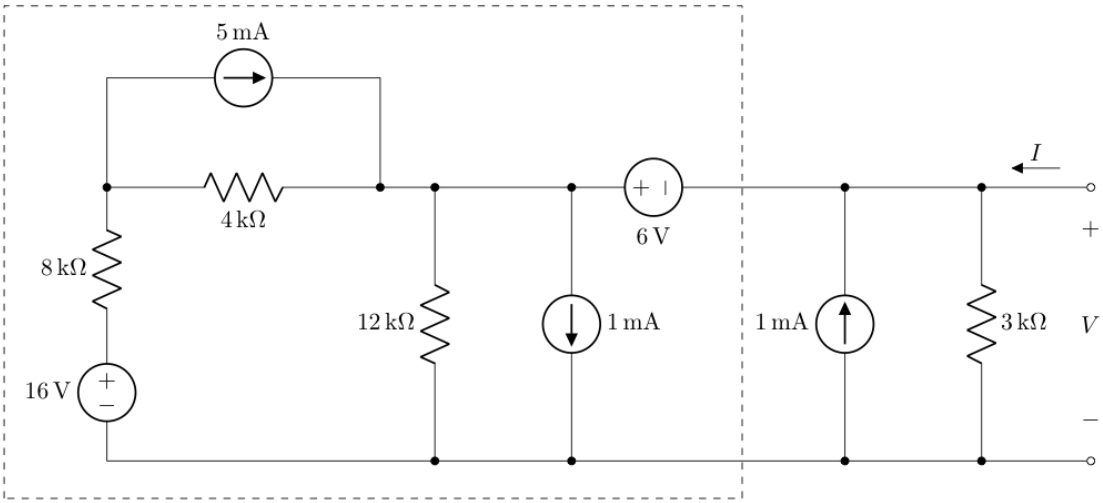
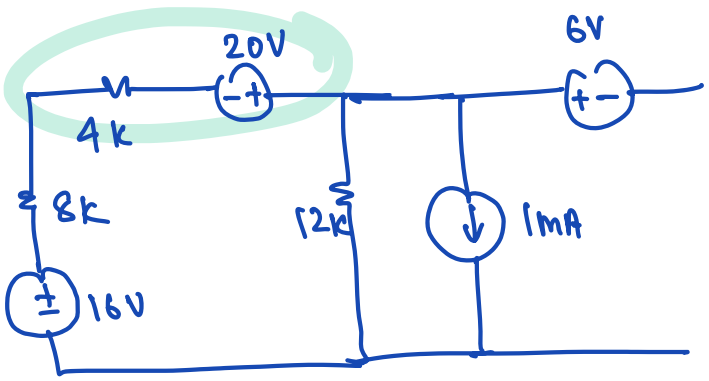
■ **Question 1 of 4** *[CO2] [16 marks]*



Circuit 1

a)



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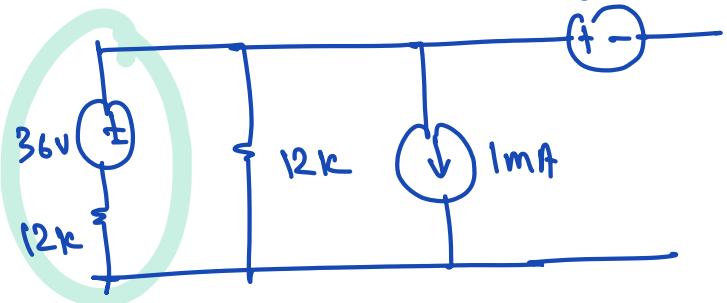

