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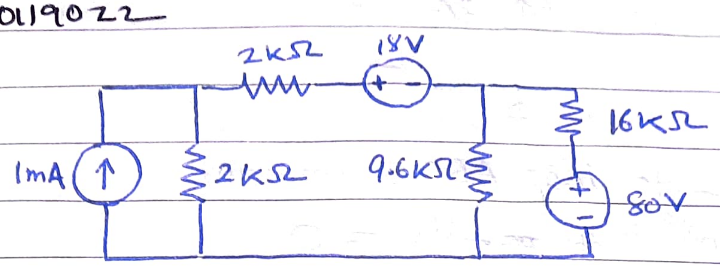
TUTORIAL - 1 · EEN - 112

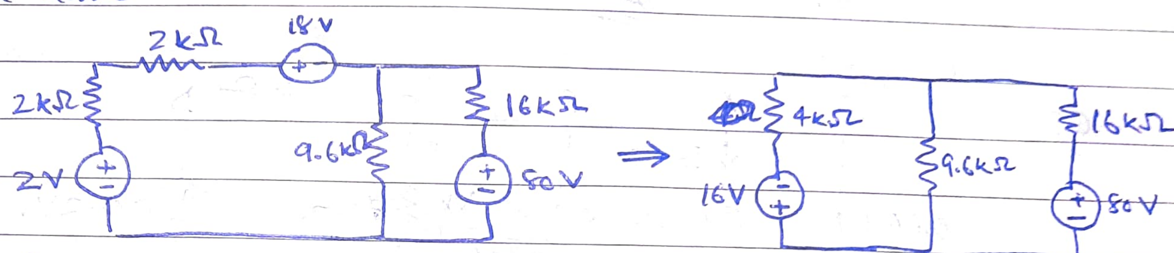
HARSH PANDEY

20119022

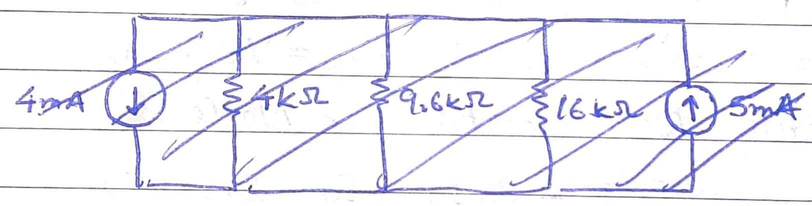
Q1



Transforming 1mA constant current source to a voltage source, we have



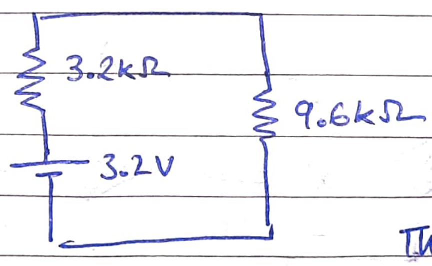
Converting 16V and 80V constant voltage sources to ~~current~~ equivalent voltage sources, we have by Millman's theoram



$$\Rightarrow \quad E_{eq} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{-\frac{16}{4} + \frac{80}{16}}{\frac{1}{4} + \frac{1}{16}} = \frac{1}{\left(\frac{5}{16}\right)} = \frac{16}{5} \text{ V}$$

$$r_{eq} = \frac{r_1 r_2}{r_1 + r_2} = \frac{16 \times 4}{20} = \frac{16}{5} \text{ k}\Omega$$

$\therefore$



$$\therefore I = \frac{3.2}{(3.2 + 9.6) \times 10^3}$$

$$= 0.25 \text{ mA}$$

Thus power absorbed by 9.6kΩ resistor =

$$P = I^2 R$$

$$= (0.25 \text{mA})^2 \times (9.6 \text{k}\Omega)$$

$$= 0.6 \text{ mWatt} \quad \underline{\underline{A}}$$

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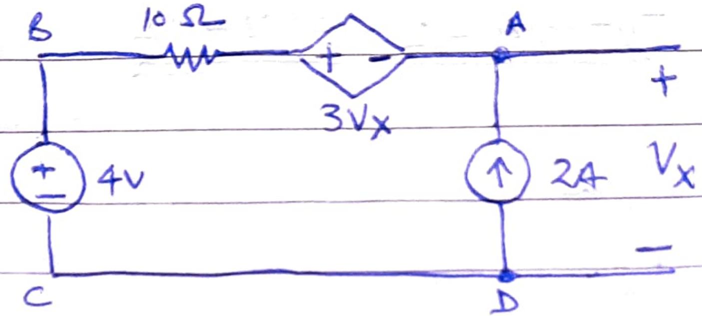
Q2



