

Node 1

$$i_1 - i_2 + i_3 - i_4 = 0$$

$$\frac{v_1}{10} + \frac{v_1}{5} + 12 + \frac{v_1 - v_2}{2} = 0$$

$$\frac{v_1 + 2v_1 + 120 + 5v_1 - 5v_2}{10} = 0$$

$$\frac{8v_1 - 5v_2 + 120}{10} = 0$$

$$8v_1 - 5v_2 + 120 = 0$$

$$8v_1 - 5v_2 = -120 \quad \text{--- (1)}$$

Node 2

$$i_3 + 2i_5 + i_6 = i_7 \quad (i_7 + i_6)$$

$$\frac{v_1 - v_2}{2} + 12 + 6 = \frac{v_2}{4}$$

$$\frac{v_1 - v_2 + 24 + 12}{2} = \frac{v_2}{4}$$

$$\frac{v_1 - v_2 + 36}{2} = \frac{v_2}{4}$$

$$4v_1 - 4v_2 + 144 = 2v_2$$

$$4v_1 - 6v_2 = -144 \quad \text{--- (2)}$$

$$8v_1 - 5v_2 = -120 \quad \text{--- (1) } \times 6$$

$$4v_1 - 6v_2 = -144 \quad \text{--- (2) } \times 5$$

$$48v_1 - 30v_2 = -720$$

$$20v_1 - 30v_2 = -720$$

$$48V_1 - 20V_2 = 0$$

$$28V_1 = 0$$

$$V_1 = 0$$

In eqn 1

$$8V_1 - 5V_2 = -120$$

sub $V_1 = 0$ into eq. (1)

$$8(0) = -$$

$$8(0) - 5V_2 = -120$$

$$\frac{-5V_2}{-5} = \frac{-120}{-5}$$

$$V_2 = 24$$

$$V_1 = 0, \quad V_2 = 24$$

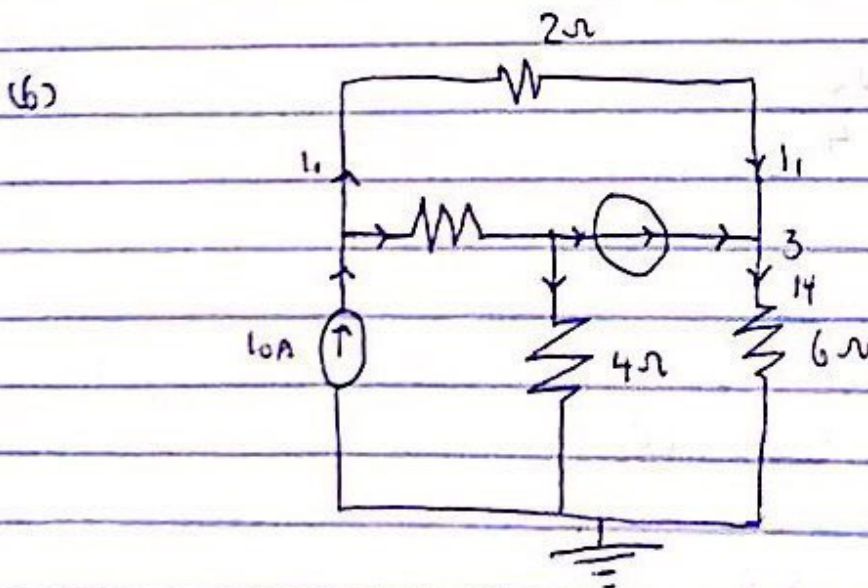
Current flowing through resistors

$$10\Omega: \frac{V_1}{10} = \frac{0}{10} = 0A$$

$$5\Omega: \frac{V_1}{5} = \frac{0}{5} = 0A$$

$$2\Omega: \frac{V_1 - V_2}{2} = \frac{0 - 24}{2} = -12A$$

$$4\Omega: \frac{V_2}{4} = \frac{24}{4} = 6A$$



Node 1 $10 = I_1 + I_2$

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

$$10 = \frac{3V_1 - 3V_3 + 2V_1 - 2V_2}{6}$$

$$60 = 5V_1 - 2V_2 - 3V_3 \quad \text{--- (i)}$$

Node 2 $64 + I_3 = I_2$

$$\frac{64}{1} + \frac{V_2}{4} = \frac{V_1 - V_2}{3}$$

$$\frac{256 + V_2}{4} = \frac{V_1 - V_2}{3}$$

$$768 + 3V_2 = 4V_1 - 4V_2$$

$$768 = 4V_1 - 7V_2 \quad \text{--- (ii)}$$

Node 3 $64 + I_1 = I_4$

$$64 + \frac{V_1 - V_3}{2} = \frac{V_3}{6}$$

$$2 \times \frac{128 + V_1 - V_3}{2} = \frac{V_3}{3}$$

$$384 + 3V_1 - 3V_3 = V_3$$

$$3V_1 - 4V_3 = -384 \quad \text{--- (iii)}$$

Using Cramer's rule

$$5V_1 - 2V_2 - 3V_3 = 60$$

$$4V_1 - 7V_2 + 0 = 768$$

$$3V_1 + 0 - 4V_3 = -384$$

$$\begin{bmatrix} 5 & -2 & -3 \\ 4 & -7 & 0 \\ 3 & 0 & -4 \end{bmatrix}$$

$$\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 60 \\ 768 \\ -384 \end{bmatrix}$$

$$V_1 = \frac{\Delta_1}{\Delta}$$

$$V_2 = \frac{\Delta_2}{\Delta}$$

$$V_3 = \frac{\Delta_3}{\Delta}$$

$$\Delta = (+140 + 0 + 0) - (32 + 0 + 63)$$

$$+140 - (+95)$$

$$= +140 - 95$$

$$\Delta = 45$$

$$\Delta_1 = (1690 + 0 + 0) - (6144 + 0 - 9064)$$

$$= 1690 - (-1920)$$

$$\Delta_1 = 3600$$

$$\Delta_2 = (-15360 + 0 + 4608) - (-960 + 0 - 6912 - 10752 - (-7872) - 10752)$$

$$+ 7872$$

$$\Delta_2 = -2880$$

$$\Delta_3 = (13440 - 4608 + 0) - (3072 + 0 - 1260)$$

$$8832 - (1812)$$

$$\Delta_3 = 7020$$

$$V_1 = \frac{\Delta_1}{\Delta} = \frac{3600}{45} = 450 //$$

$$V_2 = \frac{\Delta_2}{\Delta} = \frac{-2880}{45} = -640 //$$

$$V_3 = \frac{\Delta_3}{\Delta} = \frac{7020}{45} = 1560 //$$