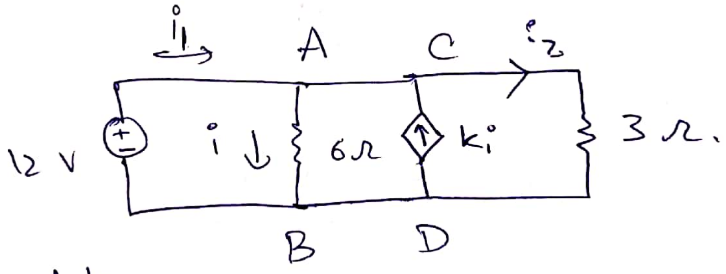
Tutorial 5

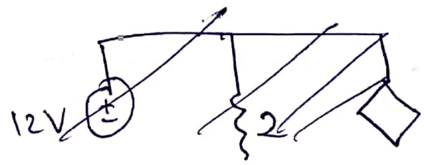
Ans 1.

Find i_1.

a) $k = 2$



Solving for general k,



$$i = \frac{12}{6} = 2\,A.$$

$$i_2 = \frac{12}{3} = 4\,A$$

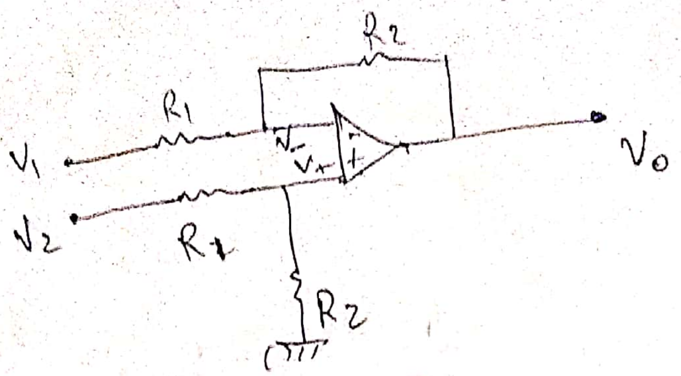
Applying KCL at node (A) / (C)

$$i_1 = i - ki + i_2$$

$$i_1 = 2 - 2k + 4 = 6 - 2k$$

k	i_1
2	2 A
3	0 A
4	-2 A

Ans 2.



$R_1 = 100\,k\Omega$

$R_2 = 900\,k\Omega$.

(Potential divider)

$$V_+ = \frac{V_2 R_2}{R_1 + R_2} \qquad V_- = \frac{V_o R_1 + V_1 R_2}{R_1 + R_2}$$

for an Ideal opamp, $V_+ = V_- \Rightarrow \frac{V_2 R_2}{R_1+R_2} = \frac{V_o R_1 + V_1 R_2}{R_1+R_2}$

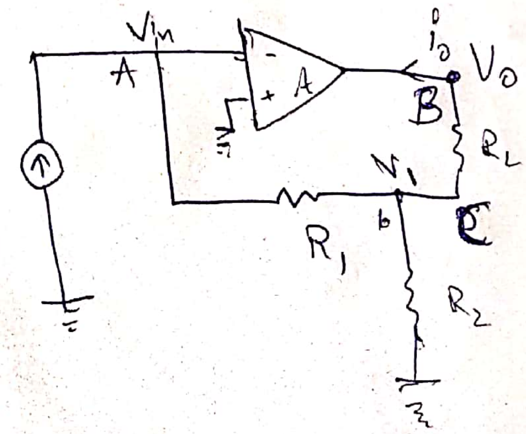
$$\Rightarrow \quad V_2 R_2 - V_1 R_2 = V_o R_1$$

$$\Rightarrow \quad V_o = \frac{(V_2 - V_1) R_2}{R_1}$$

It's a differential amplifier.

Ans 3.

a) $A_F = \frac{i_o}{i_{in}} = \frac{A R_1 + (1+A) R_2}{R_L + (1+A) R_2}$



For an non-ideal opamp,

$$V_o = A(V_+ - V_-)$$

$$V_1 = \frac{\frac{V_{in}}{R_1} + \frac{V_o}{R_L}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_L}}$$ {Using potential divider rule}

$$i_o = \frac{V_o - V_1}{R_L} = \frac{-AV_{in} - V_1}{R_L}$$

$$i_o = \frac{-AV_{in} - \frac{\left(\frac{V_{in}}{R_1} + \frac{(-AV_{in})}{R_L}\right)}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_L}}}{R_L}$$

In Branch AC,

$$i_{in} = \frac{V_{in} - V_1}{R_1} = \frac{V_{in} - \frac{\left(\frac{V_{in}}{R_1} + \frac{(-AV_{in})}{R_L}\right)}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_L}}}{R_1}$$

$$i_{in} = \frac{\frac{V_{in}}{R_2} + \frac{V_{in}}{R_L} + \frac{AV_{in}}{R_L}}{\frac{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_L}}{R_1}} = \frac{[R_L + (1+A)R_2]V_{in}}{(R_1+R_2)R_L + R_1 R_2}$$

$$\Rightarrow \boxed{\frac{V_{in}}{i_{in}} = \frac{(R_1+R_2)R_L + R_1 R_2}{R_L + (1+A)R_2}} \quad \text{--- (1)}$$

