Assoc. Prof. Dr. Eman Azab & Dr. Wassim Alexan

Assignment II

You will be asked to solve one of the assigned problems during your tutorial in the week of 10-15 December 2022

Name:	
I.D. Number	
Tutorial:	
TA Name	

Assignment 2 — ELCT301, Electric Circuits I

Faculty of IET — Winter 2022

Assoc. Prof. Dr. Eman Azab & Dr. Wassim Alexan

---

1. For the network shown in *Figure 1*, use the superposition principle to find V_o.

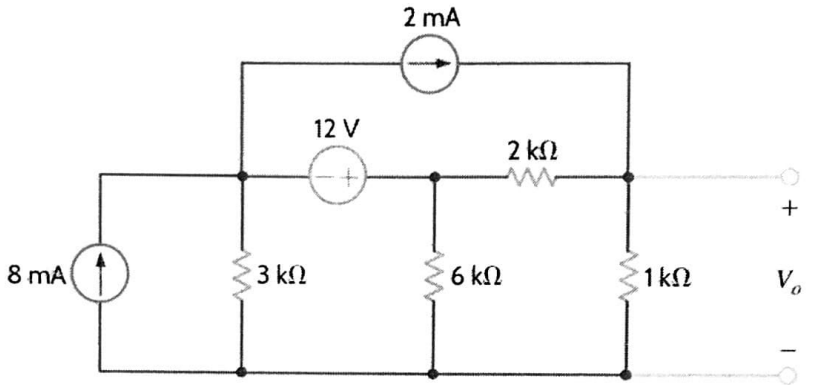


Figure 1

Sol.

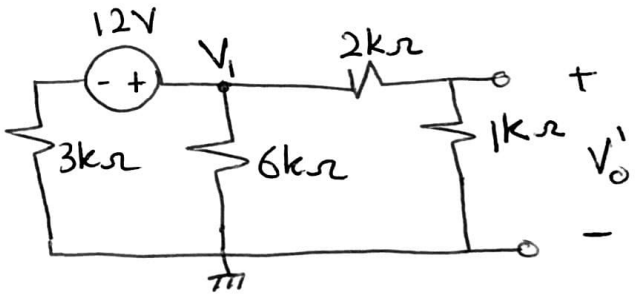
Circuit due to 12V Source:-

Nodal @ V_1:-

$$\therefore \frac{V_1}{6k} + \frac{V_1 - 12}{3k} + \frac{V_1}{2k+1k} = 0$$

$$\therefore V_1 = \frac{24}{5} V$$

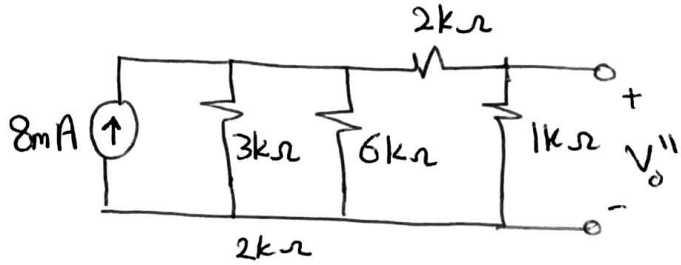
$$\therefore V_o' = V_1 \times \frac{1k}{2k+1k} = \frac{8}{5} V \quad \#$$

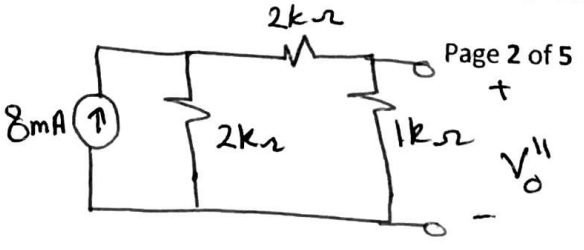


Circuit due to 8mA Source:-

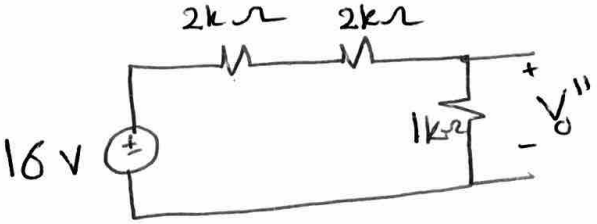
$\therefore 3k // 6k = 2k\Omega$

$\therefore$ Source transformation [8mA // 2kΩ]





