

# Math 36 – Mathematical Modeling for the Social Sciences – Fall 2020

**Website:** <https://canvas.dartmouth.edu/courses/43105/>. The website will contain all reading materials, lectures, and homework assignments related to the course and will be used to collect assignments. There will also be a Google Drive folder to hold code and datasets. The link to this shared drive will be posted on the Canvas page.

**Text:** Handouts and links will be posted on the Canvas page. An unofficial textbook for the first part of the course is “Introduction to the Modeling and Analysis of Complex Systems” by Hiroki Sayama, which is an OpenSUNY textbook and can be downloaded for free at <https://textbooks.opensuny.org/introduction-to-the-modeling-and-analysis-of-complex-systems/>

**Prerequisites:** Math 13 and Math 20 or equivalent.

**Instructor:** Warren Lord

**Contact Information:** Warren.M.Lord@Dartmouth.edu

**Office Hours:** To be determined (see section below on Course Format).

**x-hour:** The x-hour will not be used on a regular basis but you should keep that time slot (F 5:10-6:00pm ET) available in case we need to make up lectures due to unforeseen circumstances.

**Class meeting time:** Tu/Th 2:50-4:40pm. See section on Synchronous Component below for more detail.

**Course Overview:** The course will introduce you to the techniques of mathematical modeling. We will use Covid-19 modeling as an ongoing example throughout the course, although other examples from areas such as physics, ecology, economics, and sociology will also be introduced to motivate and practice specific modeling techniques. Modeling is inherently a cross-disciplinary subject and requires bringing together a wide range of skills. Although the emphasis will be on the mathematics behind the modeling techniques, the course will also introduce computing skills, scientific interpretation, and communication.

Although you will be expected to develop core competencies in each of the skill areas related to modeling, you are also encouraged to individualize your course objectives depending on your interests, background, and career goals. For instance, computer science majors may wish to put extra emphasis on developing coding skills, social science and economics majors may wish to emphasize the interface of the assumptions and interpretations of mathematical models with their interdisciplinary areas of interest, math majors may wish to go more in-depth on the mathematical analysis of the models, and other students may wish to improve their scientific writing and communication skills. Conversely, students who have an in-depth background in one area may wish to use the class as a chance to broaden their skillset in other directions.

Time permitting, the course will introduce a variety of modeling techniques including differential equations (compartment models and stratified versions), curve fitting models, stochastic models, agent-based, and network models. There will be a strong emphasis on the simulation of models for which we will be using MATLAB and some numerical analysis will be introduced. The course will cover basic linear algebra, which will be applied to various topics throughout the course, and will also touch on basic optimization techniques. The analysis of the models will be aided by the use of Mathematica’s symbolic mathematics software.

Communication of results is an important part of the modeling process and there will be some discussion of the fundamentals of scientific writing.

**Course format:** The course will have a synchronous and asynchronous component:

**Asynchronous component:** The asynchronous component will consist of pre-recorded lectures and readings which will be posted on Canvas before the class period to which they pertain. The pre-recorded lectures and readings should be viewed prior to the Zoom meeting for which they are assigned. The lectures will be posted under the Lectures module on Canvas and the readings will be linked from the Readings module. I will maintain a syllabus that lists the readings for each day and will try to post them at least a week in advance. The pre-recorded lectures will be broken up into small pieces (roughly 10-20 mins each) and will often end with a reference to a Homework question which can be addressed after watching the video.

**Synchronous component:** The synchronous component will be conducted via Zoom (link provided on Canvas under Course Information) and will consist mostly of discussion of the pre-recorded lectures and readings, questions about the pre-recorded lectures and readings, and discussion of student responses to homework questions in which students will be expected to present their findings.

Attendance at the Zoom meetings will be a very important component of the class and is expected for all students, time-zone permitting – if technical or time zone issues prevent this, please let me know as soon as possible. The synchronous sessions will be recorded and posted on the Canvas page for those who cannot attend due to time-zone limitations, however it is expected that you will attend the live session if at all possible.

Since you will be expected to spend part of the time that you would normally spend in lecture during an on-campus semester watching the pre-recorded lectures, we will usually not use the entire 110 minutes allotted for the synchronous Zoom lectures. The expectation is that if watching the pre-recorded lectures takes  $x$  minutes, then the Zoom class should last  $110 - x$  minutes. I will treat the remaining  $x$  minutes as office hours.

I expect that if you have questions of a general nature regarding the reading and pre-recorded lectures, that you ask those during the first part of the Zoom class time before class is dismissed so that other students can benefit from the ensuing discussion. If you have questions that are more specific to your individual situation or that would not be useful for the general class, feel free to ask them in the time after the class is dismissed. If you need to discuss something of a personal nature, feel free to email me so that we can set up a separate Zoom meeting.

