# Engr098 Lab5

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## Objective

The goal of this experiment is to determine the closed-loop voltage gain $\frac{v_o}{v_s}$ and output current $i$ for the non-inverting op-amp circuit using a 741 operational amplifier. The analysis will be performed analytically and verified with PSpice simulation.

## Given Parameters

- Open-loop voltage gain $A = 2 \times 10^5$
- Input resistance $R_i = 2\ \mathrm{M\Omega}$
- Output resistance $R_o = 50\ \Omega$
- Feedback resistor $R_f = 20\ \mathrm{k\Omega}$
- Input resistor $R_1 = 10\ \mathrm{k\Omega}$
- Source voltage $v_s = 2$ V

## Circuit Diagram

## Theoretical Analysis

### Step 1: Closed-Loop Gain Derivation

For a non-ideal op amp with finite open-loop gain $A$, the closed-loop gain is:

$$\frac{v_o}{v_s} = \frac{A \cdot \beta}{1 + A\beta}$$

where

$$\beta = \frac{R_1}{R_1 + R_f} = \frac{10\,\mathrm{k\Omega}}{10\,\mathrm{k\Omega} + 20\,\mathrm{k\Omega}} = \frac{1}{3}$$

Thus,

$$A\beta = (2 \times 10^5)\left(\frac{1}{3}\right) = 6.67 \times 10^4$$

Hence,

$$\frac{v_o}{v_s} = \frac{A}{1 + A\beta} \cdot \frac{R_1 + R_f}{R_1} = \frac{2 \times 10^5}{1 + 6.67 \times 10^4} \cdot 3 \approx 2.99$$

### Step 2: Output Voltage and Current

$$v_o = 2.99 \times v_s = 2.99 \times 2 \text{ V} = 5.98 \text{ V}$$

The output current through the 20 kΩ feedback resistor is

$$i = \frac{v_o}{R_f} = \frac{5.98 \text{ V}}{20 \text{ k}\Omega} = 2.99 \times 10^{-4} \text{ A} = 0.299 \text{ mA}$$

## PSpice Simulation

**Simulation results:**

$$v_o \approx 5.98 \text{ V}, \quad i \approx 0.30 \text{ mA}$$

## Discussion

The analytical and simulated values are consistent. Because the open-loop gain $A$ is very large, the closed-loop gain approaches the ideal value:

$$\frac{v_o}{v_s} \approx 1 + \frac{R_f}{R_1} = 3$$

The small difference (2.99 instead of 3) is due to the finite open-loop gain and nonzero output resistance.

## Conclusion

The closed-loop voltage gain of the op-amp circuit is approximately:

$$\boxed{\frac{v_o}{v_s} = 2.99}$$

and the output current when $v_s = 2$ V is:

$$\boxed{i = 0.30 \text{ mA}}$$

Theoretical and simulation results match closely, verifying the circuit design and analysis.