

# Math 7450 syllabus

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**OBJECTIVES:** The course will cover topics of current interest in mathematical modeling. Topics include (but not limited to), continuous time and discrete time models in physical, chemical and biological systems. Applications in engineering and finance will be also addressed.

- To integrate analytical and computational techniques in the mathematical modeling of complex problems in physical chemical and biological systems.
- The course will provide an integrated approach of theoretical and computational techniques, parameter estimation and model validations methods.

**REQUIREMENTS:** In general, you are expected to

1. write codes in C++ to implement algorithms and numerical methods;
2. Review linear algebra concepts other wise All mathematics required is self contained.

## 1 Prerequisite

COMS 6100 and COMS 6500.

## 2 Textbook

Mathematical and Experimental modeling by H.T. Banks and H.T. Tran.  
The material covered in the course is not be limited to this textbook.

### **3 Course content**

#### **3.1 Foundations of modeling**

Modeling philosophy; Simulation vs. Analytic results; Stochastic vs. Deterministic Models; Fundamentals of Modeling; Validity and Purpose of Models

#### **3.2 Differential Equations**

Forward problems and inverse Problems; Mechanical Vibrations; Mathematical and statistical aspects of inverse problems; Stability analysis; Case study; Implementation in C++; Matlab and Maple.

#### **3.3 Stochastic modeling and simulation**

Master Equation; Markov Chains; Analyzing Markov Chains; Stochastic Differential equations; Case studies

#### **3.4 stochastic Differential Equations**

Solving scalar Stratonovich SDEs; Linear Scalar SDEs; Additive noise and multiplicative noise; Linear scalar SDEs; Moment equations; Scalar SDEs reducible to linear SDEs; Vector SDEs; Vector Ito Formula; Fokker-Planck Equation; Vector Linear SDE; Moment Equations; Linearization; Vector Stratonovich SDEs; Numerical Methods for SDEs; Stability analysis of numerical methods; Case studies; implementation in C++; Maple and Matlab.

#### **3.5 Simulating Biochemical Systems**

The Gillespie Algorithms; Gillespie's Direct Method; Gillespie's First Reaction Method; Implementation of the direct method; Reactions; The Gibson-Bruck Algorithm. A constant time method; Practical implementation considerations; The Tau Leap Method; Implementations in C++.

#### **3.6 Agent Based Models**

Mathematical and computational Modeling; Limits to modeling; Agent based Models; Implementing agent based model in C++, Java and Matlab; Case

study; General considerations when analyzing a model

## 4 Grading policy

Two take home tests will be given which will count 50 percent towards the Final grade and homework problems count 20 percent toward the final grade. Final examination: A project which will have a graded written and presentation component count 30 percent.

Final Examination date is on December 15, 2011.

90-100 A, 80-89 B, 70-79 C, 60- 69 D Below 60 F.

The Grade I indicates that the student has not completed all course requirements because of illness or other uncontrollable circumstances especially which may occur toward the close of the term. Mere failure to makeup work or turn in required work on time does not provide a basis for the grade I .

**Please note the following dates and information:** Last day to drop the course without a grade-September 9, 2011 Last day to drop with a "W"-November 2, 2011.

**ADA Statement:** If you have a disability that may require assistance of accommodations, or if you have any questions related to any accommodation for testing, note taking, reading, etc., please speak with me as soon as possible. You may also contact the Office of Disabled Student Services (898-2783) with any questions about such services.