

## Assignment 10: Functions and Differential Equations (40 Points)

Date Due: April 26, 2024

Instructor: Trani

### Problem 1

Steel is an important material to civil engineers because it is used in the construction of building structures. The certification of steel beams requires heating over a period of time to test their properties for fire safety. The first-order differential equation ( $dT/dt$ ) that estimates the rate of change of temperature of a steel beam as a function of time is:

$$\frac{dT}{dt} = -H1(T - T_a)^{1.2} - H2(T)^{0.25}$$

Where:

$\frac{dT}{dt}$  is the rate of change of the steel beam temperature with time (degrees C./minute)

$T$  is the steel beam temperature (degrees C.)

$T_a$  is the ambient temperature (degrees C.)

$H1, H2$  are a constants of proportionality (1/minutes)

$t$  is the time of the cooling process (minutes)

#### Task 1

Create a Simulink model to estimate the temperature profile of the steel beam tested in the laboratory. Assume the following parameters:

$T_a = 18$  degrees Celsius

$T_o = 280$  degrees Celsius (initial temperature of the steel beam)

$H1 = 0.08$  (1/minutes)

$H2 = 0.03$  (1/minutes)

Simulate the cooling period to be 60 minutes.

#### Task 2

Export the temperature profile to Matlab and make a nice plot of temperature against time.

Use the plot generated to find the time for the beam to reach 200 and 100 degrees. You can find the times from the graphical solution or by interpolating the exact value of time from the Simulink model output.

#### Task 3

If a fire-rated cementitious compound is applied to the steel beam changes the value of  $H1$  to 0.20, find out the changes in the cooling time to reach 200 and 100 degrees Celsius.

## Problem 2

Use Matlab to solve a recent problem in one of your other CEE classes. The idea is to solve the problem parametrically to obtain a solution for multiple input values in the problem. The solution requires that **you create a function in Matlab to solve the problem**. The function needs to have at **least one output and one or more inputs**.

### Task 1

Describe the problem. Tell the variables that need to be evaluated and the known input parameters.

### Task 2

Create a function in Matlab to solve the problem. Clearly state the input(s) and your output(s) of the function.

### Task 3

Use a Matlab script to call the function created in Task 2 and solve the problem parametrically for several numerical values of the input.

### Task 4

Make a plot of your input vector versus the output. Make a comment on the output.

## Problem 3

A formula to estimate the roadway noise of an interstate highway is:

$$L=10*\log_{10}(q)+20*\log_{10}(u)-10*\log_{10}(d)+25;$$

where:

L = Sound pressure level (dBA) at location of the observer  
q = traffic volume(veh/hr)  
u = mean speed(mi/hr), and  
d = distance from the highway to the center of observer(ft).

Note log10 in Matlab is the logarithm base 10.

### Task 1

Write a **Matlab function** to calculate the value of L given values of q, u, and d.

### Task 2:

Create a Matlab script (separate to the function) to test the Matlab script created in Task 1 to calculate the value of L under the following conditions: q = 2500 veh/hr, u = 60 mi/hr, and d = 200 feet. Display the solution in the Command Window. Label appropriately.

### Task 3

Modify the Matlab script to create solutions for L as a function of distance to the observer (to be plotted in the x-axis) ranging from 200 to 1,000 feet (steps of 50 feet). Plot the answers obtained. Use Matlab vector operations and not a FOR loop.

### Task 4

OSHA requires parks and recreational areas to be located in land with noise levels (L) below 65 dBA. Using the solution obtained in Task 3, state the minimum distance needed from a park to the highway.