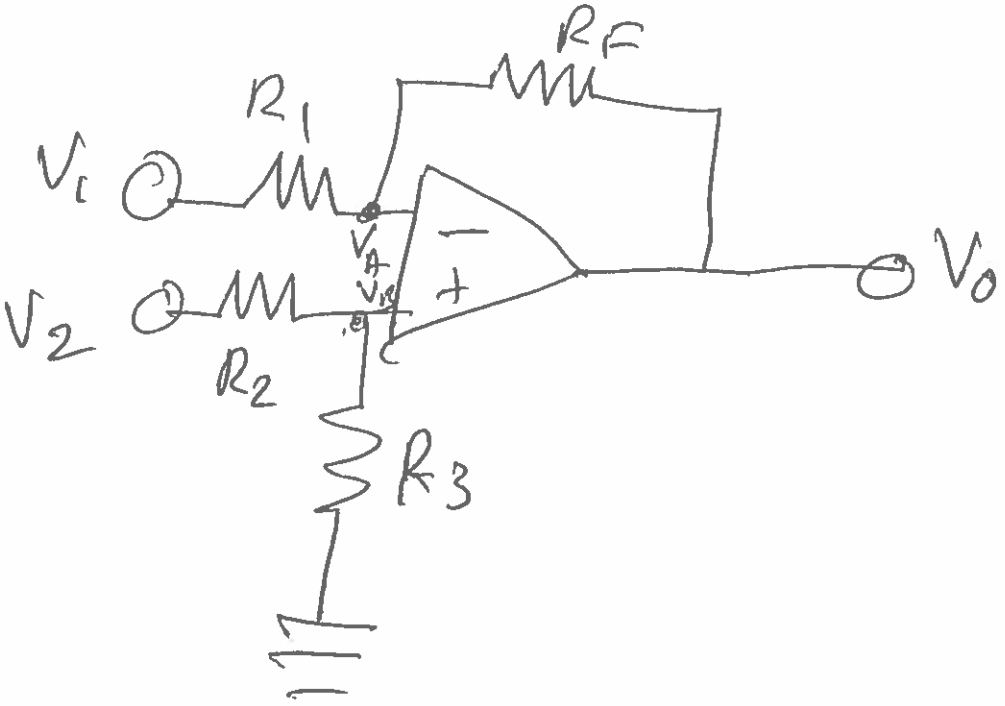
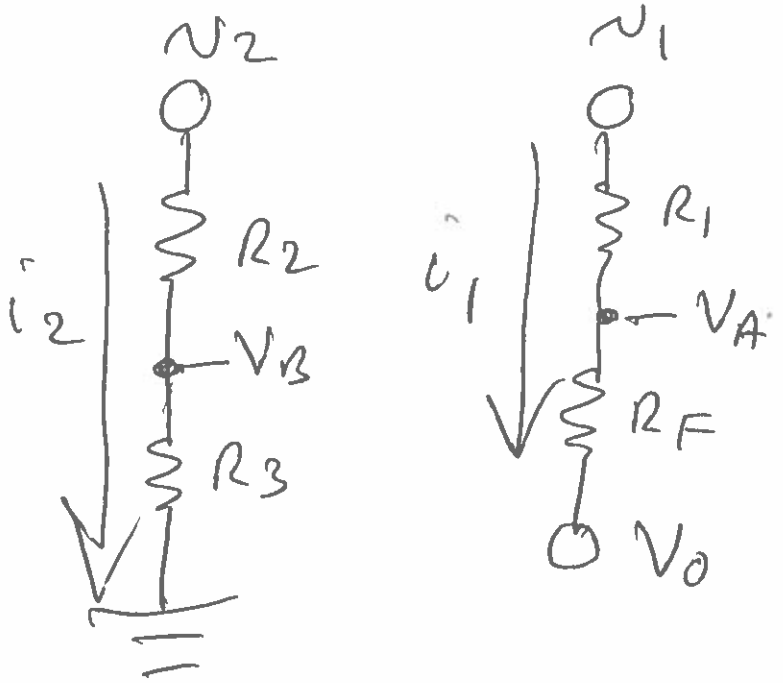