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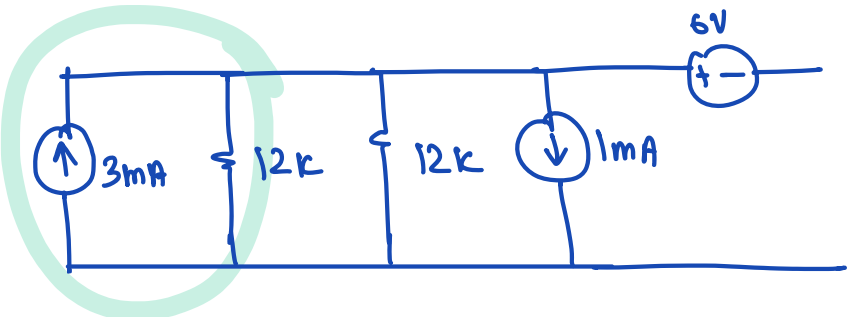
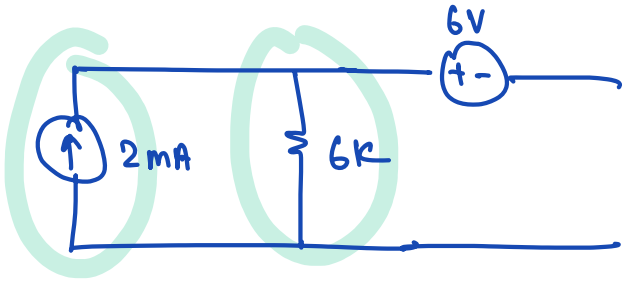
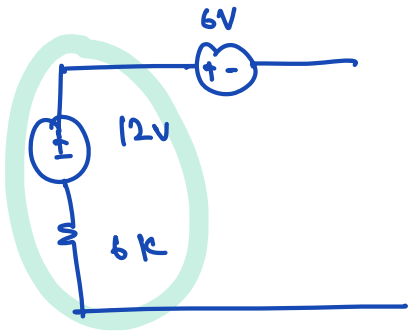
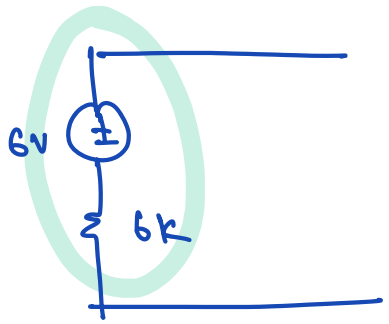




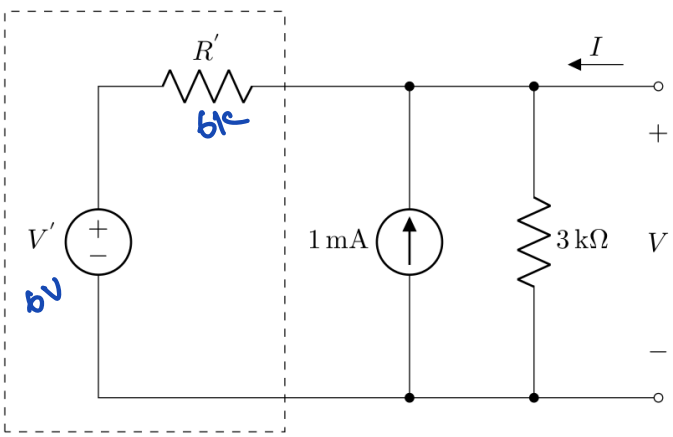


(Total 7 steps)



