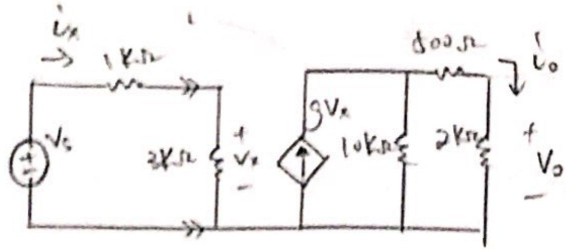
HW5 Solution

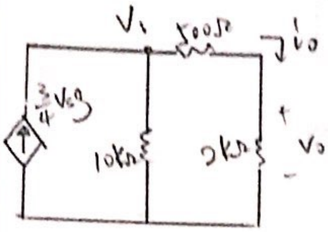
4.3.



$$V_x = i_x \cdot 3\,k\Omega = \frac{V_s}{4k\Omega} \cdot 3\,k\Omega$$

$$= \frac{3}{4} V_s$$

then, the right hold circuits:



at V_1:

$$V_1 = \frac{3}{4} 3 V_s \cdot \left(10k\Omega \,||\, (2k\Omega + 500\Omega)\right)$$

$$= \frac{6000}{4} 3 \, V_s$$

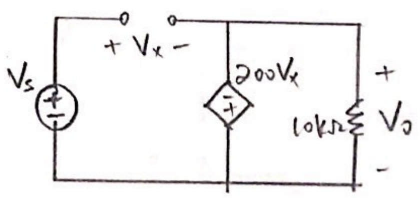
then, $V_o = \frac{2000}{2000+500} \cdot V_1 = \frac{4}{5} \cdot \frac{6000}{4} 3\, V_s \Rightarrow \boxed{\frac{V_o}{V_s} = 3.6}$

$i_o = \frac{V_o}{2k\Omega}$ & $i_x = \frac{V_s}{4k\Omega} \Rightarrow \frac{i_o}{i_x} = \frac{V_o/2k\Omega}{V_s/4k\Omega} = 2 \cdot \frac{V_o}{V_s} = \boxed{7.2}$

$$P_i = V_s\, i_x = \frac{V_s^2}{4k\Omega} = \frac{100\ V^2}{4000\ \Omega} = \boxed{0.025\ W}$$

$$P_o = i_o^2 \cdot 2k\Omega = (7.2 \cdot i_x)^2 \cdot (2k\Omega) = \left(7.2 \cdot \frac{V_s}{4k\Omega}\right)^2 \cdot (2k\Omega) = \boxed{0.648\ W}$$

4.6



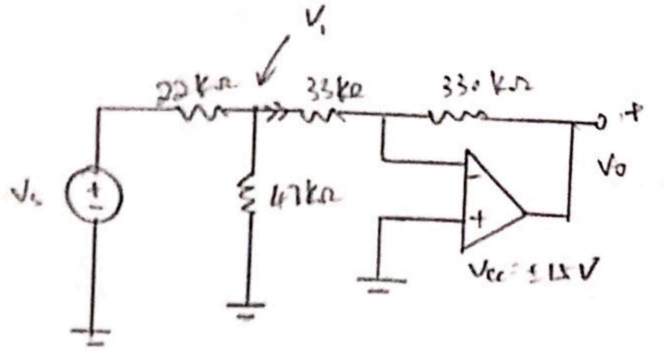
$V_x = V_s - V_o$

$200 V_x + V_o = 0$

$\Rightarrow 200 V_s - 200 V_o + V_o = 0$

$\Rightarrow \boxed{\frac{V_o}{V_s} = \frac{200}{199}}$

4.30



$$\frac{V_A - V_S}{22\,k\Omega} + \frac{V_A - 0}{47\,k\Omega} + \frac{V_A - 0}{33\,k\Omega} = 0 \Rightarrow V_A = 0.468\,V_S$$

inverting amplifier:

$$V_o = -\frac{330\,k\Omega}{33\,k\Omega} V_1 = -10\,V_1$$

$$\boxed{\frac{V_o}{V_s} = -4.68}$$

$\Rightarrow -15V \le -4.68\,V_s \le 15\,V \Rightarrow$ $\boxed{-3.202\,V \le V_s \le 3.202\,V}$

4.38

Without doing any calculation, we see that $V_{cc} = \pm 15V$

so that $V_o \le 15\,V$. and we could never reach a gain of 10.

