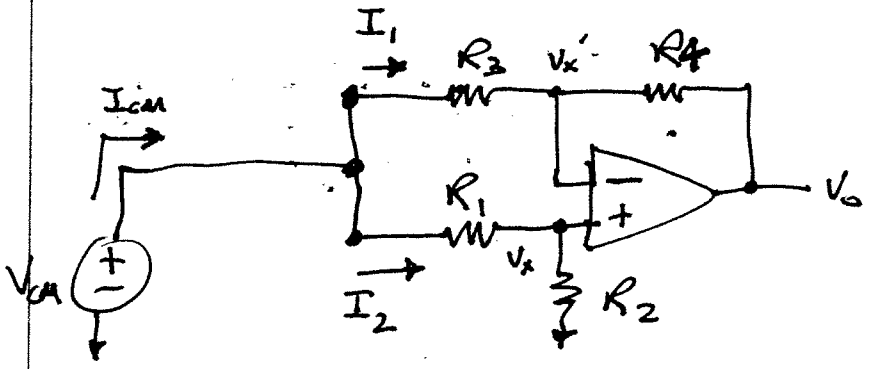
Common-Mode & Differential Input Resistance

* Common-Mode Input Resistance



$$R_{IN,cm} = \frac{V_{cm}}{I_{cm}}, \qquad I_{cm} = I_1 + I_2$$

$$I_2 = \frac{V_{cm}}{R_1 + R_2}$$

$$V_x = \frac{V_{cm} R_2}{R_1 + R_2}$$

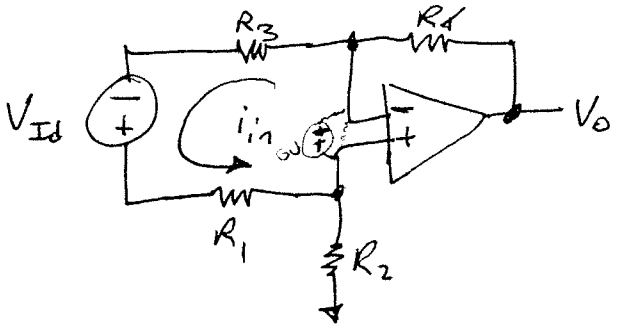
$$I_1 = \frac{V_{cm} - V_x}{R_3} = \frac{V_{cm} - \frac{V_{cm} R_2}{R_1 + R_2}}{R_3} = \frac{V_{cm} R_1}{(R_1 + R_2) R_3}$$

$$I_{cm} = I_1 + I_2 = \frac{V_{cm} (R_1 + R_3)}{(R_1 + R_2) R_3}$$

$$\boxed{R_{IN,cm} = \frac{(R_1 + R_2) R_3}{R_1 + R_3}}$$

"Input Resistance is a function of R_1, R_2, R_3"

Differential Input Impedance



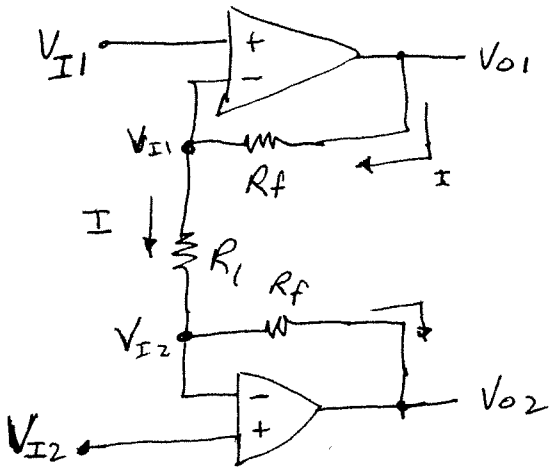
$$R_{IN} = \frac{V_{Id}}{i_{in}} \qquad \text{KVL:} \quad i_{in} R_3 - V_{Id} + i_{in} R_1 \overset{+0}{=} 0$$

$$V_{Id} = i_{in}(R_3 + R_1)$$

$$\boxed{R_{IN} = \frac{V_{Id}}{i_{in}} = R_3 + R_1}$$

Ideally, we would like $R_{IN} = \infty$

Instrumentation Amplifiers



$$I = \frac{V_{I1} - V_{I2}}{R_1}$$

$$V_{o1} = V_{I1} + \frac{R_F}{R_1}(V_{I1} - V_{I2})$$

$$V_{o2} = V_{I2} - \frac{R_F}{R_1}(V_{I1} - V_{I2})$$

$$V_{oo} = V_{o1} - V_{o2} = V_{I1} - V_{I2} + 2\frac{R_F}{R_1}(V_{I1} - V_{I2})$$

$$\boxed{A_d = \frac{V_{oo}}{V_{IO}} = 1 + 2\frac{R_F}{R_1}}$$