$V_0 = ?$



$V_A = V_B$

$$i_1 = \frac{V_1 - V_A}{R_1} = \frac{V_A - V_0}{R_F}$$

$$i_2 = \frac{V_2 - V_B}{R_2} = \frac{V_B - 0}{R_3}$$

$$V_B = \frac{R_3}{R_2} V_2 - \frac{R_3}{R_2} V_B$$

$$V_B \left(1 + \frac{R_3}{R_2}\right) = \frac{R_3}{R_2} V_2$$

$$V_B \left(\frac{R_2 + R_3}{R_2}\right) = \frac{R_3}{R_2} V_2$$

$$V_B = \left(\frac{R_3}{R_2 + R_3}\right) V_2$$

$$V_A - V_O = \frac{R_F}{R_1} V_1 - \frac{R_F}{R_1} V_A$$

$$V_A + \frac{R_F}{R_1} V_A = V_O + \frac{R_F}{R_1} V_1$$

$$V_A \left(\frac{R_1 + R_F}{R_1}\right) = V_O + \frac{R_F}{R_1} V_1$$

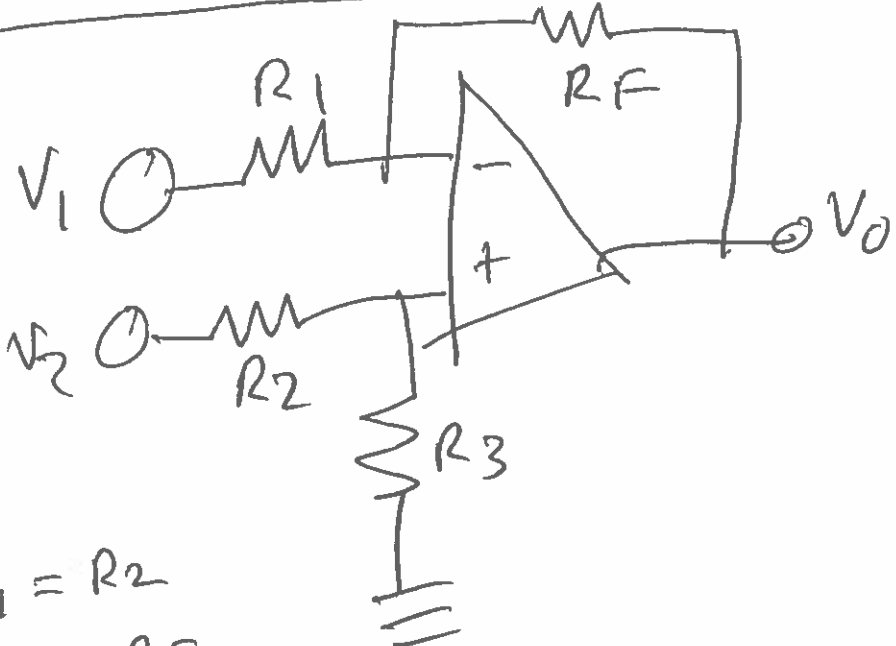
$$V_A = \left(\frac{R_1}{R_1 + R_F}\right)\left(V_O + \frac{R_F}{R_1} V_1\right)$$

Use $V_A = V_B$

$$\left(\frac{R_1}{R_1+R_F}\right)\left(V_0 + \frac{R_F}{R_1}V_1\right) = \left(\frac{R_3}{R_2+R_3}\right)V_2$$

$$V_0 = \left(\frac{R_1+R_F}{R_1}\right)\left(\frac{R_3}{R_2+R_3}\right)V_2 - \frac{R_F}{R_1}V_1$$

