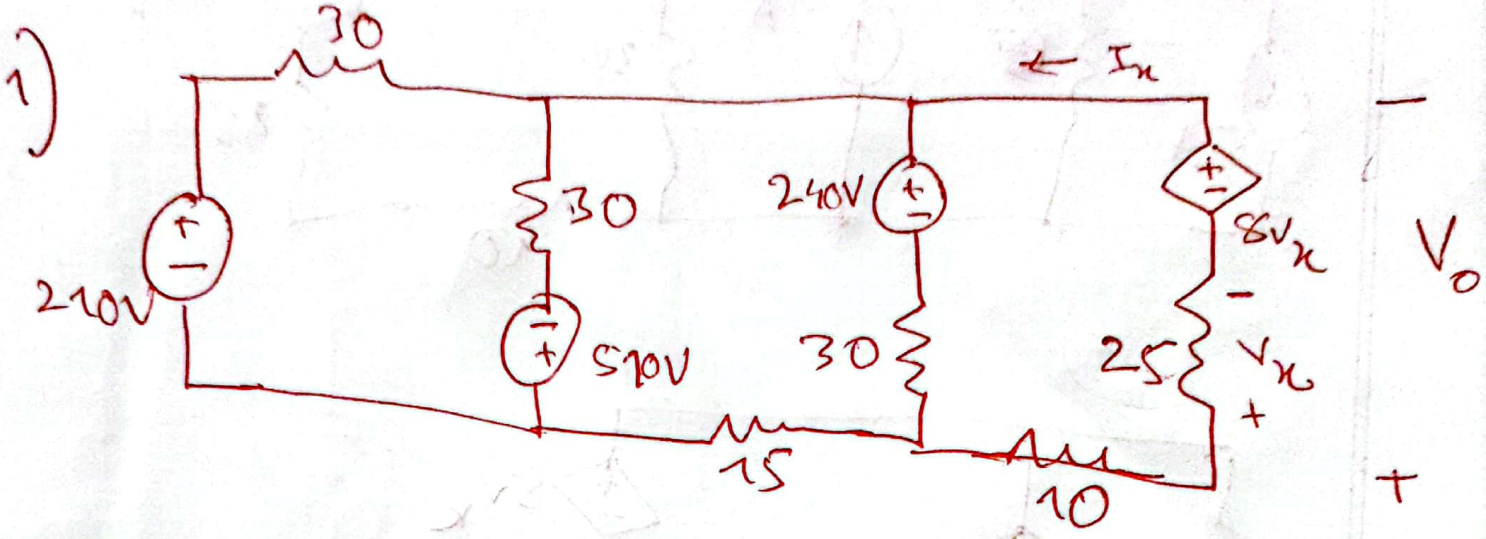
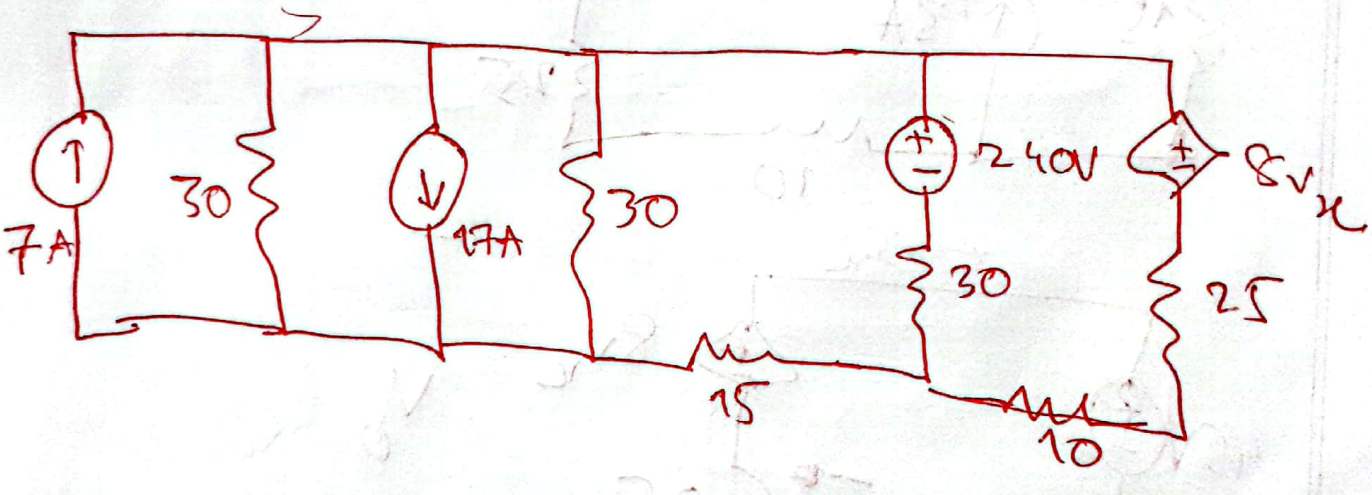
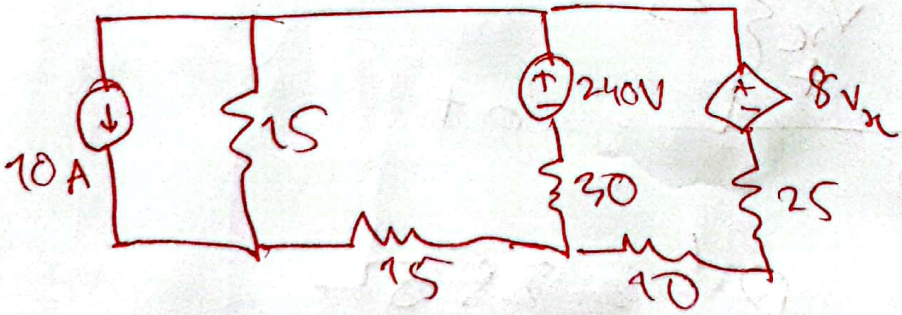
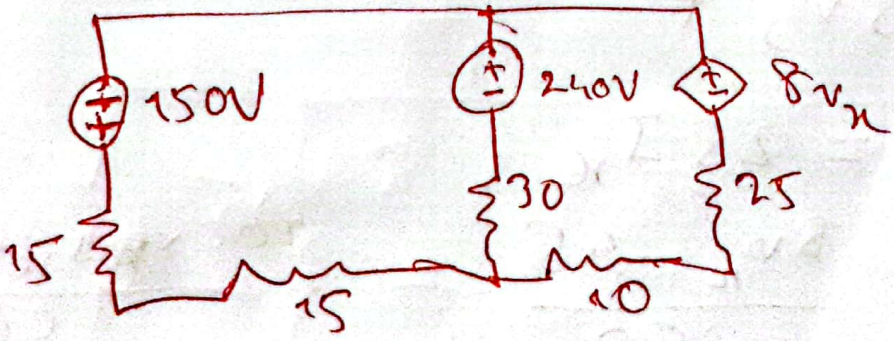
# Set -A

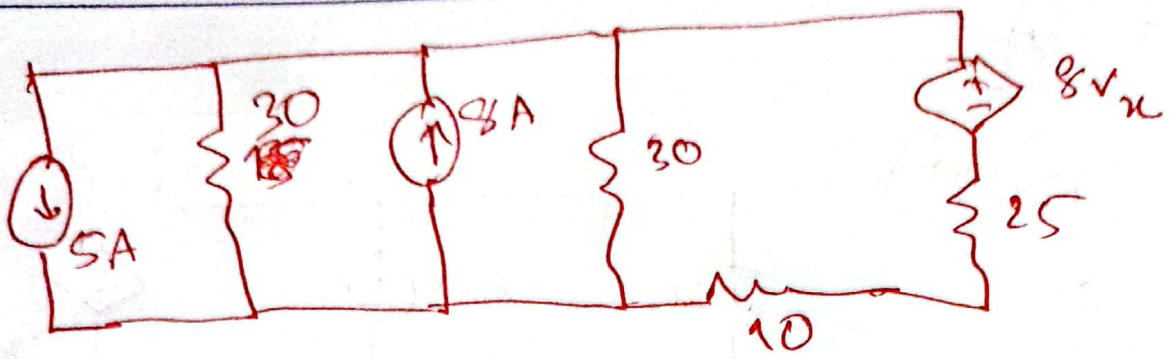
1)

