Question (1)

$q = 10 \sin(4\pi t)$ mC

$v = 2 \cos(4\pi t)$ V

(A) $p = vi$

$= v \cdot \frac{dq}{dt} = [2\cos(4\pi t)] \cdot \frac{d}{dt}[10\sin(4\pi t)]$

$= 2\cos(4\pi t) \cdot 10\cos(4\pi t) \cdot 4\pi$

$p = 80\pi \cdot \cos^2(4\pi t)$

$p\big|_{0.5} = 80\pi \cdot \cos^2\left(\frac{4\pi}{2}\right)$

$$\boxed{p\big|_{0.5} = 80\pi = 251.33 \text{ mW}}$$

(B) $\text{Energy} = \int_0^{0.6} p \cdot dt$

$= \int_0^{0.6} 80\pi \cos^2(4\pi t)$

$= \int_0^{0.6} 40\pi [1 + \cos(8\pi t)] \cdot dt$

$= 40\pi \left[t + \frac{\sin(8\pi t)}{8\pi} \right]_0^{0.6}$

$= 40\pi \left[0.6 + \frac{1}{8\pi} \sin(8\pi \times 0.6) \right]$

$$\boxed{E = 78.34 \text{ mJ}}$$

Question (2)

(A) Nodal Analysis

Node 2:

$$\frac{V_1 - V_2}{2} + 5 = \frac{V_2 - V_3}{2}$$

$$V_1 - V_2 + 10 = V_2 - V_3$$

$$V_1 - 2V_2 + V_3 = -10 \quad \text{——(1)}$$

Super Node:

$$\frac{V_1}{4} + \frac{V_3}{8} + \frac{V_1 - V_2}{2} = \frac{V_2 - V_3}{2}$$

$$2V_1 + V_3 + 4V_1 - 4V_2 = 4V_2 - 4V_3$$

$$4V_1 + 2V_1 - 8V_2 + 5V_3 = 0$$

$$6V_1 - 8V_2 + 5V_3 = 0 \quad \text{——(2)}$$

Mesh:

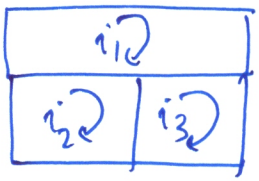
$$V_1 - V_3 = -10$$

$$V_1 - V_3 = -10 \quad \text{——(3)}$$

$V_1 = 10$ V
$V_2 = 20$ V
$V_3 = 20$ V

Question (2)

(B) Mesh Analysis.



Mesh 1: $-10 + 4i_1 - 2i_2 - 2i_3 = 0$.

$$4i_1 - 2i_2 - 2i_3 = 10 \quad \text{—— (1)}$$

Super Mesh: $6i_2 + 10i_3 - 2i_1 - 2i_1 = 0$

$$-4i_1 + 6i_2 + 10i_3 = 0 \quad \text{—— (2)}$$

Node '0': $i_3 = i_2 + 5$

$$i_2 - i_3 = -5 \quad \text{—— (3)}$$

$$i_1 = \frac{5}{2}, \quad i_2 = -\frac{5}{2}, \quad i_3 = \frac{5}{2}$$

$V_1 = -4i_2$

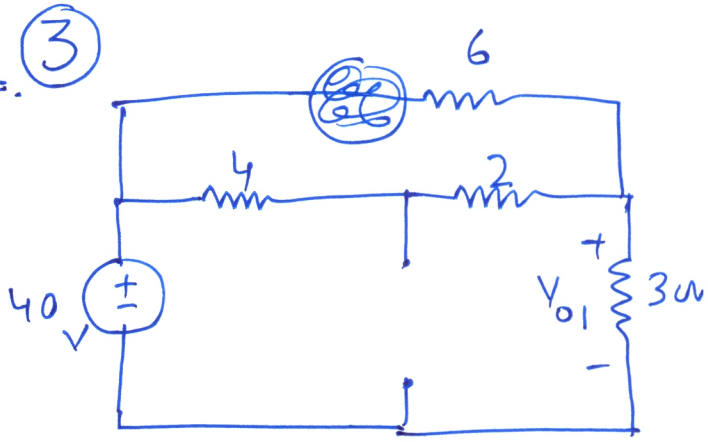
$= -4\left(-\frac{5}{2}\right) \Rightarrow$ $\boxed{V_1 = 10\ V}$