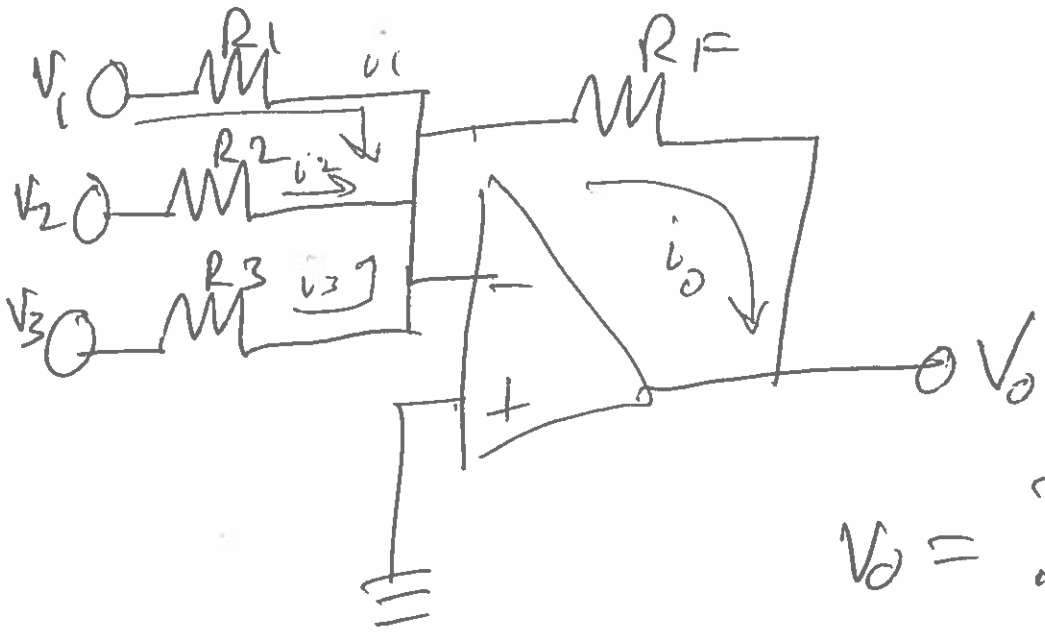
$$\boxed{V_0 = \frac{R_3}{R_1}\left(\frac{R_1+R_F}{R_2+R_3}\right)V_2 - \frac{R_F}{R_1}V_1}$$



Difference Amplifier

if $R_1 = R_2$
and $R_3 = R_F$

$$V_0 \rightarrow \frac{R_F}{R_1}(V_2 - V_1)$$



$$V_0 = ?$$

$$i_1 = \frac{V_1}{R_1} \qquad i_2 = \frac{V_2}{R_2} \qquad i_3 = \frac{V_3}{R_3}$$

$$i_0 = i_1 + i_2 + i_3 = \frac{0 - V_0}{R_F}$$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = -\frac{V_0}{R_F}$$

