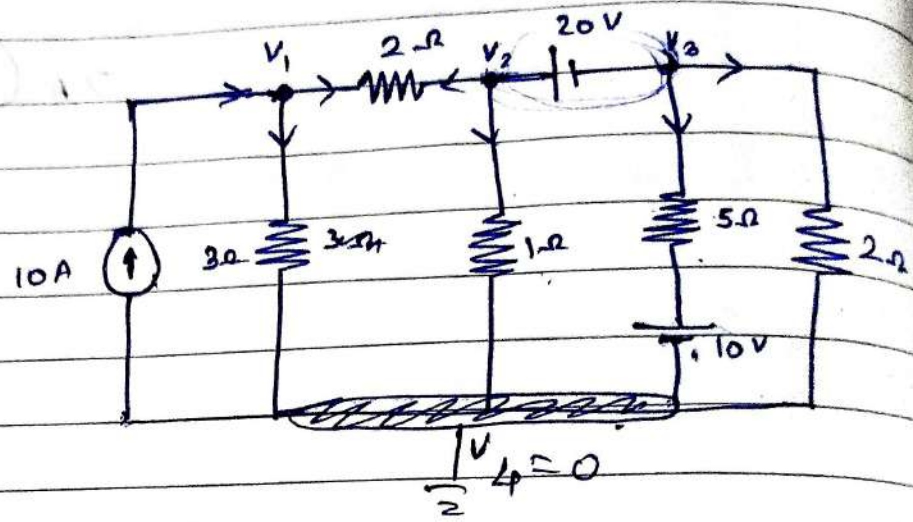
$$= -4.62 \text{ V}$$

$$V_2 = V_b - V_c$$

$$= -12.31 \text{ V}$$

Date :

Type 2




Supernode 2 & 3

Type 2

(1) KCL to node 1

(2) volt source eqn

(3) KCL to Supernode

$$0 = \frac{V_2 - V_1}{2} + \frac{V_2 - V_4}{1} +$$

- KCL at node $V_1$

$$10 = \frac{V_1 - V_2}{2} + \frac{V_1 - V_4}{3}$$

$$60 = 3V_1 - 3V_2 + 2V_1 - 2V_4$$

$$60 = 5V_1 \cancel{- 3V_2} - 3V_2 \quad \text{—— (i)}$$

- $20 = V_2 - V_3$ —— (ii)

- Considering $V_2$ and $V_3$ as supernode

$$0 = \frac{V_2 - V_1}{2} + \frac{V_2}{1} + \frac{V_3 - 10}{5} + \frac{V_3}{2}$$

$$0 = 5V_2 - 5V_1 + 10V_2 + 2V_3 - 20 + 5V_3$$

$$20 = -5V_1 + 15V_2 + 7V_3 \quad \text{—— (iii)}$$

$V_1 = 18.94$ $V_2 = 11.57$ V $V_3 \sim -8.42$ V

Date :

# Thevenin's, Norton & Max power

## step 1 : To find $V_{TH}$

(i) Redraw circuit with disconnecting the ~~compom~~ branch through which output is recquired

ii] Mark terminal A & B

iii] Apply mesh or nodal

iv] Choose a path from B to A free from Current Source and apply KVL and hence find $V_{AB}$

$$V_{AB} = V_{th}$$

## Step 2: To find $I_N$

i] Redraw the circuit by S.C branch through which output is req.

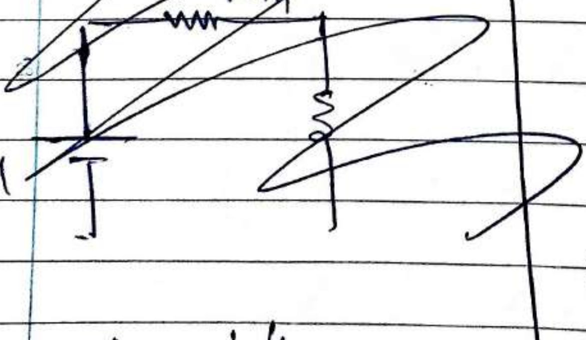
ii] If S.C branch is horizontal then ~~pass~~ I direction rigthwards

If S.C branch is Vertical " " downwards

iii] Apply mesh or nodal and find I through S.C branch and hence we get $I_N$.

