Toppersnotes
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UGC-NET

Paper - 2

NATIONAL TESTING AGENCY (NTA)

ELECTRONIC SCIENCE

Paper 2 – Volume 2

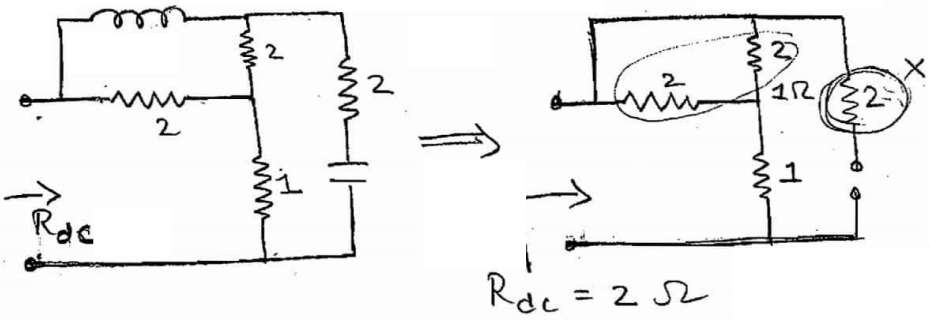
SIERRA INNOVATIONS

Index

Unit – 3 (1)

Unit – 3 (1)

Network Theory Ace



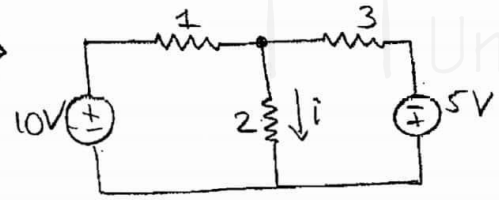
$R_{dc} = 2\,\Omega$

Methods of Analysis :

- Mesh Analysis = KVL + Ohms' Law [I↑ V↓]
- Nodal Analysis = KCL + Ohms' Law [V↑ I↓]

In nodal analysis, we can eliminate the use of simple nodes, if not required.

1)



Find 'i' using mesh & nodal analysis

Mesh Analysis

① $10 - 3i_1 + 2i_2 = 0$

$\therefore 3i_1 - 2i_2 = 10$

② $5 - 5i_2 + 2i_1 = 0$

$\therefore 2i_1 - 5i_2 = -5$

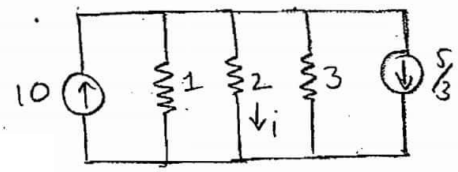
From ① & ②

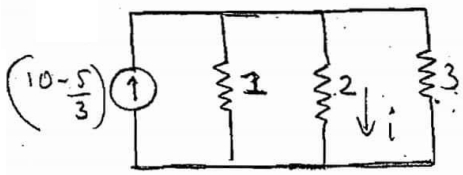
$i_1 = \frac{60}{11}$ $\quad i_2 = \frac{35}{11}$

Now,

$i = i_1 - i_2$

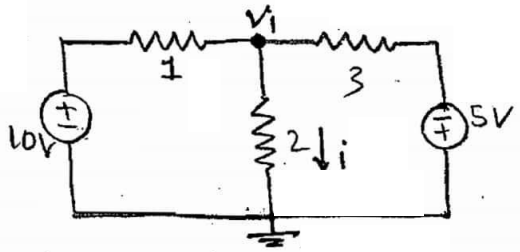
$= \frac{25}{11}$ A





$i = \left(10 - \frac{5}{3}\right)\left[\frac{3}{2+3+6}\right]$

$= \frac{25}{3} \times \frac{3}{11} = \frac{25}{11}$ A



Nodal Analysis

$$\frac{V_1-10}{1}+\frac{V_1}{2}+\frac{V_1-5}{3}=0$$

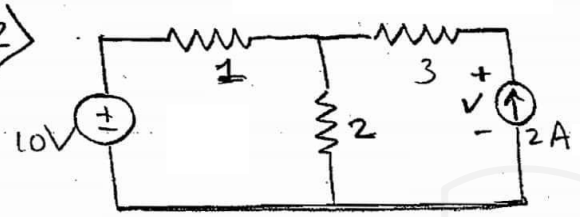
$$6V_1-60+3V_1+2V_1-10=0$$

$$V_1=\frac{50}{11}\ V$$

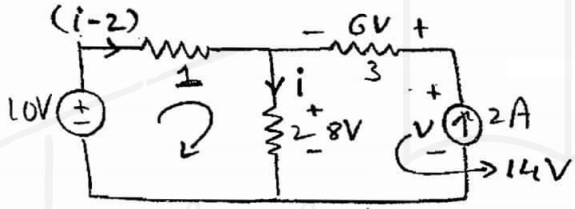
Now,

$$i=\frac{V_1}{2}=\frac{25}{11}\ A.$$

2)



