

EECE 502: *Mathematical Methods in Engineering*

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Text: *Mathematical Methods in Chemical Engineering* by Arvind Varma and Massimo Morbidelli, Oxford University Press, New York, 1997. Handouts, lecture notes and references constitute additional course material. Class meets *TuTh 4-5:30 p.m.* unless other special arrangements are made.

Grading: 10% for homework exercises, 20% each for 3 in class tests, 30% for term project (due **December 19, 2007**)

Syllabus

1. Tensors, Matrices and Their Applications, Tensor Algebra and Elements of Tensor Calculus, Numerical Linear Algebra: Solution of Systems of Linear and Nonlinear Algebraic Equations and the Algebraic Eigenvalue Problem (Chapter 1, class notes and handouts)
2. Advanced Topics in ODEs: General Results for Systems of Linear First Order ODEs, Phase Portraits of multi-dimensional Linear Systems, Nonlinear Systems, Elementary Stability and Bifurcation Analysis, Green's Function, Series Solutions and Special Functions, Orthogonal Polynomials, Differential Eigenvalue Problems, Sturm-Liouville Problems (Chapters 3-4, class notes and handouts)
3. PDEs: Classification and General Results including the Maximum Principle, Detailed discussion of Laplace's, Wave and Diffusion Equations (class notes and handouts); Boundary Conditions; External vs. Internal Problems; Finite, Semi-Infinite and Infinite Spatial Domains; Solution in Different Coordinate Systems
4. Analytical Methods for Partial Differential Equations: Selected Topics from Chapters 5, 7 & 8, PDEs arising from models for Reaction-Diffusion-Convection Phenomena, Instability and Pattern Formation in Systems Governed by PDEs.
5. Numerical Solution to ODEs and PDEs: Finite Difference Method, Method of Weighted Residuals, Pseudo-Spectral Methods, Introduction to Finite Element Method and Femlab©
6. Perturbation Methods: Regular and Singular Perturbation, Method of Multiple Scales, Homogenization (Chapter 9)
7. Introduction to Lattice Methods, Stochastic Simulation Techniques

Objectives

Mathematical tools are indispensable to process modeling and analysis, engineering design and research. The objective of EECE 502 is to introduce a spectrum of widely used mathematical methods in chemical engineering to help solve problems commonly encountered in practice and/or graduate research projects.

The term mathematical methods should be viewed in a modern context. Dimensional analysis, scaling arguments and considerations of orders of magnitude (e.g. Astarita, *Chemical Engineering Science* **52**:4681-98, 1997) are powerful tools. Analytical methods help derive closed form solutions, especially for linear equations. Although these traditional tools form the backbone of engineering analysis, it is important to recognize the increasing role of computer simulations based on first principle models in engineering R&D.

EECE 502 will emphasize analytical techniques. In addition, numerical solution of prototypical problems such as solution of a system of linear equations, solution of the algebraic eigenvalue problem and Finite Difference/Spectral Collocation/Finite Element methods for numerical solution of ordinary and partial differential equations will be discussed. Whenever possible, computer programs will be given out and homework problems that require their use will be assigned. Some exposure to commercial software such as Femlab © will also be provided as time permits.