

Mathematical and Computational Modeling in Biology and Physics
MATH 50730-01 – Spring 2006

MWF 1:55 – 2:45, 131 DeBartolo
Instructor: Mark Alber (631-8371) malber@nd.edu

Introductory course on applied mathematics methods with emphasis on modeling of biological problems in terms of differential equations and stochastic dynamical systems. Students will be working in groups on several projects and will present them in class at the end of the course.

SYLLABUS:

1. Linear difference and differential equations in 1 dimension with applications to population dynamics. Second order linear difference and differential equations. Nonlinear differential equations and their phase diagrams. Applications: populations with carrying capacity, infection transmission. Linear differential equations in 2 dimensions. Solution via eigenvalues and phase diagrams.
2. Nonlinear systems of differential equations. Applications: competing species systems, epidemiology. First integrals and Lyapunov functions. Applications: predator-prey systems, classical physics, HIV transmission. Periodic orbits: Poincare-Bendixson method, Bendixson-duLac Criterion, Hopf Bifurcation. Chaotic dynamics with applications to population dynamics.
3. Nonlinear methods of empirical analysis: distinguishing deterministic chaos from randomness. Application: biological data sets. Elements of statistical analysis. Methods of Bioinformatics.
4. Markov processes in biology and physics. Stochastic dynamical systems. Application: birth-death processes in population models. Cellular Automata: definition, examples. Application: population models over time and space, Game of Life, statistical physics. Theory and simulation of one-dimensional cellular automata. Applications: plant and animal growth. Monte Carlo simulations in physics and biology. Examples from biophysics.

BOOKS:

“Nonlinear Dynamical Systems and Chaos with Applications to Physics, Biology, Chemistry and Engineering”, Steven H. Strogatz, Studies in Nonlinearity, Addison-Wesley Publishing Company, 1994.

“An Introduction to Stochastic Processes with Applications to Biology”, Linda J.S. Allen, Pearson Education, Inc., 2003.

“Modeling Biological Populations in Space and Time”, Eric Renshaw, Cambridge Studies in Mathematical Biology, Cambridge University Press, 1995.