

Computational Modeling & Simulation I (Interdisciplinary Science)
CS 346

Spring 2021

Homework 2—Stage 1

Due **BY 11:59PM** Monday, March 29

(Please see the notes below!)

- **IMPORTANT NOTE:** As it was with HW1 Stage 1, *collaboration is prohibited* on HW2 Stage 1. You must do **all work for this assignment without consulting with people** other than your Prof. and TA. (You may use resources from the `mathworks.com` domain, as usual.)

- HW2 is a 2-Stage assignment; this assignment sheet is for Stage 1.

Because the class cannot move on to Stage 2 until everyone has submitted Stage 1, **please be sure to submit your work on time!** Because of the need for on-time submissions, work submitted up to 24 hours late will be subject to a 2% penalty, and work submitted more than 24 hours late will be subject to a 20% penalty. Please make sure this does not affect you—please submit your work on time!

- Please read the **HW Notes & Guidelines** document (posted on the CS346 website) carefully! For this HW, each person should submit a single `.m` file and a single PDF document. Please use the string `HW2` in the folder name for submitting this assignment and `hw2` as part of filenames, as well as the required identifiers. See documents on the course website for additional HW guidelines and submission instructions.

Please make sure all submissions are to your Private folder!

The **HW Notes & Guidelines** document contains full instructions for submitting HWs, as well as containing other *important* guidelines about naming conventions for files you submit, and about your PDF write-up—not following those guidelines will result in deductions on your submitted work. Please read that document and let me know if you have any questions.

Project: Predator / Prey and Other Interactions!

- This assignment is about modeling system dynamics with interactions, focusing on predator / prey interactions. (See Chapter 4.2 of your textbook for additional details!) All code is to be written in Matlab; as usual, looking at a classmate's code or sharing specifics about code on an assignment is a violation of course policy (unless that classmate is your teammate for team assignments, which does not apply here).
- Some exercises ask you to develop models. When an exercise asks you to develop a model, your write-up should include not only the model itself—e.g., the differential equations (or finite difference equations), constants, and initial conditions that may

comprise the model—but also an explanation of how the model was developed, including what each variable / parameter in the model stands for (“ G is the growth constant ...”), what simplifying assumptions were made, and what the reasons were for your decisions (“We assume H is constant because we are modeling on the order of months, not years ...”). If other information is pertinent (e.g., why a certain variable / parameter is *not* present in a model), explain that in the write-up as well.

- Some exercises ask you to run simulations. When an exercise asks you to run a simulation, your write-up should include the values of constants / parameters employed for each run of the simulation (e.g., in simulation 0, $G = 0.01, dt = 0.1, \dots$; in simulation 1, $G = 0.01, dt = 0.01, \dots$) and a very brief explanation of why you chose to run those particular values for simulations (“We tested five values between 0 and 1 to illustrate how the system behaves with short time parameters, which is consistent with our assumption that ...”), as well as a description of the results of the simulation (“...observed that ..., and in particular, at time $t = 3$, ...”). Descriptions of results should be concise and information-heavy; feel free to include figures (e.g., Matlab plots of time series) in write-ups to illustrate your observations.
- Some exercises below ask for you to run multiple experiments / tests and come to conclusions based on the data you generate. As noted below, code submitted for these exercises would ideally, when run, perform sufficient tests (and display sufficient output) to convincingly demonstrate your conclusion, without needing to modify the code and run additional tests. Even though you may have done many, many tests to come to your conclusions—and that should be documented in your write-up (see the *HW Notes & Guidelines* document)—it is common in practice to have your code, when run, do a representative sample of the full range of tests you did; your write-up can thoroughly explain how a user of your code can modify code to run all of the tests you did, if they want to fully replicate your work.

In general, and for these exercises in particular, if it’s not stylistically possible or appropriate to automate testing that way, please explain that and give thorough instructions on how to use your code to replicate your results.

- As emphasized in other course documents, readability is essential: Please use good commenting and documentation style, and make sure both your code and your write-up are easy to read and understand.

Exercises

1. **Up The Food Chain!** These exercises are based on Project 3, Chapter 4.2 in your textbook—here, you’ll be modeling predator / prey interactions with three species involved! There’s a prey species Y (e.g., tuna) and a predator species P (e.g., sharks) that consumes Y , and in addition, there’s a third species H (e.g., humans) that hunts both P and Y .

- (a) Develop a predator-prey model for this scenario, under the assumption that H hunts P and Y equally—e.g., in the specific case mentioned above, that humans have equal fishing rates (i.e., the same rate constants in the relevant models) for tuna and sharks. Moreover, assume that the timeframe to be modeled will be on the order of months (rather than, e.g., decades), so we can assume the population of H stays constant over the time being simulated.

In your write-up (code is not required for this part of the exercise), give the differential equations for this model. As always, be sure to document your process, which includes listing the assumptions and sources used in developing the model!

- (b) Analytically solve (using mathematics, not computational tools such as Matlab!) for the equilibria solutions for the equations you developed. As always, explain your answers!
- (c) To illustrate the predator-prey interactions between P and Y , without H , use your model to run several simulations with no fishing (but with different values of other relevant factors for predator-prey interaction).

Then, run additional simulations with fishing, gradually increasing the fishing rate (i.e., the rate constant for H hunting P and Y), but keep it lower than the birth rate of Y . As always, document your process (including what values you used in simulations) and report your results.

For this part of the exercise, please submit the code for your simulations, which should include the display of visualizations to demonstrate your work (i.e., graphs of results). It could be effective and helpful to have time series visualizations both on-screen in Matlab upon running your code and also present in your write-up, as part of documenting your work.

In addition, please also answer the following questions in your write-up: As the fishing rate changes, what happens to the number of prey and predators? How do you explain the impact of predator H given your model of P , Y , and H ?