$$\therefore V_o'' = 16 \times \frac{1k}{2k+2k+1k} = \frac{16}{5} V \quad \#$$

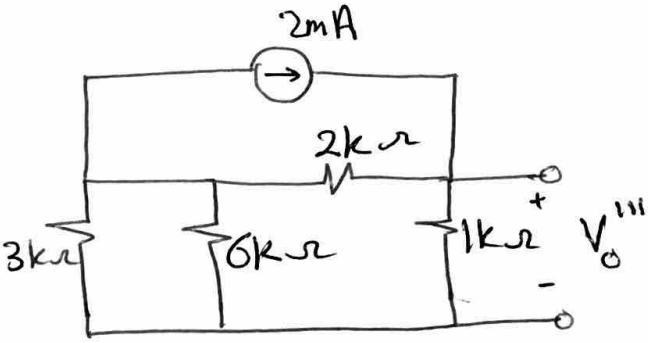


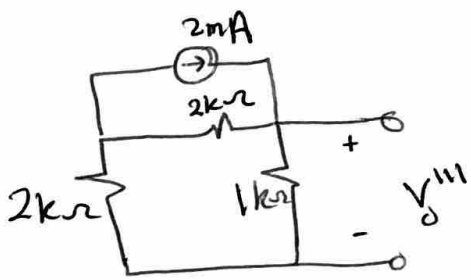
Circuit due to 2mA source :-

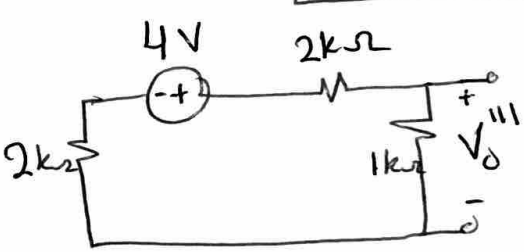
$\therefore 3k // 6k = 2k\Omega$

$\therefore$ Source transformation [2mA // 2kΩ]

$$\therefore V_o''' = 4 \times \frac{1k}{2k+2k+1k} = \frac{4}{5} V$$







$$\therefore V_o = V_o' + V_o'' + V_o'''$$

$$= \frac{8}{5} + \frac{16}{5} + \frac{4}{5} = \frac{28}{5} V$$

2. For the network shown in *Figure 2*, use the superposition principle to find I_o.

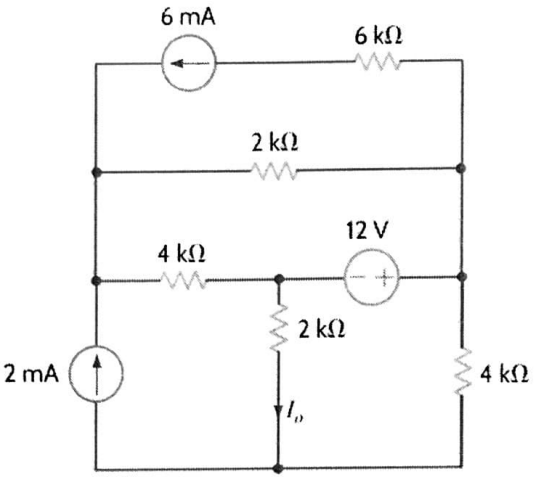
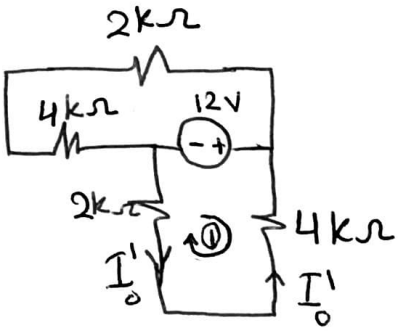


Figure 2

Sol:

Circuit due to 12V Source :-



KVL ① :-

$-2k\,I_o' - 12 - 4k\,I_o' = 0$

$I_o' = -2\,mA$ #

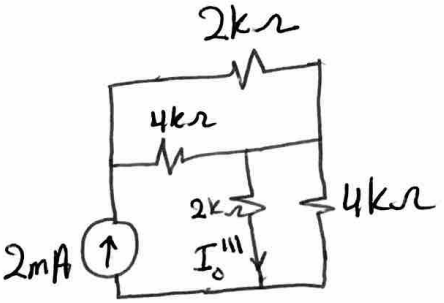
Circuit due to 6mA Source :-

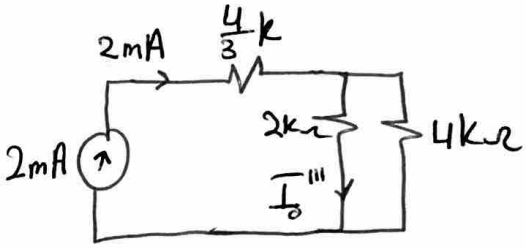
$I_o'' = 0\ A$ #

Circuit due to 2mA source :-

$= 2k // 4k = \frac{4}{3} k\Omega$

$I_o'' = 2mA \times \frac{4k}{2k+4k} = \frac{4}{3} mA$ #





$I_o = I_o' + I_o'' + I_o'''$

$= -2 + 0 + \frac{4}{3} = -\frac{2}{3} mA$ #

3. For the network shown in *Figure 3*, use the superposition principle to find V_o.

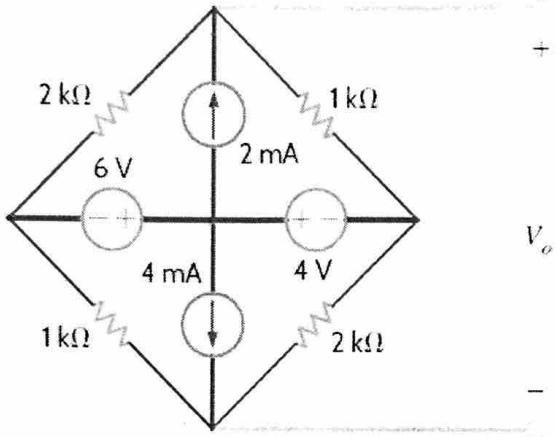
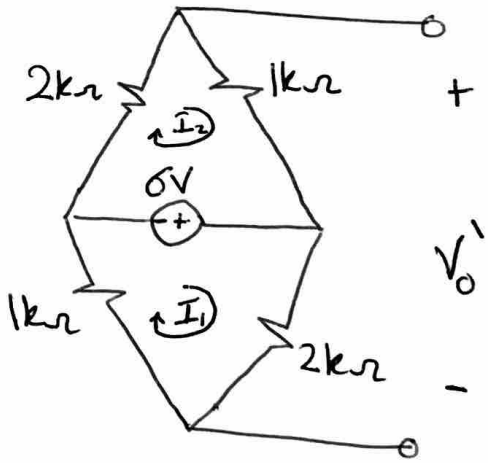


Figure 3

Sol:

Circuit due 6V source:-



mesh (1)

$2k\,I_1 + 1k\,I_1 - 6 = 0$

$I_1 = 2\,mA$

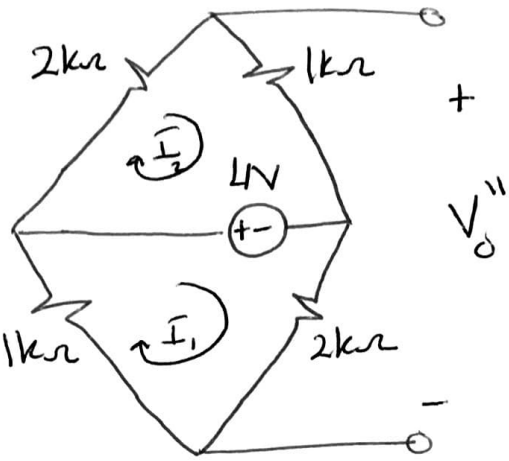
mesh (2)

