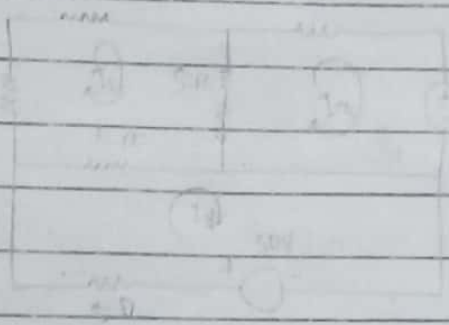
Assignment (EDC)

Solving circuits using mesh and nodal analysis

1 Find $V_s$ in figure 1, so that current in 10Ω resistor could be i) 5A ii) 0A



Soln

Using mesh analysis

In mesh 1,

$$50 - 5I_1 - 5(I_1 - I_2) = 0$$

$$\text{or, } 50 - 10I_1 + 5I_2 = 0$$

$$\text{or, } 5 - 2I_1 + I_2 = 0 \quad \text{---(I)}$$

In mesh 2,

$$5(I_2 - I_1) + 10I_2 + 5(I_2 - I_3) = 0$$

$$\text{or, } 20I_2 - 5I_1 - 5I_3 = 0$$

$$\text{or, } 4I_2 - I_1 - I_3 = 0 \quad \text{---(II)}$$

In mesh 3,

$$V_s - (-10I_3) + 5(I_3 - I_2) = 0$$

$$\text{or, } V_s + 15I_3 - 5I_2 = 0 \quad \text{---(III)}$$

When current is 5A in 10Ω resistor

Solving (I) and (II) and putting $I_3 = 5A$, and solving (III)

$$I_1 = -3.57A \quad I_2 = -2.14A$$

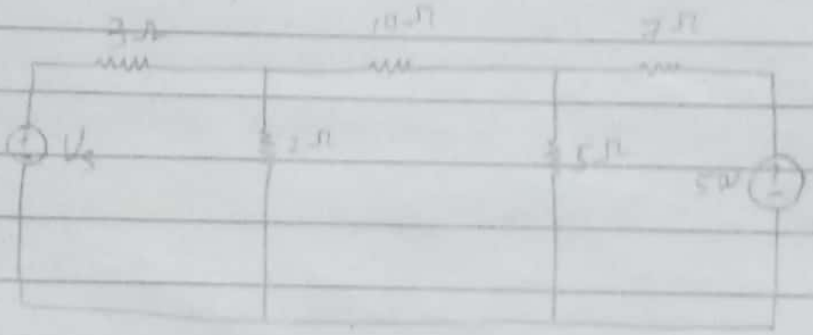
$$\therefore V_s = 64.3V$$

When current in 10Ω resistor is 0A.

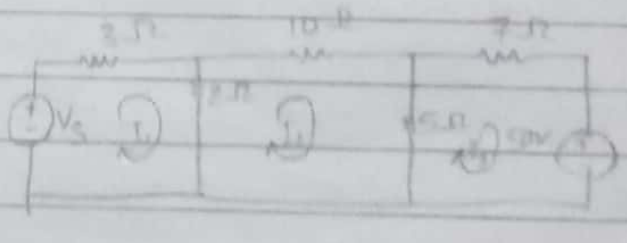
$$I_1 = \frac{20}{7} A = 2.85A \qquad V_s = 3.57V$$

$$I_2 = \frac{-5}{7} A = -0.714A$$

2. Find $V_s$ in figure 2, so that current in 10Ω is zero amperes using i) Mesh analysis ii) Nodal analysis.



Sol$^n$: i) Using mesh analysis



In mesh 1,

$V_s - 3I_1 - 2(I_1 - I_2) = 0$

or, $V_s - 5I_1 + 2I_2 = 0$ —(i)

In mesh 2,

$-2(I_2 - I_1) - 10I_2 - 5(I_2 - I_3) = 0$

or, $17I_2 - 2I_1 - 5I_3 = 0$ [$\because I_2 = 0A$]

or, $17I_2^{0} - 2I_1 = 5I_3$ $\therefore 2I_1 = -5I_3$ —(ii)

