Mathematics 161B, Differential Calculus

Course Description & Syllabus

Bowdoin College Spring 2009

…[T]he elements of mathematics should be treated as the study of a set of fundamental ideas, the importance of which the student can immediately appreciate:…every proposition and method which cannot pass this test, however important for a more advanced study, should be ruthlessly cut out. …[W]ith the time thus gained, the fundamental ideas placed before the pupils can be considerably enlarged…. [I]mportant systematic applications of these ideas to the concrete world should be simultaneously studied…. [S]implify the details and emphasize the important principles and applications.

…If mathematical teaching is not now revivified by a breath of reality, we cannot hope that it will survive as an important element in the liberal education of the future.

Alfred North Whitehead, **Mathematics and Liberal Education**, **1912**

Instructor.

William Barker
Office: Searles 105, Extension 3571
barker@bowdoin.edu

Meeting Schedule.

Class Sessions:	TuTh 11:30 – 12:55, Searles 217
Laboratory:	M 1:30 – 3:25, Searles 117

Prerequisites.

Any student prepared for a standard first semester calculus course is prepared for Mathematics 161.

An Online Textbook!

Our section of Mathematics 161 will use a **totally online** textbook:

Smith & Moore, *Calculus: Modeling and Application*, 2nd Edition, Mathematical Association of America.

The development of this online text has been supported by an NSF grant to the Mathematical Association of America. It is the second edition of a textbook originally published in regular printed form as part of the NSF-sponsored *Calculus Reform Initiative* and used in selected sections of Math 161 at Bowdoin for the past fifteen years. The online version is presented using MathML (Mathematical Markup Language) and must be viewed using **Firefox**.

The online format allows the book to take advantage of hyperlinks, electronic demonstrations, and unlimited examples via the use of a computer algebra system. Currently there is **no fee** for using the book. The link to the text is:

http://www.math.duke.edu/education/calculustext/

Some preparation of one's computer is necessary for the text to operate and appear correctly. The necessary instructions are located on the **Getting Started** page:

http://www.math.duke.edu/education/calculustext/start.html

The Smith & Moore Curriculum.

The textbook *Calculus: Modeling and Application*, 2nd Edition, by David Smith & Lawrence Moore, was originally developed at Duke University as part of a nationwide effort to improve the teaching of calculus. The course builds the calculus curriculum around

(1) problems in the natural and social sciences that require calculus techniques,

(2) computer laboratories, similar to laboratories for a science course, and

(3) an emphasis on *conceptual understanding*, not solely on *computational skills*.

Central to Bowdoin's implementation of the course is the computer application *Mathematica*, a sophisticated integration of text-processing, numeric and symbolic computation, graphics, and programming.

Textbooks and Supplies.

Required but free:

Smith & Moore, *Calculus: Modeling and Application*, 2nd Edition, online text published by the MAA.

Required purchases:

Jim Hoste, *Mathematica Demystified*, McGraw Hill, 2009.
An excellent introduction and basic reference for the most recent versions of *Mathematica*. The first computer laboratory of the course will make heavy use of this book.

A scientific calculator.
Though *Mathematica* will be the more commonly used tool in our course, all students in Mathematics 161 are required to have a scientific calculator. A calculator with graphics is even better, though not required.

Optional purchase:

Student Version of *Mathematica* for your own computer.
Mathematica for Students is the complete version of *Mathematica* but sold to students at a fraction of the normal price. There are various pricing arrangements.
Consult the Wolfram Research website:
http://www.wolfram.com/products/student/mathforstudents/

How is Mathematics Learned?

"It is simplistic to suppose that people remember what they are told, and understand the things that are explained to them clearly. More commonly, people remember what interests them, and understand the things that they enjoy understanding." Edwin Moise

We hope you will *learn how to think about* and *work with* the tools of calculus. To achieve this goal the course uses a variety of teaching methods:

- We learn best by ***thinking*** and ***acting***, not by watching and listening. Learning is something we must *do*, not have done to us. This course is structured around student *activities*—in the classroom, in the laboratory, and in the out-of-class team sessions.
- Most of us learn best by working on ***real–world problems*** in which we have an interest—or at least in which we see that others might have an interest.
- We learn best by ***working with others***. Problems that seem impossible when we tackle them alone become tractable when working in a group.
- We learn by ***talking*** about what we are doing—by explaining what we have discovered, by discussing a common strategy for a group to attack a problem, by asking questions.
- We learn by ***writing***. Writing forces us to organize our ideas. Often real learning takes place only when we try to explain a problem solution in writing.
- We learn by ***reading***...if we are actively engaged in the process. Reading a math text is not like reading a newspaper: *we rarely "get it all" the first time*. We must read it numerous times, with pencil in hand.