Applying KVL to loop ABCD, we have

$+3V_x - 2(10) - 4 + V_x = 0$

$\Rightarrow 4V_x = 24$

$\Rightarrow V_x = 6V$ Ans

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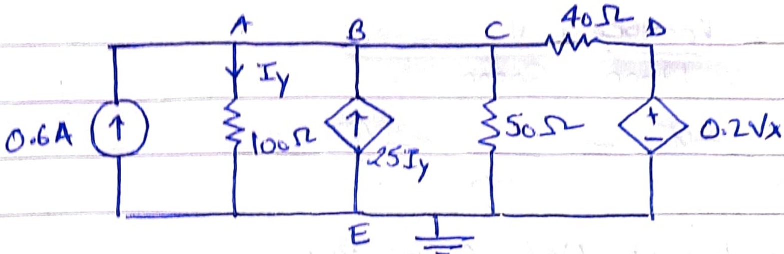
Q3



Let E be the reference Node at 0 Voltage
Since there is no resistance between A, B or C $\Rightarrow V_A = V_B = V_C$
also $V_C - V_E = V_X \Rightarrow V_C = V_X$ and $V_D = 0.2V_X$.

Thus writing node equation at C, we have.

$$\frac{V_C - V_D}{40} + \frac{V_C - V_E}{50} - 25I_y + \frac{V_A - V_E}{100} - 0.6 = 0$$

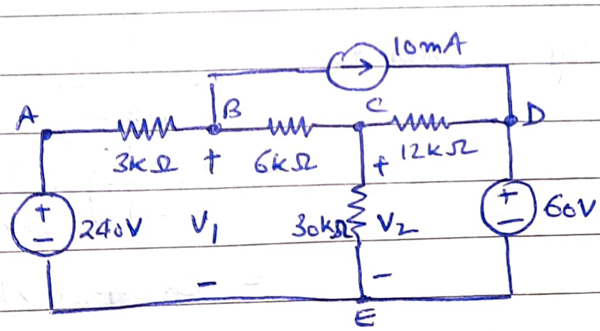
$$\Rightarrow \frac{V_X - 0.2V_X}{40} + \frac{V_X}{50} - 25I_y + \frac{V_X}{100} - 0.6 = 0$$

Also $I_y = \frac{V_A - V_E}{100} = \frac{V_X}{100}$

$$\Rightarrow \frac{0.8V_X}{40} + \frac{V_X}{50} - \frac{24V_X}{100} = 0.6$$

$$\Rightarrow \frac{-20V_X}{100} = 0.6 \Rightarrow \boxed{V_X = -3V} \text{ Ans}$$

Q4



To find V_1, V_2 and power absorbed by 6K resistor

Let E be the reference node at 0V.
$\therefore V_A = 240V$ and $V_D = 60V$

Nodal equation at Node C, we have

$$\frac{V_C - V_B}{6000} + \frac{V_C - V_D}{12000} + \frac{V_C - V_E}{30000} = 0$$

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$$\Rightarrow \frac{V_C - V_B}{6000} + \frac{V_C - 60}{12000} + \frac{V_C}{30000} = 0$$

$$\Rightarrow \frac{17V_C}{60000} - \frac{V_B}{6000} = \frac{1}{200} \quad -(1)$$