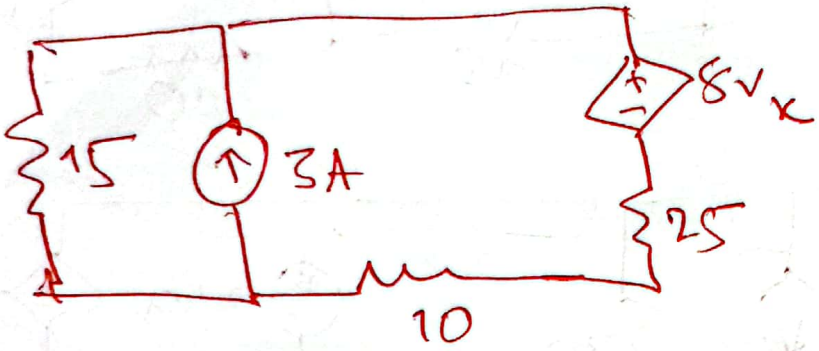

30
$I_x$
240V
8$V_x$
$V_o$
210V
30
510V
30
25
$V_x$
15
10

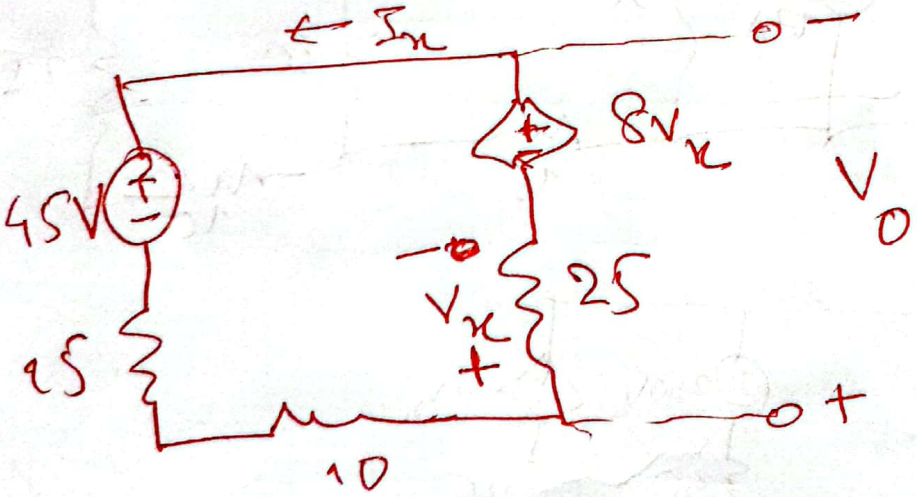

7A
30
17A
30
240V
8$V_x$
30
25
15
10


10A
15
240V
8$V_x$
30
25
15
10


150V
240V
8$V_x$
15
30
25
15
10




(a) $V' = 45V$, $R' = 25\Omega$

(b) $V_x = 25 I_x$

$$I_x = \frac{8V_x - 45}{50} = \frac{200 I_x - 45}{50}$$

