ENGR 504: Course Introduction (Fall 2024)

- scientific computing
- course information

Scientific computing

Scientific computing

- scientific computing involves developing and studying *numerical algorithms* for solving mathematical problems in various scientific and engineering fieleds
- most mathematical problems cannot be solved exactly (some can)
- use an iterative algorithm that ultimately converges to a solution

Numerical errors: numerical computing involves the presence of errors

- results of computations are approximate
- goal: ensure the resulting error is tolerably small

Problem solving process

- mathematical models formulated to explain observed phenomena
- develop algorithms for efficient, accurate, and reliable solutions
- implement algorithm in a computer to simulate the physical process numerically
- interpret and validate the computed results

General strategy for solving problems

replace a difficult problem with an easier one that has same or closely related solution

- replacing in infinite-dimensional spaces with finite-dimensional spaces
- replacing infinite processes with finite processes, such as replacing integrals or infinite series with finite sums, or derivatives with finite differences
- replacing differential equations with algebraic equations
- replacing nonlinear problems with linear problems
- replacing complicated functions with simple functions, such as polynomials
- replacing general matrices with matrices having a simpler form

Problem solving environment

high-level languages for numerical computing:

- MATLAB
- Julia
- Python
- R
- ...

Outline

- scientific computing
- **course information**

Course topics

- numerical errors and floating point numbers
- vectors and matrices with their practical examples
- numerical methods for solving linear equations
- linear and nonlinear least squares
- nonlinear equations and optimization
- eigenvalue problems
- numerical differentiation and integration
- applications in engineering, finance, data analysis,...

Course information

Main references

- S. Boyd and L. Vandenberghe. *Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares*. Cambridge University Press, 2018.
- U. M. Ascher. *A First Course on Numerical Methods*. Society for Industrial and Applied Mathematics, 2011.
- M. T. Heath. *Scientific Computing: An Introductory Survey* (revised second edition). Society for Industrial and Applied Mathematics, 2018.

Grading

- Homework (30%)
- Midterm exam (20%)
- Final exam (50%)

weights are approximate, and we reserve the right to adjust them if necessary

(see syllabus on Moodle for detailed information)