$$\boxed{V_0 = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)}$$

— Summing Amplifier

$$Z = -5X + 2Y + 4W$$

$$Z = -5X + 2Y + 4W$$

$$Z = -5X - (-2Y - 4W)$$ — Save later

$$Z = 2Y + 4W - 5X$$ — Close to 9 summing AMP

$$Z = -\left(-2\left(Y + 2W - \frac{5}{2}X\right)\right)$$

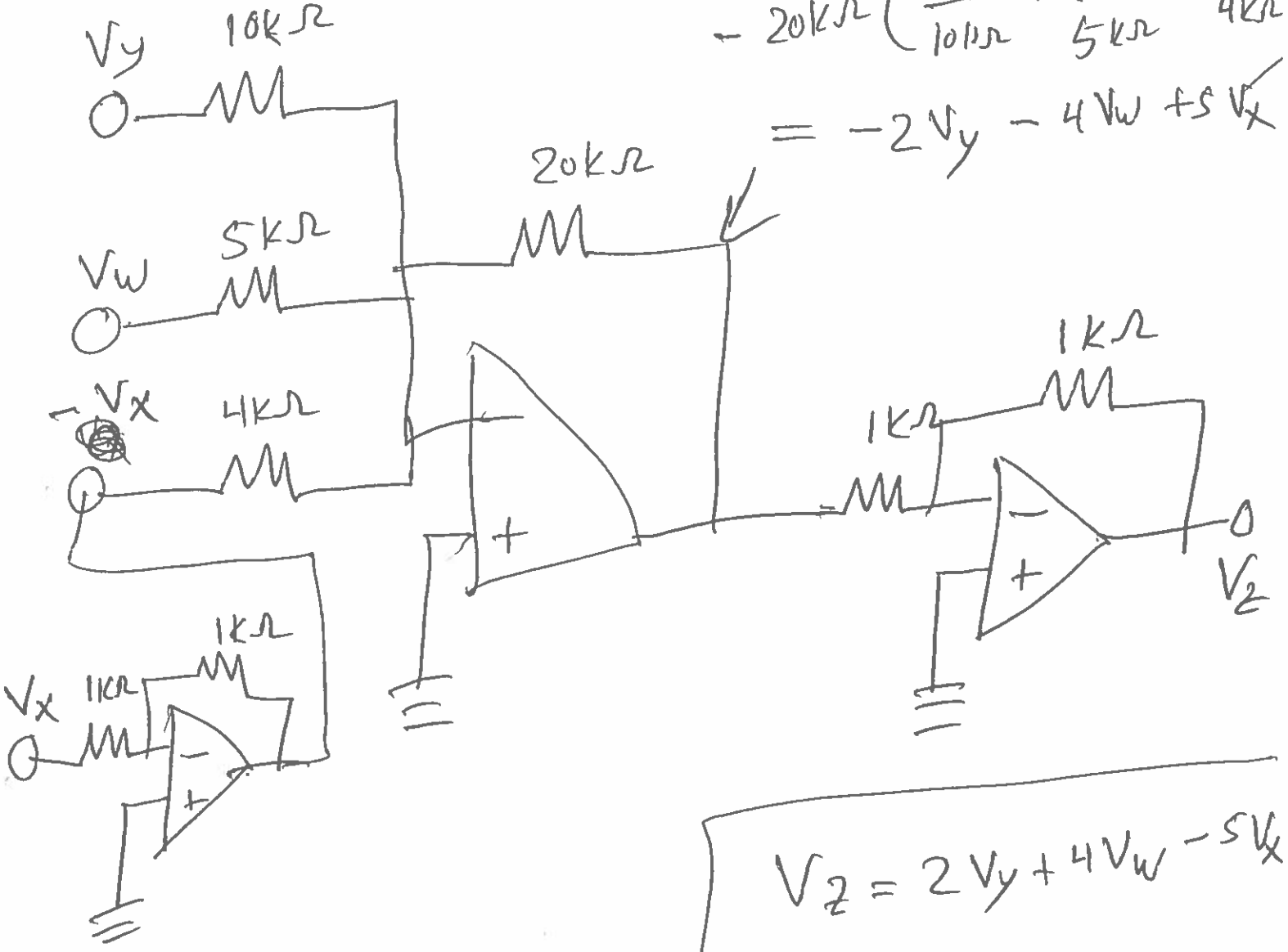
$$-\left(-R_F\left(\frac{V_Y}{R_1} + \frac{V_W}{R_2} - \frac{V_X}{R_3}\right)\right)$$