Components of the Course.

You will ***read the online textbook***. In particular, the designated sections of the text should be read *prior* to the class sessions for which they are assigned.

Individual assignments will contain questions based on the textbook readings, laboratories, and projects. Some problems will require the use of *Mathematica*.

Most weeks will also have ***collaborative assignments***. Collaborative assignment groups consisting of three or four students will be assembled during the first week of the course.

In the ***computer laboratories*** you will work in pairs on *Mathematica* projects designed to deepen your understanding of the primary concepts and to explore important applications.

There will be ***two examinations*** given during the term as well as a ***final examination***. All the exams will emphasize the *conceptual* aspects of the course.

Individual and Collaborative Assignments.

You will often find that there is no example in the text or in class work that exactly mirrors an assigned problem or project. This is by design. We want you to learn how to apply the *principles* discussed in the texts and the class sessions, not merely copy procedures you see laid out in examples.

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 ***Individual Cover Sheet*** with every assignment. This sheet can be downloaded from our *Blackboard* site.

The **collaborative assignments** will be completed in your *Assignment Group*. All members of the group must not only participate in the analysis of the problems but should discuss the specific phrasing and organization of the final submission. Final submissions must include a ***Collaborative Report*** — downloadable from *Blackboard* — on which the signatures of all participants should 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.

Assignments will generally be due on **Wednesdays** and **Fridays** by 5:00pm, to be submitted via the Math 161B homework box located at the South end of Searles' first floor hallway. In addition to help I provide during office hours, I also watch for e-mail questions and, when appropriate, forward my responses to the whole class.

Submitted work should be in prose and should be clear enough that an educated reader would understand the problems posed and the solutions given. *This is particularly important for the collaborative assignments.* When appropriate you are encouraged to use *Mathematica* to help with problem solutions.

Collaborative Learning and Cooperation.

As a member of a group you are responsible not only for your own learning but for the learning of the other members of your group.

Be prepared. Prior to meeting do the readings and think about the problems.

Contribute to the assignment solutions. Everyone has this responsibility.

Listen carefully and with respect to each other.

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 in a group submission.

The Assignment Groups.

"In the first three years of college I never expected to learn anything from my fellow students. The line ran from the teacher in front of the room to me. Then another line ran from him to the student sitting next to me."

Ken Macrorie

The collaborative assignments will be done within designated *Assignment Groups*. Each group will consist of three or four members, each with an assigned role. The roles should be rotated so that everyone samples each task. The roles are as follows:

Scribe. The scribe **writes up** the solutions. More complete and creative solutions receive higher grades. The scribe should attempt to do much of the write-up during the group sessions themselves. All group members should examine the final paper before submission.

Manager. The manager **schedules** group meetings and **notifies** members of times and locations.

Clarifier. During meetings the clarifier **monitors group dynamics**, making sure that no member of the group is left out or hopelessly lost. The clarifier is to be a **careful observer**; it is not assumed that the clarifier has greater understanding of the material than anyone else in the group.

Reporter. The Reporter **records** the particulars of group sessions in the *Collaboration Report*. *The report must be the first page of the assignment submission.* It must (1) say when the group met, (2) list who was present (and for how long) at each meeting, (3) specify what roles everyone had, and (4) contain the signatures of all group members, vouching for their full participation in the assignment solutions.

In groups of three students, the roles of Reporter and Manager should be merged.

Class Attendance.

You cannot be an effective member of your project group nor laboratory pair unless you are an effective and involved member of the class. You cannot be an effective and involved member of the class unless you are present.

Examination Schedule.

There will be **two examinations** given during the term as well as a **final examination** at the end of the semester. All these exams will emphasize the conceptual aspects of the course as opposed to the strictly computational. The dates for these exams are as follows:

First Exam: Monday, **March 2**, 1:30pm.
Second Exam: Monday, Monday, **April 13**, 1:30pm.
Final Exam: Friday, **May 15**, 9:00am.

Course Grade.

Grades will be given for each individual assignment, collaborative assignment (which includes the projects), and electronic laboratory submission. The course grade will be determined by these grades and the exam grades as follows:

Individual Assignments 20%
Collaborative Assignments 15%
Laboratory critiques 5%
Exams 60%
First Exam 15%
Second Exam 15%
Final Exam 30%

The Honor Code.

