Modeling Biological Systems (BIOL 340/MATH 340)

Spring 2023

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Item	Course details
Lectures	TTh 12:30pm - 1:45pm, ISC 115
Dr. H's info	Office = ISC 360 Email = hartvig@geneseo.edu Office hrs: Mon 4:00pm - 6:00pm (Zoom only) Tues. 2:30pm - 4:00pm, Wed. 2:00pm - 3:00pm (ISC 360)
Dr. L's info	Office = South 324D Office phone = 245.5383 Email = leary@geneseo.edu Office hrs: Mon 2:00-4:00, Wed 1:30-2:30, Fri 9:00-10:00, or by appointment.
Textbook	There is no required textbook.
Required software	The latest versions of `R`, `RStudio`, LaTeX, and `Excel` (or equivalent)
Required hardware	Each day you need to bring a computer running Windows, Mac, or Linux that is capable of accessing the college's WiFi (no Chromebooks!). Feel free to bring a power cord - all seats have dedicated power outlets.
Expected backup	Files should be stored in a folder that automatically syncs in the cloud. This is a free service through Google Drive (recommended), Dropbox, iCloud, or OneDrive.

1 Overview

The field of biology is growing rapidly, with discoveries ranging from molecular biology through integrated global systems. These scientific fields, along with everything in between, are filled with data from experiments that test a wide range of theories. These theories are most often expressed quantitatively and tested using mathematics, statistics, and computational methods. In this class you will work to build and test a sampling of these models to better understand the dynamics of biological systems.

Note that this class fulfills a requirement for the Biomathematics Minor, and credit for this course can also be used toward both a Mathematics major (as a 300-level elective) and a Biology major (as a 300-level elective). It does not fulfuill a laboratory requirement in biology.

2 Resources

1. **Laptop**. You need to bring a laptop to all meetings. The seats have plugs so you can bring your power cord. You must be able to download files, find them on your computer, group them into folders, and send files as attachments.
2. **Software**. Install the latest versions of `R` (`https://cran.case.edu/`), `RStudio` (`https://www.rstudio.com/products/rstudio/download/#download`), and LaTeX. The latter is a large program that may take hours to install! See `https://tug.org/texlive/`

`acquire-netinstall.html` for Windows machines and `http://www.tug.org/mactex/` on a Mac. All required software is free.

3. See the Provost's website for additional resources for success at `https://wiki.geneseo.edu/display/PROVOST/Syllabus+Resources+Related+to+Student+Success`.

Installing LaTeX for Windows Users

1. Download the installer program (`install-tl-windows.exe`).
2. Click on "Show in folder" or open the file manager, navigate to the Downloads folder.
3. Right-click on `install-tl-windows.exe`.
4. Choose "Run as Administrator".
5. Proceed with the installation.

3 Expected Learning Outcomes

Upon successful completion of this class you will be able to:

1. use the standard scientific approach to correctly model biological systems, including observation, hypothesis development, measurement and data collection, experimentation through replicated model runs, evaluation of evidence, and employment of mathematical and statistical analysis;
2. distinguish between analytic and numerical models,
3. distinguish between stochastic and deterministic models,
4. use software to quantitatively test hypotheses with data and build and evaluate mathematical and simulation models of biological systems,
5. create and present a semester-long project involving the development and the analysis of a model of a biological system, and
6. assess the value of model results discussed in the news and in scientific and mathematical literature.

3.1 These outcomes can only be realized if you know your computer

To understand and complete work in the field of biomathematics, and excel in this course, you must be able to use, or figure out how to use, your computer to solve computational problems. This includes the following skills:

1. create a folder for this class, such as "MBS - Spring 2022";
2. download a file from the internet, find it, and move it into this folder;
3. install, run, and use Excel, R, RStudio, and LaTeX;
4. search the internet for help on using your computer, coding in R, or whatever you need to do;
5. use a cloud backup system. This is so you'll never have to say "I lost my work!"

4 Grading stuff

The following table shows the breakdown for points.

