

MATH 6313.001 (81775/008784) Syllabus
Numerical Analysis
Fall 2021, TuTh 4:00–5:15pm, SCI 3.250, Hybrid/Blended

Instructor: Dr. Minkoff

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Note that I will maintain a web page for this course linked from my main web page and will use eLearning.

Office Hours: Tuesdays 2–3pm or by appointment.

Course Modality and Expectations:

Hybrid Instructional Mode: In class traditional learning at the date and time of the class for all students who are physically at UTD in Fall 2021. Asynchronous learning for students who are unable to be physically present at UTD in Fall 2021. International students who arrive at UTD at any point in the Fall semester are required by the university to attend in person after they arrive.

Course Platform: For asynchronous students I will post class lecture recordings in Microsoft Teams/Streams. I will also use Teams for office hours. I will post lecture notes for the coming lecture before the start of class each day. Homework assignments will be posted on my website. Students will turn the homework in via eLearning. In the “assignments” section for the class you will see an assignment listed that will allow you to upload your scanned homework each week. *Note that each student will upload a single pdf file with their homework assignment each week.* Please do not upload multiple files for each assignment. *The pdf file you upload will be named following the convention “Student name Assignment number.pdf”.* For example, when John Smith uploads homework 1 the file will be named “John Smith Assignment 1.pdf”. You will be given 2 chances to upload your homework each week in case of unintended error. The assignments will be open for submission 24 hours before they are due. They will be due at the start of class (4pm) on the date they are due (generally Thursdays).

Expectations: I will post recordings of the lectures for asynchronous students and lecture notes in eLearning for all students to access. However, I always expect the in-person students to attend class and to turn up on time. Rarely do students do well in classes which they do not attend. Regular class participation is expected regardless of course modality. Students who fail to participate in class regularly are inviting scholastic difficulty. Successful participation is defined as consistently adhering to University requirements, as presented in this syllabus. Failure to comply with these University requirements is a violation of the Student Code of Conduct (<https://policy.utdallas.edu/utdsp5003>).

Academic Conduct: I take academic dishonesty *very seriously* and will not tolerate it in this class in any form. **Academic misconduct includes willfully cheating on or**

giving aid during an exam or copying homework assignments (from the web, from each other, or from a solutions manual). Blatant copying on an exam, homework assignment, or computer assignment will be reported to the university as an academic conduct violation. Further information on the academic conduct policy can be found at <https://conduct.utdallas.edu/dishonesty/>

Asynchronous Learning Guidelines: If you are participating asynchronously, it is essential that time is put into listening to the posted video recordings, studying the lecture notes and completing the homework assignments. Late homework will not be accepted.

Prerequisite: Knowledge of a high-level programming language and linear algebra and calculus through multivariable calculus. I expect students to be able to both understand proofs we do in class and to be able to prove results themselves on the homework. Therefore I prefer that students have successfully completed an undergraduate Real Analysis course before taking this course. Note that we will be using Matlab exclusively in this course. It is highly recommended that all students taking this course will have a working knowledge of MATLAB.

Course Description (from the catalog): A study of numerical methods including the numerical solution of non-linear equations, interpolation, approximation by polynomials, numerical integration. Numerical solution of ordinary differential equations including initial value problems and two-point boundary value problems.

Texts — Required: *Numerical Analysis: Mathematics of Scientific Computing*, 3rd Edition, by Kincaid and Cheney. Publisher: Brooks/Cole, 2002.

Additional Reference: *An Introduction to Numerical Analysis* by Atkinson. Publisher: John Wiley & Sons 1989.

Grading Policy:

Homework	40%
Midterm Exam	30%
Final Exam	30%
<hr/> Total	<hr/> 100%

Homework: There will be one homework due every 1–2 weeks on Thursdays (the length of time will depend on the schedule). Homework is due by the START of class on Thursday. Students will turn in their homework using eLearning. Homework can be turned in early, but late homework will not be accepted.

