Multivariable Calculus

Mathematics 1800-C

Fall 2019

Instructor:	Subhadip Chowdhury	**Email:**	schowdhu@bowdoin.edu
Office Location:	Searles 104	**Office Phone:**	(207) 725-3572
Class Sessions:	MWF 10:40–11:35	**Classroom:**	Searles 113
Lab Sessions:	R 1:15–2:40	**Lab:**	Searles 117
Study Group Leader:	Mustafa Aydogdu	**Study Group Session:**	T 8-9PM

Course Webpage

All regular announcements, instructor office hours, daily individual homeworks, group projects, handouts, lab assignments 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.

Textbooks and Supplies

- *Calculus: Multivariable*, 7^{th} edition, by Hughes-Hallet, Gleason, McCallum et al.

  A scanned copy of chapter 13 is available on Blackboard in case your book hasn't arrived in mail yet.

- *Mathematica*, for your own computer.

  Bowdoin has a license allowing students to download the program onto their personal computers. To learn how to download Mathematica from the Bowdoin network, follow the steps at

  https://bowdoin.teamdynamix.com/TDClient/KB/ArticleDet?ID=25361

- *A scientific calculator*

  Though Mathematica will be our most commonly used technology tool, you should also have a scientific calculator. The use of calculators is NOT permitted for most 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 1800 you must either have

1. completed Bowdoin's Math 1700 or Math 1750, or
2. been given a mathematics placement of Math 1800 when you entered Bowdoin.

If you do not satisfy at least one of these two conditions you will need the permission of the Chair of the Mathematics Department in order to register for Math 1800. No prior experience with Mathematica is required but a familiarity with mathematical computing softwares is encouraged.

The MCSR Distribution Requirement

Math 1800 can be used to satisfy Bowdoin's Mathematical, Computational, or Statistical Reasoning (MCSR) distribution requirement. Courses in this category enable students to use mathematics and quantitative models and techniques to understand the world around them either by learning the general tools of mathematics and statistics or by applying them in a subject area.

In Math 1800 you will learn how to apply the tools of calculus to perform fundamental computations and solve fundamental problems in two- and three-dimensions. We live in a three-dimensional world, enough of a reason to require expanding calculus techniques to functions of more than one variable. But dimensionality refers to more than physical dimensions. From this point-of-view (especially in an era of "big data") we often confront problems with literally thousands of dimensions. Math 1800 provides the first steps into how calculus is applied in these multi-dimensional situations.

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 online questions as clearly as possible, please realize that certain questions are best answered in a face-to-face discussion.

Course Description

The emphasis of the course will be on developing an understanding of the calculus of functions of two and three variables, as well as the geometry of associated curves and surfaces in two and three dimensions. Multivariable calculus is a fundamental pillar for many other things:

- It *extends single variable calculus to higher dimensions*. You will see that the structures are much richer than in single variable and that the fundamental theorem of calculus generalizes to higher dimensions.
- It *provides vocabulary* for understanding fundamental processes and phenomena. Examples are planetary motion, economics, waves, heat, finance, epidemiology, quantum mechanics or optimization.
- It *teaches important background* needed in social sciences, life sciences and economics. But it is rigorous enough that it is also suited for students in core sciences like physics, mathematics or computer science.
- It *builds tools for describing geometrical objects* like curves, surfaces, solids and intuition which is needed in other fields like linear algebra or data analysis. Geometry is currently an extremely popular topic: tomography methods in medicine, computer games, Google earth, social network analysis all use geometry.

- It *relates to culture and history*. The quest for answering questions like "where do we come from", "what will future bring us", "how can we optimize our time in between" all use calculus. The history of calculus contains fascinating stories, starting from Archimedes, 2300 years ago up to the modern times, where new branches of multivariable calculus are developed to understand the structure of nature.
- It *develops problem solving methods*. Examples are optimization problems with and without constraints (which is the bread and butter for economics), geometric problems, computations with scalar and vector fields, area and volume computations.
- It *makes you acquainted with a powerful computer algebra system* which allows you to see the mathematics from a different perspective. Such systems are more and more needed for visualization, experimentation and to build laboratories for your own research.
- It *prepares you for further study in other fields*. Not only in mathematics and its applications, but also in seemingly unrelated fields like game theory, probability theory, discrete mathematics, sociology, or number theory, where similar structures and problems appear, even in a discrete setting. Without geometric intuition and paradigms learned in calculus, it is rather hard to work in those fields.
- It *improves thinking skills*, problem solving skills, visualization skills as well as computing skills. You will see the power of logical thinking and deduction and why mathematics is timeless.

The Components of the Course

- You will need to read the textbook. In particular, the designated sections of the text should be read *prior/concurrently to the class sessions for which they are assigned.* This will get updated in the lecture notes and homework. You do not need to submit the solutions for the practice problems in the lecture notes, but you should try to work them out yourself to solidify your understanding. We will explain the material and work out harder examples from the section in class.
- Individual assignments will contain questions based on the textbook readings and class work. These assignments with their due dates will be regularly posted on Blackboard. The typical due date pattern is:
  - Monday's homework is due Friday same week,
  - Wednesday and Friday's homeworks are due Wednesday next week.