Nodal equation at Node B, we have

$$\frac{V_B - V_C}{6000} + \frac{V_B - V_A}{3000} + (10mA) = 0$$

$$\Rightarrow \frac{V_B - V_C}{6000} + \frac{V_B - 240}{3000} + 0.01 = 0$$

$$\Rightarrow \frac{V_B}{2000} - \frac{V_C}{6000} = \frac{7}{100} \quad -(2)$$

Multiply equation (2) by 1/3 and adding to (1), we get

$$\frac{41V_C}{180000} = \frac{17}{600} \Rightarrow V_C = \frac{5100}{41} V$$

$$\Rightarrow V_B = \frac{7440}{41} V.$$

$$\therefore V_2 = V_C - V_E = V_C = \frac{5100}{41} V$$ Ans

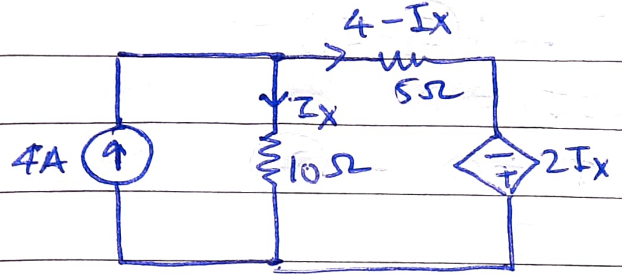
$$\therefore V_1 = V_B - V_E = V_B = \frac{7440}{41} V$$ Ans

Power absorbed by 6k resistor $= \frac{(V_B - V_C)^2}{6k\Omega}$

$$= \left(\frac{2340}{41}\right)^2 \frac{1}{6000}$$

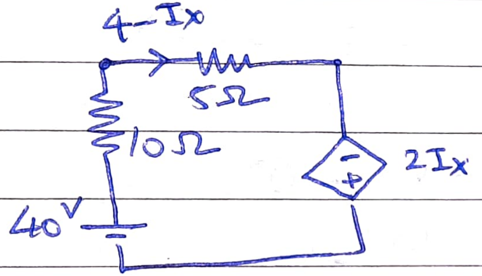
$$= 0.5428 \text{ W}$$

Q5



Applying source transformation on 4A independent current source after applying current distribution, we have

