Math 434A/534A, Spring 2008
Mathematical and Computational Modeling in Biology and Physics

MWF 1:55-2:45pm, Edward J. DeBartolo Hall 126
Instructor: Mark Alber (631-8371), malber@nd.edu

Introductory course on mathematical and computational modeling in terms of differential equations and stochastic dynamical systems. Students will be working in groups on several projects and will present final projects in class in 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. 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 two-dimensional stochastic 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.