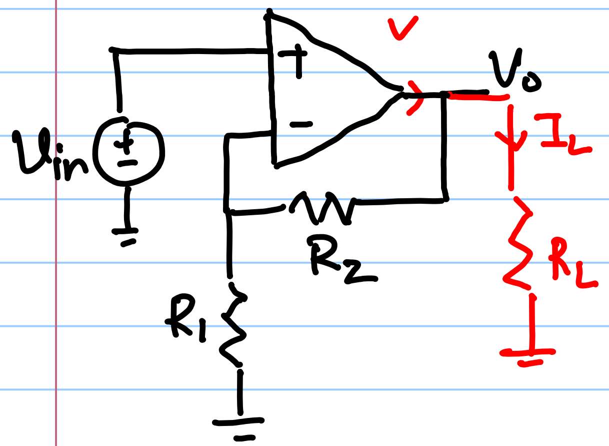
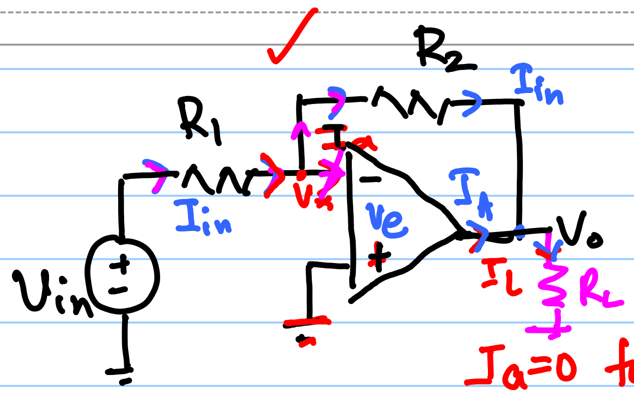
Lecture # 09



Non-inverting

$$\frac{V_o}{V_{in}} = \left(1 + \frac{R_2}{R_1}\right)$$

$$I_L = \frac{V_o}{R_L} = \frac{(1 + R_2/R_1)\, V_{in}}{R_L}$$



$J_a = 0$ for $Z_{in} \to \infty$

$V_o = A V_e$

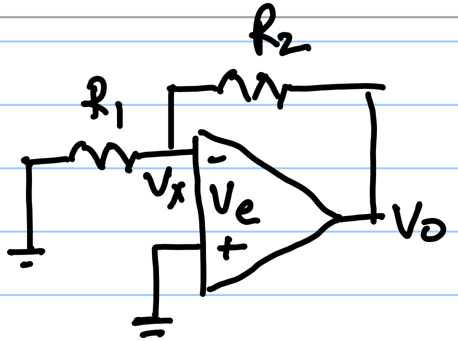
if $A \to \infty$ $\xrightarrow{\text{In −ve fdb}}$ $V_e = 0$

$\Rightarrow V_x = 0$, $V_e = 0 - V_x = 0$

$$\frac{V_{in} - V_x}{R_1} = -\frac{(V_o - V_x)}{R_2}$$

$$\frac{V_o}{V_{in}} = -\frac{R_2}{R_1}$$

"Inverting"