⇒



∴ In loop we have

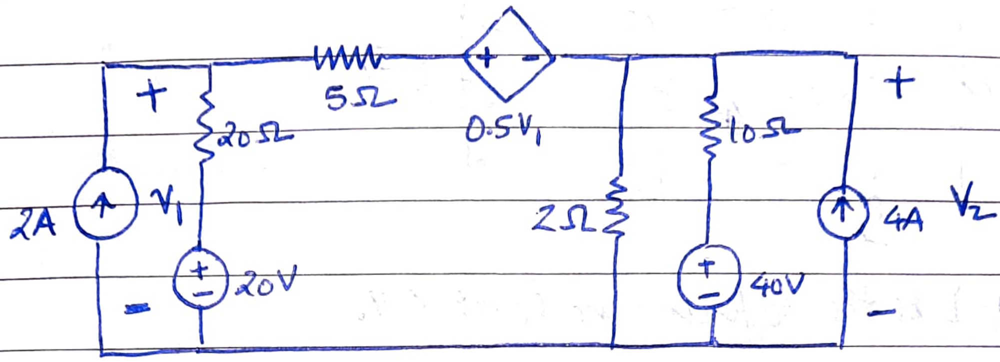
$-(4-I_x)5+2I_x+40-(4-I_x)10=0$

$\Rightarrow (4-I_x)15 = 40+2I_x$

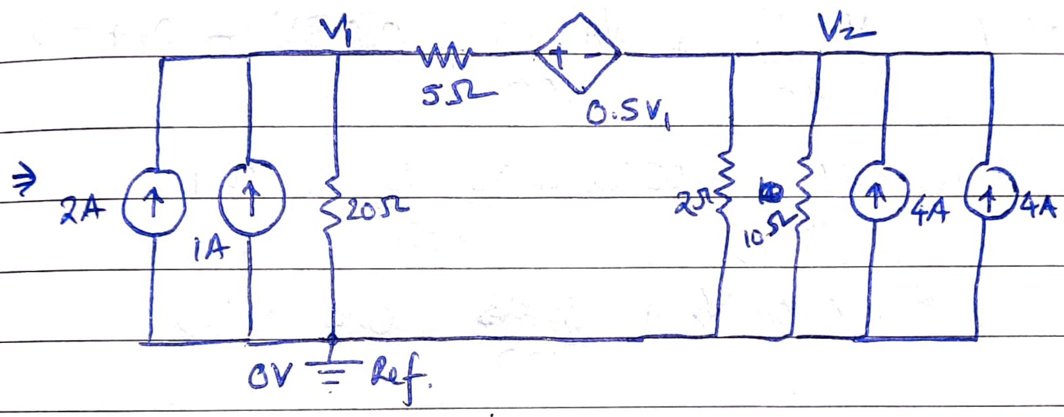
$\Rightarrow 20 = 17 I_x$

$\Rightarrow I_x = \frac{20}{17} A \approx 1.1764 A$ Ans

Q6



⇒



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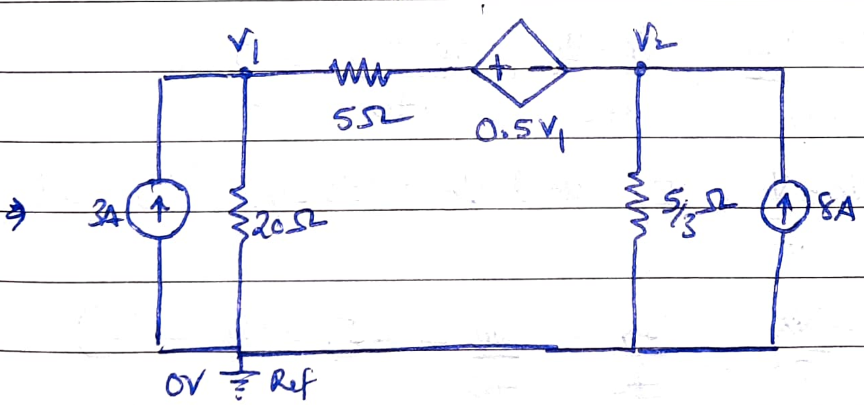

Node equation at V_1, we have

$$\frac{V_1 - V_2 - 0.5V_1}{5} + \frac{V_1 - 0}{20} = 3$$

$$\Rightarrow \frac{3V_1}{20} - \frac{V_2}{5} = 3 \quad \text{—(1)}$$

Node equation at V_2, we have

$$\frac{V_2 + 0.5V_1 - V_1}{5} + \frac{3V_2}{5} = 8 \Rightarrow \frac{4V_2}{5} - \frac{V_1}{10} = 8 \quad \text{—(2)}$$

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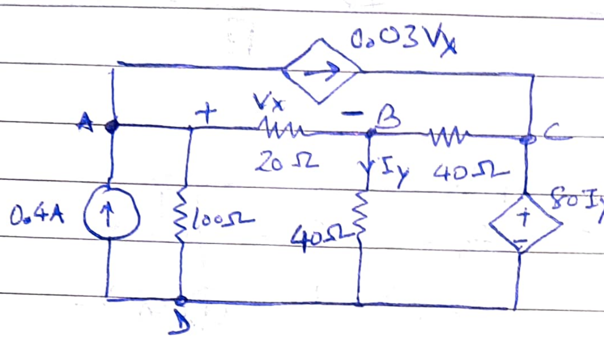
Multiplying equation ① by 4 and and adding equation ②, we get

$$\frac{V_1}{2} = 20 \Rightarrow V_1 = 40V$$
$$\therefore V_2 = 15V$$
Ans

Q7



Let D be the reference node at 0 V.

At Node A: $\frac{V_A - V_B}{20} + \frac{V_A - V_D}{100} + 0.03V_x - 0.4 = 0$

$\Rightarrow \frac{V_x}{20} + 0.03V_x + \frac{V_A - V_D}{100} = 0.4$

$\Rightarrow 0.08V_x + \frac{V_A \cancel{-V_D}}{100} = 0.4$ — ①

Node B: $\frac{V_B - V_A}{20} + \frac{V_B - V_D}{40} + \frac{V_B - V_C}{40} = 0$

Also $\frac{V_B - V_D}{40} = I_y$ and $V_C = 80I_y$. $\{V_D = 0\}$

$\Rightarrow -\frac{V_x}{20} + \frac{I_y}{40} + \frac{V_B}{40} - 2I_y = 0$ — ②

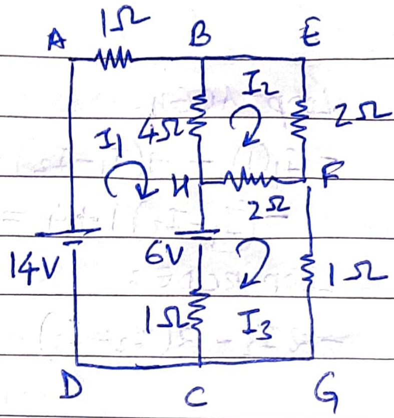
~~or $-\frac{V_x}{20} + \frac{V_B}{40}$ + ...~~