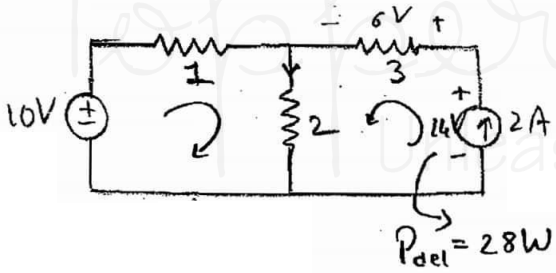
Find power delivered by current source using mesh & nodal



$$-10+i-2+2i=0$$

$$i=4\ A$$

$\therefore P_{deliv.}=+2\times14=28W$

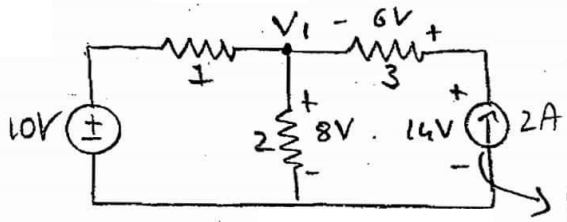


$$-10+i_1+2(i_1-i_2)=0$$

$$3i_1-2i_2=10 \quad \text{—①}$$

By comparision: $i_2=-2$ —②

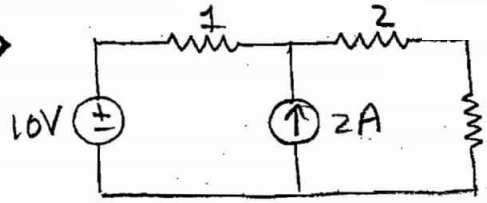
$\therefore\ 3i_1=6 \Rightarrow i_1=2$



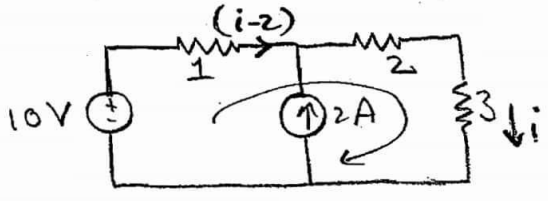
$$\frac{V_1-10}{1}+\frac{V_1}{2}-2=0$$

$$\therefore\ V_1=8\ V$$

3)

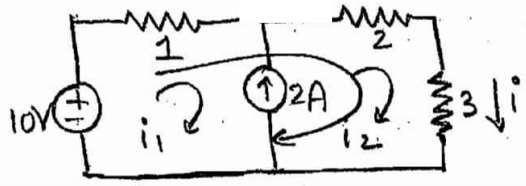


Find i using mesh & nodal analysis



$$-10-i-2+5i=0$$

$$i=2$$



Here $i_2 = i$

$10 - i_1 - 5i = 0$

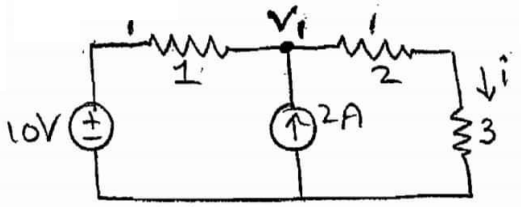
$i_1 + 5i = 10$

$\therefore \quad 6i = 12 \Rightarrow \boxed{i = 2\,A}$

Now,

$i - i_1 = 2$

$i_1 = i - 2$

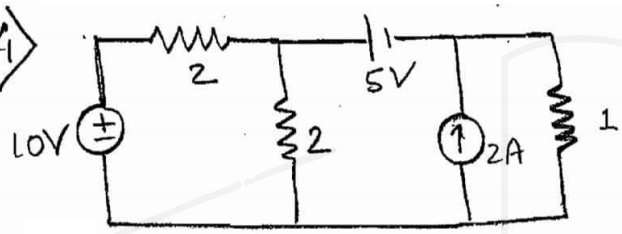


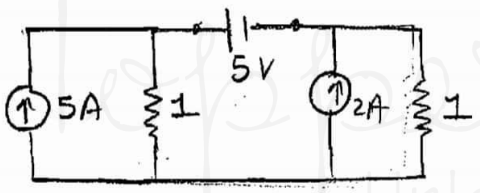
$\frac{V_1 - 10}{1} + 2 + \frac{V_1}{5} = 0$

$6V_1 = 60 \Rightarrow V_1 = 10\,V$

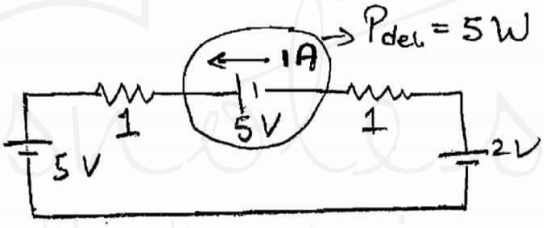
$i = \frac{V_1}{5} = \frac{10}{5} = 2\,A$

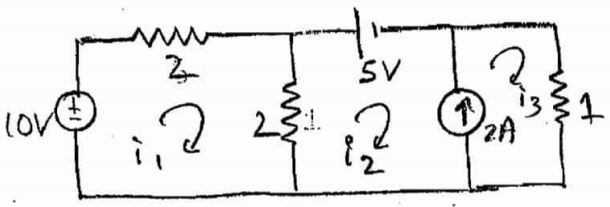
4) Find the power delivered by 5V source using mesh and nodal analysis.





