Solutions to Quiz-1 (Group-B) IEC102

Q1. Find V_A in the circuit shown in Fig. Q1

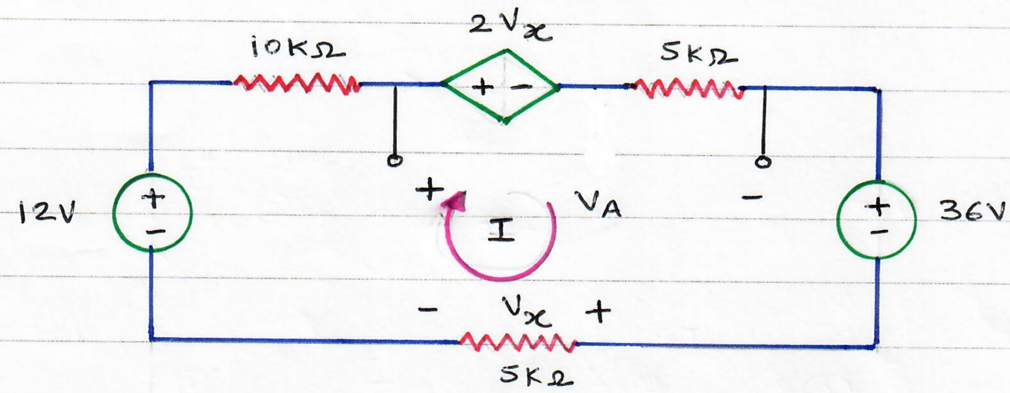


Fig. Q1

Applying KVL around the loop (let I be the loop current)

$$-12 + 10\times10^3 I + 2V_x + 5\times10^3 I + 36 + V_x = 0$$

$$\Rightarrow \quad 24 + 3V_x + 15\times10^3 I = 0 \quad \cdots (A)$$

But $I = \dfrac{V_x}{5\times10^3}$

Substituting the value of I in eq (A)

$$24 + 3V_x + 15\times10^3 \times \frac{V_x}{5\times10^3} = 0$$

$$\Rightarrow \quad 24 + 6V_x = 0 \quad \Rightarrow \quad V_x = -4V$$

$$\therefore \quad I = \frac{V_x}{5\times10^3} = \frac{-4}{5\times10^3} = -0.8\ mA$$

$$V_A = 2V_x + 5\times10^3 I = 2\times-4 + 5\times10^3\times-0.8\times10^{-3}$$

$$= -8 - 4 = -12V$$

$$\boxed{V_A = -12V}$$

Q2 Find v_1, v_2, and v_3 in the circuit of Fig. Q2 using nodal analysis. (Use the concept of super node).

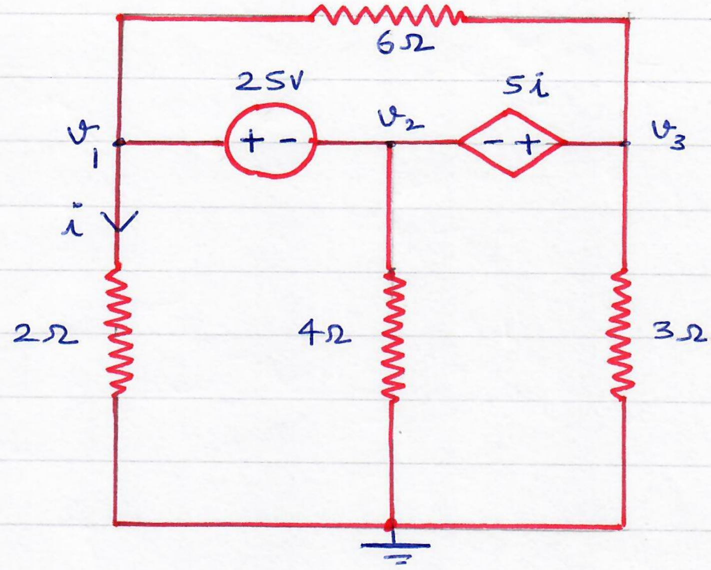
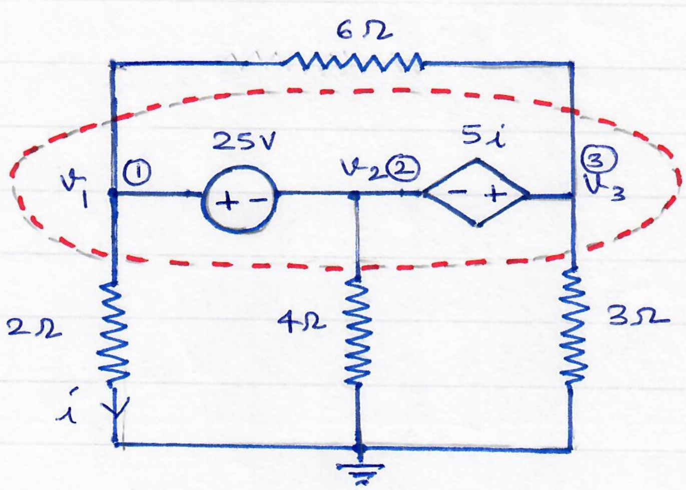


Fig. Q2

Sol.