$6 + 2k\,I_2 + 1k\,I_2 = 0$

$I_2 = -2\,mA$

$V_o' = 1k\,I_2 + 2k\,I_1 = -2 + 4 = 2\,V$ #

Circuit due to 4V source:-



mesh ①

$1k I_1 + 4 + 2k I_1 = 0$

$I_1 = \frac{-4}{3}$ mA

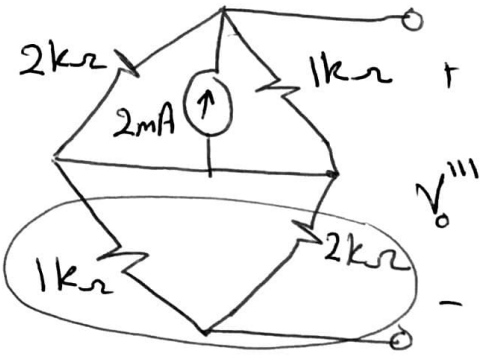
mesh ②

$1k I_2 - 4 + 2k I_2 = 0$

$I_2 = \frac{4}{3}$ mA

$V_o'' = 1k I_2 + 2k I_1 = \frac{4}{3} - \frac{8}{3} = -\frac{4}{3}$ V #

Circuit due to 2mA source:-

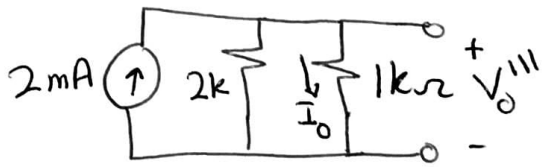


$I_o = 2\text{mA} \times \frac{2k}{2k+1k} = \frac{4}{3}$ mA

$V_o''' = \frac{4}{3} \times 1 = \frac{4}{3}$ V

Will be shorted

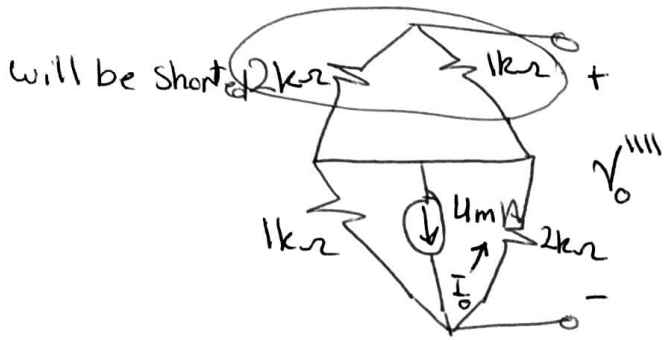
Circuit due to 4mA source:-



$V_o'''' = -\left[4\text{mA} \times \frac{1k}{1k+2k}\right] \times 2k\Omega$

$= -\frac{8}{3}$ V

Will be shorted



$V_o = V_o' + V_o'' + V_o''' + V_o''''$

$= 2 - \frac{4}{3} + \frac{4}{3} - \frac{8}{3} = -\frac{2}{3}$ V

4. For the network shown in *Figure 4*, use the superposition principle to find I_o.

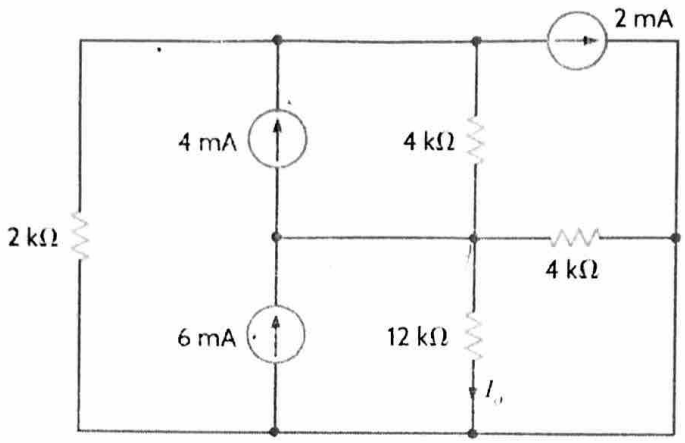
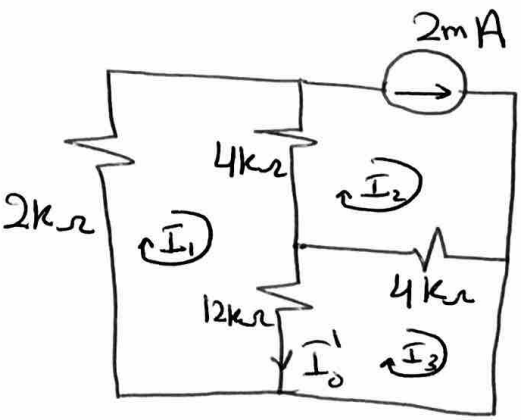


Figure 4

Sol:

Circuit due to 2mA Source :-



mesh ①

$$2k\bar{I}_1+4k(\bar{I}_1-\bar{I}_2)+12k(\bar{I}_1-\bar{I}_3)=0$$

$$\boxed{18k\bar{I}_1-4k\bar{I}_2-12k\bar{I}_3=0} \longrightarrow ①$$

mesh ②

$$\boxed{\bar{I}_2=2mA} \longrightarrow ②$$

mesh ③

$$12k(\bar{I}_3-\bar{I}_1)+4k(\bar{I}_3-\bar{I}_2)=0$$

$$\boxed{-12k\bar{I}_1-4k\bar{I}_2+16k\bar{I}_3=0} \longrightarrow ③$$

from ①, ② and ③

$\bar{I}_1=1,556mA$ $\bar{I}_3=1,667mA$

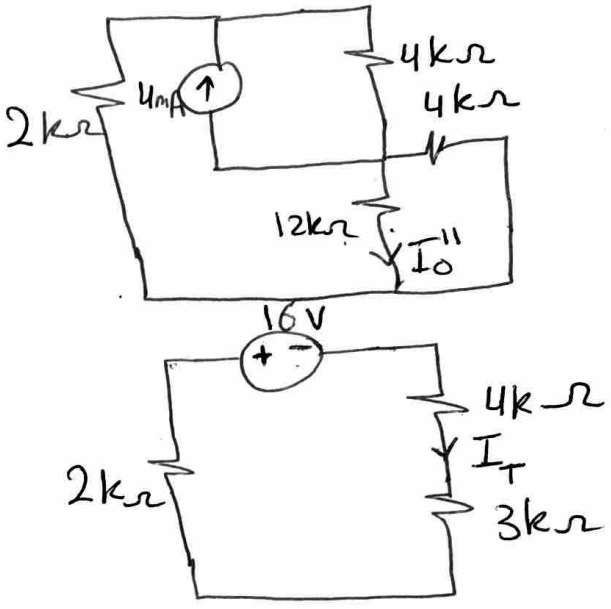
$$\bar{I}_o'=\bar{I}_1-\bar{I}_3=1,556mA-1,667mA=-0,111\ mA\ \#$$

