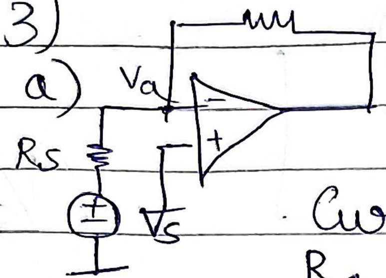
Endsem Solution

3. Theory -

3)

a)



By Virtual GND, $V_a = 0$

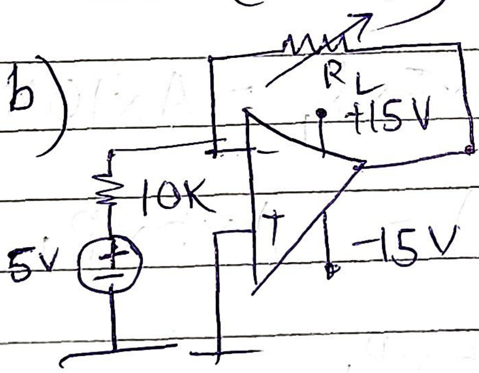
Current flowing through $R_s = V_s/R_s$

→ Same current flows through R_L.

$\therefore I_{(R_L)} = V_s/R_s$ (½ M)

→ Current through R_L does not change even if we change R_L (as long as OP-AMP does not saturate) (½ M)

b)



$$\frac{5 - V^-}{10K} = \frac{V^- - V_o}{R_L}$$

$$V_o = A(V^+ - V^-)$$

$$V_o = -AV^-$$

$$5R_L - V^- R_L = 10K\,V^- - 10K\,V_o$$

$$\frac{5R_L + 10K \times V_o}{R_L + 10K} = V^-$$

$$\therefore V_o = -A\left(\frac{5R_L + 10K \times V_o}{R_L + 10K}\right)$$

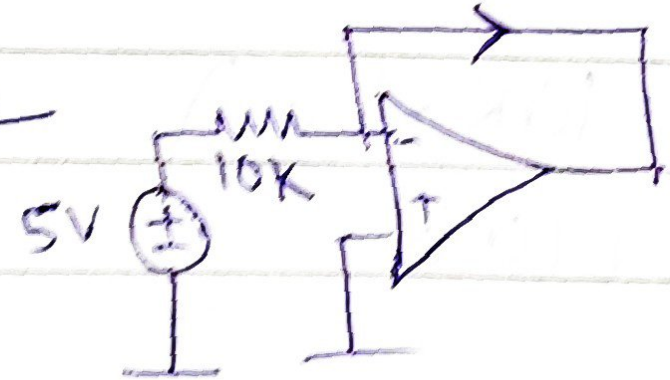
$$V_o R_L + V_o \times 10K = -A \times 5 \times R_L - A \times 10K \times V_o$$

$$V_o (R_L + 10K + A \times 10K) = -A \times 5 \times R_L$$

$$\therefore V_o = \frac{-A \times 5 \times R_L}{R_{L/A} + 10k_{/A} + A \times 10K}$$

$$\therefore V_o = \left.\frac{-5R_L}{10K}\right\} \frac{1}{2}M$$

$R_L = 0\,\Omega$



$I = 0.5\,mA$

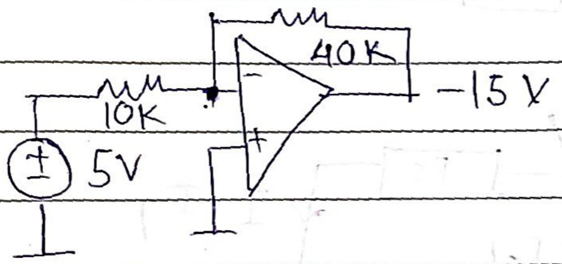
$V_0 = -15V$, @ $3 = \frac{R_L}{10K}$

$\boxed{\therefore R_L = 30K}$ (1/2 M)