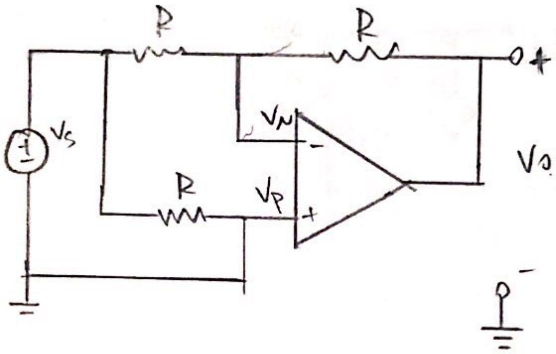
since $10 \cdot 2V = 20V > 15V$ (Noninverting op-Amp w/ gain $= \frac{R_f + 10k\Omega}{10k\Omega}$)

Case 1. : gain $= \frac{0 + 10k\Omega}{10k\Omega} = 1$. Case 2 : gain $= \frac{40k\Omega + 10k\Omega}{10k\Omega} = 5$. Case 3 : gain $= \frac{90k\Omega + 10k\Omega}{10k\Omega} = 10$

A simple fix is to lower input voltage or increase Vcc of amplifier

4-48

when switch is closed.,



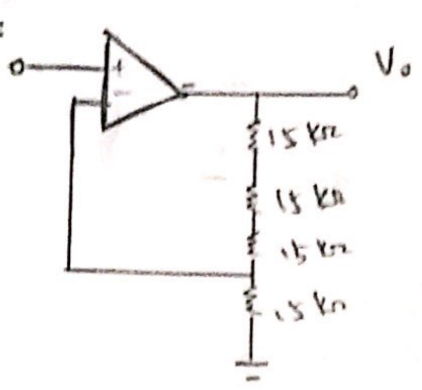
$V_p = V_N = 0$

Inverting amplifier

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

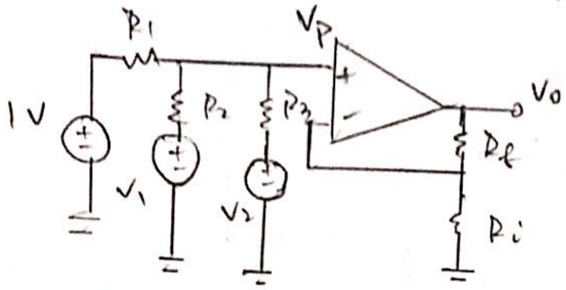
$\therefore$ claim not correct

4.63



Note:
multiple answer are correct

4.68.



→ zero out V_1, V_2.

$$\frac{V_{p,1} - 1}{R_1} + \frac{V_{p,1}}{R_2} + \frac{V_{p,1}}{R_3} = 0$$

$$\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right)V_{p,1} = \frac{1}{R_1}$$

$$\Rightarrow \frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} = \frac{1}{3} \text{ by letting } R_1 = R_2 = R_3 = 1\,k\Omega$$

$$V_{o,1} = \frac{R_f + R_i}{R_i} \cdot V_{p,1} = \left(\frac{R_f+R_i}{R_i}\right)\left(\frac{1}{3}\right)(1V) \rightarrow \text{let } R_f = 17\,k\Omega,\ R_i = 1\,k\Omega$$

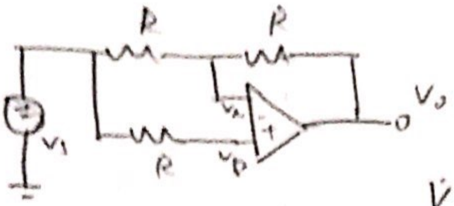
Similarly, zero out 1V, V_2, the relationship $V_{o,2} = 6V_1$ still holds and for $V_{o,3} = 6V_2$.

$$\therefore R_1 = R_2 = R_3 = R_i = 1\,k\Omega,\ R_f = 17\,k\Omega$$

Note:
multiple solutions possible.