Circuit due to 4mA Source :-

* Source transformation [4mA, 4kΩ]
* 4k // 12k = 3kΩ

$$I_T = \frac{-16}{4k+3k+2k} = \frac{-16}{9}\ mA$$

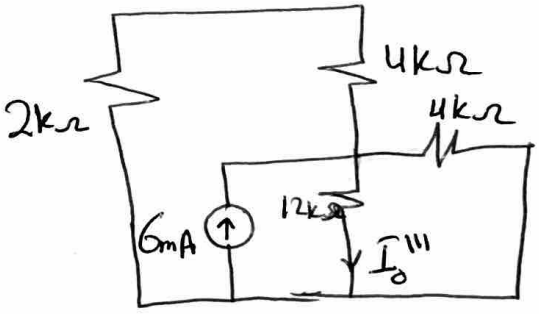
$$\therefore I_o'' = I_T \times \frac{4k}{4k+12k} = \frac{-4}{9}\ mA\ \#$$

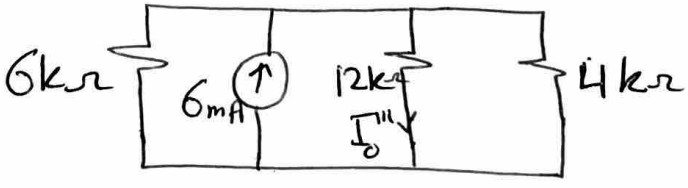


Circuit due to 6mA Source :-

* 4k, 2kΩ = 4k + 2k = 6kΩ
* 6kΩ // 4kΩ = 2,4kΩ

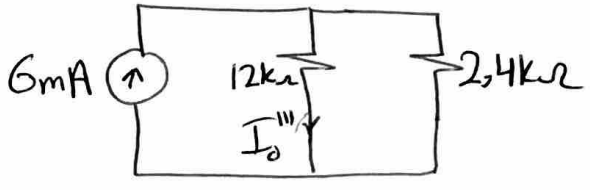
$$* I_o''' = 6mA \times \frac{2,4k\Omega}{2,4k\Omega + 12k\Omega} = 1\ mA\ \#$$





$$I_o = I_o' + I_o'' + I_o'''$$

$$= -0,111 - \frac{4}{9} + 1 = \quad mA\ \#$$



5. Use the principle of superposition to find the voltage v_o and i_o in the circuit in Figure 5

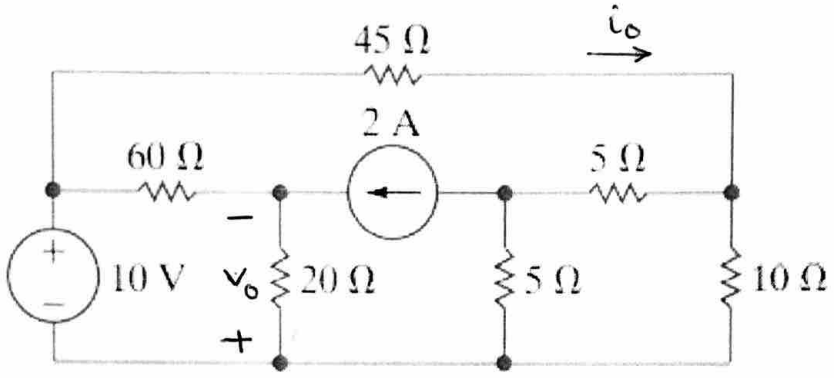
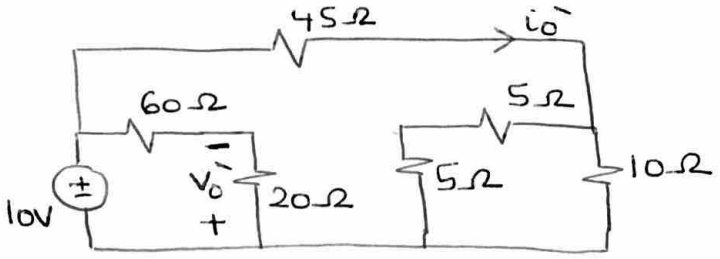


Figure 5

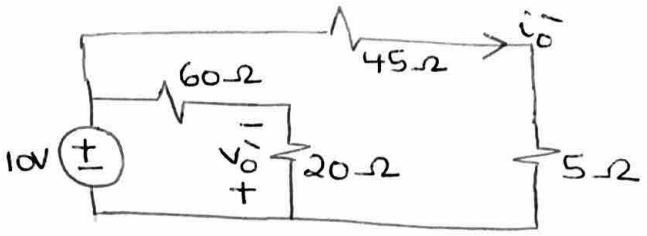
Sol.