Till $R_L = 30K$, current $I = 0.5mA$
After that OP-AMP → sat

→ $R_L = 40K$

$V_0 = -15V$



$\frac{5 - V^-}{1} = \frac{V^- + 15}{4}$

$\therefore 20 - 4V^- = V^- + 15$

$\therefore 5 = 5V^-$

$\therefore V^- = \cancel{2.5V}\ 1V$

$I = 0.4mA$

$R_L = 50K$

$V_0 = -15V$

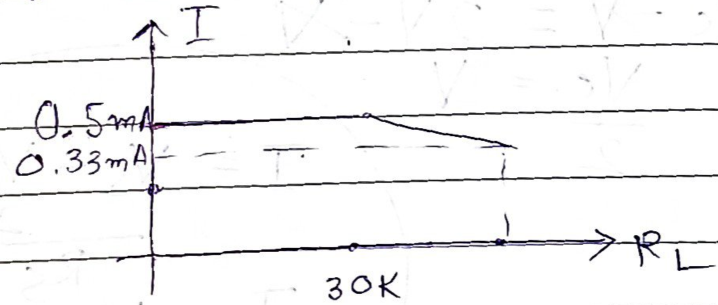
$\therefore 5 - V^- = \frac{V^- + 15}{5}$

$25 - 5V^- = V^- + 15$

$10 = 6V^-$

$\therefore V^- = \frac{10}{6}$

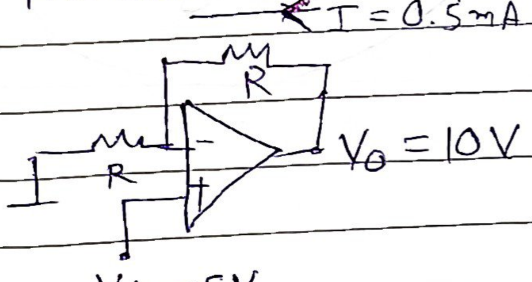
$I = 0.33mA$



(1M)

4. Hardware Implementation

1)



$\frac{10 - 5}{R} < 0.5mA$

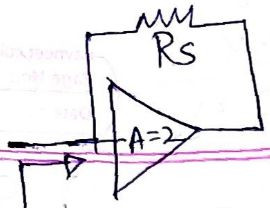
$\therefore \frac{5}{0.5} K\Omega < R$

$\therefore R > 10K\Omega$

(2M)

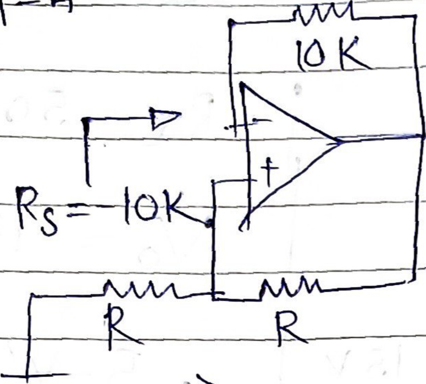
2)

a)



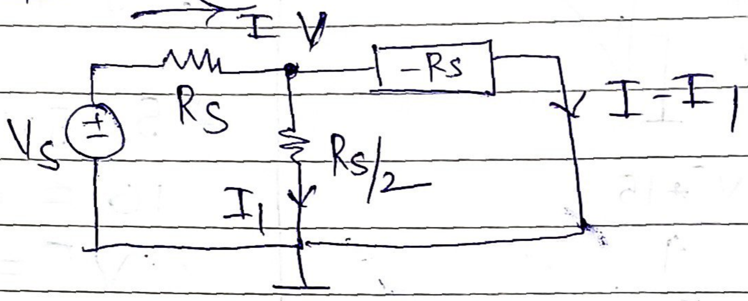
$\boxed{R_S = 10\,K\Omega}$

$$\frac{R_S}{1-A} = -R_S$$



(1M)

b)



$$\frac{V_S - V}{R_S} = \frac{V}{R_S/2} + \frac{V}{-R_S}$$ (2M)