$R_1 \sim 1 \quad R_2 \sim \frac{1}{2} \quad R_3 \sim \frac{2}{5}$

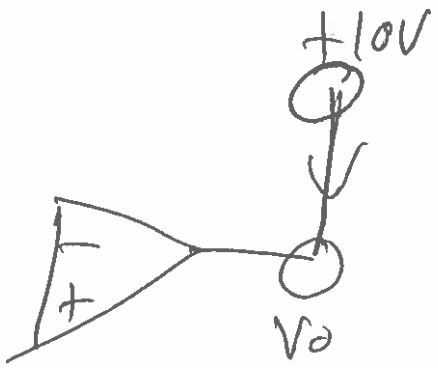
$R_F \sim 2$

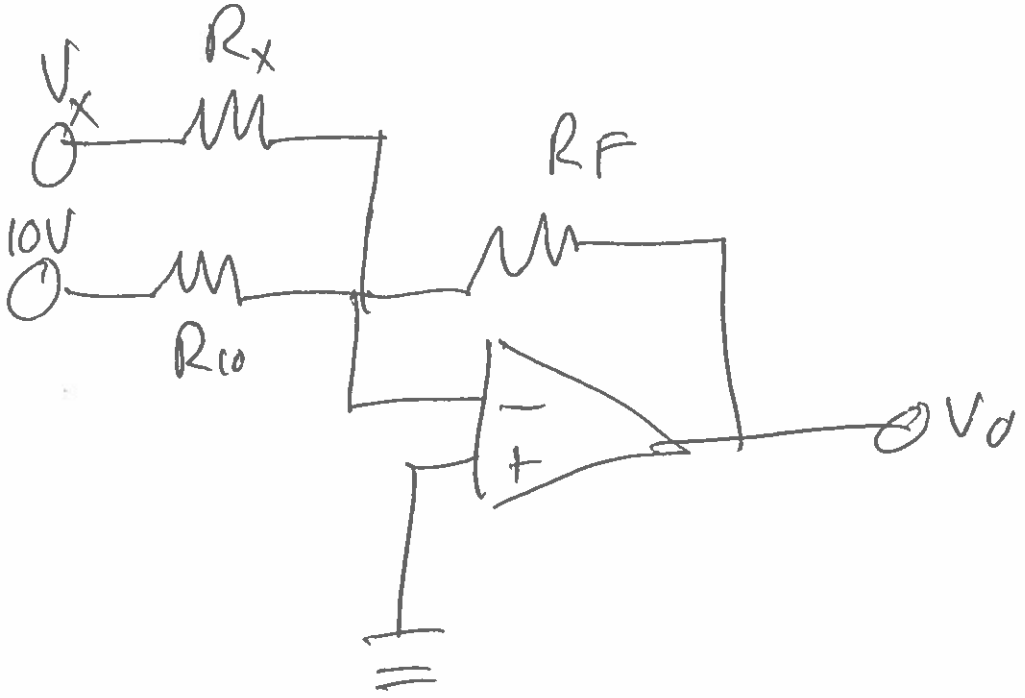
$$-20k\Omega\left(\frac{V_y}{10k\Omega}+\frac{V_w}{5k\Omega}+\frac{-V_x}{4k\Omega}\right)$$

$$=-2V_y-4V_w+5V_x$$

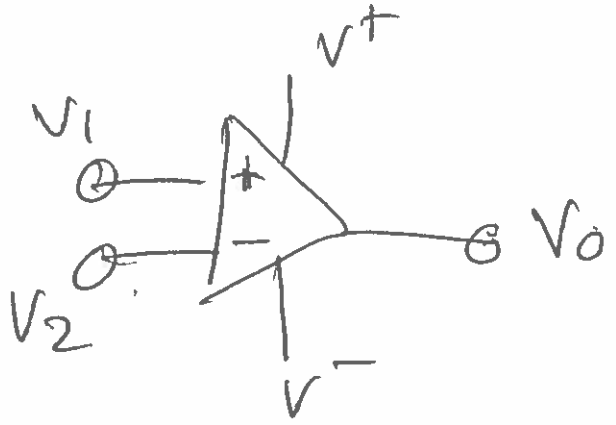


$$V_2 = 2V_y + 4V_w - 5V_x$$





$$V_0 = -R_F \left(\frac{V_X}{R_X} + \frac{10V}{R_{10}} \right)$$



$V_o = ?$ if $V_1 > V_2$ $V_o = +12V$ @ V^+

$10V > 8V$

if $V_1 < V_2$ $V_o = -12V$ @ V^-

$8V < 10V$