Circuit due to the 10V Source:



$$v_o' = \frac{-10(20)}{20+60} = -2.5 \quad \text{(Voltage division rule)}$$

$(5+5)\,//10 \Rightarrow 10//10 \Rightarrow 5\,\Omega$



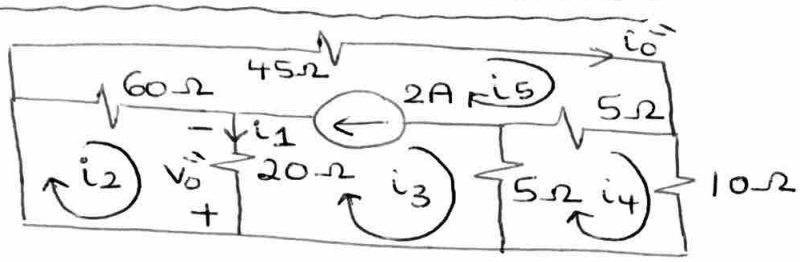
KVL @ outer loop

$$\therefore -10 + 50 i_o' = 0$$

$$\therefore 50 i_o' = 10$$

$$\therefore i_o' = \frac{10}{50} = 0.2\,A$$

Circuit due to the 2A source :



$$i_1 = \frac{2(60)}{60+20} = 1.5\,A \quad \text{(current division rule)}$$

$\therefore V_o'' = -20 i_1$

$\therefore V_o'' = -30\,V$

$i_o'' = i_5$

@ mesh 5 & 3 (Supermesh)

$\therefore 45 i_5 + 5(i_5 - i_4) + 5(i_3 - i_4) + 20(i_3 - i_2) + 60(i_5 - i_2) = 0$

$\therefore 110 i_5 - 10 i_4 + 25 i_3 - 80 i_2 = 0 \longrightarrow (1)$

$2 = i_5 - i_3 \longrightarrow \therefore i_3 = i_5 - 2 \longrightarrow (2)$

@ mesh 4

$\therefore 10 i_4 + 5(i_4 - i_3) + 5(i_4 - i_5) = 0$

$\therefore 20 i_4 - 5 i_3 - 5 i_5 = 0 \longrightarrow (3)$

@ mesh 2

$\therefore 60(i_2 - i_5) + 20(i_2 - i_3) = 0$

$\therefore 80 i_2 - 60 i_5 - 20 i_3 = 0 \longrightarrow (4)$

Sub. by eq. 2 in 1

$\therefore 110 i_5 - 10 i_4 + 25(i_5 - 2) - 80 i_2 = 0$

$\therefore 135 i_5 - 10 i_4 - 80 i_2 = 50 \longrightarrow (A)$

Sub. by eq. 2 in 3

$\therefore 20i_4 - 5(i_5 - 2) - 5i_5 = 0$

$\therefore 20i_4 - 10i_5 = -10 \longrightarrow (B)$

Sub. by eq. 2 in 4

$\therefore 80i_2 - 60i_5 - 20(i_5 - 2) = 0.$

$\therefore 80i_2 - 80i_5 = -40 \longrightarrow (C)$

Solving eq.s A, B & C

$\therefore i_2 = -0.4\ A$

$i_4 = -0.45A$

$i_5 = 0.1\ A \longrightarrow \therefore i_o'' = 0.1\ A$

$i_o = i_o' + i_o'' = \boxed{0.3\ A}$

$V_o = V_o' + V_o'' = \boxed{-32.5\ V}$

6. Use the principle of superposition to find the voltage v_o and the power supplied\absorbed by the dependent source in Figure 6

