Multivariable Calculus

Mathematics 1800-B

Spring 2019

Instructor:	Subhadip Chowdhury	**Email:**	schowdhu@bowdoin.edu
Office Location:	Searles 103	**Office Phone:**	(207) 725-3572
Class Sessions:	MWF 10:40–11:35	**Classroom:**	Searles 213
Lab Sessions:	R 1:15–2:40	**Lab:**	Searles 117

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.

Office Hours

- TBA. 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 email. 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

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 mathematical computer software is required.

Textbooks and Supplies

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

  Alternately, just the multivariable version. A scanned copy of chapter 12 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, go to

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

- *A scientific calculator*

  Though Mathematica will be our most commonly used technology tool, students in Mathematics 1800-C should also have a scientific calculator.

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.

Course Objectives

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.

The primary goals are for you to:

- understand functions of several variables and their **gradients**, with emphasis on **contour plots** in the plane and **graphs** in space of functions of two variables;
- master the computational techniques for, and the uses of, **double integrals** of functions of two variables;
- develop facility working with **parametric curves** in 2 and 3 dimensions;
- understand **line integrals** in the plane and master the vector calculus results associated with conservative vector fields and **Green's Theorem.**

The Components of the Course

- You will need to **read the textbook**. In particular, the designated sections of the text should be read prior to the class sessions for which they are assigned. This will get updated in the 'Prep Assignment' section of the Blackboard menu. You do not need to submit the solutions for the practice problems in the prep assignment, 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.

  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 twelve 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.
- 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.
- we will use some of the class and lab sessions to work on practice problems. Paper copy of **handouts** will be provided and an electronic copy will be available on Blackboard. Depending on how much we are able to cover during class period, part of it might get assigned as homework.
- 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, quizzes, and exams. 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.
- *You can get an additional 10% score by completing the extra credit collaborative projects.*
- *Scores will* NOT *be curved. However, the cutoff percentage for letter grades will be set at my discretion.*

The individual weights are as follows:

Individual assignments	15%
Collaborative Projects	20%
Quizzes, Labs, class work and class participation	10%
Midterm 1	15%
Midterm 2	20%
Final exam	20%

Important Dates

Midterm # 1	Thursday, February 28, 2019
Midterm # 2	Thursday, April 11, 2019
Final Exam	Thursday, May 16, 2019, 8:30 AM - 11:30 AM

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.
- You may work on the **individual assignments** with others, but you must write your final presentation in your own words and you must complete and attach an **Assignment Cover Sheet** with every submission. This sheet can be downloaded from Blackboard. Assignments will need to be submitted to me personally at the beginning of the classes.
- The point of the homework is for you to work out what you do and don't understand. You should help each other to understand the materials and come and ask me if all of you get stuck together. 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.
- The **collaborative projects** will be completed in your Assignment Group (of size 3). 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 **Collaboration Report** (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.*

- 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.

Advice on Collaborative Learning

The goal of **collaborative projects** is to ensure that everyone learns with and from their peers. 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. Here are some ideas that past students have come up with to help your group function at its full potential.

- **Schedule enough meetings**, well in advance, and make sure to attend every one of them.
- **Be prepared.** Prior to meeting do the readings and think about the problems.
- **Contribute** to the assignment solutions. Make sure that everyone is equally involved.
- **Listen carefully** and with respect to each other. Don't interrupt and don't tune out.
- **Ask for help** when you need it.
- **Give help** when it is requested.
- **Criticize ideas, not people.** Be tolerant, respectful, and caring.
- **Never agree to something you don't understand.** Don't rush to the finish before others.

Low scores and late submission policies

- You can **replace up to three quiz grades** by going to a mathematics or related talk, and turning in a 1–2 page summary of the talk. Talks from other departments with a math flavor to them can also count. (eg: biology, chemistry, computer science, digital and computational studies, earth and oceanographic science, economics, education, environmental studies, neuroscience and physics are all good places to look) For talk announcements, check out the posters around Searles, Druckenmiller, Kanbar, Adams, VAC and elsewhere. Also check the Bowdoin events calendar, dept. websites, the digest, e-mail announcements, and the ES newsletter.
- In general, late submission (even 15 mins late) of homework assignments will **NOT** be accepted. In extenuating circumstances, with proper prior notice, I will try to provide extensions to individuals. If I am not present to recieve your submission, you can put it in the Math 1800-B homework box located at the South end of Searles' first floor hallway.
- I will drop two of your lowest *individual homework* scores, no-questions-asked.

