TEACHING PORTFOLIO

KEATON QUINN

This document serves as a overview of my teaching effectiveness. It contains the following information.

- A summary of my teaching evaluations. These are the averages of students responses to prompts on official end-of-semester surveys from my time at Wellesley College, Boston College, and the University of Illinois Chicago.

- Selected student quotes from official end-of-semester surveys about my teaching, ranging from 2018 to 2025.

- A report from a visit of my Calculus 2 class at Wellesley College this Fall 2025 semester. It provides a summary of the events during the lecture observed, along with the thoughts of the author on my teaching style and notes on our follow-up conversation.

- A syllabus from my Spring 2025 Calculus 1 course at Wellesley College in which I employed mastery-based grading. The syllabus demonstrates my implementation of the grading scheme, including how mastery was evaluated.

- A syllabus from my Fall 2023 Calculus 2 for math and science majors course at Boston College. It includes information on how I attempted to encourage participation and revision in a more typically run "3-midterms-and-a-final" type class.

- A lesson-planned lecture handout from my Fall 2024 Calculus 1 at Wellesley College. A document like this (without my comments and instructions) was provided to students at the beginning of each class, and lecture followed its content closely. Students were typically tasked with solving the examples during class, working alone and with those around them.

- An example written homework assignment from my Spring 2025 Calculus 2 course. These types of assignments were used to get students thinking more deeply about lecture topics. This particular one is an example of applications course content to economics, and to math itself. In addition there is a reflection question that aims to help them identify more with the mathematics community.

- An assessment from my Spring 2023 Linear Algebra course. This is an example of how mastery of course topics was tested. Student solutions were evaluated (essentially) credit / no credit, with earning credit an indication of mastery of a topic.

- A course calendar for my Fall 2024 Calculus 2 class at Wellesley College demonstrating my organization of a semester's class. This spreadsheet is linked to on the course's webpage. Several students have expressed their appreciation for its availability and detail.

The table below is a summary of my teaching evaluations from Fall 2024 and Spring 2025 at Wellesley College as a visiting lecturer. It contains the averages of scores from approximately 120 students from Calculus 1 and Calculus 2. These evaluations can be made available upon request.

Prompt	Average/3
Clarity, Responsiveness, and Feedback	2.75
Course Engagement	2.73
Inclusive Classroom Engagement	2.86

The following table is a summary of my teaching evaluations from Fall 2021 to Spring 2024 at Boston College as a visiting assistant professor. It contains the averages of scores from approximately 420 students from Calculus 1 for life science majors, Calculus 2 for math/science majors, Calculus 2 for life science majors, Linear Algebra, and Differential Geometry. These evaluations can be made available upon request.

Prompt	Average/5
The instructor was effective in helping students understand difficult concepts, methods, and subject matter.	4.46
The instructor was available for help outside of class.	4.58
The instructor stimulated interest in the subject matter.	4.28
The instructor motivated me to do my best work.	4.31
How would you rate this instructor overall as a teacher?	4.25
I received timely feedback on my assignments and assessments.	4.56
I received meaningful feedback on my assignments and assessments.	4.37

The next table is a summary of teaching evaluations from Fall 2015 to Fall 2019 at the University of Illinois at Chicago as a graduate student teaching assistant and instructor of record. It contains the averages of scores from approximately 100 students. Courses include the Emerging Scholars Program workshops for Calculus 1,2, and 3, and Introduction to Advanced Mathematics (introduction to proofs). These evaluations can be made available upon request.

Prompt	Average/5
Rate the instructor's overall teaching effectiveness.	4.66
The instructor was sensitive to the cultural/human diversity, diverse worldviews, learning disability, and/or physical disability of the students.	4.73
Instructor was enthusiastic about coordinating the course.	4.61
Instructor's style of presentations held your interest during the course.	4.62
Students were encouraged to participate in class discussion.	4.75
Students were encouraged to ask questions and were given meaningful answers.	4.73
Instructor made students feel welcome in seeking help/advise in or outside the class.	4.72

The following selected quotes are from anonymous students on the same teaching evaluations and demonstrate their opinions regarding my style of teaching:

Prof. Quinn was extremely organized and clear. In class, I was always engaged, and understood each step as he wrote it out. The assignments each week were clear, relevant, and helpful practice. Each week I felt like I was learning more and more, but it never felt rushed, as it was always building upon something we had done previously. I also was able to interact with peers through his group work assignments, which strengthened the camaraderie in the classroom as well as my own understanding of topics through explaining them to others in my group who were struggling (and conversely, my peers explaining them to me). Prof. Quinn's endless availability and clear communication meant I never hesitated to ask for help or attend office hours. I will truly miss having class with him!

– Calculus 2, Spring 2025, Wellesley College.

I loved the collaborative table-group-work we did on the white boards. In this class, I was actually able to explain the math I was doing to others! This proved very beneficial, as in turn, I was better able to understand the topics. I didn't just know/memorize formulas for example, I knew the "whys."

– Calculus 1, Spring 2025, Wellesley College.

I really liked how my professor went through a lot of examples on the board, as it helped me understand the process of getting to a solution for a particular type of problem, and it was super helpful to look back at if I was stuck on a homework assignment. I actually also liked the webwork assignments. At first I was mad that the webwork didn't tell me what I did wrong, but now I realize in doing that it forced me to go back to my notes, find an example, and really work through the concept, which I think was more beneficial for my understanding in the end. I also liked the written homework assignments, and how they would lead me through an exploration of sorts of a concept or apply the concept to real life. I really like those types of problems and I think they're kinda fun, and the written homework never took me more than and hour and a half to complete so it was a good length. I liked how the webworks hammered in the concept, and the written homework then applied that concept.

– Calculus 2, Fall 2024, Wellesley College.

The most valuable features of this course were the instructor's clear and structured approach to teaching and their use of diverse examples to illustrate key concepts. For instance, the step-by-step walkthroughs of complex problems during lectures provided a solid foundation for understanding and applying calculus principles. The regular problem sets were well-designed to reinforce the material, challenging enough to encourage critical thinking while still being manageable.

– Calculus 1, Fall 2024, Wellesley College.

"[The class] is extremely organized and all the assignments help contribute to an understanding of the course objectives. Professor Quinn is phenomenal, and explained everything very clearly and in a way that showed that he cared about us truly understanding the material."

– Calculus 2 (Life science majors), Spring 2024, Boston College.

"The course was structured perfectly and the material was presented so the learner is both independent and also supported in a well–maintained balance facilitated by the professor."
– Calculus 2 (Life science majors), Spring 2024, Boston College.

"Professor Quinn is an incredibly warm, kind, and welcoming professor. He is probably the most caring of the math professors at BC. I can tell he has a genuine interest in the success of his students, and he wants to encourage and push us all to succeed. Although the class was very difficult, Professor Quinn welcomed constant questions during lectures and office hours. I really appreciate his sincerity and warm personality."
– Differential Geometry, Spring 2024, Boston College.