Item	Number	Points for each	Total pts
Homework assignments	6	15	90
Modeling challenge 1	1	10	10
Modeling challenge 2	1	20	20
Modeling challenge 3	1	30	30
Modeling challenge 4	1	40	40
Modeling challenge 5	1	50	50
Project Proposal	1	10	10
Speed Presentation 1	1	10	10
Speed Presentation 2	1	20	20
Final Presentation	1	70	70
Total			350

The homework assignments are due at the beginning of class on the day they are due. A late fee of -25% pts will be subtracted for each 24 hour period late. Homework assignments will generally be handed back within one week of their due dates.

Your final project will culminate with a 15 minute presentation during the finals time slot. The project will require you to develop, implement, and analyze a computational and/or mathematical model of a biological system of your choice. There are several assignments during the semester to help keep you on track. Draft rubrics for your speed and final presentations are included at the end of this document.

Your final grade will be converted from a numerical value to a letter grade using the following relationships. We will round grades to three significant figures. The values below are presented as proportions.

Score		Letter Grade		Score
0.933	$\leq$	A	$\leq$	∞
0.900	$\leq$	A-	$<$	0.933
0.867	$\leq$	B+	$<$	0.900
0.833	$\leq$	B	$<$	0.867
0.800	$\leq$	B-	$<$	0.833
etc.				

Note: Any grades may be contested up to one week after they have been returned.

4.1 Modeling Challenges

The dates for these are provided in the Schedule (see page 4). These will involve your writing (or modifying) a computer model. Some challenges will have a written part in addition to the computer part. The written part will be closed-book/computer and count 25% of the grade while you may use the internet and any notes for the computer part. You are not, however, allowed to interact with anyone during any part of the challenge.

5 Attendance

Coming to class is important for success. If you can't make class you must let us know 24 hrs before class begins. If you are missing a Challenge day we will likely be able to provide it to you electronically.

6 Schedule

Date	Day	Topic	What's due
1/24/2023	Tue	Intro to R + programming 1	Have R, RStudio, and LaTeX installed/working
1/26/2023	Thu	Intro to programming 2 + Sweave	
1/31/2023	Tue	Overview of project and build groups	HW 1 due
2/2/2023	Thu	Intro to discrete time/stochastic models	Project proposal due
2/7/2023	Tue	Parameterization + statistics	
2/9/2023	Thu	Modeling Challenge 1	Prepare for Modeling Challenge
2/14/2023	Tue	Intro to ODE/deterministic models and analysis	
2/16/2023	Thu	Systems of ODEs (SIR) - and R0 (new)	HW 2 due
2/21/2023	Tue	Stability of equilibria in DE models	
2/23/2023	Thu	Modeling Challenge 2	Prepare for Modeling Challenge on systems of equations
2/28/2023	Tue	Diversity Summit (no class)	
3/2/2023	Thu	Building a network model	HW 3 due
3/7/2023	Tue	Disease dynamics on a network	
3/9/2023	Thu	Modeling Challenge 3	Prepare for Modeling Challenge
3/14/2023	Tue	Spring Break	
3/16/2023	Thu	Spring Break	
3/21/2023	Tue	Systems of discrete equations	
3/22/2023	Wed	Submit presentation to CL and GH by 5pm	Email pptx or pdf and all modeling files
3/23/2023	Thu	Speed presentation 1	Prepare for Speed Presentation
3/28/2023	Tue	SIR Variations (vector borne diseases)	HW 4 due
3/30/2023	Thu	R0 in General Differential Equation Models	
4/4/2023	Tue	Modeling Challenge 4	Prepare for Modeling Challenge
4/6/2023	Thu	TBA (Simulation? Nondimensionalizing? Generating Functions?)	
4/11/2023	Tue	TBA Continued	
4/12/2023	Wed	Submit presentation to CL and GH by 5pm	Send files
4/13/2023	Thu	Speed presentation 2	Prepare for Speed Presentation
4/18/2023	Tue	Data in a Policy Framework. Using R on DHS Surveys	
4/20/2023	Thu	Application Assignment	HW 5: Have read paper, answered questions for discussion
4/25/2023	Tue	Modeling movement in space	
4/26/2023	Wed	GREAT DAY	
4/27/2023	Thu	Evolutionary Programming and Genetic Algorithms	
5/2/2023	Tue	Group Project Day	HW 6 due
5/4/2023	Thu	Review	

5/9/2023	Tue	Modeling Challenge 5	Prepare for Modeling Challenge
5/14/2023	Sun	Submit presentation to CL and GH by 5pm	Include all files
5/18/2023	Thu	Presentations. 8:00-10:30 am.	

