

# SAMPLE SYLLABI

Subhadip Chowdhury

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**Part I**

**University of Chicago**

# ELEMENTARY FUNCTIONS AND CALCULUS I

## COURSE SYLLABUS

Autumn 2023

Math 131

### §A. Key Information

- **Instructor:** Depends on the section in which you are enrolled. (See [table 1](#) on page 2.)
- **Class Meetings:** Monday, Wednesday, and Friday at a regularly prescribed place and time for your section (also found in [table 1](#) on page 2). The locations might get updated as late as the morning of Sep 27 - please check back.
- **Tutorial Sessions:** Tuesdays and Thursdays at a regularly prescribed place and time for your subsection (also in [table 1](#) on page 2). Attendance and participation is mandatory and accounts for 5% of your grade. See Canvas for which tutorial you should be attending.
- **Canvas:** Our course Canvas page (<https://canvas.uchicago.edu/courses/51908>) will effectively function as a homepage for our course and contain all relevant information. It is recommended that you check Canvas daily for updates, announcements, and assignments.
- **Office Hours:** Please see Canvas for up-to-date office hours. This syllabus will eventually list the office hours for each section once they are finalized. Note that a student should only attend the office hours of the instructor of the section in which you are enrolled. *It is highly recommended to book a meeting ahead of time.*
- **Textbook:** Calculus, 9th Edition by Varberg, Purcell, Rigdon. ISBN-13: 9780131429246. Any version that you are comfortable using (hardback, PDF, etc.) will suffice. For any homework exercise assigned directly from the textbook, a pdf scan of the problems will be provided. Any other homework will be assigned through Canvas.
- **Weekly Exercise Sets:** Will be assigned weekly and graded for both completeness and correctness. Due dates will usually be Friday at 6pm, and the total weight of weekly exercise sets is 10%. Late Homework may receive a late penalty of up to 20% per day, and homework submitted more than 48 hours after the due date will receive no credit. Exceptions such as medical emergency will be handled on a case-by-case basis.
- **Suggested Exercises:** Announced in Canvas and will provide extra practice. Not for a grade, but some test questions may be selected from these exercises.
- **Tutorial Quizzes:** Will occur at the conclusion of Thursday tutorial sessions (except midterm weeks) and will combine to account for 5% of your overall grade.
- **Midterm Exams:** Will occur twice in the evening, once on *October 18* and another on *November 15*. Both will occur at 7pm (as per your registration schedule). Room assignments will be announced in due time. Each midterm will account for 25% of your overall grade (for a total of 50%).
- **Final Exam:** Will occur once at a common time (among all sections) during the final exam week (TBD). The final will be cumulative, run two hours, and account for 30% of your overall grade.

It is the policy of the Department of Mathematics that the following rules apply to final exams in all undergraduate mathematics courses:



- The final exam must occur at the time and place designated on the College Final Exam Schedule. In particular, no final examinations may be given during the tenth week of the quarter, except in the case of graduating seniors
- Instructors are not permitted to excuse students from the scheduled time of the final exam except in the cases of an Incomplete.

Section	Instructor	Class Meetings (MWF)	Tutorial Sessions (TR)
10	Zoalroshd, Seyed	8:30-9:20am Ryerson Phys Lab 177	8-9:20am (T1) Social Sciences Rsch Bldg 106 (T2) Social Sciences Rsch Bldg 107 (T3) Social Sciences Rsch Bldg 108
20	Nguyen, Hoan	9:30-10:20am Eckhart Hall 207A	8-9:20am (T1) Gates-Blake Hall 211 (T2) Hinds Lab Geo Sci 180 (T3) Gates-Blake Hall 401
22	Sutton, Callum	9:30-10:20am Saieh Hall for Economics 247	8-9:20am (T1) Gates-Blake hall 411 (T2) Gates-Blake Hall 502 (T3) Gates-Blake Hall 506
24	Zhang, Samanda	9:30-10:20am Pick Hall 022	8-9:20am (T1) Harper Mem Library 141 (T2) Harper Mem Library 150 (T3) Wieboldt Hall 102
25	Gravel, Katherine	9:30-10:20am Saieh Hall for Economics 103	9:30-10:50am (T1) Eckhart Hall 117 (T2) Gates-Blake Hall 211 (T3) Classics Building 313
28	Chowdhury, Subhadip	9:30-10:20am Ryerson Phys Lab 177	9:30-10:50am (T1) Gates-Blake Hall 401 (T2) Gates-Blake Hall 411 (T3) Gates-Blake Hall 506
30	Olson, Mark	10:30-11:20am Ryerson Phys Lab 276	11-12:20pm (T1) Gates-Blake Hall 211 (T2) Kent 106 (T3) Gates-Blake Hall 401
32	Bowman, David	10:30-11:20am Pick Hall 022	11-12:20pm (T1) Gates-Blake Hall 502 (T2) Gates-Blake Hall 506 (T3) Harper Mem Library 141
34	Devlin, Charley	10:30-11:20am Eckhart Hall 207A	12:30-1:50pm (T1) Eckhart Hall 117 (T2) Gates-Blake Hall 211 (T3) Cobb Hall 103
40	Li, Ray	11:30-12:20pm Eckhart Hall 207A	12:30-1:50pm (T1) Gates-Blake Hall 401 (T2) Gates-Blake Hall 502 (T3) Gates-Blake Hall 506
44	Wilson, Christopher	11:30-12:20pm Eckhart Hall 117	11-12:20pm (T1) Harper Mem Library 151 (T2) Stuart Hall 209 (T3) Psychology Green Hall 101
46	Su, Boyang	11:30-12:20pm Kent Chem Lab 106	12:30-1:50pm (T1) Harper Mem Library 151 (T2) Stuart Hall 209 (T3) Gates-Blake Hall 411
50	Contreras Hip, Andres	12:30-1:20pm Ryerson Phys Lab 177	5-6:20pm (T1) Wieboldt Hall 230 (T2) Wieboldt Hall 130 (T3) Cobb Hall 116
52	Yao, Yuhui	12:30-1:20pm Ryerson Phys Lab 276	5-6:20pm (T1) Cobb Hall 219 (T2) Social Sciences Rsch Bldg 105 (T3) Social Sciences Rsch Bldg 106

Table 1: Instructors and Meeting Times

**Registration Changes:** Once we begin classes, if you wish to change your registration, you will need to contact [mathadvising@math.uchicago.edu](mailto:mathadvising@math.uchicago.edu). Note that you have until Week 3 to finalize your math registration.

## §B. Course Description

Calculus can be viewed broadly as the study of change. Some of the immediate questions to ask about any changing quantity could be: “how do we know if it is changing”, “when is it increasing or decreasing”, and perhaps more importantly, “how fast is the quantity changing?”. We hope to answer these questions by interpreting mathematical quantities as functions that are represented graphically, numerically, analytically, or verbally; and interpret their derivative as their rate of change.

Math 131, along with the first couple of weeks of Math 132, covers the content of a typical differential calculus course. We will provide a careful but comprehensive treatment of limits, continuity, and differentiability of non-trigonometric algebraic functions, and applications of the derivative. Here is some general advice that may prove helpful moving forward. Start your homework assignments early, so that if you need help you have sufficient time to meet with me or the Junior Tutors. Begin studying for quizzes and exams well in advance. Put your good study habits into practice by reviewing formulas and working through extra suggested problems when necessary, so that you can identify weaknesses and seek help. Remember that part of doing real math is productive failure: you’ll try things that don’t work; learn something from that failure; try something new that works a bit better, and... after a while, you will figure it out, and come out with a much more robust understanding of the structure of mathematics.

### Learning Goals

We will cover much of Chapters 0-3. Below is a rough outline of coverage, and a summary of our main learning goals.

- Ch 0 - Preliminaries, Sections 0.1-0.6 (6 lectures);
  - Define basics of Set theoretic concepts focusing on number sets.
  - Learn how to write down your arguments logically and about different techniques of proving a statement.
  - Solve inequalities with a focus on those relevant to  $\epsilon - \delta$  proofs.
  - Use coordinate geometry to find equations of circles and straight lines.
  - Sketch and identify the graphs of elementary functions, specifically polynomials, power functions, absolute, and greatest integer function.
  - Describe different properties of function: domain, range, composition, translations, symmetry, odd/even, roots, asymptotes, etc.; and how they affect the graphs.
- Ch 1, Sections 1.1-1.3, 1.5, and 1.6 (5 Lectures);
  - Understand the intuitive concept of Limits graphically and numerically
  - Define Limits rigorously using  $\epsilon - \delta$  and give proofs using appropriate justification and notation
  - Define and evaluate (using algebra) the limit of a function as the input approaches a point (possibly from just one side) or at infinity.
  - Learn to use Squeeze theorem as necessary.
  - Use infinite limits to provide a formal definition of asymptotes
  - Define and determine the continuity of a function at a point or in general, and correctly characterize types of discontinuities.
  - State and use the Intermediate Value Theorem.
- Ch 2, Sections 2.1-2.3 and 2.5-2.8 (8 Lectures);
  - Experiment in DESMOS with the tangent and velocity problem
  - Learn how to formally define derivative and recognize points where a function is (and is not) differentiable, with appropriate justification. Be able to match a function with the graph of its derivative function.
  - Compute derivatives correctly for sums, constant multiples, powers, and polynomials functions; their products and quotients; and correctly use the chain rule for function composition.

- Evaluate higher order derivatives and apply them to Physics in the context of velocity and acceleration.
- Learn to differentiate functions implicitly and find equation of tangent lines to a curve.
- Relate the rates of change of variables in an applied problem.
- Ch 3, Sections 3.1-3.4 (4 Lectures).
  - Identify relative and absolute extrema (maximum and minimum points) of a function graphically.
  - Use calculus to identify critical points and inflection points of functions and correctly apply them to identifying extrema.
  - Determine absolute extrema for a function on a closed interval.
  - Interpret monotonicity and concavity of a graph using derivatives and use information about  $f$ ,  $f'$ , and  $f''$  to create examples of functions.
  - Interpret derivative as a rate of change in the context of statistics and economics.

### §C. Details of each type of assignment and test

- **Active Participation:** You are expected to be an active participant in this course. Math is not a spectator sport! Math is best learned actively. During class, listen actively and think actively. Contribute your meaningful thoughts. There are many ways to participate in this course, including: attending class meetings and discussion, asking and answering questions in class, working with others both inside and outside of the classroom, and attending office hours.

If you feel that you need to miss class for some reason, you are responsible for letting me know via email as soon as possible, as well as getting any material and announcements that you miss from fellow classmates. In particular, you should obtain and read the class meeting notes and do the corresponding reading in the textbook before seeking additional help with the material from that day.

- **Weekly Exercise Sets:** Usually 3-5 problems on the content covered in each lecture will be assigned as homework after the session. Wednesday, Friday, and Monday's problems will be due on Friday. You will be uploading a PDF of your work directly to Gradescope via Canvas. Your instructor will walk you through the process as necessary.
- **Tutorial Worksheets:** During each tutorial session, students will work in groups to complete a practice problem worksheet under the direction of the Junior Tutors. Note that these sessions have a set agenda and are not meant to be office hours. Participation is mandatory and counts towards your grade.
- **Tutorial Quizzes:** Each Thursday tutorial session (that does not follow a midterm exam) will conclude with a quiz on topics encountered since the previous quiz (and/or exam). Quizzes may contain questions of the form of true-false, multiple choice, and/or free response. As per official department policy regarding Math 131, your two lowest quiz scores (this includes any quiz you miss) will be dropped.
- **Midterms:** Each Midterm will cover the content covered in class up to the week before. These will be cumulative. Requests for make-up midterms should be made directly to me and will be considered on a case-by-case basis by my discretion. If you anticipate needing to request a make-up exam, communicate with me as soon as possible.
- **Final Exam:** The final exam is comprehensive and every question will be graded and scored out of 100pts. That overall Final Exam score will remain worth 30% of your overall grade in our course.
  - Our Final will include questions from topics which directly relate to Sections 0.1-1.3 (namely, those on Midterm 1) as well as those relating to Sections 1.5-3.1 (namely, those on Midterm 2). Every student's performance on these questions (of the Final related to Midterm 1 topics) will be tallied separately from the over Final Exam score. Similarly for questions of the Final related to Midterm 2 topics.
  - If the percentage of the points earned on the questions of the Final related to Midterm 1 exceeds that of your Midterm 1 score, then your Midterm 1 subscore on the Final will replace your Midterm 1 grade. Similarly for Midterm 2.

Let's consider two examples.

1. Say you earned a 42% on Midterm 1, and on the questions of the Final relating to Midterm 1 you earned 75% of those points. Regardless of your overall Final Exam score, your new Midterm 1 score will be 75%.
2. Say you earned an 87% on Midterm 1, and on the questions of the Final relating to Midterm 1 you earned 75% of those points. Regardless of your overall Final Exam score, and your Midterm 1 score will remain an 87%.

Ultimately, your overall Final Exam score will always count. However, if you show (on the Final) that you have learned the Midterm 1 material better (than you knew it back a couple weeks ago), you can replace your Midterm 1 grade with that better performance from the questions of the Final relating to Midterm 1 (and similarly for Midterm 2).

### §D. Collaboration Policy on Homework

Collaboration on written homework is encouraged; however, you need to carefully balance learning with your fellow students and finding your own path through the material. You must follow the collaboration guidelines below.

1. When you solve homework problems, outside materials are not allowed unless the instructor give explicit permission. (By outside materials, we mean materials like web pages and solutions that are not distributed by the instructor. If you are unsure, just ask!)
2. Unless otherwise specified, you may use mathematical software for written homework problems; if you do so, include a printout/screenshot that shows not only the answer but also the commands you used ("Show your work!"). Note that many of the computational problems demand that you show every step of an algorithmic process, so don't rely on software to skip any steps!
3. On your written homework, you must indicate who your collaborators are. (If you collaborate with different people on different problems, say so!)
4. Work on a problem by yourself until you have your own "idea" about the problem; after that, you may start collaborating. A valuable idea can be as simple as a sense of why you are stuck!
5. Keep written collaborative work separate from your written individual work. The same applies when you discuss problems with tutors or me.
6. Do the actual write-up of your homework assignment without collaboration notes so as to reflect your own understanding of the problem. If you cannot write the solution without referring to your collaboration notes, then you have not yet understood the solution. In that case, go back to step (4).

Note that the last guideline above means that while you are collaborating (including with me at Office Hours!), you cannot be simultaneously working on the final draft of your homework! To ensure productive collaborations, you should not work in groups larger than four people on any given problem at any given time. Large groups of people "working together" are not really working together! **If anything is unclear, ask the instructor!**

### §E. How to determine your grade?

The weights of each different type of assignment are as follows:

Weekly E-Sets	10%
Tutorial Attendance and Participation	5%
Tutorial Quizzes	5%
Midterm 1 and 2	25% each
Final Exam	30%

Your numerical score will then be rounded to the nearest integer and converted into a letter grade for your overall course grade, taking into account the difficulty of the exams and the overall distribution of scores. The initial guideline for grade determinations will be the following: A 93-100%; A- 90-92%; B+ 88-89%; B 83-87%; B- 80-82%; C+ 78-79%; C 73-77%; C- 70-72%; D+ 68-69%; D 60-67%.



Note that it is the policy of the Department of Mathematics that Math 13100 cannot be taken with a Pass/Fail (P/F) grading scheme, regardless of your major or purpose in taking the course.

**W and I grades:** You may meet with your College Adviser (not the instructor) to request a “W” (withdrawal) grade until 5pm of Monday on Week 9.

“I” (Incomplete) grades are rarely given, and only to those who have done the majority of the work in the course of passing quality, who, because of illness or other good reasons, are unable to complete all the course work by the end of the quarter.

Final decision regarding any changes to these guidelines will be that of the Director and Co-Directors of Undergraduate Studies in the Department of Mathematics and will be communicated to all in Canvas. Any such changes can only (if anything) loosen the requirements from what is given above.

## §F. Helpful Resources

Performing well in this course will be a function of your engagement and investment. A minimum requirement of yourself should be actively participating in class meetings and tutorial sessions, taking notes to support your studying, and successfully understanding all exercises that are assigned. Moreover, we encourage you to observe your thoughts related to classwork, homework, and other class documents. Calculus, a mathematical study of change, connects to many topics within a broad range of areas of study, so taking the time to explore connections between what we have studied and what you’ve studied previously will only enrich your experience in this course.

### Office Hours

Please stop by office hours to ask questions! We have set aside this time specifically to help you learn and be successful in the course. Any and all questions are welcome in class or in my office. Big-picture questions beyond “How do I solve this problem?” are highly encouraged. (Even questions about math that aren’t immediately about your next homework due. Gasp!) Over and over, the students in our courses that improve the most are the ones that most frequently attend office hours. If you are unable to make any of the office hours, please email the instructor to set up an appointment.

### College Core Tutor Program

The College Core Tutor Program (<https://college.uchicago.edu/academics/college-core-tutor-program>) is a peer-based tutoring program for UChicago undergraduates designed to provide one-on-one assistance and small group support to undergraduate students in scientific and quantitative subjects, including chemistry, economics, mathematics, statistics, computer science, physics, and biology. Their tutors are upperclassmen in the College with exceptional academic records or graduate students — many of them former Teaching Assistants in the Core science courses.

It should be noted that these tutors are not affiliated with this specific section of the course or the math department in general, so they may explain things differently than or use different conventions to how they were discussed in class. Always be sure to double check with our authoritative sources: your notes from class, the textbook, and me, either in class or office hours.

No appointments are necessary; drop-in Sundays through Thursdays between 6 p.m. and 10 p.m. CST starting the third week of the quarter through the week of final exams.



## Academic Accommodations

If you need any special academic accommodations, please provide your instructor with a copy of your Accommodation Determination Letter (provided to you by the Student Disability Services office) as soon as possible so that you may discuss how your accommodations may be implemented in this course. If you are in the process of obtaining accommodations, please inform your instructor as soon as possible. More information can be found here: <https://disabilities.uchicago.edu/>.

## Religious Accommodations

The University of Chicago is home to students of all the world's major religions and, though firmly a secular institution, values the rich diversity of spiritual expression and practice found on campus. It is therefore the policy of the University that students who miss class, assignments, or exams to observe a religious holiday must be accommodated as follows: (i) absences may not be counted as a missed class in any course in which attendance is a measure of academic performance; (ii) reasonable extensions of time must be given, without academic penalty, for missed assignments; and (iii) exams must be reasonably rescheduled without academic penalty. Students must inform their instructors in writing of their need to observe a religious holiday reasonably well in advance of the absence, preferably at the beginning of the quarter. More information can be found at the following; <https://provost.uchicago.edu/handbook/clause/policy-religious-accommodation-missed-classes-assignments-and-exams>.

## Wellness Resources.

Know that UChicago has counseling available both 24/7 and by appointment through <http://wellness.uchicago.edu>. Also know that medical care (beyond that related to Covid-19) is available, including 24/7 access to medical professionals to address your health care questions.

## §G. Classroom Norms

### 'Growth', not 'Ability'

There is a very prevalent belief that you are either “good” or “bad” at math, and if you are “bad” at it, then you will always be bad at it no matter how hard you try. This is extremely false, and the mathematics community bears a lot of responsibility for perpetuating this myth. In reality, mathematics is just like any other discipline or skill: you can improve more and more with practice.

We are all capable of growth in mathematics. You should measure your success in this class by how much your understanding of the concepts have improved over the course of the quarter. Also, math is very hard, so you should expect to struggle with the material! When you struggle, you are learning and growing. Not all people show their struggle in equal ways, so you should always be wary of judging your progress based on your perception of your peers' struggle. You are probably doing better than you think.

### Respecting Each Other

We are not all coming to this class with the same privileges, resources, time, and knowledge. It's really important to keep this in mind when working with each other on homework assignments and during class meetings. **It is our strong belief that as a community, mathematicians and scientists need to do a much better job of making our disciplines more accessible to people of all races, genders (including gender non-conforming folks), sexual identities, and class backgrounds.** While this is a priority for us in the classroom, we do not claim to know how to best honor this commitment, and so **we are very open to feedback from students when it comes to making the course more accessible and inclusive to all identities.**

It's also important to think about how to respect one another when working together in groups. It's not equally easy for all of us to speak up in a large group, and the voices of historically underrepresented/marginalized students are most easily drowned out in group work. So please keep this in mind when working together. Here are some concrete examples of positive collaborative behavior:

- Making sure everyone who wants it has the opportunity to speak frequently. This can mean checking in with each other to make sure everyone is following along and contributing when they have an idea.
- Respecting people's pronouns and other aspects of their identity.
- Making sure that everyone's ideas are acknowledged when writing up the final solution to a problem. When working in groups, solutions often evolve organically; an idea might pop into your head and you may think it's yours and yours alone, but perhaps you only arrived there because of something else that someone already said. Pay attention to what people are saying and try to learn from one another.

We will do our best to check in with folks periodically during the quarter. **If at any time in the quarter you want to be working in a group but do not have a group of students to work with, please let the instructor know and they will help you find a working group. If at any time in the quarter, you find yourself in a group of students for which the above behaviors aren't being practiced and people aren't feeling respected, please let the instructor know as well.**

## §H. Policies and Protocols

### Attendance and Absence

**Attendance is *crucial* to success in this class.** Your best chance to discuss new material, ask questions, and avoid confusion is during class. So, don't miss class! You are responsible for all material and announcements from class, even in case of absence. Much of this information will be available on Canvas. Please check in with your instructor and with your classmates when you are back.

That said, life happens. We get the flu (or COVID!). Relatives need your help. When this happens, do what you need to do. We trust that you are an adult and will make the best choices that you can. We appreciate it if you can notify the instructor in advance of an absence, if possible. While we do not track attendance during class, we will alert your course advisor in the event of multiple missed classes, missed homework assignments, etc.

### Academic Integrity

Academic honesty is central to the spirit of a UChicago education. On individual work, take care to independently communicate your submissions (regardless of how many others you may have collaborated with along the way to developing a solution). On tests and the final, let your work be original to your mind and your thoughts.

Violations of academic integrity are serious and will be handled seriously. Resulting punishment could include (at least) taking a zero for an assignment where an instructor has probable cause that cheating or plagiarism has occurred. For more details, regarding academic honesty within the College, please visit the following link: <https://college.uchicago.edu/advising/academic-integrity-student-conduct>.

### Technology in the Classroom

Encouraged for learning math; discouraged for distracting yourself or others! As a matter of courtesy, please turn off or silence cell phones, pagers, and other communication and entertainment devices prior to the beginning of class. At some points in the course, we may be explicitly using laptops or cell phones to better understand the mathematics we're studying. Please respect your fellow students by not using any of them in a way that is distracting or counterproductive to class.

### UChicago Health Pact

All students on campus are required to adhere to the guidelines in the UChicago Health Pact in order to promote a safe environment in the classroom. For the most up-to-date information on University policies, visit: <https://goforward.uchicago.edu>. Any concerns over inappropriate PPE usage, physical distancing, cleaning or disinfection, or other COVID19 related public health concerns should be directed to UCAIR. If there is an emergency, call 773-702-8181 or dial 123 on any campus phone. If you were potentially exposed to COVID-19 or your COVID-19 test results come back positive, reach out immediately to: [C19HealthReport@uchicago.edu](mailto:C19HealthReport@uchicago.edu) Follow whatever subsequent instructions you receive from this team of medical professionals.

## Sexual Misconduct Policy

The University of Chicago recognizes that members of the university community are responsible for ensuring that the community is free from discrimination and other forms of sexual misconduct based on sex or gender, including sexual harassment, sexual assault, stalking, domestic violence and dating violence. Faculty are considered “Individuals with Title IX Reporting Responsibilities” of the University and are obligated to report information to the Title IX Coordinator related to sexual misconduct. If you think your rights, or the rights of someone else in the university community, have been violated you can find information on resources and reporting at: <https://umatter.uchicago.edu/>.

**Title IX Coordinator:** Bridget Collier, Associate Provost & Director (bcollier@uchicago.edu, 773-702- 5671)

## Recording and Deletion Policy

The Recording and Deletion Policies for the current academic year can be found in the Student Manual under Petitions, Audio & Video Recording on Campus.

- Do not record, share, or disseminate any course sessions, videos, transcripts, audio, or chats.
- Do not share links for the course to those not currently enrolled.
- Any Zoom cloud recordings will be automatically deleted 90 days after the completion of the recording.

## Zoom Protocols

Whenever there is a virtual component to the course (such as during Office Hours), there is an expectation that students in this course will be actively engaged and on camera while on Zoom. If a student requires an exception, they will need to reach out to me directly.

*The instructor reserves the right to make changes to this syllabus as necessary. Any changes will be announced in class and on Canvas in a timely manner.*

## **Part II**

# **The College of Wooster**

# APPLIED DIFFERENTIAL CALCULUS

## SYLLABUS

Spring 2023 - First Half

Math 110

### §A. What is this class?

Calculus can be viewed broadly as the study of change. Some of the immediate questions to ask about any changing quantity could be: “*how do we know if it is changing*”, “*when is it increasing or decreasing*”, and perhaps more importantly, “*how fast is the quantity changing?*”. We hope to answer these questions by interpreting mathematical quantities as functions that are represented graphically, numerically, analytically, or verbally; and interpret their derivative as their rate of change.

This course and MATH 115 together form a typical first-semester course on differential calculus. Here is some general advice that may prove helpful moving forward. Start your homework assignments early, so that if you need help you have sufficient time to meet with me or the ZI. Begin studying for quizzes well in advance. Put your good study habits into practice by reviewing formulas and working through extra problems when necessary, so that you can identify weaknesses and seek help. Remember that part of doing real math is productive failure: you’ll try things that don’t work; learn something from that failure; try something new that works a bit better, and... after a while, you will figure it out, and come out with a much more robust understanding of the structure of mathematics.

### §B. Key Information

#### Course Info

- **Class Meetings:** MWF 8:00 AM - 8:50 AM (EST), Taylor 210
- **Thursday Meetings:** Th 8:00 AM - 9:20 AM (EST), Taylor 210

#### How to find me

- **Instructor:** Subhadip Chowdhury
- **Email:** [schowdhury@wooster.edu](mailto:schowdhury@wooster.edu)
- **Phone:** 330-263-2473
- **Office:** Taylor 307

#### Zone Intern

- **Name:** Rey Silvanus
- **Email:** [rsilvanus24@wooster.edu](mailto:rsilvanus24@wooster.edu)

#### Office Hour

- [MS Bookings link](#)

#### Required Study Materials

- **Textbook:** We will mainly use lecture notes and activities written especially for this class. You can use [Calculus Volume 1 - OpenStax](#) as a reference. The text is open-source and freely available online.
- **Computing Software:** We will use [DESMOS](#).

#### Class announcements

- **Available on:** <https://moodle-2223.wooster.edu/>  
Check Moodle and your Wooster email at least once before and after each class.

Additional details on some parts of the syllabus are available on Moodle.

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### §C. Prerequisites

The prerequisite for this course is a solid understanding of precalculus mathematics. Students generally place into Math 110 either by earning a grade of C- or higher in Math 105 or by their score on Wooster's pre-arrival math placement test. If you have any concerns regarding your preparedness level for this course, please do not hesitate to speak with me.

### §D. How do I earn a grade

Our course is graded by a methodology called the Learning-Based Grading system, also called standards-based or mastery-based grading, in which most graded work do not have a point value or percentage. Instead, you earn your grade by showing **appropriate engagement** with the course (including active participation and appropriate civil conduct in the classroom, as described in [section D.1](#) below) and **demonstrating evidence of skill on the learning objectives** that describe the major ideas covered by each assignment. These objectives are listed in [section J](#) and will be updated throughout the semester.