## Step 3: ~~Equivalent Circuit~~ To find : $R_{TH} = R_N$

~~Thevenin's~~

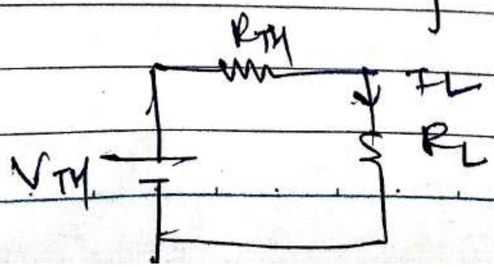


$$R_{TH} = R_N = \frac{V_{TH}}{I_N}$$

## Step 4: eq. ckt

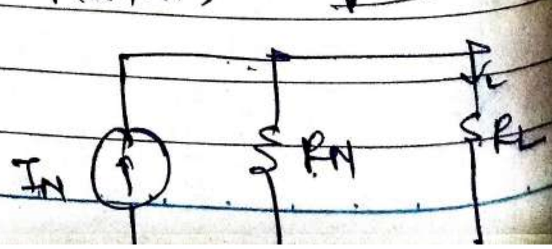
Thevenin's

$$I_L = \frac{V_{TH}}{R_{TH} + R_L}$$




Norton's

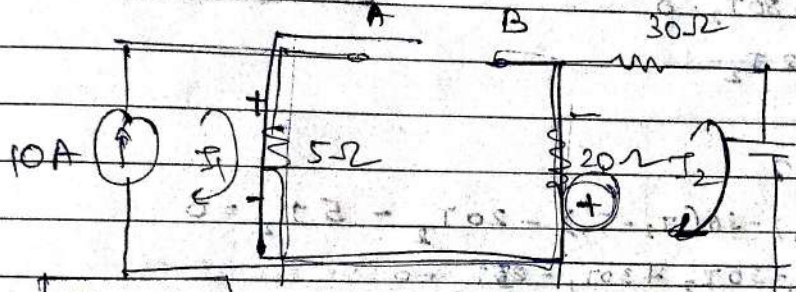
$$I_L = \frac{I_N \times R_N}{R_N + R_L}$$



Max power : $P_{max} = \frac{V_{TH}^2}{4R_{TH}}$

Note : if dependend source depends upon Nodal volt then only Nodal Analysis

# To find $V_{TH}$



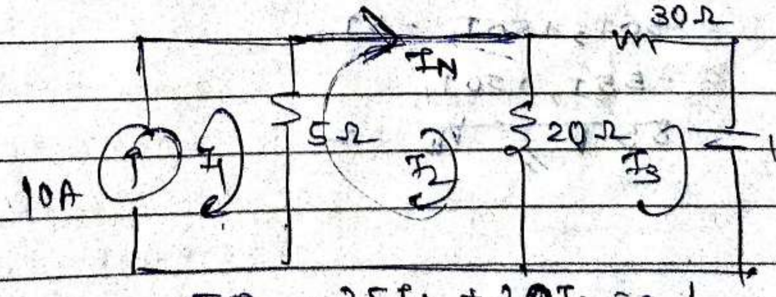

$\boxed{I_1 = 10\,A}$

$-50 I_2 = 100$

$\boxed{I_2 = -2\,A}$

$V_{AB} = 20 I_2 + 5 I_1 = -40 + 50 = 10V$

To find $I_N$




$I_1 = 10\,A$

$5I_1 - 25I_2 + 20I_3 = 0$

$20I_2 - 50I_3 = 100$

$2I_2 - 5I_3 = 10$

$I_2 = 0.5882\,A$

$I_3 = -1.7647\,A$

$-25I_2 + 20I_3 = -50$

~~$25I_2 - 20I_3 = 50$~~

~~$I_2 - I_3 = 2$~~

$I_2 = 0.5$

$I_2 = 0, \quad I_3 = -2A$

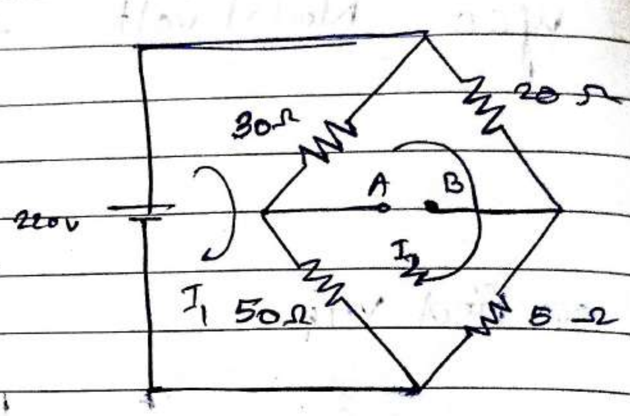
$I_1 = 10$

$5I_1 - 25I_2 + 20I_3 = 0$

$20I_2 - 50I_3 = 100$

$I_N = I_2 = 0.5882$ A

$R_{TH} = R_N = \dfrac{V_{TH}}{I_N} = \dfrac{10}{0.5882} = \underline{\underline{17.0010\Omega}}$




→ $V_{th}$:

KVL Mesh 1

$\cancel{200}\ 220 - 30(I_1 - I_2) - 50(I_1 - I_2) = 0$

$\cancel{200}\ 220 - 30I_1 + 30I_2 - 50I_1 + 50I_2 = 0$

$\cancel{200}\ 220 - 80I_1 + 80I_2 = 0$

~~$5 = 2I_1 - 2I_2$~~

KVL mesh 2

$-50(I_2 - I_1) - 30(I_2 - I_1) - 20I_2 - 5I_2 = 0$

$-50I_2 + 50I_1 - 30I_2 + 30I_1 - 25I_2 = 0$

$-105I_2 + 80I_1 = 0$

8 $I_1 =$ ~~10.5 A~~ $I_2 =$ ~~8 A~~ 8.8 A

$= 11.55$ A

$V_{AB} = -50(I_2 - I_1) - 5I_2$

$= -50I_2 + 50I_1 - 5I_2$

$= -55I_2 + 50I_1$

$= 85\text{ V} = V_{th} =$

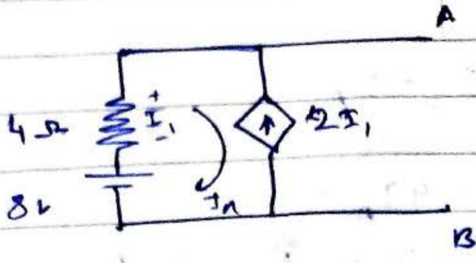
a

$I_x = I_1$.

