

## 1 Course Outline

Text: There is no required text for this course, but the following texts should be available in the library and may be used as references.

- D. K. Arrowsmith and C. M. Place [1990], *An Introduction to Dynamical Systems*, Cambridge Press
- J. Hale and H. Kocak [1991], *Dynamics and Bifurcations*, Springer-Verlag
- S. Wiggins [1990], *Introduction to Applied Nonlinear Dynamical Systems and Chaos*, Springer-Verlag

This course will focus on finding the behaviour of dynamical systems which cannot be solved exactly. The course will begin with an introduction to dynamical systems (discrete and continuous). We will consider local bifurcations and finally global dynamics such as the saddle-loop bifurcation and the Smale horseshoe map. Other topics, to be chosen by class interest, may be considered.

Topics

1. Introduction to discrete and continuous dynamical systems
2. Hyperbolic Equilibria and the Hartman-Grobman Theorem
3. Poincaré Maps
4. Hamiltonian Systems
5. Lupinov functions
6. 1-parameter bifurcations
7. Centre Manifold Theorem
8. Global Dynmaics
9. Chaos

All homework assignment and handouts will be available from the web page in pdf format. If you have any problems downloading or viewing/printing these documents please let me know.

## 2 General Information

**Instructor** David Iron

**Times** Monday, Wednesday and Friday 10:30-11:30

**Location** The lectures will be held in LSC B7123

**Web Page** Brightspace Course Page

**Office hours** Tues. 1:00-2:30 Thurs. 1:00-2:30

## 3 Instructor Information

**Name** David Iron

**Office** Chase 322

**Phone** (902) 494-2385

**email** iron@mathstat.dal.ca

## 4 Grading

**Homework** 60%

**Final Project** 40%

For students enrolled in 4200, each homework will contain optional bonus questions. For students enrolled in 5200 all of the assignment questions will be graded normally.

The final project will be composed of both a written report and an oral presentation. The written report will be due on the last day of classes and should be roughly 15-20 double spaced pages in length. It may be typed, Latexed or handwritten as long as it is legible. Original mathematical results are not required, but the mathematics should be a relatively current. I will supply a list of papers you may wish to choose your topics from. A some point in the term every student must discuss and get approval of a research topic for their final paper.

The oral presentations should be roughly 20 minutes in length and will all take place during the final week of classes.

The course will be delivered live. If there is a student needing copies of the lecture notes contact me and I will try and arrange to have notes posted.

## 5 Grading Scheme

The grading scheme is as follows:

A+	A	A-	B+	B	B-	C+	C	C-	D	F
[90, 100]	[85, 90)	[80, 85)	[77, 80)	[73, 77)	[70, 73)	[65, 70)	[60, 65)	[55, 60)	[50, 55)	[0, 50)

## 6 Final Notes

- Late homework will be penalized at 10% per day.
- Homework will be accepted as on time up to 6:00pm on the due date. Email submissions will be accepted, but must be in either pdf or postscript format. I will set up a dropbox in Brightspace. Homework submissions will be accepted in the drop box, via email or paper.
- The university policy states that all cases of academic misconduct *must* be handled through official channels. I have no latitude in this matter. I do encourage people to work in groups, but I must insist that each student write up their own homework. Please read the paragraph on academic honesty on pages 25-26 in the Calendar.
- Students with permanent or temporary disabilities who would like to discuss classroom or exam accommodations are asked to contact me as soon as possible. For information on available services see <http://www.dal.ca/~services/ssd.html>.

## 7 Student Accommodations

Students may request accommodation as a result of barriers related to disability, religious obligation, or any characteristic under the Nova Scotia Human Rights Act. Students who require academic accommodation for either classroom participation or the writing of tests, quizzes and exams should make their request to the Office of Student Accessibility & Accommodation (OSAA) prior to or at the outset of each academic term. Please visit

[https://www.dal.ca/campus\\_life/academic-support/accessibility.html](https://www.dal.ca/campus_life/academic-support/accessibility.html)

for more information and to obtain Form A - Request for Accommodation. A note taker may be required to assist a classmate. There is an honorarium provided for the note taker of \$75-100/course/term. If you are interested, please contact OSAA at [access@dal.ca](mailto:access@dal.ca) or 494-2836 for more information. Lectures and tutorials will not be recorded, but please speak with your instructor if you would like to use your own recording device in class.

