Math 493

Fall 2016

Instructor	:	Maria R. D'Orsogna
Lectures	:	alternate Fridays 10:00 - 12:00 in room tba
Office hours	:	By appointment
Contact	:	dorsogna@csun.edu or (818) 617 - 2991
Meeting times:	:	Sept. 2, 16, 30; Oct. 14, 28; Nov. 11, Dec. 2, 9

Course description:

Math 493 is a student seminar class. We will study current topics in applied mathematics with a special emphasis on biological and sociological modeling. We also have a series of guest lectures from postdocs and graduate students. You will attend talks, ask questions, prepare summaries and critiques, give oral presentation(s) to the class on a topic of your choosing. All your work must be typed in Latex, so please download it and learn how to use it. It is important for you to write in a clear, logical manner; give clear, concise and well-structured account of your chosen topic; show that you understand the key issues; give examples to support and/or to question hypothesis and results; give a full bibliography and appropriate referencing; write in correct, standard English. The following are *suggested* topics. If there is any other topic you wish to study, please let me know. You should do a thorough literature search and find the most current research papers that apply. Use the papers/books below as starting points, and take your time researching in the library. You may want to perform your own simulations or calculations if you are curious. If books are cited, please select a chapter.

1. Models of transport and movement:

Learn about different transport modes in biological systems, such as the random unbiased and biased walk, the telegrapher's equation, discrete and continuum limits, and ways to study them. Good starting points are "Random walk models in biology" Edward A Codling, Michael J Plank, Simon Benhamou (Journal of the Royal Society Interface, 2008), "On a generalization of Smoluchowski's diffusion equation" (P. C. Hemmer, Physica 1961), "Random Walks and Their Applications: Widely used as mathematical models, random walks play an important role in several areas of physics, chemistry, and biology" (George H. Weiss, American Scientist 1983), Receptors: Models for binding, trafficking, and signaling, by Douglas Lauffenburger and Jennifer Linderman

2. The Ising model:

Learn about this basic modeling system (together with its extensions, the Potts model and the Heisenberg model) and how it is used in various contexts. This topic is many many texbooks. Some of them are "Exactly Solved Models in Statistical Mechanics" (R. J. Baxter, 1982) and "Introduction to Modern Statistical Mechanics" (David Chandler, 1987) For applications, one can use gang activity modeling in "Ising Model for Gang and Graffiti" (Othman Ayouche, et al Imperial College London); Social applications of two-dimensional Ising models (Stauffer, American Journal of Physics, 2008); "Application of the ising model to hemoglobin" (W. Yap, H. Saroff , Journal of Theoretical Biology 1971)

3. Clustering, growth and nucleation:

Learn about the basic ways to describe the formation of clusters of particles (this is used in polymer growth, cloud formation, surface science). Good starting points are "The Becker-Dring Equations" (Marshall Slemrod, Modeling in Applied Sciences, Engineering and Technology pp 149-171, 2000), "A view of statistical physics" (chapter 5 and 6 Pavel Krapivsky and Sidney Redner, 2010), "Coarsening and accelerated equilibration in mass-conserving heterogeneous nucleation" (Tom Chou and Maria DOrsogna, Phys. Rev. E, 2011), and "The role of discrete-particle noise in the Ostwald ripening" (Baruch Meerson, Leonard Sander and Peter Smereka, Europhysics Letters, 2005); "Models for spatial polymerization dynamics of rod-like polymers" (Leah Edelstein-Keshet and Bard Ermentrout, Journal of Mathematical Biology 2000).

4. Random sequential adsorption and car parking models:

Learn about random sequential adsorption on lattices, also known as "car parking" models, where building blocks need to be deposited on given lines or surfaces. These are used to study adsorption of chemicals on chains or cars being parked on streets. Cases of "jamming" may arise where the space cannot fill completely. Good starting points are “Random and cooperative sequential adsorption” (J. W. Evans Reviews of Modern Physics 1993), “Kinetic models for scission and depolymerization reactions”, (E. A. Boucher, Journal of polymer science 1977), “Reaction kinetics of polymer substituents. Neighbouring - substituent effects in pairing reactions” (E.A. Boucher, Journal of Chemical Society, Faraday Transactions 1972), “Kinetic models for irreversible processes on a lattice” Nicholas Owen Wolf (Thesis, 1979), “Kinetics, statistics and mechanisms of polymer-transformation reactions” (E. A. Boucher, Progress in Polymer Science, 1978), “Kinetics and statistics of occupation of linear arrays. A model for polymer reactions” (E. A. Boucher, Journal of Chemical Physics, 1973), “Interparticle gap distributions on one-dimensional lattices” (M. R. DOrsogna, T. Chou, J. Phys. A, 2005)