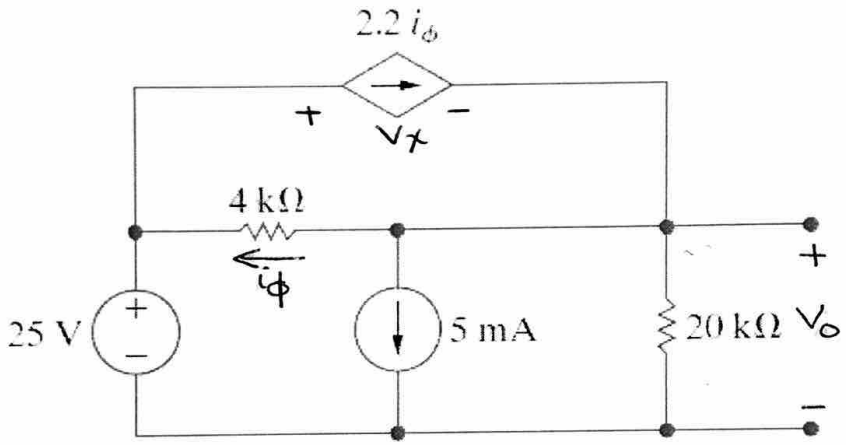
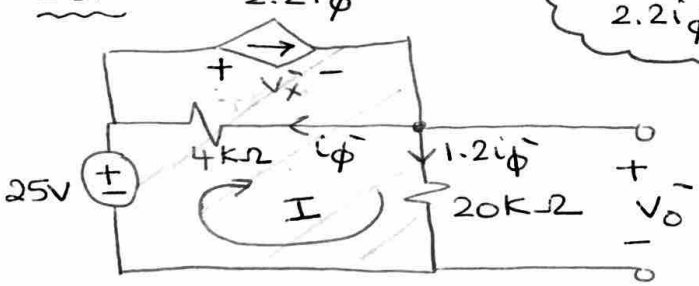


Figure 6

Sol.



$$P_{2.2i_\phi} = (2.2\, i_\phi)\, V_x \longrightarrow (A)$$

$$V_o = (20k)1.2\, i_\phi \longrightarrow (1)$$

KVL @ loop I

$$\therefore -25 - i_\phi(4k) + 1.2\, i_\phi(20k) = 0$$

$$\therefore 20000\, i_\phi = 25$$

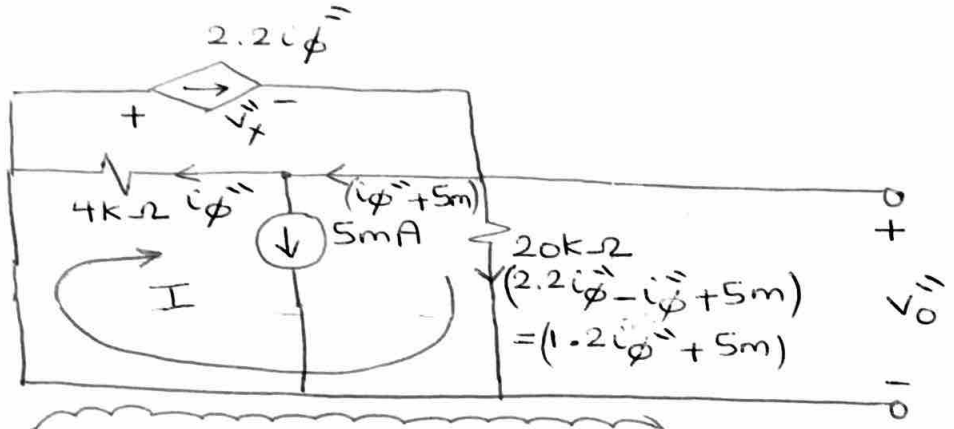
$$\therefore i_\phi = \frac{1}{800}\ A \longrightarrow (2)$$

Sub. by 2 in 1

$$\therefore \boxed{V_o = 30V}$$

KVL @ dashed loop

$$\therefore V_x + 1.2\, i_\phi(20k) - 25 = 0 \longrightarrow \therefore V_x = -1.2\, i_\phi(20k) + 25 = \boxed{-5V}$$



$\therefore$ $V_o'' = (20k)(1.2i_\phi'' + 5m)$ ⟶ (3)

KVL @ loop I

$\therefore$ $20k(1.2i_\phi'' + 5m) - 4k\,i_\phi'' = 0$

$\therefore$ $20k\,i_\phi'' = -100$

$\therefore$ $i_\phi'' = \frac{-100}{20k} = \frac{-1}{200}\ A$ ⟶ (4)

Sub. by 4 in 3

$\therefore$ $\boxed{V_o'' = -20\ V}$

$\because$ $V_x'' = -4k\,i_\phi''$

$\therefore$ $\boxed{V_x'' = 20\ V}$

$\because$ $V_o = V_o' + V_o''$

$\therefore$ $V_o = 30 - 20 = 10V$

$\because$ $i_\phi = i_\phi' + i_\phi''$

$\therefore$ $i_\phi = \frac{1}{800} - \frac{1}{200} = \frac{-3}{800}\ A$ ⟶ (B)

$\because$ $V_x = V_x' + V_x''$

$\therefore$ $V_x = -5 + 20 = 15V$ ⟶ (C)

Sub. by B & C in A

$\therefore$ $\boxed{P_{2.2i_\phi} = \frac{-99}{800}\ w}$ "This Source Supplies $\frac{99}{800}$ w"