or, $i_x = 4i_x - \frac{45}{50}$

or, $i_x = \frac{45}{50} \cdot \frac{1}{3} = 0.3A$

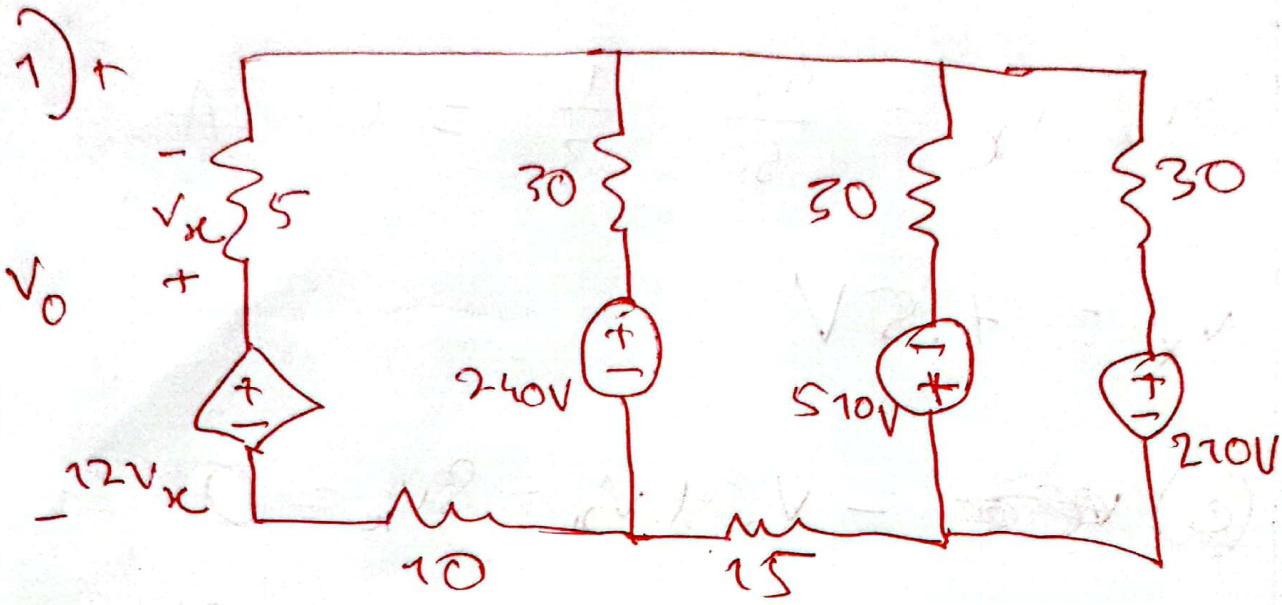
$v_x = 7.5V$

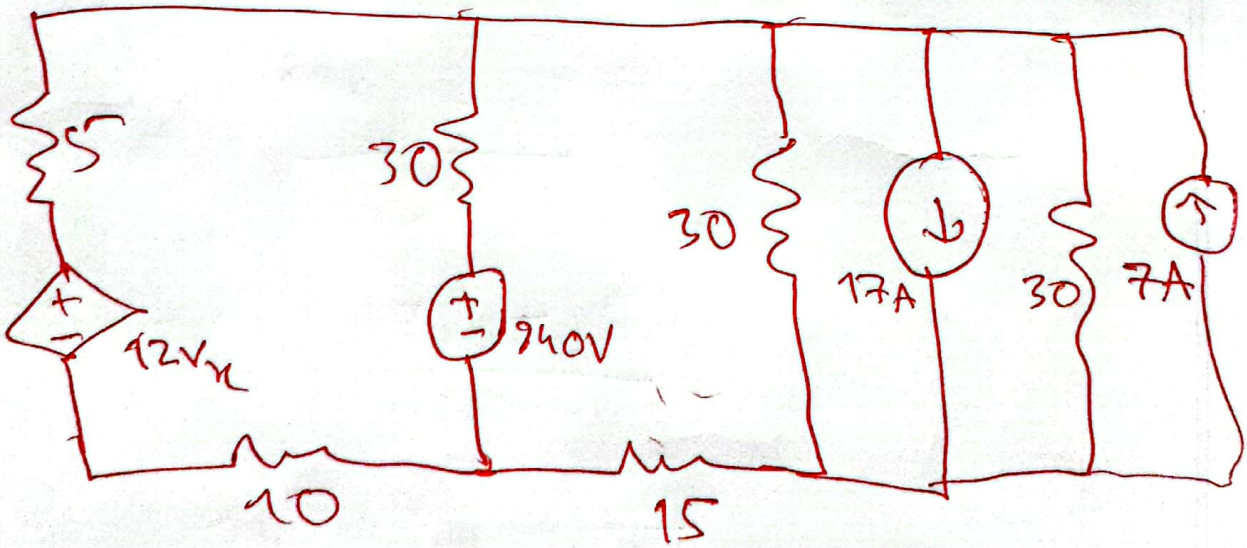
(c) $-v_0 + v_x - 8v_x = 0$

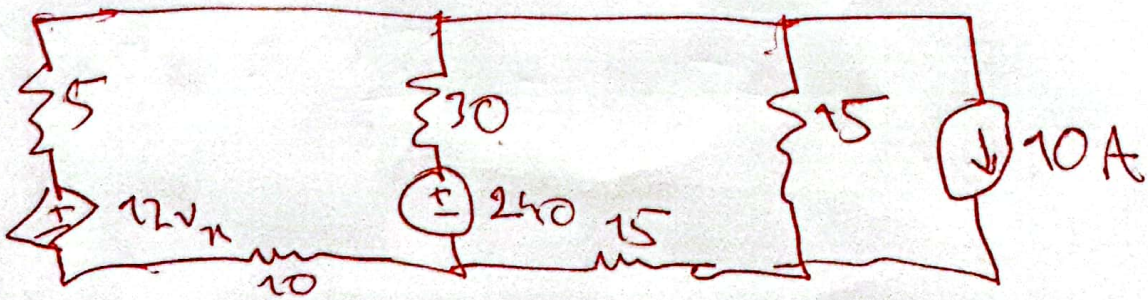
or, $v_0 = -7v_x = -52.5V$

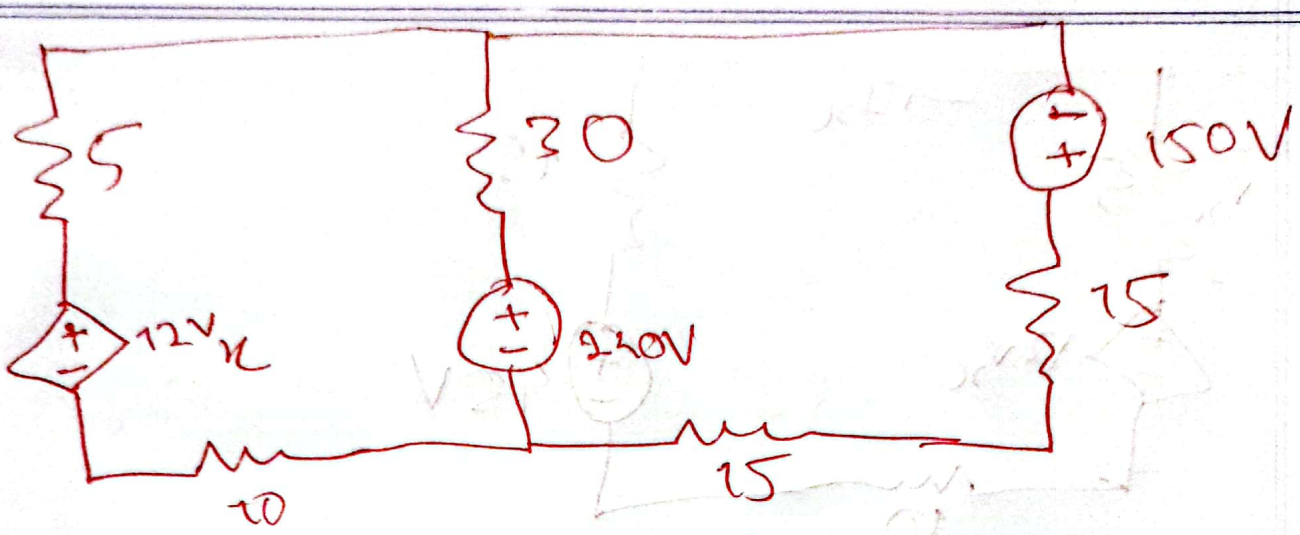
Set-B

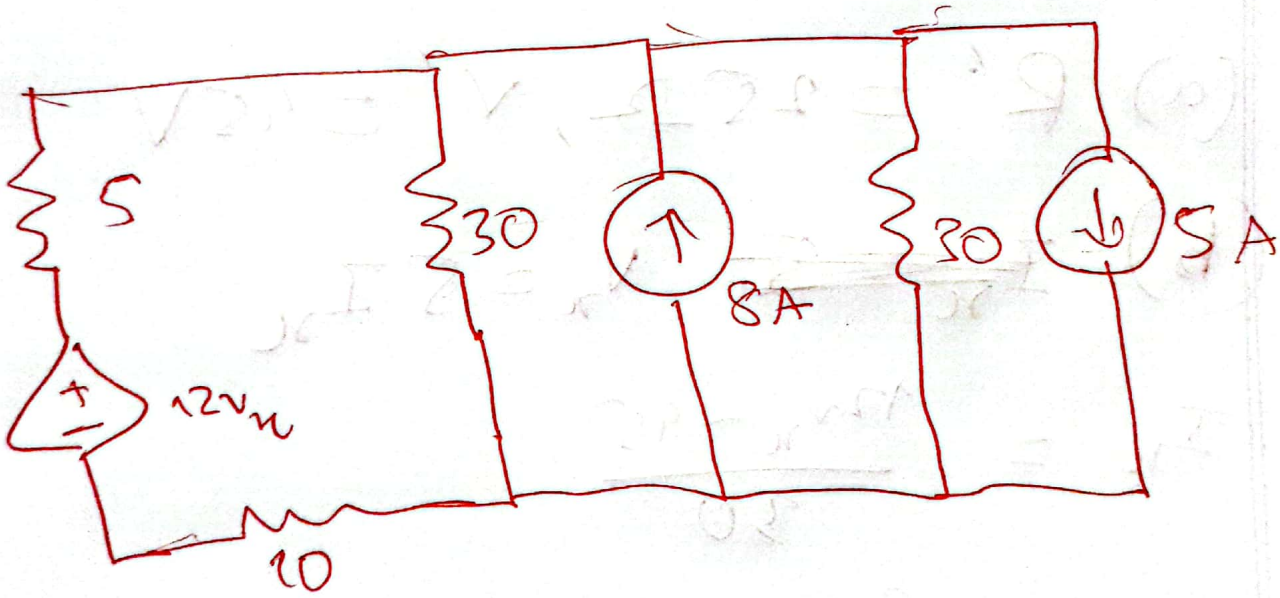
1)