Now, in Branch CB,

$$i_o = \frac{-V_0 + V_1}{R_L} = \frac{+AV_i + \left(\frac{\frac{V_{in}}{R_1} + \left(-\frac{AV_{in}}{R_L}\right)}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_L}}\right)}{R_L}$$

$$\frac{i_o}{v_i} = \frac{+A\left(\frac{1}{R_1} + \frac{1}{R_2}\right) + \frac{1}{R_1}}{\left[\frac{R_1R_2 + (R_1+R_2)R_L}{R_1 R_2 \cancel{R_L}}\right] \times \cancel{R_L}}$$

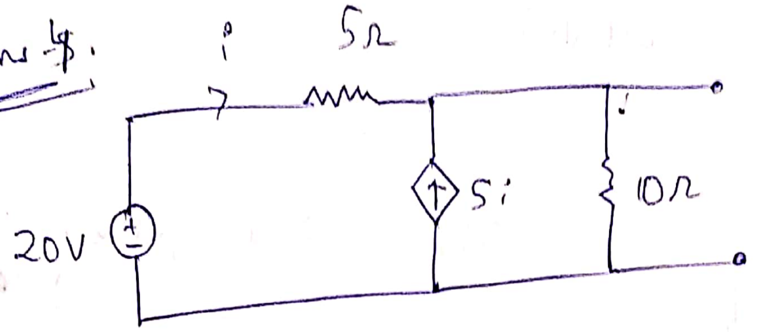
$$\frac{i_o}{v_i} = \frac{+[A(R_1+R_2) + R_2]}{R_1R_2 + (R_1+R_2)R_L} \quad \text{--- (2)}$$

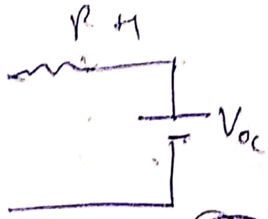
Mul (1) & (2)

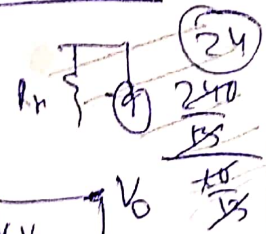
$$\Rightarrow \frac{i_o}{i_{in}} = \frac{[A(R_1+R_2) + R_2]}{R_L + (1+A)R_2}$$

$$\boxed{\frac{i_o}{i_{in}} = \frac{AR_1 + (1+A)R_2}{R_L + (1+A)R_2}}$$

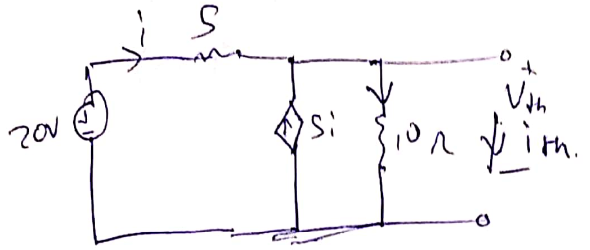
Ans 4.







i) Thevenin's equivalent :)



$$6i = \frac{V_{th}}{10}$$

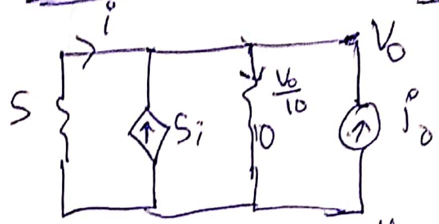
$$20 - 5i - 6i \times 10 = 0$$

$$i = \frac{20}{65} = \frac{4}{13}$$

$$V_{th} = 6 \times 10 \times \frac{4}{13}$$

$$\boxed{V_{th} = \frac{240}{13}\ V}$$

R_{th} calculation



(dependant sources will remain in the circuit)

$$i_0 + i + 5i = \frac{V_0}{10}$$

$$5i + \frac{V_0}{10} \cdot 10 = 0$$

$$\frac{V_0}{10} = -\frac{i}{2} \Rightarrow i = -\frac{V_0}{5}$$

$$\Rightarrow i_0 = \frac{6}{5}V_0 + \frac{V_0}{10}$$

$$i_0 = \frac{13 V_0}{10}$$

$$\therefore \boxed{R_{th} = \frac{V_0}{I_0} = \frac{10}{13}\ \Omega} = R_{th}$$

Norton Equivalent

$$i_N = i = \frac{20}{5} = 4\ A$$

$$i_{Nor} = \frac{V_{oc}}{R_{th}} = \frac{240}{13} \times \frac{13}{10} = 24\ A$$

$$\boxed{i_{Nor} = 24A}$$

* Method used for calculation of Rth :

-> Connect either a voltage source or a current source, across the nodes where equivalent has been asked and evaluate $\frac{V_0}{I_0}$ which will be equal to Rth