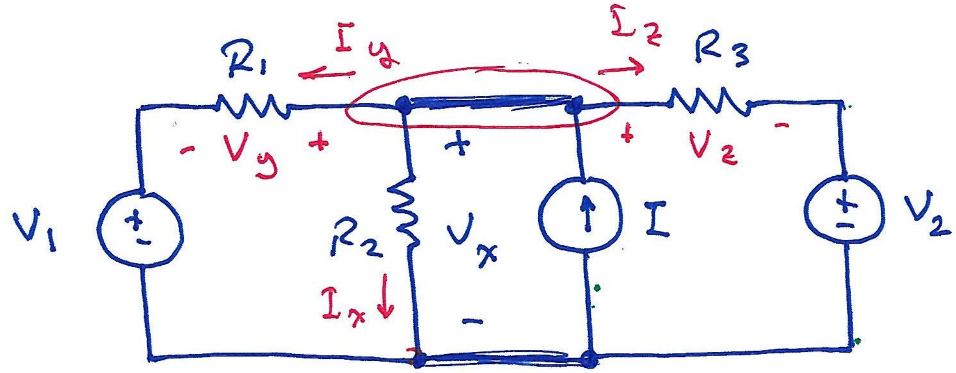
1



$V_x = ?$

$$V_y - V_x = -V_1 \Rightarrow V_x = V_y + V_1$$

$$V_z + V_2 = V_x$$

$$V_z + V_2 = V_y + V_1$$

$$I_y + I_z + I_x = I$$

$$\Downarrow$$

$$V_x = A V_1 + B V_2 + C I$$

properties of the circuit

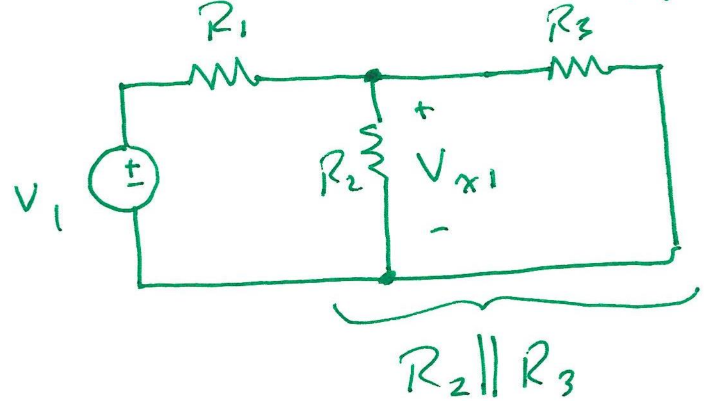
$$V_x = A V_1 + B V_2 + C I$$

Turn off V_2 and I

i.e., $V_2 = 0$, $I = 0$

Then $V_{x1} = A V_1$

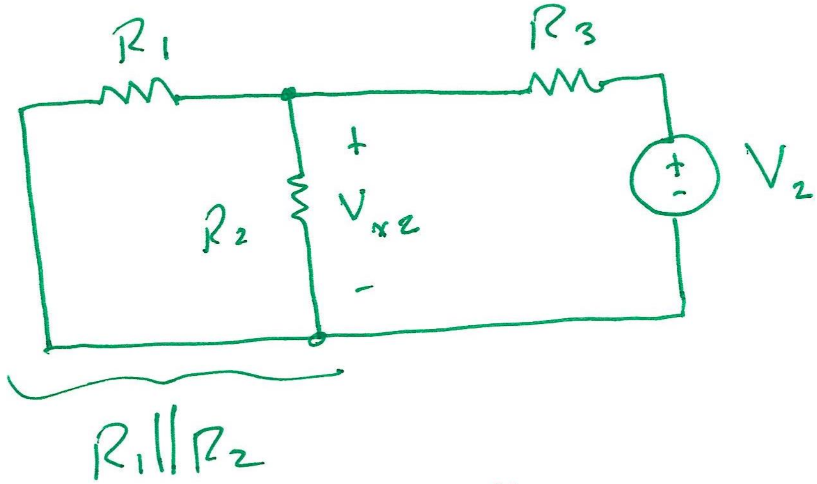
and $A = \frac{V_x}{V_1}$



$$V_{x1} = \underbrace{\frac{R_2 \| R_3}{R_1 + (R_2 \| R_3)}}_{A} V_1$$

To determine B:

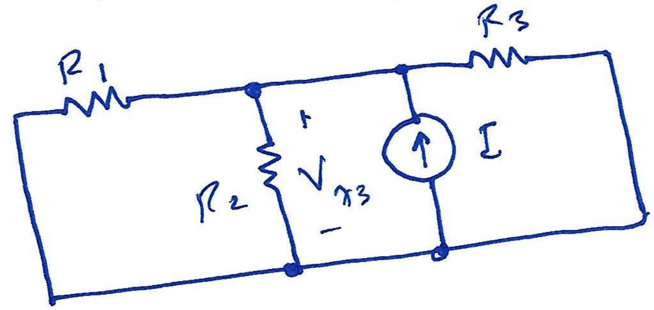
Turn off V_1 and I.



$$V_{x2} = \underbrace{\frac{R_1 \| R_2}{R_3 + (R_1 \| R_2)}}_{B} \cdot V_2$$

To determine C:

Turn off V_1 and V_2.

