4.4) $\frac{V_o}{V_S} = ?$ and $\frac{i_o}{i_x} = ?$

From $\boxed{V = i \cdot R \quad , \quad i_x = \frac{V_s}{1.5k\Omega}}$

Again from Ohm's Law $\boxed{V_o = -50\, i_x \cdot 2.2k\Omega}$

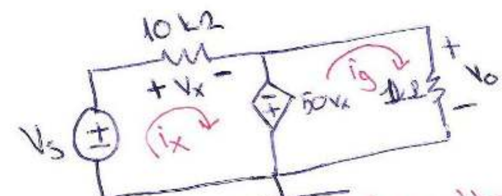
Substituting i_x, we get

$$\boxed{V_o = -165\, V_s \Rightarrow \frac{V_o}{V_s} = -165}$$

Since the direction of i_o is opposite

$$\boxed{50\, i_x = -i_o \Rightarrow \frac{i_o}{i_x} = -50}$$

4.5) $\frac{V_o}{V_s} = ?$



↳ place the ground!

We do mesh analysis

KVL @ mesh X

$$\boxed{\Rightarrow 10k\Omega\, i_x - 50V_x - V_s = 0}$$

KVL @ mesh Y

$$\boxed{\Rightarrow 1k\Omega\, i_y + 50V_x = 0}$$

By using Ohm's Law

$$\boxed{V_x = i_x \cdot (10k\Omega)}$$

4.5) cont. Substituting V_x into equation.

we get

$$\boxed{\begin{aligned} &-490k\Omega\, i_x - V_s = 0 \\ &1k\Omega\, i_y + 500k\Omega\, i_x = 0 \end{aligned}}$$

By solving two equations for two unknowns,

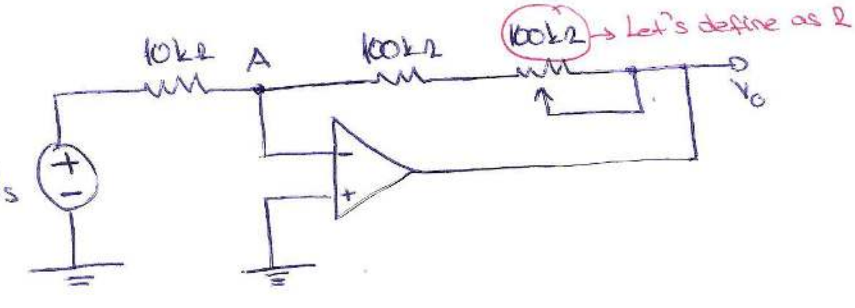
we get
$$\boxed{\begin{aligned} i_x &= -\frac{1}{490k\Omega} V_s \\ i_y &= \frac{50}{49k\Omega} V_s \end{aligned}}$$

By using Ohm's Law, we get

$$V_o = i_y \cdot 1k\Omega = \frac{50}{49} V_s$$

$$\Rightarrow \boxed{\frac{V_o}{V_s} = \frac{50}{49}}$$

4.22)



KCL @ node A (By using OpAmp properties we can find $V_A = 0$)

$$\boxed{\Rightarrow \frac{V_s}{10k\Omega} + \frac{V_o}{(100+R)k\Omega} = 0}$$

$$\boxed{\frac{V_o}{V_s} = -\frac{(100+R)}{10}}$$

for $R = 0$

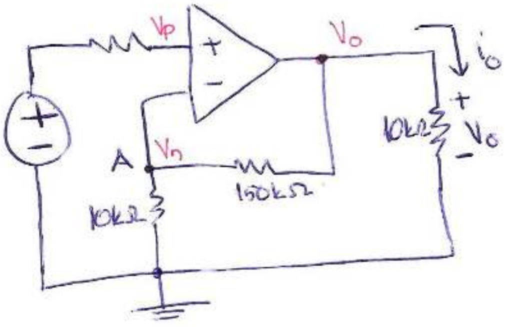
$$\frac{V_o}{V_s} = -10$$

For $R = 100$

$$\frac{V_o}{V_s} = -20$$

Then $\boxed{\frac{V_o}{V_s} \in [-20, -10]}$

4.23)



$V_{cc} = \pm 24V$

a) Using opAmp Properties, we obtain

$$\boxed{V_s = V_p = V_n = V_A}$$

KCL @ node A

$$\boxed{-\frac{V_s}{10} + \frac{V_o - V_s}{150} = 0} \Rightarrow \boxed{V_o = 16\,V_s}$$

