

# ORDINARY DIFFERENTIAL EQUATIONS

## MATHEMATICS 2208

Fall 2019

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<b>Office Location:</b>	Searles 104	<b>Office Phone:</b>	(207) 725-3572
<b>Class Sessions:</b>	MW 1:15–2:40	<b>Classroom:</b>	Searles 217
<b>Lab Sessions:</b>	M 1:15–2:40	<b>Lab:</b>	Searles 216

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### Course Webpage

All regular announcements, instructor office hours, daily homeworks, group projects, handouts, and individual grades will be posted on Blackboard

<http://blackboard.bowdoin.edu>

Check this site on a regular basis to track your progress. General course policies, syllabus, tentative schedule and outline of the course will be also available as pdf files on Blackboard.

### Textbook and Software

- *Differential Equations*, 4<sup>th</sup> edition, by Blanchard, Devaney and Hall (ISBN-10: 1133109039, ISBN-13: 9781133109037)

A scanned copy of first couple of sections from chapter 1 is available on Blackboard in case your book hasn't arrived in mail yet.

- *GNU Octave*, for your own computer.

GNU Octave is a free Scientific Programming Language that is compatible with most Matlab scripts. We will be extensively using GNU Octave (or Matlab) during lecture period for either demonstrations or for you to do your own programming. Homework problems throughout the semester will require you to use Octave. You can download a free copy for your own use from the link below.

<https://www.gnu.org/software/octave/>

- *DFIELD*, and *PPLANE*, some Java applets.

You do NOT need to buy the textbook to access these tools. They are free to download from Blackboard. You may need Java Runtime environment to run these on your computer (download [here](#)).

- *A scientific calculator*

The use of calculators is NOT permitted for all in-class exams. But you may certainly use them when completing homework assignments, and occasionally this may be required.

### Prerequisites

In order to be considered for admission into Math 2208 you must have been completed Bowdoin's Math 2000. If you do not satisfy this criteria you will need the permission of the Chair of the Mathematics Department in order to register for Math 2208. No prior programming background is assumed.

### Office Hours

- MW 3-4:30PM, T 2-4PM, R 5:45-7PM. These time slots are common for all the courses I am teaching this semester.
- If you can't make it to any of the weekly office hours, you can email me to schedule appointments with me. These will depend on my availability.
- I am usually in the office every weekday about 10-6PM. *If my door is open*, you are welcome to knock on my door and come in with quick questions.
- Any and all questions are welcome in class or in my office, but be aware that I will not simply "give you the answer" to any problem. Big-picture questions beyond "How do I solve this problem?" are highly encouraged.
- I also welcome questions through the [discussion forum](#) available on Blackboard.. Though I strive to answer all email questions as clearly as possible, please realize that certain questions are best answered in a face-to-face discussion.

### Course Goals

- **Math 2208 Specific Goals:** Learn how to use differential equations (DEs) to model real world phenomena. There are three main categories of tools we focus on to analyze such DE models.
  1. Know how to solve a variety of DEs (analytical techniques) "by hand".
  2. Know how to analyze DEs without explicitly solving them (qualitative techniques). This means saying something about the solutions without solving.
  3. Know how to approximate solutions using algorithms implemented on a computer (numerical techniques).

While we will learn several analytical techniques, understanding their limitations should be one of main takeaways of the course. This is why, when compared to more traditional courses on the subject, more emphasis is placed on qualitative and numerical techniques and the use of computer software.

- **Putting it all together:** Given a real world phenomena, can you derive a model, pick the right tool to analyze it (not all tools work on every model), and then interpret that result in the context of the real world phenomena?
- **Life Long Skills:** Your abilities of general problem solving skills, self learning, self evaluation and how to formulate ideas and solutions will be refined throughout the course. This means problems appearing on homework or exam will not "be just like problems" you have seen before. You might be asked to explore new topics in homework before I cover them in class and you will be asked to grade parts of your own homework. Finally, how you present your solutions will also be evaluated.

