NAME ___________________________________________

SECTION NUMBER _______________________________

CAMPUS MAILBOX NUMBER ________________________

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Problem 1 _________________/ 20

Problem 2 _________________/ 20

Problem 3 _________________/ 20

Total _____________________/ 60
Problem 1 (20 points)

The locomotive shown below is about to make contact with a bumper modelled as a set of springs and dampers. We wish to compute how much the bumper will deflect when the train runs into it. Create a new script file and name your program \texttt{lastname_problem1.m}.

The equations of motion for this train engine when it contacts the bumper are the following:

\[
\frac{dv}{dt} = -\frac{1}{m} (cv + kx) \quad v(0) = 10 \text{ m/s}
\]

\[
\frac{dx}{dt} = v \quad x(0) = 0 \text{ m}
\]

where \(v\) is the velocity of the engine and \(x\) is the deflection of the bumper, \(m\) is the mass of the engine (2000 kg), \(c\) is a damping coefficient (20,000 N-s/m), and \(k\) is a spring stiffness (40,000 N/m).

If you use the Euler method to solve this problem, your time marching equations will be:

\[
v_{i+1} = v_i - \frac{1}{m} (cv_i + kx_i) \Delta t
\]

\[
x_{i+1} = x_i + v_i \Delta t
\]

Write a program to solve these equations and find the maximum deflection of the bumper. Use a \(\Delta t\) of 0.01 sec. HINT: One way to find the maximum deflection would be to use a while loop and run your Euler method only while the velocity is positive. As soon as the velocity crosses zero, the bumper will be at maximum deflection and will start moving backwards.

Your program should print the maximum deflection to the command window like this:

\[
\text{The maximum deflection of the bumper is #.## m.}
\]
Problem 2 (20 points)

For this problem you will write a function and a main program. Call your function lastname_circle.m and your main program lastname_problem2.m.

The function should have the following form:

\[
\text{lastname\_circle}(x0, y0)
\]

The function should draw a circle with radius of 0.6 centered at \(x_0, y_0\).\(^1\)

The main program should do the following:

(a) Load the Excel file called pattern_data.xlsx. This will load a 2-column matrix. The first column is a series of \(x_0\) locations, and the second column is a series of \(y_0\) locations. Each row of this matrix represents an \(x_0, y_0\) pair where a circle should be drawn.

(b) Call the \text{lastname\_circle} function for each \(x_0, y_0\) pair from the Excel data. When you have done this for all the pairs, the figure window should look like this:

\[\text{Figure}\]

\(^1\) Recall that the equation for a circle with origin \(x_0, y_0\) and radius \(R\) may be written as

\[
x = x_0 + R \cos \theta
\]

\[
y = y_0 + R \sin \theta
\]
Problem 3 (20 points)

For this problem, you should write a main program called lastname_problem3.m. Your program should do the following:

(a) Load the data from the Excel file called data.xlsx. The data are a set of measured displacements taken from an experiment. The data points were sampled with a \( \Delta t \) of 0.001 sec. Plot EVERY 10\(^{th} \) POINT of this data set versus time. (That is, plot the 1\(^{st} \) point, 11\(^{th} \) point, 21\(^{st} \) point, and so forth.) Use red ‘+’ symbols to plot the data.

(b) Your program should then plot the following function using a blue line—again use a \( \Delta t \) of 0.001 sec. Put the function on the same plot you created in part (a). The function is an analytical prediction of the experimental data—it is NOT a differential equation so you should NOT use Euler’s method.

\[
x(t) = Ae^{-kt} \cos(\omega t)
\]

where the following variables are constants: \( k = 0.2, \omega = 15.71, A = 2 \).

Label the \( x \)-axis as “Time [s]” and the \( y \)-axis as “Amplitude [m]”.

WHEN YOU ARE DONE, EMAIL ALL YOUR M-FILES TO YOUR INSTRUCTOR IN A SINGLE EMAIL.

COMPLETE THE PEER EVALUATION ON THE NEXT PAGE.

TURN IN THIS EXAM PAPER AND CHECK THAT YOUR FILES HAVE BEEN RECEIVED BY YOUR INSTRUCTOR BEFORE YOU LEAVE.
ROSE-HULMAN INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

ME 123  Comp Apps I

PEER EVALUATION:

Your name (again):___________________________

Name of your partner for project 1 ________________________________
Comments regarding your partner for project 1:

Name of your partner for project 2 ________________________________
Comments regarding your partner for project 2:

Name of your partner for project 3 ________________________________
Comments regarding your partner for project 3: