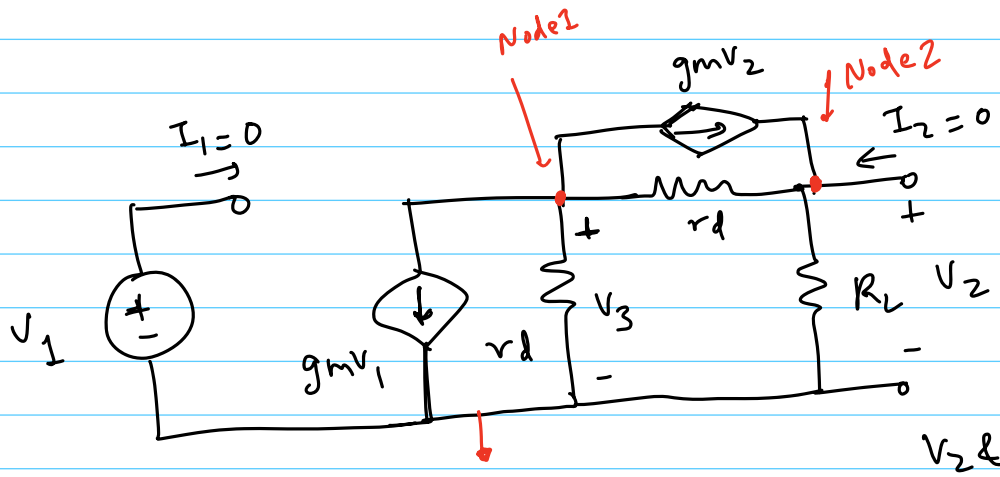
Ans. 1



Node Voltage Analysis

V_2 & V_3 are unknowns.

KCL at Node 1

$$gmV_1 + \frac{V_3}{r_d} + gmV_2 + \frac{V_3 - V_2}{r_d} = 0$$

$$\boxed{V_2\left(gm - \frac{1}{r_d}\right) + V_3\left(\frac{2}{r_d}\right) = -gmV_1}$$

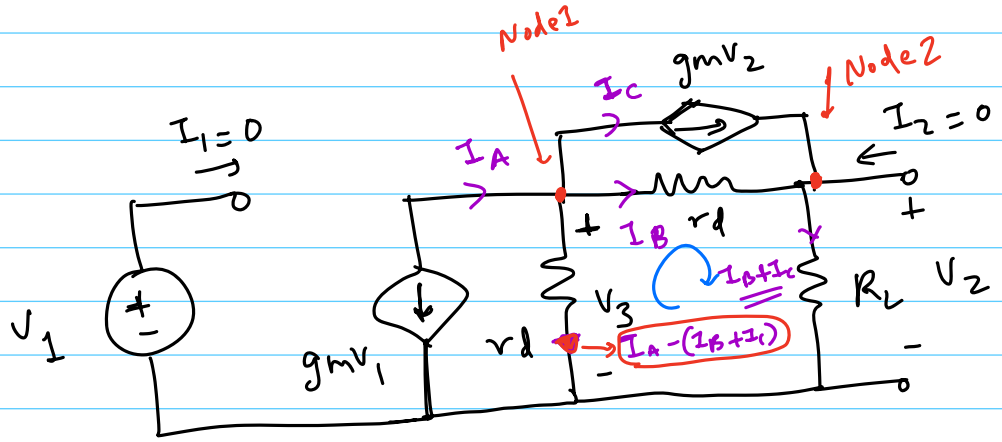
KCL at Node 2

$$gmV_2 = \frac{V_2}{R_L} + \frac{V_2 - V_3}{r_d}$$

$$\boxed{V_2\left(\frac{1}{R_L} + \frac{1}{r_d} - gm\right) + V_3\left(-\frac{1}{r_d}\right) \Rightarrow 0}$$

$$\Rightarrow \begin{bmatrix} \left(gm - \frac{1}{r_d}\right) & \frac{2}{r_d} \\ \left(\frac{1}{R_L} + \frac{1}{r_d} - gm\right) & -\frac{1}{r_d} \end{bmatrix} \begin{bmatrix} V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} -gmV_1 \\ 0 \end{bmatrix}$$

Loop Current Analysis



$$\boxed{I_A = -g_m V_1} \quad - (1)$$

$$I_C = g_m V_2 \; ; \; V_2 = (I_B + I_C) R_L$$

$$I_C = g_m (I_B + I_C) R_L$$

$$\boxed{I_C (1 - g_m R_L) + I_B (-g_m R_L) = 0} \quad - (2)$$

KVL in loop

$$\left[I_A - (I_B + I_C) \right] r_d - I_B r_d - (I_B + I_C) R_L \Rightarrow 0$$

$$\boxed{I_A (r_d) + I_B (-2r_d - R_L) + I_C (-r_d - R_L) = 0} \quad - (3)$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -g_m R_L & 1 - g_m R_L \\ r_d & -2r_d - R_L & -r_d - R_L \end{bmatrix} \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} = \begin{bmatrix} -g_m V_1 \\ 0 \\ 0 \end{bmatrix}$$

Ans.2

Six currents,

Loops :-

Loop1 :- 1 - 2 - 5 - 1

Loop2 :- 1 - 5 - 4 - 1

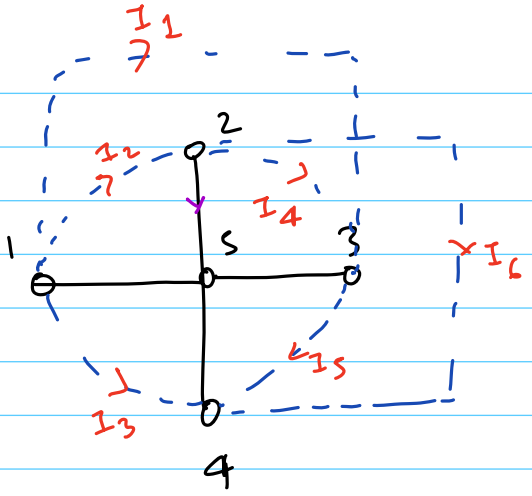
Loop3 :- 5 - 2 - 3 - 5

Loop4 :- 5 - 3 - 4 - 5

Loop5 :- 1 - 3 - 5 - 1

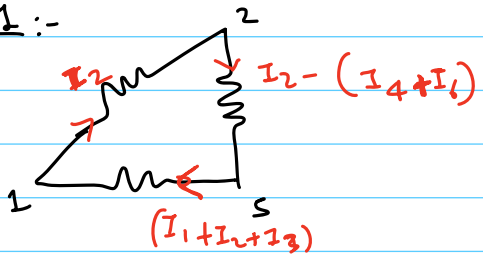
Loop6 :- 1 - 2 - 4 - 1

a)



