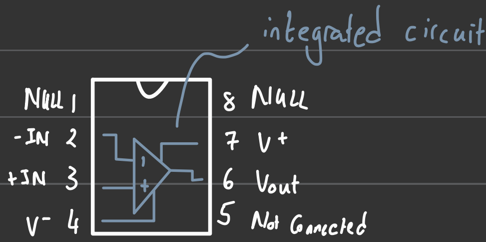
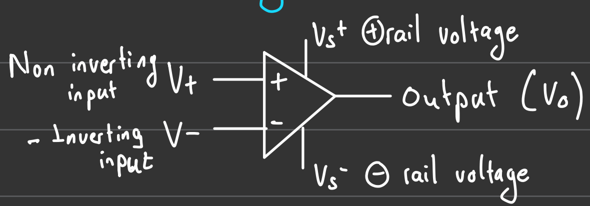
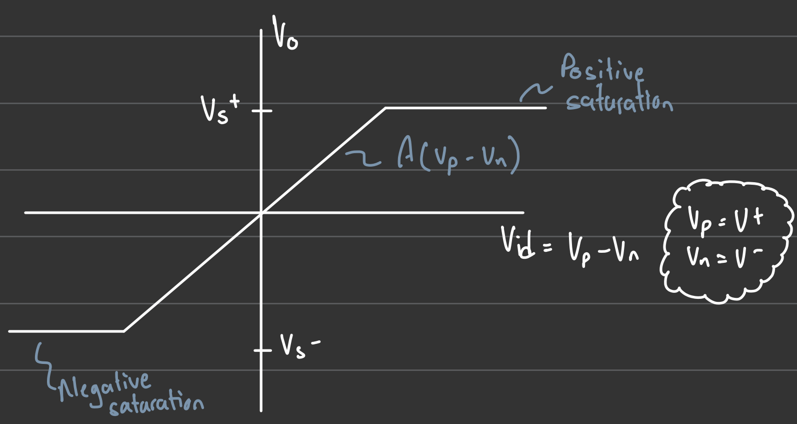
Operational Amplifiers:



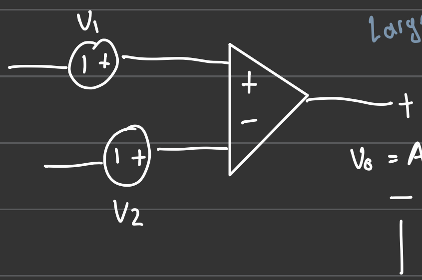
Symbol:



Plotting output V vs input differential V



Ideal Op Amp



Large open loop gain.

$V_o = A_{OL}(v_1 - v_2)$

$V_{icm} = \frac{1}{2}(v_1 + v_2)$

Avg. between v_+ and v_-

$V_{id} = v^+ - v^-$

$= v_1 - v_2$

Assumptions

Infinite input impedance

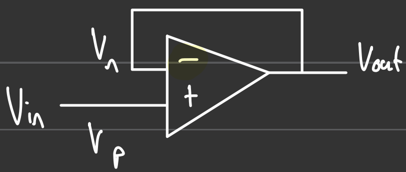
Infinite differential gain

Zero common-mode gain

Zero output impedance

Infinite bandwidth

Negative feedback



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

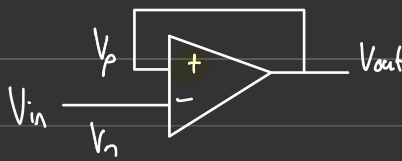
$V_{in} < V_o \Rightarrow V_o \downarrow$

$V_{in} > V_o \Rightarrow V_o \uparrow$

V_o tends to V_{in}

$\Rightarrow V_n = V_p$

Positive feedback



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

- $V_{in} < V_o \Rightarrow V_o$ +Rail
- $V_{in} > V_o \Rightarrow V_o$ - Rail

Method

1) Confirm negative feed back
   ↳ Looking at feedback loop.
2) Assume $V_n = V_p$ and $i_n = i_p = 0A$ (bc. ∞ input impedance)
3) Use standard circuit analysis to determine valus. (A_v, R_i, R_{out}...)
   ↳ KCL, KVL .... (Usually KCL @ V_n)
4) Test that the op-amp is inbetween the linear region.

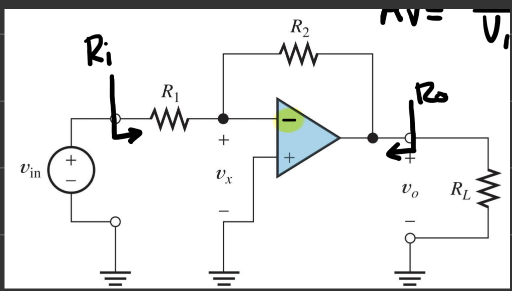
Inverting Amplifiers

From steps above:

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

Input R: $R_i = R_1$

Output R: $R_o = 0\Omega$



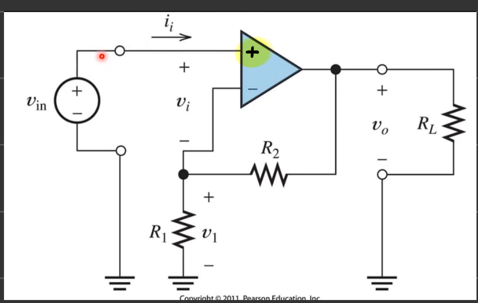
↳ Vin goes to ⊖ side

Non-inverting Amplifiers

Gain: $A_v = 1 + \frac{R_2}{R_1}$

$R_i = \infty$

$R_o = 0\ \Omega$



↳ Vin goes to ⊕ side