Summer 2009 Course Offering
ECE6930 *Solving Mathematical Problems with MATLAB*
Dept. of Electrical and Computer Engineering,
Utah State University

Course Syllabus

Course Title: *Solving Mathematical Problems with MATLAB*
Online registration information:
SR 36348 ECE 6930 ST: SOLVING MATH PRBLMS MATLAB, section 003.

Course First offered: Summer 2009 Course for ECE Dept. of Utah State University.

Target audience: Seniors/graduates of electrical engineering or computer engineering

Lead Instructor:
Dingyu Xue, Visiting Professor, DPhil,
CSOIS, ECE Dept. of Utah State University
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Co-Instructor:
YangQuan Chen, Associate Professor, Ph.D.
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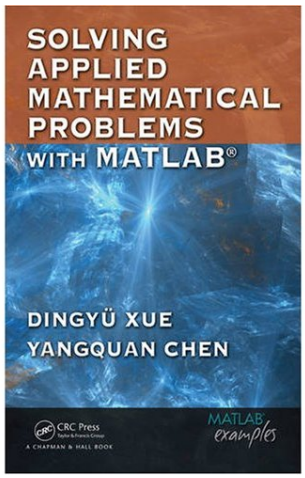

Office Hours: Thursdays, 9-11:30AM

Lecture Time: Thursdays, 12:00-5:00PM
Lecture Place: ENLAB109
First Lecture: Tuesday, June 16, 2009. **(*not* June 11th)**
Final Exam: Last week of July 2009.

Text (Will be given to students in parts for FREE!):

- Xue Dingyu and Chen YangQuan. Solving applied mathematical problems with MATLAB", Boca Raton: CRC Press, 2008. (ISBN：978-1420082500) 1300 pages of interactive PPT for CAI purposes are provided with the book plus a companion CD.

Other References:

1. MathWorks, MATLAB/Simulink manuals, with all PDFs available from MathWorks
2. Other related books for teaching mathematics using MATLAB.

Prerequisites:

Undergraduate mathematics courses on calculus, linear algebra. It is better to have some background of other mathematics courses, but not necessary.

Motivation of the Course:

Computational Thinking[1],coined and promoted by JeannetteWing of Carnegie Mellon University, is getting more and more attention. "It represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use" as acknowledged by Dr. Wing, "Computational Thinking draws on math as its foundations." The present course responds to "Computational Thinking" by offering the readers enhanced math problem solving ability and therefore, the readers can focus more on "*Computational Thinking*" instead of "*Computational Doing*."

The breadth and depth of one's mathematical knowledge might not match his or her ability to solve mathematical problems. In today's applied science and applied engineering, one usually needs to get the mathematical problems at hand solved efficiently in a timely manner without complete understanding of the numerical techniques involved in the solution process. Therefore, today, arguably, it is a trend to focus more on how to formulate the problem in a form suitable for computer solution and on the interpretation of the results generated from the computer. We further argue that, even without a complete preparation of mathematics, it is possible to solve some advanced mathematical problems using a computer. We hope this course is useful for those who frequently feel that their level of math preparation is not high enough because they still can get their math problems at hand solved with the encouragement gained from reading the textbook used for this course.

Using computers to solve mathematical problems today is ubiquitous. MATLABr/Simulink is considered as the dominant software platform for applied math related topics. Sometimes, one simply does not know one's problem could be solved in a much simpler way in MATLAB or Simulink. From what Confucius wrote, "The craftsman who wishes to work well has first to sharpen his implements,"[2] it is clear that MATLAB is the right, already sharpened "implement." However, a bothering practical problem is this: MATLAB documentation only shows "this function performs this," and what a user with a mathematical problem at hand wants is, "Given this math problem, through what reformulation and then use of what functions will get the problem solved." Frequently, it is very easy for one to get lost in thousands of functions offered in MATLAB plus the same amount, if not more, of functions contributed by the MATLAB users community. Therefore, the major

[1] http://www.cs.cmu.edu/afs/cs/usr/wing/www/Computational Thinking.pdf
[2] Confucius. http://www.confucius.org/lunyu/ed1509.htm

contribution of this course is to bridge the gap between “problems” and “solutions” through well grouped topics and tightly yet smoothly glued MATLAB example scripts and reproducible MATLAB-generated plots.