7. Use the superposition principle to find V_2 in the network shown in Figure 7

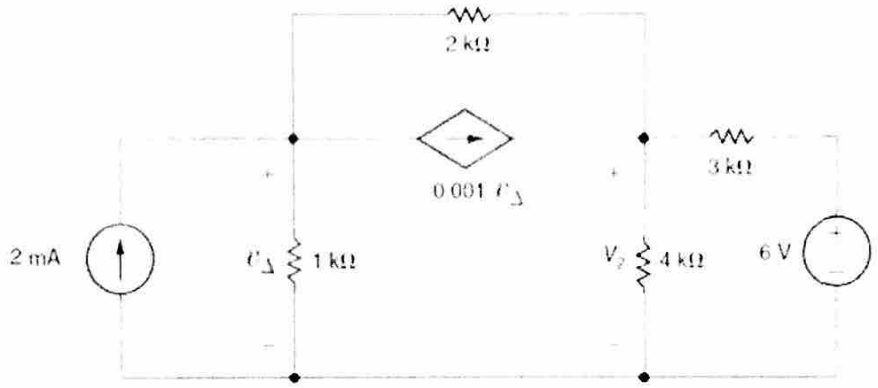
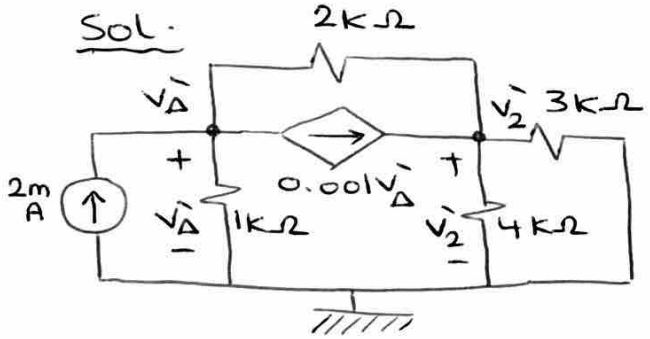


Figure 7

Sol.



@ V_Δ

$$(\times 2K)\ -2m + \frac{V_\Delta}{1K} + 0.001V_\Delta + \frac{V_\Delta - V_2}{2K} = 0$$

$$\therefore\ -4 + 2V_\Delta + 2V_\Delta + V_\Delta - V_2 = 0$$

$$\therefore\ 5V_\Delta - V_2 = 4 \longrightarrow (1)$$

@ V_2

$$(\times 12K)\ \frac{V_2 - V_\Delta}{2K} - 0.001V_\Delta + \frac{V_2}{4K} + \frac{V_2}{3K} = 0$$

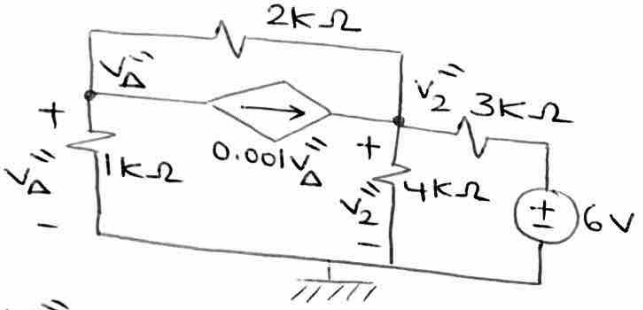
$$\therefore\ 6V_2 - 6V_\Delta - 12V_\Delta + 3V_2 + 4V_2 = 0$$

$$\therefore 13V_2' - 18V_\Delta' = 0 \longrightarrow (2)$$

Solving eq.s 1 & 2

$$\therefore V_\Delta' = \frac{52}{47}\ V$$

$$V_2' = \frac{72}{47}\ V$$



@ V_Δ''

$$(\times 2k)\ \frac{V_\Delta''}{1K} + 0.001V_\Delta'' + \frac{V_\Delta'' - V_2''}{2K} = 0$$

$$2V_\Delta'' + 2V_\Delta'' + V_\Delta'' - V_2'' = 0$$

$$\therefore 5V_\Delta'' - V_2'' = 0 \longrightarrow (3)$$

@ V_2''

$$(\times 12k)\ \frac{V_2'' - V_\Delta''}{2K} - 0.001V_\Delta'' + \frac{V_2''}{4K} + \frac{V_2'' - 6}{3K} = 0$$

$$6V_2'' - 6V_\Delta'' - 12V_\Delta'' + 3V_2'' + 4V_2'' - 24 = 0$$

$$\therefore 13V_2'' - 18V_\Delta'' = 24 \longrightarrow (4)$$

Solving eq.s 3 & 4

$$\therefore V_\Delta'' = \frac{24}{47}\ V\ ,\ V_2'' = \frac{120}{47}\ V$$

$$\because V_2 = V_2' + V_2'' \Longrightarrow \therefore \boxed{V_2 = \frac{192}{47}\ V}$$