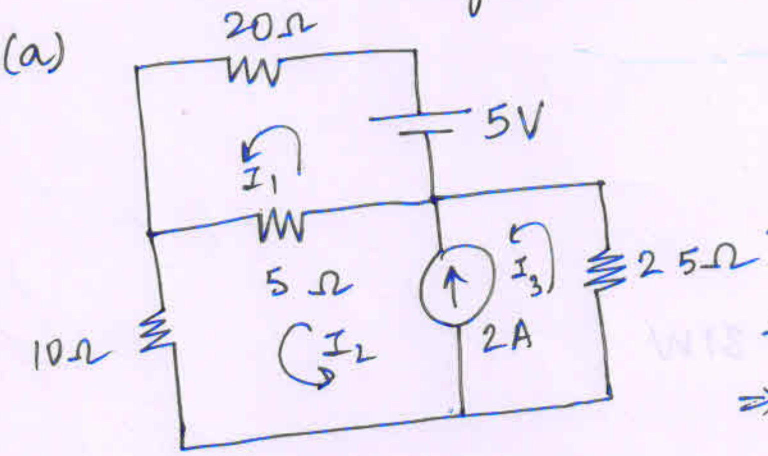
ESC201

Assignment 2 Solutions

Ans 1. (a)



$$20I_1 + 10I_2 + 25I_3 = 5$$

$$I_2 - I_3 = 2$$

$$\therefore 20I_1 + 10I_2 + 25I_2 = 55$$

$$\Rightarrow 20I_1 + 35I_2 = 55$$

$$\Rightarrow 4I_1 + 7I_2 = 11 \quad \text{——— (1)}$$

$$20I_1 + 5(I_1 - I_2) = 5$$

$$\Rightarrow 25I_1 - \frac{5}{7}(11 - 4I_1) = 5$$

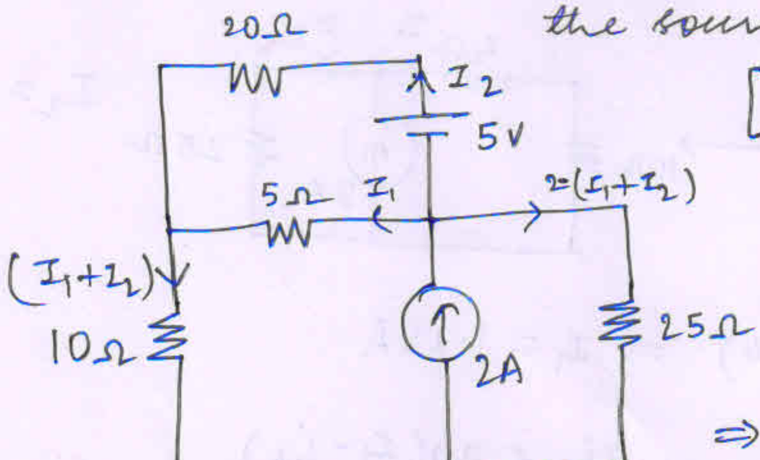
$$\Rightarrow 25I_1 - \frac{55}{7} + \frac{20}{7}I_1 = 5$$

$$\Rightarrow I_1 = \frac{\left(5 + \frac{55}{7}\right)}{\left(25 + \frac{20}{7}\right)} = 0.46\text{A}$$

$$\therefore P_{5V} = -0.46 \times 5 \text{ W} = -2.31\text{W}$$

Shows that power is supplied by the source.

(b)