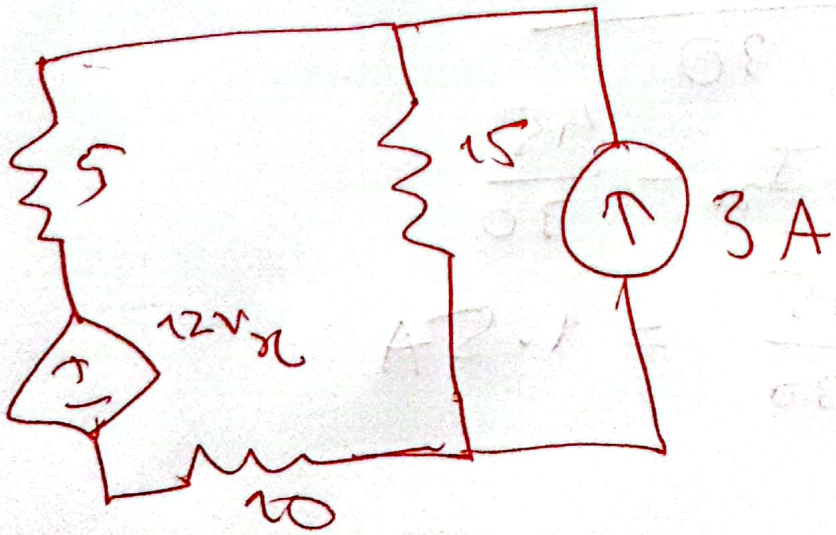

5
$V_x$
+
$V_o$
$12V_x$
30
240V
30
510V
30
270V
10
15

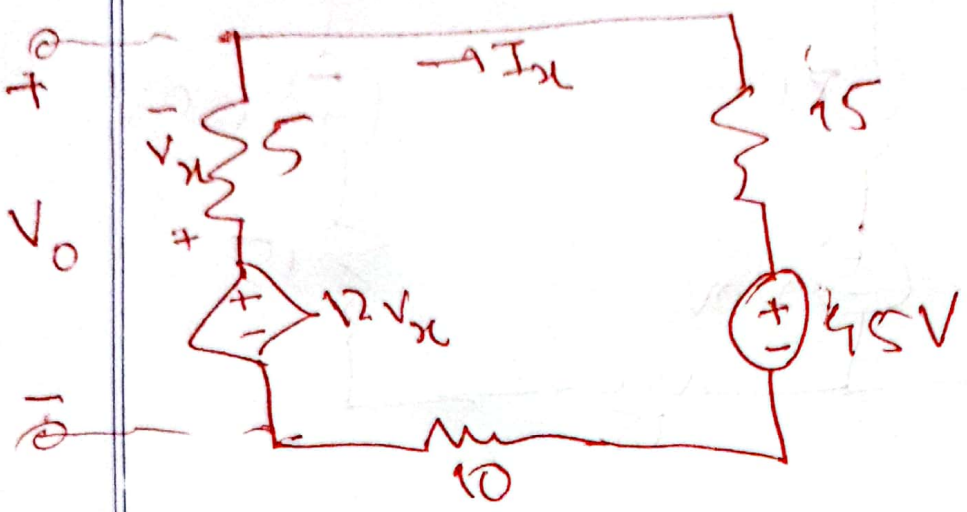

5
$12V_x$
30
240V
30
17A
30
7A
10
15


5
$12V_x$
30
240
15
15
10A
10


5
30
150V
12V_x
220V
15
10
15


5
30
8A
30
5A
12V_x
10


5
15
3A
12V_x
10




(a) $R' = 25\,\Omega$, $V' = 45V$

(b) ~~$I_x$~~ $V_x = 5I_x$

$$I_x = \frac{12V_x - 45}{30}$$

$$= \frac{60I_x - 45}{30}$$

$$= 2I_x - \frac{45}{30}$$

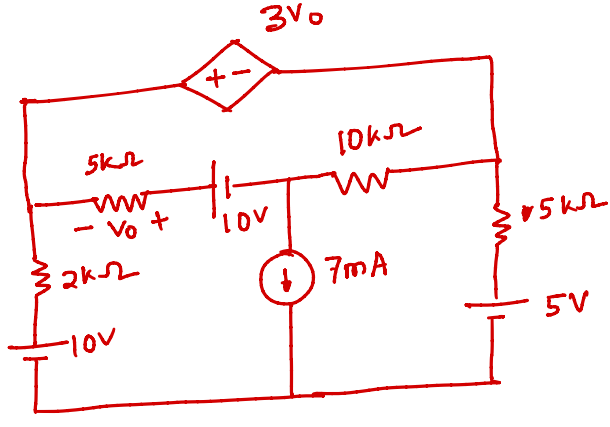
or, $I_x = \frac{45}{30} = 1.5A$

$$V_x = 5I_x = 7.5V$$

(c) $$-V_o - V_x + 12V_x = 0$$

or, $$V_o = 11V_x = 82.5V$$

Q.

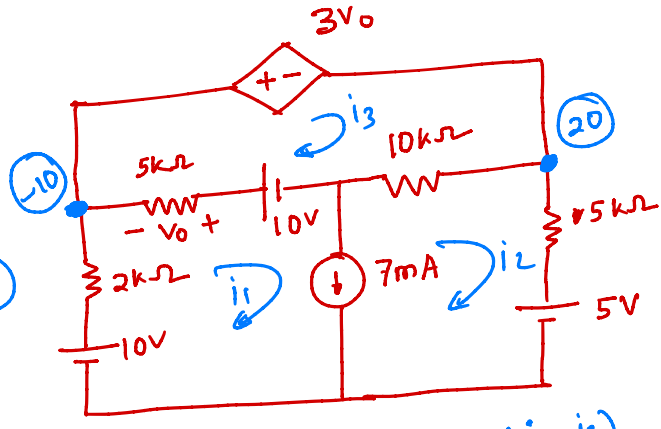



(a) Use Nodal/Mesh analysis to find out the node voltage/ mesh currents

(b) Find out the voltage and power across dependent source.

## Meshanalysis

### Supermesh




$-10 + 2k i_1 + 5k(i_1 - i_3) + 10$

$+10k(i_2 - i_3) + 5k i_2 + 5 = 0$

$\Rightarrow 7k i_1 + 15k i_2 - 15k i_3 = -5$ — (i)

$i_1 - i_2 = 7mA$ — (ii)

$v_o = 5k(i_3 - i_2)$

### mesh-3

$10k(i_3 - i_2) - 10 + 5k(i_3 - i_1) + 3V_0 = 0$

$\Rightarrow 10k(i_3 - i_2) - 10 + 5k(i_3 - i_1) + 15k(i_3 - i_1) = 0$

$\Rightarrow 10k(i_3 - i_2) + 20k(i_3 - i_1) = 10$

$\Rightarrow -20k i_1 - 10k i_2 + 30k i_3 = 10$

$\Rightarrow -2k i_1 - 1k i_2 + 3k i_3 = 1$ — (iii)

$i_1 = 10mA \quad i_2 = 3mA \quad i_3 = 8mA.$

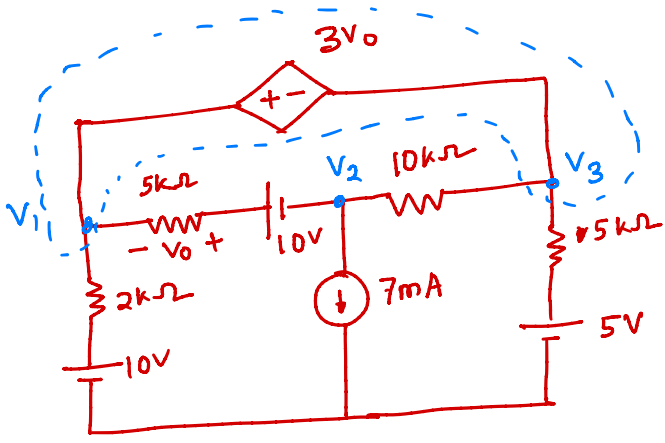
voltage across dependent source $\pm 30V$

current $= 8mA.$

So power $= +vi = +(-30)(8 \times 10^{-3})$

$= -0.24$ watt (Ans.)