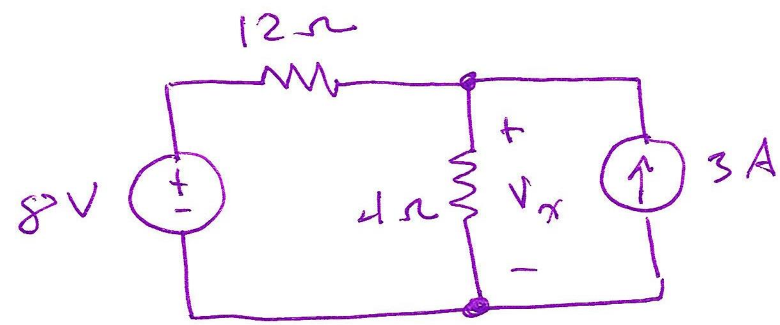


$$V_{x3} = \underbrace{(R_1 \| R_2 \| R_3)}_{C} I$$

Then $V_x = V_{x1} + V_{x2} + V_{x3}$

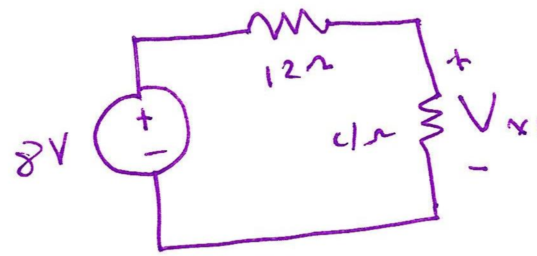
$$= \underbrace{\frac{R_2 \| R_3}{R_1 + (R_2 \| R_3)}}_{A} \cdot V_1 + \underbrace{\frac{R_3 \| R_2}{R_3 + (R_1 \| R_2)}}_{B} \cdot V_2$$

$$+ \underbrace{(R_1 \| R_2 \| R_3)}_{C} \cdot I$$



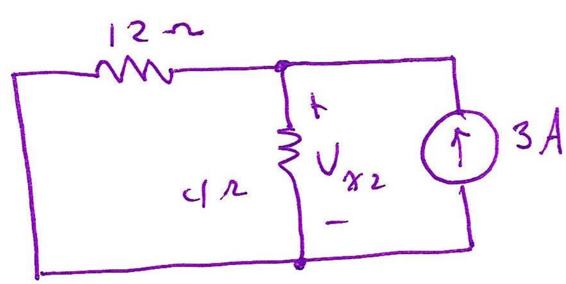
Using the superposition method,

① Solve for V_{x1}



$$V_{x1} = \frac{4}{12+4} \cdot 8V = 2V$$

② Solve for V_{x2}:

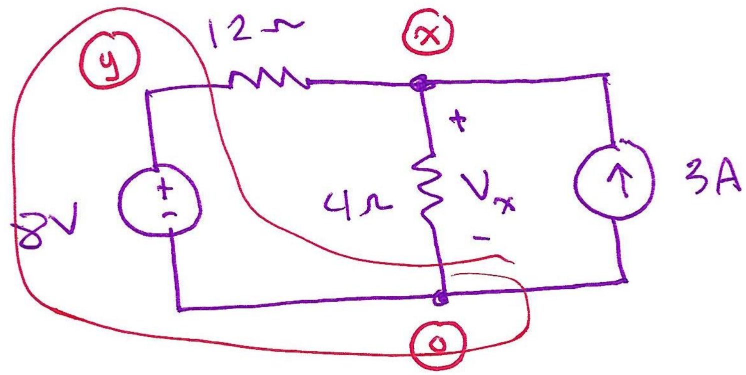


equivalent of $12\Omega \| 4\Omega$

$$V_{x2} = (3\Omega)(3A) = 9V$$

③

$$V_x = V_{x1} + V_{x2} = 2V + 9V = 11V$$



Alternate solution:

Nodal Analysis

$V_y = 8\,V$ (constraint)

$$\frac{V_x - V_y}{12\,\Omega} + \frac{V_x}{4\,\Omega} - 3A = 0$$ (KCL at node x)

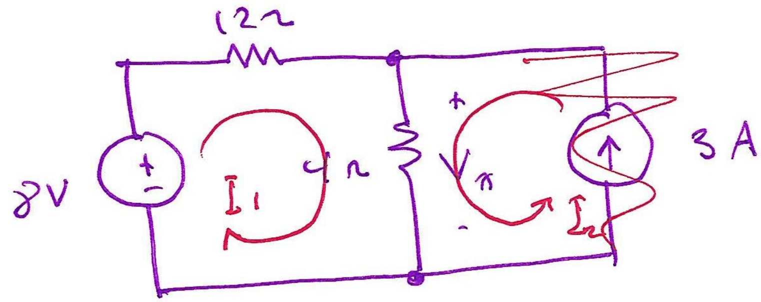
$$\frac{V_x - 8}{12} + \frac{V_x}{4} - 3 = 0$$

$$V_x - 8 + 3V_x - 36 = 0$$

$$4V_x = 44$$

$$V_x = 11\,V$$

Mesh Analysis:



$V_x = 4\Omega(I_1 + I_2)$

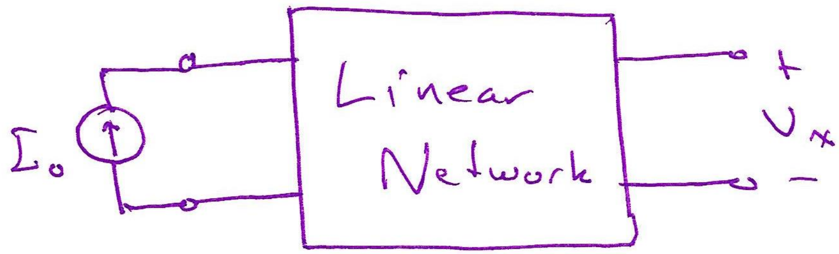
$I_2 = 3A$ (constraint)

$-8V + 12\Omega I_1 + 4\Omega(I_1 + I_2) = 0$ (KVL)

$16 I_1 + 4 = 0$

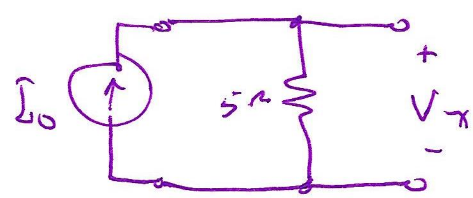
$I_1 = -\frac{1}{4} A$

$V_x = 4\left(-\frac{1}{4} + 3\right) = \frac{11}{4} \cdot 4 = 11V$

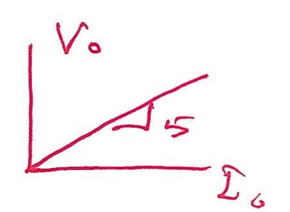


A linear network is made up of any combination of R, VCCS, VCVS, CCVS, CCCS.

When the input is I_o, the output is $V_x = 5 I_o$.

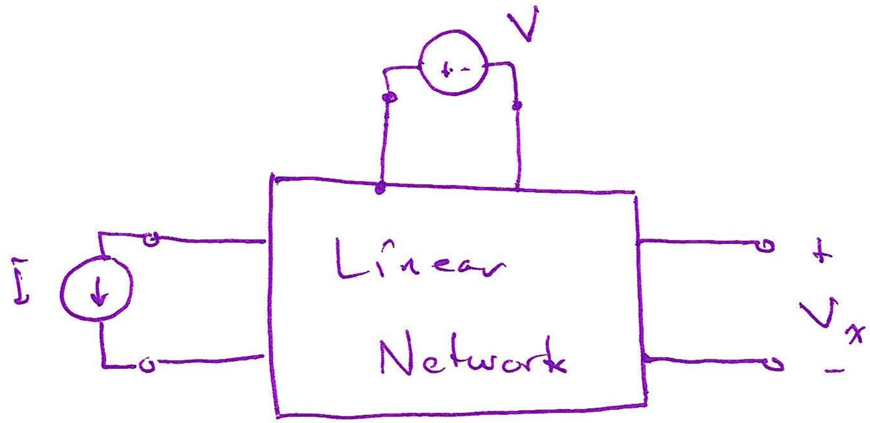


$V_x = 5 I_o$



What is the output when $I_o = 2A$? 10V

What is the output when $I_o = 3A$? 15V



If $V = 3V$ and $I = 2A$, $V_x = 7V$

If $V = 4V$ and $I = 3A$, $V_x = 10V$

What will V_x be when $V = 2V$ and $I = 5A$?

$$V_x = A V + B I$$

$$7 = A 3 + B 2$$

$$10 = A 4 + B 3$$

$$3A + 2B = 7$$
$$4A + 3B = 10$$

$$\begin{bmatrix} 3 & 2 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} A \\ B \end{bmatrix} = \begin{bmatrix} 7 \\ 10 \end{bmatrix}$$

Using Cramer's Rule:

$$A = \frac{\begin{vmatrix} 7 & 2 \\ 10 & 3 \end{vmatrix}}{\begin{vmatrix} 3 & 2 \\ 4 & 3 \end{vmatrix}} = \frac{21 - 20}{9 - 8} = \frac{1}{1} = 1$$

$$B = \frac{\begin{vmatrix} 3 & 7 \\ 4 & 10 \end{vmatrix}}{\begin{vmatrix} 3 & 2 \\ 4 & 3 \end{vmatrix}} = \frac{30 - 28}{1} = 2$$

$$V_x = 1 \cdot V + 2 \cdot I$$

So, when $V = 2V$ and $I = 5A$,

$$V_x = 1(2V) + 2(5A)$$

$$= 2 + 10$$

$$= 12V$$