$\therefore I_x = -2I_x$

$3I_x = 0$

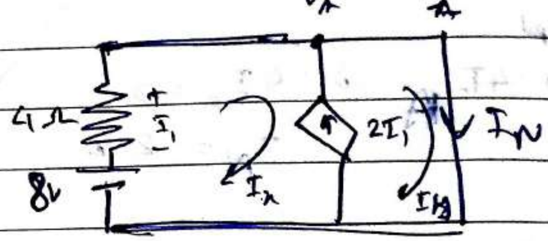
$I_x = 0$ A




Q

$\therefore V_{AB} = 8 - 4I_x$

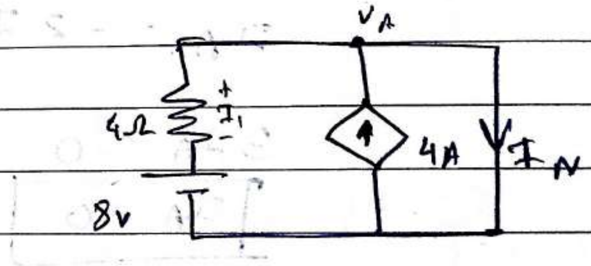
$= 8$ V




$8 - 4I_x = 0$

$8 = 4I_x$

$\Rightarrow I_x = 2$ A




$4 = I_y - I_x$

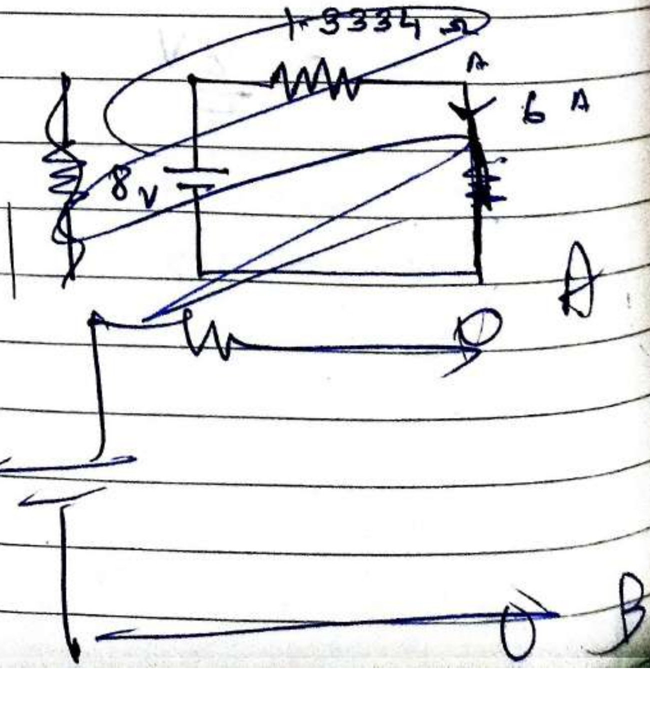
$4 = I_y - 2$

$I_y = 6$ A

$\therefore I_N = 6$ A

$R_{th} = \frac{8}{6}$

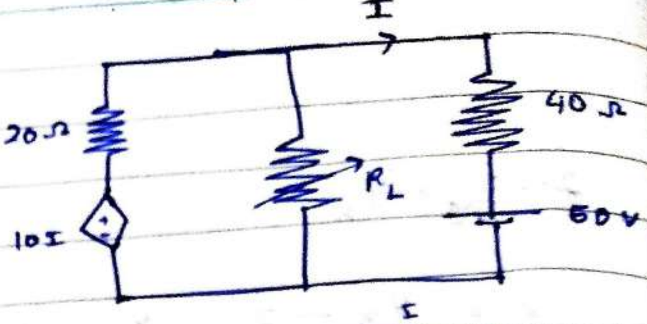
$= 1.3334\ \Omega$




$\cancel{V_L}\ \cancel{I_L = \frac{8}{1.34}}$

5.