$\Rightarrow$





$-10 + 2i_1 + 2(i_1 - i_2) = 0$

$2i_1 - i_2 = 5$ — (1)

$2(i_2 - i_1) + 5 + i_3 = 0$

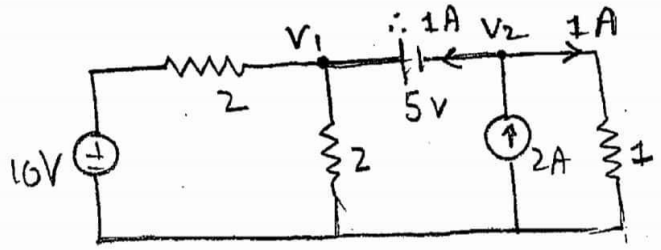
$-2i_1 + 2i_2 + i_3 = 5$ — (2)

$-i_2 + i_3 = 2$ — (3)

$i_2 + i_3 = 0$

$2i_2 = -2$

$i_2 = -1 \Rightarrow \boxed{P_{del.} = 5W}$



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

$V_1 + V_2 = 7$ — (1)

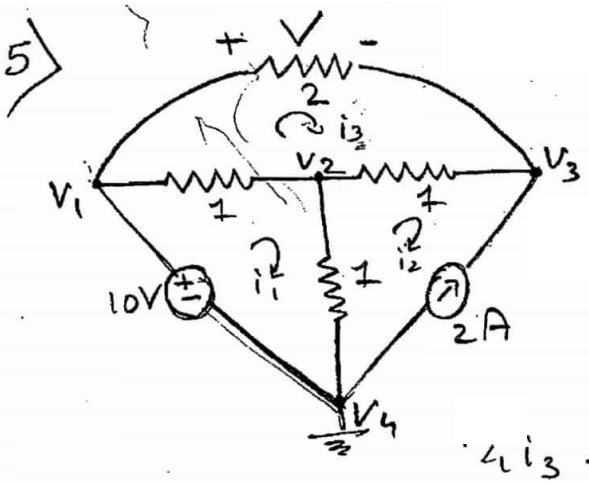
$V_1 - V_2 = 5$ — (2)

$\therefore \quad V_1 = 6\ V$

$V_2 = 1\ V$

$\therefore P_{deliv.} = 5 \times 1$

$= 5W.$

5) 

Find V using mesh & nodal analysis

MESH :-

$10 - 2i_1 + i_3 + i_2 = 0$ — (1)

$i_2 = -2$ — (2)

$4i_3 - i_1 - i_2 = 0$ — (3)

$\therefore \quad -2i_1 + i_3 + 8 = 0 \quad \Rightarrow \quad 4i_3 - 2i_1 = -8$

& $\quad -i_1 + 4i_3 + 2 = 0 \quad \quad -8i_3 + 2i_1 = +4$

$-7i_3 = 4$

$i_3 = -\frac{4}{7}$

$\therefore V = 2\left(-\frac{4}{7}\right) = \boxed{\frac{8}{7}\ V}$

NODAL :-

$V_1 = 10\ V$ — (1)

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

$\therefore \quad 3V_2 - V_3 = 10$ — (2)

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

$\therefore \quad 3V_3 - 2V_2 = 14$ — (3)

From (2) & (3), ;

$6V_2 - 2V_3 = 20$

$-6V_2 + 9V_3 = 42$

$7V_3 = 62$

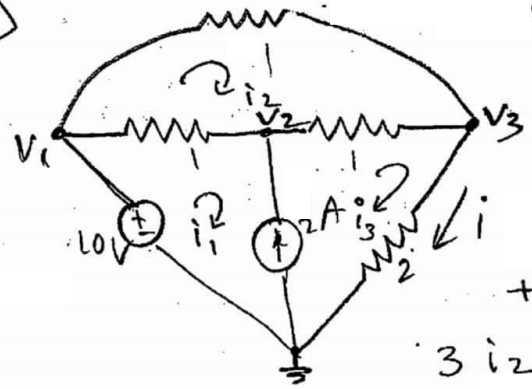
$V_3 = \frac{62}{7}$

$\therefore V = V_1 - V_3$

$= 10 - \frac{62}{7}$

$\boxed{V = \frac{8}{7}\ V}$

6)



Find 'i' using mesh & nodal.

