












Differential Equations

Math 221


Instructor Info —

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



Course Info —

-  **Prereq:** Math 112 and CSCI 100 or equivalent
-  Mon, Wed & Fri
-  2:15p-3:05p
-  TBA + Microsoft 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 analyze 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 you derive a model, pick the right tool to analyze it (not all tools work on every model), and then interpret that result in the context of the real world phenomena.

Life Long Skills: Your abilities of general problem solving skills, self learning, self evaluation and how to formulate ideas and solutions will be refined throughout the course. This means problems appearing on homework or tests will not “be just like problems” you have seen before. You might be asked to explore new topics yourself before I cover them in class. Finally, how you present your solutions will also be evaluated.

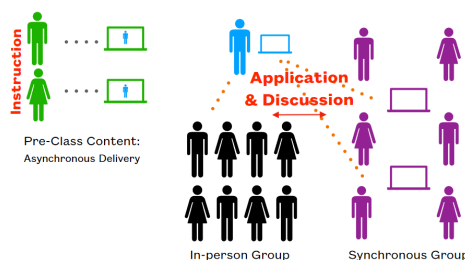
Grading Scheme

Projects	40%
Take-home Tests	30%
Final Exam	15%
Pre-class Quizzes	5%
In-class Participation	10%













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.

? I can't run DFIELD or PPLANE.

- ! You may need [Java Runtime environment](#) to run these on your computer.

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

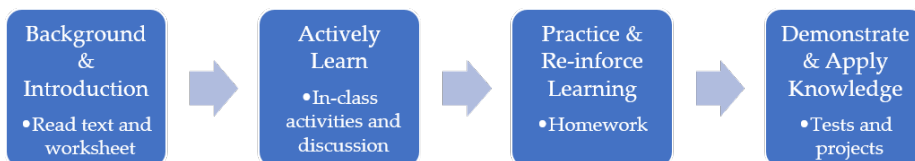
- ! In general, late submission (even 15 mins late) will NOT be accepted and will result in a grade of zero for the test. If any conflict arises with any of the test dates, please let me know as soon as possible, and you can take the test early. Missed exams can only be made up at my discretion, and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

? Do I have to attend all classes synchronously?

- ! Although attendance is not directly part of your grade, you are expected to attend the lectures synchronously if you are on-campus. If you are taking this class remotely, you should also try to stick to the 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 activity.

- **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.
- **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 IT with any technical issues, and we will try to help.
- **Empathy (See details [here](#)):** This has been a tough few months for all of us, for many 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 activity 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 to work on the day's activity (e.g. use Python) 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 as necessary).
- Participate fully in each class by reading and watching videos on the assigned sections 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 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.
- 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 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.
- 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. Office Hour meetings will not be recorded.
- 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.

- To address privacy concerns, you will only be able to stream recorded sessions online, you will not be able to download it.
- 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.

We're All Human

- **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 lectures... 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.

- **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.

Diversity and Inclusion Statement

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.

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.

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 he or she 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.

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 the rules of the institution as described in The Scot's Key and the Handbook of Selected College Policies.

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.

To learn more about the College's expectations for academic integrity in student research and writing endeavors, or to learn about available modules and quizzes designed to help students learn about plagiarism, citation, and the proper incorporation of source material into research essays, please contact the office of the Dean for Curriculum and Academic Engagement.

The Wooster Ethic

"I hereby join this community with a commitment to the Wooster Ethic upholding academic and personal integrity and a culture of honesty and trust in all my academic endeavors, social interactions, and official business of the College. I will submit only my own original work, and respect others and their property. I will not support by my actions or inactions the dishonest acts of others."

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, or ext. 2205.

The Learning Center - APEX

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 at the APEX front desk or visit the Learning Center Website for additional options.

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. Students seeking ELL support are encouraged to visit the APEX front desk.

The Learning Center also coordinates accommodations for students with diagnosed disabilities. At the beginning of the semester, students should contact the Learning Center (ext. 2595) 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.