When you submit most work, I will evaluate it relative to the quality standards made clear on each assignment. If your work meets the standard, then you will receive full credit for it. Otherwise, you will get helpful feedback and, on most items, the chance to reflect on the feedback, revise your work, and then reassess your understanding.

This feedback loop represents and supports the way that people learn. Learning happens over time, as we revisit ideas and reflect on them. In this class, your final grade will reflect how well you eventually understand each topic. You can make mistakes without penalty, as long as you eventually demonstrate fluency in the topic.

#### D.1. Types of Assignments

##### Active Participation and Engagement (daily)

For aspiring young scholars and professionals, consistent effort is a necessary starting point. Full engagement will be expected in your future college courses and in professional setting, so they are also expected here. The active participation of every student in all activities (whether whole class, small group, or individual) leads to the best learning environment for everyone. Some ways in which engagement can be demonstrated include the following:

- participating in collaborative group work
- giving constructive feedback during in-class discussions
- asking relevant questions in class, during office hours, or through email
- creating an inclusive & welcoming class environment for peers

See also [section E.1](#) for attendance and absence policies.

##### Edfinity Homework (One set for every Learning Target)

We will be using an online homework system called Edfinity for most homework assignments this semester. These are meant to help build your computational skills. There will be at least one Homework set per

course standard. You will access your Edfinity assignments through Moodle and you can see more info on our Moodle course page.

Satisfactory completion of Edfinity homework is one of the course standards as described in [section J](#).

### Quizzes (almost every week)

Rather than midterm or final exams, we will have in-class quizzes almost every Friday, and on the last day of class. The tentative dates are listed in Moodle.

Each quiz will cover all of the standards that we have discussed up to that point in the class. For example, the first quiz should cover about 3 standards. The second quiz will cover about 6 standards, and so on. In this way, the last two quizzes in the final weeks of the course will have all course standards present.

See [section D.2](#) for an explanation of how course standards are scored in quizzes. Having each quiz contain questions pertaining to every standard we have covered thus far means each new quiz is another opportunity to show your proficiency in the course standards. If you initially struggle with a particular standard, you will have the time and opportunity to study, practice, and try again.

Note that there will be no make-up quizzes. If you miss a quiz, you will have the opportunity to complete a course standard again on subsequent quizzes. See [section E.2](#) for certain exceptions to this rule.

## D.2. How are Course Standards scored?

Each standard represents about 1–2 days of classwork. They are listed in [section J](#) approximately in the chronological order we will cover them. For each standard, you'll earn one of the following scores:

- **M** (Meets Expectation) - Understanding of the concepts is evident through correct work and clear, audience-appropriate explanations. There may be some need for revision or expansion, but no significant gaps or errors are present.
- **P** (Partial Understanding) - Demonstrates useful progress, but with a major gap. Gaps include: major math errors, incomplete work, or unclear communication or reasoning that leaves understanding in doubt. **Additional review is necessary. Reassess in the next quiz.**
- **X** (Not Assessable) - Fragmentary or no response. An insubstantial attempt, too many errors to correct each individually, or uses an inappropriate method or tool for this problem. **Must be redone from the beginning.**

**Note:** You may sometimes get a **P\*** on a standard in a Quiz. This grade indicates work that contains an error which I think is minor, but I need to talk with you about it. Come to my office to discuss a **P\*** within two days after it is returned. If you can convince me that the error was minor and explain how to fix it, then I will update the **P\*** to an **M** for free. If I don't hear from you within two days, a **P\*** automatically becomes a **P**.

You will receive helpful feedback on unsatisfactory work, the chance to reflect on the feedback, revise your work, and then reassess your understanding in the next quiz. My hope is that this method of grading will keep you clearly informed as to the expectations of the class and how well you are meeting them, while also removing the (often distracting) elements of linear grading that uses letters or total points. If you have questions or concerns at any time, please feel free to discuss them with me.



### Description of Scores on Moodle

- When you earn a **M** grade on a standard the first time during a quiz, it will be marked as **In-Progress** in Moodle.
- If you earn a second grade of **M** on that same standard during a quiz, it will be marked as **Complete** in Moodle.

I recommend you keep track of which standards you have completed and to what degree separately, in your own records (using your returned quizzes), and then compare against what I have recorded on Moodle. This will help ensure no user error on my part because if you see a discrepancy between your records and Moodles, please let me know and I will fix it.

**Note:** One important thing to keep in mind during this class is that you should not be discouraged if you don't earn **M** on a standard the first time. That's normal. I'm only interested in what you can show me you can do by the end of the semester. However, do not put off finishing the standards; it will be hard to catch up if you fall too far behind.

### How is the final letter grade determined?

To determine your course base grade (the letter **A/B/C/D/F** without plus/minus modifications), use the following table. *To earn a grade, you must complete all the requirements in the column for that grade;* your base grade is the highest grade level for which all the requirements have been met or exceeded. There are no grades of **A+**, **D+**, or **D-** at Wooster. If you do not meet all of the criteria for a **D**, your grade will be an **F**.

Category	A	B	C	C-	D
Participation & Engagement	Frequent	Regular	Occasional	Occasional	Minimal
Course Standards (16)	<b>In Progress</b> on at least 15; <b>Complete</b> on at least 12	<b>In Progress</b> on at least 13; <b>Complete</b> on at least 10	<b>In Progress</b> on at least 11; <b>Complete</b> on at least 8	<b>In Progress</b> on at least 10; <b>Complete</b> on at least 6	<b>In Progress</b> on at least 9

I will set +/- grades based on how close you are to the next higher (or lower) letter grade. For example, a student who has frequently participated in class, and gets **In-Progress** on 15 standards but **Complete** on only 11, would earn a grade of A-. Please contact me any time during the semester if you want to review your current progress.

**Note:** A grade of C- or higher is necessary to receive credit toward any major or minor, and/or to continue to subsequent calculus courses such as MATH 115 or MATH 120.

## §E. Policies

### E.I. Attendance and Absence

Attendance is crucial to success in this class. Your best chance to discuss new material, ask questions, and avoid confusion is during class. So, don't miss class! You are responsible for all material and

announcements from class, even in case of absence. Much of this information will be available on Moodle. Please check in with me and with your classmates when you are back.

That said, life happens. We get the flu (or COVID!). Relatives need your help. When this happens, do what you need to do. I trust that you are an adult and will make the best choices that you can. I appreciate it if you can notify me in advance of an absence, if possible.

*It is College of Wooster policy that a student may not miss more than 25% of class meetings (e.g. about 6-7 classes for a half-credit course in spring semesters), through any combination of excused and unexcused absences. If you think you will miss more than one class in a row, you should contact me beforehand to let me know, and meet me afterward to discuss how you can catch up and move forward in the course. If you miss three classes in a row, I will send out an academic alert. If you miss more than 7 classes, you should contact Dean Jen Bowen and/or Amber Larson, Director of the Academic Resource Center. They can help you consider options for dropping the course.*

## E.2. Early and Late Work

### Early Work

**Quizzes:** You can arrange to take a quiz up to one day early if you have a conflicting extracurricular college event on that day, and you got permission from the Dean's office or your coach. *In such cases, you must give me a heads-up by Monday of the week leading up to the quiz.* Contact me directly regarding other cases.

### Late Work and Tokens

In general, our course policy is to not accept any late work. Each student starts the semester with **3 tokens** (and can have a max of 3 tokens at any time), which can be used to purchase exceptions to this rule. The token menu is below. *To purchase an exception, send me an email.* The cost of each item is listed at the beginning:

- *(Costs 1 token)* Extend the deadline of an Edfinity homework by 24 hrs.
- *(Costs 2 tokens)* Take a checkpoint quiz on Monday or Tuesday next week. This will need to be in person at my office - email me to discuss availability. This does not apply to the final quiz.

Please note that tokens may not be "stacked". For example, you aren't allowed to extend the deadline of an assignment by 2 days by using two tokens. Note that any leftover token at the end of the course will be counted towards class engagement, but has no value towards your scores.

If you have significant extenuating circumstances that cause you to miss multiple assignments (even with tokens), see me to discuss arrangements.

## E.3. Special Accommodations

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the **Academic Policies, Procedures & Support Services** document for further details or go to the ARC website.

### E.4. Email Responses

I do my best to reply to emails promptly and helpfully. However, I receive a lot of email. To help both you and me, here are some specific expectations about emails:

- If you email me between 8:00 am and 5:00 pm on a weekday, I'll reply to you on the same day.
- If you email me in the evening or overnight (after 5:00 pm), I will reply to you the next weekday.
- If your email asks a question that is answered in the Syllabus or on Moodle (such as in an announcement or an assignment sheet), I may reply by directing you to read the appropriate document.

See Moodle for further instructions and examples of good professional emails.

## §F. How to get help?

### F.1. My Office Hours

Please come see me during my office hours if you have questions or just want to discuss something from class. These will be most effective if you have spent some time formulating your questions beforehand - often you will answer your own questions during that process! You can also contact me via Email or MS Teams with your questions. See the email response section above for my 'business hours'!

### F.2. Zone Intern Office Hours

Rey Silvanus (class of '24) is your ZI for this course. Rey will be present during our Thursday class meetings. He will assist us with Desmos labs, problem sessions, and other assignments much in the same way as the instructor: by answering questions and providing guidance. The main role of a zone intern is to be a peer-tutor and mentor to help strengthen your understanding of the course material. Rey will hold his own office hours within the math center.

**See Moodle for office hour times and further instructions.**

### F.3. Math Center

You can also get help regarding this course in the Math Center, located at Taylor 301; no appointment is necessary. The Math Center is open on weekday afternoons (run by Prof. Kirsch) and on Sunday through Thursday evenings (run by peer tutors). This is a resource that is very useful when you need it; however, understand that working with a tutor in the Math Center is no substitute for spending time working out problems yourself.

## §G. Academic Integrity and Collaboration

In this class, your primary goal in this course is to develop a deep personal understanding and expertise in the theory behind Calculus concepts. Collaboration and cooperation are extremely helpful in the learning process, and we will have many opportunities for collaborative work. However, there are some portions of our class that must be done independently.

The College's understanding and expectations regarding issues of academic honesty are fully articulated in the Code of Academic Integrity as published in [The Scot's Key](#) and form an essential part of the implicit

contract between the student and the College. The Code provides a framework at Wooster to help students develop and exhibit honesty in their academic work. You are expected to know and abide by these rules.

In this class, we will use the following definition of plagiarism:

#### Definition 7.1

**Plagiarism** is the act of submitting the work of someone else as if it were your own. Specifically, this action misleads the instructor to think that the work is the result of learning and understanding by the student named on the paper, when in fact the understanding truly belongs to someone else. This may apply to an entire solution, or individual parts of a solution.

#### G.I. Specific academic honesty expectations

It is often unclear what exactly “collaboration” means when working on assignments. The following section should clarify what my expectations are regarding this and give guidelines for avoiding plagiarism in assignments. The list is intended to be helpful but not exhaustive. If you are unsure about the appropriateness of some form of assistance on an assignment, you should always ask me.

- **Edfinity Homework:** On homework problems, you are permitted to discuss big ideas and hints with your classmates, but every step of every solution should be one that you understand yourself and that you have generated on your own. Utilize the Math center to practice problems similar to the homework with your ZI and to enhance your study strategies, but please understand that your ZI is not going to do the homework for you.

Any collaboration should occur only when your collaborator is at essentially the same stage of the problem solution as yourself. In particular, if you have not yet started problem #4 and you ask a friend (who has already completed it), “How did you do problem 4?”, this counts as **plagiarism**.

- **Outside resources in general:** On all work, unless directly stated otherwise, the only resources you may use are our class notes (including any worksheet on Moodle) and the approved textbook (see the first page). You are not permitted to go looking for completed solutions to problems in other texts or resources. **In particular, usage of internet resources is completely off-limits for completing homework problems.** Often, full solutions for our homework problems can be found online. If you see such a solution prior to submitting homework, there is essentially no way that you can claim to have an original solution.
- **Copying:** Copying a solution, or any part of a solution, from any source (friend, internet, book, etc.) in any setting, constitutes **plagiarism**.
- **Past students or Peer tutors:** On any assignment, basing your work on the efforts of another student who previously completed this course or one like it, or a tutor not specifically approved by me, is considered **plagiarism**.
- **Math Center Tutors:** You are encouraged to seek their help on homework, and after you have taken a quiz to clarify and understand a concept. If you seek their help before putting forth any personal effort, this will be considered **plagiarism**.

### G.2. Consequences of academic dishonesty

Evidence of dishonest behavior on any assignment will be grounds for a minimum penalty of earning an N or 0 on all relevant objectives for that assignment. Other penalties may include permanently failing the relevant objectives (regardless of other work) or, in severe cases, failure of the course. **Peers who willingly assist others in acts of plagiarism are equally guilty and will suffer similar penalties.** In all cases, the guidelines established in [The Scot's Key](#) will be followed. I reserve the right to discuss the nature and origins of any assignment with any student prior to assigning a grade.

### G.3. A positive note

Remember that I want you to be successful. That is, I want you to develop a deep, personal understanding of the material we study so that you become a better student of mathematics who can go on to do well in all of your future endeavors. Every part of this course structure - including both collaborative work and restrictions on collaboration - are intended to help you with this. You will often struggle, and that's intentional - struggle (and eventual success!) is essential to learning. Indeed, productively failing (and learning from it) is part of your final grade.

In all aspects of the course, please understand that I am generous with hints and am always willing to discuss problems with you. I will never simply give you an answer, but I will offer direction and guidance that will assist you in coming up with a solution on your own. This is by far the most satisfying way to solve a problem, and the difficulty is well worth it. You are always welcome to discuss your questions or concerns with me at any time.

## §H. Academic Policies, Procedures & Support Services

### H.1. Conflicts with Academic Responsibilities

The College of Wooster is an academic institution and its fundamental purpose is to stimulate its students to reach the highest standard of intellectual achievement. As an academic institution with this purpose, the College expects students to give the highest priority to their academic responsibilities. When conflicts arise between academic commitments and complementary programs (including athletic, cultural, educational, and volunteer activities), students, faculty, staff, and administrators all share the responsibility of minimizing and resolving them.

As a student, you have the responsibility to inform the faculty member of potential conflicts as soon as you are aware of them, and to discuss and work with the faculty member to identify alternative ways to fulfill your academic commitments without sacrificing the academic integrity and rigor of the course.

### H.2. College Policy on Final Examinations

No final examinations are to be given during the last week of classes or on reading days. Students who wish to reschedule a final exam must submit a petition to the Dean for Curriculum and Academic Engagement in advance of the examination. The student must confer with the instructor before submitting a petition, and the instructor should indicate to the Dean if they support the petition. Normally, such petitions are granted only for health reasons. If other reasons necessitate a request for a change in a final exam, the request must be submitted three weeks in advance of the examination. You can find [electronic petition forms on the Registrar's website](#).

### H.3. Course Withdrawal Options (for 2022-23 Academic Year)

**Students may withdraw from a course after the half-semester course drop deadline (Tues., Jan. 31) until the last day of this class (Mon., Feb. 27, 2023).** Students may withdraw from one course, up to 1.25 credits, at any time through the last day of that class, as long as their total remaining credits are 3.0 or above. This may be done without documentation of extenuating circumstances. Requests to drop enrollment below 3.0 credits will require additional documentation through a [Petition for an Exception to an Academic Policy](#).

Note that because the federal government guidelines define courses as ‘attempted’ after 6 weeks (or 3 weeks for a half-semester class), if a student withdraws from a course after that point, it will be noted as a ‘W’ on their transcript.

### H.4. Academic Resource Center: Academic Support and Disabilities

**Contact:** Amber Larson, [alarson@wooster.edu](mailto:alarson@wooster.edu), (330)263-2595, [ARC Website](#)

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services, programs and 1:1 meetings available to all students. Popular areas of support include time management techniques, class preparation tips and test taking strategies. In addition, the Academic Resource Center coordinates peer-tutoring for several academic departments. Students are encouraged to schedule an appointment.

An additional support that the Academic Resource Center offers is English Language Learning. Students can receive instruction or support with English grammar, sentence structure, writing, reading comprehension, reading speed, vocabulary, listening comprehension, speaking fluency, pronunciation, and American culture through 1:1 meetings with the Academic Resource Center staff, ELL Peer Tutoring, ELL Writing Studio courses, and other programming offered throughout the year.

The Academic Resource Center also coordinates accommodations for students with diagnosed disabilities. At the beginning of the semester, students should contact the Academic Resource Center to make arrangements for securing appropriate accommodations. Although the Academic Resource Center will notify professors of students with documented disabilities and the approved accommodations, students are encouraged to speak with professors during the first week of each semester. If a student does not request accommodations or does not provide documentation to the Academic Resource Center, faculty are under no obligation to provide accommodations.

Your success in this course is important to me. If there are circumstances that may affect your academic performance or impact your learning in particular portions of the class, please let me know as soon as possible. You do not need to share specifics, but together we can develop strategies to meet both your needs and the requirements of the course. There are also a range of resources on campus, including the [Writing Center](#), [Math Center](#), [STEM Success Initiative](#), and [APEX](#).

### H.5. The College Libraries and the Research Help Desk

**Contact:** [library@wooster.edu](mailto:library@wooster.edu), 330-263-2493, [Libraries website](#)

Your librarian for this course is Ian McCullough. You can ask your librarian for help with research in this class and can make an appointment with them using the [research consultation form](#) for help



with your research and information needs, including finding and using items we have in the Libraries; learning expert tips to refine your search for articles in magazines, journals, and newspapers; making an appointment with a librarian for help on a project; and learning how to evaluate the information you discover.

#### H.6. Basic Needs, Food Security & Access to Course Materials

**Contact:** Dean of Students Office, [dos@wooster.edu](mailto:dos@wooster.edu), 330-263-2545, Galpin Hall

We learn as whole people. To learn effectively you must have basic security: a roof over your head, a safe place to sleep, enough food to eat. If you have trouble with any of those things or need assistance obtaining the course materials for this or other classes, please talk with me or with staff in the Dean of Students office. Together we can work to make sure those needs are met. There is a [Technology Assistance Application](#) (Wooster login required) and Wooster alums have created a fund to assist students who encounter a personal financial crisis during their time at the College; find out more about this [Emergency Funding](#) through the DoS office.

#### H.7. Diversity and Inclusion

The College of Wooster is committed to inclusive excellence in undergraduate education, and our department seeks to actively foster a welcoming learning environment in which diversity and individual differences are valued, respected, and celebrated. Diversity comes in many forms, including but not limited to, race, color, national origin, ancestry, sex, gender identity and expression, sexual orientation, socioeconomic status, religion, age, and physical and/or mental abilities. The diversity that students and staff bring to the classroom is an invaluable resource, strength, and benefit to everyone at the College of Wooster. As such, we remain vigilant and attentive about issues of diversity, equity, and inclusion in the classroom. Expressions or actions disparaging others are contrary to the mission of the department and will not be tolerated.

It is also important that we all be respectful of everyone's privacy around health concerns, vaccination status, and any accommodations that are necessary for the classroom. It is not appropriate to question why someone requests physical distancing, chooses to wear a mask or requires any other accommodations. As part of our participation together in this class, we commit to showing respect to each other as individuals, to working together to create a learning environment that fosters a sense of belonging and inclusion to all members, and to understanding that our differences are also strengths. Your suggestions are encouraged and appreciated, and please contact me—via email, office hours, or after class—if you have any concerns or questions.

No student is required to take an examination or fulfill other scheduled course requirements on recognized [religious holidays](#). Please declare your intention to observe these holidays at the beginning of the semester.

#### H.8. Names, Pronouns & Pronunciation

All people have the right to be addressed and referred to as they prefer. I will do my best to address and refer to all students by the names and pronouns that they share in class, regardless of what is listed on the roster, and I support classmates in doing so as well. I would like for you to refer to me as **Prof. Chowdhury** or **Dr. Chowdhury**. I use he/him/his pronouns. Please share the name you prefer to be called and pronouns you wish to use in this class with me via classroom introductions or privately.

If you are interested in changing your chosen name and/or including your pronoun(s) in The College of Wooster system, [you can find additional information here](#). What appears in The College of Wooster system is what will display in all platforms across Microsoft Teams. At present, there is no alternative way to change your name or to add pronouns in Teams, but you can add a background that includes these for any video platform.

I encourage everyone in this classroom to create a space of mutual respect and support by also giving each other some grace around pronouns, pronunciation of names, etc., if or when we make mistakes. This is not at all to absolve anyone of responsibility for using correct pronouns, names, and pronunciations. But I find it useful to acknowledge that even with the best of intentions, sometimes we can all still make mistakes.

### H.9. Title IX Reporting Policy

**Contact:** Joe Hall, [jhall@wooster.edu](mailto:jhall@wooster.edu), [Title IX website](#)

The College of Wooster is committed to fostering a campus community based on respect and nonviolence. To this end, we recognize that all Wooster community members are responsible for ensuring that our community is free from discrimination, gender bias, sexual harassment, and sexual assault. In accordance with Title IX, Wooster is legally obligated to provide supportive options for all reports of sexual harassment and sexual assault that occur on our campus. Faculty who become aware of an incident of sexual violence, including harassment, rape, sexual assault, relationship violence, or stalking, are mandated reporters at the College and are required to notify Wooster's Title IX Coordinator. The purpose of this disclosure is to ensure that students are made aware of their reporting options and resources for support. For more information about your rights and reporting options at Wooster, including confidential and anonymous reporting options, please visit <https://inside.wooster.edu/title-ix/>.

### H.10. Discriminatory or Bias-Related Harassment Reporting Policy

**Contact:** Visit the [Bias Reporting website](#)

The College of Wooster is committed to promoting its mission of inclusivity and equity in all aspects of the educational enterprise. This commitment extends to all rights, privileges, programs and activities, including housing, employment, admissions, financial assistance, and educational and athletic programs at the College. The College's Bias Incident Reporting Process is designed to effectively respond to bias concerns raised by faculty, students, staff, alumni and visitors to the College. If you or someone you know are the victims of bias, you can:

- [File a report online](#) (where you may choose to identify yourself or not)
- Contact Security and Protective Services: 2590 (from campus phone) or 330-263-2590
- Call the Anonymous Tip Line: 2337 (from campus phone) or 330-263-2337
- Contact the Dean of Students Office: 2545 (from a campus phone) or 330-263-2545
- Contact the Vice President for Equity, Inclusion, and Diversity Cheryl Nuñez at 330-263-2356

### H.11. Well-being at Wooster



**Contact (24/7):** (330) 263-2319, or visit the [Wellness Center website](#)

The College of Wooster is committed to supporting the wellbeing of our students. During the course of their academic careers, students experience challenges that may interfere with their learning & health (both physical and mental), including but not limited to: strained relationships, adjusting to a new environment, chronic worrying, persistent sadness or loss of interest in enjoyable activities, family conflict, grief and loss, domestic violence, unwanted sexual experiences, difficulty concentrating, drug/alcohol problems, significant changes in eating and sleeping patterns, microaggressions, challenges with organization, procrastination and/or lack of motivation. Counseling Services at the Longbrake Student Wellness Center is a free and confidential resource providing short-term counseling and connections to community agencies for students needing longer term or specialized resources. You can make an appointment by calling 330.263.2319 between 8:30am-4:30pm during weekdays or by emailing Lori Stine ([lstine@wooster.edu](mailto:lstine@wooster.edu)). You can also find helpful resources on the Counseling Services website at <https://inside.wooster.edu/health/counseling/>.

Students also have free access to TimelyCare, a telehealth service providing scheduled medical and counseling appointments as well as 24/7 crisis consultation with licensed professionals. Students use their Wooster email to establish an account at [TimelyCare: Telehealth for Scots](#). TimelyCare also provides students access to nutritionists and health coaches about issues of sleep and exercise, and psychiatry (with a referral from doctor or counselor).

If you or a friend is in crisis, please call Campus Safety at 330-287-3333 or the National Suicide Prevention Lifeline (1-800-273-TALK) or connect with the Crisis Text Line by Texting “4HOPE” to 741-741.

**For financial concerns:** Dean of Students Office, [dos@wooster.edu](mailto:dos@wooster.edu) (330) 263-2545, [DoS website](#)

**For safety concerns:** Campus Security and Protective Services (330)263-2590 or [cw-security@wooster.edu](mailto:cw-security@wooster.edu), [Campus Safety website](#). **In the care of an emergency, call: 330-287-3333.**

### §I. Disclaimer

I reserve the right to make changes to this syllabus if needed. Any changes will be announced to the class in a timely manner.

## §J. Math 110 Course Standards

### Functions

I can use *functions* and other pre-calculus mathematics proficiently.

- S1. **Functions Fundamentals** - I can correctly identify types of functions from formulas and graphs. I can identify the domain and range of a function or properties such as increasing and decreasing. I can graph and interpret piecewise functions. I can represent functions in multiple ways.
- S2. **Inverses, Exponential, and Logarithmic Functions** - I can identify graphically whether a function has an inverse and explain what it means for a function to be one-to-one. I can graph exponential and logarithmic functions and use their properties to solve application problems.

### Limits & Continuity

I can calculate, use, and explain the idea of *limits*.

- S3. **Limits and Graphs** - I can evaluate limits of functions, including one-sided limits, by graphical means, using appropriate justification and notation. I can use limit expressions to create my own examples of functions and can explain why my examples are correct.
- S4. **Continuity** - I can use continuity to evaluate limits using appropriate justification and notation. I can determine the points at which a function is (and is not) continuous.

### Derivatives

I understand the *meaning of the derivative*.

- S5. **Derivative Definition** - I can explain the geometry of the definition of the derivative. I can interpret rates of change using secant and tangent lines. I can calculate derivatives and estimates of derivatives using difference quotients and from graphs. I can correctly interpret the derivative as a rate of change in context and assign appropriate units.
- S6. **Differentiability** - I can recognize points where a function is (and is not) differentiable, with appropriate justification.
- S7. **Derivatives and Graphs I** - I can match the graph of a function with its derivative and vice-versa. I can create my own examples of functions that satisfy various differentiability, continuity, and limit conditions and can explain why my examples are correct.

### Derivative Formulas

I can use derivative formulas to calculate derivatives *efficiently*.

- S8. **Essential Derivative Formulas** - I can compute derivatives correctly for sums, constant multiples, and power, polynomial, exponential, and logarithmic functions.
- S9. **Product & Quotient Rules** - I can compute derivatives correctly using the product and quotient rules.
- S10. **Chain Rule** - I can compute derivatives correctly using the chain rule for function composition.

- S11. Combining Formulas & Strategy** - I can compute derivatives correctly using multiple rules in combination. I know which rules to apply to compute the derivative of a function.

### Applications of Derivatives

I can use derivatives to understand and solve *genuine applications*.

- S12. Maxima and Minima** - I can identify relative and absolute extrema (maximum and minimum points) of a function graphically. I can use calculus to identify critical points and inflection points of functions and correctly apply them to identifying extrema. I can determine absolute extrema for a function on a closed interval.
- S13. Derivatives and Graphs II** - I can interpret  $f'$  and  $f''$  for a function  $f$  graphically and descriptively. I can use information about  $f$ ,  $f'$ , and  $f''$  to create my own examples of functions and can explain why my examples are correct.
- S14. STEM Applications** - I can interpret the derivative as a rate of change. I can do this in the context of economics and population growth. I can use derivatives to explain the relationship between position, velocity, and acceleration functions, and solve problems in these contexts.
- S15. Applied Optimization** - I can correctly setup applied optimization problems. I can use calculus to solve applied optimization problems.