$$[10(I_1 + I_2) + 20I_2] - [25(2 - I_1 - I_2)] = 5$$

$$\Rightarrow 10I_1 + 30I_2 - 50 + 25I_1 + 25I_2 = 5$$

$$\Rightarrow 11I_2 + 7I_1 = 11 \quad \text{——— (1)}$$

$$10(I_1 + I_2) + 5I_1 = (2 - I_1 - I_2)25$$

$$\Rightarrow 15I_1 + 10I_2 = 50 - 25I_1 - 25I_2$$

$$\Rightarrow 40I_1 + 35I_2 = 50$$

$$\Rightarrow 8I_1 + 7I_2 = 10 \quad \text{——— (2)}$$

From (1) and (2),

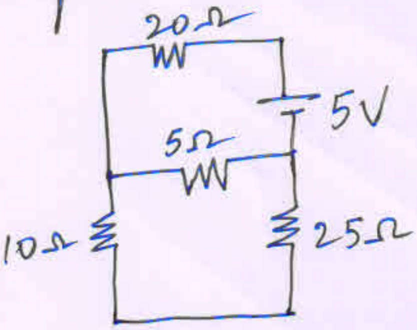
$$11I_2 + \frac{7}{8}(10 - 7I_2) = 11$$

$$\Rightarrow \left(11 - \frac{49}{8}\right) I_2 = 11 - \frac{70}{8}$$

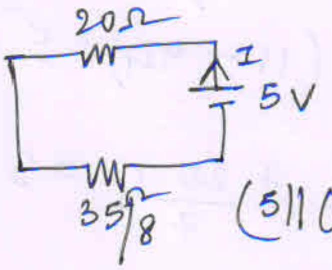
$$\Rightarrow I_2 = 0.46A$$

$$\therefore P_{5V} = -0.46 \times 5W = -2.31W$$

(c) Open circuit current source:



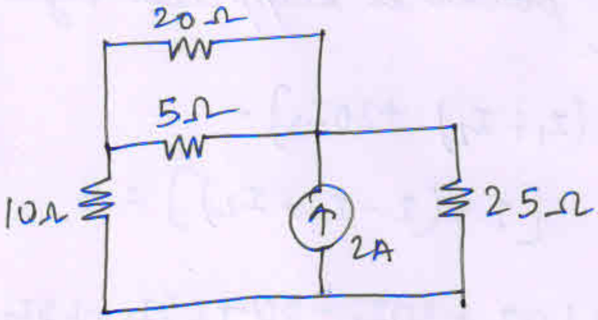
$\longrightarrow$



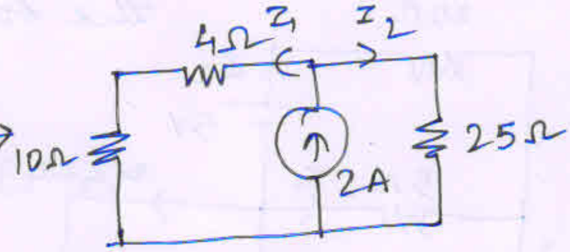
$(5 \| (10+25))$

$$\therefore I = \frac{5}{20 + \frac{35}{8}} A = 0.2A$$

Short circuit voltage source:

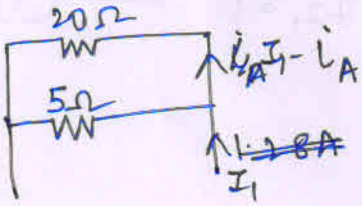


$\longrightarrow$



$I_2 = 2 - I_1$

$$25(2 - I_1) = I_1(10+4) \Rightarrow I_1 = 1.28A$$



$\cancel{5(1.28)}\ 5i_A = 20(I_1 - i_A)$

$$\Rightarrow i_A(5+20) = 20I_1$$

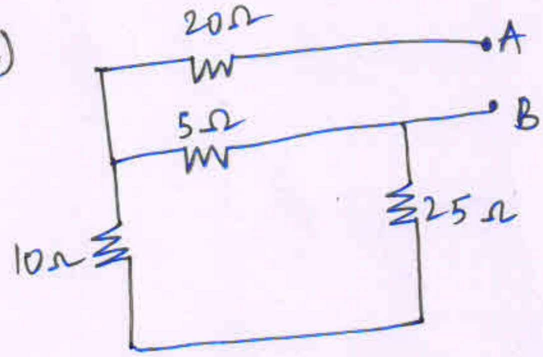
$$\Rightarrow i_A = \frac{4}{5} I_1$$

$$\Rightarrow I_1 - i_A = \frac{I_1}{5} = 0.26A$$

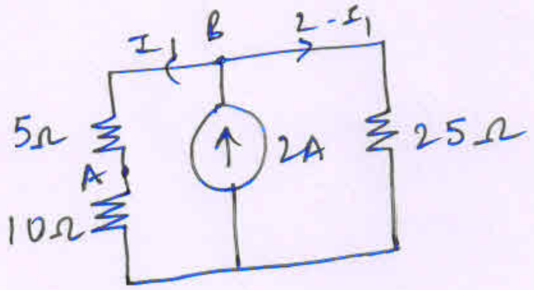
$\therefore I = 0.2A + 0.26A = 0.46A$

$P_{5V} = -0.46A \times 5V = -2.31W$

(d)

