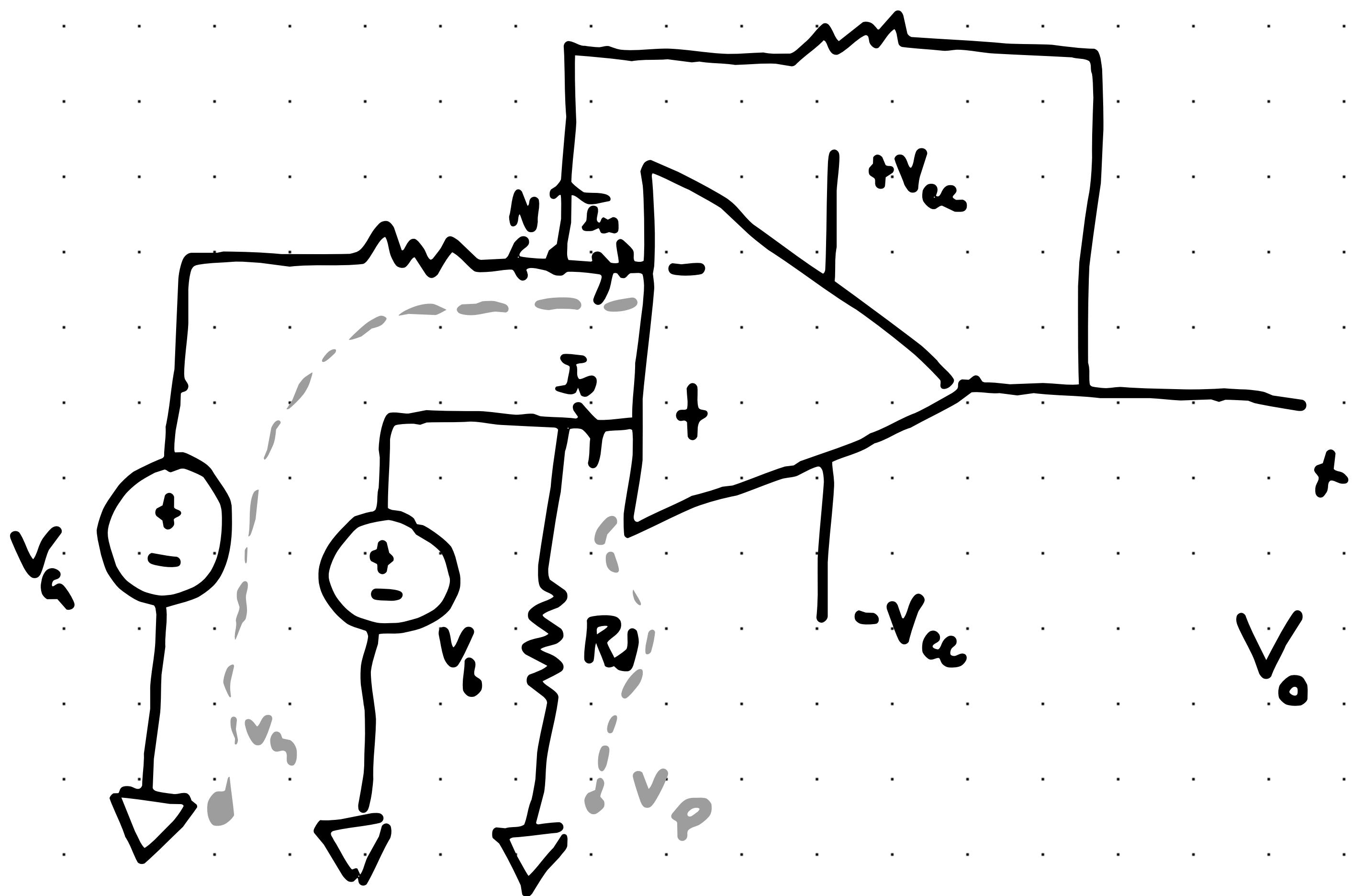


Difference Amplifier

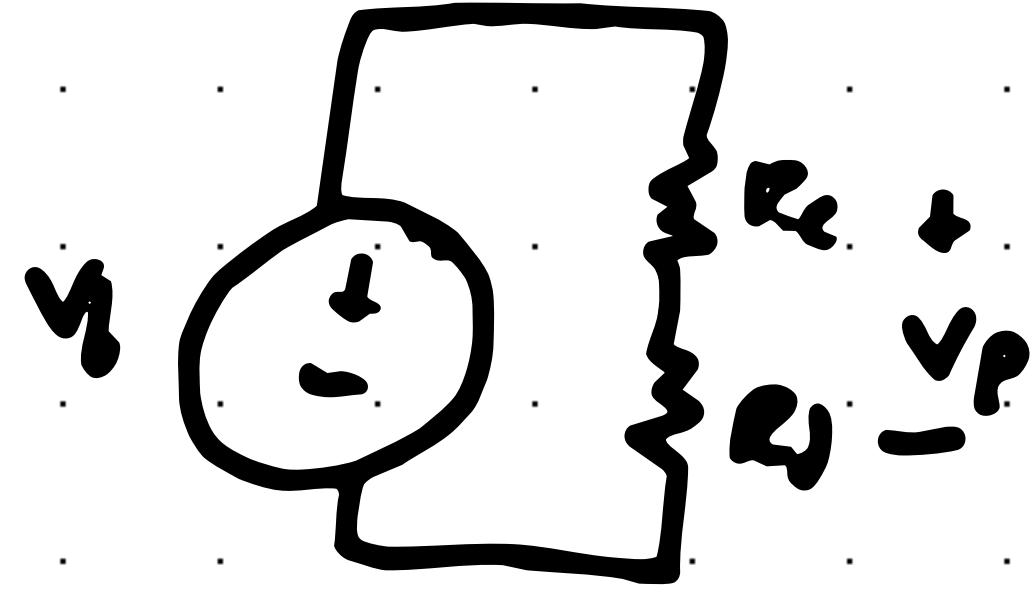
Fully Inverting and Non-Inverting Input with two Voltage Supplies, will give you the Differences.

$$I_P = I_n = 0$$

$$V_P = V_n$$

Using Voltage Divider identity

$$V_p = \frac{R_d}{R_c + R_d} V_b$$



$$\sum I = 0$$

note (5)