### The Components of the Course

- You will need to [read the textbook](#). Several homework and suggested review problems will come directly from the book, and possibly quiz or exam problems. Some in class examples will be similar or identical to the book, but many will be different. The overall topic choice and course philosophy will be from the book. The designated sections of the text should be read prior to the class sessions for which they are assigned.

- **Weekly assignments** will contain questions based on the textbook readings and class work. These assignments with their due dates will be regularly posted on Blackboard.

You are encouraged to work on the weekly assignments with others, but you must write your final solution in your own words and you must complete and attach an **Assignment Cover Sheet** with every submission. This sheet can be downloaded from Blackboard.

As is typical for ODE courses in the Mathematics Department, homework will generally be corrected by student graders who work under my supervision; this is done to ensure that you regularly receive graded assignments in a timely manner. *Please inform me immediately if you find any mistake in graded homeworks.*

- There will be three longer **projects** built around more challenging questions from the exercises, to showcase interesting applications of the study materials. These will require you to do programming in Octave or use the Java applets.

You are allowed to work in groups of size **at most 2 (two)** to work on the projects. In your report you should include pictures and graphs of data and of solutions of your models *as appropriate*. Remember that one carefully chosen picture can be worth a thousand words, but a thousand pictures aren't worth anything. Final submissions must include a **Project Report Cover Sheet** (downloadable from Blackboard) on which the signatures of all participants must appear along with *brief but substantive* discussions of any issues confronted at your meetings. If any group member did not participate in an important aspect of the assignment, this must be stated in the Report. *One submission for your entire group will suffice.*

- We will regularly go into a **computer lab** during the lecture period for either demonstrations or for you to do your own programming. We will almost exclusively use Octave/Matlab. Homework problems throughout the semester will require you to use Octave/Matlab.
- Research shows that interactions and being active lead to deep learning. Thus, you can expect each class to contain portions where students will work on problems. Paper copy of **worksheets** will be provided and an electronic copy will be available on Blackboard.
- Additionally, there will be occasional **quizzes** and **two midterms** given during the semester, as well as a **final examination** at the end of the semester. The final exam will be according to the Registrar's office schedule. All exams will emphasize the concepts of the course.

**Grading Policy**

- Grades will be given for each weekly assignment, quiz, and exam. In addition, each lab will include a short assignment that will be collected and graded. Both your score and how it ranks relative to the other scores in the class will determine your final grade.
- *Scores will NOT be curved. However, the cutoff percentage for letter grades will be set at my discretion.*
- The following weights are tentative and subject to change on an individual basis.

The partial weights are as follows:

Weekly assignments .....	20%
Projects .....	10%
Quizzes .....	5%
Midterm 1 .....	15%
Midterm 2 .....	20%
Final exam .....	30%

**Important Dates**

Midterm # 1 .....	Wednesday, October 9, 2019
Midterm # 2 .....	Wednesday, November 6, 2019
Final Exam .....	TBA

*Please let me know immediately of any problems with these dates. Please note that the date of the final exam is set by the Registrar’s office and cannot be altered. Individual changes in final exam dates are allowed only for particularly serious situations such as three exams in a two-day period.*

**Assignment and Projects Policies**

- Homeworks are extremely important, as it is the best way for you to engage with the material on a regular basis. The problems assigned will be carefully chosen to highlight essential concepts. I also expect that in case you need extra practice with a certain concept, you will seek *extra, unassigned problems from the textbook to work out*; I am always happy to discuss how to locate good practice problems in your book.
- The point of the homeworks is for you to work out what you do and don’t understand. When your graded homework has been handed back to you, you should go through it and see if you understand what has been written on it by the grader. If you don’t, you should come to office hours and ask.
- As you are solving problems in this course, remember that getting the "answer" is only one of the steps. Don’t think of what you write as just showing your instructor that you have done the homework. Write as if you were explaining what you are doing to one of your classmates who missed that day of class. Think of writing as part of the process of learning. The more carefully and clearly you write your mathematics, the more likely it is to be correct, and the more likely you will be to remember it. *Correct answers without explanation will not reap full credit, but clear explanations with an incorrect answer can certainly earn partial credit.*