## 8 Course Policies related to Academic Integrity

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate

## 8.1 Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. Information: [https://www.dal.ca/dept/university\\_secretariat/academic-integrity.html](https://www.dal.ca/dept/university_secretariat/academic-integrity.html)

## 8.2 Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia). Information: [https://www.dal.ca/campus\\_life/academic-support/accessibility.html](https://www.dal.ca/campus_life/academic-support/accessibility.html) Student Code of Conduct Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. Code: [https://www.dal.ca/dept/university\\_secretariat/policies/student-life/code-of-student-conduct.html](https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html)

## 8.3 Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness Statement: <http://www.dal.ca/cultureofrespect.html> Recognition of Mi'kmaq Territory Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit or e-mail the Indigenous Student Centre (1321 Edward St) ([elders@dal.ca](mailto:elders@dal.ca)). Information: [https://www.dal.ca/campus\\_life/communities/indigenous.html](https://www.dal.ca/campus_life/communities/indigenous.html) Important Dates in the Academic Year (including add/drop dates) [https://www.dal.ca/academics/important\\_dates.html](https://www.dal.ca/academics/important_dates.html) University Grading Practices [https://www.dal.ca/dept/university\\_secretariat/policies/academic/grading-practices-p.html](https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-p.html)

# 9 Student Resources and Support

## 9.1 Advising

General Advising [https://www.dal.ca/campus\\_life/academic-support/advising.html](https://www.dal.ca/campus_life/academic-support/advising.html)  
Science Program Advisors: <https://www.dal.ca/faculty/science/current-students/academic-advising.html>  
Indigenous Student Centre: [https://www.dal.ca/campus\\_life/communities/indigenous.html](https://www.dal.ca/campus_life/communities/indigenous.html)  
Black Students Advising Centre: [https://www.dal.ca/campus\\_life/communities/black-student-advising.html](https://www.dal.ca/campus_life/communities/black-student-advising.html)  
International Centre: [https://www.dal.ca/campus\\_life/international-centre/current-students.html](https://www.dal.ca/campus_life/international-centre/current-students.html)

## 9.2 Academic supports

Library: <https://libraries.dal.ca/>  
Writing Centre: [https://www.dal.ca/campus\\_life/academic-support/writing-and-study-skills.html](https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html)  
Studying for Success: [https://www.dal.ca/campus\\_life/academic-support/study-skills-and-tutoring.html](https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html)  
Copyright Office: <https://libraries.dal.ca/services/copyright-office.html>  
Fair Dealing Guidelines <https://libraries.dal.ca/services/copyright-office/fair-dealing.html>

### 9.3 Other supports and services

Student Health & Wellness Centre: [https://www.dal.ca/campus\\_life/health-and-wellness/services-support/student-health-and-wellness.html](https://www.dal.ca/campus_life/health-and-wellness/services-support/student-health-and-wellness.html)

Student Advocacy: <https://dsu.ca/dsas>

Ombudsperson: [https://www.dal.ca/campus\\_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html](https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html)

### 9.4 Safety

Biosafety: <https://www.dal.ca/dept/safety/programs-services/biosafety.html>

Chemical Safety: <https://www.dal.ca/dept/safety/programs-services/chemical-safety.html>

Radiation Safety: <https://www.dal.ca/dept/safety/programs-services/radiation-safety.html>

Scent-Free Program: <https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html>

Dalhousie COVID-19 information and updates: <https://www.dal.ca/covid-19-information-and-updates.html>

## 10 Course Policies on missed or late academic requirements

In the event that you are absent for three days or fewer resulting in missed or late academic requirements, you will be required to submit a Student Declaration of Absence Form to your instructor, see: [https://www.dal.ca/campus\\_life/safety-respect/student-rights-and-responsibilities/academic-policies/student-absence.html](https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/academic-policies/student-absence.html)

We understand that circumstances can arise that can interfere with completing your course work. We will drop your two lowest homework scores to function as a buffer for all.