$I = I_1$




$10I - 20I_1 - 40I_1 - 50 = 0$

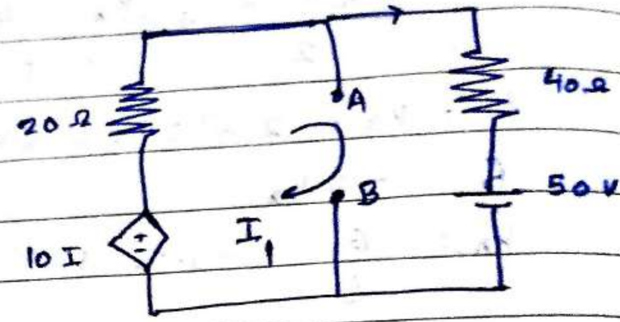
$50I_1 = 50$

$I_1 = 1\ A$

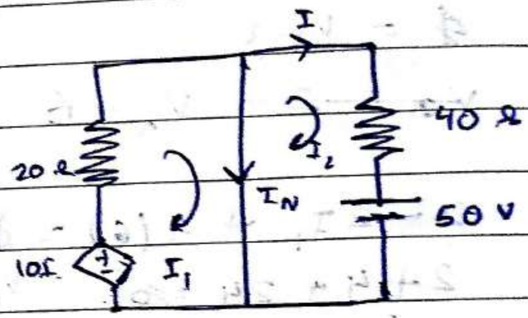
$\therefore I = I_1 = 1\ A$

$V_{AB} = 10 - 20I_1$

$= -10\ V$




$I_N = I_1 - I_2$




$\cancel{10I_1 - 20I_1 = 0}$

$\cancel{I_1 = 0\ A}$ $\quad -20I_1 + 10I_2 = 0 \quad$ —ii

$-40I_2 - 50 = 0$

$40I_2 = -50$

$I_2 = 1.25\ A$

$20I_1 = 10(1.25)$

$I_1 = 0.625\ A$

$I_N = -0.625\ A$

$R_{th} = \frac{V_{th}}{I_N} = \frac{-10}{-0.625} = 16\ \Omega$

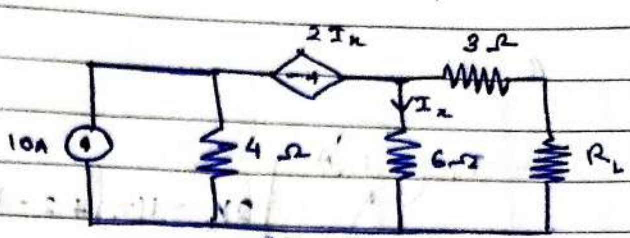
$P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{(-10)^2}{4(16)}$