b) Applying KVL in loops

Loop 1 :-

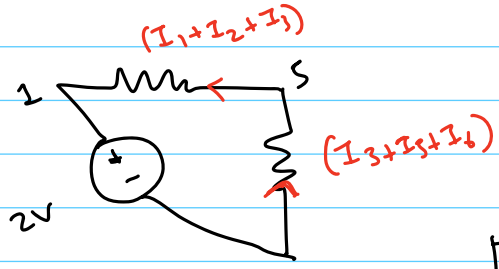


$$-I_2R - (I_2 - (I_4+I_6))R - (I_1+I_2+I_3)R = 0$$

$$I_2 + I_2 - I_4 - I_6 + I_1 + I_2 + I_3 = 0$$

$$\boxed{I_1 + 3I_2 + I_3 - I_4 - I_6 = 0} \quad -(1)$$

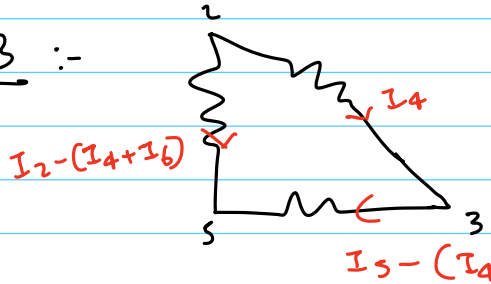
Loop 2 :-



$$2 + (I_1+I_2+I_3)2 + (I_3+I_5+I_6)2 = 0$$

$$\boxed{I_1 + I_2 + 2I_3 + I_5 + I_6 = -1} \quad -(2)$$

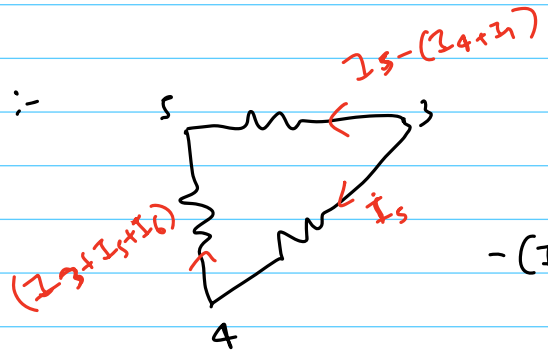
Loop 3 :-



$$[I_2 - (I_4+I_6)]R - I_4R - [I_5 - (I_4+I_1)]R = 0$$

$$I_1 + I_2 - I_4 - I_5 - I_6 = 0 \quad -(3)$$

Loop 4 :-

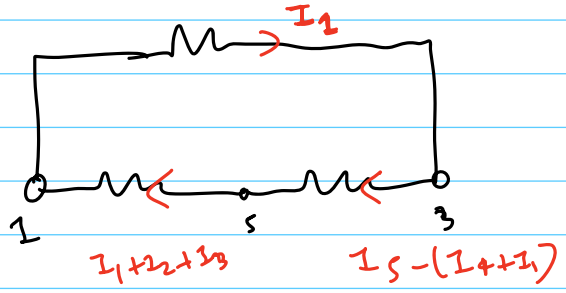


$$-(I_3 + I_5 + I_6)R + (I_5 - I_4 - I_1)R - I_5 R = 0$$

$$-I_1 - I_3 - I_4 - I_5 - I_6 = 0$$

$$I_1 + I_3 + I_4 + I_5 + I_6 = 0 \quad -(4)$$

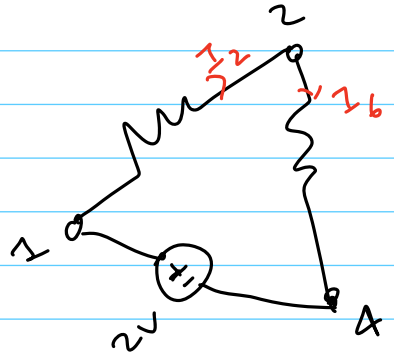
Loop 5 :-



$$+I_1 + (I_5 - I_4 - I_1) + (I_1 + I_2 + I_3) = 0$$

$$I_1 + I_2 + I_3 - I_4 + I_5 = 0 \quad -(5)$$

Loop 6 :-



$$2 = 2I_2 + 2I_6$$

$$I_2 + I_6 = 1 \quad -(6)$$

$I_1\ I_2\ I_3\ I_4\ I_5\ I_6$

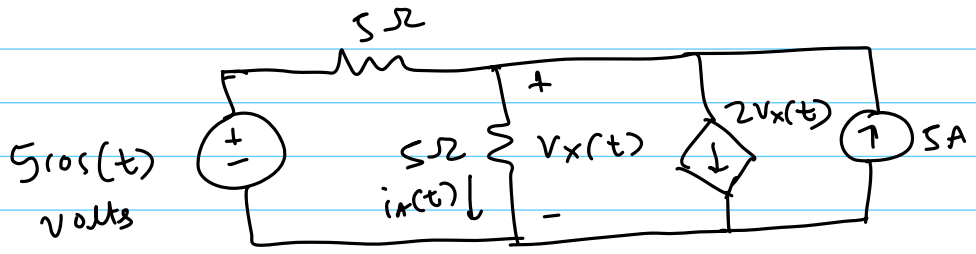
c)
$$\begin{bmatrix} 1 & 3 & 1 & -1 & 0 & -1 \\ 1 & 1 & 2 & 0 & 1 & 1 \\ 1 & 1 & 0 & -1 & -1 & -1 \\ 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & -1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ I_5 \\ I_6 \end{bmatrix} = \begin{bmatrix} 0 \\ -1 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

d) Solving using Matlab

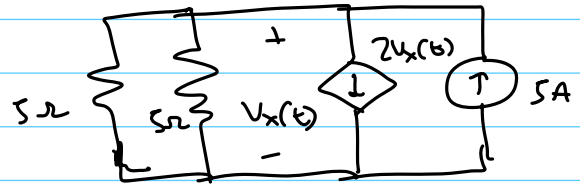
$I_1 = \frac{1}{2}$, $I_2 = \frac{1}{2}$, $I_3 = -\frac{3}{2}$, $I_4 = 0$,