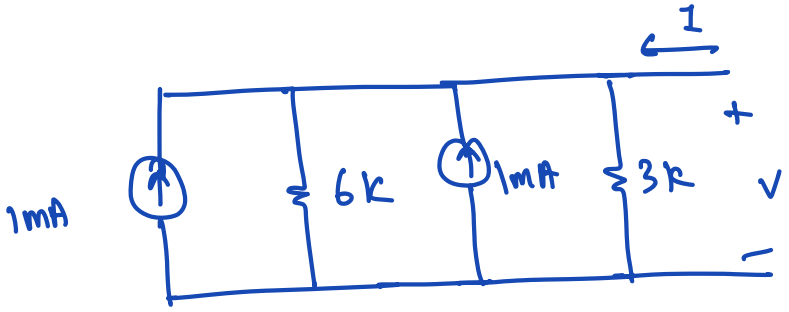
$V' = 6$

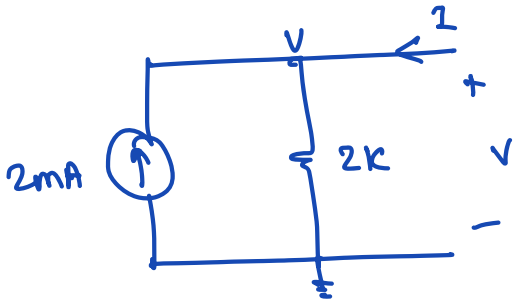
$R' = 6\text{K}$



Circuit 2

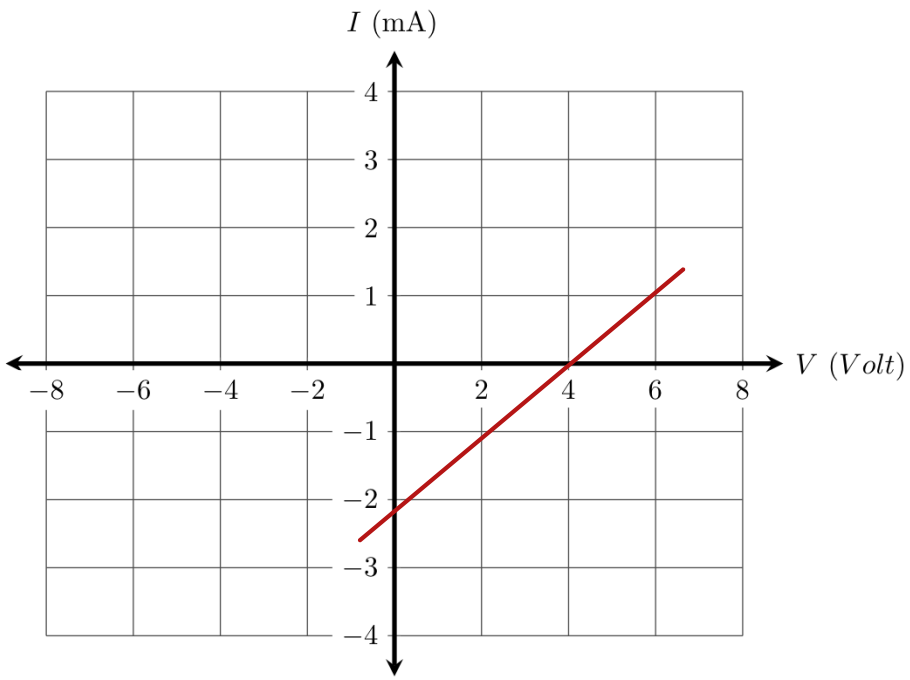
(b) ***[7 marks]*** Derive a **Current-Voltage Relationship** from *Circuit 2*. The $I-V$ equation cannot contain any variables other than I and V pointed out in the diagram. Plot the $I-V$ relation in the grid provided above.





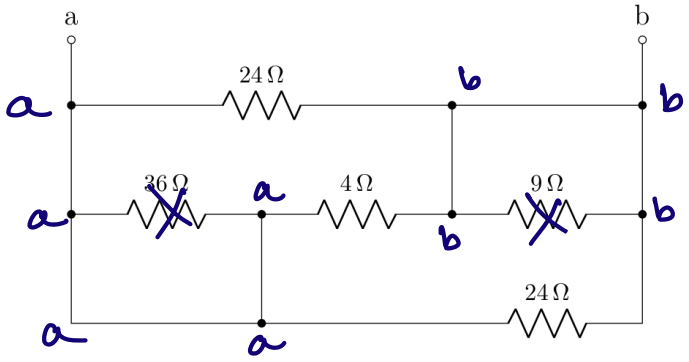
$$2 + \frac{0 - V}{2} + I = 0$$

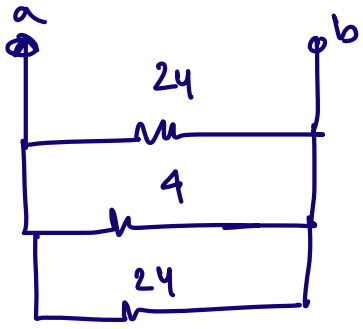
$$\boxed{I = \frac{V}{2} - 2}$$



■ Question 2 of 4 *[CO3] [8 marks]*

Determine R_{ab}, the equivalent resistance between the terminals a and b in the circuit shown below.

