Mathematical Techniques for Engineers – Spring 2016

Course Description

Engineers need a broad perspective in order to approach problems from different viewpoints. However, by specializing in a specific field, engineers might miss out on some of the techniques used by other disciplines, which could in turn have expanded their skillsets.

This course seeks to introduce several of these methods. Topics range broadly, from physics to computer science to finance, but there is a sequential connection between topics. For a complete list of topics, see the course schedule below.

These topics will be developed through a case study, where each week problems in a different field are solved by establishing the appropriate mathematical framework. There is a heavy emphasis on problem solving.

Students will also visualize their answers in Mathematica and learn how to use the professional typesetting system LaTeX, an academic and industry standard.

Prerequisites

This course assumes knowledge of single-variable calculus. Anything past this level of mathematics will help but is not required.

Course Instructor

For class-related questions, comments, or concerns, contact the course instructor.

Arun Kannan – 1st year Computer Science/Mathematics double major

Email: arun@virginia.edu

Professor of Contact

If a student has a serious issue with the class, grades, or teacher, contact the supervising professor.

Gianluca Guadagni – Applied Mathematics Professor

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Course Materials

The course will use supplemental handouts produced by the instructor and online readings.

Grading Policy

Grades in this course are based on attendance and weekly problem sets. Problem sets account for 60% of the total grade, and attendance the remaining 40%. Problem sets are graded on effort and completion. Coming to class and being a participant are criteria for attendance.

Schedule

Week	Lecture Topic	HW Due	Field of Interest and Some Applications
1	Introductory Mathematical Techniques, Part 1 -Integration Techniques -Approximations: Series and Integral Bounds		Computational Mathematics: Numerical analysis, estimation, data interpretation
2	Introductory Mathematical Techniques, Part 2 -Asymptotic Expansions -Numerical Methods	PS 1, RD 2	Computational Mathematics: Numerical analysis, estimation, data interpretation
3	Material Balances -Steady-State Conditions	PS 2, RD 3	Chemical Engineering: Reactor processes and constraints, massive physical systems
4	Regression and Generalizations -Best Linear Unbiased Estimator -Applications	PS 3, RD 4	Statistics: Decision-making, generalized curve-fitting, data interpretation
5	Fourier Analysis, Part 1 -Fourier Series and Fourier Transform	PS 4, RD 5	Computational Mathematics: Numerical analysis, estimation, data interpretation
6	Fourier Analysis, Part 2 -Schrödinger Equation	PS 5, RD 6	Physics: Mathematical modelling of physical phenomena, data visualization
7	Fourier Analysis, Part 3 -Signal Processing	PS 6, RD 7	Electrical Engineering: Image and signal processing
8	Dynamic Programming and Djikstra's Algorithm	PS 7, RD 8	Computer Science: Google Maps, DNA sequencing
9	Markov Chains and Random Walks, Part 1	PS 8, RD 9	Mathematics and Computer Science: Google Search, applications to neural networks
10	Markov Chains and Random Walks, Part 2	PS 9, RD 10	Mathematics and Computer Science: Prediction of various phenomena
11	The Black-Scholes Model, Part 1	PS 10, RD 11	Finance: Market prediction and analysis
12	The Black-Scholes Model, Part 2	PS 11, RD 12	Finance: Market prediction and analysis

For clarification, problem set (PS) 3, for example, has problems from material covered in week 3. Reading (RD) 3 would prepare students for the lecture during week 3.

Should there be additional time during the semester, there are a wide variety of topics that can be covered, including:

1. Maxwell's Equations (Physics)
2. Oscillations (Materials Science and Mechanical Engineering)
3. Operatory Theory (Mathematics and Physics)
4. Probability (Mathematics)
5. Circuitry (Electrical and Biomedical Engineering)