Respect your classmates, and they will return the favor. Respect includes creating an environment conducive to learning: in particular, listening, helping your classmates, and contributing actively.

**Office Hours:** Although you are encouraged to ask as many questions as possible during the synchronous meetings, it is not always possible to do so, and furthermore, some students will not be able to attend the synchronous meetings due to time-zone constraints. Therefore two hours of additional office hours will be scheduled. I will send a poll during the first week of class to determine time slots which will be accessible to the most students. Priority will be given to time slots which are accessible for students living in time-zones which make it impossible for them to attend the synchronous component.

**Grading:** There will be (roughly) 9 homework assignments which will be equally weighted and account for 90% of your final grade. The extra 10% is for “oomph”, meaning that you regularly went above and beyond what was expected. This “oomph” can come in several forms, and will be dependent on your individualized

course objectives (see section on Course objectives). Examples: including doing extra in-depth mathematical or numerical analyses on homework questions; writing and sharing extensions to the code that I share on Canvas; making insightful contributions to in-class discussions and debates; demonstrating improvement in scientific writing skills by turning in well written writeups for homework questions in which you are asked to answer real-world questions via modeling; informing the application of the mathematical models by including in-depth discussion (in class and on homeworks) of interdisciplinary knowledge on topics like demographics, epidemiology, and economics; finding, incorporating, and sharing external datasets to aid with fitting model output and parameters; other (surprise me).

Grades on homework assignments will be letter grades with a brief description of what I liked and usually some tips for improvement. The grades will be whole letters (e.g. “A” or “B”).

### **Homework:**

Homeworks will be turned in on Canvas under the Homeworks Module. When you click on an assignment you should see a .pdf file containing the prompts and a link to turn in the homework. Be sure to click on your assignment again after you upload to see that it uploaded correctly (in the past some students believe they have turned in homework but it either didn’t upload or was corrupted during the upload).

Homeworks will be due weekly. The first homework will be due on Wednesday the 23rd of September, and usually due every Wednesday thereafter, but the schedule may change. The up-to-date schedule can be found on Canvas under the Schedule tab.

Homeworks are expected to be turned in by 11:59pm on the date they are due. If you cannot make that deadline let me know. Generally, I will okay an extension by a day or possibly two under rare circumstances. If circumstances are going to make the assignment more than a day or two late then I will generally urge you to do the problem set on your own but to not spend the time writing up the assignment and turning it in. This policy is designed to ensure that you do not get behind on the assignments. If an assignment is not turned in due to circumstances outside of your control, such as major tech issues, family emergencies, or a major sickness, such as Covid-19, then I will excuse that homework and not count it against you when I tally the final grades.

Homeworks will consist of multiple problems with a range of formative to summative problem types. The formative questions will help you practice component skills in support of modeling, and the summative questions will allow you to put together multiple formative skills in order to answer real-world questions using modeling techniques. The homeworks in the first few weeks will focus more heavily on formative questions and will progress to more summative questions as the semester progresses.

Homeworks should be typed up (for example Word or latex) and converted to pdf. For problems that require extensive mathematical derivations, it is okay to attach an extra file containing a scan or picture of your neatly hand-written derivations. Please make sure the scan is neatly legible and try to limit the file size of the upload. .png, .jpg, and .pdf files are acceptable for the additional attachment, but the typewritten portion should be converted to .pdf. In the .pdf files, please embed any figures in the document near the problem to which they pertain (i.e., not as an appendix of figures).

**Coding and Software:** I will introduce coding in Matlab, the use of Mathematica for symbolic manipulation, and potentially other software as needed throughout the term. No previous experience with coding is necessary to take this course, and it is expected that students will have a wide range of backgrounds in coding. I will provide all code necessary to implement the models, and students will only be expected to learn enough Matlab and Mathematica to make minor modifications to the code in order to address the homework assignments, and to learn to import data and make plots at the command line. The code will be provided in Google Drive.

That said, students who feel competent in coding are encouraged to extend the code that I provide to add additional functionality to better address homework questions. The only caveat is that if you do write additional code then it is expected that you share the code with class so that others can benefit from your efforts. I will create a folder on Google Drive in which you can place any new code that you create.

Please include your name as author in the comments section of your code and format them in a similar manner to the way my code is written (specifically, with a comment section up front describing the purpose of the code and a description of inputs and outputs).

**Honor Principle:** You are permitted — indeed, encouraged — to work together in groups when solving homework problems. However, your final write-up of all homework assignments should be your own. See the material available at <http://tinyurl.com/y8cps5q7> for more information on citation of sources. If any Honor Code expectations are ever unclear to you, please ask for clarification.

### **Consent to record**

(This language may soon be edited. Please watch this space for updates.)