~~Node~~ $\Rightarrow -\frac{V_x}{20} + \frac{V_B}{20} - \frac{2V_B}{40} = 0$

$\Rightarrow \boxed{V_x = 0}$

$\therefore V_A = 40V$

Q8



For Loop ABCD :

$-1(I_1) - 4(I_1 - I_2) - 6 - 1(I_1 - I_3) + 14 = 0$

$\Rightarrow 6I_1 - 4I_2 - I_3 = 8$ — ①

For Loop BEFH :

$-I_2(2) - 2(I_2 - I_3) - 4(I_2 - I_1) = 0$

$\Rightarrow -4I_1 + 8I_2 - 2I_3 = 0$

$\Rightarrow -2I_1 + 4I_2 - I_3 = 0$ — ②

For Loop HFGC :

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

$\Rightarrow -I_1 - 2I_2 + 4I_3 = 6$ — ③

$6I_1 - 4I_2 - I_3 = 8$ — ①

$-2I_1 + 4I_2 - I_3 = 0$ — ②

$-I_1 - 2I_2 + 4I_3 = 6$ — ③

Substracting ② from ① and ~~Substracting~~ Adding 4×② to equation③, we get

$8I_1 - 8I_2 = 8$ and

$-9I_1 + 14I_2 = 6$

$\Rightarrow -9I_1 + 14I_2 = 6$ and $I_1 - I_2 = 1$

$\therefore I_2 = 3A$, $I_1 = 4A$

$\Rightarrow I_3 = 4A$

Thus power absorbed 4Ω $= (I_1 - I_2)^2 R$

$= 1^2 \times 4$

$= 4$ Watt

Current through 1Ω = 4A

Current through 4Ω = 1A

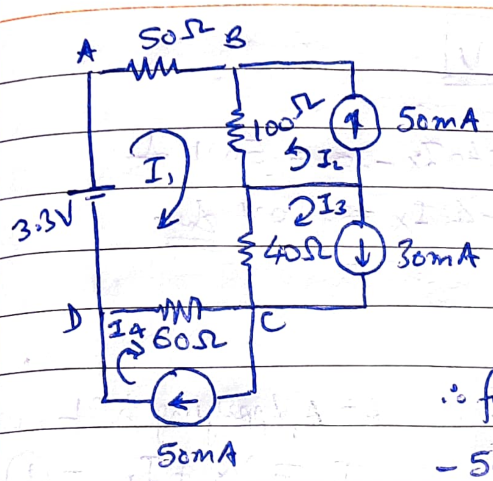
Current through 2Ω (b/w EF) = 3A

current through 2Ω (b/w HF) = 1A from H to F

current through 1Ω (b/w FG) = 4A

current through 1Ω (b/w HC) = 0A

Q9



We observe that $I_2 = 50\,mA$, $I_3 = 30\,mA$ and $I_4 = 60\,mA$ as the corresponding loops contain independent current sources.

Let I_1 be in mA

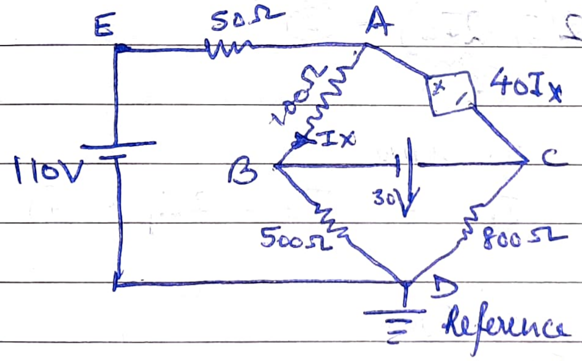
$\therefore$ for Loop ABCD, we have

$$-50 I_1 - 100(I_1 + 50) - 40(I_1 - 30) - 60(I_4 - 50) + 3300 = 0$$

$$\Rightarrow \quad 250 I_1 + 800 = 3300$$

$$\Rightarrow \quad I_1 = 10\,mA \quad \underline{\underline{A}}$$

Q10



~~For Node A:~~ ~~$\frac{V_A - V_E}{50} + \frac{V_A - V_B}{100}$~~

We observe $V_C = V_A - 40I_X$ and $V_B = V_C - 30$

$$\Rightarrow \quad V_B = V_A - 40 I_X - 30 \quad \text{—(1)}$$

Also $\frac{V_A - V_B}{100} = I_X$ —(2)