"[Quinn] is an extreme asset to the community. He pushes his students intellectually, does not take it easy on us, but is constantly there for support, and is just a kind person. ... [H]e is one of the strongest professors in the department."
– Differential Geometry, Spring 2024, Boston College.

"Professor Quinn was an excellent instructor, and made the class feel very welcoming. He created a respectful environment where everyone felt comfortable to ask questions and discuss the material with one another. He consistently asked us for feedback to make sure we fully understood concepts, and took it into great consideration when explaining course material. He motivated us to do our best work, while maintaining a friendly supportive classroom environment. Additionally, he was consistently available outside of class to help explain any concepts, and made the material very engaging during lectures."
– Linear Algebra, Spring 2023, Boston College.

"He ensured that everyone's opinion was well–respected and heard. He was very considerate of everyone's questions and it didn't matter how far or how slow you were in the class."
– Calculus 2 (Math/Science majors), Fall 2022, Boston College.

"I have always despised Math and have never been a fan of my math teachers, however, I really really enjoyed Professor Quinn's class because he made difficult concepts very simple and worked with students to make sure we understood what was being taught. He always checked in on the class to see if there were any questions and was always very open to taking questions at any time."
– Calculus 1 (Life science majors), Fall 2021, Boston College.

"[Quinn] was always very clear and willing to demonstrate on the board what was going on with our math problems. He was never impatient and would occasionally laugh with us creating an environment where we felt comfortable asking questions knowing he would always answer them and never shame us for not knowing. He was always attentive and fair. He knows plenty and was always able to elaborate on the material. He would write clearly on the board and draw pictures so we could better understand. He was great."
– Calculus 3, Emerging Scholars Workshop, Spring 2018, UIC.

Visit to Keaton Quinn's Fall 2025 Math 116 Class
by Oscar Fernandez, September 29, 2025

The Class. Before the class started, Keaton had already written up a few reminders on the board for students. These included due dates for the upcoming homeworks, "foundations check" dates (more on foundations checks below), and a reminder of his office hour time and location today. Students were chatting with each other in what felt like a relaxed atmosphere. There were 27 students present, sitting at tables in groups of 4.

Keaton began the class promptly at 11:20 am. He first asked students how they were doing and for a thumbs up/down response. He then reviewed the due dates he had written up earlier. Keaton also mentioned the upcoming foundations check reattempt. Foundations checks assess the core course content. Each foundations check can be reattempted one more time, providing students an opportunity to increase their grade (if they do better on the reattempt). Keaton reminded students of the growth mindset nature of this course structure and invited students to email him with requests to meet before the assessments. A few minutes later Keaton pivoted to the day's math lesson: power series. This began the portion of the class that works through the skeletal outline for the lesson.

Keaton's course is built around the skeletal outlines he prepares and distributes to students ahead of time. These skeletal outlines contain definitions, theorems, and examples, with white space strategically positioned to allow and encourage students to fill in the blanks with the concepts, example solutions, and other information Keaton works through during class. While working through these outlines in class he fields questions as they arise and adds helpful insights and perspectives on the content. The last 20 to 30 minutes of class are dedicated to group work on handouts Keaton distributes in class.

Keaton began the power series journey by writing up a mnemonic device—PLAN DR RIGHT—he uses to help students remember the many infinite series convergence and divergence tests. He then introduced the notion of a power series by writing up its definition and comparing/contrasting it to infinite series. (Throughout the class, Keaton divided the board with vertical lines to help keep his writing organized.) Keaton then explained how substituting x-values into a power series yields an infinite series which may converge or diverge. He then wrote up a power series,

$$\sum_{n=0}^{\infty} x^n = 1 + x + x^2 + \cdots,$$

and worked together with the class to investigate the convergence/divergence of the infinite series generated when $x = 1/2$ and $x = 5$. Keaton would pose questions to students ("What type of series did we get?") and students—different each time—would answer ("Geometric!"). After finishing this introductory power series work, Keaton asked: "Where are you confused?" Some students voiced questions; Keaton answered them. Keaton then spent the next 40 minutes working through three power series examples contained in his skeletal outlines,

$$\sum_{n=1}^{\infty} \frac{(x-3)^n}{n}, \qquad \sum_{n=0}^{\infty} \frac{x^n}{n!}, \qquad \sum_{n=0}^{\infty} n!(x-4)^n. \tag{1}$$

Keaton analyzed these series' convergence using the ratio test and then investigated the endpoint convergence via the PLAN DR RIGHT mnemonic and previously covered tests. Along the way, Keaton covered the theorem that formally establishes that the three convergence set outcomes encountered in the examples are the only possible ones for power series convergence. After the first example, Keaton took a break and told a few jokes. He then invited students to tell their own. (A few students did.) We all had some good laughs.

Keaton dedicated the last 30 minutes of class to group work. Students—most working at the boards—worked collaboratively to solve exercises on a handout Keaton passed out. Keaton circled the room, checking in with students and providing hints and clarifications as needed. Two minutes before the class session ended, Keaton used a clapping exercise ("If you can hear me, clap once. If you can hear me, clap twice.") to bring attention back to him for a few last announcements. Class ended promptly at 12:35.

Reflections on the Class. Keaton has clearly built a good rapport with his students. They feel comfortable asking him questions (and answering his questions)—by the end of the class all but 9 of the 27 students had contributed either a question or an answer—and also feel comfortable working with each other in class. These outcomes are natural results of Keaton's careful course planning. His skeletal outlines, for example, contain just the right amount of content to allow for group work time. And the examples he worked on for the day—the power series in (1)—were carefully chosen to illustrate the various possibilities that arise in power series convergence and allow students opportunities to reflect on their points of confusion and voice them. Furthermore, Keaton's method of soliciting questions also points to a deliberate attempt to spark conversation and engagement—Instead of asking, "Any questions?", Keaton's "Where are you confused?" reframe removes the stigma of voicing confusion.

In our follow-up conversation, Keaton shared that he reflects on what went well and what could be improved after each class, and uses these reflections to modify future lessons. This reflective practice contributes to the fine tuning he has done over time to his course structures, pacing, and student engagement techniques. Keaton has also masterfully built in the same reflective practice on the student side. His system of foundations checks—and their reattempt possibilities—encourages students to develop a growth mindset by incentivizing them to revisit previously assessed content and working to understand it better.