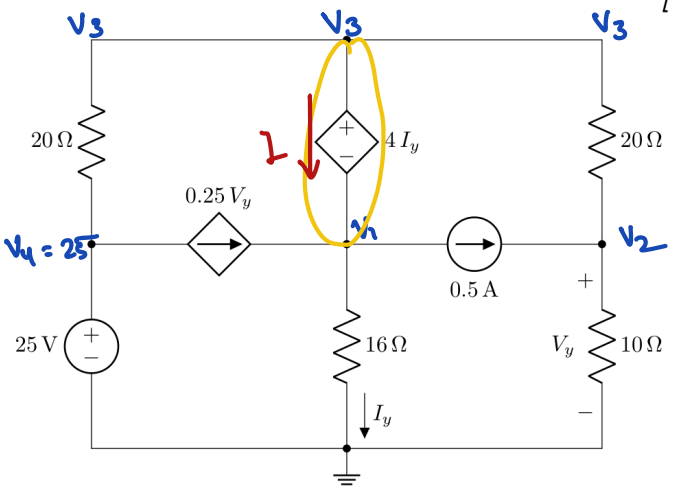




$R_{ab} = 24 \parallel 24 \parallel 4$

$R_{ab} = 3\,\Omega$

■ **Question 3 of 4** *[CO3] [16 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.

(b) *[4 marks]* Determine the power of the $4\,I_y$ dependent voltage source (with appropriate ± sign). Also mention, whether the source is supplying or consuming the power.

1) $I_y = \frac{V_1}{16}$ ——— (I)

$V_y = V_2$ ——— (II)

2) $-0.5 + \frac{V_2}{10} + \frac{V_2 - V_3}{20} = 0$ ——— (III)

3) $\frac{3}{20} V_2 - \frac{V_3}{20} = 0.5$

3+1) $-0.25\,V_2 + \frac{V_1}{16} + 0.5 + \frac{V_3 - 25}{20} + \frac{V_3 - V_2}{20} = 0$ ——— (IV)

2) $\frac{V_1}{16} - \frac{3}{10} V_2 + \frac{1}{10} V_3 = 0.75$

$V_3 - V_1 = 4 I_y$ ——— (V)

