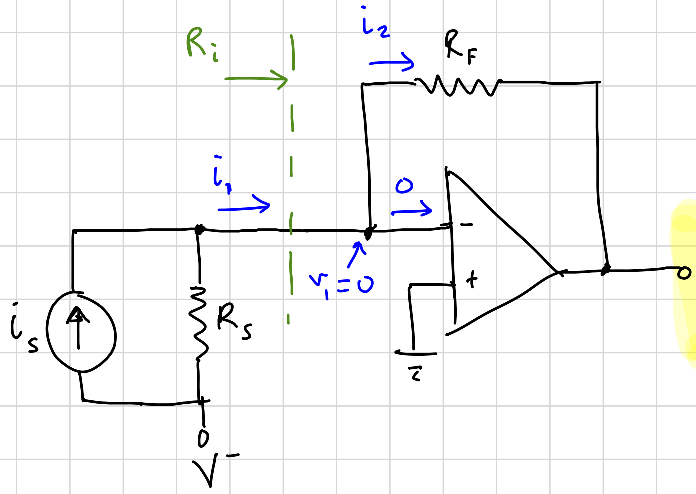
Lecture #23 — Op-Amp Applications

- Current-to-voltage converter

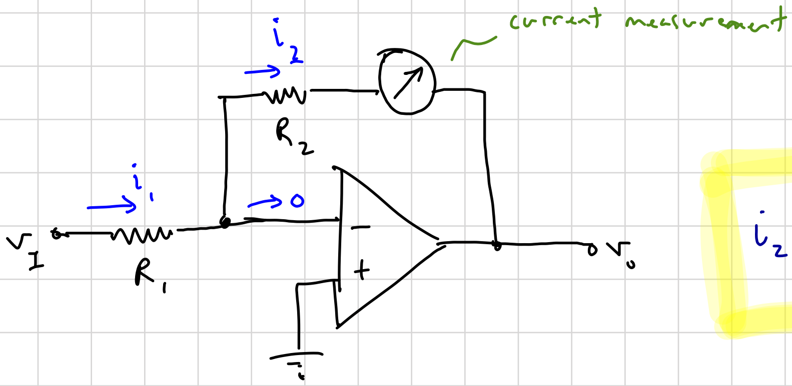


since $R_i = \frac{v_1}{i_1} \simeq 0 \rightarrow R_s >> R_i$, $i_1 = i_s = i_2$

$$\boxed{v_o = -i_2 R_F = -i_s R_F}$$

conversion based linearly on R_F

- Voltage-to-current converter



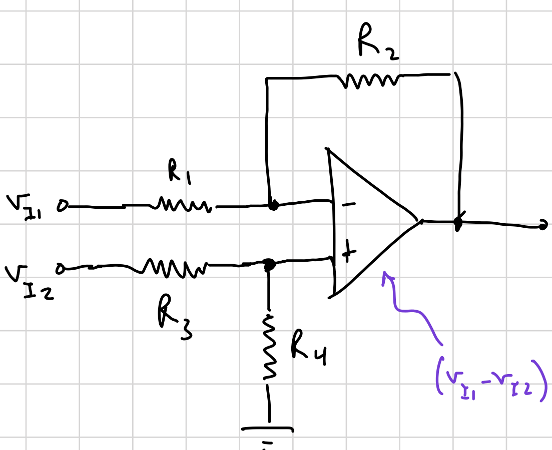
$$\boxed{i_2 = i_1 = \frac{v_I}{R_1}}$$

There are more complex versions but the same principle applies:

$$i = \frac{v_I}{R}$$

- Difference Amplifier

→ an inverting or noninverting type amplifier for difference (gain depends on ratio of resistors)



Analyze using superposition and concept of "virtual short"

→ set $v_{I1} = 0$, solve for v_o
→ set $v_{I2} = 0$, solve for v_o
add

$$\boxed{v_o = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4/R_3}{1 + R_4/R_3}\right)v_{I2} - \frac{R_2}{R_1} v_{I1}}$$

However, must have $v_o = 0$ if $v_{I1} = v_{I2}$ (no difference) to eliminate unwanted feedback.

$$\therefore \frac{R_4}{R_3} = \frac{R_2}{R_1} \quad \text{and} \quad \boxed{v_o = \frac{R_2}{R_1}\left(v_{I2} - v_{I1}\right)}$$