Suggestions for Improvement. During our follow-up meeting, Keaton and I discussed the balance between training students in computational techniques and teaching them the subject's theoretical underpinnings. This is a difficult balance to strike in calculus courses. Fortunately, Keaton is trying out a new ordering of topics in his course. Rather than starting with integration first, Keaton chose to begin with sequences first. A small minority of us (Keaton's colleagues) have tried this approach and found it successful. After discussions with those colleagues, Keaton decided to try out the new approach this semester. This route elongates the onramp to integration techniques—they are now not covered until about halfway into the semester—and also lowers the initial calculus prerequisites for students, since sequences and series require only proficiency with limits and some derivatives. (Students tend to be more comfortable with these topics than integration, especially given the open-ended nature of calculating antiderivatives.) This "sequences first" approach also furnishes a natural way to connect integration and sequences and series—by couching integration as a natural extension of infinite and power series ideas. (The intermediary here are equipartition Riemann *sums*, whose *infinite* limit yields the *definite integral*, under appropriate circumstances.) Herein lies my suggestion for improvement: make this coming connection more explicit in the course and in the pre-integration lessons. Calculus 2 has a reputation for being a hodgepoge of myriad convergence tests and integration techniques that have little to no connection to each other. However, by taking a sequences first approach, Keaton has already laid the foundation for previewing—and emphasizing—the natural connection between the course's two main topics (integration and infinite series).[i] Making these points and connections explicit will help further engage students, pro-

[i]Mathematicians are well aware of this deep connection—in real analysis, the Integrability Criterion (which gives conditions for a function's integrability) reframes integration in terms of sequences of partitions of an interval. This in part explains why many real analysis courses begin with discussions of sequences and series first, paralleling the topics ordering Keaton has chosen for his course this semester.

vide a strong reason to care about all those series tests and integration techniques covered in the course, and furnish a meaningful theoretical overlay that bookends the entire course and its main results.

Final Comments. Keaton arrived at Wellesley already an experienced educator and a student-centered teacher. Through his receptiveness to feedback, willingness to try new things, and desire to improve, Keaton has leveraged his own growth mindset to tweak his course structures and learning experiences to improve student engagement, outcomes, and belonging. His efforts have clearly paid off. Keaton's students are engaged and enjoy working with him and their classmates; his course structures foster learning while building in opportunities for reflection and growth through setbacks; and his pacing and organization allow plenty of group work and just-in-time teaching time to help struggling students. Altogether, Keaton has succeeded in creating a learning community centered around collaboration and connection, an atmosphere in which students enjoy doing mathematics with him and their peers, and a course that reframes knowledge gaps as growth opportunities, and celebrates and rewards improvement.

MATH 115 Section 02
Calculus I
Spring 2025 Syllabus

1. Course Information

Contact Information. Keaton Quinn (he/him), kq101@wellesley.edu, in Science Center E434.

Course Webpage. Class material will be posted to the learning management system Sakai. You will be automatically added to the page, which you can access here

https://sakai.wellesley.edu/portal/site/202502-20338

Any lecture notes and links to homework assignments will be posted there. In addition, scores will be periodically synced to Sakai's grade book.

Prerequisites. Students are expected to have a working understanding of standard, high school-level algebra and trigonometry. However, we will devote class time to reviewing these topics.

Textbook. We will use *Calculus Simplified* by Fernandez. The textbook is not required for the course but it is recommended. The library has copies on reserve or the bookstore has copies for purchase. A pdf will be posted to Sakai for you to use. Sections of the text will be listed in the course calendar when they are relevant.

Office Hours. These are drop-in hours you can attend to get questions answered without needing to schedule ahead of time. Times will be announced later and posted to the course webpage. If you cannot make these times, or would prefer to talk privately, you can email me to set up a meeting. There is a chance some will be moved remotely to Zoom. You may be asked to wear a mask while attending in-person office hours. Please note that while I am happy to help you, these are not the place to start working on problems. You should arrive with specific questions on things you have already attempted, or on class material.

We also have a tutor available to help you with the course. More information will be provided on their availability as the semester starts.

Semester Goals. Student learning goals for the semester include

- Understand foundational function vocabulary (domain, range, interval, input/output/function value, graph of a function).
- Understand the point of limits and compute them graphically and algebraically.
- Learn the notion of the derivative, compute the derivative of functions, and interpret the derivative in context.

- Use the derivative to answer questions about a function.
  - Process and complete related rates problems
  - Find extrema
  - Sketch graphs
  - Process and complete optimization problems
- Understand that area can be computed using a limit process similar to differentiation.

In addition to the above, broader goals for the semester are improvement in the following areas.

- Problem solving skills, computational skills, mathematical explanations, algebraic and geometric reasoning.
- Organization, communication, collaboration, perseverance, and resilience.

Information For Success.

- This course is expected to take (on average) at least 12 hours per week to complete.
- Actively attend and participate in all the classes.
- Make it Daily. You will do much better if you work the course almost every day (even if only for a short time) rather than if you try to do the homework right before the deadline. Learning math is much like learning to play an instrument, or training for a sport: you need to get on a schedule where you do it every day, not just once a week in a marathon session.
- Come to the drop-in office hours. When you have questions, come see me. Don't wait if you feel like you are struggling with the course or a topic.
- Work alone and work with others. Try starting homework on your own, then discuss problems with peers. Talking about math with others is one of the best ways to strengthen your learning and have fun in the process.
- Be patient - doing math can be hard. Someone once said "Those who don't think math is hard haven't been doing math long enough." Part of learning problem-solving skills is a lot of getting stuck and false starts. This doesn't mean you're doing anything wrong, but it helps to try again and talk it out. Don't wait until the last minute to do homework, give yourself time to get stuck and ask for help.
- Be Communicative. Instructors make our email addresses available for a reason. If you miss a class or an assignment deadline, find yourself generally falling behind, suffer or anticipate a personal crisis, or have general concerns about the class or your performance in it, we will do our best to find ways to help within the course policies. No problem is too small, since small problems tend to pile up quickly and are easier to address.

Academic Honesty. Use of large language models (ChatGPT, Gemini, etc.) is prohibited in this class. Make sure your work is your own. There is a major difference between working together to share ideas and letting someone else do the work for you, or doing someone else's work. If you need the other person, or their work, to be in the room with you for you to do your write-up, you are probably copying. Academic honesty is essential and cases of cheating will be taken seriously. University procedures will be followed for any infractions. See the following link for details.

https://www.wellesley.edu/about-us/policies-procedures/honor-code/procedures

Accommodations. If you are a student with a documented disability seeking reasonable accommodations in this course please contact Accessibility and Disability Resources (ADR) to get a letter outlining your accommodation needs, and submit that letter to me. You should request accommodations as early as possible in the semester, or before the semester begins, since some situations can require significant time for review and accommodation design. If you need immediate accommodations, please arrange to meet with me as soon as possible. If you are unsure but suspect you may have an undocumented need for accommodations, you are encouraged to contact (ADR). They can provide assistance including screening and referral for assessments. Disability Services can be reached at accessibility@wellesley.edu, at 781-283-2434, by scheduling an appointment online at their website, https://www.wellesley.edu/adr or by visiting their offices on the 3rd floor of Clapp Library, rooms 316 and 315.

