MATH 371: Math Modeling in Physiology & Medicine
Fall 2022 Course Syllabus

NJIT Academic Integrity Code: All Students should be aware that the Department of Mathematical Sciences takes the University Code on Academic Integrity at NJIT very seriously and enforces it strictly. Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Any form of plagiarism such as copying of homework or projects, or any form of cheating in quizzes and exams, is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to report suspected instances of cheating to your instructor, and protect your educational investment by knowing and following the Academic Code of Integrity policy that is found at: *http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf*

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online resources inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu

COURSE INFORMATION

Course Description: Mathematical models of diverse physiological and biological processes such as SIR epidemic model, action potential generation in neurons, enzyme kinetics, oxygen-hemoglobin binding, and genetic regulatory networks. The biology is introduced with each topic. Emphasis is on quantitative problem solving, model building, and numerical simulation.

Number of Credits: 3

Prerequisites: MATH 222 with a grade of C or better

Course-Section and Instructors:

Course-Section	Instructor
Math 371-001	Professor J. MacLaurin

Office Hours for All Math Instructors: Fall 2022 Office Hours and Emails

Required Textbook:

Title	*Mathematical Models in Systems Biology: An Introduction*
Author	B. P. Ingalls

Edition	1st (2013)
Publisher	MIT Press
ISBN #	978-0262018883

University-wide Withdrawal Date: The last day to withdraw with a **M** is **Monday, November 14, 2022**. It will be strictly enforced.

COURSE GOALS

Course Objectives

- Extend previously acquired knowledge of calculus and differential equation to the study of dynamical models of biological and physiological processes
- Learn new mathematical modeling techniques to analyze dynamical biological models in several variables
- Learn modeling principles and tools broadly applicable to many fields of biology and physiology
- Learn basic models in the study of neurophysiology, biochemical reaction pathways and genetic networks
- Learn to use MATLAB to solve and visualize complex problems describing biological processes

Course Outcomes

- Students will become skilled at analyzing and solving dynamic mathematical models arising in physiology
- Students will become familiar with the fundamental modeling principles in the study of biological processes
- Students will be able to use both numerical and analytical solution methods to tackle biological models
- Students will demonstrate mastery of the learned material through testing in quizzes and exams

POLICIES

DMS Course Policies: All DMS students must familiarize themselves with, and adhere to, the Department of Mathematical Sciences Course Policies, in addition to official university-wide policies. DMS takes these policies very seriously and enforces them strictly.

Grading Policy: The final grade in this course will be determined as follows:

Class participation / Effort	5%
Homework & Quizzes	25%
Short Project	15%
Midterm Exam	20%
Final Exam	35%

Your final letter grade will be based on the following tentative curve.

A	90 - 100	**C**	60 - 66
B+	81 - 89	**D**	55 - 59
B	74 - 80	**F**	0 - 54
C+	67 - 73		

Attendance Policy: Attendance at all classes will be recorded and is **mandatory**. Please make sure you read and fully understand the Math Department's Attendance Policy. This policy will be strictly enforced.

Homework and Quiz Policy: Homework is assigned each week, and is expected to be uploaded on time through the Canvas learning platform. Late submissions will not be accepted, unless an explicit permission of the instructor is obtained. In-class short quizzes will be given roughly every other week, announced in advance.

MATLAB: Use of MATLAB (or another high-level coding language like python) is mandatory, and students should install MATLAB on their personal laptop or desktops. MATLAB is free to all NJIT students:

https://ist.njit.edu/matlab

Exams: There will be one exam during the semester and a cumulative final exam during the final exam week:

Midterm Exam	TBA
Final Exam Period	December 16 – 22, 2022

The final exam will test your knowledge of all the course material taught in the entire course. Make sure you read and fully understand the Math Department's Examination Policy. This policy will be strictly enforced.

Makeup Exam Policy: There will be **NO MAKE-UP QUIZZES OR EXAMS** during the semester. In the event an exam is not taken under rare circumstances where the student has a legitimate reason for missing the exam, the student should contact the Dean of Students office and present written verifiable proof of the reason for missing the exam, e.g., a doctor's note, police report, court notice, etc. clearly stating the date AND time of the mitigating problem. The student must also notify the Math Department Office/Instructor that the exam will be missed.