Mesh :-

$+10 - i_1 \cdot i_3 - i_1 = 2$ — (1)

$3i_2 - i_1 - i_3 = 0$ — (2)

$10 - i_1 - 3i_3 + 2i_2 = 0$ — (3)

Now, from (2) & (1); $3i_2 - i_3 + 2 - i_3 = 0$

$3i_2 - 2i_3 = -2$ — (4)

Now, from (1) & (3); $-i_3 + 2 - 3i_3 + 2i_2 = 10$

$\therefore 2i_2 - 4i_3 = +8$ — (5)

$$\begin{array}{r} 6i_2 - 4i_3 = -4 \\ -6i_2 + 12i_3 = -24 \\ \hline 8i_3 = -28 \end{array}$$

NODAL :- $V_1 = 10\ V$ — (1)

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

$2V_2 - V_3 = 12$ — (2)

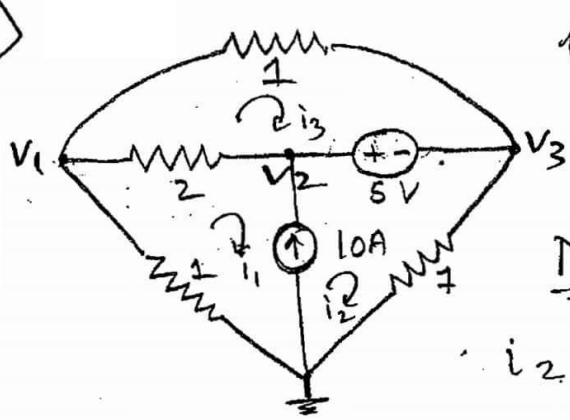
$$\frac{V_3 - 10}{1} + \frac{V_3 - V_2}{1} + \frac{V_3}{2} = 0$$

$\therefore -2V_2 + \frac{5}{2}V_3 = 20$ — (3)

$\therefore 4V_3 = 32$

$V_3 = 8\ V \Rightarrow i = \frac{8}{2} = \boxed{4A}$

4)



What is the power delivered by the ubg source ?

Mesh :-

$$i_2 - i_1 = 10 \quad \text{—— (1)}$$

$$3i_1 + 2i_2 - 2i_3 = -5$$

$$\therefore 3(i_2 - 10) + 2i_2 - 2i_3 = -5$$

$$3i_2 - 30 + 2i_2 - 2i_3 = -5$$

$$\therefore 5i_2 - 2i_3 = 25 \quad \text{—— (2)}$$

$$3i_3 - 2i_1 = 5$$

$$3i_3 - 2(i_2 - 10) = 5$$

$$\therefore -2i_2 + 3i_3 = -15 \quad \text{—— (3)}$$

$$10i_2 - 6i_3 = 75$$

$$-4i_2 + 6i_3 = -30$$

$$8i_2 = 45$$

$$\therefore \boxed{i_2 = \frac{45}{8}}$$

$$i_3 = \frac{4(\frac{45}{8}) - 25}{2}$$

$$= \frac{45 - 50}{4} = -\frac{5}{4}$$

$$P_{del.} = -5 \times \left(\frac{45}{8} + \frac{5}{4}\right)$$

$$= \boxed{\frac{-275}{8}\ W}$$

NODAL :-

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

$$5V_1 - V_2 - 2V_3 = 0 \quad \text{—— (1)}$$

$$(V_2 - V_3) = 5 \quad \text{—— (2)}$$

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

$$-3V_1 + V_2 + 4V_3 = 20 \quad \text{——} (3)$$

From ① & ② $\quad -7V_1 + 3V_2 = 20$

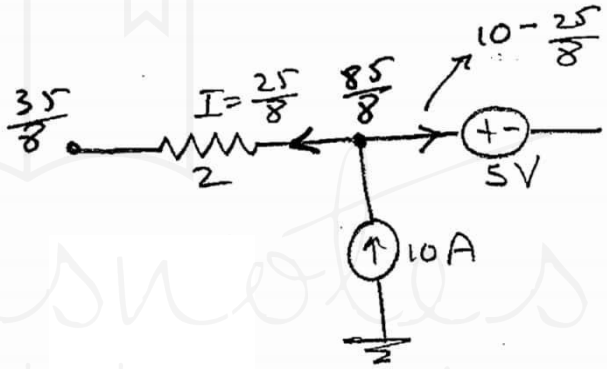
From ② & ③ ; $\quad 5V_1 - 3V_2 = -10$

$$16V_1 = 70$$

$$\therefore \boxed{V_1 = \frac{35}{8}}$$

$$V_2 = 7\left(\frac{35}{8}\right) - 20$$

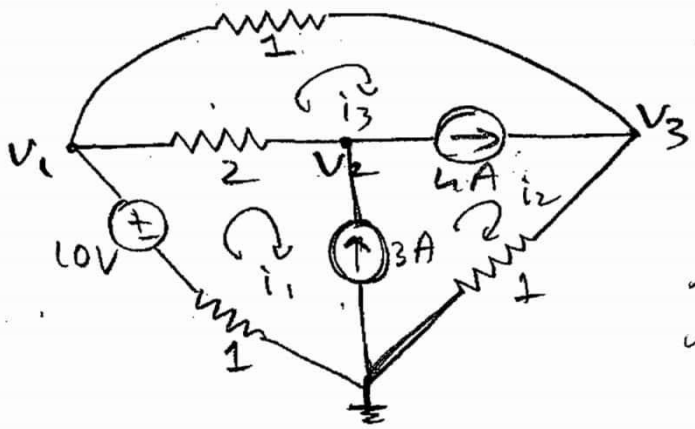
$$\therefore \boxed{V_2 = \frac{85}{8}}$$



$$\therefore P_{delivr} = -5\left(10 - \frac{25}{8}\right)$$

$$= -\frac{275}{8} \text{ W}$$

8)



Find power delivered by dtg source using mesh & nodal.

