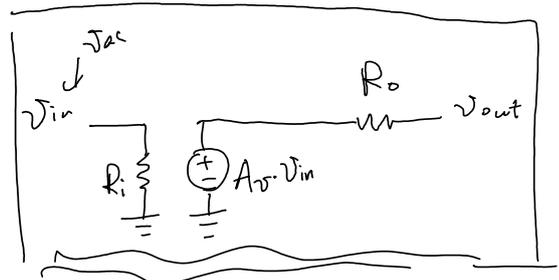


# EE 105 Discussion Welcome!

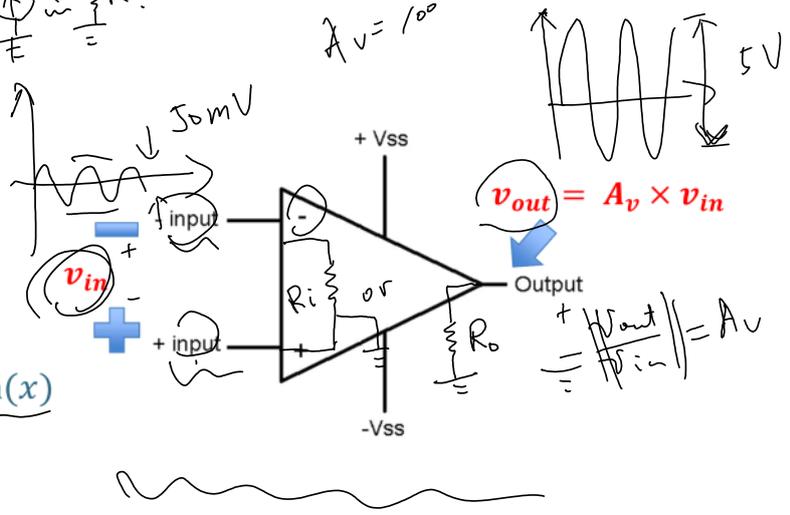
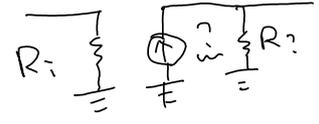
K. Peleaux & Qianyi Xie

# OpAmp

$$v_{in}^- = \underbrace{V_{DC}}_{\text{Bias Point}} + v_{ac}$$



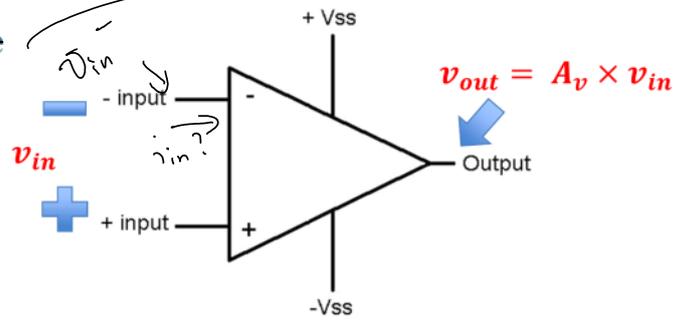
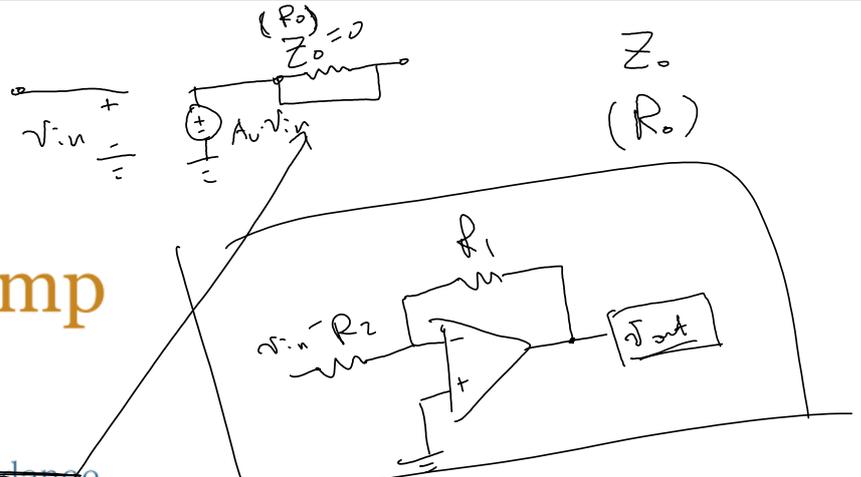
- OpAmp
  - Operational Amplifier
- 'Amplifier'
  - $v_{out} = A_v \times v_{in}$
  - Gain:  $A_v$
- 'Operational'
  - $+, -, \int S(t)dt, \frac{dS(t)}{dt}, e^x, \ln(x)$