$= 1.5625\ W$

Q Given

$I_x = I_2$

$I_1 = 10$ A



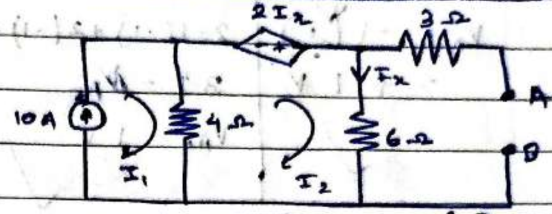

$-4(I_2 - I_1) + 2I_x - 6I_2 = 0$

$-4I_2 + 4I_1 + 2I_2 - 6I_2 = 0$

$4I_1 - 8I_2 = 0$

$40 = 8I_2$

$I_2 = 5$ A

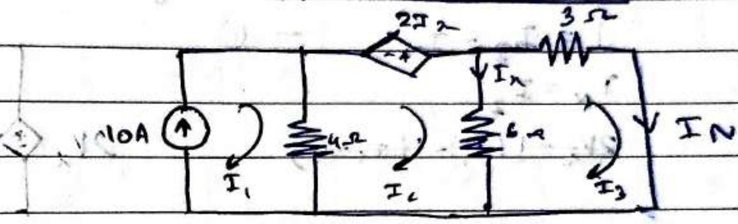



$V_{AB} = 6I_2 - \cancel{3I_2}$

$= 6(5) - \cancel{3(5)}$

$= 30 - \cancel{15}$ V

$\cancel{= 15\ V}$




$I_3 = I_N$

$I_x = I_2 - I_3$

$-4(I_2 - I_1) + 2I_x - 6(I_2 - I_3) = 0$

$-4I_2 + 4I_1 + 2I_2 - 6I_2 + 6I_3 = 0$

$4I_1 - 8I_2 + 6I_3 = 0$

$8I_2 - 6I_3 = 40$ A — i

$-4I_2 + 4I_1 + 2I_2 - 2I_3 - 6I_2 + 6I_3 = 0$

$40 = 8I_2 - 4I_3$ — i

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

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

$6I_2 - 9I_3 = 0$ — ii

$I_2 = 7.5$ A

$I_3 = 5$ A $= I_N$

$\cancel{I_N} =$

$R_{th} = \frac{30}{5} = 6\ \Omega$

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

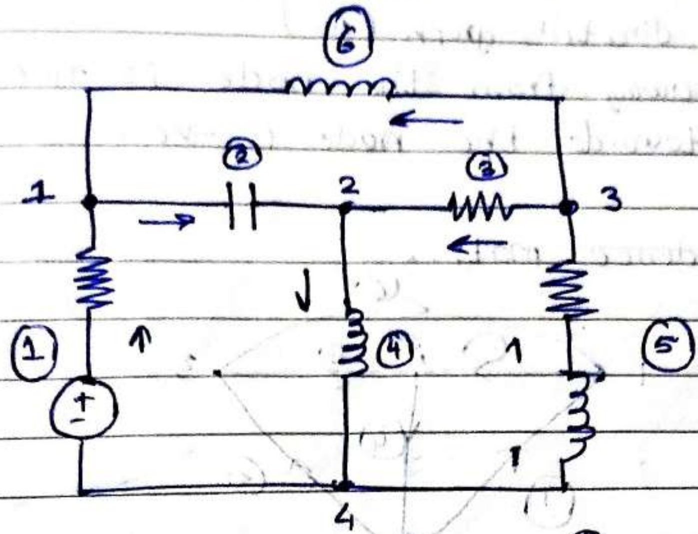
$= \frac{(30)^2}{4(6)}$

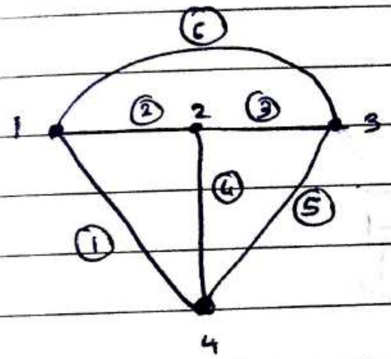
$= \cancel{12\ W}\ 37.5$ W

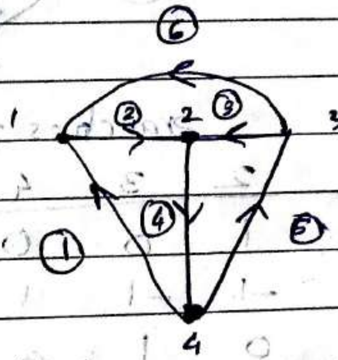
Date :

# Graph theory

Current Source => open circuit
Voltage Source => Straight line



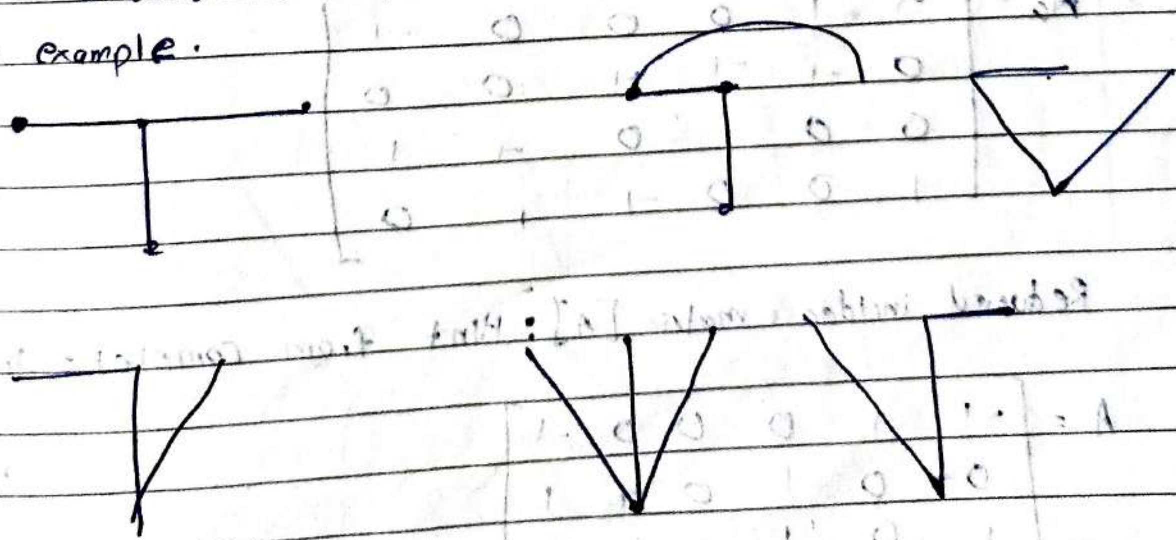




directed graph

Tree : Max no. of branches should be present but they should not form a loop

Tree example.



Incidence matrix

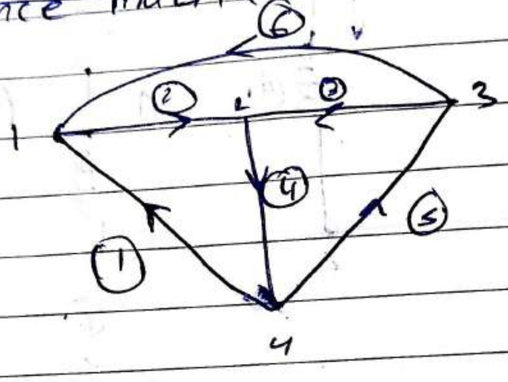
1] complete incidence matrix

Note: Use directed graph ($A_a$)

2] current away from the node is +ve

current towards the node is -ve.

~~Reduced incidence matrix~~




branches ⟶

| node | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | -1 | 1 | 0 | 0 | 0 | -1 |
| 2 | 0 | -1 | -1 | 1 | 0 | 0 |
| 3 | 0 | 0 | 1 | 0 | -1 | 1 |
| 4 | 1 | 0 | 0 | -1 | 1 | 0 |

$$A_a = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & -1 \\ 0 & -1 & -1 & +1 & 0 & 0 \\ 0 & 0 & 1 & 0 & -1 & 1 \\ 1 & 0 & 0 & -1 & 1 & 0 \end{bmatrix}$$

Reduced incidence matrix [A]: Hint from complete incidence mat

remove any of the

$$A = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 & -1 & 1 \\ 1 & 0 & 1 & -1 & 1 & 0 \end{bmatrix}$$