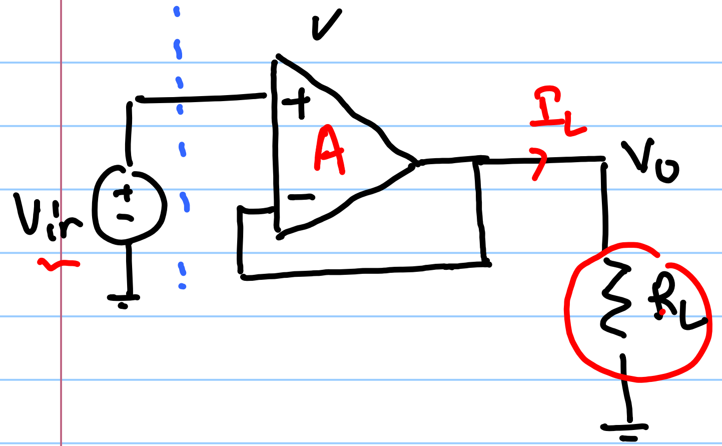
$$V_x = \frac{R_1}{R_1 + R_2} V_o$$

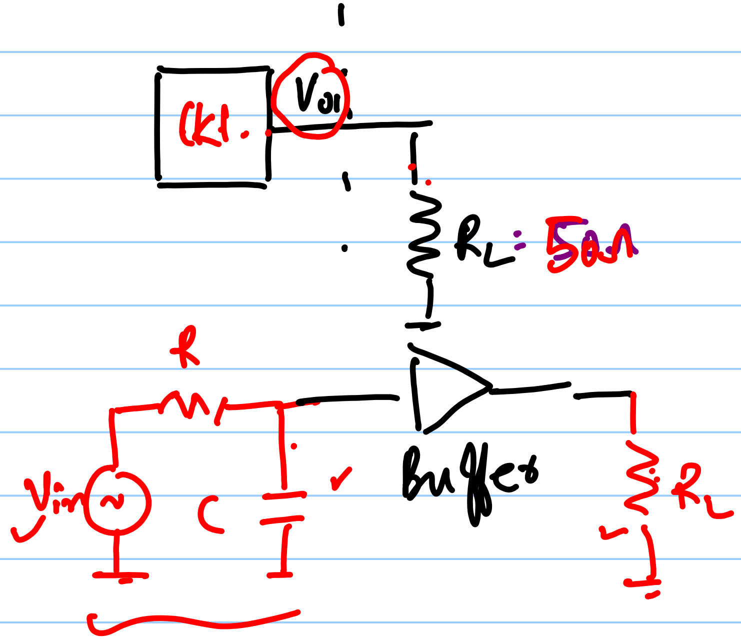
$$V_e = 0 - V_x = -\frac{R_1}{R_1 + R_2} V_o$$

$\beta < 0$

$$I_L = -\frac{R_2/R_1 \; V_{in}}{R_L}$$

"Buffer" "Unity Gain Config."

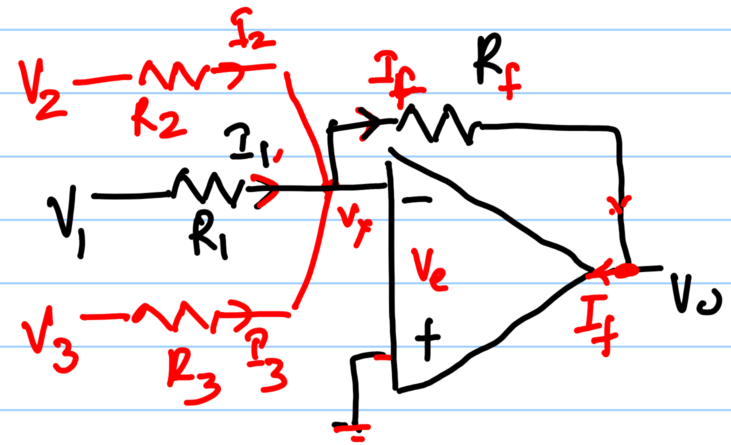




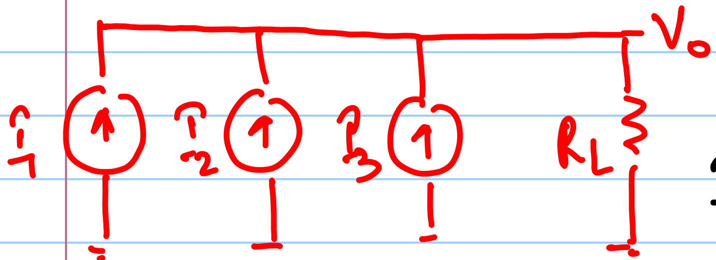
$$\frac{V_o}{V_{in}} = 1$$

$$(V_{in} - V_o)\, A = V_o$$

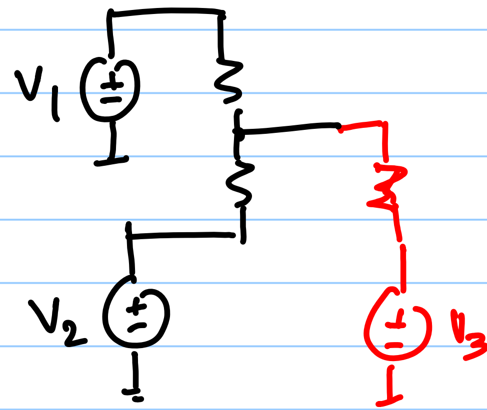
$$V_o = \frac{V_{in}}{1 + \frac{1}{A}}$$



$$\underset{I_1}{\frac{V_0}{R}} = \alpha \underset{I_1}{\frac{V_1}{R}} + \beta \underset{I_2}{\frac{V_2}{R}} + \gamma \underset{I_3}{\frac{V_3}{R}}$$