(1) Consent to recording of course and group office hours

a) I affirm my understanding that this course and any associated group meetings involving students and the instructor, including but not limited to scheduled and ad hoc office hours and other consultations, may be recorded within any digital platform used to offer remote instruction for this course;

b) I further affirm that the instructor owns the copyright to their instructional materials, of which these recordings constitute a part, and distribution of any of these recordings in whole or in part without prior written consent of the instructor may be subject to discipline by Dartmouth up to and including expulsion;

b) I authorize Dartmouth and anyone acting on behalf of Dartmouth to record my participation and appearance in any medium, and to use my name, likeness, and voice in connection with such recording; and

c) I authorize Dartmouth and anyone acting on behalf of Dartmouth to use, reproduce, or distribute such recording without restrictions or limitation for any educational purpose deemed appropriate by Dartmouth and anyone acting on behalf of Dartmouth.

(2) Requirement of consent to one-on-one recordings

By enrolling in this course, I hereby affirm that I will not under any circumstance make a recording in any medium of any one-on-one meeting with the instructor without obtaining the prior written consent of all those participating, and I understand that if I violate this prohibition, I will be subject to discipline by Dartmouth up to and including expulsion, as well as any other civil or criminal penalties under applicable law.

### **Religious Observances**

Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please meet with me before the end of the second week of the term to discuss appropriate accommodations.

### **Student Accessibility and Accommodations**

Students requesting disability-related accommodations and services for this course are encouraged to schedule a phone/video meeting with me as early in the term as possible. This conversation will help to establish what supports are built into my online course. In order for accommodations to be authorized, students are required to consult with Student Accessibility Services (SAS; [student.accessibility.services@dartmouth.edu](mailto:student.accessibility.services@dartmouth.edu); SAS website; 603-646-9900) and to email me their SAS accommodation form. We will then work together with SAS if accommodations need to be modified based on the online learning environment. If students

have questions about whether they are eligible for accommodations, they should contact the SAS office. All inquiries and discussions will remain confidential.”

**Diversity & Inclusion** I would like to create a learning environment for my students that supports a diversity of thoughts, perspectives and experiences, and honors your identities (including race, gender, class, sexuality, religion, ability, etc.) To help accomplish this:

Please contact me (in person or electronically) or submit anonymous feedback if you have any suggestions to improve the quality of the course materials regarding diversity.

If you have a name and/or set of pronouns that differ from those that appear in your official college records, please let me know.

If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to come and talk with me. I want to be a resource for you. If you prefer to speak with someone outside of the course, the Associate Dean of the College for Diversity Programs is an excellent resource.

I (like many people) am still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone) that made you feel uncomfortable, please talk to me about it.

As a participant in course discussions, you should also strive to honor the diversity of your classmates.

### **Mental Health and Wellness**

The academic environment at Dartmouth is challenging, our terms are intensive, and classes are not the only demanding part of your life. There are a number of resources available to you on campus to support your wellness, including your undergraduate dean (<https://students.dartmouth.edu/undergraduate-deans/>), Counseling and Human Development (<https://students.dartmouth.edu/health-service/counseling/about>), and the Student Wellness Center (<https://students.dartmouth.edu/wellness-center/>). I encourage you to use these resources to take care of yourself throughout the term, and to come speak to me if you experience any difficulties.

### **Title IX**

At Dartmouth, we value integrity, responsibility, and respect for the rights and interests of others, all central to our Principles of Community. We are dedicated to establishing and maintaining a safe and inclusive campus where all have equal access to the educational and employment opportunities Dartmouth offers. We strive to promote an environment of sexual respect, safety, and well-being. In its policies and standards, Dartmouth demonstrates unequivocally that sexual assault, gender-based harassment, domestic violence, dating violence, and stalking are not tolerated in our community.

The Sexual Respect Website (<https://sexual-respect.dartmouth.edu>) at Dartmouth provides a wealth of information on your rights with regard to sexual respect and resources that are available to all in our community.

Please note that, as a faculty member, I am obligated to share disclosures regarding conduct under Title IX with Dartmouth's Title IX Coordinator. Confidential resources are also available, and include licensed medical or counseling professionals (e.g., a licensed psychologist), staff members of organizations recognized as rape crisis centers under state law (such as WISE), and ordained clergy (see [https://dartgo.org/titleix\\_resources](https://dartgo.org/titleix_resources)).

Should you have any questions, please feel free to contact Dartmouth's Title IX Coordinator or the Deputy Title IX Coordinator for the Guarini School. Their contact information can be found on the sexual respect website at: <https://sexual-respect.dartmouth.edu>.

### **Textbook Costs and Financial Difficulty**

If you encounter financial challenges related to this class, please let me know.