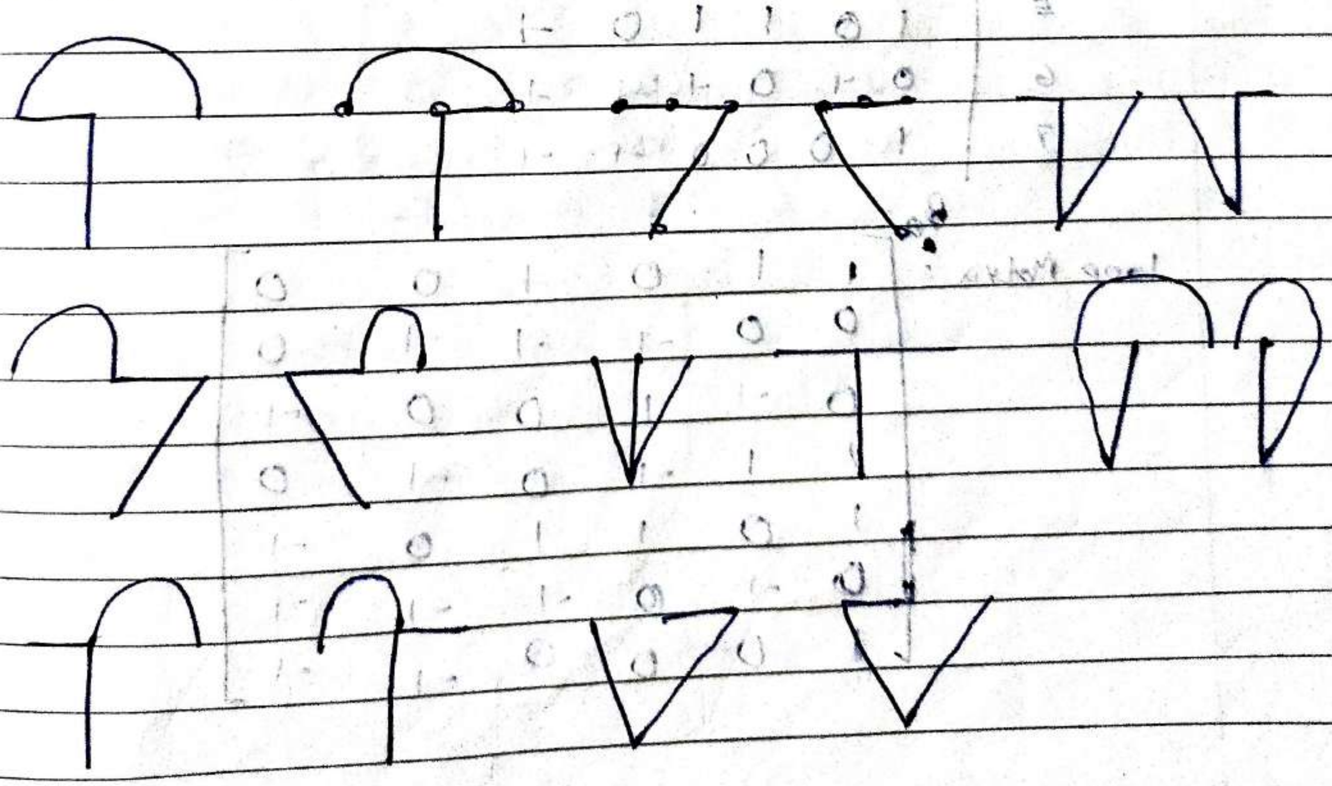
No of possible trees => $|A \cdot A^T|$

$$A = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & -1 & 1 \\ 1 & 0 & 1 & -1 & 1 & 0 \end{bmatrix}_{6\times 3}$$

$$A^T = \begin{bmatrix} -1 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & -1 \\ 0 & -1 & 1 \\ 1 & 1 & 0 \end{bmatrix}_{3\times 6}$$

$$A \cdot A^T = \begin{bmatrix} 1+1+1 & -1 & -1 \\ -1 & 1+1+1 & -1 \\ -1 & -1 & 1+1+1 \end{bmatrix} = \begin{bmatrix} 3 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 3 \end{bmatrix}$$

$|A \cdot A^T| = 16$



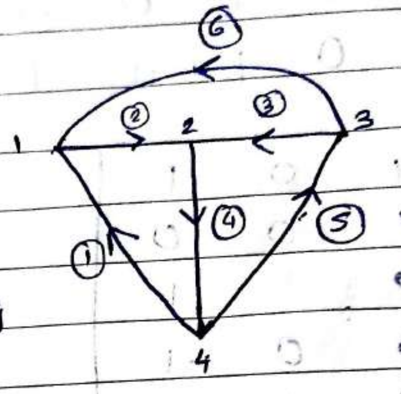
Date :

Circuit matrix
or
loop matrix ($B_a$) → Use components / branches

Note: Use directed graph

Clockwise current = 1

Anticlockwise current = −1




loop 1 : {1, 2, 4}

loop 2 : {3, 4, 5}

loop 3 : {2, 3, 6}

loop 4 : {~~1, 3, 4, 6~~} → {1, 2, 3, 5}

loop 5 : {~~2, 4, 5, 6~~} 1, 3, 4, 6

loop 6 : {2, 4, 5, 6}

loop 7 : {1, 5, 6}

| loops | 1 | 2 | 3 | 4 | 5 | 6 | ~~7~~ |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | |
| 2 | 0 | 0 | −1 | −1 | −1 | 0 | |
| 3 | 0 | −1 | 1 | 0 | 0 | −1 | |
| 4 | +1 | 1 | −1 | 0 | −1 | 0 | |
| 5 | 1 | 0 | 1 | 1 | 0 | −1 | |
| 6 | 0 | −1 | 0 | −1 | −1 | −1 | |
| 7 | 1 | 0 | 0 | 0 | −1 | −1 | |