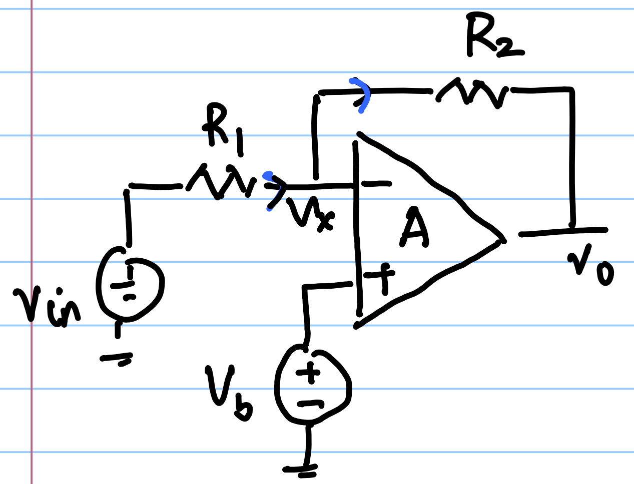
$$I_1 = \frac{V_1}{R_1} \Rightarrow \frac{0 - V_0}{R_2} = I_1$$



$$I_L = I_1 + I_2 + I_3 = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

$$I_L \times R_f = \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right) R_f = -V_o$$

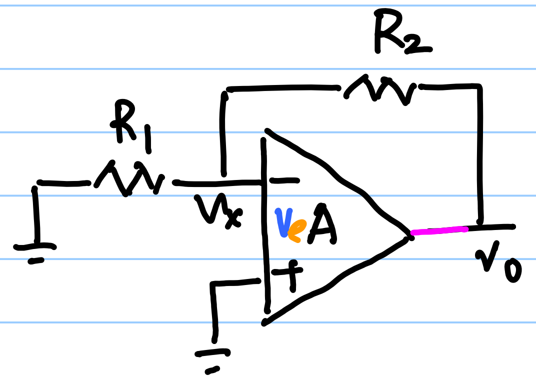
$$V_o = -\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3\right)$$



$$\frac{V_{in} - V_x}{R_1} = \frac{V_x - V_o}{R_2}$$

$$A(V_b - V_x) = V_o$$

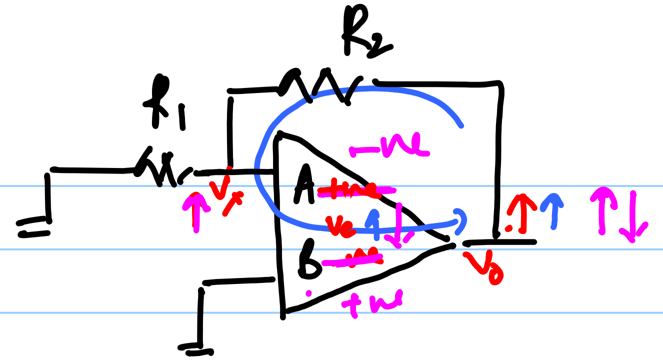
$$\frac{V_{in} - V_x}{R_1} = \frac{V_x - A(V_b - V_x)}{R_2}$$



$$V_e = V_+ - V_- = 0 - \frac{R_1}{R_1 + R_2} V_o = \beta V_o$$

$\beta < 0$

$$V_{in} \cdot \frac{R_2}{R_1} = V_x\left(1 + \frac{R_2}{R_1} + A\right) - A \cdot V_b$$