  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 multivariable calculus 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.*
- Around six longer collaborative projects will be built around more challenging questions. Electronic copies of the assignment details will be available on Blackboard. These will be due typically within seven to ten days. The teams for the projects will be decided in second week and will change several times over the semester.

  The collaborative projects will be completed in your Assignment Group (of size 3-4). All members of the group must not only participate in the analysis of the project but should discuss the specific phrasing

and organization of the final submission. 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 the 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. *A single submission for your entire group will suffice.*

- In the computer lab sessions you will work on Mathematica projects designed to deepen your understanding of the primary course concepts. Depending on your familiarity with Mathematica, you may find that you complete labs during the lab period, or you may find that you need some more time to complete them as homework. Either way is fine. I will announce when the Lab Homework is due depending on the workload.
- 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 handouts 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 midterms will be during Thursday Lab times. 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 daily assignments, quiz, and exams. In addition, each lab will include short assignments 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:

Individual assignments	20%
Group assignments (projects + handouts)	15%
Quizzes	10%
Midterm 1	15%
Midterm 2	15%
Final exam	25%

Important Dates

Midterm # 1	Thursday, October 10, 2019
Midterm # 2	Thursday, November 14, 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

- *Often there will be no example in the text or in class work that exactly mirrors an assigned problem or project. This is by design.* To learn how to apply the principles discussed in the text and the class sessions, you cannot merely copy procedures you see laid out in examples.
- 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 homework 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.*
- When appropriate you are encouraged to use Mathematica to help with problem solutions.

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 but only with prior permission. 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 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

- I support and adhere to the principles of The Bowdoin College Academic Honor Code. 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.

Monday	Wednesday	Thursday	Friday
	4-Sep	5-Sep	6-Sep
	Syllabus Overview + 3D Coordinate Geometry + 13.1 (Vectors in 3D)	**Lab 0 (Intro to Mathematica)** + Vectors	13.3 (Dot Product, Angle, Projection)
9-Sep	11-Sep	12-Sep	13-Sep
13.4 (Cross Product, Area, Volume)	Lines and Planes	**Lab 1 (Lines and Planes) + Distances**	**Quiz 1 + Handout 1**
16-Sep	18-Sep	19-Sep	20-Sep
12.1-12.2(Functions of several variables)	12.3, 12.5 (Contour Plots) + **Conic Sections and Quadric Surfaces**	**Lab 2 (3D Graphing)**	**Quiz 2 + Handout 2**
23-Sep	25-Sep	26-Sep	27-Sep
12.4 (Linear Functions)	17.1 (Parametrized Curves - Straight line, Circle, Helixes)	**Handout 3 (Cycloid and Hypocycloid) + Epicycloid and the Rotary Engine**	17.2 (Arc length and Curvature)
30-Sep	2-Oct	3-Oct	4-Oct
Lab 3 (Parametric Plotting)	**Handout 4 (Lab contd. + Angles)**	**Quiz 3** + 14.1-14.2 (Partial Derivatives)	14.3 (Tangent Plane and Local Linearity)
7-Oct	9-Oct	10-Oct	11-Oct
Handout 5 (Review)	**Review**	**Midterm 1**	14.6 (Chain Rule)
14-Oct	16-Oct	17-Oct	18-Oct
Fall Vacation	14.4 (Gradients and Directional Derivatives)	**Lab 4 (Gradients and Contour Plots)**	14.5 (Three dimensional Gradient and Tangent Plane)
21-Oct	23-Oct	24-Oct	25-Oct
Quiz 4 + Handout 6	15.1 (Stationary Points) + **Mathematica Project**	**Lab 5 (Ordinary Linear Regression)**	14.6 (Clairaut's Theorem and Hessian)

Monday	Wednesday	Thursday	Friday
28-Oct	30-Oct	31-Oct	1-Nov
15.3 (Lagrange Multipliers) + **Rocket Science**	15.2 (Unconstrained Optimization)	**Lab 6 (Max/Min Problems) + Quiz 5**	16.1-16.2 (Definite Integral of Functions of Two Variables)
4-Nov	6-Nov	7-Nov	8-Nov
16.2-16.3 (Type I/II regions, Triple Integrals)	16.4 (Double Integral in Polar Coordinates) + **Normal Probability Distribution**	**Lab 7 (Volume Integration)**	Polar Volume Integration (Cylindrical Coordinates)
11-Nov	13-Nov	14-Nov	15-Nov
Handout 8 (Curves in Polar Coordinates)	**Review**	**Midterm 2**	Spherical Coordinates
18-Nov	20-Nov	21-Nov	22-Nov
17.3 (Vector Fields)	17.4 (Flow of a Vector Field)	**Handout 9**	18.1-18.2 (Line Intergrals on Paramterized Curves)
25-Nov	27-Nov	28-Nov	29-Nov
Thanksgiving Break			
2-Dec	4-Dec	5-Dec	6-Dec
18.3 (Gradient Fields - Path-Independent)	18.4 (Path-dependent fields, Circulation, Curl)	**Lab 8 (Vector Fields)**	18.4 (Path-Dependent Fields and Green's Theorem)
9-Dec	11-Dec	12-Dec	13-Dec
Applications and Generalizations of Green's Theorem	**Handout 10**	**Reading Period**	**Reading Period**