1. An oscilloscope screen with vertical sensitivity of 5V/div and horizontal sensitivity of 2 msec/div is shown below. A function generator supplies an input signal to a 741 op-amp circuit with ±16 V power.
   - Sketch a 125 Hz, 10 Vp-p input triangle wave.
   - Sketch the output waveform if the 741 op-amp circuit has a gain of -4.

2. Mark the following questions with a T (for true) or F (for false):
   ___ a. The resolution for an ADC is the range divided by $2^N$, where $N$ is the number of bits.
   ___ b. The DMMs used in the ME 360 labs have both manual and autoranging scales.
   ___ c. Uncertainty is the difference between a measured value and the true value.
   ___ d. A multiplexer is a switching device to connect different analog signals to the same ADC.
   ___ e. In Signal Express the user selects the sampling rate and the number of samples to read.
   ___ f. In LabView the Front Panel and Block Diagram are used to create a VI (Virtual Interface).
   ___ g. To prevent aliasing, sample a signal at less than 5-10 times its highest frequency component.
   ___ h. An op-amp circuit should have an input impedance of at least 10 kΩ to prevent loading.
   ___ i. All measured values have both bias and precision uncertainties.
   ___ j. Computed uncertainty is based on partial derivatives.
3. An ME professor’s son weighs 125 pounds. What is the professor’s son’s mass in both \textit{lbm} and \textit{kg}?

4. A motor shaft is rotating at 1750 RPM. What is the shaft speed in \textit{Hz}? What is the shaft speed in \textit{rad/sec}?

5. You are given two capacitors: $C_A = 0.00047 \ \mu F \ (\pm 5\%)$ and $C_B = 220 \ pF \ (\pm 2\%)$
   - What is the parallel ($C_P$) capacitance in units of \mu F?
   - What is the uncertainty in the parallel capacitance ($U_{CP}$) in units of \mu F?
6a. Ten measurements of resistance (in kΩ) are listed below. Assume that the Thompson’s-τ approach has already been applied. Determine the mean value and the precision uncertainty for the mean at a 95% confidence level.

\[
\begin{array}{c|c|c|c|c}
9.79 & 10.01 & 9.92 & 9.93 & 9.83 \\
9.85 & 9.91 & 10.02 & 9.86 & 9.78
\end{array}
\]

6b. An Agilent #34405A DMM was used to measure the resistances tabulated above. Data from the manufacturer’s spec sheet is given below. Note that all of the resistors were measured (accidentally!) on the 1.00000 MΩ scale. Determine the bias uncertainty in resistance for the mean or average resistance value.

**Table 24** DC Accuracy ± (% of reading + % of range)

<table>
<thead>
<tr>
<th>Function</th>
<th>Range [Ω]</th>
<th>Test Current or Burden Voltage</th>
<th>Input Impedance [Ω]</th>
<th>1 Year 23°C ± 5°C</th>
<th>Temperature Coefficient 0°C - 18°C</th>
<th>28°C - 55°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>100.0000Ω</td>
<td>1.0mA</td>
<td>-</td>
<td>0.05±0.008 [3]</td>
<td>0.0060±0.0008</td>
<td></td>
</tr>
<tr>
<td>1.00000kΩ</td>
<td>0.83mA</td>
<td>-</td>
<td>-</td>
<td>0.05±0.005 [3]</td>
<td>0.0060±0.0005</td>
<td></td>
</tr>
<tr>
<td>10.0000kΩ</td>
<td>100μA</td>
<td>-</td>
<td>-</td>
<td>0.05±0.006 [3]</td>
<td>0.0060±0.0005</td>
<td></td>
</tr>
<tr>
<td>100.000kΩ</td>
<td>10.0μA</td>
<td>-</td>
<td>-</td>
<td>0.05±0.007</td>
<td>0.0060±0.0005</td>
<td></td>
</tr>
<tr>
<td>1.00000MΩ</td>
<td>900nA</td>
<td>-</td>
<td>-</td>
<td>0.06±0.007</td>
<td>0.0060±0.0005</td>
<td></td>
</tr>
</tbody>
</table>
7. A moment causes a stress in a beam due to bending according to the formula, \( \sigma = \frac{6PL}{wt^2} \). Nominal measured values and bias uncertainties are listed below.

- load, \( P = 57.8 \text{ lbf} \pm 2\% \)
- length, \( L = 1.78 \text{ feet} \pm 0.03 \text{ feet} \)
- width, \( w = 5.678 \pm 0.062 \text{ inch} \)
- thickness, \( t = 0.197 \pm 0.003 \text{ inch} \)

a. Determine the nominal bending stress, \( \sigma \) (in psi)

b. Determine the uncertainty in the bending stress, \( U\sigma \).

c. Which measurement had the largest effect on the uncertainty in the bending stress?

d. If you eliminated the uncertainty in the measurement found in c), what would be the remaining uncertainty in the bending stress, \( U\sigma \)?
8. Design a two op-amp circuit that will convert the load cell output values (E₁) to the desired circuit output values (E₀) in the table on the right. Use standard ME 360 resistor values, i.e., 10kΩ, 33kΩ, 56kΩ, 100kΩ, 330kΩ and 560kΩ.

   a) Draw a schematic diagram of your circuit showing all connections to power, input E₁, and output E₀.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Load Cell Output, E₁</th>
<th>Circuit Output, E₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg</td>
<td>mV</td>
<td>volts</td>
</tr>
<tr>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2.3</td>
<td>-39</td>
<td>2.3</td>
</tr>
<tr>
<td>4.9</td>
<td>-83</td>
<td>4.9</td>
</tr>
<tr>
<td>7.6</td>
<td>-128</td>
<td>7.6</td>
</tr>
</tbody>
</table>

   b) Draw your circuit on the breadboard below. Show all power and input/output connections to the circuit. Draw resistors like this — 47 k —