### Academic Engagement

I am developing *habits of academic engagement* that will prepare me for upper-level coursework.

- S16. Homework** - I am consistently completing the homework sets posted on Edfinity.

For this standard, a **Complete** designation will be awarded for an overall Edfinity score of at least 90%, or an **In-Progress** designation for an overall Edfinity score of at least 75%.

These standards connect to Wooster's graduate qualities, including in the following areas:

- Independent Thinking, through the ability to:
  - ▶ Engage in critical and creative thinking.
  - ▶ Embody the intellectual curiosity, passion, and self-confidence necessary for life-long learning.
  - ▶ Appreciate and critique ideas.
- Integrative and Collaborative Inquiry, through the ability to:
  - ▶ Actively integrate theory and practice.
- Dynamic Understanding of the Liberal Arts through the ability to:
  - ▶ Understand disciplinary knowledge in mathematics, and physical and natural sciences.
  - ▶ Demonstrate quantitative literacy.
  - ▶ Employ deep knowledge, insight, and judgment to solve real world problems.
- Effective Communication, through the ability to:

- ▶ Exhibit skill in written and digital communication.
- ▶ Engage in effective discourse through active listening, questioning, and reasoning.
- Justice and Civic/Social Responsibility, through the ability to:
  - ▶ Actively promote equity and inclusion.

Week	Monday	Wednesday	Thursday	Friday
Jan. 11-13 Week 1	Classes begin Wed., Jan. 11	First Day of Class (Precalculus Review)	Essential Function Types & Function Properties, part 1	Essential Function Types & Function Properties, part 2
Jan. 16-20 Week 2	MLK Day - no class	An Informal Introduction to Limits	Evaluating Limits Graphically and Numerically, One-sided Limits	Quiz 1 Standards #1-3
Jan. 23-27 Week 3	Continuity	Derivative - difference quotient and Tangent lines	Matching Practice	Quiz 2 Standards #1-5
Jan. 30-Feb. 3 Week 4	Differentiability Practice	Basic Differentiation Rules (Constant, Power, Sum, Diff)	Product and Quotient Rule	Quiz 3 Standards #1-8
Feb. 6-10 Week 5	Product and Quotient Rule contd.	Chain Rule	Practice	Quiz 4 Standards #1-11
Feb. 13-17 Week 6	Shape of a Graph (Maxima, Minima, and FDT)	Shape of a Graph II (SDT, Concavity, Inflection Point)	STEM Applications	Quiz 5 Standards #1-14
Feb. 20-24 Week 7	Practice	Applied Optimization Problems	More Optimization	Quiz 6 Standards #1-15
Feb. 27 Final quiz	Quiz 7 Standards #1-15	Second half classes begin Wed., March 1		

# MATHEMATICAL FOUNDATIONS OF COMPUTING

Spring 2023

Math 130

*Welcome to Math 130! You can call me Prof./Dr. Chowdhury. I am the instructor for this course, and I am glad to have you here!*

## §A. What is this class?

We will study an area of Mathematics that computer science is built on, called Discrete mathematics, and learn how to demonstrate proper understanding of discrete mathematics concepts and methods using proof techniques. Discrete math is the study of counting, patterns, and structures involving discrete (separate, not continuous) objects – like people, meals, clothing, and board games. We can use it to model and understand a wide range of real-world problems, from social networks to March Madness.

This class will be hard work. Part of doing real math is productive failure: You'll try things that don't work; learn something from that failure; and try something new that works a bit better. And... after a while, you will figure it out, and come out with a much stronger understanding of the structure of mathematics.

## §B. Key Information

### Course Info

- **Class Meetings:** MWF 9:00 AM - 9:50 AM (EST), Taylor 206 (until Feb 27.)

### How to find me

- **Instructor:** Subhadip Chowdhury
- **Email:** [schowdhury@wooster.edu](mailto:schowdhury@wooster.edu)
- **Phone:** 330-263-2473
- **Office:** Taylor 307

### Zone Intern

- **Name:** Patrick May
- **Email:** [pmay24@wooster.edu](mailto:pmay24@wooster.edu)

### Office Hour

- [MS Bookings link](#)

### Required Study Materials

- **Textbook:** We will mainly use PowerPoint lecture slides created specifically for this class - these will be available on Moodle. You can use [Applied Discrete Structures](#) by Al Doerr and Ken Levasseur as a reference. The text is open-source and freely available online.

### Class announcements

- **Available on:** <https://moodle-2223.wooster.edu/>

*Check Moodle and your Wooster email at least once before and after each class.*

**Additional details on some parts of the syllabus are available on Moodle.**

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## §C. Catalog Description

This course introduces discrete mathematics. Topics include set theory, logic, truth tables, proof techniques, sequences and summations, induction and recursion, combinatorial counting techniques, discrete probability, graphs, and trees.

**Prerequisites:** one CSCI course with minimum grade C-.

## §D. Course Objectives

Basically, this course teaches mathematics applied to situations that involve things that can be separated and counted. For example, counting the number of times a loop in a computer program executes involves separating things (the different iterations of the loop) and counting them. So, in Math 130, we look at the mathematical processes that computer science is built on, especially the structures that are the basis for the data structures you'll encounter later. After successful completion of this course, you will be able to ...

- Convert logical statements from informal language to propositional and predicate logic expressions
- Apply formal logic proof techniques (direct proof, proof by contradiction, and induction, counting arguments) in the construction of a sound argument.
- Perform the operations associated with sets, functions, and relations
- Compute permutations and combinations of a set and interpret the meaning in the context of the particular application.
- Calculate probabilities of events and expectations of random variables for elementary problems such as games of chance.
- Solve a variety of basic recurrence relations.
- Illustrate by example the basic terminology of graph theory, as well as some of the properties and special cases of each type of graph/tree.

In addition to everything above, we will focus on some important ideas that span discrete mathematics as well as all of mathematics. Specifically, I want you to...

- Succeed! Specifically, I want you to develop a deep understanding of the ideas outlined above. You can expect me to push you in many ways to help you achieve these. As a result, this class will not be easy, but that's good: You learn by struggling!
- Improve your ability to see patterns, make conjectures, and write proofs independently. These will happen through class activities, homework, and quizzes. This will happen with time, experience, and hard work.
- Learn how to persevere in problem-solving, reason abstractly, construct arguments and critique others' arguments, model with mathematics, and look for and make use of structure.



- Discover math from a new point of view. Discrete math is often surprising for students: It looks different from most other kinds of math. That's great! Mathematics is truly about structure, pattern, and proof – things that will be central to our study of discrete mathematics.

## §E. How do I earn a grade

Our course is graded by a methodology called the Learning-Based Grading system, also called standards-based or mastery-based grading, in which most graded work do not have a point value or percentage. Instead, you earn your grade by showing **appropriate engagement** with the course (including active participation and appropriate civil conduct in the classroom, as described in [section E.1](#) below) and **demonstrating evidence of skill on the learning objectives** that describe the major ideas covered by each assignment. These objectives are listed in [section K](#) and will be updated throughout the semester.

When you submit most work, I will evaluate it relative to the quality standards made clear on each assignment. If your work meets the standard, then you will receive full credit for it. Otherwise, you will get helpful feedback and, on most items, the chance to reflect on the feedback, revise your work, and then reassess your understanding.

This feedback loop represents and supports the way that people learn. Learning happens over time, as we revisit ideas and reflect on them. In this class, your final grade will reflect how well you eventually understand each topic. You can make mistakes without penalty, as long as you eventually demonstrate fluency in the topic.

### E.1. Types of Assignments

#### Active Participation and Engagement (daily)

For aspiring young scholars and professionals, consistent effort is a necessary starting point. Full engagement will be expected in your future college courses and in a professional setting, so they are also expected here. The active participation of every student in all activities (whether whole class, small group, or individual) leads to the best learning environment for everyone. Some ways in which engagement can be demonstrated include the following:

- participating in collaborative group work
- giving constructive feedback during in-class discussions
- asking relevant questions in class, during office hours, or through email
- creating an inclusive & welcoming class environment for peers
- Completing the weekly homework on time.

See also [section F.1](#) for attendance and absence policies.

**Weekly Homework.** These are traditional practice problems and proofs using the ideas we've learned in class. *They will be at a higher level of difficulty than quizzes.* In addition to any other

instructions given with the assignment, I expect you to follow the guidelines below to get the best scores on your homework:

- **Explain fully and present a convincing argument.** This is required for every problem, even if not explicitly stated. Use appropriate proof techniques, take care with quantifiers and logical reasoning, and communicate plans clearly to the reader.
- **Follow the Math 130 Writing Guidelines** (available in Moodle). This includes correct spelling, grammar, and punctuation amongst a whole bunch of other best practices.
- **Turn in solutions for the questions in order** (for example, do not turn in work for question 2 after work for question 1). The easiest way to do this is to start each problem on a new page and not put more than one answer on a single page.
- Certain homework problems may involve writing pseudo-code that produces the desired output from the given input. Format your answer for these with proper spacing and syntax.
- **Make your answer legible.** Your answer script should not look like scratch work. Responses that consist of only answers with no work shown, or where the work is insufficient or difficult to read, or which have significant gaps or omissions (including parts left blank) will be given a grade of 0.

**Note:** Homeworks are due at 5 PM every Tuesday.

#### Quizzes (see the schedule)

Rather than midterm or final exams, we will have in-class quizzes almost every Friday before Spring Break, and alternate Fridays after Spring Break. The tentative dates are listed in Moodle.

Each quiz will cover all of the standards that we have discussed up to that point in the class. For example, the first quiz should cover about 3 standards. The second quiz will cover about 5 standards, and so on. In this way, the last two quizzes in the last weeks of the course will have all course standards present.

See [section E.2](#) for an explanation of how course standards are scored in quizzes. Having each quiz contain questions pertaining to every standard we have covered thus far means each new quiz is another opportunity to show your proficiency in the course standards. If you initially struggle with a particular standard, you will have the time and opportunity to study, practice, and try again.

Note that there will be no make-up quizzes. If you miss a quiz, you will have the opportunity to complete a course standard again on subsequent quizzes. See [section F.2](#) for certain exceptions to this rule.

#### E.2. How are Course Standards scored in quizzes?

Each standard represents about 1–2 days of classwork. They are listed in [section K](#) approximately in the chronological order we will cover them. For each standard, you'll earn one of the following scores:

- **M** (Meets Expectation) - Understanding of the concepts is evident through correct work and clear, audience-appropriate explanations. There may be some need for revision or expansion, but no significant gaps or errors are present.
- **P** (Partial Understanding) - Demonstrates useful progress, but with a major gap. Gaps include: major math errors, incomplete work, or unclear communication or reasoning that leaves understanding in doubt. **Additional review is necessary. Reassess in the next quiz.**
- **X** (Not Assessable) - Fragmentary or no response. An insubstantial attempt, too many errors to correct each individually, or uses an inappropriate method or tool for this problem. **Must be redone from the beginning.**

**Note:** You may sometimes get a **P\*** on a standard in a Quiz. This grade indicates work that contains an error which I think is minor, but I need to talk with you about it. Come to my office to discuss a **P\*** within two days after it is returned. If you can convince me that the error was minor and explain how to fix it, then I will update the **P\*** to an **M** for free. If I don't hear from you within two days, a **P\*** automatically becomes a **P**.

You will receive helpful feedback on unsatisfactory work, the chance to reflect on the feedback, revise your work, and then reassess your understanding in the next quiz. My hope is that this method of grading will keep you clearly informed as to the expectations of the class and how well you are meeting them, while also removing the (often distracting) elements of linear grading that uses letters or total points. If you have questions or concerns at any time, please feel free to discuss them with me.

#### Description of Scores on Moodle

- When you earn a **M** grade on a standard the first time during a quiz, it will be marked as **In-Progress** in Moodle.
- If you earn a second grade of **M** on that same standard during a quiz, it will be marked as **Complete** in Moodle.

I recommend you keep track of which standards you have completed and to what degree separately, in your own records (using your returned quizzes), and then compare against what I have recorded on Moodle. This will help ensure no user error on my part because if you see a discrepancy between your records and Moodles, please let me know and I will fix it.

**Note:** One important thing to keep in mind during this class is that you should not be discouraged if you don't earn **M** on a standard the first time. That's normal. I'm only interested in what you can show me you can do by the end of the semester. However, do not put off finishing the standards; it will be hard to catch up if you fall too far behind.

#### How is the final letter grade determined?

To determine your course base grade (the letter **A/B/C/D/F** without plus/minus modifications), use the following table. *To earn a grade, you must complete all the requirements in the column for that*

*grade*; your base grade is the highest grade level for which all the requirements have been met or exceeded. There are no grades of **A+**, **D+**, or **D-** at Wooster. If you do not meet all of the criteria for a **D**, your grade will be an **F**.

Category	A	B	C	C-	D
Participation & Engagement	Frequent	Regular	Occasional	Occasional	Minimal
Homework Score	70%	60%	50%	45%	40%
Course Standards (16)	<b>In Progress</b> on at least 15; <b>Complete</b> on at least 12	<b>In Progress</b> on at least 13; <b>Complete</b> on at least 10	<b>In Progress</b> on at least 11; <b>Complete</b> on at least 8	<b>In Progress</b> on at least 10; <b>Complete</b> on at least 6	<b>In Progress</b> on at least 9

I will set +/- grades based on how close you are to the next higher (or lower) letter grade. For example, a student who has frequently participated in class, gets 90% homework score, gets **In-Progress** on 16 standards, but **Complete** on only 12, would earn a grade of A-. Please contact me any time during the semester if you want to review your current progress.

**Note:** A grade of C- or higher is necessary to receive credit toward any major or minor.

## §F. Policies

### F.I. Attendance and Absence

**Attendance is crucial to success in this class.** Your best chance to discuss new material, ask questions, and avoid confusion is during class. So, don't miss class! You are responsible for all material and announcements from class, even in case of absence. Much of this information will be available on Moodle. Please check in with me and with your classmates when you are back.

That said, life happens. We get the flu (or COVID!). Relatives need your help. When this happens, do what you need to do. I trust that you are an adult and will make the best choices that you can. I appreciate it if you can notify me in advance of an absence, if possible.

*It is College of Wooster policy that a student may not miss more than 25% of class meetings (e.g. about 6-7 classes for a full-credit course in spring semesters), through any combination of excused and unexcused absences.* If you think you will miss more than one class in a row, you should contact me beforehand to let me know, and meet me afterward to discuss how you can catch up and move forward in the course. If you miss three classes in a row, I will send out an academic alert. If you miss more than 7 classes, you should contact Dean Jen Bowen and/or Amber Larson, Director of the Academic Resource Center. They can help you consider options for dropping the course.

## F.2. Early and Late Work

### Early Work

**Homework:** If you know about an absence in advance (including any religious holiday), you may arrange an early drop-off time for homework, send work with a friend, or leave it with our ZI.

**Quizzes:** You can arrange to take a quiz up to one day early if you have a conflicting extracurricular college event on that day, and you got permission from the Dean's office or your coach. *In such cases, you must give me a heads-up by Monday of the week leading up to the quiz.* Contact me directly regarding other cases.

### Late Work and Tokens

In general, my course policy is to not accept any late work. Each student starts the semester with **3 tokens**, which can be used to purchase exceptions to this rule. The token menu is below. *To purchase an exception, send me an email.* The cost of each item is listed at the beginning:

- (Costs 2 tokens) Delay a checkpoint quiz until Monday or Tuesday next week. This will need to be in person at my office - email me to discuss availability. This does not apply to the final quiz.
- (Costs 1 token) Reassess a Learning Target outside of quizzes during specific weeks. *Standards 1-10 are available after Spring break, the rest of the standards are available during the last 2 weeks.*



**Warning:** For a course standard to be marked as “Complete”, one of the ‘M’ must come from a quiz.

Throughout the semester, there will be opportunities for earning more tokens through class engagement or satisfactory performance in homework. Please note that any leftover token at the end of the course will be counted towards class engagement, but has no value towards your scores. If you have significant extenuating circumstances that cause you to miss multiple assignments/quizzes (even with tokens), see me to discuss arrangements.

## F.3. Special Accommodations

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the **Academic Policies, Procedures & Support Services** document for further details or go to the ARC website.

## F.4. Email Responses

I do my best to reply to emails promptly and helpfully. However, I receive a lot of emails. To help both you and me, here are some specific expectations about emails:

- If you email me between 8:00 am and 5:00 pm on a weekday, I'll reply to you on the same day.

- If you email me in the evening or overnight (after 5:00 pm), I will reply to you the next weekday.
- If your email asks a question that is answered in the Syllabus or on Moodle (such as in an announcement or an assignment sheet), I may reply by directing you to read the appropriate document.

**Note:** See Moodle for further instructions and examples of good professional emails.

## §G. How to get help?

### G.1. My Office Hours

Please come see me during my office hours (book a meeting first) if you have questions or just want to discuss something from class. These will be most effective if you have spent some time formulating your questions beforehand - often you will answer your own questions during that process! You can also contact me via Email or MS Teams with your questions. See the email response section above for my 'business hours'!

### G.2. Zone Intern Office Hours

Patrick May (class of '24) is your ZI for this course. Patrick will be present during all of our class meetings. He will assist us with in-class discussions, problem sessions, and other assignments much in the same way as me: by answering questions and providing guidance. The main role of a zone intern is to be a peer tutor and mentor to help strengthen your understanding of the course material. Patrick will hold his own office hours within the Math Center.

**See Moodle for office hour times and further instructions.**

## §H. Academic Integrity and Collaboration

In this class, your primary goal in this course is to develop a deep personal understanding and expertise in the theory behind Discrete Math concepts. Collaboration and cooperation are extremely helpful in the learning process, and we will have many opportunities for collaborative work. However, there are some portions of our class that must be done independently.

The College's understanding and expectations regarding issues of academic honesty are fully articulated in the Code of Academic Integrity as published in [The Scot's Key](#) and form an essential part of the implicit contract between the student and the College. The Code provides a framework at Wooster to help students develop and exhibit honesty in their academic work. You are expected to know and abide by these rules.

In this class, we will use the following definition of plagiarism:

**Definition 8.1**

**Plagiarism** is the act of submitting the work of someone else as if it were your own. Specifically, this action misleads the instructor to think that the work is the result of learning and understanding by the student named on the paper, when in fact the understanding truly belongs to someone else. This may apply to an entire solution, or individual parts of a solution.

**H.1. Specific academic honesty expectations**

It is often unclear what exactly “collaboration” means when working on assignments. The following section should clarify what my expectations are regarding this and give guidelines for avoiding plagiarism in assignments. The list is intended to be helpful but not exhaustive. If you are unsure about the appropriateness of some form of assistance on an assignment, you should always ask me.

- **Weekly Homework:** You are allowed to work collaboratively on homework problems but make sure you understand the steps yourself and that you submit your own work. Utilize the Math center to practice homework problems and other similar problems with your ZI and to enhance your study strategies, but please understand that your ZI is not going to do the homework for you.

Any collaboration should occur only when your collaborator is at essentially the same stage of the problem solution as you. In particular, if you have not yet started problem #4 and you ask a friend (who has already completed it), “How did you do problem 4?”, this counts as **plagiarism**.

- **Outside resources in general:** On all work, unless directly stated otherwise, the only resources you may use are our class notes (including any worksheet on Moodle) and the approved textbook (see the first page). While you are not permitted to go looking for completed solutions to problems in other texts or resources, you are allowed to look up examples and instructional videos online to enhance your learning. Often, full solutions for our homework problems can be found online. If you see such a solution prior to submitting homework, there is essentially no way that you can claim to have an original solution.
- **Math Center Tutors:** You are encouraged to seek their help on homework, and after you have taken a quiz to clarify and understand a concept. Please seek their help only after putting forth significant personal effort.

If there is any evidence of dishonest behavior, the guidelines established in [The Scot’s Key](#) will be followed. I reserve the right to discuss the nature and origins of any assignment with any student prior to assigning a grade.

**H.2. A positive note**

Remember that I want you to be successful. That is, I want you to develop a deep, personal understanding of the material we study so that you become a better student of mathematics who can go on to do well in all of your future endeavors. Every part of this course structure - including



both collaborative work and restrictions on collaboration - are intended to help you with this. You will often struggle, and that's intentional - struggle (and eventual success!) is essential to learning. Indeed, productively failing (and learning from it) is part of your final grade.

In all aspects of the course, please understand that I am generous with hints and am always willing to discuss problems with you. I will never simply give you an answer, but I will offer direction and guidance that will assist you in coming up with a solution on your own. This is by far the most satisfying way to solve a problem, and the difficulty is well worth it. You are always welcome to discuss your questions or concerns with me at any time.

## **§I. Academic Policies, Procedures & Support Services**

### **I.1. Conflicts with Academic Responsibilities**

The College of Wooster is an academic institution and its fundamental purpose is to stimulate its students to reach the highest standard of intellectual achievement. As an academic institution with this purpose, the College expects students to give the highest priority to their academic responsibilities. When conflicts arise between academic commitments and complementary programs (including athletic, cultural, educational, and volunteer activities), students, faculty, staff, and administrators all share the responsibility of minimizing and resolving them.

As a student, you have the responsibility to inform the faculty member of potential conflicts as soon as you are aware of them, and to discuss and work with the faculty member to identify alternative ways to fulfill your academic commitments without sacrificing the academic integrity and rigor of the course.

### **I.2. College Policy on Final Examinations**

No final examinations are to be given during the last week of classes or on reading days. Students who wish to reschedule a final exam must submit a petition to the Dean for Curriculum and Academic Engagement in advance of the examination. The student must confer with the instructor before submitting a petition, and the instructor should indicate to the Dean if they support the petition. Normally, such petitions are granted only for health reasons. If other reasons necessitate a request for a change in a final exam, the request must be submitted three weeks in advance of the examination. You can find [electronic petition forms on the Registrar's website](#).

### **I.3. Course Withdrawal Options (for 2022-23 Academic Year)**

**Students may withdraw from a course after the 6th-week drop deadline until the last day of classes (Tuesday, May 9, 2023, in Spring 2023).** Students may withdraw from one course, up to 1.25 credits, at any time through the last day of that class, as long as their total remaining credits are 3.0 or above. This may be done without documentation of extenuating circumstances. Requests to drop enrollment below 3.0 credits will require additional documentation through a [Petition for an Exception to an Academic Policy](#).



Note that because the federal government guidelines define courses as ‘attempted’ after 6 weeks (or 3 weeks for a half-semester class), if a student withdraws from a course after that point, it will be noted as a ‘W’ on their transcript.

#### **I.4. Academic Resource Center: Academic Support and Disabilities**

**Contact:** Amber Larson, [alarson@wooster.edu](mailto:alarson@wooster.edu), (330)263-2595, [ARC Website](#)

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services, programs and 1:1 meetings available to all students. Popular areas of support include time management techniques, class preparation tips and test taking strategies. In addition, the Academic Resource Center coordinates peer-tutoring for several academic departments. Students are encouraged to schedule an appointment.

An additional support that the Academic Resource Center offers is English Language Learning. Students can receive instruction or support with English grammar, sentence structure, writing, reading comprehension, reading speed, vocabulary, listening comprehension, speaking fluency, pronunciation, and American culture through 1:1 meetings with the Academic Resource Center staff, ELL Peer Tutoring, ELL Writing Studio courses, and other programming offered throughout the year.

The Academic Resource Center also coordinates accommodations for students with diagnosed disabilities. At the beginning of the semester, students should contact the Academic Resource Center to make arrangements for securing appropriate accommodations. Although the Academic Resource Center will notify professors of students with documented disabilities and the approved accommodations, students are encouraged to speak with professors during the first week of each semester. If a student does not request accommodations or does not provide documentation to the Academic Resource Center, faculty are under no obligation to provide accommodations.

Your success in this course is important to me. If there are circumstances that may affect your academic performance or impact your learning in particular portions of the class, please let me know as soon as possible. You do not need to share specifics, but together we can develop strategies to meet both your needs and the requirements of the course. There are also a range of resources on campus, including the [Writing Center](#), [Math Center](#), [STEM Success Initiative](#), and [APEX](#).

#### **I.5. The College Libraries and the Research Help Desk**

**Contact:** [library@wooster.edu](mailto:library@wooster.edu), 330-263-2493, [Libraries website](#)

Your librarian for this course is Ian McCullough. You can ask your librarian for help with research in this class and can make an appointment with them using the [research consultation form](#) for help with your research and information needs, including finding and using items we have in the Libraries; learning expert tips to refine your search for articles in magazines, journals, and newspapers; making an appointment with a librarian for help on a project; and learning how to evaluate the information you discover.

## I.6. Basic Needs, Food Security & Access to Course Materials

**Contact:** Dean of Students Office, [dos@wooster.edu](mailto:dos@wooster.edu), 330-263-2545, Galpin Hall

We learn as whole people. To learn effectively you must have basic security: a roof over your head, a safe place to sleep, enough food to eat. If you have trouble with any of those things or need assistance obtaining the course materials for this or other classes, please talk with me or with staff in the Dean of Students office. Together we can work to make sure those needs are met. There is a [Technology Assistance Application](#) (Wooster login required) and Wooster alums have created a fund to assist students who encounter a personal financial crisis during their time at the College; find out more about this [Emergency Funding](#) through the DoS office.

## I.7. Diversity and Inclusion

The College of Wooster is committed to inclusive excellence in undergraduate education, and our department seeks to actively foster a welcoming learning environment in which diversity and individual differences are valued, respected, and celebrated. Diversity comes in many forms, including but not limited to, race, color, national origin, ancestry, sex, gender identity and expression, sexual orientation, socioeconomic status, religion, age, and physical and/or mental abilities. The diversity that students and staff bring to the classroom is an invaluable resource, strength, and benefit to everyone at the College of Wooster. As such, we remain vigilant and attentive about issues of diversity, equity, and inclusion in the classroom. Expressions or actions disparaging others are contrary to the mission of the department and will not be tolerated.

It is also important that we all be respectful of everyone's privacy around health concerns, vaccination status, and any accommodations that are necessary for the classroom. It is not appropriate to question why someone requests physical distancing, chooses to wear a mask or requires any other accommodations. As part of our participation together in this class, we commit to showing respect to each other as individuals, to working together to create a learning environment that fosters a sense of belonging and inclusion to all members, and to understanding that our differences are also strengths. Your suggestions are encouraged and appreciated, and please contact me—via email, office hours, or after class—if you have any concerns or questions.

No student is required to take an examination or fulfill other scheduled course requirements on recognized [religious holidays](#). Please declare your intention to observe these holidays at the beginning of the semester.

## I.8. Names, Pronouns & Pronunciation

All people have the right to be addressed and referred to as they prefer. I will do my best to address and refer to all students by the names and pronouns that they share in class, regardless of what is listed on the roster, and I support classmates in doing so as well. I would like for you to refer to me as **Prof. Chowdhury** or **Dr. Chowdhury**. I use he/him/his pronouns. Please share the name you prefer to be called and pronouns you wish to use in this class with me via classroom introductions or privately.

If you are interested in changing your chosen name and/or including your pronoun(s) in The College of Wooster system, [you can find additional information here](#). What appears in The College of Wooster system is what will display in all platforms across Microsoft Teams. At present, there is no alternative way to change your name or to add pronouns in Teams, but you can add a background that includes these for any video platform.

I encourage everyone in this classroom to create a space of mutual respect and support by also giving each other some grace around pronouns, pronunciation of names, etc., if or when we make mistakes. This is not at all to absolve anyone of responsibility for using correct pronouns, names, and pronunciations. But I find it useful to acknowledge that even with the best of intentions, sometimes we can all still make mistakes.