MESH :—

$$i_1 + i_2 + i_3 = 10 \quad \text{——} (1)$$

$$i_2 - i_1 = 3 \quad \text{——} (2)$$

$$i_2 = 3 + i_1$$

$$i_2 - i_3 = 4 \quad \text{——} (3)$$

$$3 + i_1 - i_3 = 4$$

$$\therefore i_3 = i_1 - 1$$

$\therefore\ i_1 + 3 + i_1 + i_1 - 1 = 10$

$\therefore\ 3i_1 = 8 \Rightarrow i_1 = \frac{8}{3}$

$\therefore\ P_{deliv.} = 10 \times \frac{8}{3} = \boxed{\frac{80}{3}\ W}$

NODAL :—

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

$$\therefore\ 5V_1 - V_2 - 2V_3 = 20 \quad \text{—— (1)}$$

$$\frac{V_2 - V_1}{2} + 4 - 3 = 0$$

$$\therefore\ V_2 - V_1 = -2 \quad \text{—— (2)}$$

$$\frac{V_3}{1} - 4 + \frac{V_3 - V_1}{1} = 0$$

$$\therefore\ -V_1 + 2V_3 = 4 \quad \text{—— (3)}$$

From (1) & (2); $5V_1 - V_1 + 2 - 2V_3 = 20$

$$\therefore\ 4V_1 - 2V_3 = 18 \quad \text{—— (4)}$$

$$-V_1 + 2V_3 = 4$$

$$3V_1 = 22$$

$$\therefore\ \boxed{V_1 = \frac{22}{3}\ V}$$

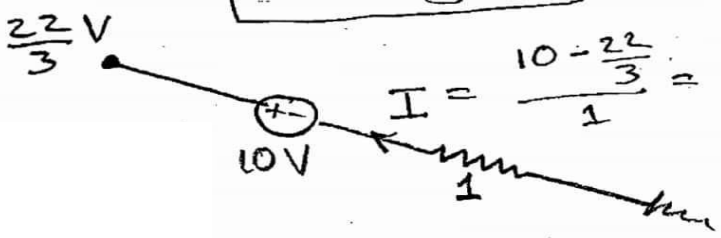
$\therefore V_3 = \frac{4 + \frac{22}{3}}{2}$

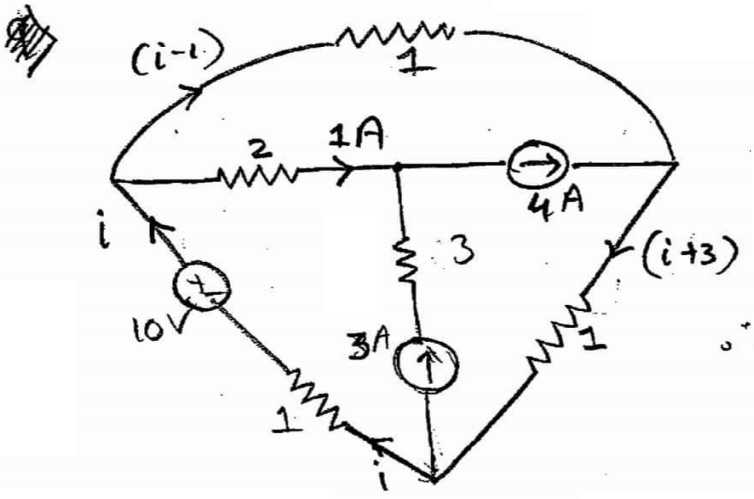
$\therefore V_3 = \frac{34}{6} V$

Now,

$P_{deliv.} = 10 \times \frac{8}{3}$

$= \frac{80}{3} W$





$i - 10 + i - 1 + i + 3 = 0$

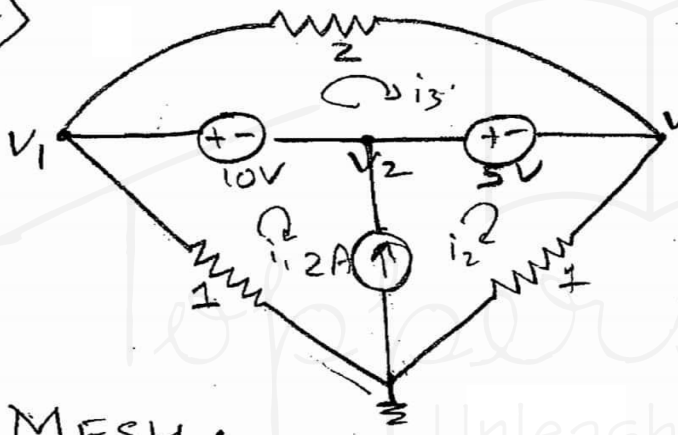
$3i = 8$

$i = \frac{8}{3}$

$\therefore P_{deliv.} = 10 \times \frac{8}{3}$

$= \frac{80}{3}$ W

Q)



Find the power delivered by the current source using mesh & nodal.