Please note that the homework constitutes a substantial portion of your overall grade. In order to learn the concepts and be able to apply them to solving problems on exams, etc., you are strongly encouraged to devote as much time as possible to working the homework problems. It is likely that not all homework problems will be able to be graded, but most of your learning will come from devoting good chunks of time each week to the homework. **Please note that students who do not attempt the MATLAB homework rarely pass the class!** I encourage you to discuss the homework assignments with other students in the class. However, I expect the homework you submit for grading to be written up by you alone (this includes computer programs which must not be duplicates of programs other students turn in).

Tests: There will be one midterm exam and one final exam. Due to the fact that this is a hybrid class, all exams will be given within eLearning. Students are not allowed to use resources from the internet or to work with other students on the exam. The exams will be closed notes and closed book. You will be given a two hour time window within which to take your 75 minute midterm and a 4 hour time window to take your 2 hour and 45 minute final exam. If you know ahead of time that you cannot take the exams in the designated time window (for example because you are in a very different time zone or because of family responsibilities), you must contact me by email at least 4 days in advance of the scheduled exam requesting to take the exam at an alternate time. Be prepared to provide appropriate evidence in support of your request.

This course will use [Honorlock](#), an online exam proctoring tool, which will be integrated with the exam system in eLearning and is provided free of charge to students by UT Dallas. To successfully take an exam, you need a web camera, a microphone, a laptop or desktop computer (no tablets/phones, but chromebooks work), the Chrome browser, a reliable internet connection, and your photo ID. As soon as possible, students are strongly encouraged to ensure that their computer has the [minimum requirements for Honorlock](#), including the built-in or external webcam. You will be prompted to install the Honorlock Chrome Extension (which you can remove after you finish the test). You will then access the exam within your eLearning course and go through the authentication process. The web camera will monitor you throughout your test. Please see the [Support Information](#) for additional information, and contact your course instructor if you cannot procure the minimum required technology. We will provide students with the opportunity to do a mock test using Honorlock prior to the first time we use it for assessment.

Student Learning Outcomes:: Numerical Analysis is the study of algorithms for solving mathematical problems on computers. Most real world integrals can't be evaluated exactly (i.e., their antiderivative isn't known). Most real world differential equations have non-constant coefficients or must be solved over irregularly-shaped domains and thus must be solved approximately on a computer. In many situations one is working with data points underlying a function rather than an explicit functional form, and therefore, one must approximate the function of interest by one which is easy to manipulate and which gives the character of the function in question at least at a specific set of points. In all of these cases the approximation used to solve the mathematical problem leads to an error which one would like to understand in order to make decisions about whether the solution is accurate enough for the given task. Does the error lie within a specified tolerance or bound? Does it grow with increasing time? In this course you will explore the world most scientists and engineers work in daily but which is different from what you have seen in previous math courses because the solutions to these problems are by necessity approximate.

Specifically, in this course you will:

1. Review how to represent numbers in different bases and how to convert between different number systems. Emphasis will be placed on base 2 which is the most important for representation of numbers on computers.

2. You will learn why round-off error is so important for numerical algorithms. All numbers represented on a computer must be stored with a finite number of bits. Hence most numbers cannot be stored exactly on a computer.
3. We will discuss finding roots of functions which is especially important in the study of optimization.
4. We will learn ways to represent a table of data values $(x, f(x))$ if the underlying function which generated the data isn't known *a priori*. The most common way to describe such data is by fitting a degree n polynomial to the set of $n+1$ points (e.g., fitting a line to two data points). However, there are many other useful representations of the underlying function.
5. We will learn how to decompose functions into a sum of sines (or exponentials) which is important for signal processing, data compression, image processing, etc. And we will learn an extremely efficient way to use computers for this purpose.
6. Most integrals can't be evaluated analytically and must be approximated on a computer. Moreover, computers can't take limits and hence approximating integrals and derivatives on computers requires dropping the limit idea and taking "small" but not infinitesimal quantities in the approximation. Our goal is to understand how accurate such approximations are – a topic that is especially important in the study of differential equations.
7. Finally we investigate iterative techniques for approximating solutions to ordinary differential equations on computers. The most basic idea is Euler's method which approximates the solution at a point in the domain by a short line segment. Other more sophisticated techniques will be discussed.

