NJIT New Jersey's Science & Technology University

THE COLLEGE OF SCIENCE AND LIBERAL ARTS

THE DEPARTMENT OF MATHEMATICAL SCIENCES

# MATH 676: Advanced Ordinary Differential Equations
## *Fall 2020 Graduate 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.

## COURSE INFORMATION

**Course Description**: A rigorous treatment of the theory and applications of differential equations and introduction to the modern theory of dynamical systems and their applications. Effective from: Fall 2019.

**Number of Credits**: 3

**Prerequisites**: MATH 222, MATH 337, and MATH 545 or MATH 645.

**Course-Section and Instructors**

| Course-Section | Instructor |
|---|---|
| Math 676-001 | Professor D. Blackmore |

**Office Hours for All Math Instructors**: Fall 2020 Office Hours and Emails

**Required Textbooks**:

| | |
|---|---|
| **Title** | *Differential Dynamical Systems + Notes* |
| **Author** | J. Meiss |
| **Edition** | Revised Edition |
| **Publisher** | SIAM |
| **ISBN #** | 978-1611974638 |

**Required Software**: MATLAB with dfield and pplane (tutoring available).

**University-wide Withdrawal Date**:The last day to withdraw with a **W** is **Monday, November 9, 2020**. It will be strictly enforced.

## COURSE GOALS

**Course Objectives and Outcomes**

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.

**Course Assessment**: The assessment of objectives achieved through homework assignments, projects, regular in-class quizzes, and the midterm and final examinations.

## 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:

| | |
|---|---|
| **Homework + Project + Quizzes** | 20% |
| **Midterm Exam** | 35% |
| **Final Exam** | 45% |

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 | | |

**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. **STUDENTS ACCUMULATING MORE THAN THREE ABSENCES WILL HAVE THEIR GRADE REDUCED.**

**Homework and Quiz Policy**: Homework is due on the assigned date; late homework will reduce the number of points awarded, and will only be accepted at discretion of the instructor. Quizzes are given on an announced topic at times specified by the instructor.

**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 23, 2020 |
| Final Exam Period | December 15 - 21, 2020 |

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.

## ADDITIONAL RESOURCES

**Accommodation of Disabilities**: Disability Support Services (DSS) 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 Chantonette Lyles, Associate Director of Disability Support Services at 973-596-5417 or via email at lyles@njit.edu. The office is located in Kupfrian Hall, Room 201. A Letter of Accommodation Eligibility from the Disability Support 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 Disability Support Services (DSS) website at:

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

**Important Dates** (See: Fall 2020 Academic Calendar, Registrar)

| Date | Day | Event |
|---|---|---|
| September 1, 2020 | T | First Day of Classes |
| September 5, 2020 | S | Saturday Classes Begin |
| September 7, 2020 | M | Labor Day |
| September 8, 2020 | T | Monday Classes Meet |
| September 8, 2020 | T | Last Day to Add/Drop Classes |
| November 9, 2020 | M | Last Day to Withdraw |
| November 25, 2020 | W | Friday Classes Meet |
| November 26-29, 2020 | R - Su | Thanksgiving Recess - University Closed |
| December 10, 2020 | R | Last Day of Classes |
| December 11 & 14, 2020 | F & M | Reading Days |
| December 15 - 21, 2020 | T - M | Final Exam Period |

# Course Outline

| Date | Sections | Topics | Assignment |
|---|---|---|---|
| 9/1 | 1.1 -1.7 | Modeling, Mechanical Systems, Nullclines, Lorenz Model | Selected Probs. |
| 9/4 | 2.1 - 2.3 | Linear Systems, Exponentials | Selected Probs. |
| 9/22 | 2.4, 2.5 | Fundamental Solution, Semisimple-Nilpotent Decomposition | Selected Probs. |
| 9/15 | 2.6 - 2.8 | Linear Stability, Floquet Theory | Selected Probs. |
| 9/18 | 3.1, 3.2 | Existence and Uniqueness, Banach Fixed Point Theorem | Selected Probs. |
| 9/22 | 3.3 - 3.5 | Dependence on Initial Conditions, Intervals of Existence | Selected Probs. |
| 9/25 | 4.1 - 4.4 | Flows, Global Existence, Linearization, Lyapunov Functions | Selected Probs. |
| 9/29 | 4.5 - 4.7 | Topological Conjugacy, Hartman- Grobman Theorem | Selected Probs. |
| 9/29 | 4.9, 4.10 | Limit Sets, Nonwandering Sets, Basins of Attraction | Selected Probs. |
| 10/2 | 4.11, 4.12 | Stability of Periodic Orbits, Poincaré Maps (Notes on DDS) | Selected Probs. |
| 10/6 | 5.1, 5.2 | Stable and Unstable Manifolds, Homoclinic and Heteroclinic Orbits | Selected Probs. |
| | | | |

| | | | |
|---|---|---|---|
| 10/9 | 5.3, 5.4 | Stable and Unstable Manifold Theorems | Selected Probs. |
| 10/13 | 6.1 – 6.4 | Nonhyperbolic equilibria and Symmetries in the Phase Plane | Selected Probs. |
| 10/16 | 6.5 – 6.7 | Index Theory, Poincaré—Bendixson Theorem, Lienard Systems | Selected Probs. |
| 10/20 | 6.6, 6.7 | REVIEW for MIDTERM EXAM | Selected Probs. |
| 10/23 | ---------- | MIDTERM EXAM | ---------- |
| 10/27 | 7.1 | Chaotic Dynamics, Smale Horseshoe, Shift Map | Selected Probs. |
| 10/30 | 7.2 | Lyapunov Exponents, | Selected Probs. |
| 11/3 | 7.3 | Strange Attractors, Fractals | Selected Probs. |
| 11/6 | 8.1 - 8.3 | Bifurcations, Unfolding and Normal Forms, Saddle-Node Bifurcations | Selected Probs. |
| 11/10 | 8.5 - 8.7 | Andronov—Hopf, Takens—Bogdanov and Homoclinic Bifurcations | Selected Probs. |
| 11/13 | 8.8 – 8.14 | Melnikov's Method and Shilnikov Bifurcation | Selected Probs. |
| 11/17 | 9.1 – 9.3 | Hamiltonian Dynamics, Poison Flows | Selected Probs. |
| 11/20 | 9.4 – 9.6 | Action Symmetries | Selected Probs. |
| 11/24 | 9.7, 9.8 | Variational Approach | Selected Probs. |
| 11/25 | 9.9, 9.10 | Lagrangian-Hamiltonian Equivalence, Linearization | Selected Probs. |
| 12/1 | 9.12-9.14 | Integrability, KAM Theory, Onset of Chaos | Selected Probs. |
| 12/4 | Notes | Hamiltonian Overview + Glimpse of Infinite-Dimensional Dynamics | Selected Probs. |
| 12/8 | --------- | REVIEW FOR FINAL EXAM | ---------- |

*Updated by Professor D. Blackmore - 8/8/2020*
*Department of Mathematical Sciences Course Syllabus, Fall 2020*