Considering the combination of node ① - ② - ③ as supernode

Applying KCL at supernode ① - ② - ③

$$\frac{v_1}{2} + \frac{v_2}{4} + \frac{v_3}{3} + \cancel{\frac{v_1 - v_3}{6}} + \cancel{\frac{v_3 - v_1}{6}} = 0$$

$$\Rightarrow \boxed{6v_1 + 3v_2 + 4v_3 = 0} \quad \ldots \text{(A)}$$

$$\boxed{v_1 - v_2 = 25} \quad \cdots \text{ (B)}$$

since there is an independent voltage source in between them

$$v_3 - v_2 = 5i$$

$\because$ there is a dependent voltage source ($5i$) in between them.

but $i = \dfrac{v_1}{2}$

$$\therefore \quad v_3 - v_2 = \frac{5v_1}{2}$$

$$\Rightarrow \boxed{5v_1 + 2v_2 - 2v_3 = 0} \quad \cdots \text{ (C)}$$

Writing eqns (A), (B), and (C) in matrix form

$$\underbrace{\begin{bmatrix} 6 & 3 & 4 \\ 1 & -1 & 0 \\ 5 & 2 & -2 \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}}_{V} = \underbrace{\begin{bmatrix} 0 \\ 25 \\ 0 \end{bmatrix}}_{B}$$

$$V = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = (A^{-1})B$$

$\therefore \quad v_1 = 7.608\text{ V}; \quad v_2 = -17.39\text{ V}; \quad v_3 = 1.6305\text{ V}$

(Q3) Use mesh analysis to find the currents i_1, i_2, and i_3 in the circuit shown in Fig. Q3

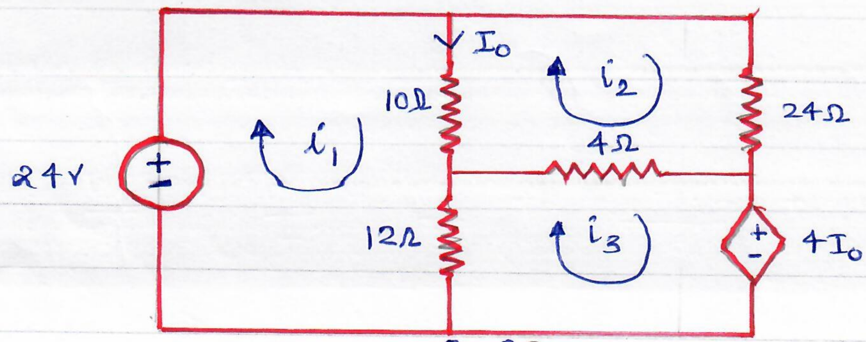


Fig. Q3

Sol. Writing mesh equations around each loop

Loop (1)

$$-24 + 10(i_1 - i_2) + 12(i_1 - i_3) = 0$$

$$\Rightarrow \quad 22i_1 - 10i_2 - 12i_3 = 24$$

$$\Rightarrow \quad \boxed{11i_1 - 5i_2 - 6i_3 = 12} \quad \cdots (A)$$

Loop (2)

$$10(i_2 - i_1) + 24i_2 + 4(i_2 - i_3) = 0$$

$$\Rightarrow \quad -10i_1 + 38i_2 - 4i_3 = 0$$

$$\Rightarrow \quad \boxed{-5i_1 + 19i_2 - 2i_3 = 0} \quad \cdots (B)$$

Loop (3) $\quad 12(i_3 - i_1) + 4(i_3 - i_2) + 4I_o = 0$

but $I_o = i_1 - i_2$

$$\therefore \quad 12(i_3 - i_1) + 4(i_3 - i_2) + 4(i_1 - i_2) = 0$$

$$\Rightarrow \quad -8i_1 - 8i_2 + 16i_3 = 0$$

$$\Rightarrow \quad \boxed{-i_1 - i_2 + 2i_3 = 0} \quad \cdots (C)$$

Solving (A), (B), and (C)