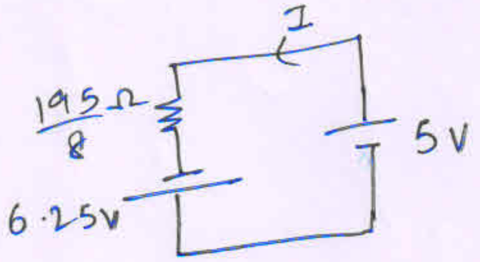


$\rightarrow R_{TH} = 20 + (5 \parallel (10+25)) = \frac{195}{8} \Omega$



$$I_1 = \frac{2 \times 25}{25+10+5} A = 1.25 A$$

$\therefore V_{AB} = -5I_1 = -6.25V = V_{TH}$

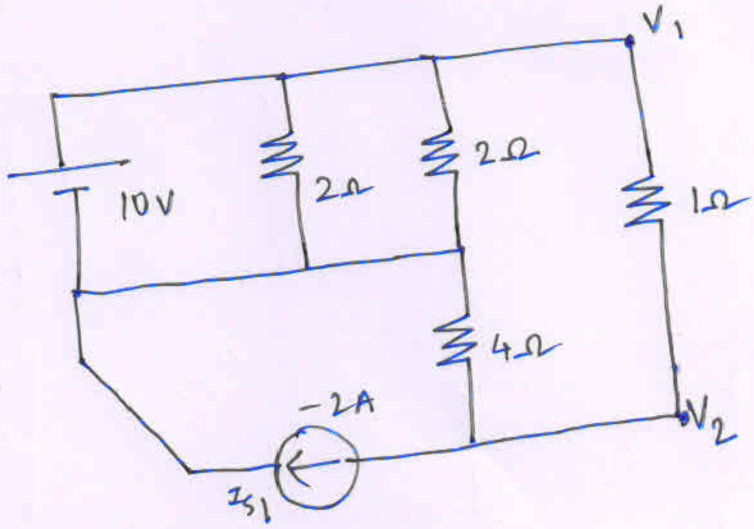


$$(6.25 + 5) = I\left(\frac{195}{8}\right)$$

$\Rightarrow I = 0.46A$

$\therefore P_{5V} = -0.46 \times 5W = -2.31W$

Ans 2.



$V_1 = V_{S1} = 10V$

Apply KCL at node 2:

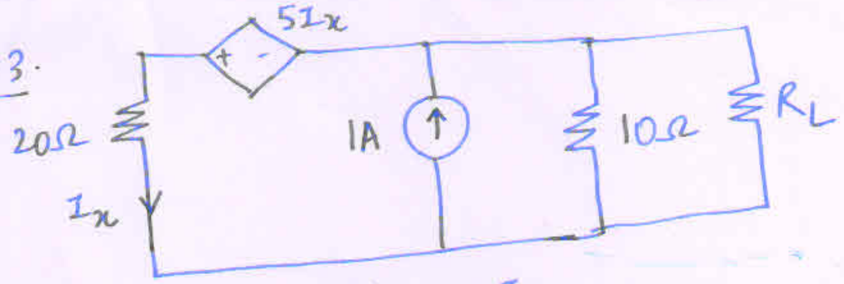
$$I_{S1} + \frac{V_2}{4} + \frac{V_2 - V_1}{1} = 0$$

$\Rightarrow V_2 = 9.6V$

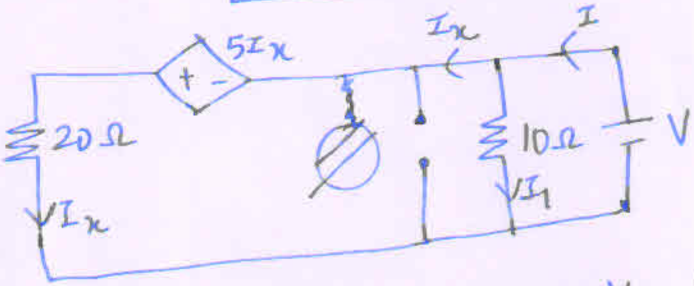
$\therefore P_{I_{S1}} = -2 \times 9.6W$

$= -19.2W$

Ans 3.



for maximum power transfer, $R_L = R_{TH}$.

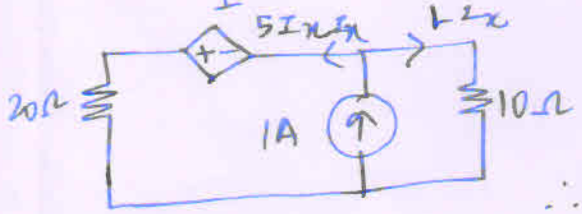


$$\frac{V + 5I_x}{20} = I_x$$

$$\Rightarrow V = 15 I_x \quad \text{—(1)}$$

$$\frac{V}{10} = I_1 \Rightarrow I = I_1 + I_x = \frac{V}{10} + \frac{V}{15} = \frac{V}{6}$$