In mesh 3,

$-5(I_3 - I_2) - 7I_3 - 50 = 0 \quad [\because I_2 = 0]$

$12I_3 + 5I_2 + 50 = 0$

$I_3 = \frac{50}{12} A = 4.16A$

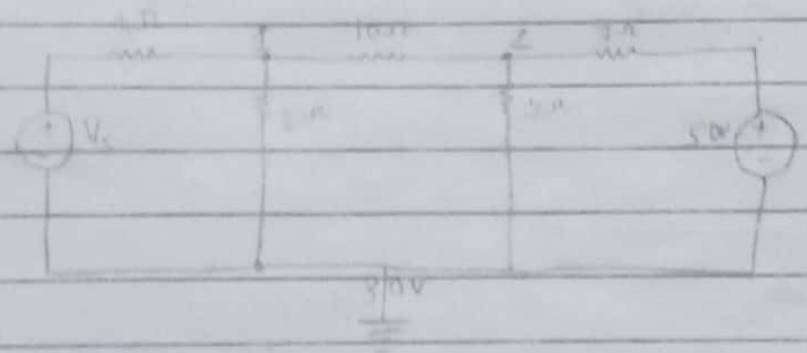
$I_1 = -10.41A$

Now, In eqn (i)

$V_s - 5(-10.41) + 2 \times 0 = 0$

$V_s = 52.05V$

Using nodal analysis




At node 1,

$\frac{V_1 - V_3 - V_s}{3} + \frac{V_1 - V_2}{10} + \frac{V_1 - V_3}{2} = 0$

$\frac{V_1}{3} + \frac{V_2}{2} - \frac{V_s}{3} = 0$

At node 2,

$$\frac{V_2 - V_3 - 50}{7} + \frac{V_2 - V_3}{5} + \frac{V_2 - V_1}{10} = 0$$

$$\frac{V_2}{7} + \frac{V_2}{5} = \frac{50}{7}$$

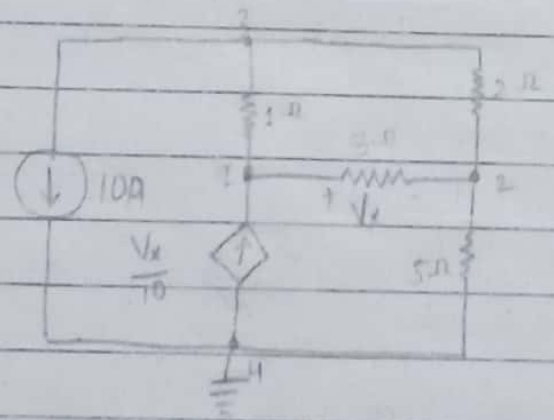
$$\text{or, } \frac{12}{35} V_2 = \frac{50}{7}$$

$$\text{or, } V_2 = 20.83\text{V} \qquad V_1 = 20.83\text{V}$$

Putting $V_1$ and $V_2$ in eqn ① we get,

$V_s = 50.08\text{ V}$

3. In the network shown in figure 3, find the current in each resistor using Nodal analysis




At node 1, $\frac{V_x}{10} + \frac{V_1 - V_3}{1} + 10 = 0$

$$\text{or, } \frac{V_x}{10} + V_1 - V_3 + 10 = 0$$

At node 2, $\frac{V_2 - V_3}{2} + \frac{V_2}{5} + \frac{V_2 - V_1}{3} = 0$

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or, $\frac{V_1 - V_x - V_3}{2} + \frac{V_2}{5} - \frac{V_x}{3} = 0$

or, $\frac{V_1 - V_x - V_3}{2} + \frac{V_1 - V_x}{5} - \frac{V_x}{3} = 0$

or, $\frac{7}{10} V_1 - \frac{31}{30} V_x - \frac{V_3}{2} = 0$ — (iii)

Solving (i) (ii) and (iii)