2. Course Structure

Attendance. Attendance will be recorded during most lectures. To receive attendance credit for the day you must be present when attendance is taken, usually at the start of the class period. Your overall attendance grade will be calculated out of 90%. If you miss a lecture, you should solicit notes from someone who was in attendance.

Online Homework. Problem sets will be assigned (roughly) daily and due in one or two class periods. They will be online using WeBWorK, which must be accessed from a campus wifi network (not eduroam), or else through Wellesley's VPN. These problems will typically be routine, straightforward problems that test understanding of the material. Your two lowest scoring problem sets will be dropped.

Written Homework. There will also be weekly written homework assignments consisting of 2 to 5 more challenging problems, typically due Fridays at 11:59pm. Your solutions must be scanned and uploaded to Gradescope. If you are having trouble with the homework problems, I'm available for assistance and hints. Late homework will generally not be accepted. You are encouraged to discuss problems with others, but your write up/submission should be your own. Homework will be graded using the following rubric.

	Completeness	Work / Explanation	Correctness
Correct	All parts completed with adequate detail and...	Work is shown/thinking is clearly expressed and explanations are given, when asked, and...	All correct, except 1-2 minor errors (mistakes in calculation or simplification).
Proficient	Most parts completed with adequate detail, and...	Work is shown, though thinking may not be explained clearly. Explanations given when asked, but...	There are more than 2 minor errors or 1 major error (misinterpretation of a question or lack of understanding of a concept from class).
Partly Correct	Several parts not completed or missing adequate detail, or...	Most work not shown or little attempt to explain ideas. Explanations not given, or...	Mostly complete but many major and minor errors.
Attempted	Most parts not attempted, or...		Almost all work incorrect or left significantly incomplete.

Assessments. Semester assessments are split into three types: There are 4 Foundations Checks, there is 1 Synthesis Check, and 1 Final Exam.

The Foundations Checks are designed to test your understanding of the foundations of the material. For example, these may ask you questions on the definitions and results from lecture. They may test your ability to implement procedures or techniques for computing limits, derivatives, and integrals. These will be graded using a mastery system described below, with the opportunity for reattempts.

The Synthesis Check is taking the place of a standard midterm. This assessment will test your ability to apply the concepts from lecture. You may be asked to use results or techniques from class to answer questions about functions in context. Questions will typically be word problems broken into multiple parts. Grading will be using a traditional points based system, and no reattempting will be offered.

The Final Exam has part of its role being a second synthesis check for material in the later half of the semester. However, it is still a cumulative assessment. Grading will be using a traditional points based system, and no reattempting will be offered.

You are only allowed to make-up a missed assessment for a serious reason. If you must miss one, please clear it with me beforehand. The Foundations checks and the Synthesis check will be held during normal class meeting times. On the Synthesis Check and Final Exam you are allowed to use one 8.5" by 11" sheet of paper containing your *handwritten* notes (on both sides). Use of notes is *not* allowed on the Foundations Checks. Calculators, textbooks, the internet, etc. will *not* be allowed on assessments.

The dates of each are the following.

- Foundations Check 1: Friday, February 7
- Foundations Check 2: Friday, February 28
- Synthesis Check: Tuesday, March 11
- Foundations Check 3: Friday, April 4
- Foundations Check 4: Tuesday, April 22
- Final exam: Self-scheduled

Foundations Checks Grading and Reattempts. Each problem on each Foundations Check will be graded using the following mastery system.

M	1 point	Mastery	The work is perfect, communication is clear and complete. Mastery of the concepts is evident. There are no non-trivial errors.
E	0.9 points	Excellent	A nearly perfect solution that has very minor mistakes or inaccuracies. Understanding of the concepts is evident through clear, audience appropriate explanations.
P	0.8 points	Progressing	A solution that has more than minor mistakes, but no significant gaps or errors are present. Some revision or expansion may be needed.
R	0 points	Revision Needed	Partial understanding of the concepts is evident, but significant gaps remain. Needs further work, more review, and/or improved explanations.
N	0 points	Not Assessable	Not enough information is present in the work to determine whether there is understanding of the concepts. The work is fragmentary or contains significant omissions.

The tradeoff to this tight grading scheme is that you will have the opportunity to reattempt the questions on each Foundations Check (FC). Reattempting will happen in a rolling fashion. Each Check will be designed to take half of the 75 minute period. During the class period of FC2, you will be presented with the new questions as well as a revised copy of FC1. You should answer the new questions and may also answer any of the revised questions for which you did not receive a mastery score. Revised questions from the first check will *not* be offered during FC3, but revised questions from the second check will be. Similarly, revised questions from the first or second check will not be offered during FC4, but revised questions from the third check will be. There will be a day near the end of the semester (TBA) during which you can reattempt revised questions from the fourth check.

A reattempt will never lower your original score. There is only the possibility increasing

	Feb 7	Feb 28	April 4	April 22	TBA
FC1	×	×			
FC2		×	×		
FC3			×	×	
FC4				×	×

The above table indicates on what dates you will be able attempt material from the Foundations Checks

Semester grades. The weighting scheme below will be used to determine your course grade at the end of the semester.

Attendance	4%
Written Homework	10%
Online Homework	16%
Foundations Checks	30%
Synthesis Check	15%
Final Exam	25%

No extra credit will be offered. No special accommodations will be given to any student except those specified by Accessibility and Disability Resources (ADR). However, in situations of long-term illness, disability, or family emergency, an alternate assessment plan may be offered. You must reach out to your instructor who will evaluate the situation (in cooperation with the dean's office if need be).

Acknowledgments

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MATH 1103-06,07 Calculus II
Fall 2023, Stokes Hall 195S
Prof. Keaton Quinn
keaton.quinn@bc.edu

Calculus has a rich history, contains interesting mathematics, and has many applications. In this class we will explore all of these. We will cover the Riemann integral, integration techniques and applications, sequences and series, and power and Taylor series.

For questions about correct course placement, talk to me or see advice at
https://www.bc.edu/bc-web/schools/mcas/department s/math/undergraduate/about-calculus.html

Textbook: We will use Single Variable Calculus, Early Transcendentals, by Stewart, Clegg, and Watson. The textbook is not required for the course but it is recommended. The BC library has copies on reserve or the BC Bookstore has hard copies in loose leaf format as well as digital copies for purchase, or you can order through Cengage. We'll cover most of chapters 5, 6, 7, and 11.

Office Hours: Monday 3:00 - 4:00 pm, Wednesday 2:00 - 3:00 pm, Friday 9:00 - 10:00 am, or by appointment. They will be held in my office, Maloney Hall 575, until further notice. There is a chance some will be moved remotely to Zoom. You may be asked to wear a mask while attending in-person office hours.

Discussion: Our TA, Sophia Fanelle (fanelle@bc.edu), will run the discussion sessions. Attendance at discussions is mandatory.

