MA 337 (001), 3 credits — Fall 2017
MWF xx:xx-xx:xx, Room:xxx

Mathematical Modeling in the Life Sciences

URL: www.ms.uky.edu/~ma337

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Course Description (Bulletin): MA 337 introduces mathematical modeling in biology and other life science disciplines using discrete and continuous tools and techniques, including difference equations and differential equations. Students will learn to construct, analyze, and simulate models and interpret the results within their biological context.

Prerequisites: A grade of B or better in MA 114 (Calculus II) or MA 138 (Calculus II with Life Science Applications) or consent of department.

Course Outline: Biology presents complex problems requiring quantitative approaches to tackle them. The first half of the course will focus on discrete models in mathematical biology, such as difference equations and matrix population models. The second half of the term will focus on continuous models, namely differential equations in mathematical biology. Examples for each type of modeling may be taken from ecology, epidemiology, molecular networks, or gene regulatory networks. By the end of the term, you will have experience posing biological problems and using mathematics to elucidate them. Course topics will be structured as follows:

Discrete Models:

- Single-species discrete population models, their equilibria and stability. Examples include: Simplified Logistic model, Ricker Model, Beverton-Holt model.
- Matrix population models. Examples will be taken from ecology.
- Analysis of multidimensional discrete models. Application: Discrete Epidemic Models.

Differential Equations:

- One-dimensional continuous population models and their qualitative analysis.
- Introduction to Epidemiological Models: the Kermack-McKendrick SIR and SIS models with no demography.
- Properties of planar systems, their equilibria, phase plane analysis, linear stability analysis, Poincare-Bendixson Trichotomy and Dulac-Bendixson Criterion. Some applications: Lotka-Volterra predator-prey model, SIR model with demography.
- Linear stability analysis for higher order systems. Application: deriving the basic reproduction number R_0 in complex epidemiological models.
- Bistability in epidemiological models.

Student Learning Outcomes: After completing this course, students will be able to:

- formulate simple dynamical models to address a biological question;
- simulate these mathematical models;
- perform standard analyses of these models;
- interpret analytical and numerical results within their appropriate biological context;
- read and critique papers in the mathematical biology literature.

Required Materials: The official textbooks for this course (both freely available through your Link Blue account) are

- *Mathematical Concepts and Methods in Modern Biology* (1st edition), edited by R. Robeva and T. Hodge. The book is freely available with a ScienceDirect subcription (which UK has). It is very readable and has many worked out examples. This text will be used for the section on discrete mathematical models.
- *Mathematical Models in Population Biology and Epidemiology* by Fred Brauer and Carlos Castillo-Chavez, 01 January 2012. This Springer textbook is freely available online through UK. This text will be used primarily for the section on continuous mathematical models, although some discrete examples may come from this text as well.

Description of Course Activities and Assignments

Class Participation: Your grade for participation will not only reflect how often you contributed to our class discussions, but the degree to which your contributions were constructive and generative of further response(s) from your fellow classmates.

Exams: There will be two midterm exams during the regular class time and a final project. Each exam is worth 75 points. Exams 1 and 2 are scheduled in the sixth and eleventh week of the semester, respectively. Absolutely no cell phone use is allowed during exams. The final project will be due on the last day of classes and replaces the final examination.

Homework: 10 homework sets will be assigned throughout the semester. Assignments will be collected at least one week after they have been assigned. Students are encouraged to brainstorm solutions to homework problems together, but solutions must be written in their own words and independently.

Final Project: Students will be asked to choose a biological question of interest, subject to the approval of the instructor, and develop a mathematical model (either discrete or continuous) to address this question. The student must write a 5-page paper including a section with analytic results, a section with numerical results, and a discussion interpreting the results within their appropriate biological context. Students will also be required to give a 20-minute presentation on their work during the last week of class. Papers will be due on the last day of class.

Course Grading: Students will obtain a maximum of 500 points in this class, divided as follows:

	Points	Percent
Homework	200	40%
Class participation	50	10%
Two Midterms	75 each	30%
Final project	100	20%
Total	500	100%

A student's final grade for the course will be based on the total points earned as follows:

Grade	Points	Percent
A	450-500	90%-100%
B	400-449.9	80%-89.9%
C	350-399.9	70%-79.9%
D	300-349.9	60%-69.9%
E	0-299.9	0%-59.9%

Note: The grading scale might be adjusted at the end of the semester. You will be guaranteed the above letter grade if your score falls within the given range, but the minimum score for each letter grade might be lowered.

Software: Students will be permitted to write their code in R or Octave. Tutorials for each will be given in class. Computers will not be permitted on exams, but will be allowed for homework.

Tentative Course Schedule: This the tentative schedule of the course

Week	Topic
1 & 2	Single-species discrete population models, their equilibria and stability. Examples include: Simplified Logistic model, Ricker Model, Beverton-Holt model.
3 & 4	Matrix population models. Examples will be taken from ecology.
5 & 6	Analysis of multidimensional discrete models First Midterm
7	Application: Discrete Epidemic Models
8	One-dimensional continuous population models and their qualitative analysis
9	Introduction to Epidemiological Models: the Kermack-McKendrick SIR and SIS models with no demography.
10 & 11	Properties of planar systems, their equilibria, phase plane analysis, linear stability analysis, Poincare-Bendixson Trichotomy and Dulac-Bendixson Criterion. Some applications: Lotka-Volterra predator-prey model, SIR model with demography. Second Midterm
12	Linear stability analysis for higher order systems. Application: deriving the basic reproduction number R_0 in complex epidemiological models.
13	Bistability in epidemiological models
14	Project presentations

Mid-term Grade: Mid-term grades will be posted in myUK by the deadline established in the Academic Calendar.