$B_a$ =

loop Matrix =
$$\begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & -1 & -1 & 0 \\ 0 & -1 & 1 & 0 & 0 & -1 \\ 1 & 1 & -1 & 0 & -1 & 0 \\ 1 & 0 & 1 & 1 & 0 & -1 \\ 0 & -1 & 0 & -1 & -1 & -1 \\ 1 & 0 & 0 & 0 & -1 & -1 \end{bmatrix}$$

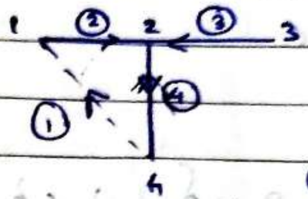
# Tieset Matrix (B)

Consider a tree and join rest of the branches with dotted line.

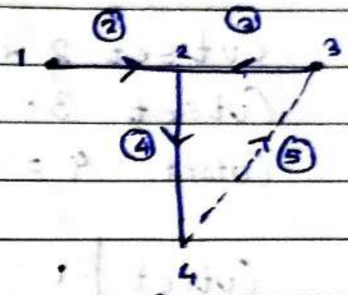
Hint: Same direction as that of the dotted is +
diff direction " " −

Tieset 1:

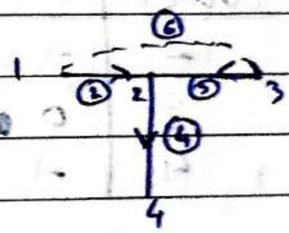
{1, 2, 4}



Tieset 2:
{5, 3, 4}



Tieset 3
{6, 2, 3}



— branches →

| Tieset | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| 2 | 0 | 0 | 1 | 1 | 1 | 0 |
| 3 | 0 | 1 | -1 | 0 | 0 | 1 |

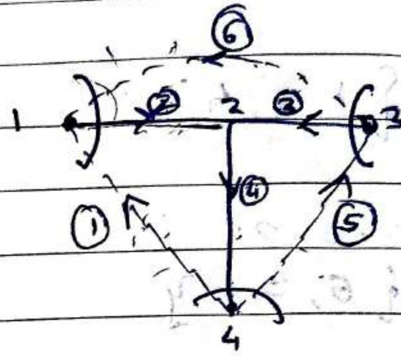
$$B = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & -1 & 0 & 0 & 1 \end{bmatrix}$$

Cutset matrix ($Q_a$)

Note: Use directed graph

- While cutting we must only cut one dark line there is no restriction of cutting dotted line.
- Always give a cut near the node
- Same direction as that of dark line = 1

  Opposite " " " = -1




Cut-set 2 = {2, 1, 6}

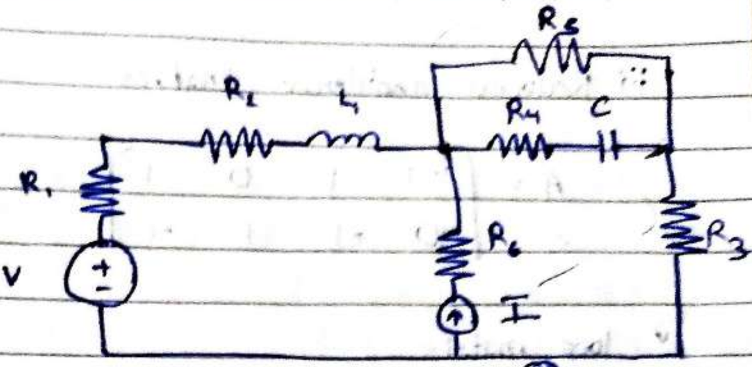
Cutset 3 = {3, 5, 6}

Cutset 4 = {4, 1, 5}

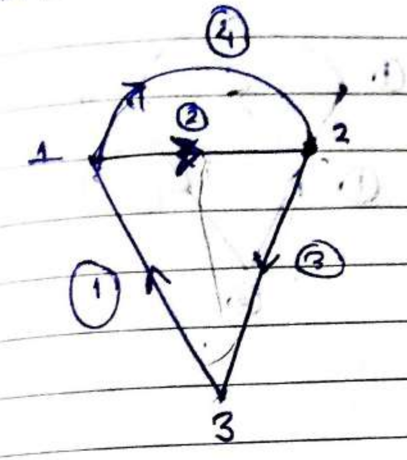
| Cutset | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 2 | -1 | 1 | 0 | 0 | 0 | -1 |
| 3 | 0 | 0 | 1 | 0 | -1 | 1 |
| 4 | -1 | 0 | 0 | 1 | -1 | 0 |