MESH :—

$i_1 + 1i_2 + 1i_3 = 0$ —— (1)×

$2i_3 = 15 \Rightarrow \boxed{i_3 = \frac{15}{2}}$ —— (2)

$i_1 + i_2 = -15$ —— (3)

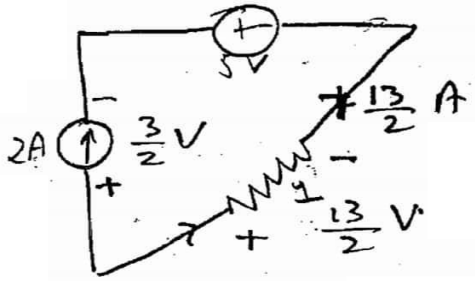
$-i_1 + i_2 = 2$ —— (4)

$\boxed{i_2 = \frac{-13}{2}}$

$i_1 = \frac{-17}{2}$

$\therefore P_{delivered} = -2 \times \frac{3}{2}$

$\boxed{= -3W}$



NODAL :—

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

$$\therefore \quad 3V_1 - V_3 = 0$$

$$\therefore \quad V_1 + V_3 = 2 \quad \text{——} \quad (1)$$

$$V_1 - V_2 = 10 \quad \text{——} \quad (2)$$

$$V_2 - V_3 = 5 \quad \text{——} \quad (3)$$

$$\Rightarrow V_2 + V_1 = 7.$$

$$\therefore \quad 2V_1 = 17$$

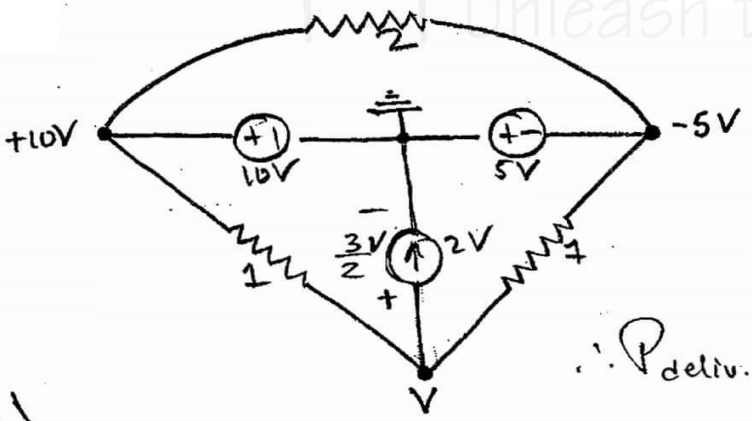
$$V_1 = \frac{17}{2}$$

$$V_2 = \frac{17}{2} - 10$$

$$\boxed{V_2 = -\frac{3}{2} V}$$

$$P_{delivered} = 2 \times \left(-\frac{3}{2}\right)$$

$$= -3\,W.$$



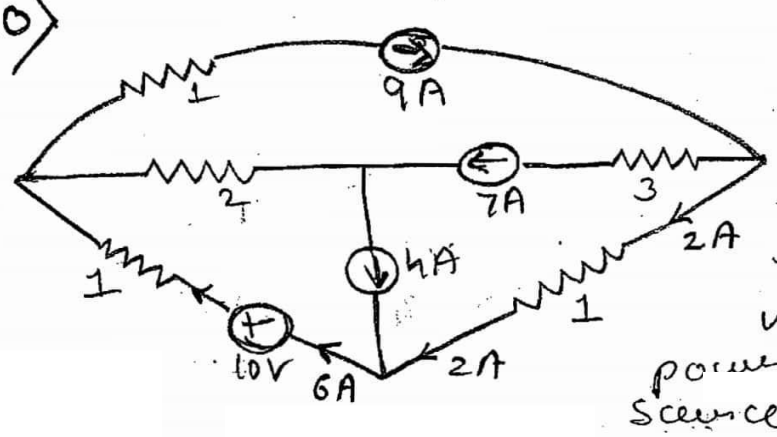
$$\frac{V-10}{1} + \frac{V+5}{1} + 2 = 0$$

$$\therefore \quad 2V = 3$$

$$V = \frac{3}{2} V$$

$$\therefore P_{deliv.} = -\frac{3}{2} \times 2 = -3W$$

10)



Just write mesh & nodal eqⁿ governing the ckt & determine power delivered by vltg source by inspection.

MESH :—

$i_1 - i_2 = 4$ —— (1) $\qquad i_3 = 9\ A$ —— (2)

