Course Summary

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Using numerical methods

1. Classify your problem
2. Choose a computational tool
3. Understand its capabilities

Types of numerical problems

- Systems of equations
  - underconstrained vs. square vs. overconstrained
  - linear vs. nonlinear
  - sparse vs. dense
- Approximation
  - approximating data points with curves
  - piecewise approximation
  - low-rank approximation
- Differential equations
  - ordinary vs. partial
  - initial value vs. boundary value

Computational tools

- Floating point numbers
- MATLAB
- Polynomials
- Matrix factorizations
  - LU
  - QR
  - SVD
- Iteration
  - bisection; Newton; secant
  - Euler; midpoint; Runge-Kutta
- Monte Carlo
  - error propagation simulation

Limits of tools

- For linear systems:
  - stability and pivoting
  - conditioning and accuracy
  - numerical rank
- For linear least squares:
  - conditioning and accuracy (normal equations vs. QR)
  - statistical evaluation of fitting results
- For nonlinear root finding
  - convergence rate; bracketing roots
- For ODEs:
  - stability
  - order of convergence (accuracy)