5. Cancer modeling and treatment:

Learn about tumor growth, metastasis, cancer treatment. Possible starting sources are: “Computational Biology of Cancer: Lecture Notes and Mathematical Modeling” (chapter 2, D. Wodarz and Natalia Komarova, 2005); “Cancer Modelling and Simulation” (edited by Luigi Preziosi); A Reaction-Diffusion Model of Cancer Invasion” (by Robert Gatenby and Edward Gawlinski, Cancer Research, 1996), “Mathematical Modeling of Tumor Growth and Treatment” (Heiko Enderling and Mark Chaplain, Current Pharmaceutical Design, 2014), “Mathematical Oncology” (Alberto d’Onofrio and Alberto Gandolfi, 2013) A Validated Mathematical Model of Cell-Mediated Immune Response to Tumor Growth (Lisette de Pillis, Ami E. Radunskaya, Charles L. Wiseman, Cancer Research, 2005), “Mathematical Modeling of Therapy-induced Cancer Drug Resistance: Connecting Cancer Mechanisms to Population Survival Rates” (Xiaoqiang Sun, Jiguang Bao and Yongzhao Shao, Scientific Reports, 2016)

6. Swarming:

Learn about models of interacting particles that can be used to represent flocks of birds, school of fish and locust swarms. Possible starting sources are “State transitions and the continuum limit for interacting, self-propelled particles". Analysis of the behavior and structure of fish schools by means of computer simulation (Comments on Theoretical Biology (Y. L. Chuang et al. Physica D, 2007); "Self-propelled particles with soft-core interactions: patterns, stability and collapse" (M. R. DOrsogna et al. Phys. Rev. Lett. 2006); "Locust dynamics: behavioral phase change and swarming" (C. Topaz et al. PLoS Comp. Biol. 2012), "A Simulation Study on the Form of Fish Schooling for Escape from Predator" (Tamon Oboshi, Shohei Kato, Atsuko Mutoh and Hidenori Itoh, Forma, 2003)

7. Oscillations in the human body – sleep and blood circulation

Learn about oscillatory systems in the body. Possible starting points are "Time Delays, Oscillations, and Chaos in Physiological Control Systems" (Leon Glass, Anne Beuter, David Larocque, Mathematical Biosciences, 1988), A limit cycle mathematical model of the REM sleep oscillator system (R. W. McCarley and S. Massaquoi, Americal Journal of Physiology, 1986), "Mathematical Models for Sleep-Wake Dynamics: Comparison of the Two-Process Model and a Mutual Inhibition Neuronal Model" (Anne C. Skeldon, Derk-Jan Dijk, Gianne Derks, Plos One, 2014), "A mathematical model of the sleep/wake cycle" (Michael J. Rempe, Janet Best, David Terman, Journal of Mathematical Biology, 2009), "Applied Mathematical Models in Human Physiology" (J.T. Ottesen, M.S. Olufsen, and J.K. Larsen, BioMath-Group Department of Mathematics and Physics, Roskilde University Denmark 2006), Cyclical neutropenia and other periodic hematological disorders: A review of mechanisms and mathematical models. (C. Haurie, Blood, 1988), "A model for ultradian oscillations of insulin and glucose" (A. Drozdov, H. Khanina, Mathematical and Computer Modelling, 1995)

8. HIV and other viruses:

Learn about the mechanistic avenues through which viruses enter the cell, and the dynamics of cell/virus proliferation. Possible starting points include "Dynamics of hepatitis B virus infection (Ruy M. Ribeiro, Arthur Lo, Alan S. Perelson, Microbes and Infection, 2002), A model for treatment strategy in the chemotherapy of AIDS (D. Kirschner and GF Webb GF, Bulletin of Mathematical Biology, 1996), "HIV-1 dynamics in vivo: virion clearance rate, infected cell life-span, and viral generation time" (Alan Perelson et al. Science, 1996), "Mathematical analysis of delay differential equation models of HIV-1 infection" (P. Nelson, Alan Perelson - Mathematical biosciences, 2002), "Mathematical analysis of HIV-1 dynamics in vivo" (Alan Perelson, P Nelson - SIAM Review, 1999)

9. The immune system:

Learn about how the immune system works. Possible starting sources are A basic mathematical model for the immune response (H Mayer, Chaos, 1995); "Modelling viral and immune system dynamics" (Alan Perelson, Nature Reviews Immunology, 2002)

10. Opinion and voter dynamics:

Learn about modeling opinon dynamics in individuals. Possible starting points are "Social consensus through the influence of committed minorities" (J. Xie, S. Sreenivasan, G. Korniss, W. Zhang, C. Lim, and B. K. Szymanski Phys. Rev. E , 2011), "Influentials, Networks, and Public Opinion Formation" (Duncan J. Watts, Peter Sheridan Dodds, Journal of Consumer Research 2007), "Opinion evolution in closed community" (K Sznajd-Weron, J Sznajd - International Journal of Modern Physics, 2000), "Statistical physics of social dynamics" (C Castellano, Reviews of Modern Physics, 2009)", "On the role of zealotry in the voter model" (M Mobilia, Journal of Statistical Mechanics, 2007), "Ultimate fate of constrained voters" (F. Vazquez, Journal of Physics A 2004)

Tentative schedule:

Sept. 16, 30 – guest lectures and discussion
Oct. 14 – student class presentations
Oct. 28, Nov. 11 – guest lectures and discussions
Dec. 2, 9 – final student presentation