Do Laboratories individually. If you have a trainer board, it would be helpful to bring it.

Preliminary –
- You will be using the LF 351 Op-amp IC. It would be good to print out of the datasheet.

**Operational Amplifier**

![Op Amp Schematic](image1)

![Op Amp IC Schematic](image2)

**Preliminary**
- What would you expect the output voltage to be relative to the input voltage?

**Experimental**
- Wire the operational amplifier with $R_F = 30\,\text{K}\Omega$ and $R_1=10\,\text{K}\Omega$. The input voltage source can be a 1000 Hertz sinusoidal waveform with amplitudes that will be varied.
- Wire $V_{EE} = -15\,\text{Volts}$ and $V_{CC} = +15\,\text{Volts}$. Pin 3, the positive input will be wired to ground which MUST be a common ground with the source. The input is wired to pin 2 and the output taken from pin 6.
- What is the maximum output voltage you would expect to see based on the power source?
- Set the signal generator at several voltages below this and verify that the amplifier is processing the signal with the amplification expected. Sketch or print the waveform.
- Increase the voltage to see the “clipping” effect. Sketch or print the waveform.
- Change the circuit to attenuate the input signal by a factor of $\frac{1}{2}$ instead of amplifying it. Be careful to chose the resistors in the correct range – too low = high current = magic smoke being let out of the IC, too large and the current into the amp may not equal zero. Sketch or print the waveform.
**Summing Amplifier (time permitting, extra credit)**

![Summing Amplifier Diagram]

Figure 3: Summing Amplifier

In this summing amplifier circuit, $R_1$ and $R_2$ are 1 kΩ resistors, $R_F$ is a 2.4 kΩ resistor and $R_{1\text{pot}}$ and $R_{2\text{pot}}$ are potentiometers wired to vary between 0 and 5 kΩ. If you are using a trainer board, you can use the 1 kΩ pot instead of one of the 5 kΩ pots. The output will be on channel 2 of the oscilloscope. Channel 1 can be used to see the input signals if desired. Be aware that you may have to change the trigger channel on the oscilloscope.

**Prelab**
- Write the equation relating $V_O$ to $V_1$ and $V_2$.
- What is the range of amplifications/attenuations for $V_1$ and $V_2$.

**Lab**
- Construct the summing circuit.
- Set $V_1$ to a sine waveform of approximately 200 kHz and 1 Vpp and set $V_2$ to a sine waveform of approximately 100 Hz and 10 Vpp.
  - Vary the potentiometers (especially $R_{1\text{pot}}$) to see the affect on the output signal of attenuating or amplifying noise (the high frequency signal). Think about which signal you would prefer.
  - Sketch or print a waveform with and without a lot of noise.