In summary, there is an urgent need for engineering students to enhance their problem solving techniques using MATLAB/Simulink. This summer course responds this need.

Outline of the Course:

Chapter 1 – Introduction to “Computer based mathematics languages”
- Why MATLAB?
- Historical review of mathematics via computers.

Chapter 2 – Essentials of MATLAB Programming
- Data Types in MATLAB
- Flow charts with loops, conditions, switches and try catches
- M-function programming
- 2D Graphics and Visualization
- 3D Graphics and Visualization

Chapter 3 – Solving Calculus Problems
- Single-variable and multivariable calculus (limitations, differentiations and integrations)
- Series expansions and summations (Taylor and Fourier)
- Numerical differentiations and integrations
- Path and surface integrations

Chapter 4 – Solving Linear Algebra Problems
- Matrix representation in MATLAB
- Matrix Analysis (determinants, ranks, eigen-systems and norms)
- Matrix Decompositions
- Matrix Equation Solutions
- Matrix Functions

Chapter 5 – Solving Integral Transforms and Complex Variable Function Problems
- Laplace Transforms
- Fourier Transforms
- Z Transforms
- Other Transforms (Hankel and Mellion)
- Singular Points, Residues and Loop Integrals

Chapter 6 – Solving Equations and Optimization Problems
- Equation Solutions (analytical and numerical)
- Unconstrained Optimization
- Constrained Programming (Linear, quadratic and others)
- Integer Programming and Binary Programming
- Mini-max Programming

Chapter 7 – Solving Differential Equation Problems
- Analytical solutions
- Initial Value ODE in MATLAB

- Special Forms of ODEs (DAE, stiff, delayed, switched ODEs)
- Boundary Value ODEs
- Block Diagram based Solutions to ODEs/
- Partial Differential Equations

Chapter 8 – Solving Data Interpolation and Data Fitting Problems

- Interpolations Problem Solutions
- Splines with Numerical differentiation and Integrations
- Function Fitting via Experimental Data
- Introduction to Filtering and Data Processing

Chapter 9 – Solving Probability and Statistics Problems

- Pseudo Random Number Generation and Probability evaluations
- Statistical Analysis
- Hypothesis Tests
- Variance Analysis

Chapter 10 – Solving Non-classical Mathematics Problems

- Fuzzy Logic and Inference
- Neural Nets in Data Processing
- Evolution Algorithms in Optimization (GAs and PSOs)
- Wavelets in Data Filtering
- Rough Sets
- Fractional-order Derivatives and Applications

Grading

Scores will be weighted as follows:

- Homework & Computer Assignments 40%
- Midterm 20%
- Final Exam 20%
- Comprehensive Project 20%
- Total 100%

Grades will be computed according to the following scale:

- A > 93%
- A- > 90%
- B+ > 87%
- B > 84%
- B- > 80%
- C+ > 77%
- C > 74%
- C- > 70%
- D+ > 67%
- D > 64%
- D- > 60%
- F < 60%

Introduction to instructors

Lead-Instructor:
Dingyu Xue received his doctorate in control engineering from Sussex University, UK in 1992. He joined the Northeastern University, China in 1993 and was employed as a professor in 1997. He is devoted to the work on MATLAB based education on mathematics, computer simulation and computer-aided control design, and published a few influential textbooks, two of which are in English. He is interested in the research of fractional-order control systems. He will be a visiting professor hosted by CSOIS from June to August 2009.

Co-Instructor:
YangQuan Chen is an Associate Professor of Electrical and Computer Engineering. His current areas of research interests include: distributed measurement and distributed control of distributed parameter systems using mobile actuator and sensor networks, mechatronics and controls (intelligent, optimal, robust, nonlinear and adaptive), applied fractional calculus, UAV cooperative control for remote sensing and real time water management and irrigation control. He holds 13 granted and 2 pending US patents. He is an author of two research monographs (Springer-Verlag 1999, 2007), 5 textbooks (SIAM Press 2007; Taylor & Francis/CRC 2008 and Tsinghua University Press 2002, 2004, 2007) and over 100 refereed journal papers.