Introduction

CS 205A:
Mathematical Methods for Robotics, Vision, and Graphics

Doug James

Instructor

Prof. Doug James

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Course Assistants

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Section (optional)

Fridays, Time 11:30am-12:20pm

Location: 260-113

Optional, but useful.

Course assistants cover supplemental material

This Friday's section: "Introduction to Julia"

On the Web

Course website:
http://graphics.stanford.edu/courses/cs205a-18-winter
http://graphics.stanford.edu/courses/cs205a

Piazza:
https://piazza.com/stanford/winter2018/cs205a/

Gradescope: (Registration code: 9P584R)
https://gradescope.com/courses/13993

Office hours' Google Hangout: http://bit.ly/2pIpwyl

Texts

- **Text:** *Numerical Algorithms*, **Justin Solomon**
  - Book available online (**PDF**), in print, or as an electronic reader
  - Check course web page...
  - Contact Justin with typos
- **Optional text:** *Scientific Computing*, Heath

Course Breakdown

- **Homeworks (approx. weekly):** 60%
  Submit with *gradescope*
- **Midterm:** 15%
- **Final exam:** 25%
- **Participation:** $\pm 5\%$
  - Corrections or comments on text
  - Participation in lecture, office hours, and/or Piazza
  - Extra credit on homework

Quick Survey

- Program?
- Department?
- Math background?

Two Roles

- **Client** of numerical methods
- **Designer** of numerical methods

Course Topics I

1. **Numerics**
   - Stability and error analysis
   - Floating-point representations
2. **Linear algebra**
   - Gaussian elimination and LU
   - Column spaces and QR
   - Eigenproblems and SVD
   - Applications
3. **Root-finding and optimization**
   - Single-variable
   - Multivariable
   - Constrained optimization

Course Topics II

- Iterative linear solvers: Conjugate gradients and friends

4. **Interpolation and quadrature**
    - Approximating integrals
    - Approximating derivatives
5. **Differential equations**
    - ODEs: time-stepping, discretization
    - PDEs: Poisson equation, heat equation, waves
    - Techniques: Differencing, finite elements (time-permitting)

Programming in Julia

https://julialang.org

- A powerful modern programming language.
- Programming on each homework assignment!
- JuliaBox: Web-based Julia programming.
  - https://juliabox.com
  - No installation necessary.

Studying for 205A

Be creative!

- Try simple examples
- Write some code
- Re-derive on paper
- Draw pictures
- Ask questions

Official Prerequisites

Math 51: Linear Algebra and Multivariable Calculus

and

CS 106B: Programming Abstractions

Typical Linear Algebra

$$
\begin{aligned}
\|A\vec{x} - \vec{b}\|_2^2 &= (A\vec{x} - \vec{b}) \cdot (A\vec{x} - \vec{b}) \\
&= (A\vec{x} - \vec{b})^\top (A\vec{x} - \vec{b}) \\
&= (\vec{x}^\top A^\top - \vec{b}^\top)(A\vec{x} - \vec{b}) \\
&= \vec{x}^\top A^\top A\vec{x} - \vec{x}^\top A^\top \vec{b} - \vec{b}^\top A\vec{x} + \vec{b}^\top \vec{b} \\
&= \|A\vec{x}\|_2^2 - 2(A^\top \vec{b}) \cdot \vec{x} + \|\vec{b}\|_2^2
\end{aligned}
$$

Necessary Calculus

- Gradient vector ∇f for $f : \mathbb{R}^n \to \mathbb{R}$
- Jacobian Df for $f : \mathbb{R}^m \to \mathbb{R}^n$
- Lagrange multipliers:

$$\min_{\vec{x}\in\mathbb{R}^n} f(\vec{x})$$
$$\text{s.t. } g(\vec{x}) = 0$$

Homework 0

Out Thursday.
Due one week later (Thurs midnight)

To review (Chapter 1):

- Linear algebra
- Calculus

Make **ample use** of Piazza & office hours.
Submit online using **gradescope**.