$$V_S - \cancel{V} = 2V - \cancel{V}$$

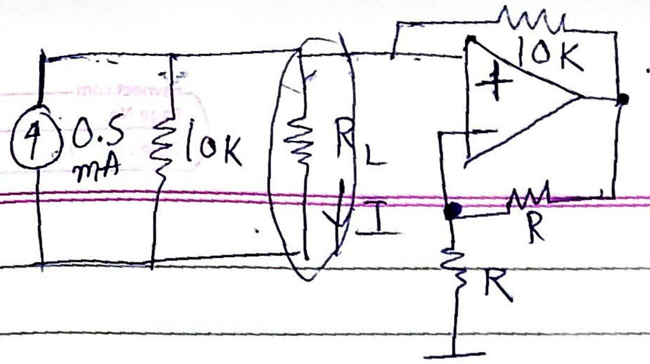
$$\frac{V_S}{2} = V$$

$$I = \frac{V_S - \frac{V_S}{2}}{R_S}$$

$$I = \frac{V_S}{2R_S}$$

3

3 (a)

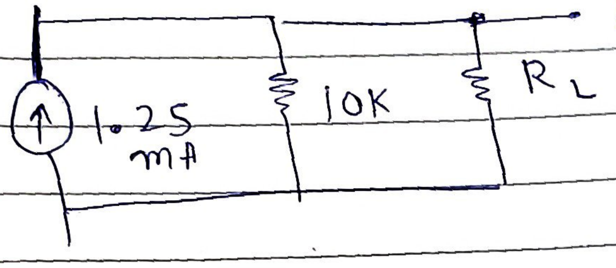


$V_o = 15V$

← 10K

0.75mA

$$I_{constant} = \frac{V \text{ constant}}{R_L}$$



$$0.5 = \frac{10K}{10K + R_L} \times 1.25$$

$5K + 0.5 R_L = 12.5 K$

$\therefore \quad 0.5 R_L = 7.5 K$

$\therefore \quad R_L \cong 15 K \rightarrow$ limiting value.

(3M)

4 → -ve R App

(a) $\dfrac{-R_s}{-R_s + R} \times V_{in} = V_{out} \rightarrow$ T.F. ($1\frac{1}{2}$M)

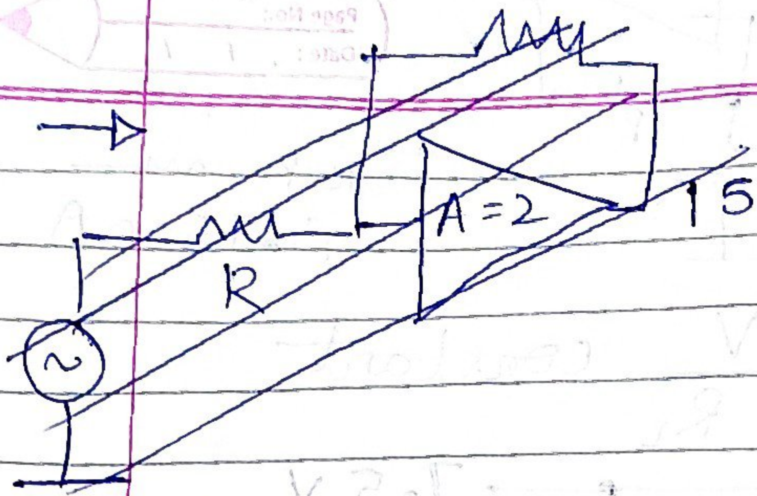
$$5 = \frac{-R_s}{-R_s + R}$$

$-5R_s + 5R = -R_s$

$5R = 4R_s$

$R = \frac{4}{5} R_s$ (1M)

$R = 8K\Omega$



$$\left\{\frac{-R_s}{-R_s+R}\right\} \times V_{in} = V_{out}$$

$$10 \times V_{in} = 15$$

$\therefore V_{in} = 1.5\ V$

and $V_{in} = -1.5\ V$.

Gain = 11

$$V_{in} = 1.36 - (-1.36)$$