**Late submission policies**

- In general, late submission (even 15 mins late) of homework assignments will **NOT** be accepted. You may turn in *up to two* homeworks late, with no questions asked, so long as you notify me before the time the homework is due. If there are extenuating circumstances in your life you may be able to hand in more than two late homework. Please see me in such an event.
- You can make up an exam if certain unavoidable reasons prevent you from taking it and if you inform me in advance. Contact me as soon as possible if you are going to miss an exam. Missed exams can only be made up at my discretion, and are subject to a lost fraction of the grade.

**Student Participation and Collaboration**

**Student participation** is an integral part of this class and is highly valued. Everyone is expected to make thoughtful contributions in the form of questions (even if unprompted), statements, and reasoned arguments. You might be also occasionally invited to present something on the board. Whenever possible, there will be opportunities for you to work through practice problems in small groups during our class meetings.

**Collaboration** is an excellent way to facilitate learning (by formulating questions and answers verbally), and will help prepare you for your future (where you most likely will have to work with others at some point). Plus you may make some new friends! Please express yourself within the bounds of courtesy and respect.

Please share your thoughts and be willing to listen attentively to perspectives that may differ from your own. Note that as a member of a group you are responsible not only for your own learning but also for the learning of the other members of your group. This means that when the work is completed and submitted, every member of the group should be able to explain how to solve all the problems.

### Class Attendance

Attend every class. Although attendance is not directly part of your grade, it is very easy in a math class to fall behind after skipping even one class. You cannot be an effective and involved member of the class unless you are present!

### General Policies

- Be courteous when using mobile devices. Make sure your cell phone is turned fully off, or silent. If you must make or receive a call, please go outside the classroom.
- Use of laptops or tablets is permitted for note-taking and labs. Please turn off your Wi-fi and sound.
- *There will be no class on Monday of the Thanksgiving week.*
- For any private communication regarding this course, please email me from your [bowdoin.edu](mailto:bowdoin.edu) email address. This is mainly for identity verification purposes.

### Miscellaneous Items of Interest

- It is my intent that students from all backgrounds and perspectives receive **equitable access and opportunity** in this course, that students' learning needs be addressed both in and out of class, and that the diversity students bring to this class be viewed as a resource, strength and benefit. It is my intent to employ materials and engage in activities and dialogue that are respectful of: gender identity, sexuality, disability, age, socioeconomic status, ethnicity, race, nationality, religion, and culture. Please share your preferences for your name and pronouns.
- No student is required to take an examination or fulfill other scheduled course requirements on recognized **religious holidays**. Students are expected to declare their intention to observe these holidays at the beginning of the semester.
- Students with **documented accommodations** have a right to have these met. I encourage you to see me in the first 2 week of class to discuss how your accommodations may support your learning process in this course. I highly encourage all students to meet with me in the first few weeks of class (or as soon as you become aware of your needs) to discuss your learning preferences, challenges you may face learning this semester, and how we can create an effective learning experience for you. *In particular, I understand that the quizzes at the beginning of class can present a challenge, and I'm eager to discuss options with you.* If you are interested in learning more about accommodations please see Lesley Levy in the Office of Student Accessibility

<https://www.bowdoin.edu/accessibility/student-accessibility-office/index.html>

- As a student, you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or

lack of motivation. These **mental health concerns** or stressful events may lead to diminished academic performance or reduced ability to participate in daily activities. Bowdoin College is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. You can learn more about the broad range of confidential mental health services available on campus at:

<https://www.bowdoin.edu/counseling/>

- As a faculty member I am considered a **Responsible Employee**, per the **Student Sexual Misconduct and Gender Based Violence Policy**. While my goal is for you to be able to share information related to your life experiences through discussion and written work, I want to be make sure you understand that as a Responsible Employee I am required to report disclosures of sexual misconduct, dating violence, stalking, and/or sexual and gender-based harassment to the University's Title IX Coordinator, Benje Douglas. My reporting to Benje does NOT mean that any actions will be taken beyond him reaching out to you and trying to schedule a time to talk to see what assistance you might need to be successful as a student here at Bowdoin. For more information please check out:

[www.bowdoin.edu/title-ix](http://www.bowdoin.edu/title-ix)

- I support and adhere to the principles of **The Bowdoin College Academic Honor Code**. Your work should never be directly copied from another student and I will expect that *you are not reading solution manuals* for this textbook. In particular, I will assume all members of the class are trustworthy in their dealings with me as well as their fellow classmates. However, should a violation of this trust be discovered, it will be reported to the Judiciary Board. The goal is not vengeance against those who violate the Code but fairness for those who adhere to it. If you have any questions about the appropriateness of a particular situation, please communicate with me.

### **Tentative Course outline and Schedule**

The following is a preliminary outline of the topics that we hope to cover. This is an idealized plan, and it *may be adjusted as the semester progresses*. But it should give some indication of the major topics to be covered in this class.

Week No.	Monday	Wednesday
1		4-Sep Syllabus Overview + 1.1 (Modelling via Differential Equations)
2	9-Sep 1.2-1.3 (Separation of Variable, Slope Field) + <b>Using DFIELD</b>	11-Sep 1.3-1.4 (Slope Field, Euler's Method) + <b>Quiz 1</b>
3	16-Sep <b>Lab 1 (Intro to Octave - Basic Plotting, ODE45)</b>	18-Sep 1.5 (Existence and Uniqueness Theorem)
4	23-Sep 1.6 (Equilibria and Phase Line)	25-Sep 1.7 (Bifurcation)
5	30-Sep <i>Project 1 (The Spruce Budworm - Hysteresis and Cusp Catastrophe)</i>	2-Oct 1.9 (Integrating Factor) + <b>Quiz 2</b>
6	7-Oct Bifurcation contd., Change of Variable techniques	9-Oct <b>Summary Worksheet + Review</b>
<b>Midterm 1 (1.1-1.7)</b>		
7	14-Oct <b>Fall Vacation</b>	16-Oct 2.1 (Predator-Prey Model) + 3.1 (Linear System)
8	21-Oct 3.1 (Linear Systems contd.) + 3.2 (Straight line solutions)	23-Oct 3.3 (Phase Portraits) + <b>Quiz 3</b>
9	28-Oct <i>Project 2 (An Application from Economics: Modeling Profit)</i>	30-Oct 3.4 (Complex Eigenvalues)
10	4-Nov <b>Lab 2 (Trace-Determinant Plane, Defective and Degenerate cases, Bifurcation)</b>	6-Nov <b>Summary Worksheet + Review</b>
<b>Midterm 2</b>		

Week No.	Monday	Wednesday
11	11-Nov <b>Lab 3 (Second Order Linear ODEs, Harmonic Oscillators)</b>	13-Nov Forced Harmonic Oscillation, Method of Undetermined Coefficients, Resonance
	18-Nov 5.1-5.2 (Equilibrium Point Analysis, Jacobian)	20-Nov Almost Linear Systems, Consequences of Poincaré–Bendixson theorem + <b>Quiz 4</b>
	25-Nov	27-Nov
<b>Thanksgiving Break</b>		
14	2-Dec <i>Project 3 (Glycolytic Oscillations - Hopf Bifurcation)</i>	4-Dec Summary Worksheet
	9-Dec <b>Lab 4 (Lorenz Equations)</b>	11-Dec <b>Review</b>