Email: I am happy to answer questions about the class via email. However, I reserve the right not to respond to email if I feel it would be best for the student to discuss his/her question during my office hours. I will not respond to email which does not include the name of the sender.

Tips for Succeeding in this Class:

1. Before you attempt the homework you should *read the sections in the textbook if appropriate and study your notes*.
2. You will benefit greatly from working with others in the class so long as you use your peers as a way to hash over concepts and not a way to "get the answers". In other words, *start early* and use your fellow-classmates to discuss the best way to approach the problems. Then go off and try to work out the details yourself.
3. **Begin the new homework assignment the same day you turn in the previous assignment!** Do not wait 3–4 days to start the homework as then you will not have enough time to digest the material or understand the point of the problems. When computer assignments are given, starting early on the homework is essential. Debugging programs takes time and your grade and learning will suffer if you attempt the computer problems at the last minute.

4. Come to office hours and get help if you are stuck. It is much better to get help early than to wait. I may ask you to show me what you've come up with at the board so you should have at least attempted the homework problems before asking for help.

COVID-19 Guidelines and Resources: The information contained in the following link lists the University's COVID-19 resources for students and instructors of record. Please see <https://go.utdallas.edu/syllabus-policies>. Texas Governor Greg Abbott's Executive Order GA-38 prohibits us from mandating vaccines and face coverings for UT Dallas employees, students and members of the public on our campus. **However, we strongly encourage all Comets to get vaccinated and wear face coverings as recommended by the CDC. To help preserve the University's in-person learning environment, UT Dallas recommends that all Comets wear face coverings indoors regardless of vaccination status.**

Class Recordings: Students are expected to follow appropriate University policies and maintain the security of passwords used to access recorded lectures. Unless the Office of Student AccessAbility has approved the student to record the instruction, students are expressly prohibited from recording any part of this course. Recordings may not be published, reproduced, or shared with those not in the class, or uploaded to other online environments except to implement an approved Office of Student AccessAbility accommodation. Any recordings will be available to all students registered for this class as they are intended to supplement the classroom experience. Failure to comply with these University requirements is a violation of the Student Code of Conduct (<https://policy.utdallas.edu/utdsp5003>).

Class Materials: The Instructor will provide class materials that will be made available to all students registered for this class as they are intended to supplement the classroom experience. These materials may be downloaded during the course. However, these materials are for registered students' use only. Classroom materials may not be reproduced or shared with those not in class, or uploaded to other online environments except to implement an approved Office of Student AccessAbility accommodation. Failure to comply with these University requirements is a violation of the Student Code of Conduct (<https://policy.utdallas.edu/utdsp5003>).

Technical Requirements: In addition to a confident level of computer and Internet literacy, certain minimum technical requirements must be met to enable a successful learning experience. Please review the important technical requirements on the Getting Started with eLearning webpage (<https://ets.utdallas.edu/elearning/students/current/getting-started>).

Course Access and Navigation: This course can be accessed using your UT Dallas NetID account on the eLearning website. Please see the course access and navigation section of the Getting Started with eLearning webpage for more information (<https://ets.utdallas.edu/elearning/students/current/getting-started>). To become familiar with the eLearning tool, please see the Student eLearning Tutorials webpage <https://ets.utdallas.edu/elearning/students/current/tutorials>). UT Dallas provides eLearning technical support 24 hours a day, 7 days a week. The eLearning Support Center (<https://ets.utdallas.edu/elearning/helpdesk>) includes a toll-free telephone number for immediate assistance (1-866-588-3192), email request service, and an online chat service.

Communication: This course utilizes online tools for interaction and communication. Some external communication tools such as regular email and a web conferencing tool may also be used during the semester. For more details, please visit the Student eLearning Tutorials webpage (<https://ets.utdallas.edu/elearning/students/current/tutorials>) for video demonstrations on eLearning tools.