$i_3 - i_2 = 7$ —— (3) $\Rightarrow \quad i_2 = 2\ A$

$\therefore i_1 = 6\ A$

NODAL :—

$$\frac{V_1 - 10}{1} + \frac{V_1 - V_2}{2} + 9 = 0 \quad \text{—— (1)}$$

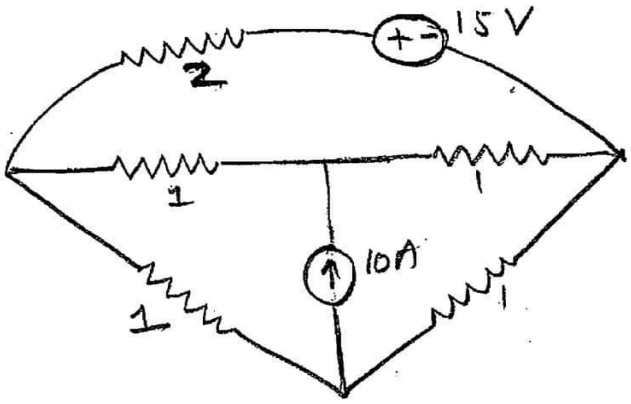
$$\frac{V_2 - V_1}{2} + 4 - 7 = 0 \quad \text{—— (2)}$$

$$\frac{V_3}{1} + 7 - 9 = 0 \quad \text{—— (3)}$$

Now,

$P_{delvird} = 10 \times 6 = \boxed{60\ W}$

11)



What is the power delivered by volty source using mesh & nodal.

MESH :—

$i_2 - i_1 = 10$ —— (1)

$4i_3 - i_1 - i_2 = -15$ —— (2) $\Rightarrow i_1 + i_2 = 4i_3 + 15$

$i_1 + i_2 + 2i_3 = -15$ —— (3) $\Rightarrow 4i_3 + 15 + 2i_3 = -15$

$P_{deliv} = +15 \times \frac{10}{2} = +\frac{75}{1}\ W$ $\qquad \therefore\ i_3 = -5A$

NODAL:—

$$\frac{V_1}{1} + \frac{V_1 - V_2}{1} + \frac{V_1 - 15 - V_3}{2} = 0$$

$$\therefore 5V_1 - 2V_1 - V_3 = 15 \quad \text{——} (1)$$

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

$$\therefore -V_1 + 2V_2 - V_3 = 10 \quad \text{——} (2)$$

$$\frac{V_3}{1} + \frac{V_3 - V_2}{1} + \frac{V_3 + 15 - V_1}{2} = 0$$

$$\therefore -V_1 - 2V_2 + 5V_3 = -15 \quad \text{——} (3)$$

From (1) & (2); $4V_1 - 2V_3 = 25$

From (2) & (3); $-2V_1 + 4V_3 = -5$

$$6V_3 = 15$$

$$V_1 = \frac{25 + \frac{15}{3}}{4}$$

$$= \frac{90}{12} = \frac{15}{2} V$$

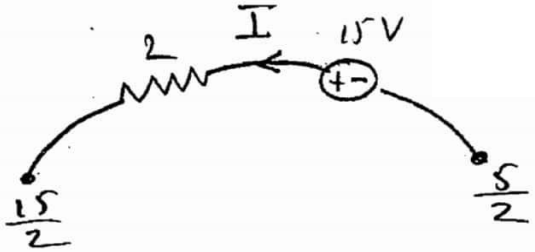
$$V_3 = \frac{15}{6} V = \frac{5}{2} V$$

$$\therefore I = \frac{V_3 + 15 - V_1}{2} = \frac{\frac{5}{2} + 15 - \frac{15}{2}}{2}$$

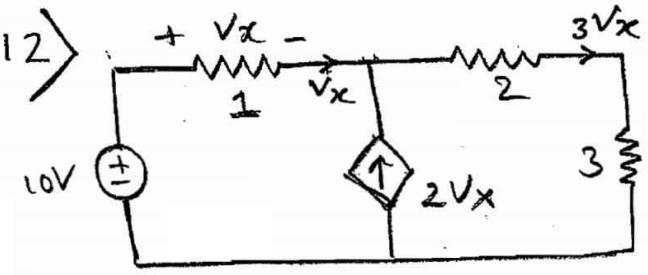
$$= \frac{20}{4} = 5 \text{ A}$$

$$\therefore P_{deliver} = 15 \times 5$$

$$= 75 \text{ W}$$



12)



Find V_x using mesh & nodal

KVL $\quad -10 + V_x + 15V_x = 0$

$\therefore \boxed{V_x = \frac{5}{8} V}$

Link equation :-

$V_x = i_1 \quad —③$

MESH :—

$i_1 + 5i_2 = 10 \quad —①$

$-i_1 + i_2 = 2V_x \quad —②$

$\therefore -3i_1 + i_2 = 0 \quad —④$

From ① & ④;

$3i_1 + 15i_2 = 30$

$-3i_1 + i_2 = 0$

$16 i_2 = 30$

$i_2 = 2 A.$

~~$\therefore i_1 = 10$~~ V

$\therefore i_1 = \frac{5}{8}$

$\therefore V_x = \frac{5}{8} V$

NODAL :—

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

$5V_1 - 50 - 10V_x + V_1 = 0$

$6V_1 - 10V_x = 50$

$3V_1 - 5V_x = 25 \quad —①$

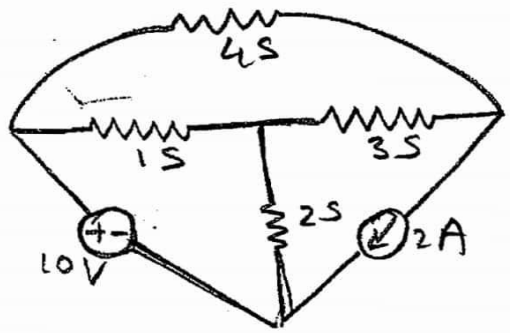
$V_x = 10 - V_1 \quad —②$

$3(10 - V_x) - 5V_x = 25$

$8V_x = 5$

$V_x = \frac{5}{8} V$

13)