## Nodal analysis




### Supernode

$V_1 - V_3 = 3V_o$

$V_o = V_2 + 10 - V_1$

$\Rightarrow V_1 - V_3 = 3(V_2 + 10 - V_1)$

$\Rightarrow V_1 - V_3 = 3V_2 + 30 - 3V_1$

$\Rightarrow 4V_1 - 3V_2 - V_3 = 30$ — (i)

### KCL at ~~node~~ supernode

$$\frac{V_1 - 10}{2k} + \frac{V_1 - (V_2+10)}{5k} + \frac{V_3 - 5}{5k} = \frac{V_2 - V_3}{10k}$$

$\Rightarrow 5(V_1 - 10) + 2V_1 - 2(V_2 + 10) + 2(V_3 - 5) = V_2 - V_3$

$\Rightarrow 7V_1 - 3V_2 + 3V_3 - 50 - 20 - 10 = 0$

$\Rightarrow 7V_1 - 3V_2 + 3V_3 = 80$ — (ii)

$V_1 = -10\ V$

$V_2 = -30\ V$

$V_3 = 20\ V$

### KCL at node 2

$$\frac{V_1 - (V_2+10)}{5k} = 7mA + \frac{V_2 - V_3}{10k}$$

$\Rightarrow 2V_1 - 2(V_2 + 10) = 70 + V_2 - V_3$

$\Rightarrow 2V_1 - 3V_2 + V_3 = 90$ — (iii)

voltage across dependent source $= \pm 30\ V$

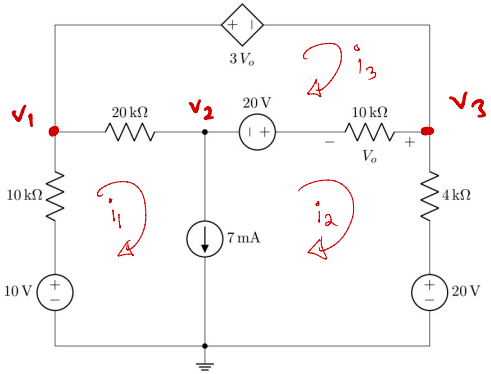
power $= +vi$

$= -0.24$ watt

(c) *[3 marks]* Determine the value of $V_o$.



## ■ Question 2 of 4 *[CO3] [15 marks]*




**Apply Nodal/Mesh analysis** to answer the following questions–

(a) *[12 marks]* Find all the node voltages/mesh currents in the circuit shown above. Note that, depending on the analysis method you are applying, you have to determine either the mesh currents or the node voltages, not both.

*[A hint: derive all the equations at first, as correct formation of the nodal/mesh equations bear majority of the marks. Proceed to solve then.]*

(b) *[3 marks]* Determine the power of the $3\,V_o$ dependent voltage source (with appropriate ± sign). Also mention, whether the source is supplying or consuming the power.

## ■ Question 3 of 4 *[CO3] [15 marks]*

Supermesh

$$-10+10ki_1+20k(i_1-i_3)-20+10k(i_2-i_3)+4ki_2+20=0$$

$$\Rightarrow 30ki_1+14ki_2-30ki_3=10 \quad \text{(i)}$$

$$i_1-i_2=7\times10^{-3} \quad \text{(ii)}$$

$$V_0=10k(i_3-i_2)$$

mesh-3

$$10k(i_3-i_2)+20+20k(i_3-i_1)+3V_0=0$$

$$\Rightarrow 10k(i_3-i_2)+20+20k(i_3-i_1)+30k(i_3-i_2)=0$$

$$\Rightarrow -20ki_1-40ki_2+60ki_3=-20 \quad \text{(iii)}$$

$$i_1=-3mA \quad i_2=-10mA \quad i_3=-8mA.$$

dependent source power

$$v_1=(3mA\times10k\Omega)+10=40V$$

$$v_2=(-10mA\times4k\Omega)+20=-20$$

voltage across the source $=60V$

$$P=+vi=60(-8mA)$$

$$=-0.48Watt$$

(Ans.)

## Nodal analysis

### Supernode

$$\frac{v_1-10}{10}+\frac{v_1-v_2}{20}+\frac{v_3-20}{4}=\frac{(v_2+20)-v_3}{10}$$

$$\Rightarrow 2v_1-20+v_1-v_2+5v_3-100=2v_2+40-2v_3$$

$$\Rightarrow 3v_1-3v_2+7v_3=160 \quad \text{(i)}$$

$$v_1-v_3=3v_0$$

$$\Rightarrow v_1-v_3=3(v_3-(v_2+20))$$

$$\Rightarrow v_1-v_3=3v_3-3v_2-60$$

$$\Rightarrow v_1+3v_2-4v_3=-60 \quad \text{(ii)}$$

node 2 : $\frac{v_1-v_2}{20}=7+\frac{(v_2+20)-v_3}{10}$

$$\Rightarrow v_1-v_2=140+2v_2+40-2v_3$$

$$\Rightarrow v_1-3v_2+2v_3=180 \quad \text{(iii)}$$

$v_1=40V \quad v_2=-60V \quad v_3=-20V$

voltage across source $= 40-(-20)=60V$

current entering through the +ve terminal

$$\frac{v_1-10}{10}+\frac{v_1-v_2}{20}+i_x=0$$

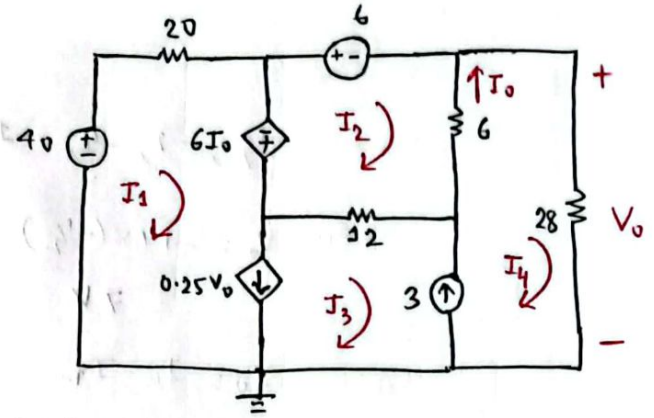
$$i_x=-8mA.$$

$$\therefore \text{power} = +vi = 60(-8mA)$$

$$= -0.48W$$

# Main Set-A (Q-3)

## Mesh Analysis:




$I_0 = I_4 - I_2$ $\quad V_0 = 28 I_4$

**Supermesh KCL:** $I_1 - I_3 = 0.25 \times (28 I_4)$

$\Rightarrow I_1 - I_3 - 7I_4 = 0 \quad \ldots (1)$

$I_4 - I_3 = 3 \quad \ldots (2)$

**Supermesh KVL:**

$20 I_1 - 6(I_4 - I_2) + 12(I_3 - I_2) + 6(I_4 - I_2) + 28 I_4 = 40$

$\Rightarrow 20 I_1 - 12 I_2 + 12 I_3 + 28 I_4 = 40 \quad \ldots (3)$

**Mesh-2 KVL**

$6 + 6(I_2 - I_4) + 12(I_2 - I_3) + 6(I_4 - I_2) = 0$

$\Rightarrow 12 I_2 - 12 I_3 = -6 \quad \ldots (4)$

Solving (1), (2), (3), (4)

$I_1 = 1A \qquad I_2 = -3A$

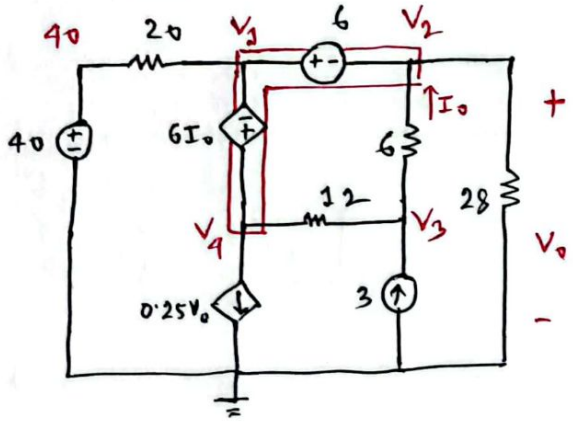
$I_3 = -2.5A \qquad I_4 = 0.5A$

(b)

$I_0 = 0.5 + 3 = 3.5\ A$

$V_0 = 28 \times 0.5 = 14\ V$

## Nodal Analysis




$V_0 = V_2 \qquad I_0 = \dfrac{V_3 - V_2}{6}$

(b)

$V_0 = V_2 = 14\ V$

$I_0 = \dfrac{35 - 14}{6} = 3.5A$

**Supernode KVL:** $V_1 - V_2 = 6 \quad \ldots (1)$

$V_4 - V_1 = 6 I_0 = 6 \times \dfrac{V_3 - V_2}{6}$

$\Rightarrow V_1 - V_2 + V_3 - V_4 = 0 \quad \ldots (2)$

**Supernode KCL:**

$\dfrac{V_2}{28} + \dfrac{V_2 - V_3}{6} + \dfrac{V_1 - 40}{20} + \dfrac{V_4 - V_3}{12} + 0.25 V_2 = 0$

$\Rightarrow \dfrac{V_1}{20} + \dfrac{19 V_2}{42} - \dfrac{V_3}{4} + \dfrac{V_4}{12} = 2 \quad \ldots (3)$

**KCL at Node-3:** $\dfrac{V_3 - V_2}{6} + \dfrac{V_3 - V_4}{12} = 3$

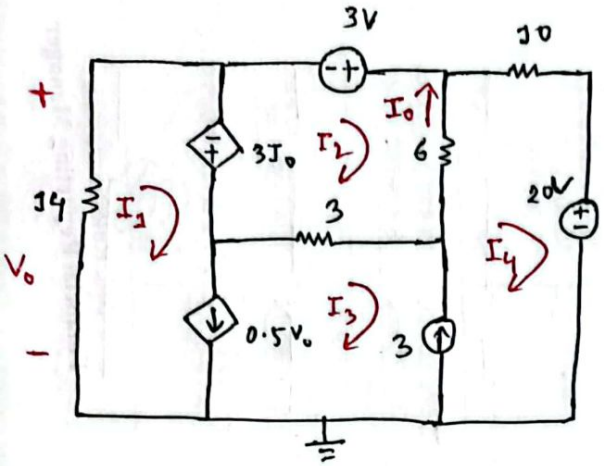
$\Rightarrow -\dfrac{V_2}{6} + \dfrac{V_3}{4} - \dfrac{V_4}{12} = 3 \quad \ldots (4)$

Solving (1), (2), (3), (4)

$V_1 = 20V, \quad V_2 = 14V, \quad V_3 = 35V, \quad V_4 = 41V$

## Main Set-B (Q-3)

### Mesh Analysis:




$V_0 = -14 I_1$ $\quad I_0 = I_4 - I_2$

**Supermesh KCL:** $\quad I_4 - I_3 = 3 \quad \cdots (1)$

$I_1 - I_3 = 0.5 V_0 = 0.5(-14 I_1)$

$\Rightarrow 8 I_1 - I_3 = 0 \quad \cdots (2)$

**Supermesh KVL:**

$14 I_1 - 3(I_4 - I_2) + 3(I_3 - I_2) + 6(I_4 - I_2) + 10 I_4 + 20 = 0$

$\Rightarrow 14 I_1 - 6 I_2 + 3 I_3 + 13 I_4 = -20 \quad \cdots (3)$

**Mesh-2 KVL:** $\quad -3 + 6(I_2 - I_4) + 3(I_2 - I_3) + 3(I_4 - I_2) = 0$

$\Rightarrow 6 I_2 - 3 I_3 - 3 I_4 = 3 \quad \cdots (4)$

Solving (1), (2), (3), (4)

$I_1 = -0.5\,A, \quad I_2 = -2A, \quad I_3 = -4A, \quad I_4 = -1\,A$

(b)

$V_0 = -14(-0.5) = 7\,V$

$I_0 = -1 - (-2) = 1A$

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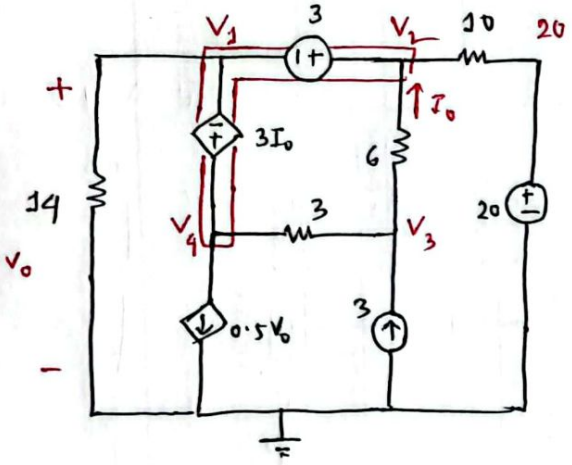
### Nodal Analysis:




$V_0 = V_1 \quad I_0 = \dfrac{V_3 - V_2}{6}$

(b)

$V_0 = V_1 = 7V$

$I_0 = \dfrac{16 - 10}{6} = 1A$

**Supernode KVL:** $\quad V_2 - V_1 = 3 \quad \cdots (1)$

$V_4 - V_1 = 3 I_0 = 3 \times \dfrac{V_3 - V_2}{6}$

$\Rightarrow V_1 - \dfrac{V_2}{2} + \dfrac{V_3}{2} - V_4 = 0 \quad \cdots (2)$

**Supernode KCL:**

$\dfrac{V_2 - 20}{10} + \dfrac{V_2 - V_3}{6} + \dfrac{V_1}{14} + \dfrac{V_4 - V_3}{3} + 0.5 V_1 = 0$

$\Rightarrow \dfrac{4V_1}{7} + \dfrac{4V_2}{15} + \left(-\dfrac{V_3}{2}\right) + \dfrac{V_4}{3} = 2 \quad \cdots (3)$

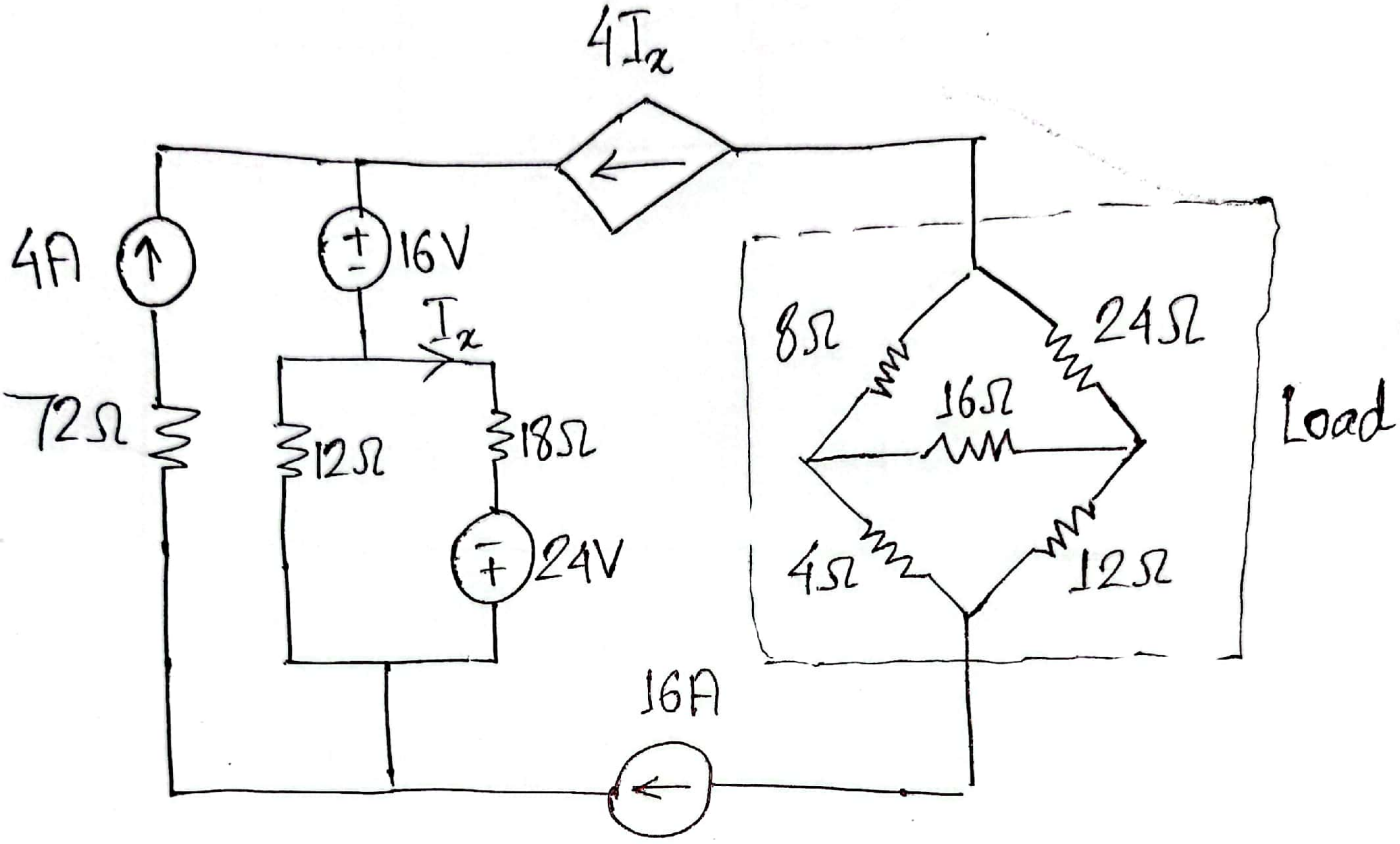
**Node-3 KCL:** $\quad \dfrac{V_3 - V_4}{3} + \dfrac{V_3 - V_2}{6} = 3$