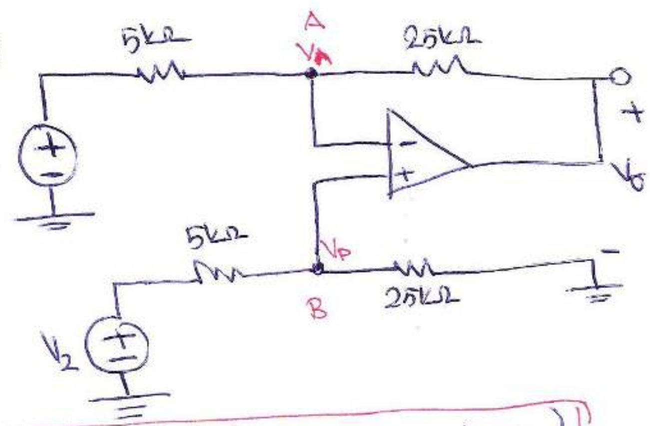
b) By using Ohm's Law $\boxed{i_o = \frac{V_o}{10k\Omega}}$

For $V_s = 1$ $\boxed{i_o = \frac{16}{10k\Omega} = 1.6mA}$

For $V_s = 3$ $\boxed{V_o = 24}$ since it is saturated ($V_c = \mp 24$, Remember the graph!)

$$\boxed{i_o = \frac{24}{10k\Omega} = 2.4\,mA}$$

4.28)



$\boxed{V_n = V_p \text{ (property of OpAmp)}}$

* KCL @ node A

$$\frac{V_1 - V_n}{5k\Omega} - \frac{V_n - V_o}{25k\Omega} = 0$$

$$\boxed{\Rightarrow \quad \frac{5V_1 + V_o}{6} = V_n}$$

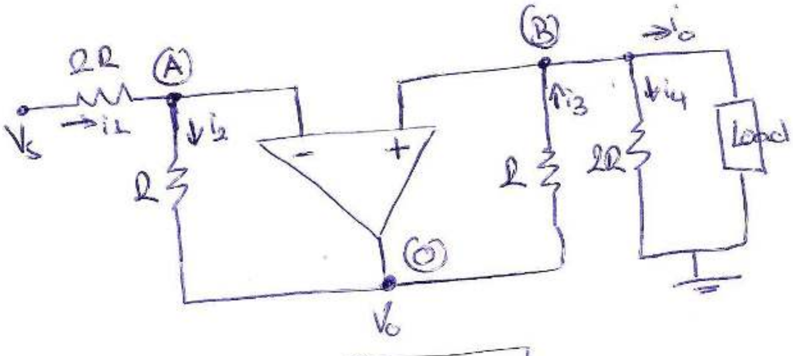
* KCL @ node B

$$\frac{V_2 - V_p}{5k\Omega} - \frac{V_p}{25k\Omega} = 0 \quad \Rightarrow \quad \boxed{\frac{5V_2}{6} = V_p}$$

Since $\boxed{V_p = V_n} \Rightarrow \boxed{5V_1 + V_o = 5V_2}$

$$\Rightarrow \boxed{V_o = 5(V_2 - V_1)}$$

4.34)



Using property of OpAmp, $\boxed{V_A = V_B}$

* KCL @ node A

$$i_1 - i_2 = 0$$

$$\Rightarrow \frac{V_s - V_A}{2R} - \frac{V_A - V_o}{R} = 0$$

$$\boxed{\Rightarrow V_A\left(\frac{-3}{2R}\right) + \frac{V_o}{R} = -\frac{V_s}{2R}} \quad (1)$$

* KCL @ node B

$$i_3 - i_4 - i_o = 0$$

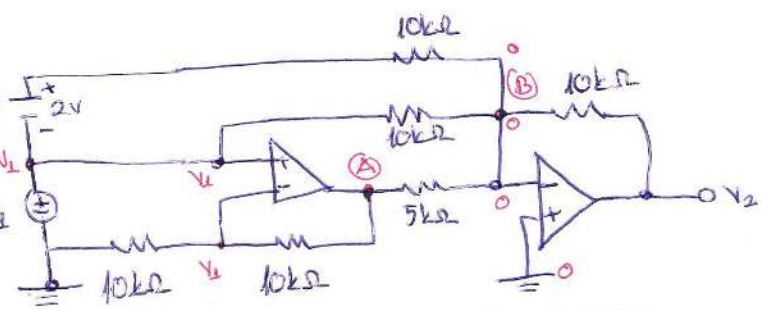
$$\Rightarrow \frac{V_o - V_A}{R} - \frac{V_A}{2R} - i_o = 0$$

$$\Rightarrow \boxed{V_A\left(-\frac{3}{2R}\right) + \frac{V_o}{R} = i_o} \quad (2)$$

4.34) Cont.

