COMPUTER BASED PORTION. You may reference a single sheet of prepared notes if you like. You must submit appropriate printouts for grading. You are encouraged to document your computer work with comments and/or visible formulae.

1. (15%) ME 460 students always need to know the “uncertainty” in a measurement. During an experiment, they obtain 5 readings from a thermocouple using a digital readout for the temperature of boiling water (which should be a constant value). These temperatures are 99.35, 99.25, 99.85, 100.00, and 99.40. Using these temperatures, estimate the 95% confidence interval (“uncertainty”) in the measurement for the temperature of the water. Print out appropriate documentation of your analysis – make sure your name is on it!

2. (15%) A class of 32 students is given an exam and the average grade is 77 with a standard deviation of 9.2. Assume the grades are normally distributed.
   a) Estimate the number of students whose grade is greater than 90.
   b) What is the probability that the average grade for 5 students selected at random is greater than 90?
   Print out appropriate documentation of your analysis – make sure your name is on it!

3. (15%) You get a real job paying $65,000 per year. You want to buy a new home that costs $180,000. Your meager savings of $10,000 will provide a downpayment to reduce the purchase price. Two loan options are available: a 20 year loan at 7% APR interest or a 30 year loan at 6% APR. These loans are compounded monthly with an interest rate MPR = APR/12. The house appreciates in value and is expected to be worth $300,000 in 20 years and $400,000 in 30 years.
   a) How much would your monthly loan payments be for each option?
   b) Taking account of the appreciated value as “Salvage Value”, what is the “Monthly Worth” of each option? Which loan is most affordable based on this criterion?
   c) What is the total interest paid for each loan over the life of the loan? Would this change your selection?
   Print out appropriate documentation of your analysis – make sure your name is on it!

4. (15%) A company must replace a process line and faces two options.

<table>
<thead>
<tr>
<th></th>
<th>First Cost</th>
<th>Annual Cost</th>
<th>Salvage Value</th>
<th>Life, years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option A</td>
<td>-$30,000</td>
<td>-$8,000</td>
<td>$ 0</td>
<td>2</td>
</tr>
<tr>
<td>Option B</td>
<td>-$45,000</td>
<td>-$10,000</td>
<td>+$5,000</td>
<td>6</td>
</tr>
</tbody>
</table>

   a) The MARR for the company is 15%. Use any suitable economic analysis to offer a recommendation for the company.
   b) If Option A will save the company $5,000 per year, compute the simple payback period.
   Print out appropriate documentation of your analysis – make sure your name is on it!
5. (15%) A small piece of metal at room temperature is immersed in boiling water at 100°C and the temperature of the metal is recorded at 2 sec intervals:

<table>
<thead>
<tr>
<th>Time, sec</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp, C</td>
<td>29.7</td>
<td>63.7</td>
<td>81.1</td>
<td>90.4</td>
<td>94.9</td>
<td>96.8</td>
</tr>
</tbody>
</table>

If the object has a lumped thermal capacitance, its temperature response follows:

\[ 0(t) = T_\infty - T(t) = \theta_0 e^{-t/\tau} \]

where \( \tau \) is the time constant for the mass and \( T_\infty \) is the temperature of the surroundings.

Use any useful feature of MatLAB or Excel to determine \( \tau \). Print documentation of your work.

3. (25%) The damped vibrations of a two-body system are described by

\[
\begin{bmatrix}
3 & 0 \\
0 & 1 \\
\end{bmatrix} \begin{bmatrix}
\ddot{x}_1 \\
\ddot{x}_2 \\
\end{bmatrix} + \begin{bmatrix}
2 & -1 \\
-1 & 2 \\
\end{bmatrix} \begin{bmatrix}
\dot{x}_1 \\
\dot{x}_2 \\
\end{bmatrix} + \begin{bmatrix}
2 & -1 \\
-1 & 3 \\
\end{bmatrix} \begin{bmatrix}
x_1 \\
x_2 \\
\end{bmatrix} = \begin{bmatrix}
0 \\
0 \\
\end{bmatrix}
\]

a) Write this system of equations as an equivalent system of first order ODEs.

b) Plot the motion and velocity of each of the two masses for \( 0 \leq t \leq 15 \) secs if \( x_1(0) = 1 \) and all other initial conditions are zero. Use a legend to distinguish the curves.

Test questions are on both sides of this sheet