INSTRUMENTAL ANALYSIS LAB
OPERATIONAL AMPLIFIERS

In this experiment you will work through a couple of handouts from Forest M. Mims III on op amp circuits. You will build a) voltage follower, b) the inverting op amp circuit, c) the non-inverting circuit, d) the difference amplifier circuit, and e) the summing amplifier circuit.

For each circuit you should generate a table of four input voltages and the corresponding output voltage. From the table calculate the gain of each circuit. Compare the actual gain with the predicted gain.

In your lab report please include detailed circuit diagrams for each circuit that you built and a description of the circuits function.

REFERENCES:
  o Fig 3-5: Voltage Follower
  o Fig 3-7: Inverting Voltage Amplifier
  o Fig 3-13: Difference Op Amp
  o Fig 3-13b: Summing Op Amp
  o See pp 69-03 for CMRR

HELPFUL HINTS AND PRECAUTIONS

1. Please note the pin assignments from the top view of the 741 OP-AMPs that you will be using. (Incorrect pin assignments can cause the Op-AMP to explode.)

2. Leave the power off until all of your connections have been checked. I suggest that you have another student check your set-up before turning the power on.

3. Note that it is common practice to omit the connections to the positive and negative power supply voltages in the circuit diagrams. However, they
must be properly connected. The pin that should be connected to the positive power supply is commonly marked +Vcc or +Vs. The pin for the negative supply is commonly marked -Vcc or -Vs. See figures 1 and 2 on the linear op amp circuits handout.

4. A good operating procedure is to number the pin connections on the circuit diagram before making the connections on the board.

5. A resistor color code is provided in the handout for your convenience. You may also reference may good resister charts on the web.

6. A method for nulling the input voltage offset is given below:

LABORATORY INSTRUCTIONS WEEK 1:
Working from the selected portions of Mim's notebook, Skoog, and the applications note, build the following circuits using any resistors you choose (but choose them wisely!) and the 741 Op Amp provided:

a) the inverting op amp circuit

b) the non-inverting circuit

c) the summing amplifier circuit

d) the difference amplifier circuit

e) the difference amplifier to measure the CMRR

For each circuit that you build, include the following in your notebook: (1) a detailed circuit diagram, (2) a clear legend to identify the resistances of all resistors chosen, and (3) an equation to describe the circuit function. For each circuit, set one input voltage to several separate values and measure the corresponding output voltage. Record your observations, including limits to the voltages you can generate.

TO HAND IN WEEK1:
• For each circuit generate a table of input voltages, the corresponding output voltage measured, and the output voltage expected from theory. Quantitatively compare these voltages using the appropriate statistical test. Explain possible sources of variations between the measured and expected output voltages (propagation of resistor errors would be best here!). Consider errors such as those of the resistors as well as any limitations of the circuit.

• Using the data from the difference amplifier set up with the same voltage at each input and measure the common mode rejection ratio (CMRR) of your 741 op amp. How useful
will circuits containing this op amp be for separating a sample signal from environmental noise (Hints: What does Mims reference give as characteristic CMRR for 741 opamp? What is a dB?)

LABORATORY INSTRUCTIONS WEEK 2:

Design an op amp circuit to measure the temperature of a solution using a pair of thermocouples. Use figure 13-3 in Skoog as a starting point, but add the following capabilities to the circuit:

a) Add a circuit to null the instrument response (set the response to zero for samples with identical temperatures).

b) Add a circuit to linearly shift the instrument response in a positive or negative direction.

c) Add a circuit to change the output gain of the instrument.

d) Add a circuit to integrate the output signal over a time period of 30 seconds.

Turn in your preliminary design at the start of lab on week two. 30% of your lab grade will be based on you preliminary design.

Test and modify your design in the lab. Consider using both fixed resistors and potentiometers for both the gain control and the null circuits.

Calibrate your circuit at two gain levels by measuring circuit output as a function of water temperature. Use appropriate statistical test to evaluate the circuit gain and associated error in the gain. What is the error in temperature measurements using the thermocouple and your circuit? Why would the integration circuit be useful for temperature measurements?

(Figures A,B, C, and D) will be provided in Lab.