### I.9. Title IX Reporting Policy

**Contact:** Joe Hall, [jhall@wooster.edu](mailto:jhall@wooster.edu), [Title IX website](#)

The College of Wooster is committed to fostering a campus community based on respect and nonviolence. To this end, we recognize that all Wooster community members are responsible for ensuring that our community is free from discrimination, gender bias, sexual harassment, and sexual assault. In accordance with Title IX, Wooster is legally obligated to provide supportive options for all reports of sexual harassment and sexual assault that occur on our campus. Faculty who become aware of an incident of sexual violence, including harassment, rape, sexual assault, relationship violence, or stalking, are mandated reporters at the College and are required to notify Wooster's Title IX Coordinator. The purpose of this disclosure is to ensure that students are made aware of their reporting options and resources for support. For more information about your rights and reporting options at Wooster, including confidential and anonymous reporting options, please visit <https://inside.wooster.edu/title-ix/>.

### I.10. Discriminatory or Bias-Related Harassment Reporting Policy

**Contact:** Visit the [Bias Reporting website](#)

The College of Wooster is committed to promoting its mission of inclusivity and equity in all aspects of the educational enterprise. This commitment extends to all rights, privileges, programs and activities, including housing, employment, admissions, financial assistance, and educational and athletic programs at the College. The College's Bias Incident Reporting Process is designed to effectively respond to bias concerns raised by faculty, students, staff, alumni and visitors to the College. If you or someone you know are the victims of bias, you can:

- [File a report online](#) (where you may choose to identify yourself or not)
- Contact Security and Protective Services: 2590 (from campus phone) or 330-263-2590
- Call the Anonymous Tip Line: 2337 (from campus phone) or 330-263-2337
- Contact the Dean of Students Office: 2545 (from a campus phone) or 330-263-2545

- Contact the Vice President for Equity, Inclusion, and Diversity Cheryl Nuñez at 330-263-2356

## I.II. Well-being at Wooster

**Contact (24/7):** (330) 263-2319, or visit the [Wellness Center website](#)

The College of Wooster is committed to supporting the wellbeing of our students. During the course of their academic careers, students experience challenges that may interfere with their learning & health (both physical and mental), including but not limited to: strained relationships, adjusting to a new environment, chronic worrying, persistent sadness or loss of interest in enjoyable activities, family conflict, grief and loss, domestic violence, unwanted sexual experiences, difficulty concentrating, drug/alcohol problems, significant changes in eating and sleeping patterns, microaggressions, challenges with organization, procrastination and/or lack of motivation. Counseling Services at the Longbrake Student Wellness Center is a free and confidential resource providing short-term counseling and connections to community agencies for students needing longer term or specialized resources. You can make an appointment by calling 330.263.2319 between 8:30am-4:30pm during weekdays or by emailing Lori Stine ([lstine@wooster.edu](mailto:lstine@wooster.edu)). You can also find helpful resources on the Counseling Services website at <https://inside.wooster.edu/health/counseling/>.

Students also have free access to TimelyCare, a telehealth service providing scheduled medical and counseling appointments as well as 24/7 crisis consultation with licensed professionals. Students use their Wooster email to establish an account at [TimelyCare: Telehealth for Scots](#). TimelyCare also provides students access to nutritionists and health coaches about issues of sleep and exercise, and psychiatry (with a referral from doctor or counselor).

If you or a friend is in crisis, please call Campus Safety at 330-287-3333 or the National Suicide Prevention Lifeline (1-800-273-TALK) or connect with the Crisis Text Line by Texting “4HOPE” to 741-741.

**For financial concerns:** Dean of Students Office, [dos@wooster.edu](mailto:dos@wooster.edu) (330) 263-2545, [DoS website](#)

**For safety concerns:** Campus Security and Protective Services (330)263-2590 or [cow-security@wooster.edu](mailto:cow-security@wooster.edu), [Campus Safety website](#). **In the care of an emergency, call: 330-287-3333.**

## §J. Disclaimer

I reserve the right to make changes to this syllabus if needed. Any changes will be announced to the class in a timely manner.

## §K. Math 130 Course Standards

The following course standards will be assessed through quizzes (and practiced through homework) during the semester. Your goal is to earn an “M” on each objective twice to get the best grade. Usually, problems on quizzes would be more direct and computational than homework assignments. See [section E.1](#) for expectations regarding homework.

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1. **FL1 (Statements and Connectives)** - Translate compound statements involving logical connectives; and write the negation, converse, and contrapositive of implications.
  2. **FL2 (Truth Tables and Logical Equivalences)** - Use truth tables and formulas (e.g. De Morgan’s law) to prove the logical equivalence of two wffs using propositional logic.
  3. **FL3 (Quantifiers and Predicates)** - Learn the proper usage of quantifiers, translate an English sentence into a predicate wff, and state its negation.

- 
4. **PT1 (Proof Techniques)** - Outline the proof structure of a given statement using a proof technique. Identify logical errors in a proof.

Additionally, *In homework* - Create a precise conjecture statement based on data. Write correct and complete proof by contradiction and proof by contrapositive.

5. **PT2 (Induction)** - Prove a statement using the principle of mathematical induction by clearly stating and proving the base case, stating the inductive hypothesis, and completing the induction step.

- 
6. **RR1 (Recursive Definition)** - Generate several instances of a sequence, set, operation, or algorithm defined using recursion.
  7. **RR2 (Recurrence Relation)** - Convert a word problem to a recurrence relation and find a closed-form solution. Examples include linear first-order (homogeneous and non-homogeneous) and linear second-order homogeneous recurrence relations.

- 
8. **ST1 (Set notation and relation)** - Represent a set using roster notation and set-builder notation. Determine if an object is an element of a set, and determine set relationships (equality, subsets).
  9. **ST2 (Set Operations)** - Perform operations on sets (intersection, union, complement, Cartesian product), determine the cardinality of a set, and write the power set of a finite set.

- 
10. **CP1 (Basic Counting Rules and PIE)** - Use the multiplication principle, the addition principle, and the Inclusion-Exclusion principles appropriately within a counting problem, including

choosing process/sets in an appropriate order, applying cases as necessary, and using complements.

11. **CP2 (Permutation and Combination)** - Use permutations and combinations appropriately within a counting problem. Use factorials and binomial symbols correctly. Avoid over- or under-counting.
  12. **CP3 (Probability)** - Determine discrete probability for independent, mutually exclusive, and conditional events.
- 

13. **RF1 (Relations and Digraphs)** - Draw the digraph of a relation and determine whether it is symmetric, reflexive, or transitive.
  14. **RF2 (Functions and their properties)** - Determine whether a given relation is a function; determine the domain, range, and codomain of a function; and determine whether it is an injection, surjection, or bijection.
- 

15. **MA1 (Matrix Operations)** - Solve equations involving matrix addition, multiplication, and the transpose of  $2 \times 2$  or  $3 \times 3$  matrices.

Additionally, *In homework* - Determine inverse and determinant of matrices.

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16. **GT1 (Graphs and their representations)** - Use and work with basic terms such as 'graph', 'vertex', 'edge', 'degree', etc. correctly in the context of graph theory problems. Use graph notation correctly (such as writing the names of edges, using sets of vertices or edges, using degrees, etc.). Determine if two given graphs are isomorphic.

Week of	Monday	Wednesday	Friday
9-Jan	No Class	Syllabus Discussion, Statements and Connectives	Truth Tables, Well-formed Formula
16-Jan	MLK Day	Propositional Logic	Quantifiers and Predicates
23-Jan	Practice and Review	Proof Techniques	Quiz 1 (Std. 1-3)
30-Jan	More Proof Techniques	Practice + Proof by Induction	Induction contd. + Quiz 2 (Std. 1-4)
6-Feb	Yet More Induction	Recursive Definition	Quiz 3 (Std. 1-5)
13-Feb	Recurrence Relation	Practice and Review	Set notation
20-Feb	Set relation	Set Operations	Quiz 4 (Std. 1-9)
27-Feb	Basic Counting Rules and PIE	Permutation	Quiz 5 (Std. 1-10)
6-Mar	Combination	Practice and Review	Quiz 6 (Std. 1-11)
Spring Break			
27-Mar	Probability	Practice and Review	Quiz 7 (Std. 1-12)
3-Apr	Relations and Digraphs	Properties of Relations	Functions
10-Apr	Properties of Functions	Matrix Operations	Quiz 8 (Std. 1-15)
17-Apr	Practice and Review	Introduction to Graph Theory	I.S. Symposium (No Class)
24-Apr	Graphs Isomorphism, Trees	Practice and Review	Quiz 9 (Std. 1-17)
1-May	Practice and Review	No Class	No Class
9-May	8-10:30AM, Quiz 10 (Std. 1-17)		

# MATH 299: CHAOTIC DYNAMICAL SYSTEMS

## SYLLABUS

**Instructor:** Dr./Prof. Subhadip Chowdhury

**Class meetings:** T/Th 1:00 PM – 2:20 PM, Taylor 200

**How to contact me:**

• **Email:** [chowdhury@wooster.edu](mailto:chowdhury@wooster.edu)

• **Phone:** 330-263-2473

• **Office:** Taylor 307

**Office Hours:** [MS Booking Link](#). Feel free to schedule an alternative time to meet if you can't make these hours. Otherwise, if my door is open, feel free to come in. You can also email me anytime.

### A. COURSE DESCRIPTION

#### Course Catalog Description

This course is an introduction to chaotic dynamical systems through theory and computer experimentation. We begin by examining discrete dynamical systems – orbits, fixed and periodic points, and bifurcations – both graphically and numerically; and transition to Devaney's definition of chaos (transitivity, dense periodic points, sensitive dependence on initial conditions). We will also build up analytic tools, including fractal geometry and a little bit of complex analysis to end the course with dynamics in the complex plane, Julia sets, and the Mandelbrot set.

#### Prerequisites

Math 125: Theory of Integral Calculus – minimum grade C-, or equivalent credit.

### B. LEARNING GOALS

The overall goal of this course is to introduce some of the spectacular new discoveries that have been made over the past thirty years in the field of Mathematics known as Dynamical Systems. By the end of the course, you will be able to

- Recognize examples of natural and artificial Dynamical Systems in various areas such as planetary motions, population, fluid dynamics, cardiac and neural dynamics, oscillator circuits, internet traffic, quantum systems, etc.
- Describe related concepts such as orbit, fixed points, periodic points, bifurcation etc.
- Use computer graphics to illustrate long term behavior of dynamical systems
- Analyze how dynamics given by precise rules can result in extremely complicated trajectories in the state-space.
- Compare various intuitive definitions of chaos (e.g., Li-Yorke vs. Devaney) that abound the literature, to clarify their relationship, if any, and to articulate an all-encompassing definition based on the concept of mixing.
- Develop various theoretical tools to identify and examine chaotic systems.



## C. COURSE CONTENT

This one-semester course is meant to serve only as an introduction to the theory of Discrete Dynamical Systems and Chaos theory, leaving opportunities for more in-depth study via Senior Independent Study. Specific topics of discussion will include **a subset of**

- Examples of Dynamical Systems from various subject areas
- Definition, examples, and classification of Orbits, Fixed points, and periodic points of discrete dynamical systems – graphical analysis using cobweb diagram and phase portraits
- Types of bifurcations – example using the Quadratic map and Logistic map
- Symbolic dynamics – the Shift map and conjugacy
- Sharkovsky's theorem – (Li-Yorke) chaos
- Sensitive dependence on initial condition (a.k.a. the butterfly effect) – Lyapunov chaos
- Transitivity, dense periodic points – Devaney's chaos
- Feigenbaum's constant – universality of chaos
- The Schwarzian derivative
- Fractals and the Hausdorff dimension
- Iterated function systems – Julia set
- Complex dynamics and the Mandelbrot set
- The Lorenz attractor

Depending on time and pace, the last couple of topics might get covered through final projects only.

## D. OTHER REQUIRED MATERIALS

### Textbook

There is no specific textbook required for this course. But you may use any edition of "*A First Course in Chaotic Dynamical Systems: Theory and Experiment*" by Robert L. Devaney as a reference. Daily class notes/worksheets will be posted on Moodle to summarize regular lectures.

### Technology

Experimentation is key to understanding the nature of dynamical systems. You may use either Octave or Python for any programming needs (both are open source and free). I will use Octave for in-class demonstrations and post the code on Moodle. Note that we will have regular homework and lab exercises that will require use of some computing software.

## E. DIFFERENT TYPES OF ASSIGNMENTS

### Homework

During each class, we will intersperse the lecture with a bunch of practice problems (I will write down the problems, you do not need the book). You are encouraged to work collaboratively on these problems, and look up solutions, if necessary, to improve your understanding.

The rest of the questions from the lecture notes will be assigned as homework problems (around 5-7) each week that must be turned before class on next week Thursday. These problems must be completed as **independent** assignments, but I welcome you to come and discuss your attempts during my office hours. Solutions to your homework should include a statement of the problem, and all statements you make should be in complete sentences.

**Note:** While a big part of this course emphasizes computer experimentation, you will be required to understand and explain all the definitions, theorems, proofs, and so forth. Solutions to your homework should include a statement of the problem, and all statements you make should be in complete sentences. Where appropriate, you should end the problem with a statement summarizing the solution. You are at the point in your mathematical education where we want to start looking at how you are communicating.

Homework problems will be graded on a 3-point scale. 3 points is like 95%, 2 points is like 85%, 1 point is like 75%. Anything below 75% will be scored as 0.

### Tests

There will be two in-class timed midterm exams about one-thirds and two-thirds way through the course. Most problems on the tests will be computational in nature (i.e., no proof questions). There is no final exam (but there is a final project, see below). A portion of the exam may be take-home.

### Lab Projects

There will be around five or six lab projects built around understanding dynamical systems through computer experimentations. I will provide mostly completed codes for the programs, and you will be asked to modify and use the program to generate a lab report detailing the investigations that you have conducted. This lab report must be typed, preferably using a Word processing program such as LaTeX (I will provide a template) and will usually consist of three types of answers.

- **Collected data.** You should present the data you have collected when necessary. This may consist of a list or table of orbits, a collection of graphs, or a series of pictures. Be reasonable about the amount of data you include. If you are asked only for the fate of orbits, we do not need to see the entire orbit; all we need is the end result.
- **An essay describing your conclusions, conjectures, or problems derived from this data.** I expect that these essays will be carefully written and readable with correct spelling and grammar. You will be graded not only on the mathematical content of your findings but also on the presentation. Please feel free to include graphs and pictures in your essays, using distinguishable for the illustrations if that helps.
- **Answers to certain questions that relate to each experiment.** Sometimes, there is no precise answer to these questions, or the correct answer is not known by anyone. These questions are meant to stimulate you to further thought about the subject of the lab.

During lab days,

- You may pair up with another student to work in groups of two. **One write-up for your entire team will suffice. But both students must submit it individually to Moodle for grading purposes.**
- You may not work with the same partner more than once during the semester.

### Final Project

You will be asked to write and present an expository paper on a final topic in place of your final exam. The due date will be the same as the timeslot reserved for the final exam according to the college schedule. I will announce more details about this halfway through the semester. Both the paper and the presentation will be graded according to a rubric specified after Spring break.

## F. HOW YOUR LETTER GRADE IS DETERMINED

The individual course components are scored with the following weights:

- Lab Projects – 20%
- Midterms – 30%
- Homework – 30%
- Final Project – 20%

Final grade cutoffs will be set as follows:

**A:** 90-100, **A-:** 87-89.9, **B+:** 84-86.9, **B:** 80-83.9, **B-:** 77-79.9, ..., **C-:** 67-69.9, **D:** 60.0-66.9, **F:** 0-59.9

**These grade cutoffs are subject to change during the semester.**

## **G. ACADEMIC POLICIES, PROCEDURES & SUPPORT SERVICES**

### **Academic Resource Center: Academic Support and Disabilities**

**Contact:** Amber Larson, [alarson@wooster.edu](mailto:alarson@wooster.edu), (330)263-2595, [ARC Website](#)

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services, programs and 1:1 meetings available to all students. Popular areas of support include time management techniques, class preparation tips and test taking strategies. In addition, the Academic Resource Center coordinates peer-tutoring for several academic departments. Students are encouraged to schedule an appointment.

An additional support that the Academic Resource Center offers is English Language Learning. Students can receive instruction or support with English grammar, sentence structure, writing, reading comprehension, reading speed, vocabulary, listening comprehension, speaking fluency, pronunciation, and American culture through 1:1 meetings with the Academic Resource Center staff, ELL Peer Tutoring, ELL Writing Studio courses, and other programming offered throughout the year.

The Academic Resource Center also coordinates accommodations for students with diagnosed disabilities. At the beginning of the semester, students should contact the Academic Resource Center to make arrangements for securing appropriate accommodations. Although the Academic Resource Center will notify professors of students with documented disabilities and the approved accommodations, students are encouraged to speak with professors during the first week of each semester. If a student does not request accommodations or does not provide documentation to the Academic Resource Center, faculty are under no obligation to provide accommodations.

### **The College Libraries and the Research Help Desk**

**Contact:** [library@wooster.edu](mailto:library@wooster.edu), 330-263-2493, [Libraries website](#)

Your librarian for this course is Ian McCullough. You can ask your librarian for help with research in this class and can make an appointment with them using the [research consultation form](#) for help with your research and information needs, including finding and using items we have in the Libraries; learning expert tips to refine your search for articles in magazines, journals, and newspapers; making an appointment with a librarian for help on a project; and learning how to evaluate the information you discover.

### **Active Participation & Engagement**

For aspiring young scholars and professionals, consistent effort is a necessary starting point. Full engagement will be expected in your future college courses and in a professional setting, so they are also expected here. The active participation of every student in all activities (whether whole class, small

group, or individual) leads to the best learning environment for everyone. Some ways in which engagement can be demonstrated include the following:

- Completing optional Moodle quizzes (graded based on completion only).
- participating in collaborative group work and labs
- giving constructive feedback during in-class discussions
- asking relevant questions in class, during office hours, or through email
- creating an inclusive & welcoming class environment for peers

### **Attendance and Absence**

Attendance is crucial to success in this class. Your best chance to discuss new material, ask questions, and avoid confusion is during class. So, don't miss class! You are responsible for all material and announcements from class, even in case of absence. Much of this information will be available on Moodle. Please check in with me and with your classmates when you are back.

That said, life happens. We get the flu (or COVID!). Relatives need your help. When this happens, do what you need to do. I trust that you are an adult and will make the best choices that you can. I appreciate it if you can notify me in advance of an absence, if possible.

It is College of Wooster policy that a student may not miss more than 25% of class meetings (e.g. about 6-7 classes for a full-credit course in spring semesters), through any combination of excused and unexcused absences. If you think you will miss more than one class in a row, you should contact me beforehand to let me know, and meet me afterward to discuss how you can catch up and move forward in the course. If you miss three classes in a row, I will send out an academic alert. If you miss more than 7 classes, you should contact Dean Jen Bowen and/or Amber Larson, Director of the Academic Resource Center. They can help you consider options for dropping the course.

### **Course Withdrawal Options (for 2022-23 Academic Year)**

*Students may withdraw from a course after the 6th-week drop deadline until the last day of classes (Tuesday, May 9, 2023 in Spring 2023).* Students may withdraw from one course, up to 1.25 credits, at any time through the last day of classes, as long as their total remaining credits are 3.0 or above. This may be done without documentation of extenuating circumstances. Requests to drop enrollment below 3.0 credits will require additional documentation through a [Petition for an Exception to an Academic Policy](#).

Note that because federal government guidelines define courses as 'attempted' after 6 weeks, if a student withdraws from a course after 6 weeks, it will be noted as a 'W' on their transcript.

### **Diversity and Inclusion**

The College of Wooster is committed to inclusive excellence in undergraduate education, and our department seeks to actively foster a welcoming learning environment in which diversity and individual differences are valued, respected, and celebrated. Diversity comes in many forms, including but not limited to, race, color, national origin, ancestry, sex, gender identity and expression, sexual orientation, socioeconomic status, religion, age, and physical and/or mental abilities. The diversity that students and staff bring to the classroom is an invaluable resource, strength, and benefit to everyone at the College of Wooster. As such, we remain vigilant and attentive about issues of diversity, equity, and inclusion in the classroom. Expressions or actions disparaging others are contrary to the mission of the department and will not be tolerated.

It is also important that we all be respectful of everyone's privacy around health concerns, vaccination status, and any accommodations that are necessary for the classroom. It is not appropriate to question why someone requests physical distancing, chooses to wear a mask, or requires any other accommodations. As part of our participation together in this class, we commit to showing respect to

each other as individuals, to working together to create a learning environment that fosters a sense of belonging and inclusion to all members, and to understanding that our differences are also strengths. Your suggestions are encouraged and appreciated, and please contact me—via email, office hours, or after class—if you have any concerns or questions.

No student is required to take an examination or fulfill other scheduled course requirements on recognized religious holidays. Please declare your intention to observe these holidays at the beginning of the semester.

### **Names, Pronouns & Pronunciation**

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### **Academic Honesty and the Code of Academic Integrity**

The academic program at the College seeks to promote the intellectual development of each student and the realization of that individual's potential for creative thinking, learning, and understanding. In achieving this, each student must learn to act rigorously, independently, and imaginatively.

The College's understanding and expectations in regard to issues of academic honesty are fully articulated in the Code of Academic Integrity as published in [The Scot's Key](#) and form an essential part of the implicit contract between the student and the College. The Code provides framework at Wooster to help students develop and exhibit honesty in their academic work. You are expected to know and abide by these rules.

Dishonesty in any of your academic work is a serious breach of the Code of Academic Integrity and is grounds for serious penalties. Such violations include turning in another person's work as your own, copying from any source without proper citation, violating expectations for a group project, submitting an assignment produced for a course to a second course without the authorization of all the instructors, and dishonesty in connection with your academic work. You will be held responsible for your actions. Particular attention should be directed to the appropriate use of materials available online. Whether intentional or not, improper use of materials is a violation of academic honesty. If you are unsure as to what is permissible, please contact your course instructor.

### **College Policy on Final Exams**

No final examinations are to be given during the last week of classes or on reading days. Students who wish to reschedule a final exam must submit a petition to the Dean for Curriculum and Academic Engagement in advance of the examination. The student must confer with the instructor before

submitting a petition, and the instructor should indicate to the Dean if they support the petition. Normally, such petitions are granted only for health reasons. If other reasons necessitate a request for a change in a final exam, the request must be submitted three weeks in advance of the examination. [Find electronic petition forms on the Registrar's website.](#)

### **Conflicts with Academic Responsibilities**

The College of Wooster is an academic institution, and its fundamental purpose is to stimulate its students to reach the highest standard of intellectual achievement. As an academic institution with this purpose, the College expects students to give the highest priority to their academic responsibilities. When conflicts arise between academic commitments and complementary programs (including athletic, cultural, educational, and volunteer activities), students, faculty, staff, and administrators all share the responsibility of minimizing and resolving them.

As a student you have the responsibility to inform the faculty member of potential conflicts as soon as you are aware of them, and to discuss and work with the faculty member to identify alternative ways to fulfill your academic commitments without sacrificing the academic integrity and rigor of the course.

### **Basic Needs, Food Security & Access to Course Materials**

**Contact:** Dean of Students Office, [dos@wooster.edu](mailto:dos@wooster.edu), 330-263-2545, Galpin Hall

We learn as whole people. To learn effectively you must have basic security: a roof over your head, a safe place to sleep, enough food to eat. If you have trouble with any of those things or need assistance obtaining the course materials for this or other classes, please talk with me or with staff in the Dean of Students office. Together we can work to make sure those needs are met. There is a [Technology Assistance Application](#) (Wooster login required) and Wooster alums have created a fund to assist students who encounter a personal financial crisis during their time at the College; find out more about this [Emergency Funding](#) through the DoS office.

### **Title IX Reporting Policy Regarding Sexual Misconduct, Harassment, Relationship Violence, and Stalking**

**Contact:** Joe Hall, [jhall@wooster.edu](mailto:jhall@wooster.edu), [Title IX website](#)

The College of Wooster is committed to fostering a campus community based on respect and nonviolence. To this end, we recognize that all Wooster community members are responsible for ensuring that our community is free from discrimination, gender bias, sexual harassment, and sexual assault. In accordance with Title IX, Wooster is legally obligated to provide supportive options for all reports of sexual harassment and sexual assault that occur on our campus. Faculty who become aware of an incident of sexual violence, including harassment, rape, sexual assault, relationship violence, or stalking, are mandated reporters at the College and are required to notify Wooster's Title IX Coordinator. The purpose of this disclosure is to ensure that students are made aware of their reporting options and resources for support. For more information about your rights and reporting options at Wooster, including confidential and anonymous reporting options, please visit <https://inside.wooster.edu/title-ix/>

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**Contact:** Visit the [Bias Reporting website](#)

The College of Wooster is committed to promoting its mission of inclusivity and equity in all aspects of the educational enterprise. This commitment extends to all rights, privileges, programs and activities, including housing, employment, admissions, financial assistance, and educational and athletic programs at the College. The College's Bias Incident Reporting Process is designed to effectively respond to bias



concerns raised by faculty, students, staff, alumni and visitors to the College. If you or someone you know are the victims of bias, you can:

- [File a report online](#) (where you may choose to identify yourself or not)
- Contact Campus Safety: 2590 (from campus phone) or 330-263-2590
- Call the Anonymous Tip Line: 2337 (from campus phone) or 330-263-2337
- Contact the Dean of Students Office: 2545 (from a campus phone) or 330-263-2545
- Contact the Vice President for Equity, Inclusion, and Diversity Cheryl Nuñez at 330-263-2356

### Well-being at Wooster

**Contact (24/7):** (330) 263-2319, or visit the [Wellness Center website](#)

The College of Wooster is committed to supporting the wellbeing of our students. During the course of their academic careers, students experience challenges that may interfere with their learning & health (both physical and mental), including but not limited to: strained relationships, adjusting to a new environment, chronic worrying, persistent sadness or loss of interest in enjoyable activities, family conflict, grief and loss, domestic violence, unwanted sexual experiences, difficulty concentrating, drug/alcohol problems, significant changes in eating and sleeping patterns, microaggressions, challenges with organization, procrastination and/or lack of motivation. Counseling Services at the Longbrake Student Wellness Center is a free and confidential resource providing short-term counseling and connections to community agencies for students needing longer term or specialized resources. You can make an appointment by calling 330.263.2319 between 8:30am-4:30pm during weekdays or by emailing Lori Stine ([lstine@wooster.edu](mailto:lstine@wooster.edu)). You can also find helpful resources on the Counseling Services website at <https://inside.wooster.edu/health/counseling/>.

Students also have free access to TimelyCare, a telehealth service providing scheduled medical and counseling appointments as well as 24/7 crisis consultation with licensed professionals. Students use their Wooster email to establish an account at [TimelyCare: Telehealth for Scots](#). TimelyCare also provides students access to nutritionists and health coaches about issues of sleep and exercise, and psychiatry (with a referral from doctor or counselor).

If you or a friend is in crisis, please call Campus Safety at 330-287-3333 or the Suicide and Crisis Lifeline (988, available 24 hours) or connect with the Crisis Text Line by Texting “4HOPE” to 741-741.