$V_1 = 183.33V$, $V_3 = 177.19V$, $V_x = 38.46V$,

$V_2 = V_1 - V_x$

$= 183.33 - 38.46$

$= 144.87V$

In 1Ω resistor,

$I_1 = 6.14A$

In 2Ω resistor,

$I_2 = \frac{144.87 - 177.19}{2}$

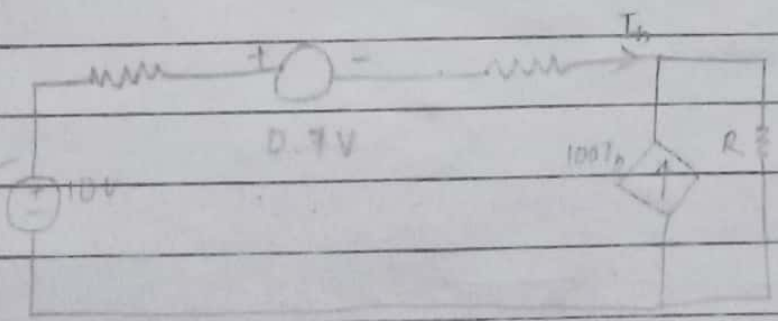
$= 16.16A$

In 3Ω resistor,

$I_3 = \frac{38.46}{3} = 12.82A$

In 5Ω resistor, $I_5 = \frac{144.87}{5} = 28.94A$

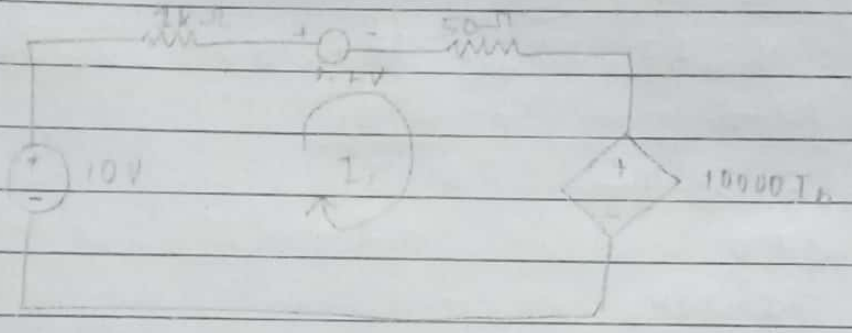
4.



Use mesh analysis to find voltage across (R) in figure 4, when i) $R = 100\,\Omega$ ii) $R = 2\,\Omega$

Soln i) When $R = 100\,\Omega$,

converting current source into voltage source,




Using mesh analysis,

$$10 - 1000I_b - 0.7 - 50I_b - 10000I_b = 0$$

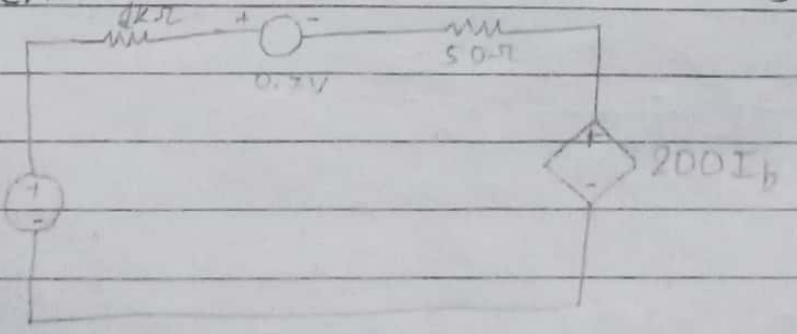
$$\text{or, } I_b = 8.34 \times 10^{-4}\,A$$