$I_5 = \frac{1}{2}$, $I_6 = \frac{1}{2}$

Ans.3



$i_A(t)$ due to only 5A current source.



$$5 = 2V_x + \frac{V_x}{2.5}$$

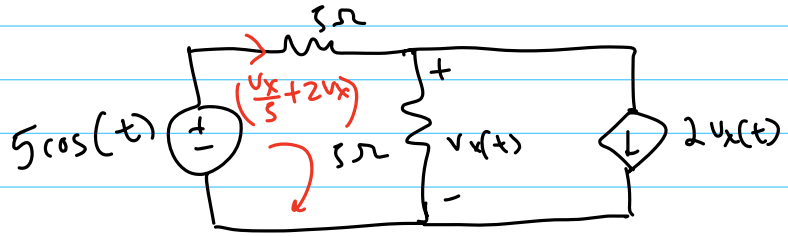
$$5 = V_x\left(2 + \frac{2}{5}\right)$$

$$5 = V_x\left(\frac{12}{5}\right)$$

$$V_x(t) = \frac{25}{12}$$

$V_x(t)$ due to 5A current source $\Rightarrow \frac{25}{12} V$

$V_x(t)$ due to voltage source.



Writing KVL

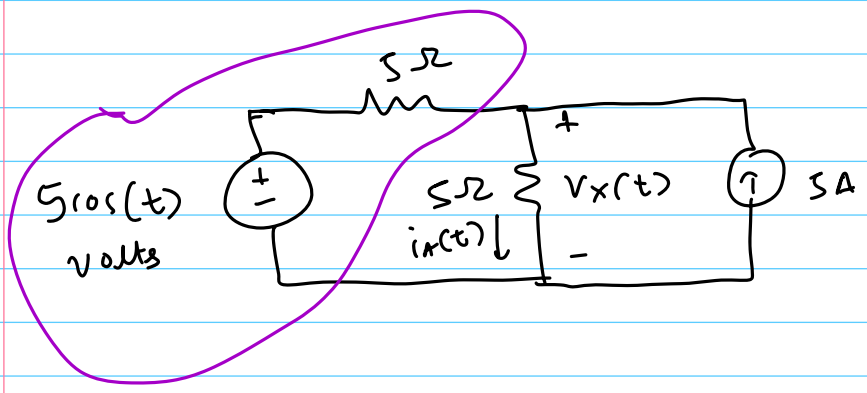
$$5\cos(t) - \left(\frac{V_x}{5} + 2V_x\right)\times 5 - V_x = 0$$

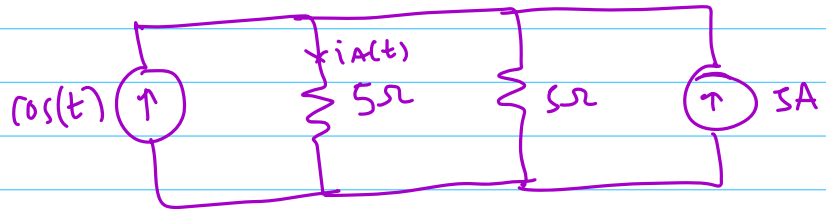
$$5\cos(t) = V_x\left(1 + 10 + 1\right)$$

