MATH 613: Advanced Applied Mathematics I: Modeling
Fall 2024 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. This means that there must not be any forms of plagiarism, i.e., copying of homework, class projects, or lab assignments, or any form of cheating in quizzes and exams. Under the University Code on Academic Integrity, students are obligated to report any such activities to the Instructor.

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 software 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: Concepts and strategies of mathematical modeling are developed by investigation of case studies in a selection of areas. Consistency of a model, nondimensionalization and scaling, regular and singular effects are discussed. Possible topics include continuum mechanics (heat and mass transfer, fluid dynamics, elasticity), waves, kinetics, population dynamics, traffic flow, and the Sommerfeld problem.

Number of Credits: 3

Prerequisites: MATH 331 and MATH 337, or departmental approval.

Course-Section and Instructors:

Course-Section	Instructor
Math 613-001	Professor V. Matveev

Office Hours for All Math Instructors: Fall 2024 Office Hours and Emails

Recommended Textbook:

Title	*Introduction to the Foundations of Applied Mathematics*
Author	Mark Holmes
Edition	2nd
Publisher	Springer
ISBN #	9783030242602

	9783030242619

University-wide Withdrawal Date: The last day to withdraw with a **W** is **Monday, November 11, 2024**. It will be strictly enforced.

COURSE CONTENT & OBJECTIVES

Concepts and strategies of mathematical modeling are developed by investigation of case studies in a selection of areas. Consistency of a model, nondimensionalization and scaling, regular and singular effects are discussed. Possible topics include continuum mechanics (heat and mass transfer, fluid dynamics, elasticity), vibrating strings, population dynamics, traffic flow, and the Sommerfeld problem.

By the end of the course, students will be able to:

- Solve quantitative problems in applied math.
- Critically read graduate textbooks, summarize the major points, and discuss the finer details.
- prepare and deliver 15 minute presentations on applied mathematics and modeling.

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	8%
Homework and Quizzes	26%
Midterm Exam	30%
Final Exam	36%

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

A	84 - 100	**C+**	60 - 69
B+	77 - 83	**D**	50 - 59
B	70 - 76	**F**	0 - 49

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 Quizzes: There will be homework assigned each week, or nearly each week. In addition, there will be several in-class quizzes throughout the semester to reinforce the learning of new material. The quiz score will count as either one full homework score, or contribute to **class participation score**, depending on whether the quiz covers material of past homework, or new material that has just been introduced.

Exams: There will be one midterm exam held in class during the semester and one comprehensive final exam.

Exams are held on the following days:

Midterm Exam	October 31, 2024
Final Exam Period	December 15-21, 2024

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: To properly report your absence from a midterm or final exam, please review and follow the required steps under the DMS Examination Policy found here:

http://math.njit.edu/students/policies_exam.php

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

Use of Generative AI: not permitted for completion of assignments, unless explicitly requested by the professor.

ADDITIONAL RESOURCES

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.

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 need an accommodation due to a disability, please contact the Office of Accessibility Resources and Services at oars@njit.edu, or visit Kupfrian Hall 201 to discuss your specific needs. A Letter of Accommodation Eligibility from the office authorizing student accommodations is 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 at:

https://www.njit.edu/accessibility/

Important Dates (See: Fall 2024 Academic Calendar, Registrar)

Date	Day	Event
September 2, 2024	Monday	Labor Day
September 3, 2024	Tuesday	First Day of Classes
September 9, 2024	Monday	Last Day to Add/Drop Classes
November 11, 2024	Monday	Last Day to Withdraw
November 26, 2024	Tuesday	Thursday Classes Meet
November 27, 2024	Wednesday	Friday Classes Meet
November 28 to	Thursday and Sunday	Thanksgiving Recess - Closed

December 1, 2024		
December 11, 2024	Wednesday	Last Day of Classes
December 12, 2024	Thursday	Reading Day 1
December 13, 2024	Friday	Reading Day 2
December 15 to December 21, 2024	Sunday to Saturday	Final Exam Period

Course Outline

(This is a tentative schedule of material)

Date	*Topic*
Sep 5	Dimensional analysis and nondimensionalization
Sep 9	Nondimensionalization examples and the Buckingham's Π theorem
Sep 12	Nondimensionalization of dynamic equations: variable scaling.
Sep 16	ODE models in 1D: stability analysis and the phase line plot
Sep 19	ODE models in 2D: linear stability analysis and the phase plane; diagonalization
Sep 23	ODE models in 2D: gradient flows, Hamiltonian systems, Lyapunov functions
Sep 26	ODE models in 2D: chemical reactions and the principle of mass action
Sep 30	ODE models in 2D: SRI model for infectious disease propagation in a population
Oct 3	ODE models: regular perturbation, asymptotic series
Oct 7	ODE models: regular perturbation, asymptotic series (continued)
Oct 10	PDE models in 2 vars.: random walks, the diffusion equation, and its numerical solution
Oct 14	PDE models in 2 vars.: equilibrium solutions of diffusion equation
Oct 17	PDE models in 2 vars.: traffic modeling, method of characteristics for hyperbolic PDEs
Oct 21	PDE models in 2 vars.: method of characteristics continued; shocks
Oct 24	PDE models in 3 or 4 vars.: Divergence Theorem and the Conservation Law in 2D/3D

Oct 28	Midterm Exam Review
Oct 31	**Midterm Exam**
Nov 4	PDE models in higher dimensions: Maxwell's equations, EM wave in vacuum, electrostatics
Nov 7	PDE models in higher dimensions: Electrostatics; equilibrium concentration near a point source
Nov 11	Einstein notation: vector and tensor operations
Nov 14	Einstein notation: partial differentiation, product rules, higher-order derivatives
Nov 18	PDE models in 3 or 4 vars.: reaction-diffusion equations, cell calcium dynamics
Nov 21	PDE models in 3 or 4 vars.: incompressible flows, inviscid and viscous fluid flows, 2D flows
Nov 25	PDE models in 3 or 4 vars.: Navier-Stokes equation derivation
Nov 26	Stochastic processes: continuous-time Markov processes
Dec 2	Stochastic processes: Chemical Master Equations (CMEs) and moment equations
Dec 5	Stochastic processes: solving CMEs using the generating function
Dec 9	Stochastic processes: finding the generating function using the method of characteristics

Updated by Professor V. Matveev - 8/2024
Department of Mathematical Sciences Course Syllabus, Fall 2024