ME 355 – System Modeling and Numerical Methods
Fall 2021

Project 2

Due Monday, October 4 by 11:59 pm
Preliminary functions due Friday, October 1 by 11:59 pm
This project must be turned in on Blackboard.

You are designing a hemisphere tank to hold water for a small village in a developing country. Due to budget constraints, it's important to keep the cost of the project down while fulfilling the needs of the village. From a case study, it is determined that the village requires a maximum of 100 m^3 of water to be stored at any given time. For safety, the CEO specifies that we should have a margin of safety of 15% of the maximum volume required for the volume of the tank.

However, the tank does not need to be full year around. For example, during the winter, the village only needs to have 40 m^3 water available. For the villagers to measure the current water in the tank, your project team decides to include a height gauge that measures the height of the water from the base of the tank.

Your job is to develop a program that determines what the height gauge should read based on the current m^3 water need of the village. You plan to accomplish this task by:

1) Modeling the volume of the water in the tank based on the height of the water, making sure to list all assumptions and including a diagram of the system.
2) Developing a function that calculates the volume of water based on the height of the gauge and the radius of the hemisphere tank.
3) Develop a root finding function in MATLAB.
4) Developing a function that utilizes the root finding function to calculate the gauge height based on a desired volume of water and radius of the tank.

Functions

To complete this task, you will need to develop **3** MATLAB functions. Preliminary versions of these functions are due on the date specified above. To get full credit for the preliminary functions you must have made a legitimate attempt. You may make changes to the functions after the preliminary function due date and prior to the final due date.

1. **volume.m**
   This function calculates the volume inside a hemisphere tank. **value = volume(h, r)** where h is the height gauge reading, r is the radius of the hemisphere, and value is the current volume of the tank based on the height gauge reading.

2. **bisection.m**
   This function performs the bisection method. **root = bisection(f, xl, xu, tolerance)** where f is an anonymous function with one independent variable, xl and xu are the lower and upper bounds of the bisection method respectively, and tolerance is the acceptable value such that the bisection algorithm is ran until the relative approximate error is less than the tolerance. Note that tolerance is a decimal, NOT a %. It can be assumed xl < xu and tolerance > 0. Be sure check if there is a guaranteed root between xl and xu and error if not!

3. **tank.m**
   This function uses the bisection method to calculate the height of the tank to within n significant figures. **height = tank(V, r, n)** where V is the desired volume of water in the hemisphere tank, r is the radius of the hemisphere tank, and height is the height gauge reading for the current volume. This function must utilize the bisection.m function and the volume.m function defined prior. You will need to assign your volume.m function as an anonymous function to be able to call bisection.m.

Modeling Documentation

For your project, your project lead requests a modeling document to describe your modeling rationale and to examine how your solution improves as the number of significant figures increases. As such, your modeling documentation must contain the following sections.

1. Introduction to the problem.
2. Explanation of your model, including your assumptions, a diagram of the system including important dimension information such as the radius and height gauge, and the model equation. The diagram can be hand drawn; however, it must be inserted into your document as a figure. Your model equation needs to be in your document as a formatted equation. For guidelines on how to format your figure and equation, refer to the **Example Report** on Blackboard. If you use ANY resource to assist you in creating the model, you must cite your source; any citation format is acceptable.
3. A study of **tank.m** where you examine the impact of increasing the value of n from 1 to 10. You should use 40 m^3 and a radius corresponding to the problem statement above for this study. You will need to plot n versus the height **<u>clearly</u>**. This may require multiple figures and changing the x or y range. Also examine the impact of changing the volume from 40 m^3 to 100 m^3. Be sure to present and then discuss these results. You should perform this study in a file called **project2.m**.
4. A brief conclusion.

Deliverables

Be sure to submit all 5 files!

1. volume.m
2. bisection.m
3. tank.m
4. project2.m
5. Modeling Documentation PDF

Rubric (Total 100 Points)

Functions 1 – **10 Points**
Functions 2 – **20 Points**
Functions 3 – **10 Points**
Turned in preliminary functions on time **– 10 points**

Modeling Documentation – **50 Points**

- Professional Format – **10 Points**
- Introduction – **5 Points**
- Model – **10 Points**
- Study – **20 Points**
- Conclusion – **5 Points**

Notes for Report

For any equations, please use the equation editor.
For Figures and Tables, please follow the guidelines outlined in the example report on Blackboard.
Include a title page.

Notes for Functions

These notes do not apply to the **project2.m** file.
All functions must be named EXACTLY as listed above. This includes capitalization.
Functional inputs and outputs must be EXACTLY as defined in the Functions section.

Test Data

If you run the following code below in the MATLAB command window, you should get the following output. Do note, this does NOT guarantee your code is correct.

```
volume(2.5, 2)
ans = 22.9074

bisection(@(x) 2*x^2+3*x-2,-10,14,0.05)
Error!

bisection(@(x) 2*x^2+3*x-2,-1,1,0.05)
ans = 0.4844

tank(20,3,3)
ans = 1.6077
```