$= \frac{V_1}{4}$

1) $-\frac{5}{4} V_1 + V_3 = 0$

$V_1 = 28\,V$ $V_2 = 15\,V$ $V_3 = 35\,V$ $V_4 = 25\,V$

(b) $I = -\left(\frac{V_3 - V_2}{20} + \frac{V_3 - 25}{20}\right)$

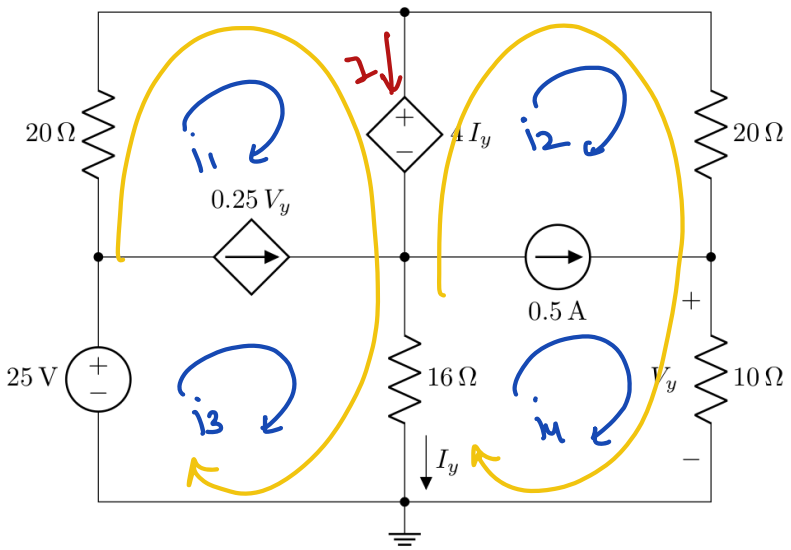
$= -1.5\,A$

$P = I \times 4I_y$

$= -10.5\,W$

supplied

Mesh:



$V_4 = 10 i_4$ ——— (I)

$I_y = i_3 - i_4$ ——— (II)

1+3

$i_3 - i_1 = 0.25 V_4$ ——— (III)

$-i_1 + i_3 - 2.5 i_4 = 0$

$$20i_1 + 4I_y + 16i_3 - 16i_4 - 25 = 0 \quad \text{——— (iv)}$$

$$\Rightarrow 20i_1 + 4i_3 - 4i_4 + 16i_3 - 16i_4 - 25 = 0$$

$$\Rightarrow \boxed{20i_1 + 20i_3 - 20i_4 - 25 = 0}$$

2 eq

$$\boxed{i_4 - i_2 = 0.5 \quad \text{——— (v)}}$$

$$-4I_y + 20i_2 + 10i_4 + 16i_4 - 16i_3 = 0$$

$$\Rightarrow -4i_3 + 4i_4 + 20i_2 + 26i_4 - 16i_3 = 0$$

$$\Rightarrow \boxed{20i_2 - 20i_3 + 30i_4 = 0}$$

$$\boxed{i_1 = -0.5A \qquad i_2 = 1A \qquad i_3 = 3.25A \qquad i_4 = 1.5A}$$

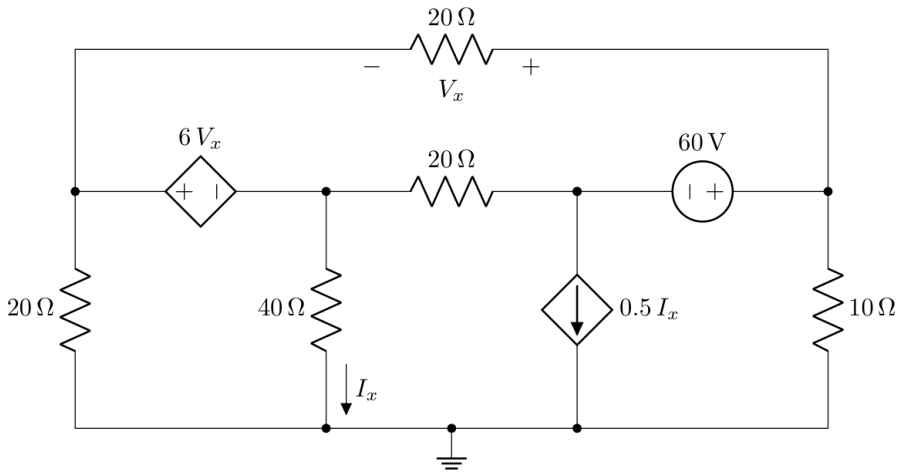
b) $I = i_1 - i_2 = -1.5A$

$P = 1 \times 4I_y$

$= -1.5 \times 4 \times (3.25 - 1.5)$

$\boxed{= -10.5W \text{ supplied}}$

■ Question 4 of 4 *[CO3] [15 marks]*



Apply Nodal/Mesh analysis to answer the following questions–

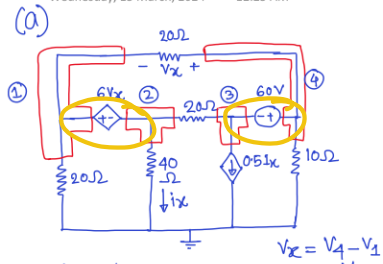
(a) ***[12 marks]*** Find all the node voltages/mesh currents in the circuit shown above. Note that, depending on the analysis method you are applying, you have to determine either the mesh currents or the node voltages, not both.