$\Rightarrow$ Using (1) and (2), we have

$$\frac{40 I_X + 30}{100} = I_X \Rightarrow \quad I_X = 0.5\,A$$

At Node D, we have.

$$\frac{V_D - V_B}{500} + \frac{V_D - V_C}{800} + \frac{V_D + 110 - V_A}{50} = 0$$

$$-\frac{(V_A - 40 I_X - 30)}{500} + \frac{(-)(V_A - 40 I_X)}{800} + \frac{110 - V_A}{50} = 0$$

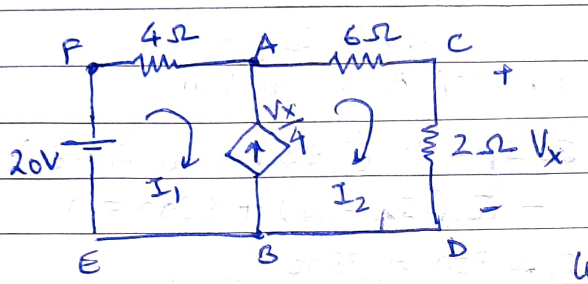
$$\frac{-V_A}{500} - \frac{V_A}{800} - \frac{V_A}{50} + \frac{50}{500} + \frac{20}{800} + \frac{110}{50} = 0$$

$$\frac{93V_A}{4000} = \frac{93}{40} \Rightarrow \boxed{V_A = 100\ V}$$

$$\therefore V_B = V_A - 40I_x - 30 = 50V \text{ Ans}$$

$$V_C = V_A - 40I_x = 80V \text{ Ans}$$

Q11



At A, Applying KCL, we have

$$I_2 = \frac{V_x}{4} + I_1 \quad -(1)$$

Writing loop equation for CDEF,

$$-4(I_1) - 6(I_2) - 2I_2 + 20 = 0$$

$$\Rightarrow 20 = 4I_1 + 8I_2$$

$$\Rightarrow 10 = 2(I_1 + 2I_2) \quad -(2)$$

Also $V_x = I_2(2) \quad -(3)$

Using (1) and (3), we have

$$I_2 = \frac{2I_2}{4} + I_1 \Rightarrow I_2 = 2I_1 \quad -(4)$$

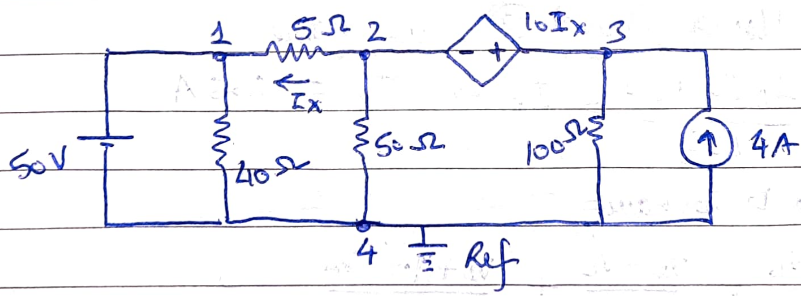
Using (4) in (2), we have

$$10 = 2(I_1 + 2I_2)$$

$$\Rightarrow 10 = 2(5I_1)$$

$$\Rightarrow I_1 = 1A \quad \therefore I_2 = 2A \text{ Ans}$$

Q12



For Node 1: $V_1 = 50V$

For Node 2:

$$\frac{V_2 - V_1}{5} + \frac{V_2 - V_4}{50} + \frac{V_2 + 10I_x - V_4}{100} - 4 = 0$$

and $I_x = \frac{V_2 - V_1}{5}$, $V_4 = 0$

$$\Rightarrow \frac{V_2 - V_1}{5} + \frac{V_2}{50} + \frac{V_2}{100} + \frac{V_2 - V_1}{50} = 4$$

