ENSC 180: Introduction to Engineering Analysis

Craig Scratchley Spring 2021

Assignment #2 – Red Bull Stratos Jump

Due: March 22 at 2:20 pm

Part 1:

Use ode45 and the design of the simple freefall function from Section 10.3 of Physical Modeling in MATLAB to model Felix Baumgartner's altitude, velocity, and acceleration for the first minute after he jumped from 38,969.4 meters above sea level. Compare by plotting modeled altitude, velocity, and acceleration with the data that was measured[1] and data derived from those measurements. Write a function that takes as parameters at least the end time (in seconds) for a plot (60 seconds for Part 1), a title, and the modelled altitude and velocity, and makes plots for the altitude, the velocity, and the acceleration for both modeled and measured/calculated data (so 3 plots with both modeled and measured/calculated data on each plot). How accurate is the model for the first portion of the minute? How accurate is the model for the last portion of that first minute? Comment on the acceleration calculated from the measured data. Is there any way to smooth the acceleration calculated from the data? (You are allowed to install the Signal Processing Toolbox for MATLAB. Ask if you would like to use something from a different MATLAB toolbox.)

Part 2:

Now consider section 10.4 on air resistance. Use the modified acceleration function, but do some research to determine what mass, m, should be used in the function. Estimate your uncertainty in the mass that you have chosen. How sensitive is the velocity and altitude reached after 60 seconds to changes in the chosen mass?

Compare by plotting again the measured data with the modeled data. Use your plotting function from Part 1 and plot for the first 60 seconds again. How accurate is the revised model? What is good and bad about the revised model? How does the revised model do when one goes beyond 1 minute of the jump?

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[1] Measured data: You will initially be provided with draft spreadsheets containing data pulled out of the video below. We would like some volunteers to pull more and better data from the video. Please let us know if you are willing to help. The video is at:

https://youtu.be/raiFrxbHxV0

Part 3:

Felix was wearing a pressure suit and carrying oxygen? Why? What can we say about the density of air in the stratosphere? How is the density of air different at around 39,000 meters than it is on the ground?

Sections ***10.6*** and ***10.7*** of the textbook give a more-complete model of drag due to air resistance, and give a reference to a Wikipedia article.

https://en.wikipedia.org/wiki/Drag_(physics)

Can we include the changes in the density of air in our model? What are the factors involved in calculating the density of air? How do those factors change when we end up at the ground but start at the stratosphere? We are providing you with a function, *stdatmo*, which you can use to model the atmosphere up to at least the stratosphere, but please explain how calculating air density up to the stratosphere is more complicated than say just in the troposphere.

Consider the product C_dA in the equation for drag due to air resistance. What methods can we employ to estimate that product? Given what we are told in the textbook about the simple drag constant, b, and given the definitions of C_d and A, does the estimate seem reasonable? Compare the measured data with our updated model by plotting for the first 4.5 minutes using your plotting function. Now how accurate is the model?

Part 4: Improving our model in order to try to more closely match the actual data.

What is the actual gravitational field strength around 39,000 meters? (See Tipler Volume 1 6e page 369.) How sensitive is the altitude reached after 4.5 minutes of the jump to simpler and more complicated ways of modelling the gravitational field strength? What other changes could we make to our model? Refer to, or at least attempt to explain, the physics behind any changes that you propose. What is a change that we could make to our model that would result in insignificant changes to the altitude reached after 4.5 minutes? How can we decide what change is significant and what change is insignificant?

Part 5:

At what altitude does Felix pull the ripcord to deploy his parachute? Recalculate the C_dA product with the parachute open, and modify your code so that you use one C_dA product before and one after this altitude. Make a single acceleration-plot figure that includes, for each of the model acceleration and the acceleration calculated from measurements, the moment when the parachute opens and the following 10 or so seconds. If you have trouble solving this version of the model, try a different solver or, in the worst case, just plot the acceleration calculated from measurements. According to this version of the model, what is the maximum magnitude of acceleration that Felix experiences? How safe or unsafe would such an acceleration be for Felix?

Part 6:

How long does it take for Felix's parachute to open? Try to adjust your code to reasonably model the period when the parachute opens. A reasonable model will have a maximum magnitude of acceleration somewhat similar to that calculated from the measured data. Redraw the acceleration figure from the previous Part but using the new model. Also, using your plotting function from Part 1, plot the measured/calculated data and the model for the entire jump from stratosphere to ground.

Titles, labels and legends should be included in all figures.