$$V_x = \frac{V_{in} \cdot \frac{R_2}{R_1} + A V_b}{1 + \frac{R_2}{R_1} + A}$$

A is +ve, B is -ve ✓

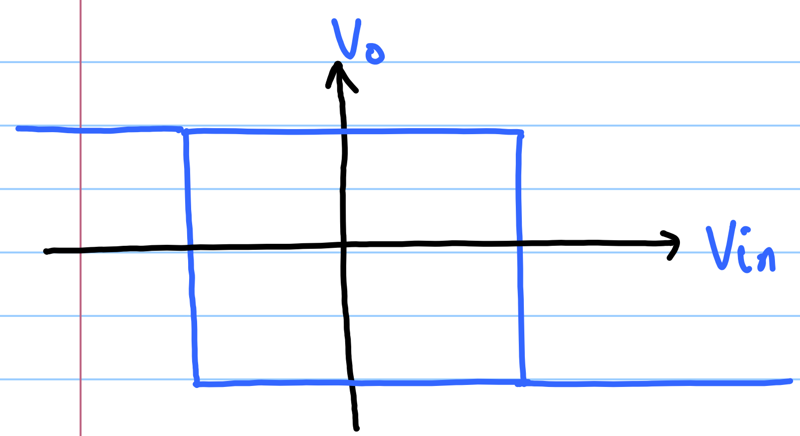
$V_e = \beta \cdot V_o$

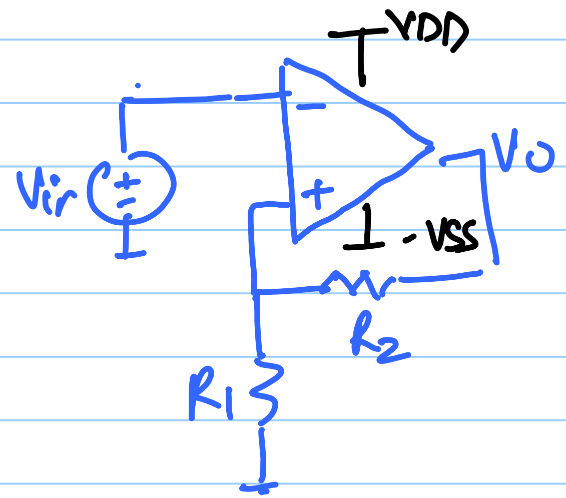
$$V_x = \frac{V_{in} \cdot R_2/R_1}{1 + R_2/R_1 + A} + \frac{V_b}{1 + \frac{(1 + R_2/R_1)}{A}}$$

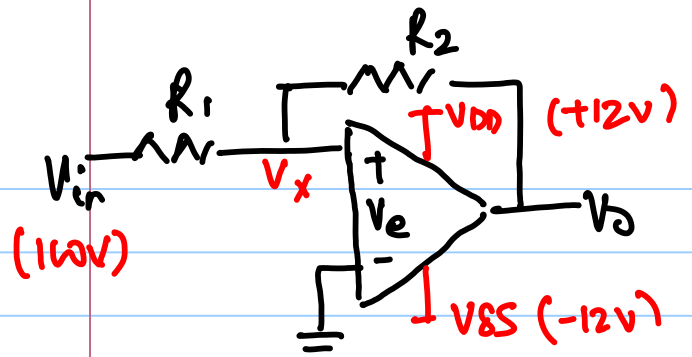
A is -ve, B is +ve

$V_e = \beta \cdot V_o$

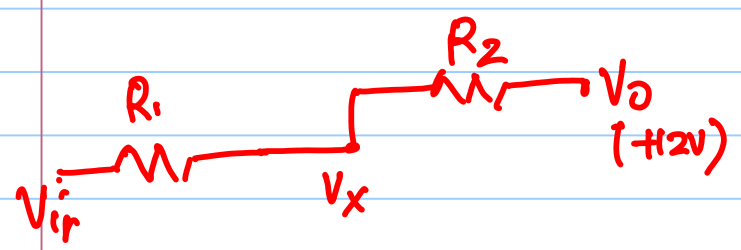
if $A \to \infty$, $\boxed{V_x = V_b}$ $\Rightarrow V_e = V_b - V_x = 0V$ ✓



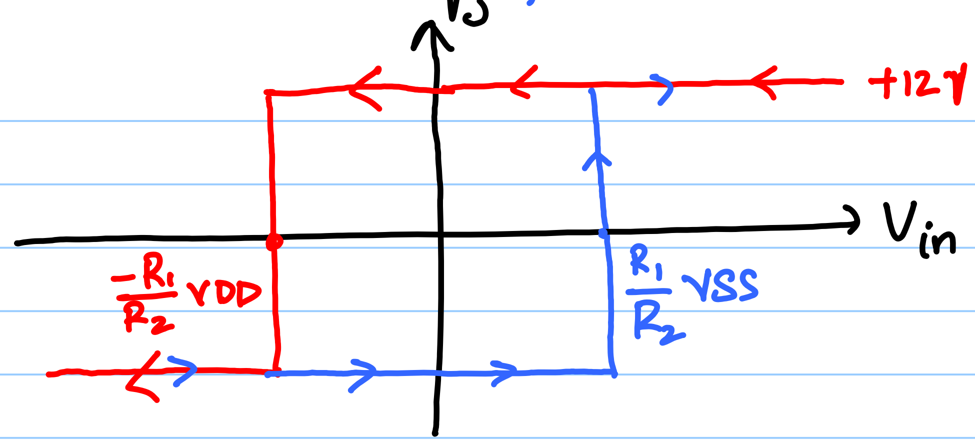




$V_e = V_x$



Non-inverting Hysteresis



|VDD| = |VSS| = 12

$$V_e = V_x = \frac{R_2}{R_1+R_2} V_{in} + \frac{R_1}{R_1+R_2} V_O$$

$$V_e = \frac{1}{R_1+R_2}\left(R_2 V_{in} + R_1 V_o \right)$$

$$V_e < 0 \Rightarrow V_{in} < -\frac{R_1}{R_2} \times 12V$$