Distance Learning Student Resources: Online students have access to resources including the McDermott Library, Academic Advising, The Office of Student AccessAbility, and many others. Please see the eLearning Current Students webpage (<https://ets.utdallas.edu/elearning/students/current>) for more information.

Server Unavailability or Other Technical Difficulties: The University is committed to providing a reliable learning management system to all users. However, in the event of any unexpected server outage or any unusual technical difficulty which prevents students from completing a time sensitive assessment activity, the instructor will provide an appropriate accommodation based on the situation. Students should immediately report any problems to the instructor and also contact the online eLearning Help Desk (<https://ets.utdallas.edu/elearning/helpdesk>). The instructor and the eLearning Help Desk will work with the student to resolve any issues at the earliest possible time.

Comet Creed: This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

“As a Comet, I pledge honesty, integrity, and service in all that I do.”

Academic Support Resources: The information contained in the following link lists the University’s academic support resources for all students. Please go to Academic Support Resources webpage (<https://provost.utdallas.edu/syllabus-policies/#academic-support-resources>) for these policies.

UT Dallas Syllabus Policies and Procedures: The information contained in the following link constitutes the University’s policies and procedures segment of the course syllabus. Please go to UT Dallas Syllabus Policies webpage (<https://go.utdallas.edu/syllabus-policies>) for these policies.

Important Dates:

Date	Notes
8/23/21	First day of class
8/30/21	Last day to register and last day to add/swap
9/8/21	Last day to drop class without a “W”
10/12/21	Midterm Exam
11/3/21	Absolute Last day to drop class
12/7/21	Last day of classes
TBD	Final Exam

The descriptions and timelines contained in this syllabus are subject to change at the discretion of the Professor.

Math 6313, Fall 2021, Tentative Schedule:

Date	Section/Topic
Tu 8/24/21	First Day Handout; §1.1 – Basic Concepts and Taylor’s Theorem
Th 8/26/21	§2.1 – Representation of Numbers in Different Bases
Tu 8/31/21	§2.1 – Floating-Point Numbers and Roundoff Errors
Th 9/2/21	§2.2 – Absolute and Relative Errors: Loss of Significance
Tu 9/7/21	§2.2 – Absolute and Relative Errors: Loss of Significance
Th 9/9/21	§3.1 – Bisection Method
Tu 9/14/21	§3.2 – Newton’s Method
Th 9/16/21	§3.2 – Newton’s Method for Nonlinear Systems
Tu 9/21/21	§3.4 – Fixed Points and Functional Iteration
Th 9/23/21	§6.1 – Polynomial Interpolation
Tu 9/28/21	§6.2 – Divided Differences
Th 9/30/21	§6.1 – Chebyshev Polynomials
Tu 10/5/21	§6.4 – Spline Interpolation
Th 10/7/21	§6.8 – Best Approximation: Least-Squares Theory
Tu 10/12/21	Midterm Exam
Th 10/14/21	§6.12 – Trigonometric Interpolation
Tu 10/19/21	§6.13 – Fast Fourier Transform
Th 10/21/21	§6.13 – Fast Fourier Transform
Tu 10/26/21	§7.1 – Numerical Differentiation and Richardson Extrapolation
Th 10/28/21	§7.2 – Numerical Integration Based on Interpolation

Date	Section/Topic
Tu 11/2/21	§7.3 – Gaussian Quadrature
Th 11/4/21	§7.3 – Gaussian Quadrature
Tu 11/9/21	§7.5 – Adaptive Quadrature
Th 11/11/21	§8.2 – Taylor-Series Methods
Tu 11/16/21	§8.3 – Runge-Kutta Methods
Th 11/18/21	§8.4 – Multistep Methods
Tu 11/23/21	WINTER BREAK
Th 11/25/21	THANKSGIVING BREAK
Tu 11/30/21	§8.4 – Multistep Methods
Th 12/2/21	§8.5 – Local and Global Errors: Stability
Tu 12/7/21	Review for Final Exam
TBD	Final Exam