ENGR 121: Computation Lab I (Fall 2015–2016)

Programming Assignment 1

This assignment comprises two questions. It is due by 11:59 pm on October 26, 2015.

You must work on this assignment on your own. Plagarized code will result in a grade of zero for the assignment.

Please read the *Submission Instructions* section towards the end of this document that describes how to package your code and submit it on-line using the BBLearn system.

1. (**10 points**) In the absence of air resistance, the Cartesian coordinates of a projectile launched with an initial velocity v_0 (m/s) and angle θ_0 (degrees) can be computed with

$$x = v_0 \cos(\theta_0)t,$$
$$y = v_0 \sin(\theta_0)t - 0.5gt^2,$$

where g is the gravitational acceleration ($= 9.81$ m/s^2) and t is the time (s). Assume that $v_0 = 8$ m/s and write a well commented MATLAB script to generate a plot of the projectile's trajectory for various initial angles ranging from $60°$ to $75°$ in increments of $5°$. Note that θ_0 is in degrees and so use the appropriate MATLAB functions, **sind** and **cosd**, to obtain the corresponding trigonometric values. Generate a vector for t from 0s to 8s in increments of 1/128s.

Generate a single plot of the height achieved (y) versus horizontal distance (x) for each of the initial angles. Label the axes appropriately and use a legend to distinguish among the different cases. Scale the plot such that the minimum height is zero using the `axis` command. The following plot shows two such trajectories corresponding to launch angles of $60°$ and $75°$, respectively.
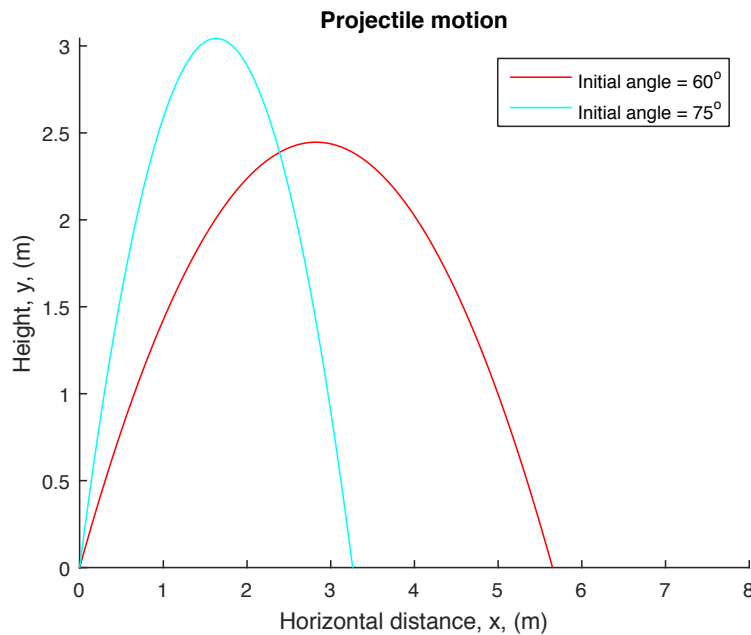
2. Medical studies have established that a bungee jumper's chances of sustaining a significant vertebrae injury increase significantly if the free-fall velocity exceeds 40 m/s after 5s of free fall. Your boss at the company wants you to determine the mass at which this criterion is exceeded given a drag coefficient of 0.35 kg/m. The following analytical equation can be used to predict fall velocity as a function of time:

$$v(t) = \sqrt{\frac{g \times m}{C_d}} \tanh\left(t \times \sqrt{\frac{g \times C_d}{m}}\right)$$

Here, v is the downward vertical velocity (m/s), t is the time (s), g is the acceleration due to gravity ($= 9.81$ m/s^2), C_d is the drag coefficient (kg/m), and m is the jumper's mass (kg). Try as you might, you cannot manipulate this equation to explicitly solve for m—that is, you cannot isolate the mass on the left side of the equation. So, an alternative way of looking at the problem involves subtracting $v(t)$ from both sides to give a new function:

$$f(m) = \sqrt{\frac{g \times m}{C_d}} \tanh\left(t \times \sqrt{\frac{g \times C_d}{m}}\right) - v(t)$$

We can now see that the answer to the problem posed by your boss is the value of m that makes the above function equal to zero. A simple and graphical approach for obtaining an estimate of the root of the equation $f(m) = 0$ is to make a plot of the function and observe where it crosses the x axis. This point, which represents the mass value for which $f(m) = 0$, provides a rough approximation of the root. Answer the following questions.

- **(10 points)** Write a MATLAB script that plots the function $f(m)$ versus m. Assume a drag coefficient of 0.35 kg/m, and for the bungee jumper to have a velocity of 40 m/s after 5s of free fall. Your output should look similar to the plot shown below when the mass is varied from 50 to 200 kg.
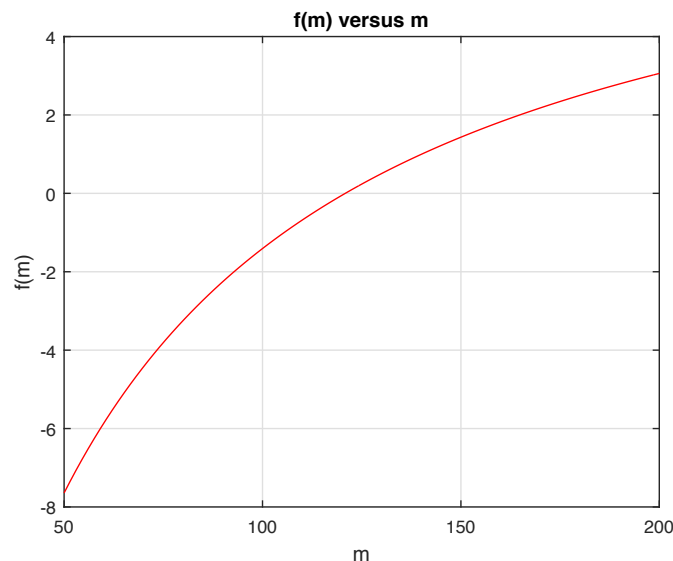
- **(10 points)** Use an algorithmic method to obtain the root automatically within your MATLAB code, that is you must not attempt to obtain the root via visual observation. Your code should achieve this by examining the vector containing the output values $f(m)$ and by pinpointing the value of m for which $f(m)$ is closest to zero. Use a `fprintf` statement to print this value. Your answer should be accurate to three decimal places.

Submission Instructions

Prepare a well-commented MATLAB script for each problem called:

Problem1_lastname_sectionnumber.m, and

Problem2_lastname_sectionnumber.m.

For instance, your files can be called Problem1_Smith_82.m and Problem2_Smith_82.m. Submit the two scripts through the BBLearn website under the link called "Assignments" by midnight of October 26, 2015. You may upload your work more than once; the latest uploaded copy will be evaluated.