ROB 501: Mathematics for Robotics

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Class Periods: Lecture meets T-Th, 10:30 to 12:00, in 1500 EECS. Lectures will be recorded and posted to Canvas.

Due to the extra-large class size, there will be two UNOFFICIAL recitation sessions created once the CoE allows us to schedule additional classrooms. Their time is NOT currently known. Attendance is NOT required. No new material will be covered in the recitation sessions. They are meant to assist with HW and to provide an organized place for you to ask additional questions.

Textbook: There is no textbook for the course. Material will be posted on Canvas.

Topics: Applied mathematics for robotics engineers. Topics include proof techniques, vectors spaces, orthogonal bases, projection theorem, least squares, recursive least squares, matrix factorizations, Kalman filter and extensions, underlying probabilistic notions, elementary real analysis in R^n, convergent sequences, contraction mappings, Newton Raphson algorithm, nonlinear constrained optimization, local vs global convergence, convexity, linear and quadratic programs.

Grading Scheme: (no absolute scale of 90-100% = A, etc.)

Homework[1](weekly)		10%
Exams[2]		90%
	Total	100%

[1]The idea is that exams are worth lots of points (I grade them!), whereas homework is for practice, clarifying certain principles, etc. I will NOT grade them personally. Your two lowest HW scores will be dropped. **NO LATE HW ACCEPTED**. HW will be due on Thursday, submitted online via gradescope (details posted later). HW sets will be based on the HW problems from last year. You can probably find HW solutions from the previous year if you really want them. Other than being dishonest, if that is how you do your HW, then the exams will seem very hard.

[2]The **Final Exam** will be given on the day and time fixed by the registrar, which is **Tuesday, December 19, 10:30 am – 12:30 pm.** No *exceptions for early exams can be made.* There will be a single midterm exam on Tuesday October 31, 6 PM to 8 PM. In compensation for the evening midterm exam, one lecture will be canceled to help accommodate my travel. Having 90% of your grade based on two exams sounds terrible, but you can ask around and find out that I am fair about grades.

BACKGROUND

Prerequisites: Graduate standing or permission of the instructor.

My assumptions: (i) you know basic matrix algebra, such as how to multiply and invert matrices, what is the rank of a matrix, and how to compute eigenvectors; (ii) you have had a course in probability and know how to compute means and variances given a density of a continuous random variable, and you have seen what is a conditional probability and how to compute it; (iii) you took vector calculus and will review how to compute gradients of functions and what is the method of Lagrange multipliers; (iv) simple properties of complex numbers; and (v) you know or will learn on your own how to use MATLAB (plotting, various types of multiplication, such as * vs .* (star vs dot star), writing a for loop, using the help command or searching on the web for commands).

APPROXIMATE SYLLABUS

1. Proof techniques (2 Lectures)
2. Abstract linear algebra fundamentals (5 Lectures)
3. Least squares problems, projection theorem, and the normal equations (3-4 Lectures)
4. Some advanced properties of matrices (2 to 3 Lectures)
5. Filtering I: (2 Lectures)
6. Review of random variables and joint probability distributions (1 to 2 Lectures)
7. Filtering II: Kalman filter and extensions (2 to 3 Lectures)
8. Introduction to real analysis in R^n (4 to 6 Lectures)
9. Convex sets and functions (1 Lecture)
10. Users tour of optimization (1 Lecture)

HW Scoring: (Each Problem)

a) **three** (3) points if the problem is perfectly correct or nearly so. Of course, "nearly so" is a subjective evaluation. I don't consider a numerical mistake to be important if it doesn't change the basic problem nor lead to greatly simplified reasoning. I am always concerned about conceptual errors.
b) **two** (2) points if there are several minor errors or at least one major error, but it is clear that the person had a good idea of how to work the problem
c) **one** (1) point if the problem was attempted, but the reasoning is quite wrong, quite incomplete, or if the solution was unreadable (illegible writing, undefined notation, etc.)
d) **zero** (0) points only if the problem was not attempted.

The total number of points for each HW set will vary from week to week because the number of assigned problems will vary. At the end of the term, when computing HW averages, each HW set will be normalized to a score of 100%.