**For financial concerns:** Dean of Students Office, [dos@wooster.edu](mailto:dos@wooster.edu) (330) 263-2545, [DoS website](#)

**For safety concerns:** Campus Safety 330-263-2590 or [cw-security@wooster.edu](mailto:cw-security@wooster.edu), [Campus Safety website](#). **In the care of an emergency, call: 330-287-3333.**

## H. SYLLABUS CHANGES

I reserve the right to make changes to this syllabus, if needed. Any changes will be announced to the class in a timely manner.

Week	Tuesday	Thursday
1 (Jan 11-13)		
2	Dynamics - Introduction, Brief History - Discrete Dynamics	Orbits, Fixed and Periodic Points
3	Graphical Analysis - Lab 1: The Computer May Lie	Attracting vs. Repelling
4	Lab 2: Rates of Convergence	Dynamics of the Quadratic family - Saddle Node and Period Doubling Bifurcations
5	Lab 3: The Transition to Chaos	Lab 4: Windows in the Orbit Diagram + Chaos in the Quadratic family
6	Introduction to Metric space	Introduction to Metric space
7	Periods of Periodic Points - Sharkovsky's Theorem	Period 3 Implies (Li-Yorke) Chaos
8	Sensitive Dependence on Initial Conditions - Lyapunov Chaos	Devaney's Chaos
9	More Examples of Chaotic Systems - Quadratic Map and Doubling Map	Lab 5: Structure of the Chaos - Logistic Map and The Feigenbaum's constant
Spring Break		
10	Subshifts of Finite Type	The Schwarzian Derivative
11	Lab 6: Newton's Method and More complicated bifurcations	Review for Exam II
12	Fractals - Cantor Set and others, Dimension	Complex dynamics and Julia set
13	Mandelbrot Set	Final Presentations
14	Final Presentations	Final Presentations



# MULTIVARIATE CALCULUS

## SYLLABUS

Fall 2022

Subhadip Chowdhury

Math 212

### §A. What is this class?

Calculus III or Multivariate Calculus is kind of like a greatest hits compilation from Calculus I and II, but a remixed version for higher dimensions! In real life, most processes depend on more than one input - if you have ever filled a tax form, you know how many inputs it requires. The same is true all the way from quadratic equations to rocket science. So, whether we do optimization using differentiation or calculate volume using integration, it's all for functions of more than one variable. To ensure the new analogues make sense, we define some new ideas such as vectors and parametric curves along the way. Finally, everything comes together to like an IKEA furniture and culminates in the idea of vector calculus, which ties all of Multivariable Calculus together into several neat little theorems.

Please make use of my office hours and plan to work hard. My classes have a high workload (as all math classes usually do!), so make sure that you stay on top of your assignments and get help early. Remember that part of doing real math is productive failure: you'll try things that don't work; learn something from that failure; and try something new that works a bit better. And... after a while, you will figure it out, and come out with a much stronger understanding of the structure of mathematics.

**Additional details on some parts of the syllabus are available on Moodle.**

### §B. Key Information

#### Course Info

- **Class Meetings:** MWF 9:00 AM - 9:50 AM (EST), Taylor 206
- **Lab Meetings:** Th 9:30 AM - 10:50 AM (EST), Taylor 206

#### How to contact me

- **Email:** [schowdhury@wooster.edu](mailto:schowdhury@wooster.edu)
- **Phone:** 330-263-2473
- **Office:** Taylor 307

#### Office Hours

*See Moodle for Up-to-date hours.* You can also stop by any time my door is open, or email me to set up an individual meeting.

#### Required Study Materials

- **Textbook:** We will mainly use lecture notes and activities written especially for this class. You can use [Calculus Volume 3 - OpenStax](#) as a reference. The text is open-source and freely available online.
- **Computing Software:** We will use [CalcPlot3D](#).

#### Class announcements

- **Available on:** <https://moodle-2223.wooster.edu/>  
*Check Moodle and your Wooster email at least once before and after each class.*

**Additional college policies are listed in a separate document called Academic Policies, Procedures & Support Services.**

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## §C. Catalog description

This course covers analytic geometry of functions of several variables, limits and partial derivatives, multiple and iterated integrals, non-rectangular coordinates, change of variables, line and surface integrals and the theorems of Green and Stokes. [MNS, Q, QL]

**Prerequisites:** MATH-10500, MATH-11000, MATH-11500, MATH-12000, and MATH-12500, minimum grade C-

## §D. How do I earn a grade

Our course is graded by a methodology called Learning-Based Grading system, also called standards-based or mastery-based grading, in which the different assignments do not have fixed weight percentages or numerical scores. Instead, you earn your grade by showing appropriate engagement with the course (by attending classes and completing homework) and demonstrating evidence of skill on the learning objectives that describe the major ideas covered by each assignment. These objectives, called **Learning Targets (LT)**, are listed in [section L](#) and may be updated throughout the semester.

To succeed in this class, you are expected to develop two kinds of skills simultaneously: *computational facility* and *conceptual understanding*. Both are essential to demonstrate fluency on the material. You will also work to improve your communication skills—with each other, with me, and with the rest of the world.

### D.I. Types of Assignments

More details on each type of assignment are given in the later parts of the syllabus. Check MOODLE for details.

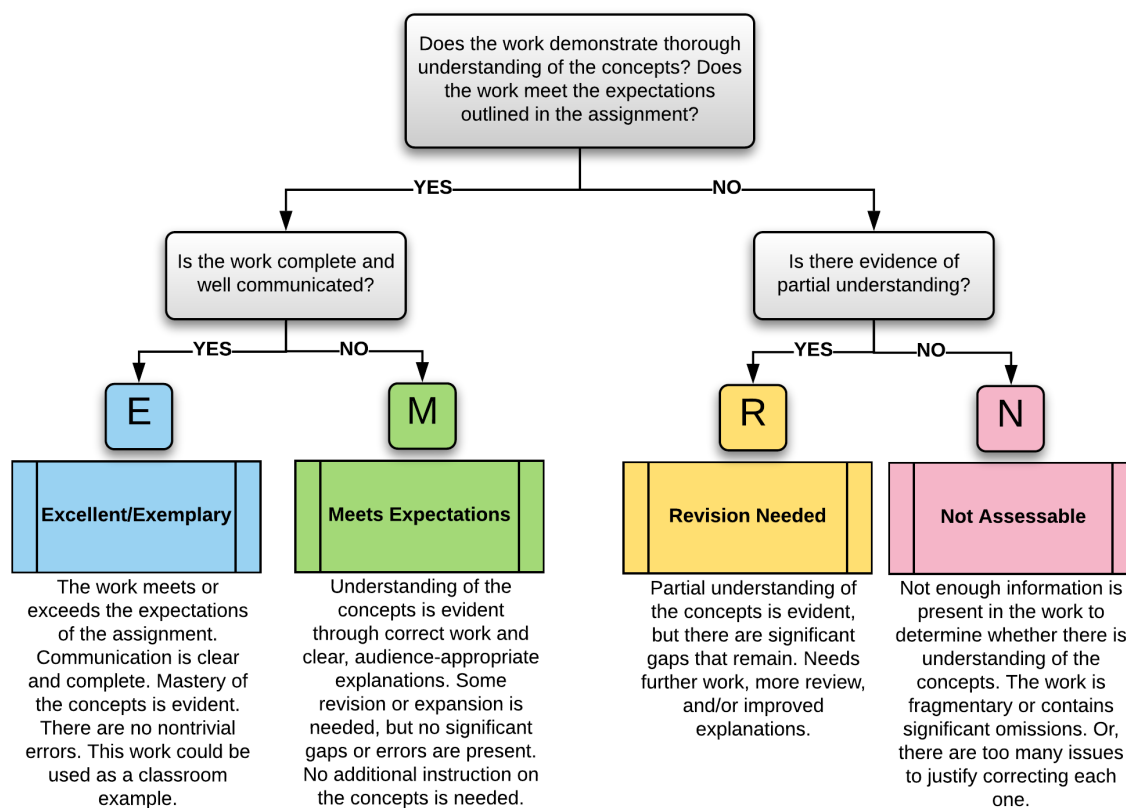
- **Daily Work** Multivariable calculus has a plethora of interrelated skills that mesh together to form a network of ideas. The best way to master this network is through daily practice and engagement with the class.

Most days, you will be expected to read a section of the textbook before coming to class. This will be your primary first exposure to new material. During most classes, collaboration and problem-solving will occupy around half of our meeting time. You will be given one or more questions to address, and we will discuss different approaches to answering these questions developed within the class.

- **CalcPlot3D Labs:** Computer literacy is a crucial skill in today's world. The computational and graphing capabilities of modern computers also make it easier to explore complex mathematical ideas without always getting bogged down in calculation. We will be using the visualization software **Cal-cPlot3D** (<https://c3d.libretexts.org/CalcPlot3D/index.html>) to complete around 5 or 6 projects this semester that will be scored based on the EMRN scale explained in [fig. 1](#).

Most projects will be group based. For each project, you will have the possibility to revise your write-up once to improve your score based on my comments.

- **Checkpoint Quizzes (almost every week):** Rather than midterm or final exams, we will have in-class checkpoint quizzes every week (covering new materials). These will be your first attempt at assessing each Learning Target. Check MOODLE for details.



EMRN rubric based on the EMRF rubric, due to Rodney Stutzman and Kimberly Race: <http://eric.ed.gov/?id=EJ717675>  
 EMRN rubric by Robert Talbert is licensed under CC BY-SA 4.0



Figure 1: EMRN Rubric

- **Exams (every ~ 3 weeks):** Additionally, there will be four in-class exams during the semester. On these exams, you will not receive a grade but rather you will have your second possible assessment on the LTs covered since the previous exam. The quizzes and exams will be given during the lab period.
- **Reassessments:** After a LT has been assessed on an exam, if you wish to have a reassessment in order to improve your score, contact me to arrange a time. You will need to let me know ahead of time which LT you wish to have reassessed. I will reassess up to two LTs per student per week. Check MOODLE for details.
- **Edfinity Homework (One set for every LT):** We will be using Edfinity for most homework assignments this semester. These are online homework assignments, to help build your computational skills. There will be at least one Homework set per learning target. Check MOODLE for details.

## D.2. How are Learning Targets scored?

When you submit most work, I will evaluate it relative to quality standards made clear on each assignment. If your work meets the standard, then you will receive credit for it. Otherwise, you will get helpful feedback and, on most items, the chance to reflect on the feedback, revise your work, and then reassess your understanding.

This feedback loop represents and supports the way that people learn. *Learning happens over time, as we revisit ideas and reflect on them.* In this class, your final grade will reflect how well you eventually understand each topic. You can make mistakes without penalty, as long as you eventually demonstrate fluency of the topic.

My hope is that this method of grading will keep you clearly informed as to the expectations of the class and how well you are meeting them, while also removing the (often distracting) elements of linear grading that uses letters or total points. If you have questions or concerns at any time, please feel free to discuss them with me.

### Description of Scores

Each LT represents about 1–2 days of classwork. They are listed in [section L](#) approximately in the chronological order we will cover them. Each LT will be graded either M, R, or N based on [fig. 1](#).

**Note:** You can not earn a **E** on a learning target.

- To show **PROFICIENCY** in a learning target, you must earn a **M** grade on that LT during a quiz, exam, or reassessment.
- To show **EXPERTISE** in a learning target, a second grade of **M** must be earned on that same LT during a quiz, exam, or reassessment.

**Note:** You may sometimes earn a **R\*** in a Quiz. This mark indicates work that contains an error which I think is minor, but I need to talk with you about it. Come to my office to discuss a **R\*** within one week after it is returned. If you can convince me that the error was minor and explain how to fix it, then I will update the **R\*** to an **M** for free - it does not use up a reassessment attempt. If I don't hear from you within one week, a **R\*** automatically becomes a **R**.

You will always have opportunities to show improvement, until the end of the course. Do not put off learning the material, however; later skills depend on earlier ones, and it will be hard to catch up if you fall too far behind.

There are also two general Learning Targets in [section L](#) that are evaluated a bit differently:

- **G1: Participation.** Your active participation in class is crucial both to your own learning and to the success of all. Attendance is therefore required, as is a willingness to share ideas and to make brief presentations.
  - ▶ **EXPERTISE** - Continued, thoughtful participation in asking and answering questions, group work, and completing labs and Edfinity homework on time.
  - ▶ **PROFICIENCY** - No issues with attendance, and participation is adequate.
  - ▶ **Inadequate** - Issues with attendance, participation, or maintaining a respectful classroom environment.
- **G2: Basic Calculus.** Perform algebraic calculations and interpret the results for the following list of concepts: limits, derivatives, integrals. Convert between the graphs and equations of conic sections.

We will **NOT** devote any class time to this material and this will be assessed through Edfinity homework. A score of more than 95% will be **EXPERTISE** and 90% – 95% will be **PROFICIENCY**.

### How is the final letter grade determined?

At the end of the semester, I am required to submit to the college a letter grade reflecting your achievement in this class. Here is how that grade will be determined.

To determine your course base grade (the letter **A/B/C/D/E/F** without plus/minus modifications), use the following table. *To earn a grade, you must complete all the requirements in the column for that grade; your base grade is the highest grade level for which all the requirements have been met or exceeded.*

Category	A	B	C	D
Homework Credits	90%	80%	70%	60%
Learning Targets (19, including 6 core and 2 general targets described above)	<b>Proficient</b> on at least 17; <b>Expert</b> on at least 8	<b>Proficient</b> on at least 15; <b>Expert</b> on at least 5	<b>Proficient</b> on at least 13; <b>Expert</b> on at least 3	<b>Proficient</b> on at least 11
Core Learning Targets (6)	<b>Expert</b> on all 6	<b>Proficient</b> on all 6; <b>Expert</b> on at least 4	<b>Proficient</b> on all 6; <b>Expert</b> on at least 2	<b>Proficient</b> on all 6

**Note:** If you do not meet all of the criteria for a **D**, your grade will be an **F**. There is no **A+** or **D-**.

I will set +/- grades based on how close you are to the next higher (or lower) letter grade. For example, if you meet all criteria for an **A** except that you are expert on 5 core LTs and 5 other LTs, that may be an **A-**. If you are instead missing something bigger, e.g. proficient in 17 LTs, expert on 5 core LTs and 3 other LTs, that may be a **B+**. Similar considerations apply to completing two out of three requirements in a column. Please contact me towards the end of the semester if you want to review your current grades.

## §E. Tokens

Each student starts the semester with **2 tokens** (and can have a max of 2 tokens at any time), which can be used to purchase exceptions to the course rules. The token menu is below. To spend a token, send me an email. Everything listed here costs 1 token:

- Reassess three different Learning Targets in the same week.
- Take an in-class 50 min long checkpoint quiz as a timed take-home exam on Moodle instead of taking it in class. *It will still need to be finished by midnight on the same day.* This does not apply to longer exams.

Please note that tokens may not be “stacked”; for example, you aren’t allowed to spend 2 tokens and assess four Learning Targets in the same week or extend the deadline of a project report by 48 hours.

I will update the number of remaining tokens per student as they are used. Note that any leftover token at the end of the course will be counted towards class engagement, but has no value towards your scores.

### E.1. Resetting the total number of Tokens

- Completing Edfinity assignments A1-B3 by Sep 30 midnight will reset your remaining tokens to 2. Please email me if you have done so, since I will not be checking Edfinity scores regularly.
- Similarly, completing Edfinity assignments A1-E3 by Nov 15 midnight will reset your remaining tokens to 2.
- There may be occasional bonus challenge problems that you can answer to earn extra tokens over the semester.

## §F. Policies

### F.1. Attendance and Absence

Attendance is crucial to success in this class. Your best chance to discuss new material, ask questions, and avoid confusion is during class. So, don't miss class! You are responsible for all material and announcements from class, even in case of absence. Much of this information will be available on MOODLE. Please check in with me and with your classmates when you are back.

That said, life happens. We get the flu (or COVID!). Relatives need your help. When this happens, do what you need to do. I trust that you are an adult and will make the best choices that you can. I appreciate it if you can notify me in advance of an absence, if possible.

If you think you will miss more than one class in a row, you should contact me beforehand to let me know, and meet me afterwards to discuss how you can catch up and move forward in the course. If you miss four or more classes, I will send out an academic alert. If you miss more than two weeks of classes, you should contact the Dean Jen Bowen and/or Amber Larson, Director of the Academic Resource Center. They can help you consider options for completing or dropping the course.

### F.2. Early and Late Work

#### Early Work

**Checkpoint Quizzes:** You can arrange to take a quiz up to two days early if you have an conflicting extracurricular college event on that day, and you got permission from the Dean's office or your coach. *In such cases, you must give me a heads-up at least a week in advance.* Contact me directly regarding other cases.

#### Make-up Work

- **Edfinity Homework cannot be turned in late.**
- Lab Reports can be turned in late up to one day using a token.
- Checkpoint Quizzes may not be taken late, but since they are based on getting competency on learning targets, you may have an opportunity to assess the same target on a later exam or office hour with no penalty.

If you have significant extenuating circumstances that cause you to miss multiple assignments (even with tokens), see me to discuss arrangements. The Academic Resource Center, which is in APEX (Gault

library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the Academic Policies, Procedures & Support Services document for further details or go to the ARC website.

### F.3. Special Accommodations

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the **Academic Policies, Procedures & Support Services** document for further details or go to the ARC website.

### F.4. Email Responses

I do my best to reply to emails promptly and helpfully. However, I receive a lot of email. To help both you and me, here are some specific expectations about emails:

- If you email me between 8:00 am and 6:00 pm on a weekday, I'll reply to you on the same day.
- If you email me in the evening or overnight (after 6:00 pm), I will reply to you the next weekday.
- If your email asks a question that is answered in the Syllabus or on Moodle (such as in an announcement or an assignment sheet), I may reply by directing you to read the appropriate document.

See MOODLE for further instructions and examples of good professional emails.

## §G. How to get help?

### G.1. My Office Hours

Please come see me during my office hours if you have questions or just want to discuss something from class. These will be most effective if you have spent some time formulating your questions beforehand - often you will answer your own questions during that process! You can also contact me via Email or MS Teams with your questions. See the email response section above for my 'business hours'!

### G.2. Teaching Assistant Office Hours

Brayden Beathe-Gateley (class of '24) is your TA for this course. Brayden will not be present during classes but will hold weekly office hours outside the classroom. You can ask them for help with Edfinity homework and for going over past checkpoint quizzes.

**See Moodle for office hour times and further instructions.**

## §H. Academic Integrity and Collaboration

In this class, your primary goal in this course is to develop a deep personal understanding and expertise in Multivariable Calculus. Collaboration and cooperation are extremely helpful in the learning process, and we will have many opportunities for collaborative work. However, there are some portions of our class that must be done independently.



The College's understanding and expectations regarding issues of academic honesty are fully articulated in the Code of Academic Integrity as published in [The Scot's Key](#) and form an essential part of the implicit contract between the student and the College. The Code provides framework at Wooster to help students develop and exhibit honesty in their academic work. You are expected to know and abide by these rules.

In this class, we will use the following definition of plagiarism:

#### Definition 8.1

**Plagiarism** is the act of submitting the work of someone else as if it were your own. Specifically, this action misleads the instructor to think that the work is the result of learning and understanding by the student named on the paper, when in fact the understanding truly belongs to someone else. This may apply to an entire solution, or individual parts of a solution.

In Math 212, collaboration is permitted and even encouraged in some circumstances! However, *you may only collaborate with students currently enrolled in math 212*. In all cases where collaboration has occurred, you must acknowledge this clearly:

**Acknowledging collaboration:** In all work, specifically lab projects, you must clearly state the name(s) of the person(s) you collaborated with on each problem.

#### H.I. Specific academic honesty expectations

It is often unclear what exactly "collaboration" means when working on assignments. The following section should clarify what my expectations are regarding this and give guidelines for avoiding plagiarism in assignments. The list is intended to be helpful but not exhaustive. If you are unsure about the appropriateness of some form of assistance on an assignment, you should always ask me.

- **Edfinity Homework:** On homework problems, every step of every solution should be one that you understand yourself and that you have generated on your own. You are permitted to discuss big ideas and hints with your classmates and your TA.

Any collaboration should occur only when your collaborator is at essentially the same stage of the problem solution as yourself. In particular, if you have not yet started problem #4 and you ask a friend (who has already completed it), "How did you do problem 4?", this counts as **plagiarism**.

- **Lab/Project Reports:** You will be divided into groups during lab sessions to work on a lab project. You are permitted to work within that group only. Note that each student will need to complete and submit their own lab report. As such, I expect that everyone in a group understands all aspects of the report. If a student was not present or did not have significant contribution to the project, this should be noted in the report.
- **Outside resources in general:** On all work, unless directly stated otherwise, the only resources you may use are our class notes (including any worksheet on Moodle) and the approved textbook (see the first page). You are not permitted to go looking for completed solutions to problems in other texts or resources. **In particular, use of internet resources is completely off limits for completing homework problems.** Often, full solutions for our homework problems can be found online. If you see such a solution prior to submitting homework, there is essentially no way that you can claim to have an original solution. Evidence of using internet sources in your work will result in a minimum penalty of earning a N on the relevant objectives.

- **Copying:** Copying a solution, or any part of a solution, from any source (friend, internet, book, etc.) in any setting, constitutes **plagiarism**.
- **Past students:** On any assignment, basing your work on the efforts of another student who previously completed this course, or one like it, is considered **plagiarism**.
- **Other instructors, the Math Center (ZIs), and TA:** Before the relevant deadlines, you are not allowed to discuss any Checkpoint Quiz problem with the ZIs in the Math Center, our TA, or seek the help of an instructor or tutor (other than me). You are encouraged to seek their help **after** you have submitted an assignment and need help checking or understanding a concept. If you seek their help before submission, this will be considered **plagiarism**.

## H.2. Consequences of academic dishonesty

Evidence of dishonest behavior on any assignment will be grounds for a minimum penalty of earning an X on all relevant objectives for that assignment. Other penalties may include permanently failing the relevant objectives (regardless of other work) or, in severe cases, failure of the course. **Peers who willingly assist others in acts of plagiarism are equally guilty and will suffer similar penalties.** In all cases, the guidelines established in [The Scot's Key](#) will be followed. I reserve the right to discuss the nature and origins of any assignment with any student prior to assigning a grade.

## H.3. A positive note

Remember that I want you to be successful. That is, I want you to develop a deep, personal understanding of the material we study so that you become a better student of mathematics who can go on to do well in all of your future endeavors. Every part of this course structure - including both collaborative work and restrictions on collaboration - are intended to help you with this. You will often struggle, and that's intentional - struggle (and eventual success!) is essential to learning. Indeed, productively failing (and learning from it) is part of your final grade.

In all aspects of the course, please understand that I am generous with hints and am always willing to discuss problems with you. I will never simply give you an answer, but I will offer direction and guidance that will assist you in coming up with a solution on your own. This is by far the most satisfying way to solve a problem, and the difficulty is well worth it. You are always welcome to discuss your questions or concerns with me at any time.

## §I. Disclaimer


I reserve the right to make changes to this syllabus, if needed. Any changes will be announced to the class in a timely manner.




## §J. Tentative course schedule

Week	Monday	Wednesday	Thursday	Friday
1 (Aug 24)		Syllabus Overview + 3D Coordinate Geometry	Lab 0 (Intro to CalcPlot3D) + Vectors in 3D	Dot Product, Angle, Projection
2 (Aug 29)	Cross Product, Area, Volume	Lines and Planes	Lab 1 (Lines and Planes) + Project 1 (Distances)	Quiz 1
3 (Sep 5)	Coordinate Systems	Parametrized Curves - Equation of Motion	Calculus of Vector valued Functions	Quiz 2
4 (Sep 12)	Geometry of Vector valued Functions	Functions of several variables	Lab 2 (3D Graphing and Contour Plots)	Quiz 3
5 (Sep 19)	Partial Derivatives and Local Linearity	Gradients and Directional Derivatives	Exam 1	Lab 3 (Gradient Vector, Tangent Plane, and Directional Derivative)
6 (Sep 26)	Three-dimensional Gradient and Tangent Plane	Practice	Chain Rule	Quiz 4
7 (Oct 3)	Local Optimization	Constrained Optimization	Lab 4 (Stationary Points) + Practice	Quiz 5
Fall Break				
8 (Oct 17)	Global Optimization	Definite Integral of Functions of Two Variables	Exam 2	Type I/II regions, Fubini's theorem
9 (Oct 24)	Double Integral in Polar Coordinates	Triple Integrals	Lab 5 (Volume Integration)	Quiz 6
10 (Oct 31)	Change of Variables - Jacobian	Practice	Lab 6 (Vector Fields) + Project 3	Quiz 7
11 (Nov 7)	Vector Fields contd.	Differential Operators	Differential Operators contd.	Quiz 8
12 (Nov 14)	Line Integrals on Parameterized Curves	Gradient Fields - Path-Independent	Exam 3	Practice
13 (Nov 21)	Practice + Setting up for Green's theorem	Thanksgiving Break		
14 (Nov 28)	Green's Theorem	Applications of Green's Theorem	Practice	Quiz 9
15 (Dec 5)	Parameterized Surface	Surface Integrals, Flux	Stoke's Theorem	Quiz 10

Exam 4 will be on the day of the final exam and will cover the material after Exam 3. You can also schedule meetings to reassess up to two (2) learning Targets.

## §L. Math 212 Learning Targets

The  - marked learning targets are considered the most important (“core”) learning targets. They are not scored differently but are used to determine final grades. See [section D.2](#) for details.

- 
- **G1: Participation.** Your active participation in class is crucial both to your own learning and to the success of all. Attendance is therefore required, as is a willingness to share ideas, engage in group work, and to make brief presentations as needed.
  - **G2: Basic Calculus.** Perform algebraic calculations and interpret the results for the following list of concepts: limits, derivatives, integrals. Convert between the graphs and equations of conic sections.
- 
- **A1: Vector Algebra.** Compute, graph, and interpret vector addition/subtraction, scalar multiplication, magnitude, dot products, cross products, angle between vectors, area of a parallelogram, and volume of a parallelepiped.
  - **A2 : Lines and Planes.** Find the equation of a line or plane satisfying given conditions.
  - **A3: Coordinate Systems.** Describe points, graphs of surfaces, and regions of space using rectangular, cylindrical, or spherical coordinates; convert representations (coordinates or equations) between coordinate systems.
  - **A4: Vector-Valued Functions and Space Curves.** Convert between parametric and geometric descriptions of curves; find parametrizations of graphs and other implicit curves; apply concepts of single-variable calculus (limits, derivatives, integrals) to parametric curves in  $\mathbb{R}^2$  or  $\mathbb{R}^3$ .
  - **A5 : Calculus with Curves.** Describe motion via vector-valued functions; find the tangent, arc length, curvature, and acceleration of a curve.
- 
- **B1: Surfaces and Level Sets.** Sketch or predict the appearance of the graph of a function or curve, planes, and other common quadric surfaces based on a formula or other description; interpret as level sets of a function; use computer software to examine shapes of graphs and level sets.
  - **B2: Partial Derivative and Local Linearization.** Evaluate and interpret the partial derivatives of a two or three variable function, normal vector to a surface generated by  $f(x, y)$ , linear approximation.
  - **B3 : Gradient and Directional Derivatives.** Geometric interpretation of the gradient and directional derivatives; find equation of tangent planes to implicit surfaces.
  - **B4: Chain Rule.** Apply and explain equality of mixed partial derivatives, including sufficient conditions for such equality to hold; compute partial derivative of composite functions using chain rule.
- 
- **C1: Unconstrained Optimization.** Locate the critical points and classify local extrema of a multivariate function.