$$\frac{V_a - V_o}{R_a} + \frac{V_a - V_o}{R_b} + i_m = 0$$

$$\frac{\frac{R_d}{R_c + R_d} V_b - V_a}{R_a} + \frac{\frac{R_d}{R_c + R_d} V_b - V_o}{R_b} = 0$$

So,

$$V_o = \frac{R_d (R_a + R_b)}{R_a (R_c + R_d)} V_b - \frac{R_L}{R_a} V_a$$

If

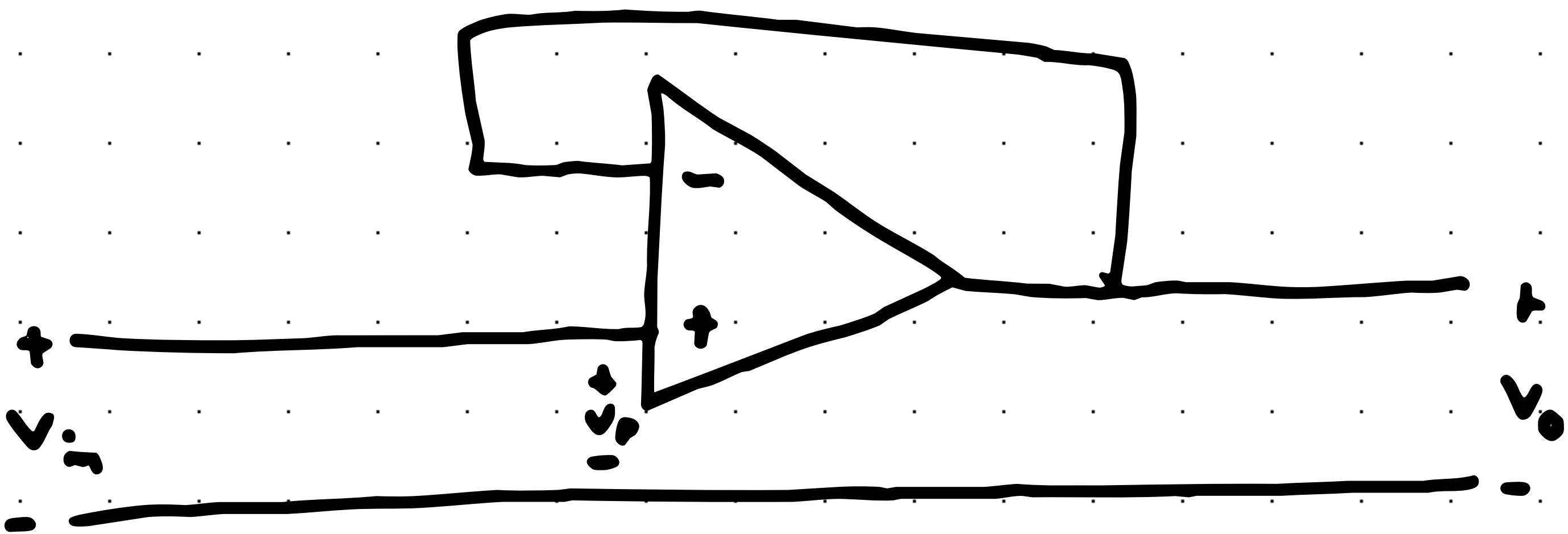
$$\frac{R_a}{R_b} = \frac{R_c}{R_d} \Rightarrow V_o = \frac{R_b}{R_a} (V_b - V_a)$$