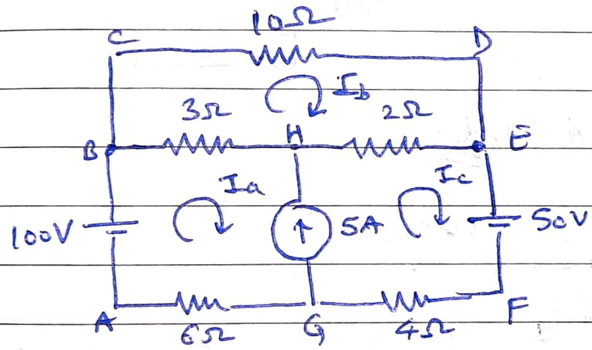
$$\Rightarrow \frac{V_2}{4} - \frac{11V_1}{50} = 4 \Rightarrow \frac{V_2}{4} - \frac{11 \times 50}{50} = 4$$

$$\Rightarrow V_2 = 60V$$

$$\therefore I_x = \frac{V_2 - V_1}{5} = \frac{60 - 50}{5} = 2A \text{ Ans}$$

$$V_3 = V_2 + 10 I_x = 60 + 10(2) = 80V \text{ Ans}$$

Q13



In Loop BCDE:

$$-10 I_b - 2(I_b - I_c) - 3(I_b - I_a) = 0$$

$$\Rightarrow 15 I_b - 3 I_a - 2 I_c = 0 \quad -(1)$$

In Loop BEFA:

$$-3(I_a - I_b) - 2(I_c - I_b) - 50 - 4 I_c - 6 I_a + 100 = 0$$

$$\Rightarrow 9 I_a - 5 I_b + 6 I_c = 50 \quad -(2)$$

Also Applying KCL at 'H', we have $I_a + 5 = I_c$ $-(3)$

$$15 I_b - 3 I_a = 2 I_a + 10 \Rightarrow 15 I_b - 5 I_a = 10$$

$$9 I_a - 5 I_b + 6 I_a + 30 = 50 \Rightarrow 15 I_a - 5 I_b = 20$$

$$I_b = 5/4 \, A = 1.25A$$

$$\therefore I_a = 7/4 \, A = 1.75A$$

Now $I_c = I_a + 5 = 6.75A$ Ans

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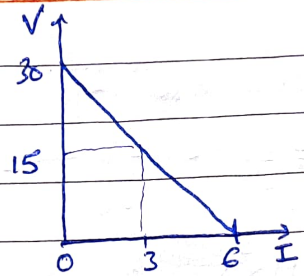
Q14 a)



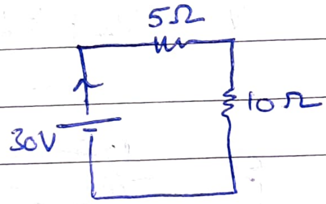
From graph, equation of straight line is, $V = 30 - 5I$

∵ A voltage drop of 30V can be produced regardless of current → source present of 30V which independent in nature.

∵ A voltage drop occurs linearly in direction of ~~cc~~ current hence a resistance ~~of~~ (ideal) is present.

$R = |\text{slope}| = 5\Omega$.

b) Applying KVL



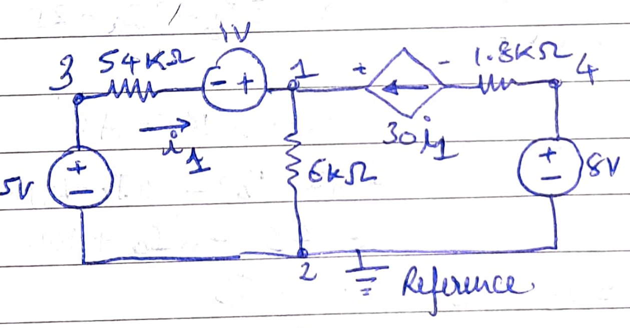
$30 - 5I - 10I = 0$

$\Rightarrow I = 2A$

$\text{Power} = I^2R = 2^2(10)$

$= 40W$

Q15



$i_1 = \dfrac{-V_1 + 1 + V_3}{54000}$

For Node 1; we have

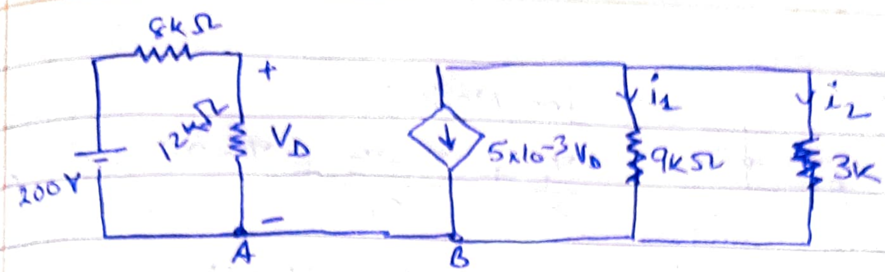
$\dfrac{V_1 - V_2}{6000} - 30i_1 + \dfrac{V_1 - 1 - V_3}{54000} = 0$