Homework: Problem sets will be assigned (roughly) daily and due in one or two class periods. They will be online using WeBWorK. These problems will typically be routine, straightforward problems that test basic understanding of the material.

There will also be weekly written homework assignments consisting of 1 or 2 more challenging problems. Your solutions must be scanned and uploaded to gradescope. If you are having trouble with the homework problems, I'm available for assistance and hints. Late homework will generally not be accepted. You are encouraged to discuss problems with others, but your write up/submission should be your own.

Attendance: Attendance in class will be recorded via responses to in-class polls taken via Poll Everywhere. To receive attendance on a given day, you must answer at least one poll given on that day. Note: you do not need to answer the polls correctly to be considered present. Your overall attendance grade will be calculated out of 90%.

Participation: Participation is measured via contributions to the class discussion board. We are using Ed Discussion for this service. Asking a question on the board earns you 1 point and answering another student's question (correctly) earns you 2. Your participation grade is computed out of 20 points. You must also have posted one question and one answer by the third week of class. You are able to ask your questions anonymously to classmates, if you wish. However, I will still be able to see the original poster. Your response to another student's question cannot be just the explicit answer. For example instead of responding to

"What is the solution to $x^2 - 5x + 6 = 0$*?"*

with *"$x = 2$ and 3"*, instead respond with

"Try factoring the polynomial. Then you can set each term equal to zero and solve each piece for x".

Exams: There will be 3 midterm exams and a cumulative final. You are only allowed to make-up a missed exam for a serious reason. If you must miss one, please clear it with me beforehand. Exams will be held during normal class meeting times. Calculators, notes, textbooks, the internet, etc. will *not* be allowed on exams.

The **midterm** and **final dates** are

- Midterm 1: Monday, September 25
- Midterm 2: Monday, October 23
- Midterm 3: Monday, November 13
- Final exam: Section 06 Wednesday, December 13 at 9:00 am
Section 07 Saturday, December 16 at 9:00 am.

Semester grades will be based on

Participation	2%
Attendance	3%
Written Homework	5%
Webwork	10%
Midterm 1	20%
Midterm 2	20%
Midterm 3	20%
Final Exam	20%

Academic Honesty: Make sure your work is your own (see above for homework collaboration). Academic honesty is essential and cases of cheating will be taken seriously. University procedures will be followed for any infractions. See the following link for details.

https://www.bc.edu/bc-web/academics/sites/university-catalog/policies-procedures

Here are some **Resources** to take advantage of:

(1) Come to class!
(2) Come to discussion!
(3) I have office hours, listed above.
(4) The Connors Family Learning Center provides peer tutoring for all Boston College Students. See www.bc.edu/libraries/help/tutoring.html or call 617-552-0611 to schedule an appointment, after add/drop.
(5) Math Department Tutoring: This is a drop-in tutoring staffed by math majors. I will let you know more after add/drop.
(6) The Math Department office maintains a list of tutors-for-hire who have indicated their availability for the term. Contact me if you are interested in being put in touch with a personal, paid tutor.

If you are a student with a documented disability seeking reasonable accommodations in this course, please contact the Connors Family Learning Center regarding learning disabilities and ADHD, or the Disability Services Office (617) 552-3470 regarding all other types of disabilities, including temporary disabilities. Advance notice and appropriate documentation are required for accommodations.

Global extrema, The Extreme Value Theorem, and The Closed Interval Method [1]

My comments are in blue and suggested instructions are red. This handout—with my comments removed, so only the black text remains—is provided to students at the beginning of lecture, and is used as a visual aid: a way to display examples and images without having to write them out. The main definitions and theorems are still written on the board. The handout can help students stay engaged and follow along during class (e.g., in case they missed something that has been erased). Throughout the lecture I reference it while elaborating on the board some motivation, computations, etc. To aid in obtaining feedback, I make use of polling software (e.g., Poll Everywhere).

Coming into this lecture, students should be familiar with the definitions of critical points, local extrema, a function being increasing or decreasing, and the first derivative test. The notion of concavity is not needed.

Goals and Topics:

- Introduce the Extreme Value Theorem (EVT). Understand the conditions needed for it to apply.
- Understand why the Closed Interval Method works (via the EVT and Fermat's Theorem). Find global extrema.
- Work through some examples where the Closed Interval Method doesn't apply but where we can still find global extrema, if they exist.

Global Extremum: Let c be a number in the domain D of a function f. Then $f(c)$ is the

- the **global maximum value** (or absolute maximum) of f on D if $f(c) \geq f(x)$ for all x in D.
- the **global minimum value** (or absolute minimum) of f on D if $f(c) \leq f(x)$ for all x in D.

Students will be familiar with local extrema so I emphasize the difference here as being the largest/smallest value of the entire graph (on the domain being considered). I give a couple situations when it would be good to know a function's global extrema, e.g., where is profit maximized, cost minimized?

Q: When is a function guaranteed to have a global minimum and maximum?

Activity: Draw a continuous function on an interval of your choosing. Does your function have a global maximum or minimum?

The purpose of this activity is to get students thinking about how the domain of a function affects the existence and location of global extrema.
Give students 2 minutes to draw their graph. Ask anyone if their graph did *not* have a global min or max and if they see why not. Lead into the idea of needing a closed and bounded interval.

The Extreme Value Theorem: If f is continuous on a closed and bounded (meaning the endpoints are finite) interval $[a, b]$, then f attains a global maximum value $f(c)$ and a global minimum value $f(d)$ at some numbers c and d in $[a, b]$.

[1] This handout is a modification of one developed as part of the MATH1100 coordinated team at Boston College.

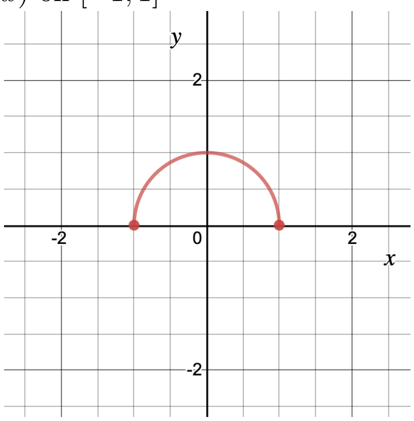
This first example helps them intuit why the hypotheses of the EVT are necessary and helps them understand that a function may still achieve a min/max even if it doesn't meet these hypotheses, just that it is not *guaranteed* to have global extrema.

I give students five minutes to work on all five parts. After about four minutes I have them compare their answers with those sitting around them. While they are working I quickly sketch each graph on the board and after the 5 minutes we quickly work through each one.

