

# Problem Set 06: Operational Amplifier Circuits

BME253L - Fall 2025

2025-11-07

Please complete the following problems and tasks, and upload your solutions to Gradescope, using the [formatting guidelines](#) below.

## 1. Design an Amplifier

You have an input signal described by the equation:

$$v_{in}(t) = 0.1 \sin(2000\pi t) \text{ V}$$

Design an operational amplifier circuit that is powered by  $\pm 12 \text{ V}$  that meets the following specifications:

- Gain: The output signal should have a peak voltage of 5 V.
  - Phase Shift: The output signal should be inverted (180-degree phase shift).
- a. Sketch your circuit, labeling all relevant components and their values.
  - b. Derive the expression for the output voltage  $v_{out}(t)$ .
  - c. Plot both the input and output signals over 5 periods of the input signal. Be sure to label your axes, including units.

## 2. Input Impedance

- Describe why we typically want the input impedance of an op-amp circuit to be very high.
- What is the input impedance of your circuit from Problem 1?
- If the input impedance of your circuit from Problem 1 isn't "ideal" given the considerations you described in part (a), suggest a modification to your circuit that would improve the input impedance.

## 3. Op-Amp Saturation

You have an input signal described by the equation:

$$v_{in}(t) = 0.2 \cos(1000\pi t) \text{ V}$$

What is the maximum gain that you can achieve with a single op-amp stage powered by  $\pm 12$  V without clipping the output signal?

## 4. DC Offset

You have an input signal described by the equation:

$$v_{in}(t) = 0.05 \sin(500\pi t) + 0.5 \text{ V}$$

Design an operational amplifier circuit powered by  $\pm 12$  V that creates an output signal described by the equation:

$$v_{out}(t) = 2 \sin(500\pi t) \text{ V}$$

### Note

Note the phase of the output signal relative to the input signal. You can use more than one op-amp stage if necessary.

- Sketch your circuit, labeling all relevant components and their values.
- For your design, how much power does your  $v_{in}(t)$  signal source deliver if your overall circuit is driving a load of 100 k $\Omega$ ?

## 5. Differential Amplifier

For the differential amplifier circuit that was presented in [lecture](#), we make an assumption that  $R_1 = R_2$  and  $R_3 = R_4$ .

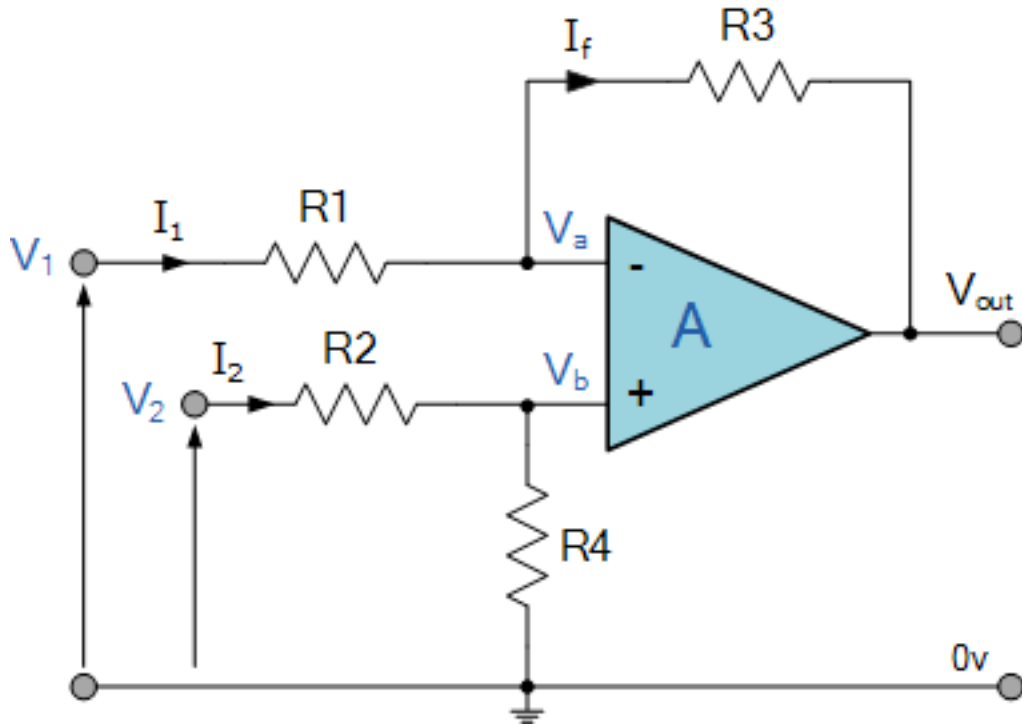


Figure 1: Differential Amplifier Circuit

If  $R_2 = (1 \pm 0.1)R_1$  and  $R_4 = (1 \pm 0.1)R_3$ , meaning that the resistors can vary by as much as 10% from their nominal values, what is the maximum possible error in the output voltage  $V_{out}$  when the input voltages are  $V_1 = 2$  V and  $V_2 = 1$  V? Assume that  $R_1 = R_3 = 10$  k $\Omega$ .