$\Rightarrow -\dfrac{V_2}{6} + \dfrac{V_3}{2} - \dfrac{V_4}{3} = 3 \quad \cdots (4)$

Solving (1), (2), (3), (4)

$V_1 = 7V, \quad V_2 = 10V, \quad V_3 = 16V, \quad V_4 = 10\,V$

4. @ Set - 1



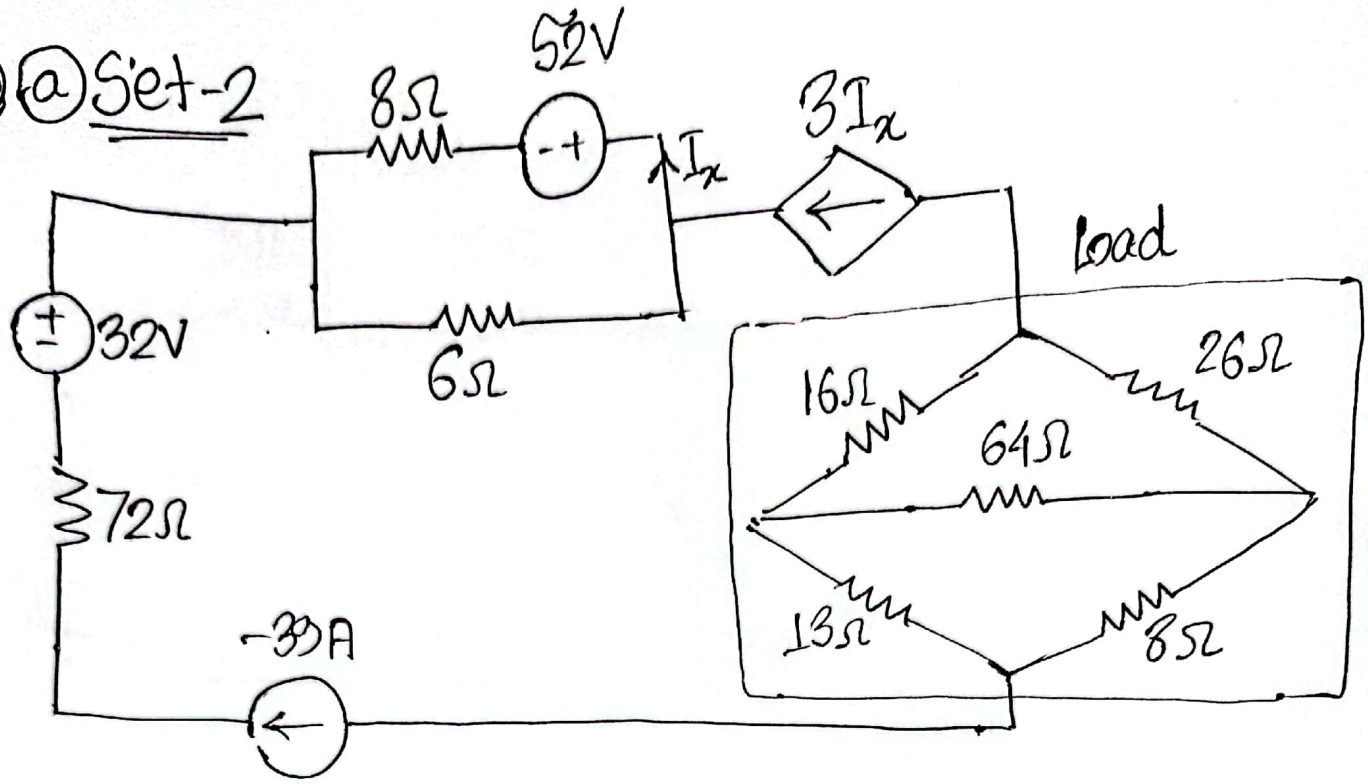

Q. In this circuit, find the value of $I_x$

$\Rightarrow 4I_x$ is in series with 16 A.

$\therefore -4I_x = 16$ [cosidering current direction]

$\Rightarrow I_x = -4A$

@Set-2



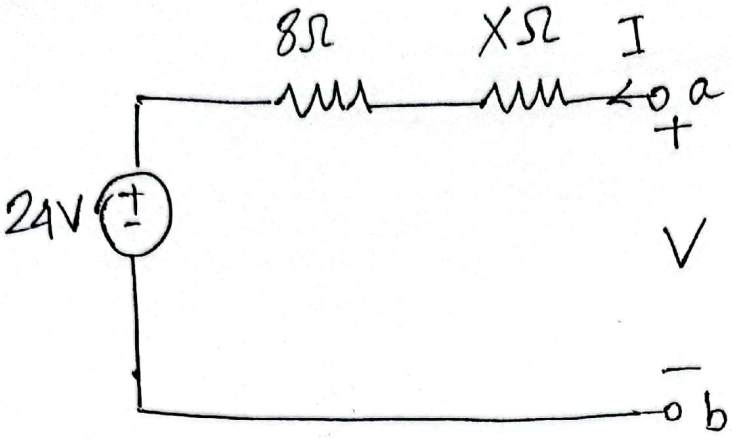

In the circuit find $I_x$.

In the circuit $3I_x$ is in series with $-39A$.

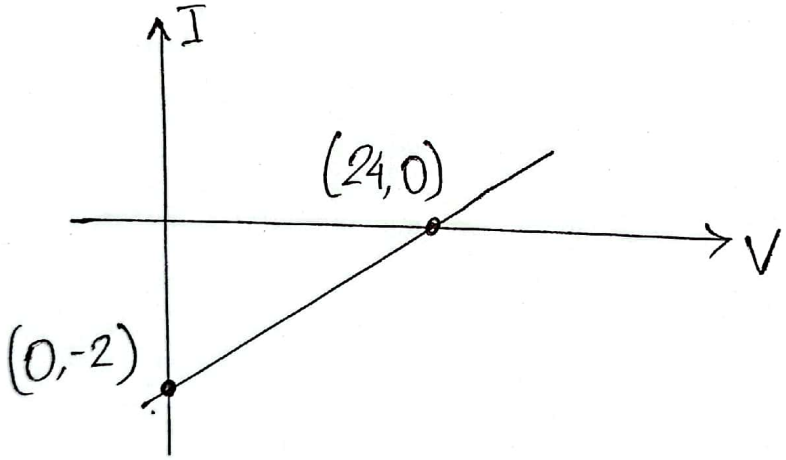
Hence, $3I_x = 39$ [considering current direction]

$\Rightarrow I_x = 13A$

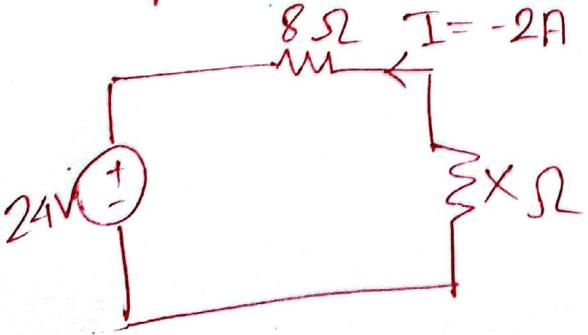
4 (b) Set-1




If the current, I vs. voltage V has the following relationship, determine the value of X.