The course instructor supports and adheres to the principles of Bowdoin's Honor Code. In particular, the students will be assumed trustworthy in all their dealings with the instructor and fellow classmates. However, should a violation of this trust be discovered, the offending act 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.

Laboratory Schedule.

Date:	**Laboratory:**	
January 26:	**Lab 1**	Introduction to *Mathematica*.
February 2:	To be announced.	
February 9:	**Lab 2**	Instantaneous Rates of Change.
February 16:	**Lab 4**	Limited Population Growth.
February 23:	**Lab 5**	Rates of Change — Puppy Growth.
March 2:	*Examination I, no laboratory.*	
March 23:	**Lab 6**	Radioactive Decay.
March 30:	**Lab 7**	Newton's Method.
April 6:	**Lab 8**	Accident Reconstruction.
April 13:	*Examination 2, no laboratory*.	
April 20:	**Lab 11**	The Spread of Epidemics.
April 27:	**Lab 20**	Area From Sums.
May 4:	*No new laboratory*.	

Readings from *Calculus: Modeling and Application.* 2nd Edition

(Starting dates are approximate)

Introduction January 20

Chapter 1. Relationships .... **January 20**
- §1.1 Related Variables
- §1.2 Mathematical Models
- §1.3 Terminology
- §1.4 Functions as Objects
- §1.5 The Algebra of Functions

Chapter 2. Models of Growth: Rates of Change .... **February 3**
- §2.1 Rates of Change
- §2.2 The Derivative: Instantaneous Rates of Change
- §2.3 Symbolic Calculation of Derivatives
- §2.4 Exponential Functions
- §2.5 Modeling Population Growth
- §2.6 Logarithms and Representation of Data

Chapter 3. Initial Value Problems .... **February 19**
- §3.1 Differential Equations and Initial Values
- §3.2 An Initial Value Problem: A Cooling Body
- §3.3 Another Initial Value Problem: A Falling Body

Chapter 4. Differential Calculus and Its Uses .... **March 3**
- §4.1 Derivatives and Graphs
- §4.2 Second Derivatives and Graphs
- §4.3 Solving Nonlinear Equations by Linearization: Newton's Method
- §4.4 The Product Rule
- §4.5 The Chain Rule
- §4.6 Derivatives of Functions Defined Implicitly
- §4.7 The General Power Rule
- §4.8 Differentials and Leibniz Notation

Chapter 5. Modeling with Differential Equations .... **April 9**
- §5.1 Raindrops
- §5.2 Euler's Method
- §5.3 Periodic Motion
- §5.5 Trigonometric and Inverse Trigonometric Functions
- §5.6 Derivative Calculations

Chapter 6. Antidifferentiation .... **April 21**
- §6.1 Finding Antiderivatives

Chapter 7. The Fundamental Theorem of Calculus .... **April 23**
- §7.1 Averaging Continuous Functions: The Definite Integral
- §7.2 The Fundamental Theorem of Calculus

	Tuesday	Thursday	
	Jan 20 **Chapter 1** § 1.1	Jan 22 §§ 1.2, 1.3	
Lab 1: Intro to *Mathematica*	Jan 27 § 1.4	Jan 29 § 1.5	
To be announced	Feb 3 **Chapter 2** §§ 2.1, 2.2	Feb 5 §§ (2.2), 2.3	
Lab 2: IROC	Feb 10 § 2.4	Feb 12 § 2.5	
Lab 4: Limited Pop Growth	Feb 17 § 2.6	Feb 19 **Chapter 3** § 3.1	
Lab 5: Puppy Growth	Feb 24 § 3.2	Feb 26 § 3.3	
March 2 **Exam I** 1:30 pm	March 3 **Chapter 4** § 4.1	March 5 § 4.2	
	Spring	**Break**	
Lab 6: Radiocarbon Dating	March 24 § 4.3	March 26 § 4.4	
Lab 7: Newton's Method	March 31 § 4.5	April 2 §§ 4.6, 4.7	
Lab 8: Accident Reconstruction	April 7 § 4.8	April 9 **Chapter 5** §§ 5.1, 5.2	
April 13 **Exam II** 1:30 pm	April 14 §§ 5.3, 5.5	April 16 §§ (5.5), 5.6	
Lab 11: Spread of Epidemics	April 21 **Chapter 6** § 6.1	April 23 **Chapter 7** § 7.1	
Lab 20: Area from Sums	April 28 §§ (7.1), 7.2	April 30 § (7.2)	
	May 5		

Final Exam: Friday, May 15, 9:00a.m.