The Professor
The Class — Overview
The Class...
Introduction
Academic Life
Non-Academic Life
Contact Information, Office Hours

1. Introduction — (1/26)

Academic Life

- MSc. Engineering Physics, Royal Institute of Technology (KTH), Stockholm, Sweden. Thesis Advisers: Michael Benedicks, Department of Mathematics KTH, and Erik Aurell, Stockholm University, Department of Mathematics. Thesis Topic: "A Renormalization Technique for Families with Flat Maxima."

Figure: Bifurcation diagram for the family $f_{a,2}$ [BLOMGREN-1994]

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Academic Life


Figure: The noisy (SNR = 4.62 dB), and recovered space curves. Notice how the edges are recovered. [BLOMGREN-1998]

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The Professor

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Non-Academic Life

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Academic Life

Postdoc

Research Associate. Stanford University, Department of Mathematics. Main Focus: Time Reversal and Imaging in Random Media (with George Papanicolaou, et. al.)

Figure: Comparison of the theoretical formula for a medium with \( L = 600 \, m, a_e = 195 \, m, \gamma = 2.12 \times 10^{-5} \, m^{-1} \). \textbf{[Left]} shows a homogeneous medium, \( \gamma = 0 \), with \( a = 40 \, m \) TRM (in red / wide Fresnel zone), and a random medium with \( \gamma = 2.12 \times 10^{-5} \) (in blue). \textbf{[Right]} shows \( \gamma = 0 \), with \( a = a_e = 195 \, m \) (in red), and \( \gamma = 2.12 \times 10^{-5} \, m^{-1} \), with \( a = 40 \, m \) (in blue). The match confirms the validity of [the theory]. [Blomgren-Papanicolaou-Zhao-2002]

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Primary Research Interests — Current

High Performance Computing

Development of algorithms achieving near-optimal GPU utilization, with applications to Computational PDEs, Computational Linear Algebra, and Computational Optimization.

Project #1: Fast Multipole Method for Waves over Vortices, w/Chris Curtis & Daniel Matteson. (S’21)

Project #2: StarPU + ScalFMM Implementation for the Fast Multipole Method, w/Susana Munguia Hernandez. (in progress)

Threadripper 3990X ~ $4,475
64 Cores, 128 Threads.

RTX 4090 ~ $1,599
16,384 CUDA Cores

Academic Life

Professor

Professor, SDSU, Department of Mathematics and Statistics. Projects: Computational Combustion, Biomedical Imaging (Mitochondrial Structures, Heartcell Contractility, Skin/Prostate Cancer Classification), carbon sequestration, compressed sensing.

Figure: [LEFT] Phase-space projections produced by the time coefficients of the POD decomposition of the rotating pattern shown in [RIGHT]. [Blomgren-Gasner-Palacios-2005]

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Fun Times... ⇔ Endurance Sports

Pre-Pandemic...

Triathlons:

- (13) Ironman distance (2.4 + 112 + 26.2) [PR] 11:48:57
- (16) Half Ironman distance 5:14:20

Running

- (1) 100k Race (62.1 miles) 15:37:46 (15:05/mi)
- (1) Trail Double-marathon (52 miles) 10:59:00 (12:32/mi)
- (5) Trail 50-mile races 9:08:46 (10:59/mi)
- (8) Trail 50k (31 mile) races 5:20:57 (10:20/mi)
- (16) Road/Trail Marathons 3:26:19 (7:52/mi)
- (30) Road/Trail Half Marathons 1:35:00 (7:15/mi)

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Contact Information

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       https://www.gradescope.com
       http://terminus.sdsu.edu/SDSU/Math543
Office Hours  https://calendly.com/blomgren_sdsu/
(see Canvas / Calendly for Hours)

The Post(?) Pandemic Reality

- Spring 2020: We went online part-way thru the semester
- Spring 2021: Zoom-U
- Spring 2022: Masked-U — not a good semester (many reasons)
- Spring 2023: The New Normal™... some modifications.

During COVID we all de-socialized to some extent; and there is definitely a "learning gap."

There is sometimes a tendency to see all this silly learning and class work as unnecessary obstacles to getting a degree.

... of least resistance and have Uncle Google, Aunt Wiki, Scuzzy Cousin Chegg, Skynet, or ChatGPT do all the heavy lifting...

Math 543: Literature

"Required" —


"Required" — (Supplemental)

Class notes and class web-page.

* SIAM members receive special pricing (30% off). SIAM student membership is free.
Math 543: Literature

Everything You Ever Wanted to Know, but Were Afraid to Ask...

“Optional” — (Classic, Comprehensive Reference)


“Optional” — (Comprehensive Reference)


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Math 543: Introduction — Grading etc.

50% Homework: both theoretical, and implementation (programming) — Recommended languages: Python, Matlab, C/C++, or Fortran; however anything goes: 6510 assembler, Java, M$-D$, Haskell...

25% Midterm: $\frac{1}{2}$ Take-Home, and $\frac{1}{2}$ In-Class.

25% Final: $\frac{1}{2}$ Take-Home, and $\frac{1}{2}$ In-Class.