Difference Amplifier

Some Different OP-Amp Configurations

(i)

~~Basic~~ Voltage follower amplifier



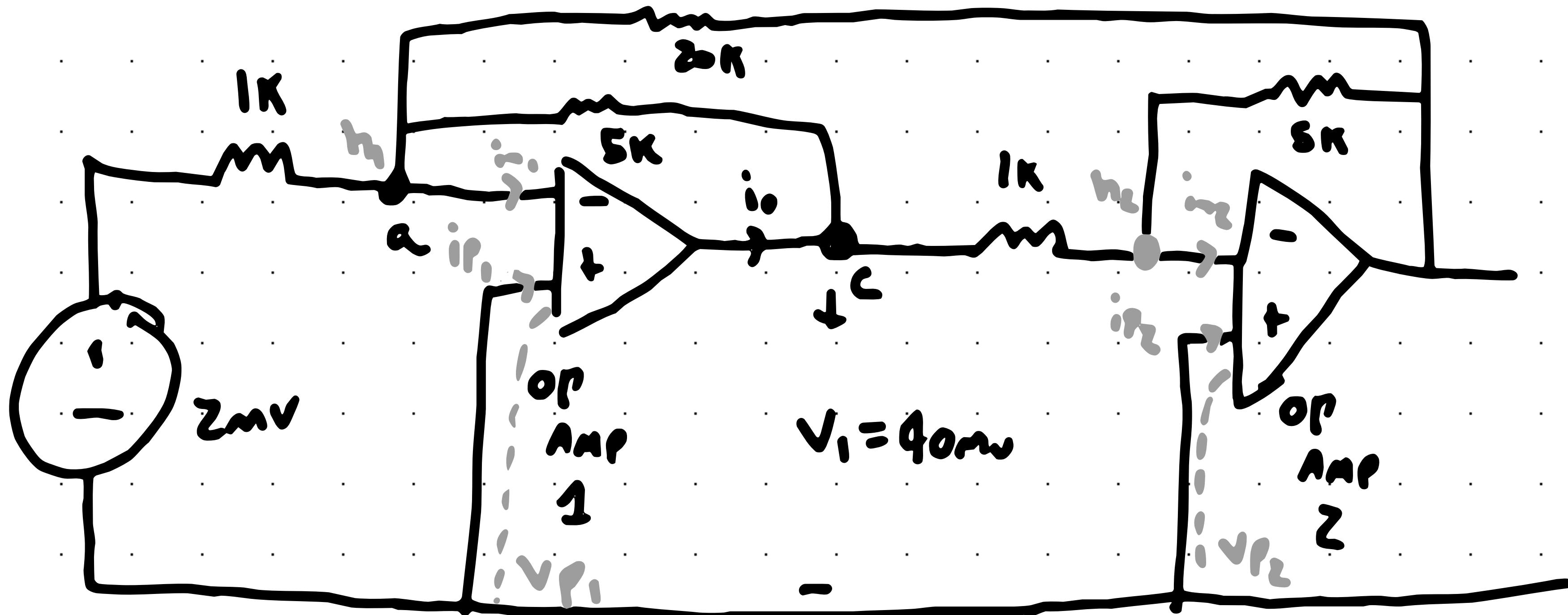
$$V_p = V_n \quad i_p = i_n$$

Since $V_{in} = V_p$ and $V_o = V_n$, then

$$V_o = V_{in}$$

2

Cascade Amplifier



Calculate V_o and i_o and the overall gain

Solution:

OP AMP ①

$$i_{n1} = i_r = 0, V_P = V_{n1},$$

Since $V_{P1} = 0, V_{n1} = 0$

$$\sum I = 0 \quad \frac{V_{n1} - 2 \times 10^{-3}}{1000} +$$

Note N_1

$$\frac{V_{n1} - 40 \times 10^{-3}}{5000} + \frac{V_{n1} - V_o}{20000} + i_o = 0$$

$$\frac{-2 \times 10^{-3}}{10^3} + \frac{40 \times 10^{-3}}{5 \times 10^3} - \frac{V_o}{20 \times 10^3} = 0$$

$$V_o = -0.2V$$

$$\sum_{I=0} I = 0 \quad i_0 = \frac{V_1 - V_{n_1}}{5 \times 10^3} + \frac{V_1 - V_{n_2}}{1000}$$

Node C

$$i_0 = 48 \text{ mA}$$

I_C & V_1 were unknown...

$$\sum_{I=0} I = 0 \quad \frac{V_0 - V_0}{5000} + \frac{V_{n_2} - V_{n_1}}{20000} + i_{n_2} \frac{V_{n_2} - V_1}{1000} = 0$$

