

Exercise Set 7

Instructions

This assignment is due by 10 pm on Tuesday, 10/27. Please check off your solutions with a ninja *before* the submission deadline, then make corrections as needed and submit your marked-up solutions at <https://sites.google.com/site/modsim2015/exercise-submissions>.

Exercise 7.0

If you successfully completed Exercise 6.2, you now have MATLAB code that allows you to simulate the cooling of a cup of coffee via conductive heat transfer, with cream added to the coffee at any time from 0 to 30 minutes after pouring the coffee.

The following exercises will ask you to modify and extend that code in order to produce a punchline graph. Before doing that, you may wish to take a few minutes to tidy it up (e.g., quantities used more than once are defined in a single place, calculations performed more than once are moved to functions, etc.). This will help to ensure that you can manipulate your code without breaking it.

Exercise 7.1

Recall the simple “design question” posed in Exercise 5.2:

Should you add the cream immediately or wait—and if you should wait, then how long?

To answer this question quantitatively, it would be helpful to have a function that returns the time at which the coffee reaches (or falls below) a certain temperature, given the time that cream is added. Please construct such a function.

You may find it helpful to use an `ode45` “event” to identify the time the target temperature is reached. See section 11.1 of the Cat Book, and/or the MATLAB documentation for `ode45` and `odeset`.¹

¹ Try `doc ode45` or `doc odeset`.

How long does it take for the coffee-and-cream mixture to reach a temperature of 320 K if the cream is added 1 minute after the coffee is poured? What happens if you add the cream after 5 minutes? What about 10 minutes? Think about how your function should handle these situations.

(Assume you want cream in your coffee—in other words, you aren’t interested in situations in which you add cream after the coffee has already cooled to your desired temperature.)

Exercise 7.2

To summarize the relationship between the time cream is added and the time it takes for the mixture to reach 320 K, create a plot of these two variables.

If your goal is to start drinking your coffee as soon as possible, what is the optimal time to add cream? What is special about this particular time? Is the answer what you expected?

Exercise 7.3

Use MATLAB to compute the optimal cream-adding time.

You may find it helpful to use `fminsearch`, which works very much like `fzero` (which we previously encountered in the floating duck problem of Exercise 4.2). It should not take more than an extra line or two of code.

Notes

- If you've been keeping all of your coffee-related code in one `.m` file up to this point, you might consider breaking it up into separate files to keep the main file from getting unwieldy. You should find the resulting code easier to test (a good thing!) but it will require some extra effort to pass parameters around (possibly tedious but hopefully not difficult).
- If you choose to stay with a single `.m` file, read section 10.1 of the Cat Book and be sure you understand the distinction between nested and parallel functions.
- Once again, a big shout-out to Exercise 8.2 in the Cat Book!