$i_1 = 2.25$ A

(Q4) Use superposition to find v_x in the circuit shown in Fig. Q4

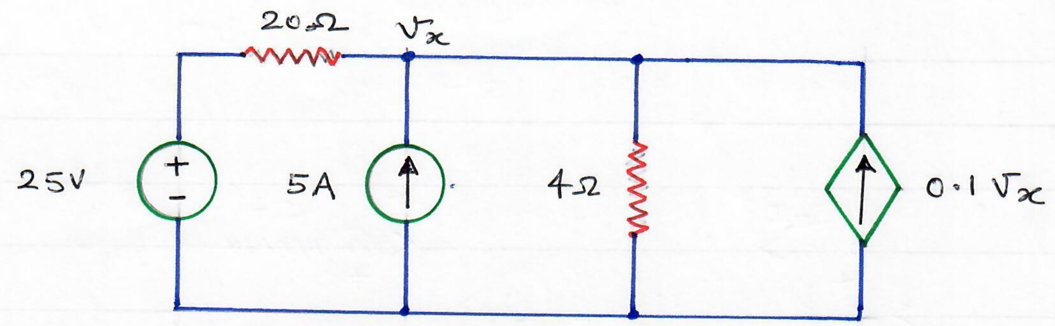


Fig. Q4

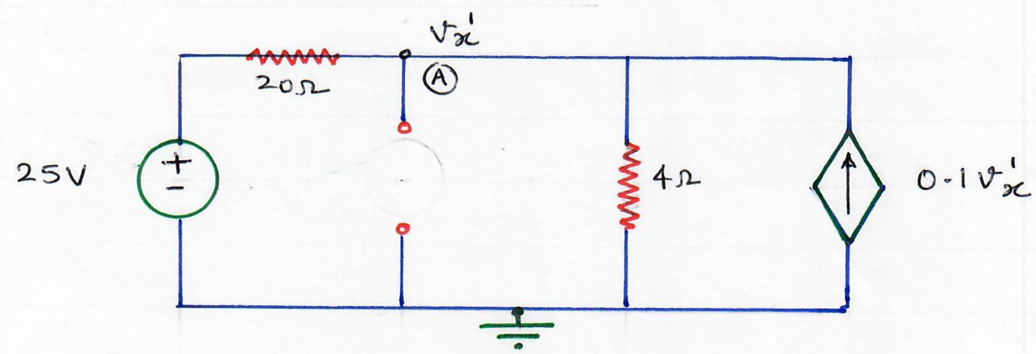
Sol.

Taking bottom node as reference node

Let v_x' be the voltage due to 25V voltage source acting alone and v_x'' be the voltage due to 5A current source acting alone

Then using superposition principle $v_x = v_x' + v_x''$

v_x' (due to 25V voltage source)



Applying KCL at node A

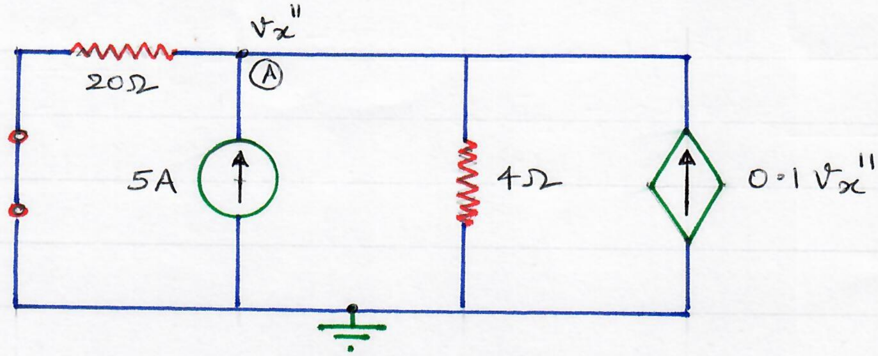
$$\frac{v_x' - 25}{20} + \frac{v_x'}{4} - 0.1v_x' = 0$$

$$\Rightarrow (0.05 + 0.25 - 0.1)\,v_x' = 1.25$$

$$\Rightarrow 0.2\,v_x' = 1.25$$

$$\Rightarrow v_x' = 6.25\text{V}$$

v_x'' (due to 5A current source)



Applying KCL at node A

$$\frac{v_x''}{20} - 5 + \frac{v_x''}{4} - 0.1\,v_x'' = 0$$

$$\Rightarrow (0.05 + 0.25 - 0.1)\,v_x'' = 5$$

$$\Rightarrow 0.2\,v_x'' = 5$$

$$\Rightarrow v_x'' = 25$$

When both the sources are active, the voltage v_x at node A is

$$v_x = v_x' + v_x''$$

$$= 6.25 + 25$$

$$\Rightarrow v_x = 31.25\ \text{V}$$