Wellness

As a student, you may experience a range of issues that can cause barriers to learning. Do your best to maintain a healthy lifestyle, and do not hesitate to seek support during times of struggle. There are many helpful resources available on campus, and an important part of being a successful college student is learning how to ask for help.

- The Longbrake Student Wellness Center offers confidential counseling services and has a counselor on call 24/7 for emergencies. Call 330-263-2319 to reach a staff member or schedule an appointment. You can view additional services online at the Counseling Services webpage.
- For financial concerns, I encourage you to reach out to the Dean of Students office at 330-263-2545.
- For safety concerns, you can reach Campus Security and Protective Services at 330-263-2590.
- YOU@WOO organizes many of these campus resources; visit <https://you.wooster.edu> to get started.

Title IX

The College of Wooster and its faculty are committed to ensuring a safe and productive educational environment for all students. In order to meet this commitment and to comply with Title IX of the Education Amendments of 1972 and guidance from the Office for Civil Rights, the College has developed policies and procedures which prohibit discrimination, sexual harassment/misconduct, and retaliation. Any member of the College community (faculty, staff, students, visitors, and third party vendors) who believes that they have been a victim of sexual harassment/misconduct, domestic violence, dating violence, bullying, cyber-bullying, stalking and/or gender-based discrimination is encouraged to file a report with the College's Title IX Coordinator (Lori Makin-Byrd - lmakin-byrd@wooster.edu; 330-263-2017). Reports can be filed in person, via email, or online at <http://wooster.edu/offices/title-ix/>.

In order to ensure student safety and address the well-being of students, the College requires all employees, including faculty members, to report incidents of sexual and gender-based violence shared with them by students to the College's Title IX Coordinator. Exceptions are situations where students are unlikely to expect that a disclosure would trigger a reporting obligation such as in a class writing assignment. A faculty member reporting to the Title IX Coordinator does NOT mean that the student will be obligated to participate in any formal proceedings; that decision remains at the discretion of the student unless the information indicates that one or more students are at risk of further harassment. Information regarding the College's non-discrimination policy (including bias-related harassment), sexual assault/sexual misconduct, Title IX, and filing a report can be found at <http://wooster.edu/offices/title-ix/>.

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 1.1 Definitions and Terminology
2	24-Aug 2.3 Separation of Variables, EUT	26-Aug 2.1 Slope Field + Phase Line	28-Aug Using DFIELD + Euler's Method
3	31-Aug Practice Worksheet	2-Sep 2.3 Integrating Factor	4-Sep Mixing Problem + Take-home Quiz 1
4	7-Sep RC-circuit + Using ODE45	9-Sep Bifurcation	11-Sep Bifurcation Diagram using Python
5	14-Sep Project 1 (The Spruce Budworm)	16-Sep Project 1 Contd. (Hysteresis)	18-Sep System of First Order ODEs + Take-home Quiz 2
6	21-Sep Nullcline and Direction Field	23-Sep Lotka-Volterra Model (Basic + Modified)	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 + Using PPLANE
8	5-Oct Trace-Determinant Plane - Degenerate and Defective Cases + Take-home Quiz 3	7-Oct Fall Break	9-Oct Bifurcation in 2D
9	12-Oct Project 2 (Higher Dim)	14-Oct Project 2 (Higher Dim)	16-Oct Second Order Linear ODEs, Harmonic Oscillators
10	19-Oct Method of Undetermined Coefficients	21-Oct Forced Harmonic Oscillation, Resonance	23-Oct Project 3 (Double Mass-Spring) + Take-home Quiz 4
11	26-Oct Multivariable Calculus Basics	28-Oct Equilibrium Point Analysis	30-Oct Project 4 (Nonlinear Pendulum)
12	SIR Disease Models	Project 5 (An approximate SIR model of COVID-19)	Project 5 contd.
13	9-Nov Almost Linear Systems	11-Nov Project 6 (Glycolytic Oscillation)	13-Nov Poincare-Bendixson Theorem and Hopf Bifurcation
14	16-Nov Finite Discrete Methods	18-Nov Discrete Logistic Map - Bifurcation and Chaos	20-Nov Take-home Quiz 5
15	23-Nov Lorenz Map and Chaos	Review	