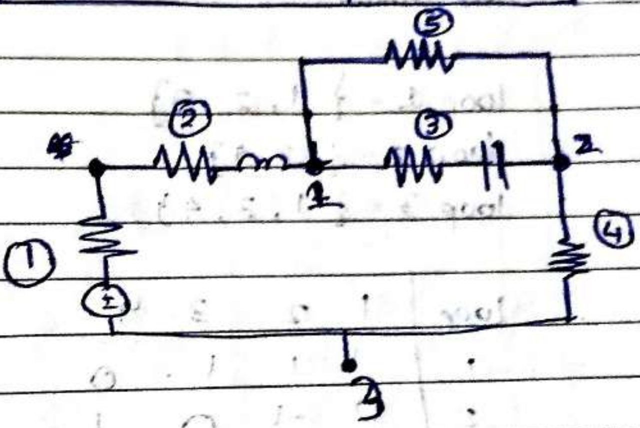
$$Q_A = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 & -1 & 1 \\ -1 & 0 & 0 & 1 & -1 & 0 \end{bmatrix}$$

Q.



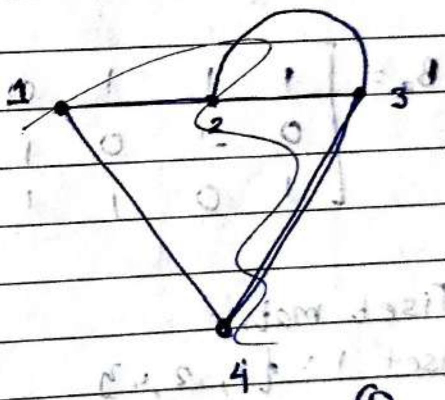

i] Incidence



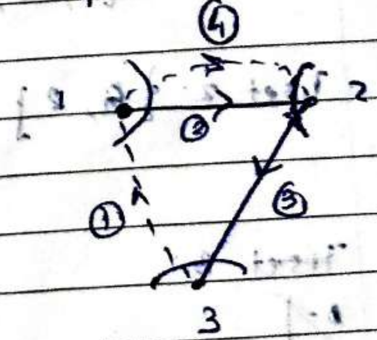




branches

| node | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | -1 | +1 | 0 | +1 |
| 2 | 0 | -1 | +1 | -1 |
| 3 | 1 | 0 | -1 | 0 |




$$A_a = \begin{bmatrix} -1 & 1 & 0 & 1 \\ 0 & -1 & 1 & -1 \\ 1 & 0 & -1 & 0 \end{bmatrix}$$




ii F-cutset

Cutset 2 = {2, 1, 4}

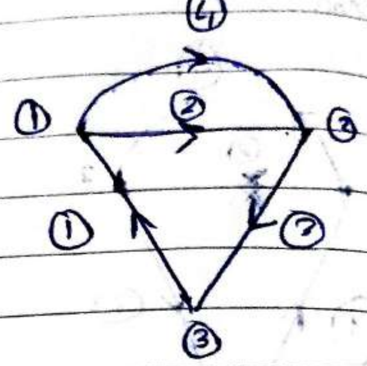
Cutset 3 = {3, 1}

| Cutset | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 2 | -1 | 1 | 0 | 1 |
| 3 | -1 | 0 | 1 | 0 |

iii Reduced incidence matrix

$$A = \begin{bmatrix} -1 & 1 & 0 & 1 \\ 0 & -1 & 1 & -1 \end{bmatrix}$$

iv loop matrix



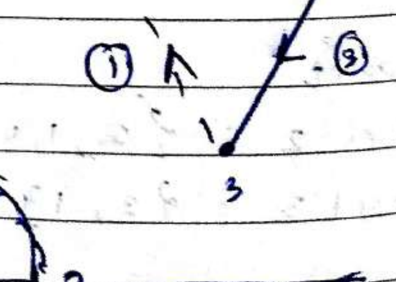
loop 1 = {1, 2, 3}
loop 2 = {2, 4}
loop 3 = {1, 3, 4}

| loop | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 |
| 2 | 0 | -1 | 0 | 1 |
| 3 | 1 | 0 | 1 | 1 |

$$B_a = \begin{bmatrix} 1 & 1 & 1 & 0 \\ 0 & -1 & 0 & 1 \\ 1 & 0 & 1 & 1 \end{bmatrix}$$

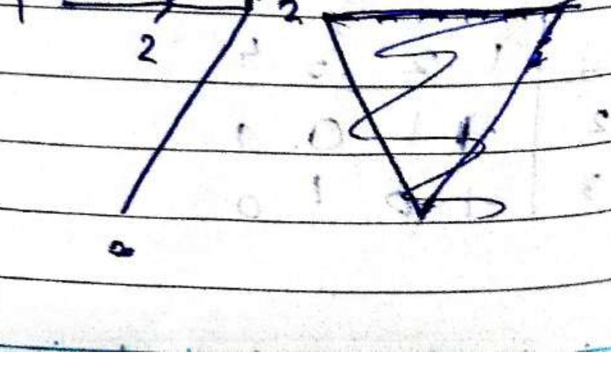
v Tiset matrix

Tiset 1 : {1, 2, 4}



Tiset 2 : {4, 2}

~~Tiset 3 :~~



Date :

Duality ⟶ Conversion

| | |
|---|---|
| Current | Volt |
| Resistance | Conductance |
| Inductance | ~~Conductance~~ Capacitor |
| Branch Current | Branch voltage |
| Mesh | Node |
| S.C | O.C |