Policies

Attendance and excused absences: Attendance in MA337 is mandatory. Be on time and remain until dismissed. Do not leave in the middle of class. Whenever possible, please notify your instructor of absences prior to class. S.R. 5.2.4.2 defines the following as acceptable reasons for excused absences: (a) serious illness, (b) illness or death of family member, (c) University-related trips, (d) major religious holidays, and (e) other circumstances found to fit as reasonable cause for nonattendance by the professor. You may be asked to verify absences in order for them to be considered excused. Senate Rule 5.2.4.2 states that faculty have the right to request appropriate verification when students claim an excused absence because of illness or death in the family. Appropriate notification of absences due to university-related trips is required prior to the absence. If you anticipate an absence for a major religious holiday please notify your instructor (in writing) of anticipated absences due to your observance of such holidays no later than the last day in the semester to add a class. Two weeks prior to the absence is reasonable, but should not be given any later. Information regarding major religious holidays may be obtained through the Ombud (859) 257-3737,

`http://www.uky.edu/Ombud/ForStudents_ExcusedAbsences.php`

You are expected to withdraw from the class if more than 20% of the classes scheduled for the semester are missed (excused or unexcused) per university policy.

Classroom behavior: Electronic devices such as mobile phones, laptops and tablets should be put away or used only as part of class activities during lectures. Mobile phones, laptops, and computers may not be used during exams.

Make-up policies: Per Senate Rule 5.2.4.2, if you are missing any graded work due to an excused absence you are responsible for informing the Instructor about your excused absence within one week following the period of the excused absence (except where prior notification is required); and for making up the missed work. The instructor will give you an opportunity to make up the work and/or the exams missed due to an excused absence, and shall do so, if feasible, during the semester in which the absence occurred. In particular, if you have university excused absences or have university-scheduled class conflicts with uniform examinations you may arrange with their instructor to take the exam at an alternate time. Generally these make-up exams will be scheduled on the day of or on the day after the regularly scheduled exam. Work-related conflicts are neither university excused absences nor university-scheduled absences.

Students needing accomodations: If you have a documented disability that requires academic accommodations, please see your instructor as soon as possible. In order to receive accommodations in this course, you must provide your instructor with a Letter of Accommodation from the Disability Resource Center (DRC). The DRC coordinates campus disability services available to students with disabilities. It is located on the corner of Rose Street and Huguelet Drive in the Multidisciplinary Science Building, Suite 407. You can reach them via phone at (859) 257-2754 and via email at drc@uky.edu. Their web address is

`http://www.uky.edu/StudentAffairs/DisabilityResourceCenter/`

Accommodations for victims of violence: By federal law, any student who is a victim of dating violence, domestic/intimate partner violence, sexual assault, or stalking (whether on or off campus) is entitled to appropriate accommodations for his or her coursework. To get help getting accommodations and other support, students who are assaulted can do any of the following:

- Tell your instructor who can assist you in accessing resources appropriate to your situation;
- Call the UK VIP Center (Violence Intervention and Prevention Center) at 257-3574 or vipcenter@uky.edu or

  `http://www.uky.edu/StudentAffairs/VIPCenter/about_contact.php`

  or walk in to the Center in Frazee Hall, lower level, between 8:30 and 5:00;
- Call the University Counseling Center at 257-8701; 2nd floor, Frazee Hall;
- Call Ms. Patty Bender from the UK Institutional Equity and Equal Opportunity at 257-8927 or patty.bender@uky.edu;
- In the case of an emergency, contact the UK Police Department at 911.
- Students may also contact community resources 24-hours a day, including:
  (a) Bluegrass Rape Crisis Center at 800.656.4673 or http://bluegrassrapecrisis.org/
  (b) Greenhouse17 (formerly Bluegrass Domestic Violence Program) at 800.544.2022 or http://greenhouse17.org/

Academic Honesty: Cheating or plagiarism is a serious offense and will not be tolerated. It will be thoroughly investigated, and might lead to failure in the course or even to expulsion from the university. See http://www.uky.edu/StudentAffairs/Code/part2.html (Sections 6.3.1 and 6.3.2) for information on cheating, plagiarism, and penalties. A summary of recent changes to rules on cheating can be found at the Academic Ombud website: http://www.uky.edu/Ombud

Tutoring Resources: If you find that you are having difficulty with any aspect of the course, you should seek help immediately. Please talk to your instructor as soon as possible. Take full advantage of your instructor's scheduled office hours. If you have conflicts with these office hours, your Instructor will be happy to schedule an alternative time to meet with you.

Good Habits: Mathematics is not a spectator sport. To understand what this means, consider how well you might learn to play tennis by watching Roger Federer. You will not learn the material in this course by listening to the lectures, and thinking to yourself - "Yes, I understand that". You must also read the book and work the problems to learn. The instructor's task is that of an assistant to help you learn as much of the material as you desire. This being said, form good study skills from the start!

- Come to class and take notes during lecture.
- Read each section of the text prior to the lecture where it will be covered.
- As you read the text, have pencil and paper handy. Work through the computations. Find examples to illustrate the theorems and results in the text.
- Begin the homework immediately after material is covered in class. Mathematics is cumulative. In order to benefit from Wednesday's lecture, you must understand the material covered on Monday.
- Find classmates and form a study group. Spend time discussing problems.
- Do not fall behind. It is very difficult to catch up in a math class after falling behind.
- Begin preparing for exams well in advance. Read the text again to review all of the material to be covered on the exam. Be sure you are familiar with the main results and theorems and how they are used in homework.
- Work additional problems to prepare for the exam.
- If you are having trouble, then seek help immediately.