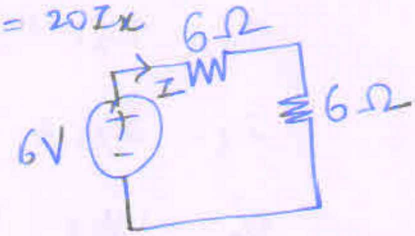
$$\therefore R_{TH} = \frac{V}{I} = V/V\left(\frac{1}{6}\right) = 6\Omega$$



KVL: $10(1 - I_x) + 5I_x = 20I_x$

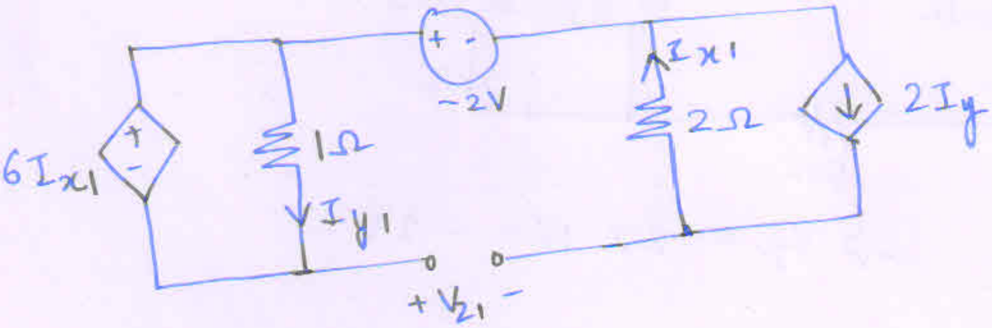
$$\Rightarrow I_x = \frac{2}{5}\ A$$

$$\therefore V_{OC} = \left(1 - \frac{2}{5}\right) \times 10 = 6V$$



$I = \frac{6}{12}A = 0.5A$ $\quad \therefore P_{max} = (0.5)^2 \times 6W = 1.5W$

Ans 4. (i) Contribution of $-2V$ source:



$$6I_{x1} = 1 \times I_{y1} \quad \text{—(1)}$$

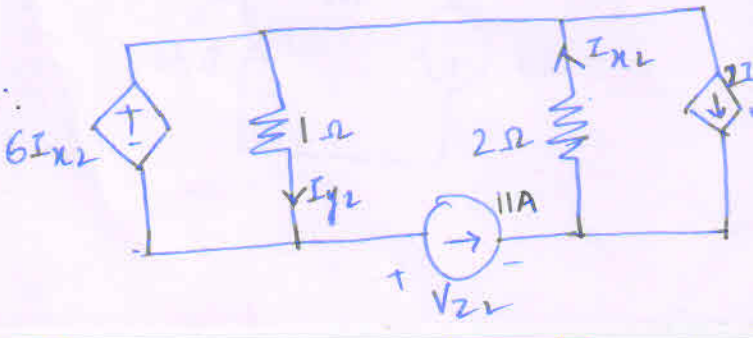
$$2I_{y1} = I_{x1} \quad \text{—(2)}$$

$$\Rightarrow I_{x1} = I_{y1} = 0$$

Also, $-V_{z1} - 1 \times I_{y1} + (-2V) - 2 \times I_{x1} = 0$

$$\therefore V_{z1} = -2V$$

(ii) Contribution of 11A source:



$V_{1\Omega} = 6I_{x2}$

$V_{1\Omega} = 1 \times I_{y2}$

$\Rightarrow 6I_{x2} = I_{y2}$

$11 = I_{x2} - 2I_{y2}$

$\therefore \quad I_{x2} = -1A, \quad I_{y2} = -6A$

Also, $\quad 2I_{x2} + I_{y2} + V_{z2} = 0$

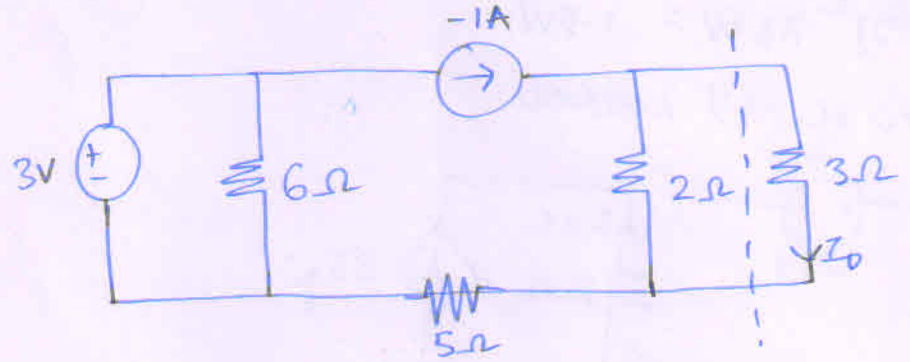
$\Rightarrow V_{z2} = 8V$

$\therefore I_x = I_{x1} + I_{x2} = -1A$

$I_y = I_{y1} + I_{y2} = -6A$

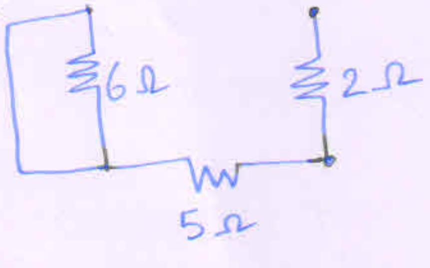
$V_z = V_{z1} + V_{z2} = 6V$

Ans 5.

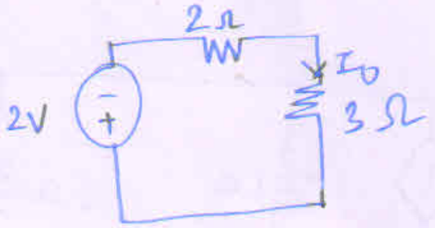


$I_{2\Omega} = -1A \quad \Rightarrow V_{TH} = 2 \times -1V = -2V$

R_{TH}:



$\Rightarrow R_{TH} = 2\Omega$

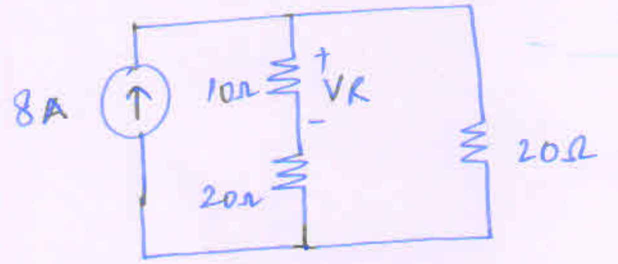


$\therefore \quad I_0 = \frac{-2}{2+3} A = -\frac{2}{5} A$

Ans 6. (a) X is an inductor :

When current has been flowing for a long time, it behaves like a short circuit.

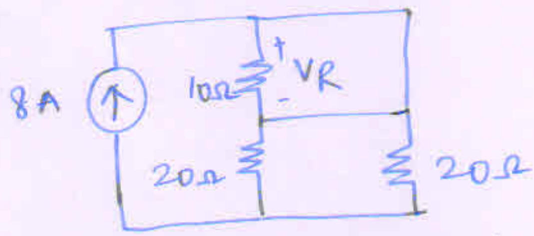
$t = 0^-$



$$\therefore I_{10\Omega} = \frac{20 \times 8}{50} A = \frac{16}{5} A$$

$$\therefore V_R = \frac{16}{5} \times 10 \, V = 32 \, V$$

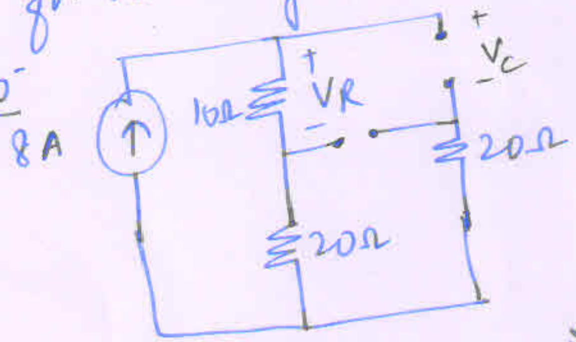
$t = 0^+$



The current through the inductor doesn't change instantaneously even after the switch is closed. Therefore, at $t = 0^+$, current through 10Ω is 3.2 A and $V_R|_{t=0^+} = 32V$

(b) X is a capacitor: When current has been flowing for a long time, it behaves like an open circuit.

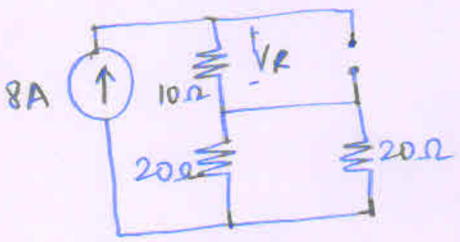
$t = 0^-$



$\therefore V_R = 10 \times 8V = 80V$

$\Rightarrow V_c = 240V$

$t = 0^+$



The voltage across the capacitor doesn't change instantaneously after the switch is closed. $V_c|_{t=0^-} = V_c|_{t=0^+} = V_R|_{t=0^+}$

$V_R|_{t=0^+} = \cancel{80V}$ 240 V