$V_2 = V_1 + 2(i_2 - i_1) = 10 + 2\left(-\frac{5}{2} - \frac{5}{2}\right)$

$= 10 + 10 = 20 \Rightarrow$ $\boxed{V_2 = 20\ V}$

$V_3 = 8(i_3) = 8\left(\frac{5}{2}\right) \Rightarrow$ $\boxed{V_3 = 20\ V}$

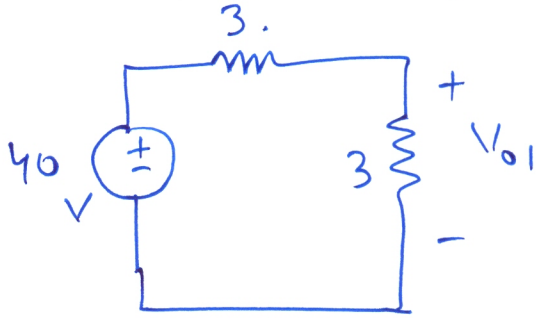
Question (3)



Source 1:

$$V_{01} = \frac{3}{3+3}(40)$$

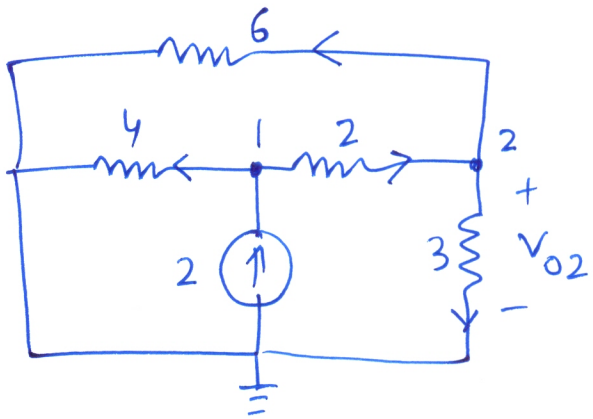
$$\boxed{V_{01} = 20\ V}$$



Source 2:

Nodal:-

Node 1:



$$\frac{V_1 - V_2}{2} + \frac{V_1}{4} = 2$$

$$2V_1 - 2V_2 + V_1 = 8$$

$$3V_1 - 2V_2 = 8 \quad \text{—(1)}$$

Node 2:

$$\frac{V_1 - V_2}{2} = \frac{V_2}{3} + \frac{V_2}{6}$$

$$3V_1 - 3V_2 = 2V_2 + V_2$$

$$3V_1 - 6V_2 = 0 \quad \text{—(2)}$$

Subtracting (1) & (2); $4V_2 = 8$

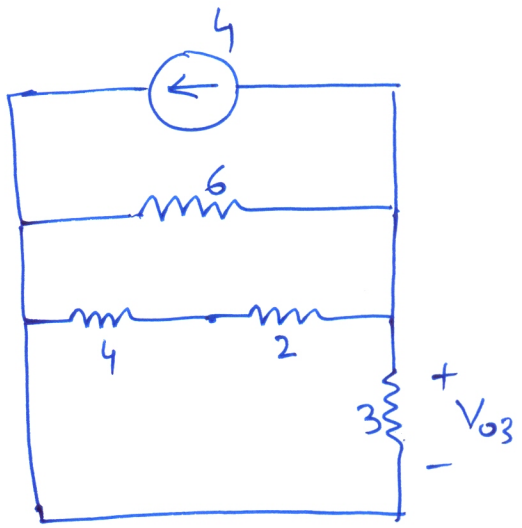
$$V_2 = 2\ V.$$

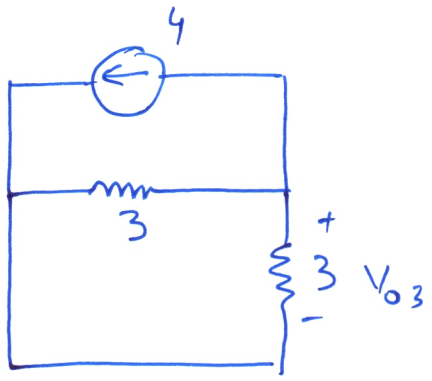
$$\boxed{V_{02} = 2\ V}$$

Source 3

$$V_{o3} = -3\left[\frac{3}{3+3} \times 4\right]$$

$$\boxed{V_{o3} = -6 \text{ V}}$$





$$V_o = V_{o1} + V_{o2} + V_{o3}$$

$$V_o = 20 + 2 - 6$$

$$\boxed{V_o = 16 \text{ V}}$$

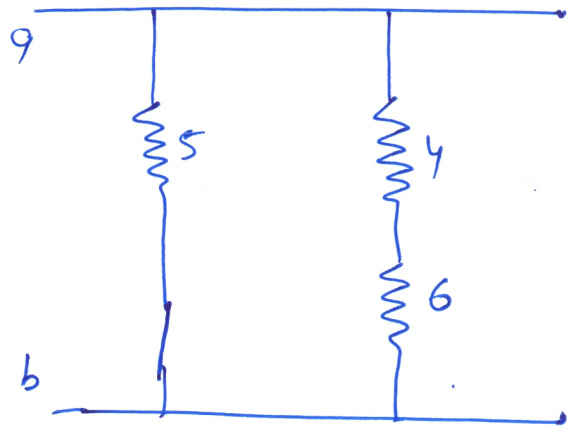
Question (4)

(A) Thevenin Resistance:-

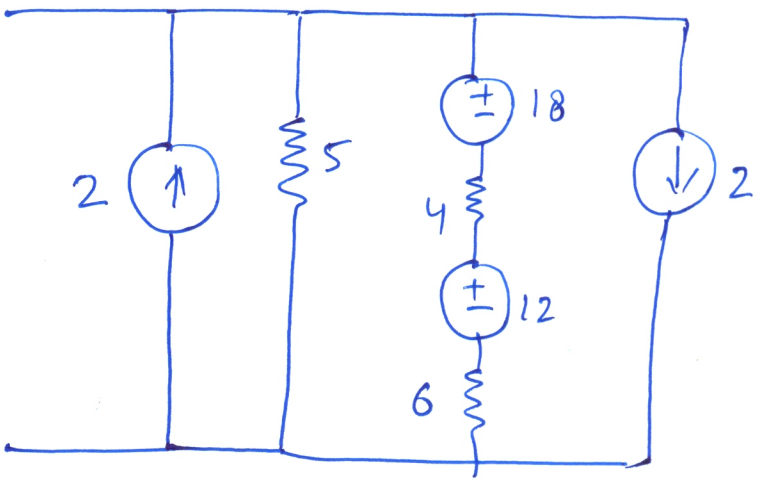
$$R_{th} = \frac{10 \times 5}{10 + 5}$$

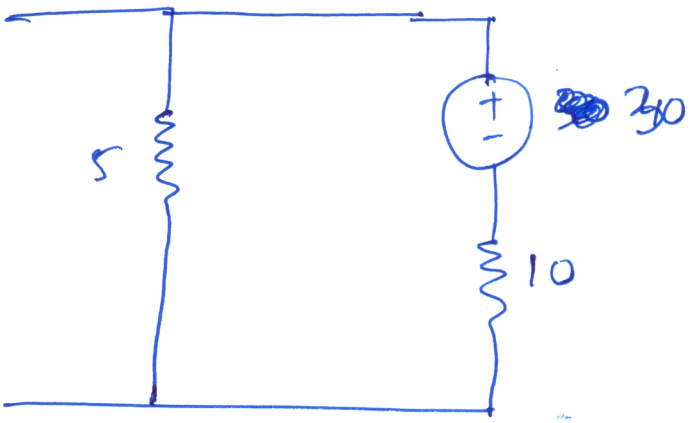
$$= \frac{50}{15}$$

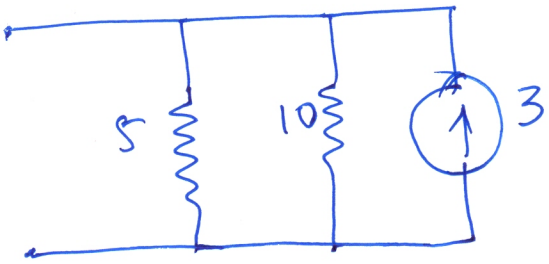
$$\boxed{R_{th} = 10/3 \ \Omega}$$

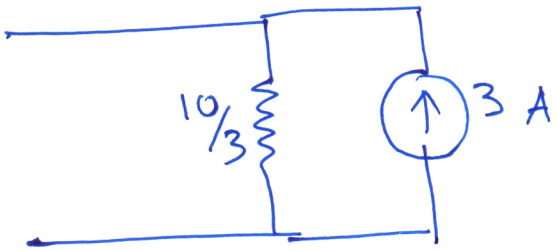


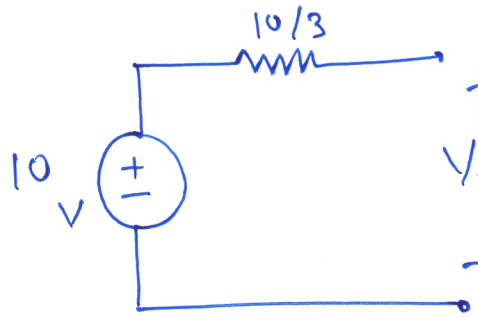
(B)





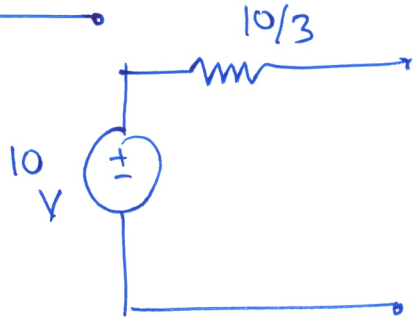




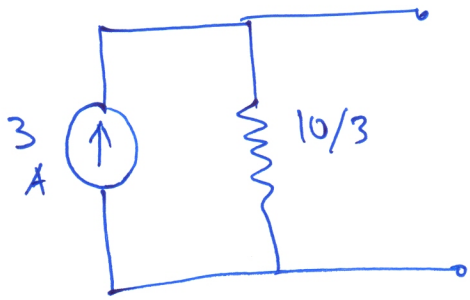


$V_{th} = 10$ V

Thevenin's Equivalent:



(C) Norton's Equivalent.



$I_N = 3$ A

Question (5)

$$-v_{out} = \frac{1}{4}(V_1 + V_2 + V_3 + V_4)$$

$$v_{out} = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3 + \frac{R_f}{R_4}V_4\right]$$

$$-v_{out} = +\frac{R_f}{R_1}(V_1 + V_2 + V_3 + V_4). \quad \text{if } R_1 = R_2 = R_3 = R_4$$

& $R_f = 10\ k\Omega$.

$$\frac{R_f}{R_1} = \frac{1}{4}$$

$$\frac{10\,k}{R_1} = \frac{1}{4}$$

$$\Rightarrow \boxed{R_1 = 40\ k\Omega}.$$