- If you think you are going to miss any quiz or exam for unavoidable reasons, please notify me beforehand. Missed exams can only be made up at my discretion, and are subject to a lost fraction of the grade.

Participation

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, statements, and reasoned arguments. You might be also occasionally invited to present something on the board. Often, the class will be split into small groups to work on the blackboards. 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.

Class Attendance

You cannot be an effective and involved member of the class unless you are present! Please try to be punctual as well. If you are late to the occasional quizzes that are administered at the beginning of the class, you will *not* be allowed any extra time.

Class Policy

- 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.
- The final exam is based on all material covered in class. If you have to miss a lecture, then I strongly recommend you study the material you missed before you return to class. I recommend doing the following steps:
  - Look at the tentative course schedule from Blackboard.
  - Read the relevant sections from the textbooks, class note, internet etc.
  - Find someone who was in class and make a copy of their notes,

  Once you have done these steps, and you still need more clarification on lectures you missed, email me to schedule an appointment.
- *For any 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

The Honor Code

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.

Monday	Wednesday	Thursday	Friday
	23-Jan	24-Jan	25-Jan
	Syllabus Overview + 12.1 (Functions of Two Variables)	**Lab 0 (Intro to Mathematica)**	12.1-12.2 (Graphs and Surfaces)
28-Jan	30-Jan	31-Jan	1-Feb
12.3 (Contour Plots) + **Heatmaps**	12.4-12.5 (Linear Functions and Level Surfaces)	**Lab 1 (3D Graphing)**	**Handout 1**
4-Feb	6-Feb	7-Feb	8-Feb
14.1-14.2 (Partial Derivatives)	14.3 (Local Linearity)	**Lab 2 (Partial Derivatives)**	13.1 (Vectors)
11-Feb	13-Feb	14-Feb	15-Feb
13.2 (More on Vectors)	13.3 (Dot Product)+ **Euclidean Geometry**	**Handout 2**	13.4 (Cross Product) + **Three Dimensional Pythagorean Theorem**
18-Feb	20-Feb	21-Feb	22-Feb
17.1 (Parametrized Curves - Straight line, Circle, Helix)	17.2 (Motion, Velocity, Acceleration)+ **Running Circles around Circles**	**Lab 3 (Parametric Plotting)**	14.6 (Chain Rule)
25-Feb	27-Feb	28-Feb	1-Mar
Handout 3	**Review**	**Midterm 1**	14.4 (Gradients and Directional Derivatives) + **Mt. Katahdin Trails**
4-Mar	6-Mar	7-Mar	8-Mar
14.5 (Three dimensional Gradient and Tangent Plane)	15.1 (Critical Points and Hessian)	**Lab 4 (Stationary Points)**	14.6 (Second-order Partial - Clairaut's Theorem and Taylor Quadratic)
11-Mar	13-Mar	14-Mar	15-Mar
Spring Vacation	**Optional Second Derivative Test Project**		**Spring Vacation**
18-Mar	20-Mar	21-Mar	22-Mar
Spring Vacation	**Optional Numerical Optimization Project**		**Spring Vacation**
25-Mar	27-Mar	28-Mar	29-Mar
15.3 (Lagrange Multipliers)+ **Rocket Science**	15.2 (Optimization) + **Line of Best Fit**	**Handout 5**	16.1-16.2 (Definite Integral of Functions of Two Variables)

Monday	Wednesday	Thursday	Friday
1-Apr	3-Apr	4-Apr	5-Apr
16.2-16.3 (Type I/II regions, Triple Integrals)	16.4 (Double Integral in Polar Coordinates) + **Normal Density**	**Lab 5 (Volume Integration)**	16.6 (Probability Density) + **Volumes of Hyperspheres**
8-Apr	10-Apr	11-Apr	12-Apr
Handout 6	**Review**	**Midterm 2**	17.3 (Vector Fields)
15-Apr	17-Apr	18-Apr	19-Apr
17.4 (Flow of a Vector Field) + **Flux Diagrams**	18.1 (Line Intergral)	**Handout 7**	18.2 (Line Intergrals on Paramterized Curves)
22-Apr	24-Apr	25-Apr	26-Apr
18.3 (Gradient Fields - Path-Independent)	**Handout 8**	**Lab 6 (Vector Fields)**	18.4 (Path-Dependent Fields and Green's Theorem)
29-Apr	1-May	2-May	3-May
18.4 (Applications and Generalizations of Green's Theorem)	**Handout 9**	**Office Hour**	21.2 (Change of Coordinates in Integrals - Jacobian)
6-May	8-May	9-May	10-May
Handout 10	**Review**	**Reading Period**	**Reading Period**