- C2 ☒: **Constrained Optimization.** Use Lagrange multipliers to find max/min given a constraint, possibly on the boundary of a region.
- 
- D1: **Double integrals.** Set up and evaluate double integrals as iterated integrals for type I/II regions; be able to switch the order of integration as necessary.
  - D2: **Change of variables.** Compute and interpret the Jacobian of a coordinate change function; use the Jacobian to transform and evaluate double integrals.
  - D3 ☒: **Triple integrals.** Set up and evaluate integrals over three dimensional regions as iterated integrals, change order of integration when useful, apply triple integrals to compute geometric quantities such as volume and mass.
- 
- E1: **Vector fields and Differential Operators.** Sketch and visualize vector fields and their flow lines using a computer; compute and interpret divergence and curl; explain how differential operators (div, grad, curl) are related.
  - E2: **Line integrals.** Compute line integrals of a vector valued function along a parameterized curve; determine if a Vector Field is conservative, find a potential function, and apply Fundamental Theorem of Line Integral.
  - E3 ☒: **Green's and Stokes's Theorem.** Explain what the boundary of a region in  $\mathbb{R}^2$  means; use Green's theorem to compute line integrals over closed curves in  $\mathbb{R}^2$ .

# TRANSITION TO ADVANCED MATHEMATICS

## SYLLABUS

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Fall 2022

Subhadip Chowdhury

Math 215

---

### §A. What is this class?

Welcome to **Transition to Advanced Mathematics**! This course is designed to bridge the gap between introductory Math courses, such as Calculus, and more abstract mathematics courses that rely heavily on proofs. We will explore several different mathematical topics, such as symbolic logic, set theory, number theory, relations, and functions. While **the primary focus of the course is on developing skills that will enable you to effectively communicate clear and correct mathematical arguments**, we will also cover expository writing and problem-solving strategies.

Please make use of my office hours and plan to work hard. My classes have a high workload (as all math classes usually do!), so make sure that you stay on top of your assignments and get help early. Remember that part of doing real math is productive failure: you'll try things that don't work; learn something from that failure; and try something new that works a bit better. And... after a while, you will figure it out, and come out with a much stronger understanding of the structure of mathematics.

**Additional details on some parts of the syllabus are available on Moodle.**

### §B. Key Information

#### Course Info

- **Class Meetings:** MWF 10:00 AM - 10:50 AM (EST), Taylor 209

#### How to contact me

- **Email:** [schowdhury@wooster.edu](mailto:schowdhury@wooster.edu)
- **Phone:** 330-263-2473
- **Office:** Taylor 307

#### Office Hours

*See Moodle for Up-to-date hours. You can also stop by any time my door is open, or email me to set up an individual meeting.*

#### Required Study Materials

- **Textbook:** There is no official textbook. We will use an inquiry-based learning (IBL) approach to complete the "Lecture Notes" workbook available on Moodle.
- **Technology:** A large portion of this class will require you to type your assignments using  $\text{\LaTeX}$ . So a laptop or PC capable of online browsing is required.

#### Class announcements

- **Available on:** <https://moodle-2223.wooster.edu/>  
*Check Moodle and your Wooster email at least once before and after each class.*

**Additional college policies are listed in a separate document called Academic Policies, Procedures & Support Services.**

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## §C. Prerequisites

Students must have completed Math 115 (or AP/ equivalent credit) with a C- or better. If you have any questions about whether this is the right class for you, speak with me immediately.

## §D. Learning Objectives & Goals

Upon successful completion of the course, you will be able to:

- Express in writing, knowledge of the terminology, concepts, basic properties and methodology of symbolic logic, set theory, relations and functions, mathematical induction, cardinality, and number systems.

- Formulate and correctly phrase mathematical statements, both verbally and in writing.
- Identify and critique the structure and logic of written proofs.
- Write a readable and mathematically rigorous proof.

Throughout this course, we will improve our mathematical reasoning and writing skills, justifying all of our work with the appropriate theorems and conveying all solutions clearly through writing. **This course fulfills the “W” requirement toward graduation at The College of Wooster.**

## §E. Components of the Course

This is not a lecture-oriented class or one in which mimicking prefabricated examples will lead you to success. You will be expected to work actively to construct your own understanding of the topics at hand with the readily available help of me and your classmates. Many of the concepts you learn and problems you work on will be new to you and ask you to stretch your thinking. You will experience frustration and failure before you experience understanding. This is part of the normal learning process. **If you are doing things well, you should be confused at different points in the semester. The material is too rich for a human being to completely understand it immediately.** Your viability as a professional in the modern workforce depends on your ability to embrace this learning process and make it work for you.

### E.1. Weekly Exercises

The exercise problems available at the end of the lecture note are designed for you to practice applying the concepts that we have learned in class and to help you develop the ability to read and write clear mathematical proofs. A certain number of these problems will be assigned at the beginning of the week (usually over the previous weekend), and students are expected to complete (or try their best to complete) them by the end of the week (or the due date). All assignments should be *carefully, clearly, and cleanly* written. Among other things, this means your work should include *proper grammar, punctuation, and spelling*. You should write a draft of a given solution before you write down the final argument, so do yourself a favor and get in the habit of differentiating your scratch work from your submitted assignment.

- Homework will usually be due at 5pm on the due date and should be uploaded to Moodle.
- In general, late homework will not be accepted without prior permission. *If you anticipate being late, let me know early, not on the deadline, and I will try to accommodate you.*
- **Working together on homework is encouraged!** However, you must still complete and turn in an assignment representing your own work.
- If you do work together in a group on a weekly exercise, please write down the names of other students in your group at the top of your submission.
- You are encouraged to check in with me or the TA regarding the accuracy of your homework **before** you submit them.

### E.2. Practically Perfect Proofs

Over the course of the semester, each student will receive about twelve problems whose solutions involve crafting coherent, convincing, and mathematically correct arguments, also known as *proofs*. These



problems are more difficult than regular homework exercises and always require careful thought, lots of attention, and lots of time to think and make mistakes.

You will need to **independently** submit a formal, correct, professionally-typeset solution (a  $P^3$  or Practically Perfect Proof) for these, and each will go through a revision process. The first time you submit your  $P^3$ , you will receive a provisional grade and feedback on your work and may choose to resubmit the assignment. An honest attempt at each  $P^3$  assignment must be submitted on the initial due date in order to be eligible for revision. All  $P^3$  assignments must be typeset in  $\LaTeX$ , which will provide you several opportunities to learn this skill.

**Note:** Senior majors in the MCS department must write their IS thesis using  $\LaTeX$ . See the next section for info about  $\LaTeX$  and guidance on typesetting your solutions.

Find the pdf file titled **Practically Perfect Proofs** in Moodle for further rules and explanations.

### E.3. $\LaTeX$

$\LaTeX$  (pronounced “lay-tek”) is a free typesetting system for preparing technical documents and is widely used in mathematics. You will learn the basics of  $\LaTeX$  in this course and use it to typeset your  $P^3$  assignments and your final expository paper. During weekly homeworks, you will be given instructions on how to typeset your work in  $\LaTeX$ . **No previous knowledge of  $\LaTeX$  is assumed.**

I highly recommend using the cloud-based TeX editor Overleaf (<https://www.overleaf.com>) if you are new to  $\LaTeX$ . They have a comprehensive tutorial/help page: <https://www.overleaf.com/learn>.

However, you can also install a local installation of  $\LaTeX$  on your personal computer (e.g., TeXShop for Mac: <http://pages.uoregon.edu/koch/texshop/> or MiKTeX for Windows: <https://miktex.org>).



**Warning:** Please note that I am **not** the right person to ask if you have *technical* issues with your local installation. If you need help with a particular technical issue, you can always try an internet search that is verbatim your issue. It is very likely that someone else in the world has had the same issue before, so the solution may be out there!

### E.4. Module Quizzes

There will be three quizzes during the semester. The quizzes will be designed to check your understanding of fundamental concepts and principles; you will be expected to apply the material learned to solve a wide variety of new and potentially unfamiliar problems and proofs.

See the ‘Lecture Note’ for a tentative schedule. I will post more details about the format of each quiz as the date approaches.

### E.5. Expository Paper

You will be writing and presenting an expository mathematical paper - a presentation of a mathematical topic, complete with an annotated bibliography. Find the pdf file titled **Expository Paper Guidelines** in Moodle for further details. Although topic selection will begin after fall break, I am providing you with the document ahead of time so that you can do a little research before deciding on a project.

### E.6. Participation Credits

The best way to maximize your experience in this course is to fully engage with the material and your classmates. Your active participation not only helps you, but it also creates a better learning environment for everyone in the course. This semester, there will be many different ways for you to demonstrate your engagement and professionalism remotely and in-person. For example,

- Completing the guided lecture notes and assignments on time.
- Completing the occasional checkpoint quizzes posted on Moodle on time,
- Asking relevant questions in class, office hours, or through email.
- Volunteering to present solutions in class.
- Giving constructive feedback to your classmates.
- Completing (to a satisfactory level decided by me) the reflection tasks.

**Note:** If I decide that not enough good faith effort was given to complete a reflection task, I may mark it as incomplete, and ask you to resubmit it.

## §F. How Semester Grade is Determined

**Your grade for the semester is not based on percentages because a lot of items in the course don't carry point values.** Also, different types of assignment assesses different skills - and they cannot be compared numerically. So instead, your grade will be based on the quantity and quality of evidence you can provide of across-the-board mastery of Math 215.

### F.1. Determine your base grade

To determine your course **base grade** (the letter A/B/C/D/F without plus/minus modifications), use the following table. To earn a grade, you must complete **all** the requirements in the column for that grade; your base grade is the **highest grade level for which all the requirements have been met or exceeded.**

Category	A	B	C	D
Weekly Homework	80%	70%	60%	50%
Module Quizzes	70%	60%	50%	40%
Reflection Tasks (3)	3	3	2	1
Participation and Engagement	Frequent	Regular	Occasional	Minimal
Practically Perfect Proofs (13)	6E, 6M	4E, 6M	2E, 6M	6M
Expository Paper				
Summary and Discussion	Required	Required	Required	
Outline and Annotated Bibliography	Required	Required		
Full First Draft	Required	Required		
Presentation (14)	11	8	5	
Peer Review	2 peers	1 peer	1 peer	
Final Submission (56)	50	44	38	32

**Note:** Again, all of the requirements in a grade column must be met or exceeded in order to earn that grade. Otherwise your grade is the highest grade for which all the requirements are met or are exceeded. For example, if you only earn 60% in weekly homeworks during the semester, you are not eligible for a grade of B or A in the course, regardless of your other performances. A grade of F is given if not all the requirements for a D are met.

## F.2. Determining plus/minus modifiers

'Plus' or 'Minus' letter grades will be assigned based on the proximity to the nearest full letter grade and will be according to the instructor's discretion. Note that you can only get the following letter grades: A, A-, B+, B, B-, C+, C, C-, D, or F.

## §G. How different types of assignments are scored

The weekly homework and module quizzes will be scored numerically for accuracy. The participation credits (reflection tasks, class engagement etc.) will be given for completion. See the pdf files on **Practically Perfect Proofs** and on **Expository Paper** for their grading scheme.

## §H. Policies

### H.I. Attendance and Absence

Attendance is crucial to success in this class. Your best chance to discuss new material, ask questions, and avoid confusion is during class. So, don't miss class! You are responsible for all material and

announcements from class, even in case of absence. Much of this information will be available on MOODLE. Please check in with me and with your classmates when you are back.

That said, life happens. We get the flu (or COVID!). Relatives need your help. When this happens, do what you need to do. I trust that you are an adult and will make the best choices that you can. I appreciate it if you can notify me in advance of an absence, if possible.

If you think you will miss more than one class in a row, you should contact me beforehand to let me know, and meet me afterward to discuss how you can catch up and move forward in the course. If you miss four or more classes, I will send out an academic alert. If you miss more than two weeks of classes, you should contact Dean Jen Bowen and/or Amber Larson, Director of the Academic Resource Center. They can help you consider options for completing or dropping the course.

## H.2. Early and Late Work

You can arrange to take a quiz up to two days early if you have a conflicting extracurricular college event on that day, and you got permission from the Dean's office or your coach. *In such cases, you must give me a heads-up at least a week in advance.* Contact me directly regarding other cases.

If you have significant extenuating circumstances that would cause you to miss an assignment deadline, meet with me to discuss arrangements.

**Note:** The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the Academic Policies, Procedures & Support Services document for further details or go to the ARC website.

## H.3. Special Accommodations

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the **Academic Policies, Procedures & Support Services** document for further details or go to the ARC website.

## H.4. Email Responses

I do my best to reply to emails promptly and helpfully. However, I receive a lot of email. To help both you and me, here are some specific expectations about emails:

- If you email me between 8:00 am and 6:00 pm on a weekday, I'll reply to you on the same day.
- If you email me in the evening or overnight (after 6:00 pm), I will reply to you the next weekday.
- If your email asks a question that is answered in the Syllabus or on Moodle (such as in an announcement or an assignment sheet), I may reply by directing you to read the appropriate document.

See MOODLE for further instructions and examples of good professional emails.

## §I. How to get help?

### I.1. My Office Hours

Please come see me during my office hours if you have questions or just want to discuss something from class. These will be most effective if you have spent some time formulating your questions beforehand - often you will answer your own questions during that process! You can also contact me via Email or MS Teams with your questions. See the email response section above for my 'business hours'!

### I.2. Teaching Assistant Office Hours

Luke Wilson (class of '24) is your TA for this course. Luke will not be present during classes but will hold weekly office hours outside the classroom. You can ask him for help with Edfinity homework and for going over past checkpoint quizzes.

**See Moodle for office hour times and further instructions.**

## §J. Academic Integrity and Collaboration

The goals of academic integrity are (i) to give credit where credit is due, and (ii) to create a record that enables other learners and scholars to trace the development of ideas. A good rule of thumb is: always cite your sources, resources, or people that you received assistance from, with as much specificity as possible. Please ask me if you have any questions about balancing academic integrity and assignments.

The College's understanding and expectations regarding issues of academic honesty are fully articulated in the Code of Academic Integrity as published in [The Scot's Key](#) and form an essential part of the implicit contract between the student and the College. The Code provides a framework at Wooster to help students develop and exhibit honesty in their academic work. You are expected to know and abide by these rules.

In this class, we will use the following definition of plagiarism:

### Definition 10.1

**Plagiarism** is the act of submitting the work of someone else as if it were your own. Specifically, this action misleads the instructor to think that the work is the result of learning and understanding by the student named on the paper, when in fact the understanding truly belongs to someone else. This may apply to an entire solution, or individual parts of a solution.

In Math 215, collaboration is permitted and even encouraged in most circumstances! However, *you may only collaborate with students currently enrolled in math 215*. In all cases where collaboration has occurred, you must acknowledge this clearly:

**Acknowledging collaboration:** In all work, specifically homeworks, you must clearly state the name(s) of the person(s) you collaborated with on each problem.

### J.1. Specific academic honesty expectations

It is often unclear what exactly "collaboration" means when working on assignments. The following section should clarify what my expectations are regarding this and give guidelines for avoiding plagiarism

in assignments. The list is intended to be helpful but not exhaustive. If you are unsure about the appropriateness of some form of assistance on an assignment, you should always ask me.

- **Lecture Note:** I encourage you to work with and get help from your peers with answering the questions in the lecture note as much as possible - and we will be specifically working on many of the problems together during class.
- **Homework:** On homework problems, every step of every solution should be one that you understand yourself and that you have generated on your own. You are permitted to discuss big ideas and hints with your classmates and your TA.

Any collaboration should occur only when your collaborator is at essentially the same stage of the problem solution as yourself. In particular, if you have not yet started problem #4 and you ask a friend (who has already completed it), "How did you do problem 4?", this counts as **plagiarism**.

- **Outside resources in general:** On all work, unless directly stated otherwise, the only resources you may use are our class notes. You are not permitted to go looking for completed solutions to problems in other texts or resources. **In particular, use of internet resources is completely off limits for completing homework problems.** Often, full solutions for our homework problems can be found online. If you see such a solution prior to submitting homework, there is essentially no way that you can claim to have an original solution. Evidence of using internet sources in your work will result in a *minimum* penalty of earning 0 on the relevant task.
- **Copying:** Copying a solution, or any part of a solution, from any source (friend, internet, book, etc.) in any setting, constitutes **plagiarism**.
- **Past students:** On any assignment, basing your work on the efforts of another student who previously completed this course or one like it, is considered **plagiarism**.
- **Office hours with Instructor and TA:** You are encouraged to seek help from me and our TA, Luke, with your homework assignments. You may not discuss a P3 assignment with the TA.

## J.2. Consequences of academic dishonesty

Evidence of dishonest behavior on any assignment will be grounds for a minimum penalty of earning a zero on all relevant tasks for that assignment. Other penalties may include permanently failing the relevant component (regardless of other work) or, in severe cases, failure of the course. **Peers who willingly assist others in acts of plagiarism are equally guilty and will suffer similar penalties.** In all cases, the guidelines established in [The Scot's Key](#) will be followed. I reserve the right to discuss the nature and origins of any assignment with any student prior to assigning a grade.

## J.3. A positive note

Remember that I want you to be successful. That is, I want you to develop a deep personal understanding of the material we study so that you become a better student of mathematics who can go on to do well in all of your future endeavors. Every part of this course structure - including both collaborative work and restrictions on collaboration - is intended to help you with this. You will often struggle, and that's intentional - struggle (and eventual success!) is essential to learning. Indeed, productively failing (and learning from it) is part of your final grade.

In all aspects of the course, please understand that I am generous with hints and am always willing to discuss problems with you. I will never simply give you an answer, but I will offer direction and guidance that will assist you in coming up with a solution on your own. This is by far the most satisfying way to solve a problem, and the difficulty is well worth it. You are always welcome to discuss your questions or concerns with me at any time.

### **§K. Disclaimer**

I reserve the right to make changes to this syllabus if needed. Any changes will be announced to the class in a timely manner.

# THEORY OF INTEGRAL CALCULUS

## SYLLABUS

Fall 2022

Subhadip Chowdhury

Math 125

### §A. What is this class?

This is the second part of a traditional Calculus II course, where we review further integration techniques, specifically, those involving trigonometric functions, and move on to explore concepts and techniques that are used to approximate definite integrals when you can't find a nice antiderivative! We will also talk about what exactly is infinity, and what it means to add up infinitely many terms together. The end goal for us is to realize that all "nice" functions can be written as a sum of (infinitely many) polynomials and this is how a computer numerically approximates Calculus!

This class may be more challenging than the previous mathematics courses you have taken. Start your homework assignments early, so that if you need help you have sufficient time to meet with me or the ZI. Begin studying for assessments well in advance. Put your good study habits into practice by reviewing definitions and working through extra problems when necessary, so that you can identify weaknesses and seek help. Remember that part of doing real math is productive failure: you'll try things that don't work; learn something from that failure; try something new that works a bit better, and... after a while, you will figure it out, and come out with a much more robust understanding of the structure of mathematics.

**Additional details on some parts of the syllabus are available on Moodle.**

### §B. Key Information

#### Course Info

- **Class Meetings:** MWF 8:00 AM - 9:50 AM (EST), Taylor 110
- **Thursday Meetings:** Th 8:00 AM - 9:20 AM (EST), Taylor 110

#### How to contact me

- **Email:** [schowdhury@wooster.edu](mailto:schowdhury@wooster.edu)
- **Phone:** 330-263-2473
- **Office:** Taylor 307

#### Office Hours

*See Moodle for Up-to-date hours.* You can also stop by any time my door is open, or email me to set up an individual meeting.

#### Required Study Materials

- **Textbook:** We will mainly use lecture notes and activities written especially for this class. You can use [Calculus Volume 2 - OpenStax](#) as a reference. The text is open-source and freely available online.
- **Computing Software:** We will use [DESMOS](#).

#### Class announcements

- **Available on:** <https://moodle-2223.wooster.edu/>  
*Check Moodle and your Wooster email at least once before and after each class.*

**Additional college policies are listed in a separate document called Academic Policies, Procedures & Support Services.**



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## §C. Prerequisites

You must have completed Math 120 (or an equivalent) with a grade of C- or better. You will also need a solid understanding of algebra, functions, trigonometry, and topics from differential Calculus. If you have any questions about whether this is the right mathematics course for you, please see me *immediately*.

## §D. How do I earn a grade

Our course is graded by a methodology called Learning-Based Grading system, also called standards-based or mastery-based grading, in which the different assignments do not have fixed weight percentages or numerical scores. Instead, you earn your grade by showing appropriate engagement with the course (by attending classes and completing homework) and demonstrating evidence of skill on the learning objectives that describe the major ideas covered by each assignment. These objectives, called **Learning Targets (LT)**, are listed in [section J](#) and may be updated throughout the semester.

To succeed in this class, you are expected to develop two kinds of skills simultaneously: *computational facility* and *conceptual understanding*. Both are essential to demonstrate fluency on the material. You will also work to improve your communication skills—with each other, with me, and with the rest of the world.

### D.1. Types of Assignments

More details on each type of assignment are given in the later parts of the syllabus. Check MOODLE for details.

- **Daily Work** Most days, you will be expected to read a section of the textbook before coming to class. This will be your primary first exposure to new material. During most classes, collaboration and problem-solving will occupy around half of our meeting time. You will be given one or more questions to address, and we will discuss different approaches to answering these questions developed within the class.
- **Checkpoint Quizzes (almost every week)**: Rather than midterm or final exams, we will have in-class checkpoint quizzes almost every week, that assess your performance in several learning targets (listed at the end). As the semester progresses, we will repeat older learning targets in quizzes for you to demonstrate completion. See the assessment section for details on how many times you need to complete each target.

Note that there will be no make-up quizzes. If you miss a quiz, you will have the opportunity to complete a learning target again on subsequent quizzes. During the finals week of the course, there will be two quizzes (one take-home, one in-class) instead of any final exam.

- **Edfinity Homework (One set for every LT)**: We will be using Edfinity for most homework assignments this semester. These are online homework assignments, to help build your computational skills. There will be at least one Homework set per learning target. Check MOODLE for details.

### D.2. How are Learning Targets scored?

When you submit most work, I will evaluate it relative to the quality standards made clear on each assignment. If your work meets the standard, then you will receive credit for it. Otherwise, you will get

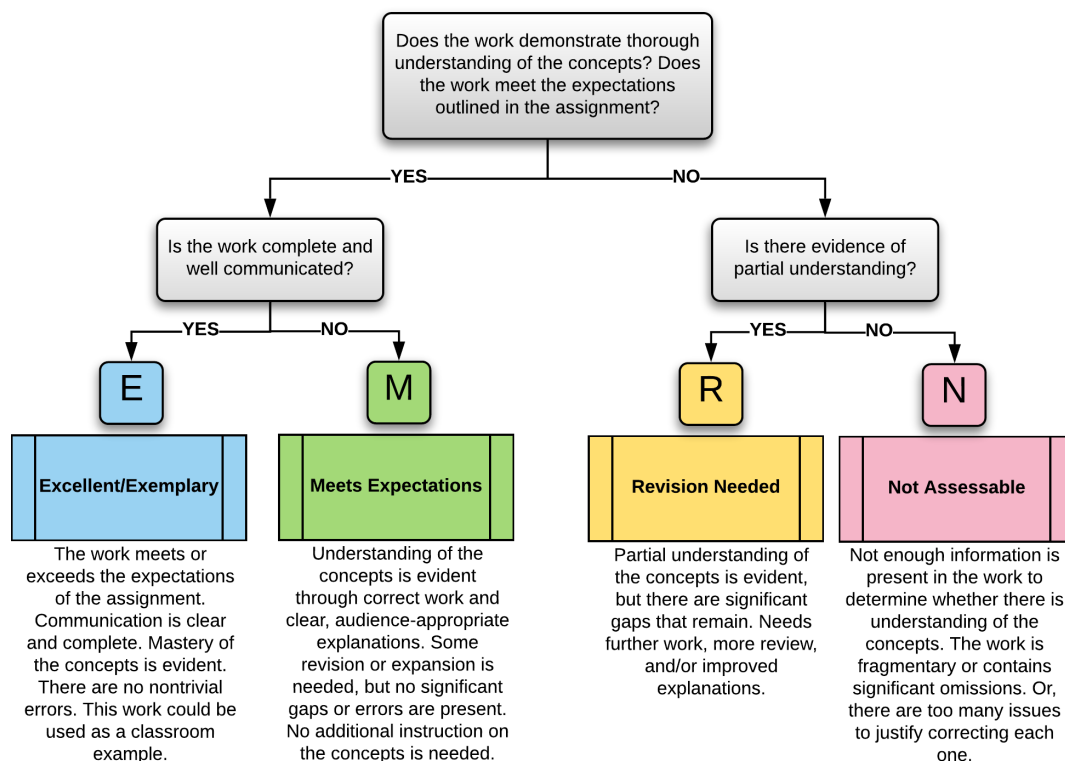
helpful feedback and, on most items, the chance to reflect on the feedback, revise your work, and then reassess your understanding.

This feedback loop represents and supports the way that people learn. *Learning happens over time, as we revisit ideas and reflect on them.* In this class, your final grade will reflect how well you eventually understand each topic. You can make mistakes without penalty, as long as you eventually demonstrate fluency of the topic.

My hope is that this method of grading will keep you clearly informed as to the expectations of the class and how well you are meeting them, while also removing the (often distracting) elements of linear grading that uses letters or total points. If you have questions or concerns at any time, please feel free to discuss them with me.

### Description of Scores

Each LT represents about 1–2 days of classwork. They are listed in [section J](#) approximately in the chronological order we will cover them. Each LT will be graded either M, R, or N based on [fig. 1](#).



EMRN rubric based on the EMRF rubric, due to Rodney Stutzman and Kimberly Race: <http://eric.ed.gov/?id=E3717675>  
EMRN rubric by Robert Talbert is licensed under CC BY-SA 4.0



Figure 1: EMRN Rubric

**Note:** Earning an E on a learning target is equivalent to an M. It shows that your work is exceptional, but has no extra effects otherwise.

- When you earn a M grade on a LT the first time during a quiz, it will be graded as **IN PROGRESS**.

- If you earn a second grade of **M** on that same LT during a quiz, it will be graded as **COMPLETE**.

**Note:** You may sometimes earn a **R\*** in a Quiz. This mark indicates work that contains an error which I think is minor, but I need to talk with you about it. Come to my office to discuss a **R\*** within one week after it is returned. If you can convince me that the error was minor and explain how to fix it, then I will update the **R\*** to an **M** for free. If I don't hear from you within one week, a **R\*** automatically becomes a **R**.

You will always have opportunities to show improvement, until the end of the course. Do not put off learning the material, however; later skills depend on earlier ones, and it will be hard to catch up if you fall too far behind.

There are also two general Learning Targets in [section J](#) that are evaluated a bit differently:

- **G1: Participation.** Your active participation in class is crucial both to your own learning and to the success of all. Attendance is therefore required, as is a willingness to share ideas and to make brief presentations.
  - ▶ **COMPLETE** - Continued, thoughtful participation in asking and answering questions, group work, regular attendance, completing Edfinity homework on time, and maintaining respectful classroom environment.
  - ▶ **IN PROGRESS** - No issues with attendance, and participation is adequate.
  - ▶ **No Credit** - Issues with attendance, participation, or disruptive behavior in the classroom.
- **G2: Calculus Prereqs.** Show your competency on the material from Calculus 110, 115, and 120.

We will **NOT** devote any class time to this material and this will be assessed through Edfinity homework. A score of 95.1 – 100% will be **COMPLETE** and 90% – 95% will be **IN PROGRESS**.