Subtracting eqn. (1) from eqn. (2), we get

$$\boxed{i_o = \frac{-V_S}{2R}}$$

4.38) 

By using OpAmp property, $\boxed{V_B = 0}$

* KCL @ node A

$$\boxed{-\frac{V_A - V_1}{10} - \frac{V_A}{5} = 0 \Rightarrow V_A = \frac{-V_1}{3}}$$

KCL @ node B

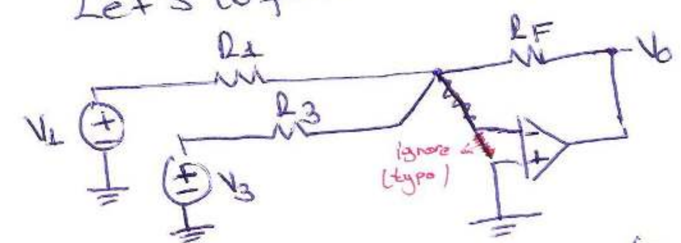
$$\Rightarrow \frac{V_1 + 2}{10} + \frac{V_1}{10} + \frac{V_A}{5} + \frac{V_2}{10} = 0$$

4.38) cont. Substituting $V_A = \frac{-V_1}{3}$ into the equation we get

$$\boxed{V_2 = -\left(\frac{4}{3}V_1 + 2\right)}$$

4.45) We can use one inverting amp and one summing amplifier.

Let's do first summing part

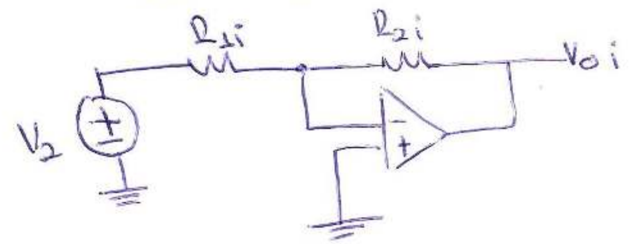


up to now $V_o = -\left(\frac{R_F}{R_1}\right)V_1 + \left(-\frac{R_F}{R_3}\right)V_3$

choose $\boxed{\begin{array}{l} R_F = 15 \\ R_1 = 5 \\ R_2 = 3 \end{array}}$

4.45) cont

Secondly inverting amp.



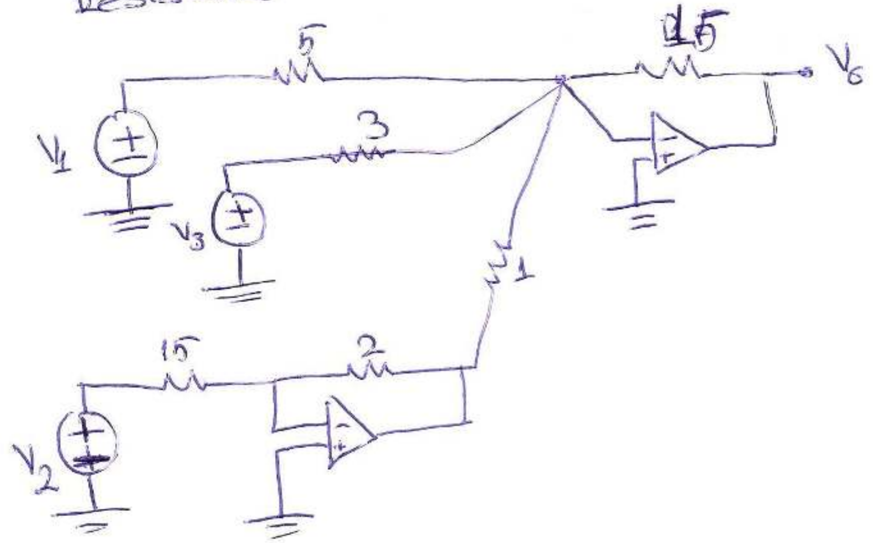
$$V_{oi} = -\frac{R_{2i}}{R_{1i}} V_2$$

we ~~need~~ can choose

$R_{1i} = 15$

$R_{2i} = 2$

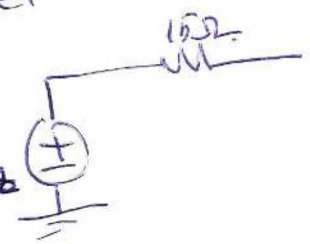
Combining this two amp with $R=1$ Resistance.



4.55) From the figure, we get the relationship between transducer and temprature. So, it is linear and for 400°c, it gives 30 mV potential. Then linear relation is

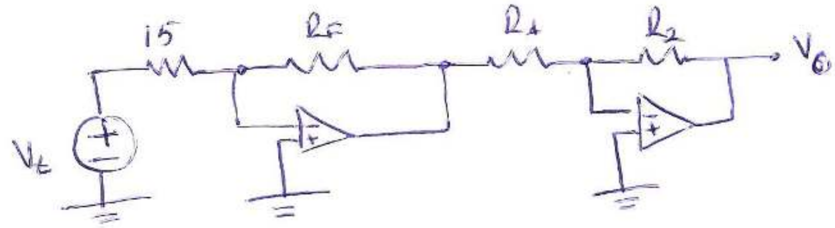
$$0.75 \times 10^{-4} \,(\text{Temprature } ^\circ c) = (\text{Potential})\ \text{Volt}$$

As it is given in the proplem we can model transducer as



Using one sum one inverting amp. we get the circuit as follows:

4.55) cont.