(b) ***[3 marks]*** Determine the voltage across the $0.5\,I_x$ dependent current source.

Q4 Set B

Wednesday, 13 March, 2024 12:25 AM

(a)



$V_x = V_4 - V_1$

$i_x = \frac{V_2}{40}$

Nodal Analysis:-

Super node equations-

$V_4 - V_3 = 60\,V$ —— (i)

$V_1 - V_2 = 6V_x$

$\Rightarrow V_1 - V_2 = 6(V_4 - V_1)$

$\Rightarrow \boxed{7V_1 - V_2 - 6V_4 = 0}$ —— (ii)

KCL at SN1 (1,2)

$$\frac{V_1}{20} + \frac{V_2}{40} + \frac{V_2 - V_3}{20} + \frac{V_1 - V_4}{20} = 0$$

$\Rightarrow 2V_1 + V_2 + 2V_2 - 2V_3 + 2V_1 - 2V_4 = 0$

$\Rightarrow 4V_1 + 3V_2 - 2V_3 - 2V_4 = 0$ —— (iii)

$\Rightarrow 4V_1 + 3V_2 - 2(V_4 - 60) - 2V_4 = 0$ [from (i)]

$\Rightarrow \boxed{4V_1 + 3V_2 - 4V_4 = -120}$ —— (iv)

KCL at SN2 (3,4)

$$0.5\,I_x + \frac{V_4}{10} + \frac{V_3 - V_2}{20} + \frac{V_4 - V_1}{20} = 0$$

$$\Rightarrow \frac{V_2}{80} + \frac{V_4}{10} + \frac{V_3 - V_2}{20} + \frac{V_4 - V_1}{20} = 0$$

$\Rightarrow V_2 + 8V_4 + 4V_3 - 4V_2 + 4V_4 - 4V_1 = 0$

$\Rightarrow -4V_1 - 3V_2 + 4V_3 + 12V_4 = 0$

$\Rightarrow -4V_1 - 3V_2 + 2(V_4 - 60) + 12V_4 = 0$

$\Rightarrow \boxed{-4V_1 - 3V_2 + 16V_4 = 240}$ —— (v)

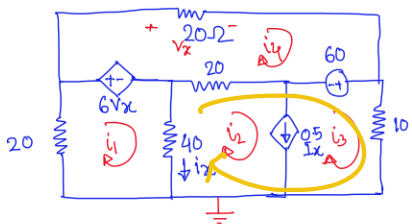
Solving (ii) (iv) (v)

$V_1 = 4\,V \quad V_2 = -32\,V \quad V_3 = -50$

$V_4 = 10\,V$

(b) $V_{0.5Ix} = V_3 = -50$

Alternative Solution:-



$V_x = -20i_4$

$I_x = i_1 - i_2$

Mesh-1:-

$60i_1 - 40i_2 + 6V_x = 0$

$\Rightarrow \boxed{60i_1 - 40i_2 - 120\,i_4 = 0}$ —— (i)

Mesh-4:-

$40i_4 - 20i_2 + 60 - 6V_x = 0$

$\Rightarrow \boxed{-20i_2 + 160i_4 = -60}$ —— (ii)

Supermesh:-

$i_2 - i_3 = 0.5i_x$

$\Rightarrow \boxed{-i_1 + 3i_2 - 2i_3 = 0}$ —— (iii)

KVL at SM:-

$\boxed{-40i_1 + 60i_2 + 10i_3 - 20i_4 = 60}$ —— (iv)

Solving (i) (ii) (iii) (iv)

$i_1 = -0.2\,A$

$i_2 = 0.6\,A$

$i_3 = 1\,A$

$i_4 = -0.3\,A$

(b) KVL at mesh-3

$V_{0.5Ix} = -60 + 10i_3 = -50\,V$