#### How is the final letter grade determined?

At the end of the semester, I am required to submit to the college a letter grade reflecting your achievement in this class. Here is how that grade will be determined.

To determine your course base grade (the letter **A/B/C/D/E/F** without plus/minus modifications), use the following table. *To earn a grade, you must complete all the requirements in the column for that grade; your base grade is the highest grade level for which all the requirements have been met or exceeded.*

Category	A	B	C	D
Homework Score	90%	80%	70%	60%
Learning Targets (17, including 2 general targets described above)	<b>In Progress</b> on at least 15; <b>Complete</b> on at least 13	<b>In Progress</b> on at least 13; <b>Complete</b> on at least 10	<b>In Progress</b> on at least 11; <b>Complete</b> on at least 7	<b>In Progress</b> on at least 9; <b>Complete</b> on at least 4

**Note:** If you do not meet all of the criteria for a **D**, your grade will be an **F**. There is no **A+** or **D-**.

I will set +/- grades based on how close you are to the next higher (or lower) letter grade. Please contact me any time during the semester if you want to review your current grades.

## §E. Tokens

Each student starts the semester with **2 tokens** (and can have a max of 2 tokens at any time), which can be used to purchase exceptions to the course rules. The token menu is below. *To spend a token, send me an email.* Everything listed here costs 1 token:

- Extend the deadline of an Edfinity homework by 24 hrs.
- Take a checkpoint quiz as a timed take-home exam on Moodle instead of taking it in class. *It will still need to be finished by midnight on the same day.* This does not apply to the final quiz.

Please note that tokens may not be “stacked”. For example, you aren’t allowed to extend the deadline of an assignment by 2 days by using two tokens.

I will update the number of remaining tokens per student as they are used. Note that any leftover token at the end of the course will be counted towards class engagement, but has no value towards your scores.

### E.1. Resetting the total number of Tokens

- Completing Edfinity assignments A1-C2 by Nov 15 midnight will reset your remaining tokens to 2. Please email me if you have done so, since I will not be checking Edfinity scores regularly.
- There may be occasional bonus challenge problems that you can answer to earn extra tokens over the semester.

## §F. Policies

### F.1. Attendance and Absence

Attendance is crucial to success in this class. Your best chance to discuss new material, ask questions, and avoid confusion is during class. So, don’t miss class! You are responsible for all material and announcements from class, even in case of absence. Much of this information will be available on MOODLE. Please check in with me and with your classmates when you are back.

That said, life happens. We get the flu (or COVID!). Relatives need your help. When this happens, do what you need to do. I trust that you are an adult and will make the best choices that you can. I appreciate it if you can notify me in advance of an absence, if possible.

If you think you will miss more than one class in a row, you should contact me beforehand to let me know, and meet me afterwards to discuss how you can catch up and move forward in the course. If you miss four or more classes, I will send out an academic alert. If you miss more than two weeks of classes, you should contact the Dean Jen Bowen and/or Amber Larson, Director of the Academic Resource Center. They can help you consider options for completing or dropping the course.

## F.2. Early and Late Work

### Early Work

**Quizzes:** You can arrange to take a quiz up to two days early if you have a conflicting extracurricular college event on that day, and you got permission from the Dean's office or your coach. *In such cases, you must give me a heads-up at least a week in advance.* Contact me directly regarding other cases.

### Make-up Work

- **Edfinity Homework cannot be turned in late.**
- Quizzes may not be taken late, but since they are based on getting competency on learning targets, you may have an opportunity to assess the same target on a later exam or office hour with no penalty.

If you have significant extenuating circumstances that cause you to miss multiple assignments (even with tokens), see me to discuss arrangements. The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the Academic Policies, Procedures & Support Services document for further details or go to the ARC website.

## F.3. Special Accommodations

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the **Academic Policies, Procedures & Support Services** document for further details or go to the ARC website.

## F.4. Email Responses

I do my best to reply to emails promptly and helpfully. However, I receive a lot of email. To help both you and me, here are some specific expectations about emails:

- If you email me between 8:00 am and 6:00 pm on a weekday, I'll reply to you on the same day.
- If you email me in the evening or overnight (after 6:00 pm), I will reply to you the next weekday.
- If your email asks a question that is answered in the Syllabus or on Moodle (such as in an announcement or an assignment sheet), I may reply by directing you to read the appropriate document.

See MOODLE for further instructions and examples of good professional emails.

## §G. How to get help?

### G.1. My Office Hours

Please come see me during my office hours if you have questions or just want to discuss something from class. These will be most effective if you have spent some time formulating your questions beforehand - often you will answer your own questions during that process! You can also contact me via Email or MS Teams with your questions. See the email response section above for my 'business hours'!

## G.2. Teaching Assistant Office Hours

Lucy Wickham (class of '23) is your TA for this course. Lucy will not be present during all classes but will hold weekly office hours outside the classroom. You can ask her for help with Edfinity homework and for going over past checkpoint quizzes.

See Moodle for office hour times and further instructions.

## §H. Academic Integrity and Collaboration

In this class, your primary goal in this course is to develop a deep personal understanding and expertise in the theory behind Calculus concepts. Collaboration and cooperation are extremely helpful in the learning process, and we will have many opportunities for collaborative work. However, there are some portions of our class that must be done independently.

The College's understanding and expectations regarding issues of academic honesty are fully articulated in the Code of Academic Integrity as published in [The Scot's Key](#) and form an essential part of the implicit contract between the student and the College. The Code provides framework at Wooster to help students develop and exhibit honesty in their academic work. You are expected to know and abide by these rules.

In this class, we will use the following definition of plagiarism:

### Definition 8.1

**Plagiarism** is the act of submitting the work of someone else as if it were your own. Specifically, this action misleads the instructor to think that the work is the result of learning and understanding by the student named on the paper, when in fact the understanding truly belongs to someone else. This may apply to an entire solution, or individual parts of a solution.

In Math 125, collaboration is permitted and even encouraged for certain tasks! However, *you may only collaborate with students currently enrolled in math 125.*

## H.I. Specific academic honesty expectations

It is often unclear what exactly "collaboration" means when working on assignments. The following section should clarify what my expectations are regarding this and give guidelines for avoiding plagiarism in assignments. The list is intended to be helpful but not exhaustive. If you are unsure about the appropriateness of some form of assistance on an assignment, you should always ask me.

- **Edfinity Homework:** On homework problems, every step of every solution should be one that you understand yourself and that you have generated on your own. You are permitted to discuss big ideas and hints with your classmates and your TA.

Any collaboration should occur only when your collaborator is at essentially the same stage of the problem solution as yourself. In particular, if you have not yet started problem #4 and you ask a friend (who has already completed it), "How did you do problem 4?", this counts as **plagiarism**.

- **Outside resources in general:** On all work, unless directly stated otherwise, the only resources you may use are our class notes (including any worksheet on Moodle) and the approved textbook (see the

first page). You are not permitted to go looking for completed solutions to problems in other texts or resources. **In particular, use of internet resources is completely off-limits for completing homework problems.** Often, full solutions for our homework problems can be found online. If you see such a solution prior to submitting homework, there is essentially no way that you can claim to have an original solution. Evidence of using internet sources in your work will result in a minimum penalty of earning a N on the relevant objectives.

- **Copying:** Copying a solution, or any part of a solution, from any source (friend, internet, book, etc.) in any setting, constitutes **plagiarism**.
- **Past students or tutors:** On any assignment, basing your work on the efforts of another student who previously completed this course or one like it, or a tutor not specifically approved by me, is considered **plagiarism**.
- **Math Center (ZIs), and TA:** You are encouraged to seek their help on homework, and after you have taken a quiz to clarify and understand a concept. If you seek their help before putting forth any personal effort, this will be considered **plagiarism**.

## H.2. Consequences of academic dishonesty

Evidence of dishonest behavior on any assignment will be grounds for a minimum penalty of earning an X on all relevant objectives for that assignment. Other penalties may include permanently failing the relevant objectives (regardless of other work) or, in severe cases, failure of the course. **Peers who willingly assist others in acts of plagiarism are equally guilty and will suffer similar penalties.** In all cases, the guidelines established in [The Scot's Key](#) will be followed. I reserve the right to discuss the nature and origins of any assignment with any student prior to assigning a grade.

## H.3. A positive note

Remember that I want you to be successful. That is, I want you to develop a deep, personal understanding of the material we study so that you become a better student of mathematics who can go on to do well in all of your future endeavors. Every part of this course structure - including both collaborative work and restrictions on collaboration - are intended to help you with this. You will often struggle, and that's intentional - struggle (and eventual success!) is essential to learning. Indeed, productively failing (and learning from it) is part of your final grade.

In all aspects of the course, please understand that I am generous with hints and am always willing to discuss problems with you. I will never simply give you an answer, but I will offer direction and guidance that will assist you in coming up with a solution on your own. This is by far the most satisfying way to solve a problem, and the difficulty is well worth it. You are always welcome to discuss your questions or concerns with me at any time.

## §I. Disclaimer

I reserve the right to make changes to this syllabus if needed. Any changes will be announced to the class in a timely manner.



## §J. Math 125 Learning Targets

- **G1: Participation.** Your active participation in class is crucial both to your own learning and to the success of all. Attendance is therefore required, as is a willingness to share ideas, engage in group work, and to make brief presentations as needed.
  - **G2: Calculus Prereqs.** Demonstrate competency in the concepts from Calculus 110, 115, and 120.
- 
- **A1: Integration by  $u$ -substitution and by parts.** Use integration techniques to evaluate integrals involving rational functions, radical expressions, exponential, logarithmic, and standard trigonometric functions.
  - **A2: Integration of Trigonometric functions.** Use various techniques to evaluate trigonometric integrals involving  $\sin$ ,  $\cos$ ,  $\sec$ ,  $\tan$ ,  $\csc$ , and  $\cot$ .
  - **A3: Integration with Trigonometric substitutions.** Evaluate integrals involving the inverse trig. functions.
- 
- **B1: Riemann Sums.** Be able to form an expression that approximates the value of a definite integral using Riemann sums and recognize such a sum as a definite integral.
  - **B2: Improper Integrals.** Be able to correctly evaluate an improper integral of Type I and type II using an appropriate limit process.
- 
- **C1: Sequences Basics.** Identify patterns in sequences, such as arithmetic and geometric sequences; interpret and convert between the explicit, list, and recursive notations of a sequence.
  - **C2: Limit and Convergence of Sequences.** Be able to explain the definition of convergence for sequence and use methods from Calculus I, specifically L'Hopital's rule, to evaluate limit of a sequence; or test convergence using relevant theorems.
- 
- **D1: Geometric Series.** Be able to explain the definition of convergence for an infinite series; identify a geometric series, know when a geometric series converges and diverges, know how to find the sum of a convergent geometric series.
  - **D2: Divergence Test.** Be able to apply the divergence test in appropriate cases to conclude that a given series diverges.
  - **D3: Integral Test.** Be able to correctly apply the integral test in appropriate cases to determine whether a given series converges or diverges.
  - **D4: Comparison and Limit Comparison Test.** Be able to correctly apply the Comparison or Limit Comparison Test to the appropriate series to correctly determine whether the series converges or diverges.

- **D5: Absolute and Conditional Convergence Test.** Be able to use a variety of tests to correctly determine whether a given series converges absolutely, converges conditionally, or diverges.
  - **D6: Ratio and Root Test.** Be able to use both the ratio test and the root test to determine whether a series converges absolutely or not.
- 
- **E1: Power Series.** Be able to identify and work with power series, and to find the interval of convergence for such a series.
  - **E2: Taylor and Maclaurin Series.** Know the Taylor Series representations for key functions such as  $\sin x$ ,  $\cos x$ ,  $e^x$ ; be able to correctly find a Taylor or Maclaurin series (or polynomial) for a function.

Date\Day	Mon	Tues	Wed	Thurs	Fri
Oct 19-21	x	x	1st Day Things, u-sub	Integral by Parts	Trig Integrals
Oct 24-28	Trig Integrals contd.	x	Integral with trig substitution	Riemann Sum	Quiz 1
Oct 31-Nov 4	Improper Integral	x	Improper Integral contd.	Comparison of improper integrals	Quiz 2
Nov 7-11	Sequence AP/GP	x	Limit of a sequence	Infinite Series	Geometric Series contd.
Nov 14-18	Divergence Test	x	Integral test	Comparison Test	Quiz 3
44886	Alternating Series	x	x	x	x
Nov 28 - Dec 3	Ratio/Root Test	x	Practice/Catch-up	Power Series	Quiz 4
Dec 5-9	Power Series contd.	x	Taylor and Maclaurin Series		Quiz 5
Final's week			Quiz 6		

# MATH 327: NUMERICAL ANALYSIS

SPRING 2022

INSTRUCTOR: SUBHADIP CHOWDHURY

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## KEY INFORMATION

### Class meetings:

MWF 2:00 – 2:50 PM, Taylor 209

### Office Hours

**See Moodle for Up-to-date hours.**

*I will adjust these based on your feedback.*

You can also stop by any time my door is open, or [email me](#) to set up an individual meeting.

### How to contact me

**Email:** [schowdhury@wooster.edu](mailto:schowdhury@wooster.edu)

**Phone:** 330-263-2473

**Office:** Taylor 307

*Be sure to read my [email responses](#) policy.*

### Textbook

None required, but any edition of Burden & Faires' *Numerical Analysis* is a good reference.

*Additional standard college policies are listed in a separate document called Academic Policies, Procedures & Support Services.*

## LEARNING GOALS

### CATALOG DESCRIPTION

This course covers error analysis, interpolation theory, solution of nonlinear equations and systems of linear and nonlinear equations, numerical differentiation and integration, and solution of ordinary differential equations. While theoretical results are discussed, there is also an emphasis on implementing algorithms and analyzing computed results.

#### Prerequisites:

- Calculus II – MATH 112 (or MATH 120+125),
- Linear Algebra – MATH 211
- Imperative problem Solving – CSCI 110 or equivalent coding experience
- Also helpful, but no required – Differential Equations, Math 221

### COURSE OBJECTIVES

The overarching goal of the course is to understand and appropriately apply approximate solution methods to various types of computational problems arising in natural science and engineering settings.

- To understand classes of mathematical problems for which finding analytic, exact solutions is impossible or impractical.
- To comprehend the theory underlying approximate solution algorithms for these problems, along with categorizing and quantifying types of error associated with each method.
- To implement, via scientific computing software (e.g. Python, MATLAB, Mathematica) approximate solution methods in a clear and efficient manner.
- To understand the limitations, advantages, and disadvantages of each method (often in terms of simplicity, speed, accuracy, and stability), leading to clear judgment about the suitability of various methods for a given computational problem.
- To communicate mathematical ideas professionally, both orally and in scientific writing.

## TOPICS COVERED

The standard undergraduate textbook in the field (Burden & Faires' *Numerical Analysis*) has sufficient material for a two-semester sequence. This one-semester course will survey a broad range of content, leaving opportunities for more in-depth study via Senior Independent Study, etc. Topics of discussion will include interpolation, solution of linear systems, solution of nonlinear equations and systems, numerical differentiation and integration, and solution of initial-value and boundary-value ODE problems.

## GRADING

To determine your course **base grade** (the letter A/B/C/D/F without plus/minus modifications), use the following table. To earn a grade, you must complete all the requirements in the column for that grade; your base grade is the **highest grade level for which all the requirements have been met or exceeded**.

Category	D	C	B	A
Lab Reports	50%	60%	70%	80%
Homework and Tests	50%	60%	70%	80%
Final Project (see Rubric)	50%	60%	70%	80%

**If you do not meet all of the criteria for a D, your grade will be an F.**

I will set +/- grades based on how close you are to the next higher (or lower) letter grade. For example, if you meet all criteria for an A except for one Homework, that may be an A-. If you are instead missing something bigger, like one Lab Report, that may be a B+. I will communicate details of this on Moodle towards the end of the semester.

## SOFTWARE USAGE

There will be two types of assignments that will be using scientific computing software in this course. Most in-class demonstration and group work will be done using **Mathematica** (Wooster has a site license, [See here](#)). For lab reports, you will be occasionally required to write programs from algorithms. You are welcome to choose any programming language of your choice, but the most prevalent for this purpose are **Octave** (free, open source alternative to MATLAB) or **Python** (free, open-source). However, note that I would be unable to help with coding in any other languages except these three.

Each student should enter the class with at least an intermediate level of proficiency in an appropriate programming language, as the content is sufficiently challenging for those without simultaneously learning to code. Furthermore, a 300-level course carries expectations of readiness to work independently and collaboratively without continual one-on-one assistance.

## LAB REPORTS

Most weeks will include a lab activity, which will involve algorithm implementation, error analysis, and sometimes also theoretical derivations. For each lab, you will need to submit typeset solutions (using LaTeX, etc.) and an electronic copy of your code. Grading criteria will include the following:

- Accuracy and thoroughness of answers (including thoughtful discussion of *why*, not just *what*)
- Professionalism in the written document (academic tone, insightful well-labeled graphs, etc.)
- Clarity & efficiency in coding (readability, documentation, no irrelevant code, etc.)

*Students may pair up for labs and submit one assignment with both students' names but may not work with the same partner more than once during the semester. **No other copying of code is permitted.***

## FINAL PROJECT

For the final project, you will be asked to learn about a numerical analysis topic not covered in class, code it up & apply it to one or more examples, then give a 10–15-minute oral presentation about the methodology and its usage, with slides/visuals. Presentations will take place during the last week of classes.

Alternatively, you could apply a computational method (including those covered in class) to an applied science problem from another course or from your research. In this case, you would write an appropriate code to solve the problem and give a presentation on the application problem and methodology used to solve it. Talk to Dr. Chowdhury if considering this option.

Grading will be based on the quality of the mathematical content (that the numerical analysis concepts are substantial & correctly applied) and of the presentation (organization, clarity, plots & visuals, usage of time, etc.). More details including a rubric will be posted to Moodle.

## POLICIES

### ATTENDANCE AND ABSENCES

**Attendance is crucial to success in this class.** Your best chance to discuss new material, ask questions, and avoid confusion is during class. So, don't miss class! You are responsible for all material and announcements from class, even in case of absence. Much of this information will be available on Moodle. Please check in with me and with your classmates when you are back.

That said, life happens. We get the flu. Relatives need your help. When this happens, do what you need to do. I trust that you are an adult and will make the best choices that you can. I appreciate it if you can notify me in advance of an absence, if possible.

If you think you will miss *more than one class in a row*, you should contact me beforehand to let me know, and meet me afterwards to discuss how you can catch up and move forward in the course. If you miss *an entire week*, I will send out an academic alert. If you miss *more than two weeks* of classes, you should contact the Dean Jen Bowen and/or Amber Larson, Director of the Academic Resource Center. They can help you consider options for completing or dropping the course.

### OTHER POLICIES

#### Special Accommodations

The Academic Resource Center, which is in APEX (Gault library) offers a variety of academic support services such as time management and class preparation, ELL peer tutoring, coordinating accommodations for students with diagnosed disabilities, etc. Please see the Academic Policies, Procedures & Support Services document for further details or go to the [ARC website](#).

## Email Responses

I do my best to reply to emails promptly and helpfully. However, I receive a lot of email. To help both you and me, here are some specific expectations about emails:

- If you email me between 8:00 am and 6:00 pm on a *weekday*, I'll reply to you on the *same* day.
- If you email me in the evening or overnight (after 6:00 pm), I will reply to you the *next weekday*.
- **If your email asks a question that is answered in the Syllabus or on Moodle** (such as in an announcement or an assignment sheet), I may reply by directing you to read the appropriate document.
  - If you've read the relevant document and still have questions about it, please make this clear in your email, by describing what you've already read, and which specific part of it you have a question about.
- Often, it's much easier to discuss questions in person. I may ask you to meet with me in my office (at a time that works for both of us) rather than answering directly in an email.
- On homework, please include photos, PDFs, or links if possible.

## Syllabus Changes

The instructor reserves the right to make changes to this syllabus, if needed. Any changes will be announced to the class in a timely manner.

# HOW TO GET HELP

## MY OFFICE HOURS

Please come see me during my office hours if you have questions or just want to discuss something from class. These will be most effective if you have spent some time formulating your questions beforehand - often you will answer your own questions during that process! You can also contact me via Email or MS Teams with your questions. See the [email response section](#) above for my 'business hours'!

**See Moodle for office hour times and further instructions.**

## TEACHING ASSISTANT OFFICE HOURS

Maxwell Hosler (class of '22) is your TA for this course. He will not be present during classes but will hold weekly office hours outside the classroom. You can ask him for help with lab reports and for going over **past** homeworks.

**See Moodle for his office hour times and further announcement from him.**

## TENTATIVE SCHEDULE

Week	Monday	Wednesday	Friday
1 (Jan 17 - 21)	MLK Day	Overview + Polynomial Interpolation	Interpolant in Lagrange Basis
2 (Jan 24 - 28)	Interpolation Error Bounds	Interpolation Error Bounds ctd. + Runge's phenomenon	<b>Lab 1 (Runge's phenomenon and Chebyshev Nodes)</b>
3 (Jan 31 - Feb 4)	Spline Interpolation	Spline Lab	Elimination algorithms
4 (Feb 7 - 11)	Computational Effort, Pivoting Strategies	<b>Lab 2 (Elimination algorithms)</b>	Vector and Matrix Norms
5 (Feb 14 - 18)	Norms contd.	Iterative methods for Linear Systems	<b>Lab 3 (Jacobi and Gauss-Seidel)</b>
6 (Feb 21 - 25)	Discrete Least Square Approximation	Continuous Least Square Approximation	Least square approx. contd.
7 (Feb 28 - Mar 4)	Intro to Nonlinear Eqns + Bracketing Algorithms	Fixed Point Iteration (Newton's Method)	<b>Lab 4 (Root Finding)</b>
8 (Mar 7 - 11)	Comparing Convergence	Order of Convergence contd.	Take-home Midterm
11 (Mar 28 - Apr 1)	Quasi-Newton methods	<b>Lab 5 (Newton for Systems)</b>	Numerical Differentiation
12 (Apr 4 - Apr 8)	Numerical Differentiation contd.	Rounding Error Instability	Interpolatory Quadrature Rules
13 (Apr 11 - Apr 15)	Quadrature Contd.	Newton-Cotes quadrature	<b>Lab 6 (Numerical Integration)</b>
14 (Apr 18-22)	ODEs, IVPs and the Existence and Uniqueness theorem	One-step Methods	Runge-Kutta contd.
15 (Apr 25 - 29)	<b>Lab 7 (IVP)</b>	Multistep Methods	I. S. Symposium (no class)
16 (May 2 - 6)	Review, Catch-up	Final Project	Final Project














# Differential Equations

Math 221


## Instructor Info —

-  Subhadip Chowdhury
-  Office Hrs: See Moodle
-  Taylor 307
-  [subhadipchowdhury.github.io](mailto:subhadipchowdhury.github.io)
-  [schowdhury@wooster.edu](mailto:schowdhury@wooster.edu)



## Course Info —

-  **Prereq:** Math 112 and CSCI 100 or equivalent
-  Mon, Wed & Fri
-  2:15p-3:05p
-  Taylor 206 + MS Teams

## Textbook —

-  D. G. Zill, *A First Course in Differential Equations with Modeling Applications*

## Software —

-  **Python 3.8** - a free, open-source programming language
-  **DFIELD** and **PPLANE** - some Java applets (see Moodle)

## Course Goals

**Math 221 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 explore such DE models.

1. Know how to solve a variety of DEs “by hand” (analytical techniques).
2. Know how to analyze and say something about DEs without explicitly solving them (qualitative techniques).
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, learn how to 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 tests will not be “just like” problems you have seen before. You will be asked to explore new topics yourself before I cover them in class. Finally, how you present your solutions will also be evaluated.

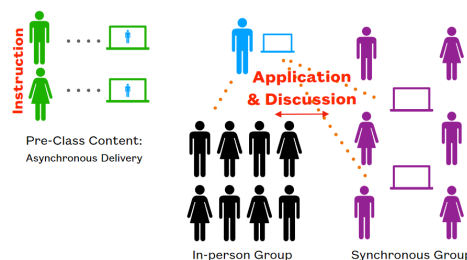
## Grading Scheme

Pre-class Quizzes .....	5%
In-class Participation .....	5%
Projects .....	35%
Take-home Tests .....	40%
Final Exam .....	15%













Scores will NOT be curved. However, the cutoff percentage for letter grades will be set at my discretion (usually B is around 85%). The weights are tentative and subject to change on an individual basis.

## Structure of the Course

We will have a Hybrid Flipped Classroom style instruction for the Fall 2020 semester.



- **Attendance and Teams** (See details [here](#)): Each student will be assigned to one of three groups. Only one group will attend each lecture in-person at-a-time with the remaining two online.

Student Groups	What Instructor Sees		
	Monday	Wednesday	Friday
Group A			
Group B			
Group C			
Students who are Remote			

# FAQs

## ? Where can I find Python?

! Experienced students are welcome to use any desired Python interface. For newer users, it is recommended to download the free [Anaconda distribution](#) of Python, and to use Jupyter notebooks, which will be demonstrated in class.

## ? Do I have to buy the textbook?

! A physical copy of the book is not mandatory. We will not be covering everything from the book and some topics will be covered out of order as I see fit. I will be providing class notes/worksheets for daily lectures and will be creating my own projects/assignments apart from book problems.

## ? What is the late submission policy for take-home exam?

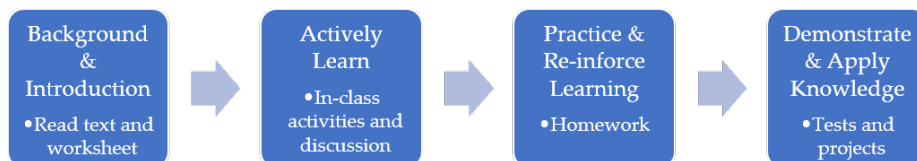
! In general, late submission (even 15 mins late) will NOT be accepted and will result in a grade of zero for the test. If any conflict arises with any of the test dates, please let me know as soon as possible, and you can take the test early. Missed exams can only be made up at my discretion, and are subject to a lost fraction of the grade.

## ? Do I have to attend all classes synchronously?

! You are expected to attend the lectures synchronously if you are on-campus. If you are in a different time-zone, you can be asynchronous, but please stick to the daily schedule and you *must check-in with me over MS Teams at least once a week*.

You will be teamed up with one member from each of the other groups into a Team of three, and while in-class you will be connected with them via MS Teams. A tablet/laptop and headphones will be needed every day in class so you can connect with your teammates and work on the day's activities.

- **Class Preparation (See details [here](#)):**
  - I will be posting lecture worksheets for each class ~two lectures beforehand via Moodle. I expect that you will have read and tried to work through questions in the worksheet at least once *before* the lecture. You are highly encouraged to get help from your peers by forming small study groups of your own.
  - Along with the worksheet, a very short Multiple-Choice quiz will be posted in Moodle before each lecture to assess what you have learned by reading (and to ensure you have read) the worksheet. Ten lowest scores of the semester will be dropped. The scores will help me understand which topics to focus on during lecture.
  - During our scheduled lecture time (2:15-3:05PM EST), we will hold live-streamed sessions (details below) to go over examples and exercises from the worksheet, further applications, and answer any of your queries. These sessions will be recorded.
- **Technology & Communication (See details [here](#)):**
  - *Moodle* will be the central organizational focal point for the course. There will be links in the “Weekly Content” section to Teams meetings and links to Teams recorded videos. Worksheets, Homework and Tests are here.
  - *Microsoft Teams* will be meeting place for live-streamed lectures and office hours. You will need to [install Teams](#) on your computers or other devices. Email me or EdTech with any technical issues, and we will try to help.
- **Empathy (See details [here](#)):** This has been a tough few months for many of us, for many different reasons. There is still a lot of uncertainty ahead. Let's all practice kindness and understanding, towards each other and ourselves.