$$\frac{5\cos(t)}{12} = V_x$$

$$V_x(t)\Big|_{\text{total}} \Rightarrow \frac{5\cos t}{12} + \frac{25}{12}$$

Ans.4

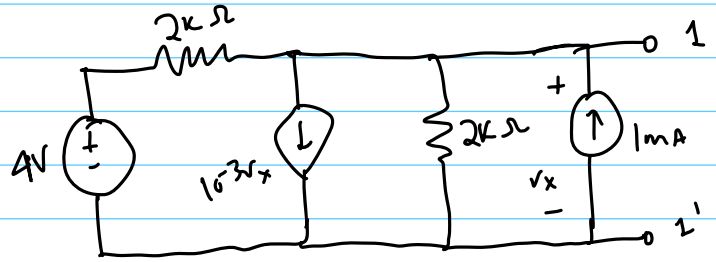


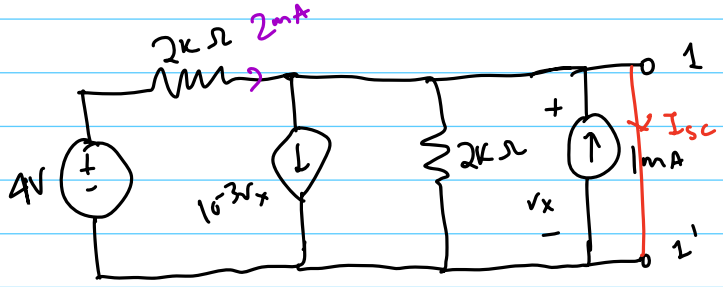


$$i_A(t) = \frac{5}{2} + \frac{\cos(t)}{2}$$

Ans. 5

a)



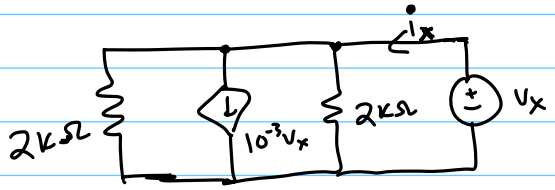


To find I_{sc} :-

$V_x = 0$

$I_{sc} \Rightarrow 3mA$

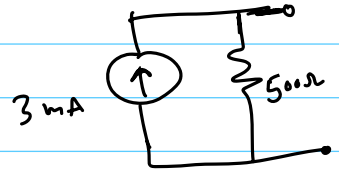
To find R_{out} :-



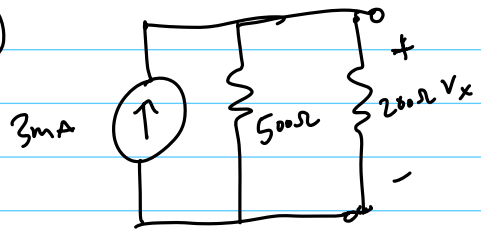
$$i_x = \frac{V_x}{2K} + \frac{V_x}{2K} + 10^{-3}V_x$$

$$i_x = \frac{V_x}{1K} + \frac{V_x}{1K}$$

$$i_x = \frac{2V_x}{1K} \quad ; \quad \frac{V_x}{1x} = 500\Omega.$$



b)

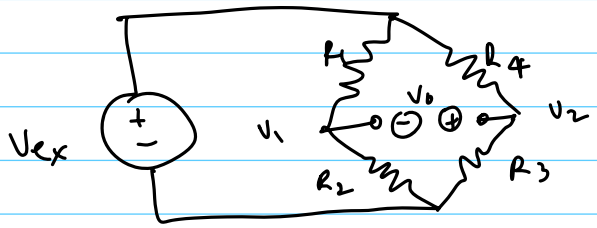


$$V_x = + (200 \| 500) \times 3m$$

$$\Rightarrow + \left(\frac{1000}{7}\right) \times 3m$$

$$\Rightarrow + 428.57 mV$$

Ans. 6



$$V_o = V_2 - V_1 = \quad Vex \left(\frac{R_3}{R_3+R_4} - \frac{R_2}{R_1+R_2} \right)$$

$$R_{eq} = (R_1 \| R_2) + (R_3 \| R_4) = \frac{R_1 R_2}{R_1+R_2} + \frac{R_3 R_4}{R_3+R_4}$$

$$V_{Th} = Vex \left(\frac{R_3}{R_3+R_4} - \frac{R_2}{R_1+R_2} \right) \quad ; R_{Th} = \frac{R_1 R_2}{R_1+R_2} + \frac{R_3 R_4}{R_3+R_4}$$