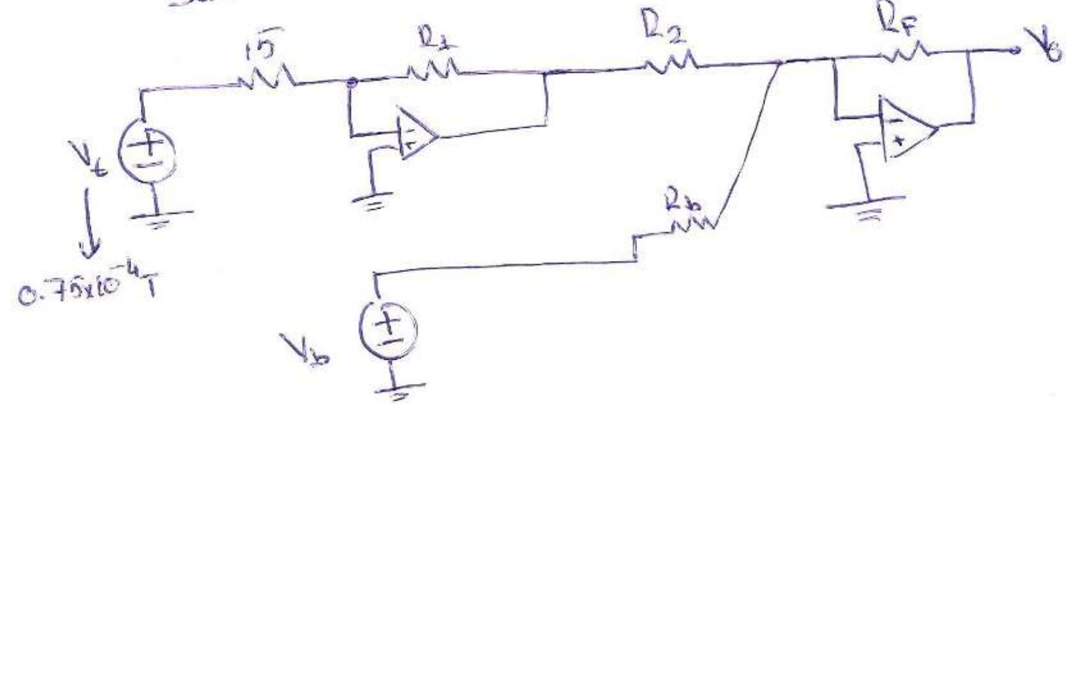


$V_t = 0.75 \times 10^{-4}\ T$ for $T = 1000°C$ we need to get $V_o = 5V$. Then by choosing $R_1 = R_2$, we can calculate RF

$$0.075\left(-\frac{R_F}{15}\right) = -5\ V$$

$$\Rightarrow R_F = 1000\,\Omega$$

4.66) Let's choose same thermocouple as problem 4.55. For this question, we need to add a bias to the output. To use ~~fewer~~ less OpAmp in the design is ~~to~~ using inverter after thermocouple and then using summation. Since the gain is negative, we will basically do subtraction



4.66) cont.

$$V_t\left(\frac{R_1}{15}\right)\left(\frac{R_F}{R_2}\right) - V_b\left(\frac{R_F}{R_b}\right) = V_o$$

when $T = 350°C$ $\quad V_o = 0$

$T = 1100°C$ $\quad V_o = 5V$

$T = 350°C \Rightarrow V_t = 262.5 \times 10^{-4}$ V

$T = 1100°C \Rightarrow V_t = 825 \times 10^{-4}$ V

Let's choose.

$R_1 = 1000$

$R_2 = 1$ and $V_b = 5V$

$R_b = 2.857$

$R_F = 1.26$.

4.66) cont.

Here is the explanation, how we choose variables.

* Firstly we choose $R_1 = 1000$, $R_2 = 1$ and $V_b = 5V$, they are in the design range,

* Now let's calculate V_o for $T = 350°C$

$$R_F \left(262.5 \times 10^{-4} \times \frac{1000}{15} - \frac{5}{R_b} \right) = V_o$$

We need to choose R_b such that $V_o = 0$

so when we solve the equation we get

$R_b = 2.857$.

* Lastly, we solve R_F such that for $T = 1100°C$, $V_o = 5V$, this gives $R_F = 1.26$.