M 348: Scientific Computation in Numerical Analysis

The University of Texas at Austin, Fall 2026

Times: TuTh 2-3:30PM CT
Location: Face-to-face in PMA 5.118
Dates: 28 classes, Tu Aug 25 – Th Dec 3, with Tu Nov 24 and Th Nov 26 off
Supporting Media: Canvas, `https://utexas.instructure.com/courses/1457395`
Registrar Information: Unique # 59160

Instructor: Joe Kileel, jkileel@math.utexas.edu
Office Hours: Wed 3-4:30PM CT in POB 3.434

Teaching Assistant: Michael Liu, Michael.Liu.2024@utexas.edu
Office Hours: TuTh 11AM-Noon CT in PMA 12.116

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. A complementary (implicit) goal of the course is for students to acquire understanding of some basic numerical methods that ultimately underpin some AI techniques.

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 languages are Matlab and Python. You are welcome to use either, although note that the textbook refers to Matlab. Matlab is free for UT students: `https://ut.service-now.com/sp?id=ut_bs_service_detail&sys_id=f9d65c7c4ff9d200f6897bcd0210c77d`. Python is open source: `https://www.python.org/`. Please confirm with the teaching assistant if you would like to use a different language. You may obtain a computer account on the Math network in the Undergraduate Computer Lab, PMA 7.122.

Homework: Homework and coding assignments will be assigned periodically. It is permitted (and indeed encouraged) for students to work together in groups.

Exams: Two 70-minute midterms will be held in class, tentatively on Tuesday, September 29 and Thursday, November 5 in PMA 5.118. A cumulative final exam will occur (tentatively) on Saturday, December 12, 8-10AM CT in PMA 5.118.

Final Grade: In determining final letter grades on the plus/minus scale, homework and coding assignments will count for 15%, each midterm will count for 25%, 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, 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 (~3 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

— Reality Check 3: Fonts from Bezier curves

5. Numerical Differentiation and Integration (~4 classes)

5.1. Numerical Differentiation

5.2. Newton-Cotes Formulas for Numerical Integration

5.4. Adaptive Quadrature

5.5. Gaussian Quadrature

— Reality Check 5: Motion Control in Computer-Aided Modeling

6. Ordinary Differential Equations (~4 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

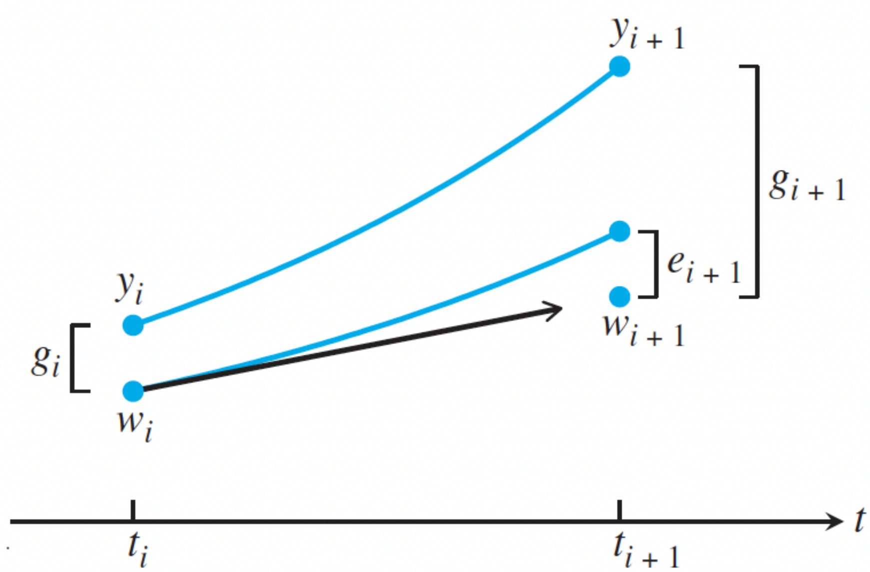
6.6. Implicit Methods and Stiff Equations

AI Policy: Generative AI use is permitted for assistance with the homework, provided that students 1) use AI responsibly, 2) conduct meaningful human review of output generated by AI, and 3) properly disclose AI use. Using generative AI tools without proper disclosure of the model and what it contributed may constitute academic misconduct under UT Austin's Institutional Rules. Also, note that while AI use is permitted in this course, it may not always be in your best interest, in terms of learning the material and getting ready for the exams.

Class Recordings: HOP 2-9970 prohibits students from recording class instruction (audio or video) unless a student obtains the instructor's permission or Disability & Access has approved audio recording as an accommodation.

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: "I pledge, as a member of the University of Texas community, to do my work honestly, respectfully, and through the intentional pursuit of learning and scholarship." The Institutional Rules include detailed descriptions of conduct and academic integrity standards: https://deanofstudents.utexas.edu/conduct/standardsofconduct.php.



A diagram illustrating what goes into the numerical analysis of an ordinary differential equation (ODE) solver. We will cover ordinary differential equations towards the end of the course. *Image credit:* Sauer, 3rd edition, page 306.