MATH 474: Linear and Nonlinear Dynamical Systems (Fall 2023)

Instructor:	Jason Bramburger
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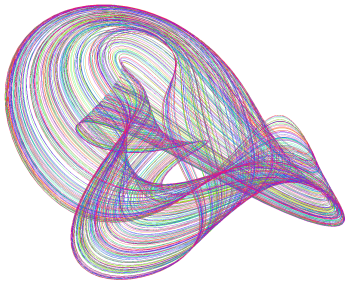
Instructor Office:	LB 901-21
Lectures:	Tuesday/Thursday 10:15 - 11:30 am
Office Hours:	Tuesday 1:00 - 4:00 pm in LB 759-06
	Virtual: by appointment only
Course Website:	Moodle



Course Topics and Goals

This course gives an overview of the theory and applications of dynamical systems modelled by differential equations and maps. We will discuss changes of the dynamics when parameters are varied, investigate periodic and homoclinic solutions that arise in applications, and study the impact of additional structures such as time reversibility and conserved quantities on the dynamics. We will also study systems with complicated "chaotic" dynamics that possess attracting sets which do not have integer dimension. Applications to chemical reactions, climate, epidemiology, and phase transitions will be discussed.

By the end of the course, you will

- have intuition into the dynamics of planar differential equations;
- be able to extract and sketch dynamical features of differential equations in two and three dimensions;
- be able to predict qualitative changes in the dynamics of mathematical models triggered by parameter changes;
- be able to interpret solutions to mathematical models in the original context.

Prerequisites

MATH 265, MATH 365, or equivalent.

Textbook

There is no required textbook as lectures will provide all relevant material and separate assignments with problems will be provided on Moodle. However, we will closely follow the textbook:

- *Nonlinear Dynamics and Chaos*, Steven Strogatz, Westview Press.

Another resource that will complement the course material is:

- *Differential Dynamical Systems*, James Meiss, Society for Industrial and Applied Mathematics (SIAM).

Instruction

Lectures will be held in-person at the times stated above. I will also post lightboard video lectures to my YouTube channel that can be used to prepare for or review class material. If you are feeling ill in any way you are encouraged to stay home and use the lecture videos to keep up-to-date with the course. You are strongly encouraged to attend class as the videos are only meant to be supplementary material and therefore may not contain everything that is covered in lecture.

Assessment

Your grade in this course will be assigned according to the following system:

30% Final Exam
30% Midterm
40% Assignments

Assignments

There will be weekly assignments. Assignments are very important; they indicate the level of difficulty of the

problems that the students are expected to understand and solve. Therefore, every effort should be made to do and understand them *independently*. The assignments will be corrected and a representative sample graded (some problems may be not graded), with solution sets posted after the due date. Late assignments will **not** be accepted without a legitimate excuse and prior approval.

Tests
This course will have a midterm test and final examination. The midterm will cover the first half of the course, while the final will cover the second half.

Calculators
Electronic communication devices (including cell phones) are not permitted in examination rooms. Only "Faculty Approved Calculators" (**SHARP EL-531** or **CASIO FX-300MS**) are allowed in examination rooms during midterm and final examinations.

Accommodations for Students with Disabilities
If you need accommodations for classes, assignments, or exams, please contact me and the Access Center for Students with Disabilities. Website: https://www.concordia.ca/students/accessibility.html.

Counselling and Psychological Services
Counselling and Psychological Services offers short-term counselling to registered Concordia students who are in Quebec. Appointments can be either virtual and in-person. Website: https://www.concordia.ca/health/mental-health/counselling.html.

Academic Integrity and the Academic Code of Conduct
This course is governed by Concordia University's policies on Academic Integrity and the Academic Code of Conduct as set forth in the Undergraduate Calendar and the Graduate Calendar. Students are expected to familiarize themselves with these policies and conduct themselves accordingly. "Concordia University has several resources available to students to better understand and uphold academic integrity. Concordias website on academic integrity can be found at the following address, which also includes links to each Faculty and the School of Graduate Studies: concordia.ca/students/academic-integrity." [Undergraduate Calendar, Sec 17.10.2]

Diversity and Inclusion Statement
Concordia University is an intentionally inclusive community that promotes and maintains an equitable and just work and learning environment. We welcome and value individuals and their differences including race, economic status, gender expression and identity, sex, sexual orientation, ethnicity, national origin, first language, religion, age, and disability. I invite and respect any concerns about inequitable access or treatment in this course.

I strive to create a learning environment for you that supports a diversity of thoughts, perspectives, and experiences, and honours your identities. To help accomplish this:

- If you have a name and/or set of pronouns that differ from those that appear in your official Concordia records, you are encouraged to let me know.
- If you feel your performance in the course is being impacted by your experiences outside of class, please come talk with me.
- I am still in the process of learning about inclusion, diverse perspectives, and identities. If something was said in class (by anyone, including me) that made you feel uncomfortable, please talk to me about it.
- As a participant in course discussion and problem-based sessions, you should strive to honour the diversity of your classmates.

Additional Course Policies

- No cell phones or computers allowed during class time.
- All announcements will be posted on Moodle. Be sure your Moodle notifications are turned on, and you check it regularly.
- I am here to facilitate your learning; let me know if you have questions! I can always be reached by e-mail, and can schedule additional office hours should you need them.

Approximate Schedule:

Week	Sections Covered	Topics
1	1, 2.1, 2.2, 2.3, 2.4, 2.5	History, flows on the line, fixed points, stability, existence & uniqueness.
2	2.6, 2.7, 3.1, 3.2, 3.4	Potentials, saddle-node, transcritical, pitchfork bifurcations.
3	3.6, 3.7, 3.3	Imperfect bifurcations, modelling insect outbreaks, laser threshold.
4	4.1, 4.2, 4.3, 4.5	Flows on the circle, ghosts and bottlenecks, modelling fireflies.
5	5.1, 5.2, 6.1, 6.2, 6.3	Linear planar systems, sketching vector fields, hyperbolic fixed points
6	6.4	Modelling rabbits and sheep, **MIDTERM**
7	6.5, 6.7, 6.8	Conservative systems, the pendulum, index theory
8	7.0, 7.1, 7.2, 7.3	Limit cycles, ruling out periodic orbits, the Poincaré–Bendixson theorem
9	8.1, 8.2, 8.3	Bifurcations in planar systems, Hopf bifurcations, chemical reactions
10	9.2, 8.7	The Lorenz system, Poincaré maps, stability of periodic orbits
11	10.0, 10.1, 10.3, 10.5	One-dimensional maps, the logistic map, Lyapunov exponents
12	Not in book	Period 3 implies chaos, the definition of chaos.