M 348: Scientific Computation in Numerical Analysis

The University of Texas at Austin, Spring 2022

Times: TuTh 2-3:30PM CT

Location: Face-to-face in PMA 5.122 (except for the first two weeks on Zoom)

Dates: 30 classes, Tu Jan 18 – Th May 5, with Tu Mar 15 and Th Mar 17 off

Supporting Media: Canvas and Piazza

Registrar Information: Unique # 53970 and QR Flag

Instructor: Prof. Joe Kileel, jkileel@math.utexas.edu

Office Hours: MonWedFri 2-3PM CT, simultaneously in POB 3.434 and on Zoom

Teaching Assistant: Mr. Chenyu Tian, chenyu@ices.utexas.edu

Office Hours: Wed 10AM-Noon CT, simultaneously in POB 5.308 and on Zoom

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Description: Solving scientific and engineering problems often requires the use of numerical methods and computers. This course teaches basic numerical methods, discusses their mathematical properties, and provides practice in computer programming. Topics include computer arithmetic, nonlinear algebraic equations, systems of linear algebraic equations, polynomial interpolation, numerical differentiation and integration, and initial-value problems for ordinary differential equations.

Prerequisites: CS 303E or 307 (or any introductory programming course) and M 341 or 340L with a grade of at least C-.

Required Textbook: Timothy Sauer, Numerical Analysis, 3rd Ed., 2017, Pearson

Programming Language: The course's official programming language will be Matlab. This is available and free for UT students, see `https://ut.service-now.com/sp?id=ut_bs_service_detail&sys_id=f9d65c7c4ff9d200f6897bcd0210c77d` Students will be introduced to Matlab through assignments, Sauer's book, as well as online resources. Students may obtain a computer account on the Mathematics network in the Undergraduate Computer Lab, PMA 7.122.

Homework: Homework and coding assignments will be assigned periodically. It is permitted for students to work together in groups. However each student must write up their own work individually.

Exams: Two 70-minute midterms will be held in class, tentatively on Thursday, February 24 and Thursday, April 7. A cumulative final exam will occur (tentatively) on Wednesday, May 11, 9AM-Noon CT.

Final Grade: In determining final letter grades on the plus/minus scale, homework

and coding assignments will count for 25%, each midterm will count for 20%, and the final exam will count for 35%. Your lowest homework score will be dropped. Letter grade cut-offs will be finalized after the final exam; however they will not be stricter than the following: A (100-90), A- (89-85), B+ (84-80), B (79-75), B- (74-70), C+ (69-65), C (64-61), C- (60-57), D (56-50), F (49-0). Throughout the semester, please check that your scores are recorded correctly in Canvas.

Tentative Course Plan: We will primarily study Chapters 0-3 and 5-6 of Sauer's book.

0. Fundamentals (~2 classes)
0.1. Evaluating a Polynomial
0.2. Binary Numbers
0.3. Floating Point Representation of Real Numbers
0.4. Loss of Significance

1. Solving Equations (~5 classes)
1.1. The Bisection Method
1.2. Fixed-Point Iteration
1.3. Limits of Accuracy
1.4. Newton's Method
1.5. Root-Finding without Derivatives
— Reality Check 1: Kinematics of the Stewart platform

2. Systems of Equations (~5 classes)
2.1. Gaussian Elimination
2.2. The LU Factorization
2.3. Sources of Error
2.4. The PA = LU Factorization
— Reality Check 2: The Euler-Bernoulli Beam

3. Interpolation (~5 classes)
3.1. Data and Interpolating Functions
3.2. Interpolation Error
3.3. Chebyshev Interpolation
3.4. Cubic Splines
3.5. Bezier Curves (if time permits)
— Reality Check 3: Fonts from Bezier curves

5. Numerical Differentiation and Integration (~5 classes)
5.1. Numerical Differentiation
5.2. Newton-Cotes Formulas for Numerical Integration
5.3. Romberg Integration
5.4. Adaptive Quadrature
5.5. Gaussian Quadrature
— Reality Check 5: Motion Control in Computer-Aided Modeling

6. Ordinary Differential Equations (~6 classes)
6.1. Initial Value Problems
6.2. Analysis of IVP Solvers
6.3. Systems of Ordinary Differential Equations
6.4. Runge-Kutta Methods and Applications

— Reality Check 6: The Tacoma Narrows Bridge

6.5. Variable Step-Size Methods

6.6. Implicit Methods and Stiff Equations

6.7. Multistep Methods

Accommodations: The University of Texas provides, upon request, academic accommodations for qualified students with disabilities. For more information, contact Services for Students with Disabilities at 512-471-6259 or ssd@austin.utexas.edu.

Student Honor Code: "As a student of The University of Texas at Austin, I shall abide by the core values of the University and uphold academic integrity."

Covid-19: You must follow all university and governmental rules. Please also exercise common sense. Legally, I am only allowed to encourage vaccine and mask use. Per UT Austin policy, lectures and office hours for the two weeks will be on Zoom.