

Advanced Seminar in Applied Mathematics

Nir Sharon

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1 Seminar description

The seminar's goal is to expose students with sufficient mathematical backgrounds to advanced topics in applied and computational mathematics. In particular, we wish to mark the following targets:

- Learning essential topics that usually do not get the center of attention in standard undergraduate courses.
- Experiencing an academic study in a small group with a research flavor and facing peer-reviewing on both sides of the process.
- Presenting advanced mathematical material in front of an “expert” audience.

2 Admin: Time, place, prerequisites

Course name: *Applied Math Seminar*
Course #: *0366-3013-01*
Time: *Tuesday 12:00-14:00*
Place: *Zoom or in-person meetings, according to the most recent directions. See website for updates.*
Contact: *Nir Sharon, Schreiber 121, nsharon@tauex.tau.ac.il*
Prerequisite: *advanced curiosity, calculus, linear algebra, numerical analysis.*
Recommended: *probability, graph and group theory.*

3 Guidelines, requirements, and grading

1. **Attendance** in all classes is mandatory. Any missed class must be approved in advance. (10% of the total grade).
2. Each student should **lecture for 1 hour** and **prepare a short abstract** on his presentation subject to publish a week before the talk. (80% of the total grade).
3. Each talk should be self-contained and include the required background. Do not hesitate to repeat things that have been presented in other talks, if necessary.
4. Examples and demonstrations, live code examples are greatly appreciated.
5. Slides can be in English or Hebrew, your choice.
6. **Peer-reviewing** each student will be assigned to two lectures **as a referee**. The referring includes reading background on the topic and prepare a reports. The report should be submitted up to a day after the talk. (10% of the total grade).

4 Schedule and tentative subjects selection

In the next table, you will find the dates of seminar meetings and suggested topics. This is a preliminary setting, where in practice, we don't have to strictly follow it.

Date	Main Topic	A provisional title
9/3	Welcome	Introduction to the seminar and its topics
16/3	20th Century's Most Important Algorithms	<ul style="list-style-type: none"> • Fast Fourier Transform (FFT) • Fast Multipole Method (FMM)
6/4	NUFFT — where real-world meets FFT	<ul style="list-style-type: none"> • NUFFT part 1 • NUFFT part 2
13/4	The sphere — a numerical perspective	<ul style="list-style-type: none"> • Spherical Harmonics • Integration over the sphere.
20/4	Introduction to optimization	<ul style="list-style-type: none"> • Convex optimization • Non-convex optimization
27/4	Advanced optimization	<ul style="list-style-type: none"> • Optimization on Lie groups • Stochastic Gradient Descent
4/5	Introduction to learning	<ul style="list-style-type: none"> • The fundamentals of learning • Classification and nearest neighbors algorithm
11/5	Learning and classification	<ul style="list-style-type: none"> • Classification: logistic regression, LDA, QDA • Boosting and Adaboost algorithm
18/5	PCA: Principal components analysis	<ul style="list-style-type: none"> • PCA part 1 • PCA part 2
25/5	Dimension reduction	<ul style="list-style-type: none"> • JL lemma and random projections • Laplacian eigenmaps
1/6	Mathematics in applications	<ul style="list-style-type: none"> • Radon transform • Group theory and applications
1/6	Randomness in computations	<ul style="list-style-type: none"> • Fast Randomized SVD • Sampling and its applications
15/6	Open subject*	

*Examples of other possible subjects (contingent upon approval): Neural Nets in inverse problems, synchronization over groups, EM algorithm, etc.