Node 0

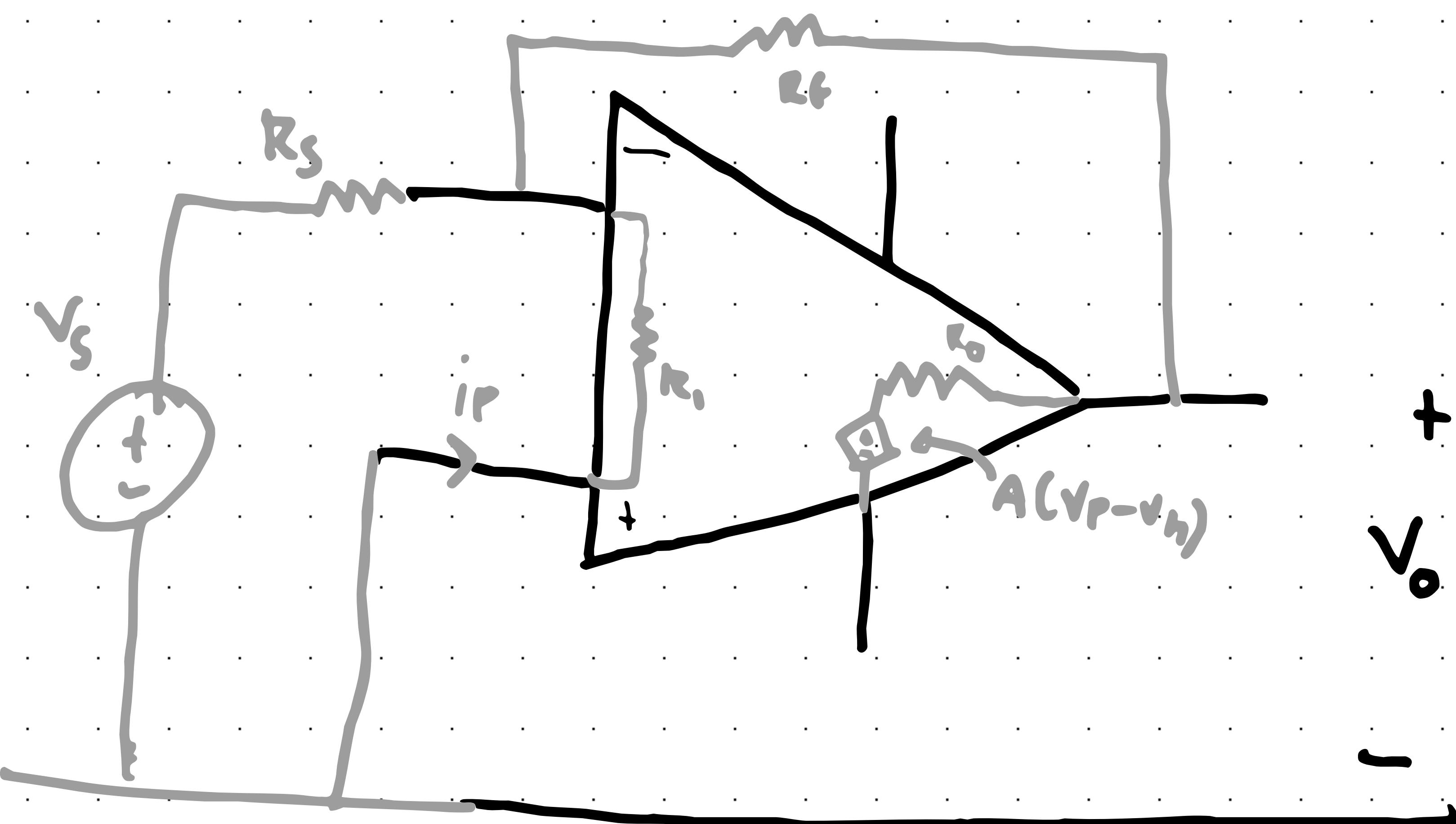
Node 1

Node 2

$$6 \text{ gain} = \frac{V_0}{V_{in}} = \frac{-0.2}{2 \times 10^{-3}} = -100 \text{ V}$$

Precal OP-Amp (will not be on the midterm)

Non-Inverting Precal OP-Amp circuit



Typical values for MA741 OP-Amp

$$R_i = 2M\Omega \quad A = 10^5 \quad R_o = 75\Omega$$

$$\sum I = 0$$

Node A

$$\frac{V_n - V_s}{R_s} + \frac{V_n - V_p}{R_i} + \frac{V_n - V_o}{R_f} = 0$$

$$\sum I = 0$$

Node B

$$\frac{V_o - V_n}{R_f} + \frac{V_o - A(V_p - V_n)}{R_o} = 0$$