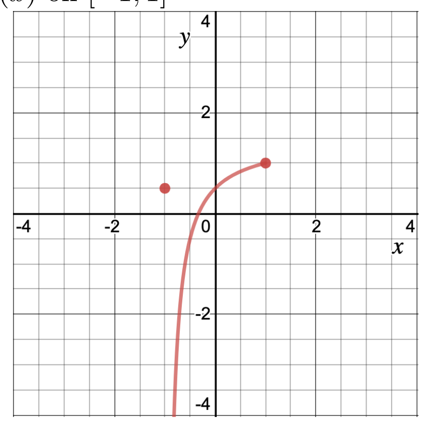
Example 1: For each of the following graphs, say whether

- The conditions of the Extreme Value Theorem are met on the interval the function is defined on.
- The function has a global max or global min on the interval.

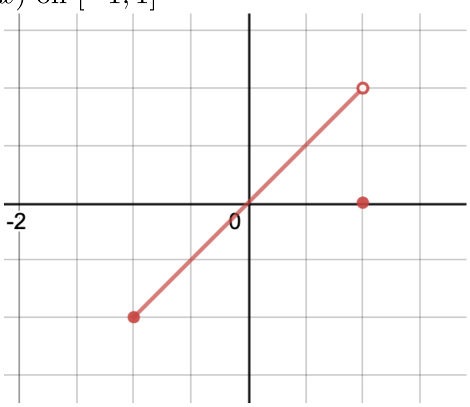
(a) $f(x)$ on $[-1, 1]$



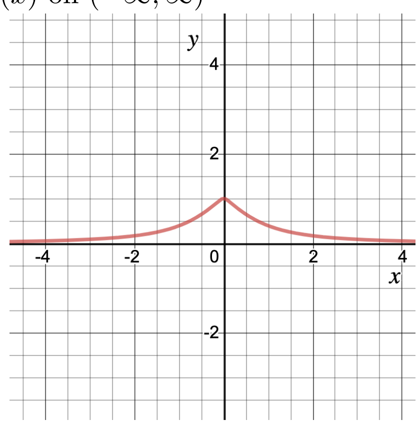
(c) $h(x)$ on $[-1, 1]$



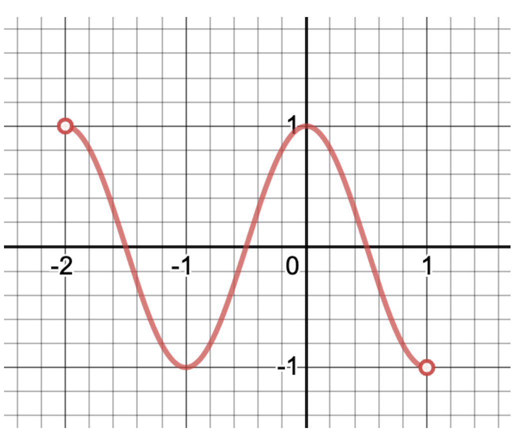
(b) $g(x)$ on $[-1, 1]$



(d) $w(x)$ on $(-\infty, \infty)$



(e) $s(x)$ on $(-2, 1)$



I write on the board and discuss with the students how extrema on a closed interval can happen either in the interior of the interval or at its endpoints. Ask them how we could find the extrema if they were in the interior (they must be at a critical point in this case). This leads into the closed interval method.

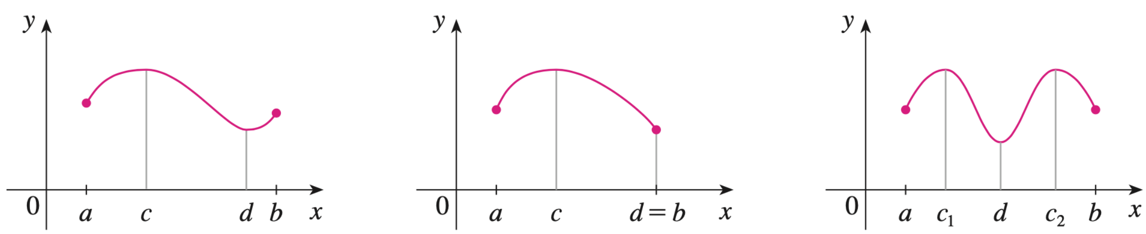
The Closed Interval Method: To find the *global* maximum and minimum values of a continuous function f on a closed interval $[a, b]$:

(1) Find the values of f at the critical points of f in (a, b)

(2) Find the values of f at the endpoints of the interval.

(3) The largest of the numbers from Steps (1) and (2) is the global maximum value; the smallest of these numbers is the global minimum value.

I usually summarize the closed interval method by drawing a table on the board for them with the words critical points and end points in the left column, and f(critical points) and f(end points) in the right column.



The next example is mechanical practice with the closed interval method. Parts (a), (b), and (c) of the example are reused from a previous lecture where we found their critical points and local extrema. Since these are repeated functions, this example helps them see how the domain affects the extrema, and how the endpoints of the interval are "artificial" from the point of view of the derivative.

Let students attempt part (a) on their own. Some may remember the function from before. Work through part (a) in full after giving them approximately 3 minutes to try it. After, remind them of the critical points for parts (b) and (c). Give them time to work, approximately 5 minutes for each. Part (b) makes a good poll question.

For part (d), give them another 3 minutes to work. Then run through this part on the board with them. They will probably be rusty with the algebra needed to find the critical points. I quickly sketch the graph of the surge function to explain the name once we've completed the problem.

Example 2: Without graphing, find the global maximum and global minimum (both x and y-values) of:

(a) $f(x) = 2x^3 - 9x^2 + 12x - 4$ on the interval $[0, 3]$
`https://www.desmos.com/calculator/pee37icxzf`

(b) $g(x) = x^2 - 2\ln(x)$ on the interval $\left[\frac{1}{2}, 2\right]$
`https://www.desmos.com/calculator/w0ldyc5osb`

(c) $r(x) = x^{2/3} + x$ on $[-1, 1]$
`https://www.desmos.com/calculator/khlbwcghig`

(d) $C(t) = 3te^{-t}$ on $[0, 4]$
`https://www.desmos.com/calculator/5argbprngi`

Note: $C(t)$ is an example of a surge function which models the concentration of a drug in the bloodstream after a dose is administered at time $t = 0$. Here we might measure t in hours and C in mg/ml.

The preceding content may take a full 50 minute lecture. The next topic may need to be pushed to the following day, or less time can be spent on Example 1, or this maybe be cut entirely depending on its importance to the course. This example reinforces that the EVT does not always apply, but that a function may still have a global min or max. It also demonstrates how more ad hoc approaches may be needed to find global extrema in general.

Have students identify any asymptotes and the values of the sided limits. Then sketch the functions near their asymptotes on the board, and have students talk with each other about what these would imply about global extrema. Run through (a) and (b) quickly. Focus on (c), since this one still has a global minimum. Ask students how they might determine the location given increasing/decreasing information for the function.

What can we do if the closed interval method doesn't apply?

Suppose we are looking for global extrema of the function $f(x)$. Remember that a global max or min of $f(x)$ *might not exist*; we need to be prepared to rule it out.