Scanned by CamScanner

when switch is open



$V_p = V_N$ and $i_p = i_N = 0$

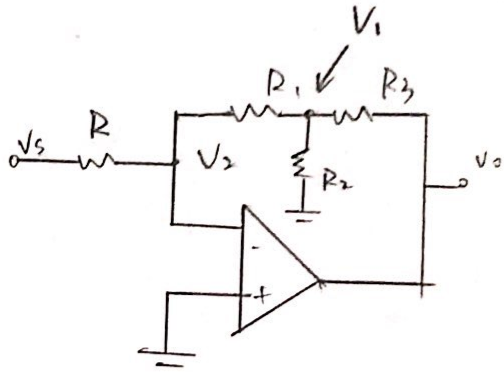
$\Rightarrow V_p = V_s = V_N$

KCL at V_N:

$$\frac{V_N - V_s}{R} + \frac{V_N - V_o}{R} = 0 \Rightarrow V_o = V_s$$

$\therefore$ claim is not correct

4.50



a) KCL at V_1:

$$\frac{V_1 - V_2}{R_1} + \frac{V_1 - 0}{R_2} + \frac{V_1 - V_o}{R_3} = 0$$

KCL at V_2

$$\frac{V_2 - V_s}{R} + \frac{V_2 - V_1}{R_1} = 0$$

Also, ideal op-Amp $\Rightarrow V_2 = 0 \Rightarrow V_1 = -\frac{R_1}{R} \cdot V_s$

then $V_o = V_s \cdot \frac{-R_1R_2 - R_1R_3 - R_2R_3}{R \cdot R_2} = V_s \cdot K$.

$$\Rightarrow K = -\frac{R_1R_2 + R_1R_3 + R_2R_3}{R \cdot R_2}$$

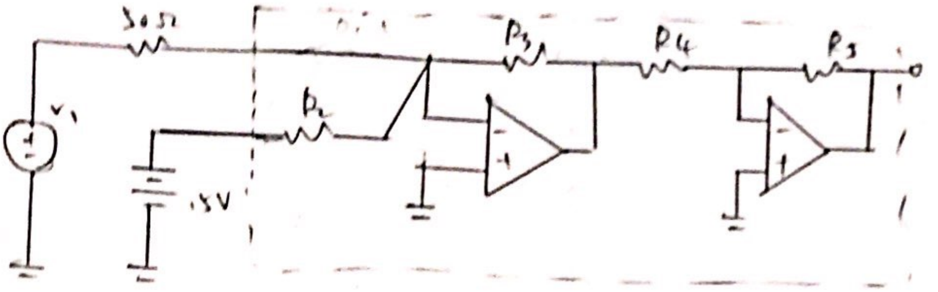
b) let $R = 1\,k\Omega$, $R_1 = 1\,k\Omega$, $R_2 = 1\,k\Omega$, $R_3 = 4.5\,k\Omega$

$\Rightarrow K = -10$

(multiple solution are possible)

4.73

Design an op-amp circuits with gain of 150 for v_1 and 0.1 for 15 V source (multiple answer acceptable, using 2 op-amp is easier)

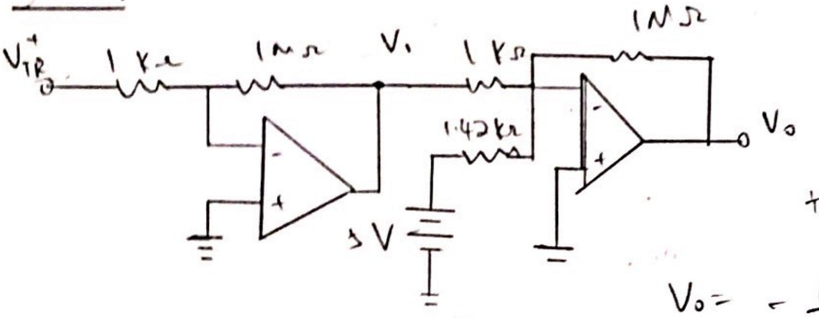


let $R_4 = R_5 = 1\,k\Omega$

and $R_3 = 7.5\ k\Omega$

$R_2 = 75\ k\Omega$

4.89



$$V_1 = -\frac{1M\Omega}{1k\Omega} V_{TR}^{+}$$

$$= -1000\ V_{TR}$$

then, inverting summer

$$V_o = -\frac{10^6}{10^3} \cdot V_{0.1} + \left(-\frac{10^6}{1.43\times10^3} \cdot 5V\right)$$

$$= 10^6 \cdot V_{TR} - 3.5\ V$$

∴ produces the correct output → could buy

When connecting to transducer, there would be an effect due to the output resistance on the overall gain. Thus, a buffer could be used (for free) to solve this.