Robotics 811, Fall 2009

Math Fundamentals for Robotics

URL: `http://www.cs.cmu.edu/~me/811`

Professor:	Michael Erdmann (me at -nospam- cmu.edu)
TA:	Alberto Rodriguez (albertor at -nospam- cmu.edu)
Location:	Scaife Hall 125
Time:	T,TH 3:00-4:20

1 Course Outline

This course covers selected topics in applied mathematics, taken from the following list:

1. Solution of Linear Equations.
2. Polynomial Interpolation and Approximation.
3. Solution of Nonlinear Equations.
4. Roots of Polynomials, Resultants.
5. Approximation by Orthogonal Functions (includes Fourier series).
6. Integration of Ordinary Differential Equations.
7. Optimization.
8. Calculus of Variations (with applications to Mechanics).
9. Probability and Stochastic Processes (Markov chains).
10. Computational Geometry.
11. Differential Geometry.

2 Course Activity

This is a graduate course. You are thus expected to pursue ideas and topics discussed in this course on your own beyond the level of the lectures. My aim is to cover some of the easy early material quickly, then spend more detailed time on the later material. My goal throughout the course is to acquaint you with fundamental algorithms and mathematical reasoning, as well as give you some implementation experience.

The course grade will be determined by performance on assignments, participation in class, and a class project. Class assignments will entail solving some problems on paper or implementing some of the algorithms discussed in the course.

The term project should take about a month of work (40 hours). It should pursue a mathematical topic in detail that is not otherwise covered in detail in the course. Ideally, the project should be connected to your research. If you are a first year graduate student, you should view the project as a springboard to research involvement. Typical project writeups are 5-10 pages long. Projects are due the last day of class. If there is time we will use the last week of class for project presentations.

3 Bibliography

The main text for this course is:

W. H. Press, B. P. Flannery, S. A. Teukolsky, and W. T. Vetterling. *Numerical Recipes in C.* Cambridge University Press. (Any edition.)

Secondary references include (in approximate order of the material covered):

- G. Strang. *Introduction to Applied Mathematics.* Wellesley-Cambridge Press. 1986.
- G. H. Golub and C. F. Van Loan. *Matrix Computations.* Johns Hopkins University Press. 1983.
- S. D. Conte and C. de Boor. *Elementary Numerical Analysis.* Third edition. McGraw-Hill. 1980.
- G. E. Forsythe, M. A. Malcolm, and C. B. Moler. *Computer Methods for Mathematical Computations.* Prentice-Hall. 1977.
- D. G. Luenberger. *Introduction to Linear and Nonlinear Programming.* Addison-Wesley. 1973.
- J.-C. Latombe, *Robot Motion Planning*, Kluwer Academic Publishers, Boston, 1991.
- R. Weinstock. *Calculus of Variations.* Dover Publications. 1974. (Reprint of 1952 McGraw-Hill edition.)
- R. Courant and D. Hilbert. *Methods of Mathematical Physics.* Volume I. John Wiley and Sons. 1989. (Reprint of 1953 Interscience edition.)
- W. Feller. *An Introduction to Probability Theory and Its Applications.* Volume 1. Third edition. John Wiley and Sons. 1968.
- F. P. Preparata and M. I. Shamos, *Computational Geometry*, Springer-Verlag, New York, 1985. (Corrected and expanded printing: 1988.)
- B. O'Neill, *Elementary Differential Geometry*, Academic Press, New York, 1966. 2nd Edition: 1997.