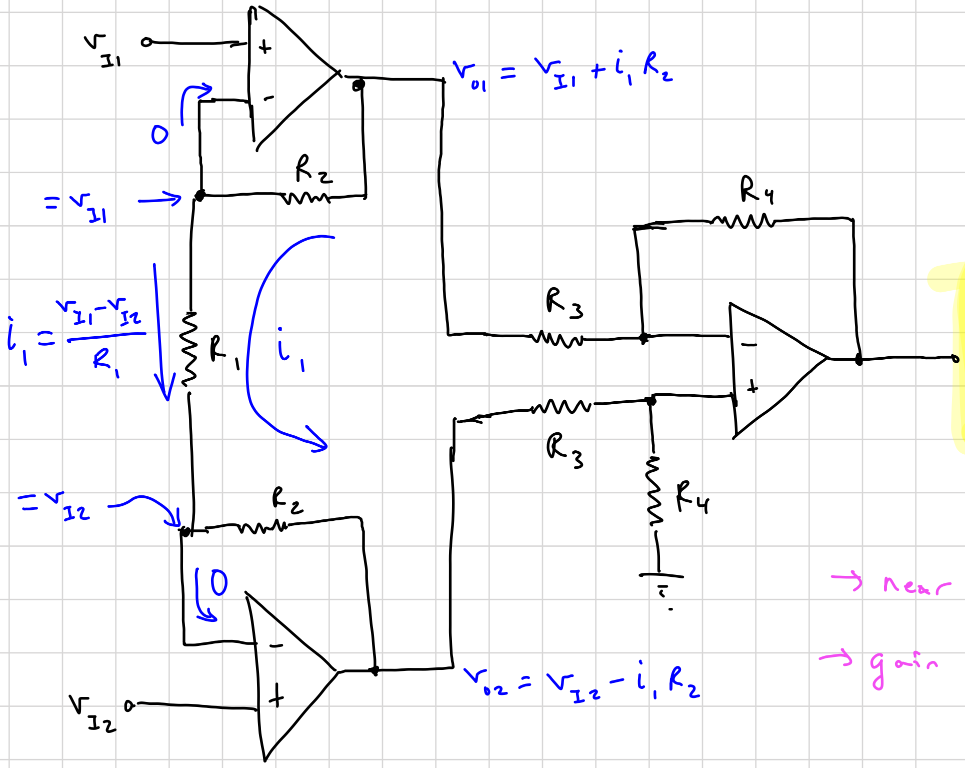
NOTE: Input resistance is $R_i = 2R_1$ if $R_1 = R_3$ and $R_2 = R_4$

- Instrumentation Amplifier

→ Need high input impedance and high gain difference amplifier

→ acheive by using voltage-follower op-amp on each input

→ Also, want to control gain by a single resistor

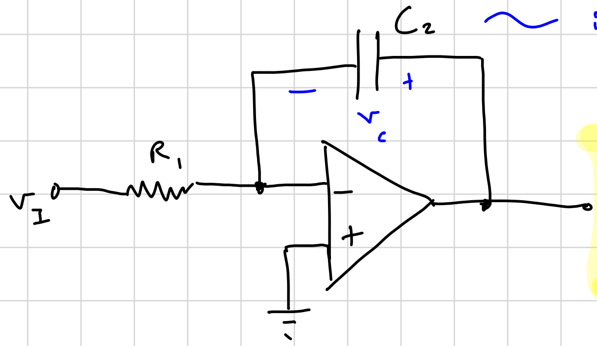


$$\boxed{v_o = \frac{R_4}{R_3}\left(v_{O2} - v_{O1}\right) = \frac{R_4}{R_3}\left(1 + \frac{2R_2}{R_1}\right)\left(v_{I2} - v_{I1}\right)}$$

→ near ∞ R_i because v_{I1} and v_{I2} go directly into opamp terminal

→ gain is direct function of R_1, which can be varied

- Integrator op-amp



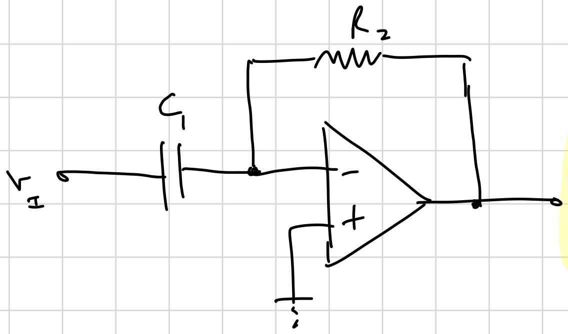
~ impedance ; $Z_2 = \frac{1}{sC_2}$ complex frequency

$$\boxed{v_o = v_c - \frac{1}{R_1 C_2}\int_0^t v_I(t')\,dt'}$$

voltage at capacitor at $t = 0$

⟹ useful in filter circuits to trim certain types of time varying signals.

- Differentiator Op-Amp



$$\boxed{v_o = -R_2 C_1 \frac{d v_I(t)}{dt}}$$