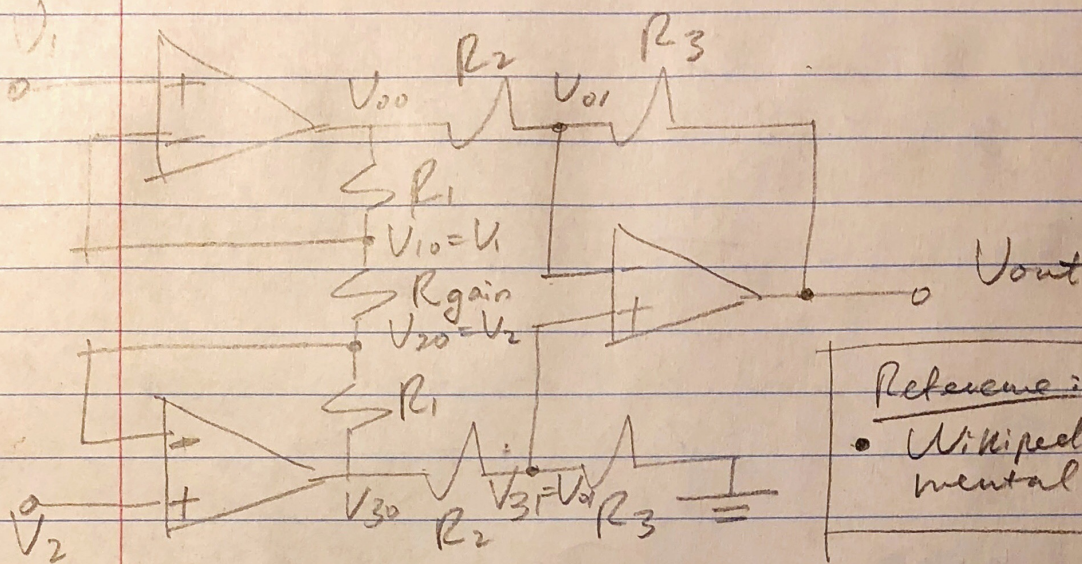


How does an instrumental amplifier work?
 Dao Tao - September 11/2018.

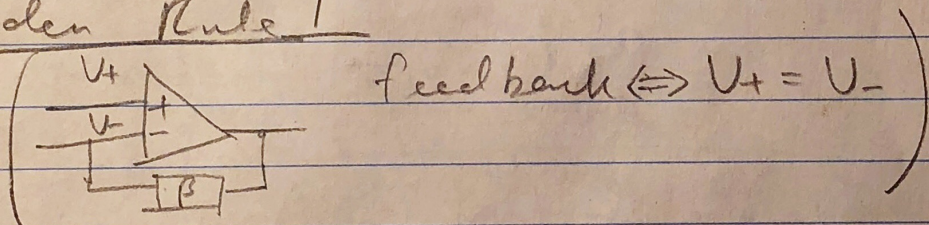


Reference:

- Wikipedia - Instrumental Amplifier

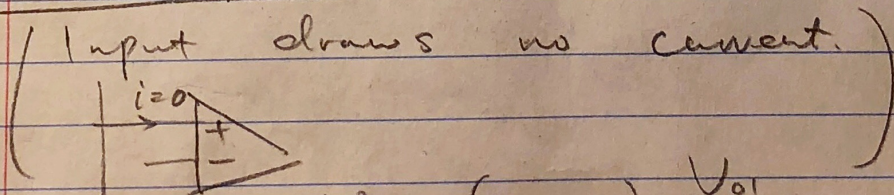
→ We know V_1, V_2 . What is V_{out} ?
 We labeled all the nets in the circuit.

Golden Rule 1



We get $V_{10} = V_1, V_{20} = V_2, V_{31} = V_{01}$

Golden Rule 2



We get $V_{30} = (R_2 + R_3) \frac{V_{01}}{R_3}$ — (1)

$V_{00} = V_1 = \frac{V_2 - V_1}{R_{gain}} R_1; V_{30} = V_2 + \frac{V_2 - V_1}{R_{gain}} R_1$ — (2)

$V_{01} - R_3 \frac{V_{00} - V_{01}}{R_2} = V_{out}$ — (3)

Put ② into ①

$$V_2 + \frac{V_2 - V_1}{R_{\text{gain}}} R_1 = (R_2 + R_3) \frac{V_{o1}}{R_3}$$

$$\text{Then } V_{o1} = \frac{R_3}{R_2 + R_3} \left(V_2 + \frac{V_2 - V_1}{R_{\text{gain}}} R_1 \right)$$

Put this into ③, together with ②

$$V_{\text{out}} = \left(1 + \frac{R_3}{R_2} \right) V_{o1} - \frac{R_3}{R_2} V_{o2}$$

We get

$$V_{\text{out}} = \frac{R_3}{R_2} \left(V_2 + \frac{V_2 - V_1}{R_{\text{gain}}} R_1 \right) - \frac{R_3}{R_2} \left(V_1 - \frac{V_2 - V_1}{R_{\text{gain}}} R_1 \right)$$

$$= \frac{R_3}{R_2} \left(V_2 - V_1 + \frac{2R_1}{R_{\text{gain}}} (V_2 - V_1) \right)$$

$$V_{\text{out}} = \frac{R_3}{R_2} \left(1 + \frac{2R_1}{R_{\text{gain}}} \right) (V_2 - V_1)$$