Math 522 – Mathematical Modeling

Course Description from Bulletin: The course provides a systematic approach to modeling applications from areas such as physics and chemistry, engineering, biology, and business (operations research). The mathematical models lead to discrete or continuous processes that may be deterministic or stochastic. Dimensional analysis and scaling are introduced to prepare a model for study. Analytic and computational tools from a broad range of applied mathematics will be used to obtain information about the models. The mathematical results will be compared to physical data to assess the usefulness of the models. Credit may not be granted for both MATH 486 and MATH 522. (3-0-3)

Enrollment: Elective for AM and other majors.

Textbook(s): TBD.

Other required material: None

Prerequisites: Undergraduate knowledge of multivariate calculus, ordinary differential equations and matrices/linear algebra; basic knowledge of probability and Matlab; or instructor's consent.

Objectives:

1. Students will be provided with the power of using the principles and methods of mathematical modeling for studies of complex systems in science, engineering, and business.
2. Students will learn how to model "real" problems and prepare the mathematical models for analysis using dimensional analysis and scaling.
3. Students will learn how to apply various tools to analyze the models including analytic and computational methods.
4. Students will study how to compare modeling results to observations and how models can be improved.
5. Students will apply the modeling techniques to 3 projects and produce detailed reports.

Lecture schedule: 3 50 minute (or 2 75 minute) lectures per week

Course Outline: Hours

1. Dimensional analysis and scaling 4
2. Discrete models 16
    a. queueing systems arising in applications in operations research such as study of lines and call centers and applications to communication systems, such as design of routers and internet performance; simulation of queueing systems
    b. optimization
        i. integer programming – linear and nonlinear with applications
        ii. network models – min cost and multicommodity flow problems with applications

3. Nonlinear dynamics (ODEs) – stability and bifurcation with applications to epidemics, pharmacokinetics, climate change 4
4. Diffusion models – advection, convection, bifurcation with applications to mixing and transport models, crime detection 8
5. Stochastic models – random walks, Brownian motion, stochastic differential equations with applications to statistical physics, finance 8
6. Exams and add-ons 5

Assessment:	Homework	10-25%
	Projects	10-20%
	Exams	20-30%
	Final Exam	20-30%

Syllabus prepared by: Charles Tier and Hemanshu Kaul
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