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Expectations and Procedures, I

- Most class attendance is “OPTIONAL” — Homework and announcements will be posted on the class web page. If/when you attend class:
  - Please be on time.
  - Please pay attention.
  - Please turn off mobile phones.
  - Please be courteous to other students and the instructor.
  - Abide by university statutes, and all applicable local, state, and federal laws.
Expectations and Procedures, II

- Please, turn in assignments on time. (The instructor reserves the right not to accept late assignments.)
- The instructor will make special arrangements for students with documented learning disabilities and will try to make accommodations for other unforeseen circumstances, e.g. illness, personal/family crises, etc. in a way that is fair to all students enrolled in the class. Please contact the instructor EARLY regarding special circumstances.
- Students are expected and encouraged to ask questions in class!
- Students are expected and encouraged to make use of office hours! If you cannot make it to the scheduled office hours: contact the instructor to schedule an appointment!

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Expectations and Procedures, III

- Missed midterm exams: Don’t miss exams! The instructor reserves the right to schedule make-up exams, make such exams oral presentation, and/or base the grade solely on other work (including the final exam).
- Missed final exam: Don’t miss the final! Contact the instructor ASAP or a grade of incomplete or F will be assigned.

**Academic honesty**: submit your own work — but feel free to discuss homework with other students in the class!

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Late HW Policy

- Assignments accepted up to 24 hours after original deadline, with a 10% penalty.
- Further extensions will only be granted in extreme, well-documented, circumstances.

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Honesty Pledges, I

- The following **Honesty Pledge** must be included in all programs you submit (as part of homework and/or projects):
  - I, [your name], pledge that this program is completely my own work, and that I did not take, borrow or steal code from any other person — real or artificial — and that I did not allow any other person to use, have, borrow or steal portions of my code. I understand that if I violate this honesty pledge, I am subject to disciplinary action pursuant to the appropriate sections of the San Diego State University Policies.

- Work missing the honesty pledge may not be graded!
Honesty Pledges, II

- Larger reports must contain the following text:
  - I, [your name], pledge that this report is completely my own work, and that I did not take, borrow or steal any portions from any other person — real or artificial — and that I did not allow any other person to use, have, borrow or steal portions of my report. Any and all references I used are clearly cited in the text. I understand that if I violate this honesty pledge, I am subject to disciplinary action pursuant to the appropriate sections of the San Diego State University Policies. [Your signature].

- Work missing the honesty pledge may not be graded!

Math 543: Computer Resources

You need access to a computing environment in which to write your code; — you may want to use any combination of Matlab (for quick prototyping and short homework assignments) and other languages; e.g. Python, C/C++ or Fortran (or something completely different, like Java or M$^\text{-D}$).

Free C/C++ and Fortran compilers are available for Linux/UNIX.

SDSU students can download a copy of matlab from https://www.mathworks.com/academia/ta-h-portal/san-diego-state-university-1108597.html [Licensing Subject to Change With Minimal Notice]

Math 543: Introduction — What you should know already

**Prerequisite:** Math 340

340 ⇒ Programming in Mathematics
- Introduction to programming in mathematics. Modelling, problem solving, visualization.

**Prerequisite:** Math 254 or Math 342A or AE 280

254 ∩ 342A ∩ AE 280 ⇒ Basic Linear Algebra
- Vectors, Matrices, Eigenvalues and Eigenvectors

\[
\vec{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}, \quad A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} = \begin{bmatrix} \vec{a}_1 \\ \vec{a}_2 \\ \vdots \\ \vec{a}_n \end{bmatrix}
\]

Solution of linear systems and eigenvalue problems show up in many applications in applied & computational mathematics / sciences / engineering.

Although we probably know about Gaussian Elimination for solving

\[
\vec{x} = A^{-1}\vec{b}, \quad \text{where } A \in \mathbb{R}^{n \times n}, \, \vec{x}, \vec{b} \in \mathbb{R}^n
\]

in infinite precision (by hand), finding this solution (or at least a good approximation thereof) in finite precision (i.e. on a computer) is sometimes a challenge — especially if we need the solution fast...
Math 543: Introduction — Why???

The computational complexity (number of operations needed) for Gaussian Elimination is $O(n^3)$, which is quite slow as $n$ grows "large."

Applications (sources of Numerical Linear Algebra problems):
- Solution of partial differential equations (PDEs)
- Optimization (Operations Research)
- Model Analysis and Fitting (Least Squares)
- Image Processing
- Protein Folding
- DNA sequencing, etc. etc. etc.
- Data Science, Machine Learning, AI, etc...

Math 543: Introduction — What We Will Discuss

- $A\tilde{x} = \tilde{b}$,
- $A\tilde{x} = \lambda\tilde{x}$,
- $Q^T AQ = \Lambda = \text{diag}(\lambda_1, \lambda_2, \ldots, \lambda_n), \quad A = U\Sigma V^*$

- QR-Factorization / Least Squares
- The S\text{ingular V}\text{alue D}ecomposition
- Conditioning and Stability
- Gaussian Elimination, Pivoting
  $\Rightarrow$ LU- and Cholesky-factorization
- Eigenvalue Problems
- Iterative Methods
  $\Rightarrow$ Arnoldi, GMRES, Lanczos, Conjugate Gradients