Math 676: Advanced Ordinary Differential Equations Fall 2024

Course Information

Course Location: CKB 226

Course Times: Tues, Fri 4:00pm-5:20pm

Instructor: Jonathan Jaquette (Jonathan.Jaquette@njit.edu)

Office Location: 624 Cullimore Hall

Office Hours: Monday 11am-12pm, Friday 11am-12pm, and by appointment.

Required Textbook:

- **Title**: Differential Dynamical Systems
- **Author**: J.Meiss
- **Publisher**; **Edition:** SIAM, Revised Edition
- **ISBN #:** 978-1611974638

Required Software: MATLAB & Mathematica

Course Website: All course announcements, and supplemental materials will be posted through the course Canvas page.

Course Content & Objectives

This course gives a rigorous treatment of the theory and applications of differential equations and an introduction to the modern theory of dynamical systems and their applications. By the end of the course, students will:

- Develop a better and more rigorous grasp of key concepts in modern dynamical systems theory
- Gain a deeper understanding of stability, bifurcations and chaos and related concepts such as attractors
- Learn how to apply dynamical systems theory in further studies in science and engineering.
- Critically read graduate textbooks, summarize the major points, and discuss the finer details
- Prepare and deliver short presentations on dynamical systems.

Course Pre-Requisites:

Math 222, Math 337, and Math 545 or Math 645, or departmental approval.

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:

Presentations(10)&Participation(5)	15%	Homework	20%
Midterm exam	30%	Final Exam	35%

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

A	88-100	**C**	62-67
B+	82-87	**D**	55-61
B	75-81	**F**	0-54
C+	68-74		

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	Oct. 25, 2023
Final Exam Period	Dec 15-21, 2023

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

There are NO MAKE-UP MIDTERM EXAMS. Students who fail to take an exam will receive a score of zero unless they have a legitimate excuse.

Tentative Schedule of Material

Week	Tuesday	Friday	Topic	Reading
1	9/3	9/6	Introduction to Dynamics	Ch 1
2	9/10	9/13	Linear Systems	Ch 2
3	9/17	9/20	Existence and Uniqueness	Ch 3
4	9/24	9/27	Dynamical Systems	Ch 4
5	10/1	10/4	Dynamical Systems	Ch 4
6	10/8	10/11	Invariant Manifolds	Ch 5
7	10/15	10/18	Invariant Manifolds	Ch 5
8	10/22	10/25	Review & Midterm	---
9	10/29	11/1	Phase Plane	Ch 6
10	11/5	11/8	Chaotic Dynamics	Ch 7
11	11/12	11/15	Bifurcation Theory	Ch 8
12	11/19	11/22	Bifurcation Theory	Ch 8
13	---	11/27*	Hamiltonian Dynamics	Ch 9
14	12/3	12/6	Hamiltonian Dynamics	Ch 9
15	12/10	---	Hamiltonian Dynamics	Ch 9

Academic Integrity

Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: NJIT Academic Integrity Code.

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

Working in Groups

I **highly recommend** finding a friend or two in this class and studying together! It makes doing homework more enjoyable (or less miserable?), and helps you learn difficult material. Even if you think you know everything, explaining concepts to someone else will help you master the material.

That said, the homework you turn in must be your own. Don't just copy someone else's work -- be it someone else in the class or someone online. If you get a significant idea or assistance from a classmate or an outside source, **BE SURE** to reference them. Citing your sources is one of the best way to avoid representing other's work as your own. While group work is great for preparing presentations and doing homework, the work you do on the midterm/final exams should be all your own.

Seminar Format

This course is a seminar and, unlike a traditional course, almost all of the talking in our meetings is done by the students. The main work of the seminar meeting will be presentations on selected topics, discussion of the readings and presentations, discussion of student generated questions, and presentation and discussion of homework problems. I'd like the seminar atmosphere to be lively but not intimidating. The goal of the group should be to push everyone's understanding. If something isn't clear, we need to stop and clarify.

In this format, the seminar members will be expected to have mastered all the basic background material before seminar, and the seminar meeting will be devoted to reinforcing, extending and enhancing your knowledge of the seminar topics. Students presenting material in any given week must thoroughly prepare those presentations in advance. Students not presenting material should still study all of the material to be presented in advance so that they may ask good questions and participate fully in the discussions. If you are unable to attend class for any reason, please contact me as soon as possible.

Meeting Organization

Below is an example agenda for one week's seminar:

Tuesday Class:

- Brief summary of the week's reading (5 min)
- Student presentations (40-50 min)
- Discussion of students' prepared questions on the reading (20-30 min)

Friday Class:

- Plan which problems to discuss (5 min)
- Discussion of homework problems (65 min)
- Closing, and planning for the next week (5 min)

Reading Questions (Active Learning)

Each week there will be about 25 pages from the book that everyone should read by Tuesday.

By Tuesday morning (before noon!), each student must post on the class's online discussion form **at least 3 questions** they had from the reading. As an alternative to only asking questions on the online forum, you may ask x many questions of your own, and post y many answers/responses to other students' questions so long as both $x \geq 1$ and $x + y \geq 3$. My suggestion would be to compile your list of questions as you are reading the week's material.

At the end of class on Tuesday we will discuss the reading questions. Ideally this will be an organic discussion, with one student posing their question about the reading, another student agreeing they found that part confusing, and another student saying how they think that question about the reading could be answered, leading into somebody else asking another question they had about the reading.

To receive a full participation grade, you must both post your reading questions online and **speak at least once in class**. If the discussion lulls, I may call on someone who hasn't spoken yet to ask their reading question. Also, if you had a question about the reading but then figured it out, that still counts!

Homework Problems (Active Learning)

Each week there will be homework problems to accompany the reading. You are strongly encouraged to work together on problems.

At the beginning of each Friday seminar, I will put the list of homework problems on the board, and we will divide into small groups for presenting a given homework problem to the class. (You'll let me know the problems you feel most comfortable with and I'll respect your preferences. Difficult problems we can all work on together.)

To make efficient use of class time there will be two rounds of problem presentations. To describe a typical week's homework discussion, suppose there six problems assigned that week, #1-#6.

- First we break into groups, with groups of 1-3 students to present each problem.
- Then each group meets for about 10 minutes to discuss their answers to their assigned problem and who will present which part of the problem.
- Then groups #1-#3 will simultaneously write their solutions on the white board. The rest of the groups continue to discuss homework problems
- When groups #1-#3 are finished writing, they will present their homework problem in turn. Questions from the rest of the class are strongly encouraged!
- Next, groups presenting on problems #4-#6 will simultaneously write their solutions on the white board. Meanwhile groups #1-#3 discuss other homework problems.
- When groups #4-#6 are finished writing, they will present their homework problem in turn. Questions from the rest of the class are strongly encouraged!

A writeup of the week's homework problems will be due after class on Friday at 11:59pm, late work will be penalized. (Your write up should be mostly be complete by class on Friday.) Homework will be submitted

through the Canvas course website, and primarily graded on completeness. As we will go over the solutions, you will receive feedback on the correctness of your work in class.

Presentations (Active Learning)

Many seminars will include short presentations prepared by students. Presentations may include discussing a section from our text or another book, readings from journals, or examples relating to the week's reading. There will be about 2 presentations per week, and each student is expected to present at least once before the midterm, and once after the midterm. At the beginning of the semester we will decide on who is presenting on which weeks. If two students wish to swap weeks that is fine, just let me know.

Each presentation should be about 15 minutes and leave 5 minutes for questions. You should not go overtime; I will set a timer. In weeks that you are giving a presentation, you are **REQUIRED** to talk to me in office hours beforehand to discuss your talk outline/ask questions about the material/etc. Student presentations will be graded on their **content**, **organization**, and **communication** according to the rubric on the last page of the syllabus.

Additional Presentation Advice

- Practice your talk to make sure the timing is right!
- It takes more time than you think to write things on a blackboard. Also, it takes more time than you think for: the listener to wait for the speaker to write something down, copy it into their notes, and then try to understand it. As a result, a good chalk talk needs to have concise board work.
- One way this manifests itself is in writing style. The writing style of blackboard presentations is different from text-book mathematical writing. For example, on a piece of paper one typically writes in complete sentences, in the second person plural, and one typically can fit more words on each line. On the chalk board, it is common to write in shorter sentences and in the imperative. (eg Writing "We simplify the above equation to obtain the following:" versus writing "Simplify!").
- When drafting presentation notes, it's important to think about how the board will look for the audience taking notes. People generally do not write down things that the presenter doesn't write on the board. I try to write down verbatim what I plan to write on the board. If I have some additional notes for what I want to say but not write, I'll write them in a different color.
- One of the things to be conscious of is how the text layout on an 8.5x11 piece of paper is different then how it gets transcribed onto the board. Being mindful of this will help the translation from notes to chalk go more smoothly. What I do is fold my piece of paper into quadrants, and then estimate that each quadrant will correspond to one column of blackboard writing.
- Some more best practices:
    - Try not to stand in front of what you're writing while you write it.
    - **TALK WHILE YOU WRITE!** Nobody likes dead air.
    - Unless you make a mistake, **DO NOT ERASE!** If it was important to write on the board, leave it up. It takes time to write things down; your note-taking audience will thank you.
    - Whenever possible, **RESUSE MATERIAL!** Using one example throughout your presentation is simple and efficient. Using many examples takes a lot more time.

- When possible, **REFER BACK**, but not too far back. If you write down an equation that gets used later AND its still on the board, its much easier to just point to it rather than copy it over again.
- Whenever possible, **AVOID LONG COMPLICATED FORUMLAS!** If the formula doesn't get used again and is not insightful, it can probably be avoided.
- To help keep your board space organized, **DRAW SEPARATING LINES!**

		UNSATISFACTORY	BASIC	PROFICIENT	DISTINGUISHED
Content	Mathematical Concepts	Displays errors in knowledge of mathematical concepts; quotes long passages from the text	Explains mathematical concepts w/o difficulty, but expresses ideas in rudimentary form.	Clearly articulates mathematical concepts.	Fully and eloquently articulates mathematical concepts. Develops connections among mathematical concepts.
	Mathematical Procedures	Has difficulty explaining mathematical procedures.	Explains mathematical procedures w/o difficulty.	Explains mathematical procedures w/o difficulty and provides partial explanations for why mathematical procedures are valid or appropriate.	Explains mathematical procedures w/o difficulty and provides full explanations for why mathematical procedures are valid or appropriate.
	Mathematical Representations (equations, diagrams)	Representations are inappropriate or unclear.	Representations are clear and appropriate, but no connections are made between representations.	Representations are clear and appropriate, with explanations of significant elements. Mentions connections among representations.	Representations are clear and appropriate, with explanations of significant elements. Clearly explains connections among mathematical representations.
	Examples	No examples or inappropriate examples.	Adequate choice of examples; may contain minor flaws.	Appropriate choice of examples.	Well-chosen and well-sequenced examples.
Organization	Presentation Structure	The presentation has no clearly defined structure, or the structure is chaotic.	The presentation has a recognizable structure.	The presentation has a clearly defined structure with some clear transitions.	The presentation has a clearly defined structure with elegant transitions.
	Timing	Greatly runs over time, ends abruptly leaving material uncovered, or ends much too early.	Presentation makes use of the allotted time (within 1-2 min), and some topics are not given an appropriate amount of time	Presentation makes use of the allotted time (within 1-2 min), with time for questions. Each topic is given an appropriate amount of time.	Talk ends on time or slightly early leaving time for questions. Each topic is given an appropriate amount of time.
Communication	Mathematical	Consistently inappropriate use of mathematical terminology and/or symbols.	Adequate use of mathematical terminology and symbols; may contain minor flaws.	Appropriate use of mathematical terminology and symbols.	Sophisticated use of mathematical terminology and symbols.
	Written	Writing is illegible or not adequately used to record information.	Writing is legible and grammatically correct.	Writing is legible and well organized.	Communicates clearly and effectively. Legible and grammatically correct.
	Oral	Does not speak clearly or demonstrates consistent grammatical errors. Rarely faces the audience while talking	Speaks clearly with no grammatical errors. Occasionally forgets to face the audience or takes long pauses while writing	Speaks clearly and effectively.	Speaks clearly and effectively in a sophisticated/engaging manner.