Let's look at the case of **discontinuities**. If $f(x)$ is discontinuous on the interval, determine the behavior of $f(x)$ at the point of discontinuity (either an endpoint or interior point) by computing limits at the point (maybe from the left and right separately if necessary, e.g. at a vertical asymptote).

Example 3: Identify any absolute extrema (both x and y-values) of the functions on the given interval via computation (not graphing). If the absolute max or min does not exist, explain why. Check your answers with the graphs.

(a) $g(x) = \frac{1}{x+5}$ on $[-10, 0]$
`https://www.desmos.com/calculator/n5ky4ml043`

(b) $h(x) = \frac{x-2}{x^2-4}$ on $[-3, 3]$
`https://www.desmos.com/calculator/d2tn1prkuk`

(c) $k(x) = \frac{1}{(3-x)^2}$ on $[0, 5]$
`https://www.desmos.com/calculator/ics1wvjfrd`

MATH116 – Spring 2025
Homework 04
Due Friday, February 28, 2025

Homework guidelines:

- Complete the problems below individually. You may work with classmates to generate ideas, but the work you eventually write down must be the result of your own thought and effort.
- Submit these problems on Gradescope, making sure to select the correct page for each problem.
  - Write your **name** and **MATH116 Section ##** in the **top left** corner of your first page.
  - **Credit your collaborators** at the **top right** corner of your top paper.
  - Write your answers in a **single column**, with problem labels along the left margin of the page and using the entire width of the page for a problem. Do NOT put problems side-by-side on the page. You may use the back of the page as long as you are not using a pen that bleeds through the paper.
  - Write neatly (no crossings-out) and use standard size paper.

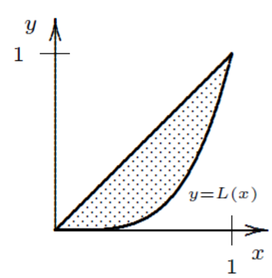
Relevant Reading: Section 6.1: Areas between curves.

1. **The Gini Coefficient** A region's income inequality can be represented by a *Lorenz curve* $L(x)$ on $[0, 1]$. If we rank households from least to greatest income, the point $(a, b) = (a, L(a))$ on the curve $L(x)$ means that the bottom a of the population receives b of the total region's income.

   For example, the statement "The bottom 80% of the population only own 20% of the total income" would be represented as the Lorenz curve passing through (0.8, 0.2).

   To measure how far a region is from absolute income equality, economists measure the area between the curve $y = x$ and the curve $L(x)$. The *Gini coefficient* of a geographical region is defined as twice this area:

$$G = 2\int_0^1 (x - L(x))\,dx.$$



   This means that $G = 0$ when the Lorenz curve is $y = x$ (called *absolute income equality* because the bottom a% of the population receives a% of the region's income for every a), and $G = 1$ when $L(x) = 0$ for $x < 1$ (that is, when the bottom a% receive no income for any $a < 1$.)

   (a) Suppose the point $(0.99, 0.8)$ is on a country's Lorenz curve. What does it mean?

   (b) We could try to model the Lorenz curve by a power function $y = x^n$ for some value of n (not necessarily a whole number).
   Let's do this for the Lorenz curve for the US in 2022. Assuming that the Gini coefficient for the U.S.[1] is $G = 0.413$, approximately what is n? (You will need to set up an integral to solve this. Round your answer to two decimal places; you should get a number between 2 and 3.)

[1] This is the calculated value for 2022, the most recent value available. See http://data.worldbank.org/indicator/SI.POV.GINI for a source link. For Gini coefficients by state, see http://en.wikipedia.org/wiki/List_of_U.S._states_by_Gini_coefficient.

(c) Consider the Lorenz curve model $y = x^n$ for the n you found in the previous part. If that is the correct model, what does it predict for how much of the total country's income goes to the top 1%?

(d) Recent reports show the top 1% earning between 18-23% of all income[2].

How does this match with what you found in part (b)? Do you think the power function model is a good model? Why or why not?

This is graded on completion only, but meant to make you think about the importance of checking a model against data, then potentially revising the model.

2. Antiderivative for $\ln(x)$. Integration by parts give that

$$\int \ln x \, dx = x \ln x - x + C.$$

In this problem, you will give a geometric explanation why this is the case (avoiding integration by parts). The purpose of the problem is not to figure out the formula (we know it now), but to show another visual way to see why it is correct.

Let a be a constant which could be any real number (a parameter).

(a) Consider the area between the graph of e^x and the x-axis from $x = 0$ to $x = a$ using vertical slices. Write down an integral expression for this area and compute it.

(b) Now consider the area between the graph of e^x and the y-axis from $y = 1$ to $y = e^a$ using horizontal slices. Write down an integral expression for this area, from horizontal slicing, but do **not** compute it. Use t for the variable of integration.

(c) Draw a picture of these areas on the same set of axes.

Using geometric reasoning, what is the sum of the two areas in parts (a) and (b)?

(d) Show how you can conclude from the previous part that

$$\int_1^x \ln t \, dt = x \ln x - x + 1.$$

(e) Differentiate the right hand side of part (d). Why can we conclude that

$$\int \ln x \, dx = x \ln x - x + C \ ?$$

[2]Source: http://www.theatlantic.com/business/archive/2016/03/brookings-1-percent/473478/. This focus on the 1% was a focus of the Occupy Wall Street movement of 2011 which said "We are the 99%" in contrast to the wealthiest 1% of Americans.

3. **Reflection Problem** Your answer to the question below will be graded based on completion, meaning the amount of apparent effort in your answer.

This reflection is intended to spark thinking about who can be a mathematician, what paths people follow to become mathematicians, and the challenges people overcome to pursue a professional career in mathematics.

Visit one of the following sites:

- https://www.lathisms.org/posters
- https://mathematicallygiftedandblack.com/circle-of-excellence/
- https://indigenousmathematicians.org/honorees-2021/
- https://hermathsstory.eu/

and read through a few of the profiles of featured mathematicians.[3] Select a mathematician who interests you and write a short paragraph (5-10 sentences) about them, explaining why you find their profile interesting. Answer at least two of the questions below explicitly, citing details from the profile you read.

- What do you find inspiring about the person's profile?
- What did the person do that is particularly impressive, and why?
- In what way does this person's profile change the way you think about "mathematicians?"
- In what ways do you relate to the person you chose?

[3] These websites highlight mathematicians who are from historically underrepresented groups in mathematics. They are all modern-day working mathematicians. One goal of this problem is to increase your awareness of mathematicians of color and female mathematicians.

Version A

MATH2210 Linear Algebra
Assessment 5

Wednesday, April 5, 2023

Name: ______________________________

BC Username: ______________________________

Question	Standard(s)	Points
1	[LM2], [LM3]	2
2	[LM4]	1
3	[LM5]	1
4	[M2]	1
5	[M3]	1

- You have **50 minutes** for this assessment.
- Closed book, closed notes. Show all of your work.
- You are NOT allowed to use a calculator.
- Read each problem carefully.
- When applicable, box your final answer.