$$V_R = 100I_b \times R$$

$$= 8.34 \times 10^{-4} \times 100$$

$$= 0.083\,V$$

ii) When $R = 2\,\Omega$, the ckt becomes



Now,

$$10 - 1000 I_b - 0.7 - 50 I_b - 200 I_b = 0$$

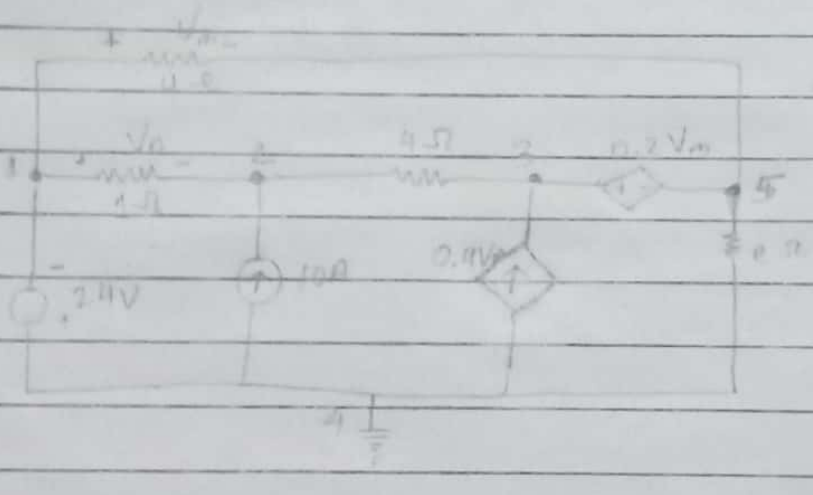
$$I_b = 7.44 \times 10^{-3} \text{ A}$$

$$V = 200 I_b \times R$$

$$= 200 \times 7.44 \times 10^{-3} \times 2$$

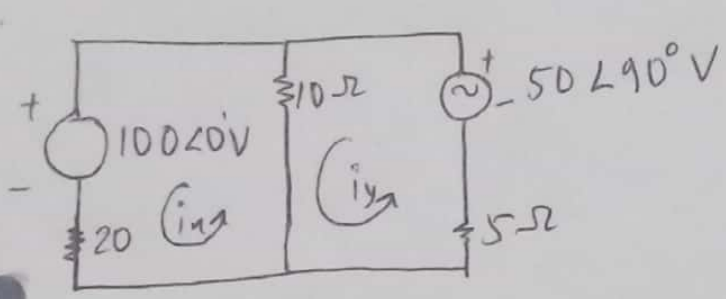
$$= 2.976 \text{ V}$$

5. Determine the current through each resistor of the circuit shown in figure 5 using Nodal analysis.



Sol$^n$:

7.




In mesh 1,

$$-100 - 20i_x - 10(i_x - i_y) = 0$$

$$\text{or, } 10 + 3i_x - i_y = 0 \quad \text{---(I)}$$

In mesh 2,

$$50i - 10(i_y - i_x) - 5i_y = 0$$

$$\text{or, } 50i - 15i_y + 10i_x = 0 \quad \text{---(II)}$$

Using Cramer's rule,

| component of $i_x$ | | $i_y$ | | constant |
|---|---|---|---|---|
| 3 | | -1 | | 10 |
| 10 | | -15 | | 50i |

$$D_x = \begin{vmatrix} 10 & -1 \\ 50i & -15 \end{vmatrix} = -150 + 50i$$

$$D_y = \begin{vmatrix} 3 & 10 \\ 10 & 50i \end{vmatrix} = 150i - 100$$

$$D = \begin{vmatrix} 3 & -1 \\ 10 & -15 \end{vmatrix} = -35$$

$$i_x = \frac{D_x}{D} = \frac{-150 + 50i}{-35} = \frac{30}{7} - \frac{10}{7}i$$

$$i_y = \frac{D_y}{D} = \frac{150i - 100}{-35} = \frac{20}{7} - \frac{30}{7}i$$

9. is mesh analysis.

In mesh 1,

$$5(i_1 - i_3) - 10j + 10(i_1 - i_2) = 0$$

$$\text{or, } 15i_1 - 10i_2 - 5i_3 - 10j = 0 \quad \text{—(i)}$$

In mesh 2,

$$5j - 10\angle 30^\circ + 8(i_2 - i_3) + 10(i_2 - i_1) = 0$$

$$\text{or, } 5j - 5\sqrt{3} - 5j + 18i_2 + 10i_1 - 8i_3 = 0$$

$$\text{or, } 10i_1 + 18i_2 - 8i_3 - 5\sqrt{3} = 0 \quad \text{—(ii)}$$

In mesh 3,

$$4j \cdot i_3 + 3i_3 - 20 + 5(i_3 - i_1) + 8(i_3 - i_2) = 0$$

$$\text{or, } 4j \cdot i_3 + 3i_3 - 20 + 13i_3 - 5i_1 - 8i_2 = 0$$

$$\text{or, } 4j \cdot i_3 + 16i_3 - 5i_1 - 8i_2 - 20 = 0$$

$$\text{or, } 5i_1 + 8i_2 + (16 + 4j)i_3 - 20 = 0 \quad \text{—(iii)}$$

Using Cramer's Rule,

| x | y | z | constant |
|---|---|---|---|
| 15 | -10 | -5 | -10j |
| 10 | 18 | -8 | $-5\sqrt{3}$ |
| 5 | 8 | 16+4j | -20 |

$$D = \begin{vmatrix} 15 & -10 & -5 \\ 10 & 18 & -8 \\ 5 & 8 & 16+4j \end{vmatrix} = 7330 + 1480j$$

$$D_x = \begin{vmatrix} -10j & -10 & -5 \\ -5\sqrt{3} & 18 & -8 \\ -20 & 8 & 16+4j \end{vmatrix} = -519.23 - 3866.41j$$

$$D_y = \begin{vmatrix} 15 & -10j & -5 \\ 10 & -5\sqrt{3} & -8 \\ 5 & -20 & 16+4j \end{vmatrix} = -4094.97 + 1480.39j$$

$$D_z = \begin{vmatrix} 15 & -10 & -10j \\ 10 & 18 & -5\sqrt{3} \\ 5 & 8 & -20 \end{vmatrix} = -5927.74 + 100j$$

$$i_1 = -0.17 - 0.493j$$

$$i_2 = -0.23 - 1.09j$$

$$i_3 = -0.77 + 0.19j$$