7 Religious Observances

It is our responsibility as faculty members, as outlined in the College's Undergraduate Bulletin, to accommodate religious observances. No exams have been scheduled to occur on notable observance days. We are happy to meet your needs in good faith if you inform us of any planned absence for religious reasons at least one week prior to the conflict.

8 Mathematics 348 Waivers

If you are interested, you may use your work in this class toward earning a waiver for Math 348, the Oral Presentation and Research Seminar. This waiver will involve making an additional presentation about the model that you develop. Students who are interested in pursuing this option should speak with Dr. Leary early in the semester.

9 Accessibility

We professors will do our best to make accommodations for persons with documented physical, emotional, or cognitive disabilities. In addition, we will do our best to accommodate challenges brought about through pregnancy, parenting, and/or caregiving. Students should contact the Office of Accessibility Services https://www.geneseo.edu/accessibility-office (585-245-5112) and the instructors to discuss needed accommodations as early as possible in the semester.

10 Academic Integrity

Sorry to discuss this but please be forewarned. Except for specifically group work ALL WORK MUST BE YOUR OWN to receive credit. For all work completed in this class you have access to the internet. For homework and in-class challenges sharing information with others is tempting. Avoid this temptation! Do your own work. Sharing information is as much a violation as is receiving information. Additionally, you also may not use a large language model, such as OpenAI's chatGPT, to edit or generate text or code because it is not guaranteed to be free from using the intellectual products of others. Feel free to review College's policy on academic dishonesty and the Student Code of Conduct, Article IV.B.5 (https://www.geneseo.edu/handbook/student-code-conduct).

Rubrics (Drafts)

The points will be scaled according the value of these presentations (see above). The second speed presentation will have higher expectations so it is possible your score might go down for that presentation. These rubrics are merely guides and may be modified later.

Speed Presentation 1 (10 pts)

Presenters _____.

0 = Not at all, 5 = Absolutely

Required Elements	0	1	2	3	4	5	Comments
Presentation introduced the topic							
Presentation showed there is a working model							
Presentation explains at least some model parameter(s)							
Presentation shows some kind of output from the model (e.g., a graph)							
The Presentation is correctly structured/formatted with title/names							
Spoken presentation is clear							
Late fee							-7.5 pts (25%) if not submitted on time

Sum of points = _____. That's _____ points out of 20

Speed Presentation 2 (20 pts)

Presenters _____.

0 = Not at all, 5 = Absolutely

Required Elements	0	1	2	3	4	5	Comments
Presentation provides a clear introduction to the problem or system							
Presentation shows a more sophisticated model of the system (e.g., equations and compartment model)							
Presentation explains parameters used in the model							
Presentation shows a clear result from the model with a beautiful graph							
Presentation shows evidence of sensitivity analysis and/or analysis of equilibria							
The Presentation is correctly structured/formatted with title/name							
Spoken presentation is clear and demonstrates an understanding of the link between the model and the real system							
Late fee							-8.75 pts (25%) if not submitted on time

Sum of points = _____. That's _____ points out of 30

Final Oral Presentation Rubric

The points will be scaled according the value of the final presentation. This rubric is merely a guide and may be modified later.

Required Elements	Possible Points	Points lost	Comments
Descriptive **title** & **Name**	10		
Abstract is a short summary of project from intro to the meaning of the results	10		
Introduction introduces problem/story	20		
Methods describe the model in sufficient detail (e.g., to be reproduced by a reader)	30		
Results explain sufficiently what was found	30		
Discussion discusses importance of results	20		
Ackn/Refs	10		
Presentation slides professional looking, balanced, use of space, fonts readable, etc.	20		
Sufficient **model complexity** for semester-long project	30		
Sufficient **analyses** (e.g., completed sensitivity analysis & analyzed equilibria)	50		
Publication-quality graphs present results clearly & correctly, showing some level of sensitivity and analysis of equilibria	30		
Spoken presentation clear, on point	20		
Questions answered clearly, if asked	20		
A **clear story** was presented	20		
Files submitted recreate results/graphs	30		
Late fee			-87.5 pts (25%) if not submitted on time

Sum of points = _____out of 350