## Attendance and Teams

- Each student will also be assigned a Team, which will consist of one Group A member, one Group B member, one Group C member, and occasionally a student who is taking the class remotely.
- On days you attend class in-person, it is your responsibility to: connect with your teammates, work through the day's activities with them via MS Teams, and summarize any in-class discussion or lecture that they are unable to participate in. You will need a laptop/tablet to work during class and headphones/earbuds to talk with your teammates.
- If you know ahead of time that you will be absent from a class, you should arrange with your teammate to switch days with them.
- While there is no mandatory attendance policy, you are the one responsible for missed material. It is very easy in a math class to fall behind after skipping even one lecture. You can still submit (and receive credit for) the pre-class quizzes even if you do not attend class. If you miss a class, read the worksheet, get notes from a classmate, and review the day's activity (on Moodle) before contacting me for help. Also remember that your teammates are counting on your attendance!
- Be courteous when using mobile devices. Make sure your cell phone is turned fully off, or silent during class. If you must make or receive a call, please go outside the classroom (or mute yourself if you are online).
- Participate fully in each class by reading the assigned sections and working on the worksheets ahead of time, being mentally focused, asking and responding to questions, and completing in-class activities.
- Be respectful in the classroom. I am happy to take any questions in class, no matter how trivial they may seem.

## Course Readings

- Worksheets for each class day will be posted to Moodle at least 4 days in advance.
- It is extremely important you complete the worksheet and read the suggested book chapters before class begins. I will assume that everyone read mindfully, took good notes, and we are all starting from the same place.
- Suggestions about reading mindfully: “reading” does not mean “skimming”. Highlight definitions and theorems for easy recall. Work through examples to the best of your ability. Reference previous examples/sections if necessary. Make notes of things you don’t understand, or questions you have about the material.
- Before coming to every lecture, complete the pre-class quiz posted to Moodle. These are very basic questions designed to test whether/how well you understood the study material.
- Although I do expect everyone to work through study materials carefully before class begins, I will not expect that everyone understands everything they’ve read. You should feel free to ask questions (in class or out of class) about material, either from the book or from the worksheet.

## In-class Activities

In-class activities make up most of class time and are the main vehicle by which you learn the material in a no-stakes environment. Consistent and honest participation and engagement with these activities is absolutely imperative for your learning, which is why they account for a relatively large portion of your course grade.

## Homework Policies

In an upper-level class, my philosophy is that homework is a tool for students to internalize and practice the course content, rather than an instrument for evaluating student performance. Lists of suggested homework problems will be regularly posted on Moodle, and questions about these problems are welcome, but homework will not be collected. In summary, homework is for your benefit, not for a grade.

## Projects Policies

- There will be multiple 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 Python or use the Java applets.
- You will be working with your team during designated class days to create a project report. *One submission for your entire team will suffice.*
- 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 Moodle) on which names 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.

## Take-home Tests

- Take-home tests will be administered via Moodle. Computational skills, conceptual understanding, and the ability to apply ideas to unfamiliar problems are all important.
- You will be required to write the solution on paper and upload a scan/picture in pdf format via Moodle. More details on this will be given in class.
- Take-home tests are timed, open-note/open-book. You may NOT post problems on the Internet or discuss problem specifics with others. Please email me to ask whether a particular resource is allowed or not.
- As you are solving problems, 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 completed the work, 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.*

## Technology & Communication

- All course materials will be posted to the course Moodle page. Check Moodle and your email daily.
- During class, you’ll need to connect with your teammates via MS Teams. You can do this via laptop, tablet, or phone. You’ll also need to work with them on the day’s activity, which will sometimes use Python. You can do this via laptop or tablet. Thus, you need to bring a computer/tablet and earbuds/headphones to class every day.
- Proper maintenance of computer accounts, files, etc. is your responsibility.
- For students joining online during class, you do not have to join with your video or audio if you don’t want to. You can unmute yourself when asking a question and otherwise use the chat feature.
- In the class team folder, you will see separate channels for general discussions, class meetings, and for office hour. Class

- meetings will be recorded and posted immediately. Office Hour meetings will not be recorded.
- To address privacy concerns, you will only be able to stream recorded sessions online, you will not be able to download it.
- I will help you create your own private team channels that no other student will have access to. You will use these for group discussions during Projects.
- The best way to contact me outside of class is by email or via chat in MS Teams or by coming to my office hours. If I ever need to contact everyone outside of class, I will use email. You are welcome to email me any time of the day or night. You should allow 24 hours response time for any emails – I usually respond faster than that, but you should not count on it. Please keep this in mind, especially when emailing me late at night or over the weekend.
- I would like to stress that communication is key to success! This will hold true throughout your college career, work career, and really your entire life. I implore you to contact me as soon as possible if you are struggling with material or if a conflict arises (see [below](#)).
- For any private communication regarding this course, please email me from your [wooster.edu email address](#). This is mainly for identity verification purposes.

## Humanizing the Classroom

- COVID-19 Statement:**
  - Nobody signed up for this.
    - Not for the sickness, not for the social distancing, not for the sudden end of our collective lives together on campus (in March) or this new patchwork system.
    - Not for an online class, not for teaching remotely, not for learning from home, not for mastering new technologies, not for varied access to learning materials.
  - The humane option is the best option.
    - We are going to prioritize supporting each other as humans.
    - We are going to prioritize simple solutions that make sense for the most.
    - We are going to prioritize sharing resources and communicating clearly.
    - We are going to practice empathy: towards ourselves and everyone else in the class community.
  - We will remain flexible and adjust to the situation.
    - Nobody knows where this is going, what we'll need to adapt, or how we'll need to adapt.
    - This situation – including the learning environment – is as new to me as it is to you. I have done my best to structure the course according to “best practices” and my own expertise. I have also done my best to make course policies fair, equitable, and humane. We may need to make adjustments as the semester progresses. Please bear with me.
    - Everybody needs support and understanding in this unprecedented moment: me, you, all of us.
  - We will follow the rules put down by the College and public health officials.
    - This will be hard. Social distancing is counter to human nature. Wearing a mask all the time is annoying. Not seeing off-campus friends or family for a semester will feel isolating. But these are the (small) sacrifices that we must make if we want our community stay healthy, and together.
- Freedom to Make Choices:**

You don't need my *permission* to turn in tests late, to miss class, or to make decisions in your life. The point of the syllabus is not to say you “cannot” do something, but rather to establish strong practices for learning and, to the best of my ability, a fair and equitable environment for that learning. But *strong learning practices* will look differently for individual students, and what is *equitable* depends on circumstances.

So, the best advice I can give you is this: be aware of the consequences of your choices, make the best choices you can in a given situation, and graciously accept the consequences of your actions if they are fair. If you think the consequences are unfair, let's chat about it.

- Productive Struggle:**

“You have to be confused before you can reach a new level of understanding.”

–Dudley Herschbach, Nobel Prize winner (Chemistry)

Everyone makes mistakes. Trial and error is how we learn. So, you'll gain greater understanding if you struggle through concepts or tasks before you ask for help. This is why the course is set up with so many layers of scaffolding before the *testing* phase: you will struggle on activities and homework. This is the purpose of activities and homework! Learn from that struggle!

However, struggling with a difficult new idea is different than struggling with learning conditions – I would never ask you to struggle when (reasonable) accommodations could improve your learning. Furthermore, your Team is there to struggle with you and support you, as you support them. I am also here to support you! I just ask that you put in an honest effort, and rather than asking me to “solve the problem”, you see me as a guide towards a clearer understanding of how you might solve it. Working together, teaching each other, and learning from each other is the basis of intellectual growth and a foundational principle of The College of Wooster.

Here's another way to think of it (from Harvard Prof. Michael Sandel): “I could give [students] detailed instructions, never letting them hold a bat until they had heard several lecture... Or, I could give them a bat and allow them to take a few swings, after which I might find one thing that the kid is doing, which if adjusted, would make [them] a better hitter.” When you try something out first it allows me to make corrections specific to your learning needs.



## Diversity and Inclusion

I consider our classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability - and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

Your success in this course is important to me. If there are circumstances that may affect your academic performance or impact your learning in particular portions of the class, please let me know as soon as possible. You do not need to share specifics, but together we can develop strategies to meet both your needs and the requirements of the course.

I encourage you to visit the [Learning Center](#) to determine how you could improve your learning as well. If you need official accommodations, you have a right to have these met. There are also a range of resources on campus, including the [Writing Center](#), [Math Center](#), [STEM Success Initiative](#), and [APEX for Academic & Career Support](#).

No student is required to take an examination or fulfill other scheduled course requirements on recognized [religious holidays](#). Please declare your intention to observe these holidays at the beginning of the semester.

## Names, Pronouns & Pronunciation

All people have the right to be addressed and referred to as they prefer. I will do my best to address and refer to all students by the names and pronouns that they share in class, regardless of what is listed on the roster, and I support classmates in doing so as well. I would like for you to refer to me as *Professor/Dr. Chowdhury*. I use he/him/his pronouns. Please share the name you prefer to be called and pronouns you wish to use in this class with me via the Moodle survey.

If you are interested in changing your chosen name and/or including your pronoun(s) in The College of Wooster system, [you can find additional information here](#). What appears in The College of Wooster system is what will display in all platforms across Microsoft Teams and Zoom. There is no alternative way to change your name or to add pronouns in Teams, but you can add a background that includes these to both Teams and Zoom. For instructions on designing a personalized background, see [here](#).

I encourage everyone in this classroom to create a space of mutual respect and support by also giving each other some grace around pronouns, pronunciation of names, etc., if or when we make mistakes. This is not at all to absolve anyone of responsibility for using correct pronouns, names, and pronunciations. But I find it useful to acknowledge that even with the best of intentions, sometimes we can all still make mistakes.

## Honesty & Academic Integrity

The academic program at the College seeks to promote the intellectual development of each student and the realization of that individual's potential for creative thinking, learning, and understanding. In achieving this, each student must learn to act rigorously, independently, and imaginatively.

The College's understanding and expectations in regard to issues of academic honesty are fully articulated in the Code of Academic Integrity as published in [The Scot's Key](#) and form an essential part of the implicit contract between the student and the College. The Code provides framework at Wooster to help students develop and exhibit honesty in their academic work. You are expected to know and abide by these rules.

Dishonesty in any of your academic work is a serious breach of the Code of Academic Integrity and is ground for serious penalties. Such violations include turning in another person's work as your own, copying from any source without proper citation, violating expectations for a group project, submitting an assignment produced for a course to a second course without the authorization of all the instructors, and dishonesty in connection with your academic work. You will be held responsible for your actions. Particular attention should be directed to the appropriate use of materials available online. Whether intentional or not, improper use of materials is a violation of academic honesty. If you are unsure as to what is permissible, please contact your course instructor.

## Privacy Policies regarding Course Materials & Recordings

The materials on this course shared on Moodle and Teams are only for the use of students enrolled in this course, for purposes associated with this course, and may not be further distributed. All class recordings will be posted only on password-protected websites (such as Moodle, Teams or Stream) that are only available to course participants and for the duration of the course. These are to be used for educational purposes only; no one should distribute recordings, screenshots, or other class material beyond class without the express permission of all involved in the recording. College classrooms are places to test out new ideas, challenge assumptions, and engage timely and sometimes sensitive issues. Students who enter this space should be able to do so with the assurance that their comments will not be shared beyond the classroom.

College policy states that no *student* may record or tape or photograph any classroom activity without the express written consent of the faculty member. If you need to record/tape a class, then you need to contact the Office of the Secretary for permission.

## Pass/Fail & Course Drop Options (for Fall 2020)

**Pass-Fail Policy:** The College is temporarily broadening the policies on electing a pass-fail grading structure:

- Students may elect a Pass-Fail grading option for any course (including those in a major/minor)
- Special note on transcript noting unique policy changes specific to Fall Semester 2020 regarding pass-fail counting toward the major.
- Students may elect as many courses as they wish on a Pass-Fail grading structure. Courses elected as Pass-Fail for Fall Semester 2020 will not count toward the maximum number of Pass-Fail courses that a student may take at Wooster.

The deadline for electing a Pass-Fail grading option is Friday, December 18, 12:00PM.

**Course drop policy:** The College is temporarily extending the deadline for dropping a course. For Fall Semester 2020: Students may drop any course by Tuesday, November 24, 4:00PM. The minimum enrollment of 3.0 credits remains in effect. Requests to drop enrollment below 3.0 credits will require additional documentation via "Other academic petitions."

## College Policy on Final Exams

No final examinations are to be given during the last week of classes or on reading days. Students who wish to reschedule a final exam must petition the Dean for Curriculum and Academic Engagement in writing in advance of the examination. The student must confer with the instructor before submitting a petition, and the instructor should indicate to the Dean if they supports the petition. *Normally, such petitions are granted only for health reasons. If other reasons necessitate a request for a change in a final exam, the request must be submitted three weeks in advance of the examination.*

## Conflicts with Academic Responsibilities

The College of Wooster is an academic institution and its fundamental purpose is to stimulate its students to reach the highest standard of intellectual achievement. As an academic institution with this purpose, the College expects students to give the highest priority to their academic responsibilities. When conflicts arise between academic commitments and complementary programs (including athletic, cultural, educational, and volunteer activities), students, faculty, staff, and administrators all share the responsibility of minimizing and resolving them.

As a student you have the responsibility to inform the faculty member of potential conflicts as soon as you are aware of them, and to discuss and work with the faculty member to identify alternative ways to fulfill your academic commitments without sacrificing the academic integrity and rigor of the course.

## Writing Center

Effective written communication is a cornerstone of the Wooster curriculum, from First-Year Seminar through Senior Independent Study. To assist students in growing as writers, the Writing Center offers a range of services at no cost, through professional staff and peer tutors. More information is on the [Writing Center website](#), and appointments are available at [writing\\_center@wooster.edu](mailto:writing_center@wooster.edu), or ext. 2205.

## The Learning Center: Academic Support and Disabilities

The Learning Center, which is in APEX (Gault library) offers a variety of academic support services, programs and 1:1 meetings available to all students. Popular areas of support include time management techniques, class preparation tips and test taking strategies. In addition, the Learning Center coordinates peer-tutoring for several academic departments. Students are encouraged to schedule an appointment.

An additional support that the Learning Center offers is English Language Learning. Students can receive instruction or support with English grammar, sentence structure, writing, reading comprehension, reading speed, vocabulary, listening comprehension, speaking fluency, pronunciation, and American culture through 1:1 meetings with the Learning Center staff, ELL Peer Tutoring, ELL Writing Studio courses, and other programming offered throughout the year.

The Learning Center also coordinates accommodations for students with diagnosed disabilities. At the beginning of the semester, students should contact the Learning Center to make arrangements for securing appropriate accommodations. Although the Learning Center will notify professors of students with documented disabilities and the approved accommodations, students are encouraged to speak with professors during the first week of each semester. If a student does not request accommodations or does not provide documentation to the Learning Center, faculty are under no obligation to provide accommodations.

## The College Libraries and the Research Help Desk

Your librarian for this course is [Zachary Sharrow](#). You can ask your librarian for help with research in this class and can make an appointment with them using the research consultation form for help with your research and information needs, including finding and using items we have in the Libraries; learning expert tips to refine your search for articles in magazines, journals, and newspapers; making an appointment with a librarian for help on a project; and learning how to evaluate the information

you discover.

## Well-being at Wooster

The College of Wooster is committed to supporting the well-being of our students. During the course of their academic careers, students experience challenges that contribute to barriers in learning and can interfere with daily life, including but not limited to: strained relationships, adjusting to a new environment, chronic worrying, persistent sadness or loss of interest in enjoyable activities, family conflict, grief and loss, domestic violence, unwanted sexual experiences, difficulty concentrating, drug/alcohol problems, significant changes in eating and sleeping patterns, microaggressions, challenges with organization, procrastination and/or lack of motivation. Counseling Services at the Longbrake Student Wellness Center is a free and confidential resource providing short-term counseling and connections to community agencies for students needing longer term or specialized resources. You can make an appointment by calling 330.263.2319 between 8:30am-4:30pm during weekdays or by emailing Lori Stine ([lstine@wooster.edu](mailto:lstine@wooster.edu)). You can also find helpful resources on the Counseling Services website at <https://www.wooster.edu/offices/health/counseling/>.

If you or a friend is in crisis, please call Security and Protective Services at 330-287-3333 or the National Suicide Prevention Lifeline (1-800-273-TALK) or connect with the Crisis Text Line by Texting "4HOPE" to 741-741.

**For financial concerns:** Dean of Students Office, [dos@wooster.edu](mailto:dos@wooster.edu) (330) 263-2545, [DoS website](#)

**For safety concerns:** Campus Security and Protective Services (330)263-2590 or [cw-security@wooster.edu](mailto:cw-security@wooster.edu), [SPS website](#). **In the care of an emergency, call: 330-287-3333.**

## Title IX Reporting Policy

The College of Wooster is committed to fostering a campus community based on respect and nonviolence. To this end, we recognize that all Wooster community members are responsible for ensuring that our community is free from discrimination, gender bias, sexual harassment, and sexual assault. In accordance with Title IX, Wooster is legally obligated to investigate incidents of sexual harassment and sexual assault that occur on our campus. Faculty who become aware of an incident of sexual violence, including harassment, rape, sexual assault, relationship violence, or stalking, are mandated reporters at the College and are required to notify Wooster's Title IX Coordinator. The purpose of this disclosure is to ensure that students are made aware of their reporting options and resources for support. For more information about your rights and reporting options at Wooster, including confidential and anonymous reporting options, please visit <http://www.wooster.edu/offices/title-ix/>.

## Discriminatory or Bias-Related Harassment Reporting Policy

The College of Wooster is committed to promoting its mission of inclusivity and equity in all aspects of the educational enterprise. This commitment extends to all rights, privileges, programs and activities, including housing, employment, admissions, financial assistance, and educational and athletic programs at the College. The College's Bias Incident Reporting Process is designed to effectively respond to bias concerns raised by faculty, students, staff, alumni and visitors to the College. If you or someone you know are the victims of bias, you can:

- [File a report online](#) (where you may choose to identify yourself or not)
- Contact Security and Protective Services: 2590 (from campus phone) or 330-263-2590
- Call the Anonymous Tip Line: 2337 (from campus phone) or 330-263-2337
- Contact the Dean of Students Office: 2545 (from a campus phone) or 330-263-2545
- Contact the Chief Diversity, Equity, and Inclusion Officer, Dr. Ivonne M. García, 2167 (from campus phone) or 330-263-2167 or email at [igarcia@wooster.edu](mailto:igarcia@wooster.edu).

## Syllabus Changes

I reserve the right to make changes to this syllabus, if needed. Any changes will be announced to the class in a timely manner. You can find a preliminary outline of the topics that we hope to cover in this course in the next page. This is an idealized plan, and it *may be adjusted as the semester progresses*.

Week	Monday	Wednesday	Friday
1		19-Aug Syllabus + Modeling Experiment	21-Aug Differential Equations and Modeling
2	24-Aug Definitions and Terminology	26-Aug Separation of Variables, EUT	28-Aug Slope Field + Phase Line
3	31-Aug Using DFIELD + Euler's Method	2-Sep Integrating Factor	4-Sep Mixing Problem + <b>Take-home Quiz 1</b>
4	7-Sep RC-circuit + Using ODE45	9-Sep Bifurcation	11-Sep Drawing a Bifurcation Diagram
5	14-Sep <b>Project 1 (The Spruce Budworm)</b>	16-Sep <b>Project 1 Contd. (Hysteresis)</b>	18-Sep System of First Order ODEs + <b>Take-home Quiz 2</b>
6	21-Sep Phase Plane and Nullcline	23-Sep Lotka-Volterra Model (Basic and Modified) + Using PPLANE	25-Sep Linear Systems - Matrix basics, The Linearity Principle
7	28-Sep Eigenvalue and Eigenvectors	30-Sep Straight Line Solutions - Two Distinct Real Eigenvalues	2-Oct Complex Eigenvalues
8	5-Oct Trace-Determinant Plane - Degenerate and Defective Cases + <b>Take-home Quiz 3</b>	7-Oct <b>Fall Break</b>	9-Oct Bifurcation in 2D
9	12-Oct <b>Project 2 (Higher Dim)</b>	14-Oct <b>Project 2 (Higher Dim)</b>	16-Oct Second Order Linear ODEs, Harmonic Oscillators
10	19-Oct Method of Undetermined Coefficients	21-Oct Forced Harmonic Oscillation, Resonance	23-Oct <b>Project 3 (Double Mass-Spring) + Take-home Quiz 4</b>
11	26-Oct Multivariable Calculus Basics - Tangent Plane and Jacobian	28-Oct Equilibrium Point Analysis	30-Oct <b>Project 4 (Nonlinear Pendulum)</b>
12	SIR Disease Models	<b>Project 5 (An approximate SIR model of COVID- 19)</b>	<b>Project 5 contd.</b>
13	9-Nov Almost Linear Systems	11-Nov Poincare-Bendixson Theorem and Hopf Bifurcation	13-Nov <b>Project 6 (Glycolytic Oscillation)</b>
14	16-Nov Finite Discrete Methods	18-Nov Discrete Logistic Map - Bifurcation and Chaos	20-Nov <b>Take-home Quiz 5</b>
15	23-Nov Lorenz Map and Chaos	Review	



**Part III**

**Bowdoin College**

# LINEAR ALGEBRA

## MATHEMATICS 2000-B

Spring 2019

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<b>Instructor:</b>	Subhadip Chowdhury	<b>Email:</b>	<a href="mailto:schowdhu@bowdoin.edu">schowdhu@bowdoin.edu</a>
<b>Office Location:</b>	Searles 103	<b>Office Phone:</b>	(207) 725-3572
<b>Class Sessions:</b>	MWF 11:45–12:40	<b>Classroom:</b>	Searles 213

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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.

### 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 discussion.

### Prerequisites

In order to be considered for admission into Math 2000 you must either have

1. completed Bowdoin's Math 1800, or
2. been given a mathematics placement of Math 2000 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 2000.

### Textbooks and Supplies

- *Linear Algebra and Its Applications*, 5<sup>th</sup> edition, by David C. Lay.
- *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.

### Course Description

At the heart of Linear Algebra is an interplay between linear equations, matrix algebra, and geometry. It has a broad range of applications within the sciences and other areas of mathematics, from geometry and computer graphics to differential equations and the dynamics of populations.

Linear Algebra begins with the study of systems of linear equations and their solutions. These systems can be viewed geometrically as vector equations, and alternatively as matrix equations. A major goal of the course will be to understand long-term behavior of linear systems over time, through the techniques of eigenvectors and eigenvalues of matrices. We will also learn how inner products allow us to find the closest approximate solution to equations for which no exact solution exists.

### The MCSR Distribution Requirement

Math 2000 can be used to satisfy Bowdoin's Mathematical, Computational, or Statistical Reasoning (MCSR) distribution requirement, through the development of the mathematical tools of linear equations, vectors, and matrices, and also through the application of such techniques to linear models in science and engineering.

### 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.
- **Daily 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 linear algebra 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.

- There will be five or six longer **Extra Credit Collaborative Projects** built around more challenging questions from the exercises, to showcase interesting applications of the study materials. Electronic copies of the assignment details will be available on Blackboard. These will be due typically within seven to ten days.
- we will use some of the class 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 Friday class 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:

Assignments .....	20%
Quizzes, class work and class participation .....	15%
Midterm 1 .....	15%
Midterm 2 .....	20%
Final exam .....	30%
Extra Credit Projects .....	10%

### Important Dates

Midterm # 1 .....	Friday, February 22, 2019
Midterm # 2 .....	Friday, April 12, 2019
Final Exam .....	Friday, May 17, 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 are encouraged to work on the **daily 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. Assignments will need to be submitted to me personally at the beginning of the classes.
- You are allowed to work in groups of size **at most 3 (three)** to work on the **extra credit collaborative projects**. 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. *One submission for your entire group will suffice.*
- The point of the homeworks 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.
- 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.

### Advice on Collaborative Learning

Collaborative learning teams are said to attain higher level thinking and preserve information for longer times than students working individually. You are strongly encouraged to work together, both in-class and on homeworks, throughout this course. 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 receive your submission, you can put it in the Math 2000-B homework box located at the South end of Searles' first floor hallway.
- I will drop two of your lowest *daily assignment* 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.

### Class 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. Whenever possible, there will be opportunities for you to work through practice problems in small groups during our class meetings. This is a chance for you to learn in an active way, collaborating with your peers. 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.

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

### The Honor Code

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.



Monday	Wednesday	Friday
	23-Jan	25-Jan
	Syllabus Overview + System of Linear Equation (1.1)	Matrices, Elem Row Operation, Reduced Echelon Form (1.1-1.2)
28-Jan	30-Jan	1-Feb
Consistent Matrices, Homogeneous Matrices (1.2, 1.5)	Matrix Operations (2.1) + <b>Adjacency Matrix of a Graph</b>	Properties of Matrix Operations (2.1 cont., 1.4)
4-Feb	6-Feb	8-Feb
<b>Handout 1</b>	Scalar Product, Norm, Linear Independence (1.3,1.7)	More on Linear Independence (1.7 cont.)
11-Feb	13-Feb	15-Feb
<b>Handout 2</b>	Matrix Inverses (2.2) + <b>Cryptography</b>	Inverse Matrix cont. and Determinants (2.3,3.1)
18-Feb	20-Feb	22-Feb
<b>Handout 3</b>	<b>Review</b>	<b>Midterm 1</b>
25-Feb	27-Feb	1-Mar
Elementary Operations and Determinants (3.2)	Vector Space (4.1)	Null Space and Range (4.2) + <b>Subspaces</b>
4-Mar	6-Mar	8-Mar
Computing $N(A)$ and $R(A)$ (4.2 cont.)	Spanning Subset and Bases (4.3)	<b>Handout 4</b>
11-Mar	13-Mar	15-Mar
<b>Spring Vacation</b>		
18-Mar	20-Mar	22-Mar
<b>Spring Vacation</b>		
25-Mar	27-Mar	29-Mar
Bases cont. and Dimension (4.5)	Rank and Orthogonal Bases (4.6)	Orthogonal and Orthonormal Sets, Gram-Schmidt Process (6.1-6.4)
1-Apr	3-Apr	5-Apr
<b>Handout 5 + Orthogonal Projection and Least Squares</b>	Linear Transformations (1.8,4.4) + <b>Lin. Transf. of the Plane</b>	Linear Transformation cont. (4.7)
8-Apr	10-Apr	12-Apr
<b>Handout 6</b>	<b>Review</b>	<b>Midterm 2</b>
15-Apr	17-Apr	19-Apr
Eigenvalues and Eigenvectors (5.1)	Characteristic Polynomials (5.2)	Complex Eigenvalues and Similar Matrices (5.5)
22-Apr	24-Apr	26-Apr
<b>Handout 7</b>	Diagonalization (5.3)	Eigenvectors and Linear Transformations (5.4)
29-Apr	1-May	3-May
Discrete Dynamical System (5.6) + <b>Spotted Owl Population</b>	<b>Handout 8</b>	Diagonalization of Symmetric Matrices (7.1)
6-May	8-May	9-May
<b>Handout 9</b>	<b>Review</b>	<b>Reading Period</b>