At point (0, -2), the ckt becomes

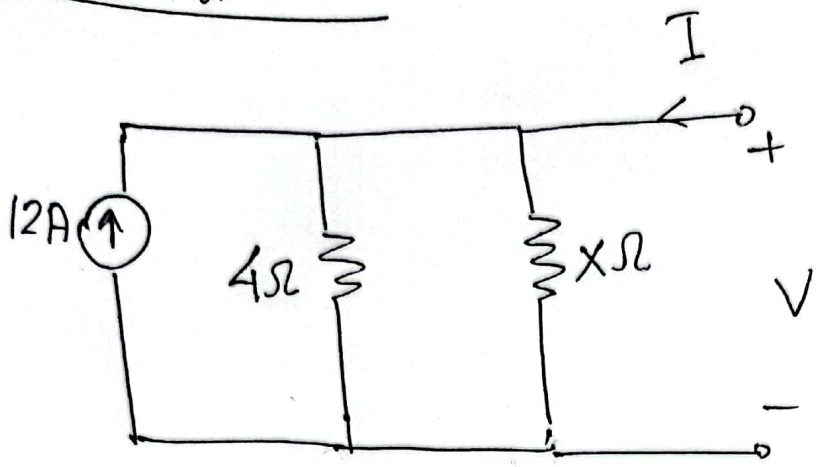



So, $\frac{-24}{8+X} = -2$

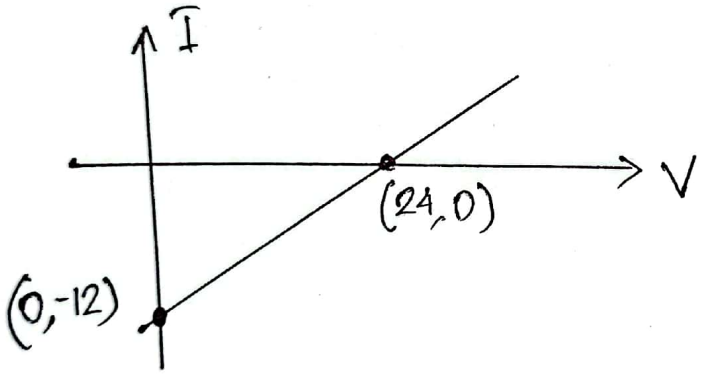
$\Rightarrow 24 = 16 + 2x$

$\Rightarrow X = 8/2 = 4$

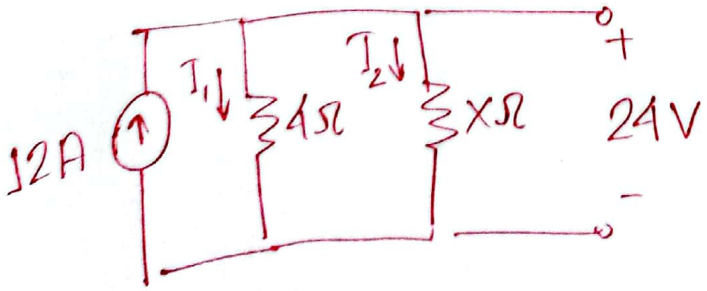
(b) Set 02 (proposed)




If the current, I vs voltage, V has the following relationship, determine the value of X.




At point (24, 0), the circuit becomes —



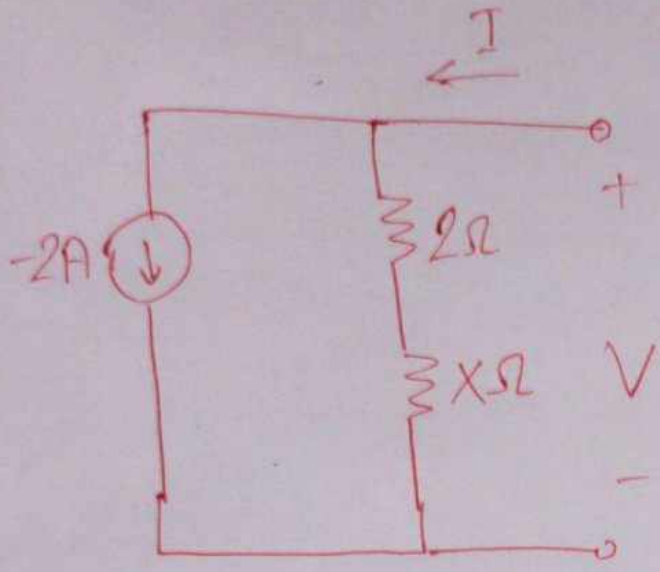

$I_1 = \frac{24}{4} A = 6A$

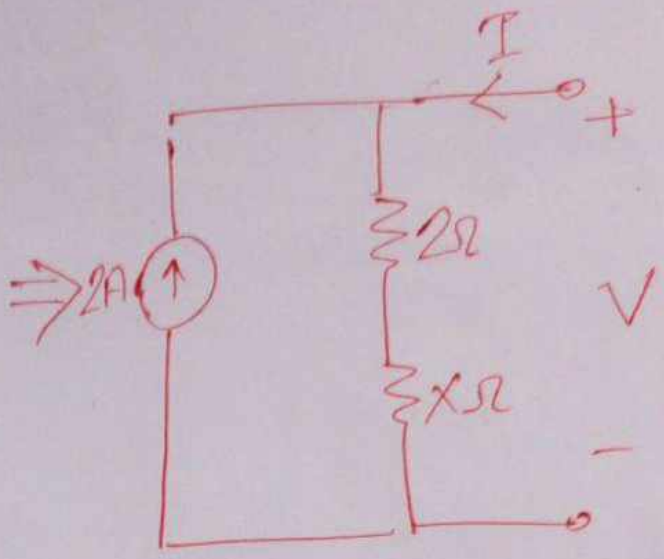
$\therefore I_2 = (12-6) A = 6A$

$\therefore X \cdot 6 = 24$

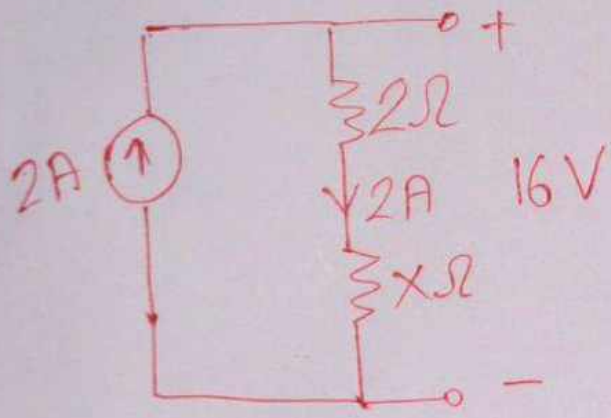
$\Rightarrow X = 4\Omega$

4(c) Set B




at point (16, 0) of the I-V graph, the ckt becomes —




$$\therefore \frac{16}{2+X} = 2$$

$$\Rightarrow 8 = 2 + X$$

$$\Rightarrow X = 6$$