Cellular Phones: All cellular phones and other electronic devices must be switched off during all class times.

ADDITIONAL RESOURCES

Math Tutoring Center: Located in the Central King Building, Lower Level, Rm. G11 (See: Fall 2022 Hours)

Further Assistance: For further questions, students should contact their instructor. All instructors have regular office hours during the week. These office hours are listed on the Math Department's webpage for Instructor Office Hours and Emails.

Additional Reading: Mathematical Models in Biology 2nd Edition (Edelstein and Keshet). Differential Dynamical Systems (Meiss), for extra resources on the mathematics.

Accommodation of Disabilities: The Office of Accessibility Resources and Services (OARS) offers long term and temporary accommodations for undergraduate, graduate and visiting students at NJIT.

If you are in need of accommodations due to a disability please contact Scott Janz, Associate Director of Disability Support Services at 973-596-5417 or via email at scott.p.janz@njit.edu. The office is located in Kupfrian Hall, Room 201. A Letter of Accommodation Eligibility from the Office of Accessibility Resources and Services office authorizing your accommodations will be required.

For further information regarding self identification, the submission of medical documentation and additional support services provided please visit the Office of Accessibility Resources and Services (OARS)

website.

Important Dates (See: Fall 2022 Academic Calendar, Registrar)

Date	Day	Event
September 5, 2022	Monday	Labor Day
September 8, 2022	Thursday	First Day of Classes
September 12, 2022	Monday	Last Day to Add/Drop Classes
November 14, 2022	Monday	Last Day to Withdraw
November 22, 2022	Tuesday	Thursday Classes Meet
November 23, 2022	Wednesday	Friday Classes Meet
November 24 to November 25, 2022	Thursday and Friday	Thanksgiving Recess - Closed
November 26, 2022	Saturday	Saturday Classes Meet
December 14, 2022	Wednesday	Last Day of Classes
December 15, 2022	Thursday	Reading Day
December 16 to December 22, 2022	Friday to Thursday	Final Exam Period

Course Outline

#	Section	Topic
1	Review	Review: linear and nonlinear ordinary differential equations (ODEs) in 1D
2	Review	Nonlinear ODE models in 1D, and stability analysis
3	Review	MATLAB introduction and solutions of 1st order differential equations
4	2.1	Principle of Mass Action and Chemical Reaction Networks
5	2.2	Separation of time scales and model reduction
6	3.1	Enzyme kinetics; Michaelis-Menten kinetics
7	3.2	Regulation of Enzyme Activity
8	3.3	Cooperativity: Hemoglobin-Oxygen binding and Calcium Buffers
9	3.4	Compartmental Modeling and Intracellular Transport
10	4.1	ODE models in 2D: vector calculus review and phase-plane analysis
11	4.2	ODE models in 2D: linear stability analysis
12	N/A	ODE models in 2D: SIR epidemiology model and the basic reproductive ratio

13	4.3	ODE models in 2D: Limit cycle oscillations and the Fitzhugh-Nagumo neuronal model
14	4.4	ODE models in 2D: Bifurcations
15		**Review for the Midterm Exam**
16	**Midterm Exam**	
17	6.1	Signal transduction pathways: Signal Amplification
18	6.2, 6.3	Signal transduction pathways: Ultrasensitivity and Adaptation
19	7.1	Modeling Gene Expression
20	7.2	Genetic Switches
21	7.3	Oscillatory Gene Networks
22	7.6	Stochastic Modeling of Biochemical and Genetic Networks
23	7.6	Stochastic Modeling of Biochemical and Genetic Networks, continued
24	8.1	Electrophysiology: Membrane potential and the Nernst Potential
25	8.2	Electrophysiology: Excitable Membranes and the Morris-Lecar Model
26	8.3	Electrophysiology: Synaptic Transmission
27	**Review for the Final Exam**	
FINAL EXAM PERIOD: December 16 – 22, 2022		

Updated by Professor J. MacLaurin - 8/31/2022
Department of Mathematical Sciences Course Syllabus, Fall 2022