MATH 302

Numerical Analysis

Semester 4, 2024

昆山杜克大学
DUKE KUNSHAN UNIVERSITY

Course meeting time: Monday and Wednesday 12:00pm - 2:30pm, CCT E4011
Recitation time: Tuesday 6:00 pm – 7:15 pm, CCT E4011
Academic credit: 4 DKU credits
Course format: Lecture

Instructor's Information

Dangxing Chen, Assistant Professor of Mathematics, Duke Kunshan University
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Office: WDR2113
Office Hours: Monday and Wednesday 2:30 pm – 3:00 pm, Tuesday 1:30 pm – 2:30 pm. If none of these slots work for you, please schedule an individual appointment with me.
Research interests: quantitative finance and numerical methods.
TA: Jiaqi Zhang (for coding)
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What is this course about?

Predicting the weather; deciding the optimal value of a financial asset; sending spacecrafts to asteroids and to the edge of the solar system. These are only a few of the tasks that are achieved through a combination of mathematical modeling and numerical simulations. In this course we will focus on the theoretical foundations and practical aspects of such numerical simulations.

First, we will discuss the most fundamental and widely used algorithms for numerical simulations. This being a mathematically focused course, we will go beyond a "numerical recipes" approach. We will discuss the main practical and theoretical considerations for designing numerical algorithms (stability, accuracy, computational cost) and delve deep into the details of each algorithm.

Second, we will not shy away from the practical aspects of implementing numerical algorithms in an efficient manner. For the implementation of the algorithms, we will be working with the programming language with your preference.

In terms of its placement within the curriculum, MATH 302 requires a solid foundation in MATH 201 Multivariable Calculus and MATH 202 Linear Algebra. MATH 303 ODE and Dynamical Systems and MATH 406 Mathematical Modeling use many of the numerical methods that we will discuss here. A strong computational background, founded on deep understanding, will also be valuable for your Signature Work.

What will I learn in this course?

After successfully completing this course, students should be able to:
1. Recall the fundamental definitions, results, and types of algorithms from numerical analysis.
2. Reproduce the proofs of the main theoretical results and demonstrate understanding.
3. Implement an algorithm in a specific programming language so that it can efficiently run on a computer.
4. Analyze the efficiency and complexity of an algorithm.
5. Evaluate different algorithms for use in a specific problem in terms of their trade-offs.
6. Apply the learned algorithms and techniques to solve problems with an interdisciplinary character.
7. Integrate knowledge from the course and literature research into a project level work on a specific numerical analysis topic.

How can I be successful in this course?

Students are expected to spend an average of 20-24 hours/week studying for this class.

To succeed, students should be prepared to devote several hours to this course on a daily basis. They are strongly encouraged to use Help Room resources and to contact instructors in a timely manner for additional help as needed.

What background knowledge do I need before taking this course?

There are two prerequisite courses:
- MATH 201 Multivariable Calculus.
- MATH 202 Linear Algebra.

Moreover, it will be useful (but not strictly required) to have some familiarity with:
- Sequences of real numbers (as discussed, for example, in MATH 205).
- Structured programming (loops, conditionals, functions, etc.) in any programming language.

References for this course (All books are suggested)

1. "An introduction to numerical analysis" by Kendall E. Atkinson, 2nd edition

How will my grade be calculated?

Course grades will be assigned according to a standard 10-pt scale: 97=A+, 93=A, 90=A-, 87=B+, etc.

Raw scores may be adjusted upward if the overall class performance does not appear to instructors to correctly reflect students' understanding but will never be revised downward.

The course grade will be based on:
Homework： 30%
Midterm (Wednesday of the 4th week): 30%
Final exam (May 8th, 3:30 pm – 5:30 pm): 40%

Homework: Weekly homework will be assigned (with coding problems).
Midterm and Final exams: The midterm will be given in the fourth week, during the lecture. The final date and time are TBA. For all the exams, they will be an in-class test. In case of documented illness or family emergency or documented University sponsored trips, you may miss the midterm, but the supporting documentation must be submitted to the instructor in advance. Do remember let me know **BEFORE** the exam. An unexcused absence from any exam will be counted as a zero.

What are the course policies?

The course is intended to foster as much collaboration as possible given the ultimate need to assess student mastery of the material on an individual basis. Classroom activities include small group discussions and collaborative responses to short problems. Working with classmates on assignments is encouraged, as is consultation with other experts (instructors, teaching assistants, more senior students who have taken the course). In all cases, clear instructions will be given concerning the policy for presenting work for credit. For example, written solutions to homework problems must be crafted separately by each individual student and not merely copied from collaborators.

In all matters, students are expected to treat each other with respect and to maintain a healthy learning environment where questions are welcome and differing perspectives are appreciated.

Academic Integrity:
As a student, you should abide by the academic honesty standard of the Duke Kunshan University. Its Community Standard states: "Duke Kunshan University is a community comprised of individuals from diverse cultures and backgrounds. We are dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Members of this community commit to reflecting upon and upholding these principles in all academic and non-academic endeavors, and to protecting and promoting a culture of integrity and trust."

Academic Policy & Procedures:
You are responsible for knowing and adhering to academic policy and procedures as published in University Bulletin and Student Handbook. Please note, an incident of behavioral infraction or academic dishonesty (cheating on a test, plagiarizing, etc.) will result in immediate action from the instructor, in consultation with university administration (e.g., Dean of Undergraduate Studies, Student Conduct, Academic Advising). Please visit the Undergraduate Studies website for additional guidance related to academic policy and procedures.

Academic Disruptive Behavior and Community Standard:
Please avoid all forms of disruptive behavior, including but not limited to: verbal or physical threats, repeated obscenities, unreasonable interference with class discussion, making/receiving personal phone calls, text messages or pages during class, excessive tardiness, leaving and entering class frequently without notice of illness or other extenuating circumstances, and persisting in disruptive personal conversations with other class members. Please turn off phones, pagers, etc. during class unless instructed otherwise. Laptop computers may be used ONLY TO TAKE NOTES. If you choose not to adhere to these standards, I will take action in consultation with university administration (e.g., Dean of Undergraduate Studies, Student Conduct, Academic Advising).

Academic Accommodations:
If you need to request accommodation for a disability, you need a signed accommodation plan from Campus Health Services, and you need to provide a copy of that plan to me. Visit the Office of Student Affairs website for additional information and instruction related to accommodations.

What is the expected course schedule?

We will cover most of the following materials from the textbooks (Tentatively, may up to some perturbation)

Week 1	Introduction Chapter 2. Root-finding for nonlinear equations
Week 2	Chapter 2. Root-finding for nonlinear equations.
Week 3	Chapter 3. Interpolation theory.
Week 4	Chapter 4. Approximation of functions
Week 5	Chapter 5. Numerical integration (and differentiation).
Week 6	Chapter 6. Numerical methods for ordinary differential equation.
Week 7	Chapter 8. Numerical solution of systems of linear equations.