MESH

$$-10 + \frac{(i_1 - i_3)}{1} + \frac{(i_1 - i_2)}{2} = 0 \quad \text{—— (1)}$$

$$\therefore \quad i_2 = 2 \quad \text{—— (2)}$$

$$\frac{i_3}{4} + \frac{(i_3 - i_2)}{2} + \frac{(i_3 - i_1)}{1} = 0 \quad \text{—— (3)}$$

$$P_{3S} = \frac{|i_2 - i_3|^2}{3} = \_\_\_\_\_ \text{ W}$$

NODAL :—

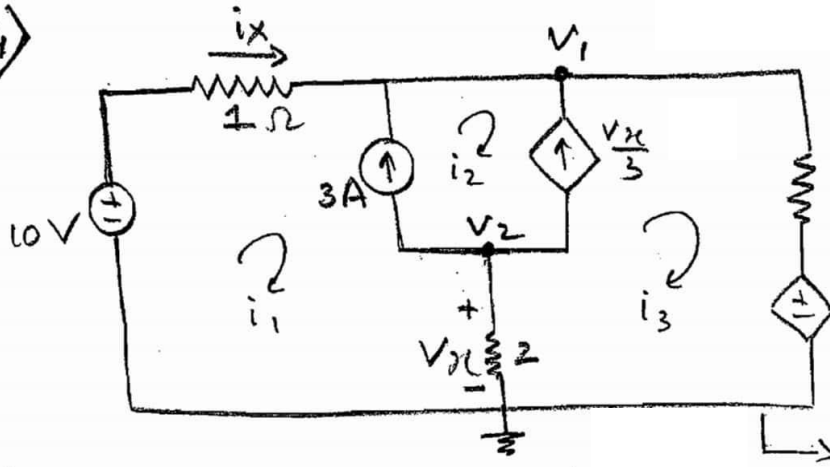
$$V_1 = 10 \quad \text{—— (1)}$$

$$1[V_2 - V_1] + 2V_2 + 3[V_2 - V_3] = 0 \quad \text{— (2)}$$

$$+2 + 3(V_3 - V_2) + 4(V_3 - V_1) = 0 \quad \text{—— (3)}$$

$$P_{3S} = [V_2 - V_3]^2 \cdot 3 = \_\_\_\_\_ \text{ W}$$

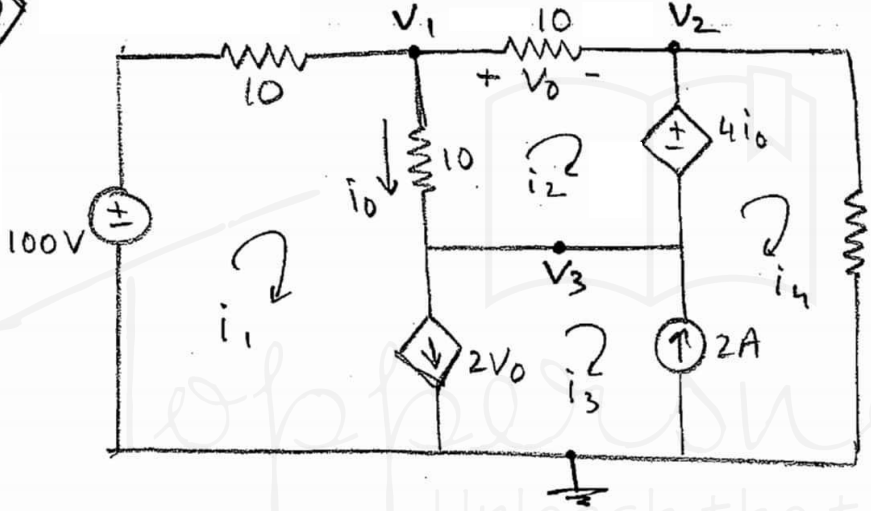
14)



Write mesh & nodal equation governing the circuit.

→ Mesh = 3 + 2 = 5
Nodal = 2 + 2 = 4

15)



→ Mesh = 4 + 2 = 6
Nodal = 3 + 2 = 5

14) MESH :-

$10 - i_1 - 4i_3 - 5i_x = 0$ —— (1)

$-i_1 + i_2 = 3$ —— (2)

$-i_2 + i_3 = \frac{V_x}{2}$ —— (3)

$i_x = i_1$ —— (4)

$V_x = (i_1 - i_3)2$ —— (5)

NODAL :-

$\frac{V_1 - 10}{1} + \frac{V_1 - 5i_x}{4} - 3 - \frac{V_x}{3} = 0$ —— (1)

$\frac{V_2}{2} + 3 + \frac{V_x}{3} = 0$ —— (2)

$V_x = V_2$ —— (3)

$i_x = 10 - V_1$ —— (4)