# Ideal-OpAmp

- Infinite Gain
- ~~Zero input impedance~~
- ~~Infinite output impedance~~

- $A_v = \infty$
- $Z_{in} = \infty$
- $Z_{out} = 0$



# Ideal-OpAmp Circuit Analysis

- Find
  - Voltage transfer function  $\frac{v_{out}}{v_{in}}$

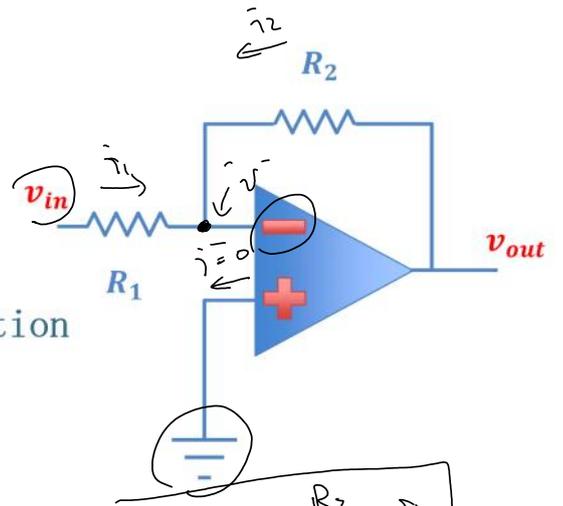
- 'Operational' - Scalar Operation

$$i_1 + i_2 + i_3 = 0 \quad i_3 = i^-$$

$$\frac{v_{in} - v^-}{R_1} + \frac{v_{out} - v^-}{R_2} = 0$$

$$\Rightarrow \frac{v_{in}}{R_1} + \frac{v_{out}}{R_2} = 0$$

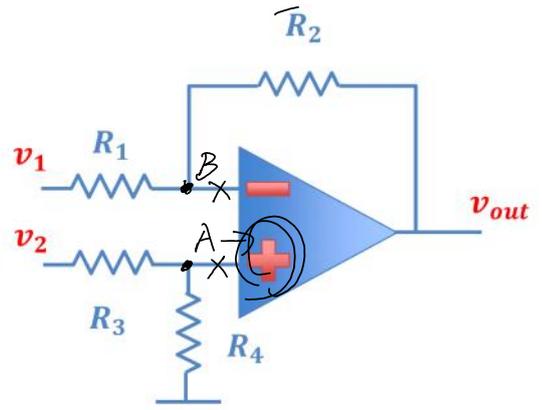
$$\Rightarrow v_{out} = -\frac{R_2}{R_1} \cdot v_{in}$$



# Ideal-OpAmp Circuit Analysis

- Find
  - Values of resistors *s.t.*

$$v_{out} = 0.5v_2 - v_1$$



- 'Operational' - Sum Operation

$$A \quad \frac{v_2 - v^+}{R_3} = \frac{v^+ - 0}{R_4} \Rightarrow v^+ = \frac{R_4}{R_3 + R_4} v_2$$

$$B \quad \frac{v_1 - v^-}{R_1} = \frac{v^- - v_{out}}{R_2} \Rightarrow v_{out} = -\frac{R_2}{R_1} v_1 + \left(1 + \frac{R_2}{R_1}\right) \frac{R_4}{R_3 + R_4} v_2$$

$$2 \quad \begin{cases} R_4 = \frac{1}{3} R_3 \\ R_1 = R_2 \end{cases}$$

Wentian M:

$D_1 \Rightarrow$  Diode

$$I_d = I_{s0} \cdot e^{\frac{V_D}{V_T}}$$

$V_T = 26 \text{ mV}$   
@ 300K

# Ideal-OpAmp Circuit Analysis

- Find - Voltage transfer function  $\frac{v_{out}}{v_{in}}$

$v_{out}(v_{in})$

- 'Operational' - ?

$$v^- = v^+ = 0$$

$$\frac{v_{in} - 0}{R_1} = I_D = I_{s0} \cdot e^{\frac{-v_{out}}{V_T}} \Rightarrow e^{\frac{-v_{out}}{V_T}} = \frac{v_{in}}{I_{s0} \cdot R_1}$$

$$\Rightarrow -\frac{v_{out}}{V_T} = \ln\left(\frac{v_{in}}{I_{s0} \cdot R_1}\right)$$

$$\Rightarrow v_{out} = -V_T \cdot \ln\left(\frac{v_{in}}{I_{s0} \cdot R_1}\right)$$