$\dfrac{V_1}{6000} - 31\left(\dfrac{6 - V_1}{54000}\right) = 0$

$\Rightarrow \dfrac{31 \times 6}{54000} = \dfrac{40V_1}{54000}$ $\Rightarrow V_1 = 4.65V$

$\therefore I_1 = \dfrac{6 - 4.65}{54000} = 25\mu A$

Q16



$$V_D = \frac{12\times10^3\,(200)}{(8+12)\times10^3} = 120V.$$ (branch AB has no current as $V_A = V_B$).

∴ Current by dependent current source $= 5\times10^{-3}\times V_D$

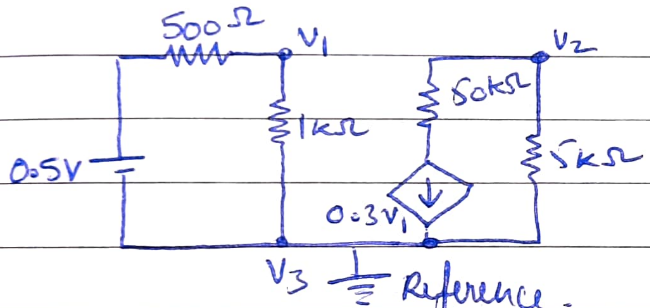
$= 5\times10^{-3}\times120$

$= 0.6\,A$

∴ Current in 9kΩ $= 0.6\times\frac{3}{9+3} = 0.15\,A$ ⇒ in 3kΩ $= 0.45A$

⇒ $i_1 = -0.15A$ and $i_2 = -0.45A$

Q18



For Node V_1:

$$\frac{V_1 - V_3}{1000} + \frac{V_1 - 0.5}{500} = 0$$

$$\Rightarrow \frac{3V_1}{1000} = \frac{0.5}{500} \Rightarrow V_1 = 1/3\,V$$

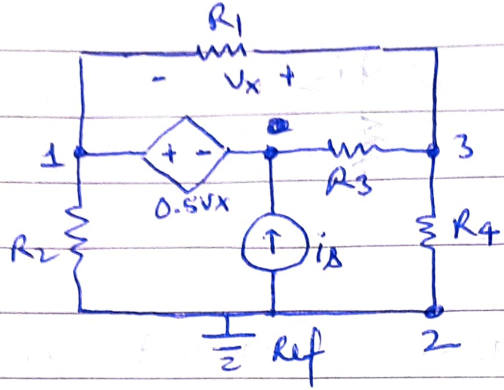
∴ Current supplied by dependent source $= 0.3V_1 = 0.1A$

∴ Power supplied by 0.5V source =

$$I = \frac{0.5}{1500} = \frac{1}{3}mA$$

∴ $P = VI = 0.5\times\frac{1}{3}\times10^{-3} = \frac{1}{6}mW$

Q19



for Node 1:

$$\frac{V_1}{R_2} + \frac{V_1 - V_3}{R_1} + \frac{V_1 - 0.5V_x - V_3}{R_3} = i_s$$

$$\Rightarrow \frac{V_1}{R_2} + \frac{V_1 - V_3}{R_1} + \frac{V_2 - V_3}{R_3} = I_s \quad -(1)$$

~~for Node 2~~

$$\cancel{I_s = \frac{V_2 - V_3}{R_3} + \frac{V_1 - V_3}{R_1} + \frac{V_1}{R_2}}$$

for Node 2 : $I_s = \frac{+V_3}{R_4} + \frac{V_1}{R_2} \quad -(2)$

for Node 3 : $\frac{V_3}{R_4} + \frac{V_3 - V_2}{R_3} + \frac{V_3 - V_1}{R_1} = 0 \quad -(3)$