1. **[LM2], [LM3]** The matrix A has reduced echelon form B:

$$A = \begin{pmatrix} 2 & 4 & -6 & 1 & 2 & 0 \\ 3 & 6 & -9 & 1 & 2 & 2 \\ 4 & 8 & -12 & 2 & 4 & 4 \end{pmatrix}, \qquad B = \begin{pmatrix} 1 & 2 & -3 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

(a) Find a basis for the image of A.

(b) Find a basis for the kernel of A.

(c) Does $Ax = b$ have a unique solution for each $b \in \mathbb{R}^3$?

2. **[LM4]** Answer the following questions, fully justifying your answer using the Rank-Nullity Theorem **and nothing else**.

   (a) Suppose the linear map $T : \mathbb{R}^7 \to \mathbb{R}^{10}$ has $\dim(\ker(T)) = 5$. What is the dimension of its image?

   (b) Let $T : \mathbb{R}^{2023} \to \mathbb{R}^{2024}$ be a linear map. Can T be surjective?

   (c) Suppose $T : \mathbb{R}^8 \to \mathbb{R}^6$ is linear and its image is at most 3 dimensional. What are the possible dimensions of its kernel?

   (d) Suppose A is a 10×3 matrix for which $Ax = \vec{0}$ has only the trivial solution. What is the rank of A?

3. [**LM5**]

(a) Find A^{-1} where

$$A = \begin{pmatrix} 10 & 3 \\ 6 & 2 \end{pmatrix}.$$

(b) Suppose $T : \mathbb{R}^3 \to \mathbb{R}^3$ is an isomorphism given by $T \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} x + y \\ 2y \\ 3x + z \end{pmatrix}$. Find the matrix of T^{-1} in the standard basis.

4. **[M2]** Consider the matrices

$$A = \begin{pmatrix} -1 & 2 \\ 5 & 4 \\ 2 & -3 \end{pmatrix}, \quad \text{and} \quad B = \begin{pmatrix} 3 & -4 \\ -2 & 1 \end{pmatrix}, \quad \text{and} \quad C = \begin{pmatrix} -1 & 0 & 4 \\ -1 & 3 & 2 \end{pmatrix}.$$

(a) Compute $2B - 6\,\mathrm{Id}_2$.

(b) What size matrix would BC be?

(c) Compute AC.

5. **[M3]** Consider the matrices

$$A = \begin{pmatrix} 4 & 0 & 0 & 5 \\ 0 & 3 & 0 & 0 \\ 1 & 7 & 2 & -5 \\ 8 & 3 & 0 & 0 \end{pmatrix} \quad \text{and} \quad B = \begin{pmatrix} 2 & 0 & 1 & 7 \\ 0 & 3 & 5 & 4 \\ 0 & 0 & 8 & 21 \\ 0 & 0 & 0 & 5 \end{pmatrix}.$$

(a) Compute $\det(A)$.

(b) Compute $\det(B)$.

(c) Explain how we know that the matrix A is invertible.

(d) Without finding A^{-1}, compute $\det(A^{-1}B)$.

MATH116 -- Fall 2024

Sections 03 and 04

Week	Class	Day	Date	Topic	Stewart, 9th Ed. **Textbook Section**	**Due**	**Notes**		
1	1	Tues	3-Sep	Introductions and Working with parameters					
	2	Wed	4-Sep	Riemann sums and the definite integral	5.1, 5.2				
	3	Fri	6-Sep	Riemann sums and the definite integral	5.1, 5.2	HW00			
2	4	Tues	10-Sep	Properties of the definite integral	5.2				
	5	Wed	11-Sep	Area functions, The FTC	5.3				
	6	Fri	13-Sep	The FTC	5.3, 5.4	HW01, WW Tutorial, WW01		Course add deadline	
3	7	Tues	17-Sep	The Net Change theorem	5.4	WW03			
	8	Wed	18-Sep	u-Substitution	5.5	WW04, WW05			
	9	Fri	20-Sep	Integration by parts	7.1	HW02, WW06			
4	10	Tues	24-Sep	Review		WW07, WW08			
	11	Wed	25-Sep	*Lake Day*					
	12	Fri	27-Sep	Exam 1			Course drop deadline		
5	13	Tues	1-Oct	Partial Fractions	7.4				
	14	Wed	2-Oct	Areas between curves	6.1				
	15	Fri	4-Oct	Mass from density	Supplement	HW03, WW09			
6	16	Tues	8-Oct	Mass from density, Volumes of solids of revolution	Supplement, 6.2	Exam 1 Corrections, WW10			
	17	Wed	9-Oct	Volumes of solids of revolution	6.2				
	18	Fri	11-Oct	L'Hopital's Rule and the growth argument	4.4				
7		Tues	15-Oct	*Fall Break*		WW11			
	19	Wed	16-Oct	Improper integrals, type 1	7.8				
	20	Fri	18-Oct	Improper integrals, type 2	7.8	WW12			
8	21	Tues	22-Oct	Infinite sequences	11.1				
	22	Wed	23-Oct	Review		HW05, WW13, WW14			
	23	Fri	25-Oct	Exam 2					
9		Tues	29-Oct	*No classes - Tanner Conference*					
	24	Wed	30-Oct	Infinite sequences	11.1	Exam 2 Corrections			
	25	Fri	1-Nov	Infinite series, telescoping series	11.2				
10	26	Tues	5-Nov	n-th term test, the harmonic series, geometric series	11.2	WW15			
	27	Wed	6-Nov	The integral test	11.3	WW16, WW17			
	28	Fri	8-Nov	Direct and limit comparison tests	11.4	HW06, WW18			
11	29	Tues	12-Nov	Alternating series test and absolute convergence	11.5				
	30	Wed	13-Nov	Ratio and root tests	11.6	WW19			
	31	Fri	15-Nov	Ratio and root tests	11.6	WW20			
12	32	Tues	19-Nov	Power series	11.8	WW21			
	33	Wed	20-Nov	Review		HW07, WW22			
	34	Fri	22-Nov	Exam 3					
13	35	Tues	26-Nov	Power series	11.9				
		Wed	27-Nov	*Thanksgiving Break*					
		Fri	29-Nov	*Thanksgiving Break*					
14	36	Tues	3-Dec	Taylor series	11.10				
	37	Wed	4-Dec	Taylor series	11.10	WW23			
	38	Fri	6-Dec	Taylor polynomials and approximation	11.11	HW08, WW24, Exam 3 Corrections			
15	39	Tues	10-Dec	Taylor polynomials and the remainder theorem	11.11	WW25			
	40	Wed	11-Dec	Wrap-up		HW09 (not collected)	Withdrawl deadline, Last day of classes		
		Fri	13-Dec	*Study Day*					
			16-Dec through 19-Dec	Final Exam - Self Scheduled					