

CPS 632 Deterministic Dynamical Systems

Spring 2009

TR: 5:30 – 7:00 pm (Holmes B0001)

- Instructor: Wensheng Shen
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- Office hour: TR 1:00 pm – 3:00 pm or by appointment
- Prerequisite: knowledge of nonlinear dynamics, linear and nonlinear differential equations, graphics, scientific visualization, and experience in computer programming. Prerequisite courses include CPS 202, CPS 504, or permission from the instructor.
- Textbook: No formal textbook.
- References: (1) Fractals and Chaos, An illustrated course
Author: Paul S Addison
Publisher: Institute of Physics Publishing, Bristol and Philadelphia
ISBN: 0-7503-0399-9
- (2) Fractals Everywhere
Author: Michael F. Barnsley
Publisher: Academic Press Professional
ISBN: 0-12-079061-0
- (3) Nonlinear Workbook: Chaos, Fractals, Cellular Automata, Neural Networks, Genetic Algorithms, Gene Expression Programming, Wavelets, Fuzzy Logic - With C++, Java and SymbolicC++ Programs
Author: Willi-Hans Steeb
Publisher: World Scientific Publishing Company
ISBN: 981-256-291-5
- (4) VTK Users Guide
Publisher: Kitware (<http://www.kitware.com/products/vtktextbook.html>)
- Description: Nonlinear dynamics have attracted immense interests in science, engineering, medicine, economics, and social science. Scientists, engineers, and economists have applied various methods developed in fractal geometry and chaotic dynamics to explain a multitude of diverse physical phenomena: from trees to turbulence, cities to cracks, and much more. Nonlinear models are known difficult to solve due to the need of a

large number of repetitive calculations. The advances in computer technology have made it possible to solve the nonlinear models both accurately and quickly. This course introduces many important topics in nonlinear dynamics, as well as widely used numerical techniques in solving nonlinear differential equations.

Objectives: The objective of this course is to provide an elementary introduction to nonlinear dynamics, including fractal geometry, chaotic dynamics, and bifurcation. This course presents a variety of deterministic mathematical models for simulating real world phenomena, numerical methods for efficiently solving the models, and programming techniques for visualizing computational results. Outcomes of a successful completion of this course include: to understand fractals, chaos, and bifurcations and their applications in computer modeling and simulation, to understand the concepts of deterministic nonlinear dynamics, to know the numerical methods in solving nonlinear ordinary/differential differential equations, to visualize numerical solutions using visualization software tools.

Topics: The topics in this course include regular fractals (the topological dimensions and the similarity dimension, the Cantor set, the Koch curve, the Koch island, the Sierpinski gasket, and the Menger sponge), random fractals (fractal boundaries, box counting dimension, and the Hausdorff dimension), regular and fractional Brownian motion (time traces, spatial trajectories, diffusion limited aggregation), chaos (population growth, logistic map, Julia sets, the Mandelbrot set), chaotic oscillation (the Duffing oscillator, the Lorenz model, the Rossler systems, and special topics (the buckled beam, the journal bearing, Chua’s circuit, the Belousov-Zhabotinsky chemical reaction, Taylor-Coutte flow, Rayleigh-Benard convection, and the ring cavity).

Grading: Homework assignments (50%)
 Projects (30%)
 Midterm (10%)
 Final exam (10%)

Average	100 – 90.0	87.0 – 89.9	83.0 – 86.9	80.0 – 82.9	77.0 – 79.9	73.0 – 76.9
Grade	A	A-	B+	B	B-	C+
Average	70.0 – 72.9	67.0 – 69.9	63.0 – 66.9	60.0 – 62.9	57.0 – 59.9	<57.0
Grade	C	C-	D+	D	D-	E

Note: extra credits may be given in home and project assignments as well as tests. Final exam may be replaced by a project.

Assignment policy: Homework assignments given in class will be due in two weeks and project assignments given in class will be due in four weeks after they are assigned. Late assignments can be accepted with a penalty at a rate of 10% per day. **No makeup tests and no incompletes. A missed test will receive 0 points.** Exceptions to these rules, at instructor's discretion, apply to cases

of illness, personal tragedy, or extraordinary circumstances beyond a student's control, if it is documented to instructor's satisfaction. Arrangement for such an exception needs to be discussed with the instructor.

Attendance: Students are expected to attend all classes. Some of the material may not be contained in the textbook. If a student misses a class, it is his/her responsibility to get class notes and handouts. Absences will be excused for documented illness, official representation of the College, an unfortunate death of a close relative, religious holiday, and other circumstances beyond student's control.

Authorship: Students are allowed to discuss ideas and help others by explaining concepts and possible solutions. All the work that is submitted, however, must be performed by individual students independently. Students must provide appropriate citations for any text fragments in books, journals, conference proceedings, web-based resources, etc. that have been used in their assignments. Students also need to acknowledge any help from others. A student is considered cheating if he/she submits materials as his/her own work that is not entirely his/her own work, or if he/she intentionally provides an answer to another person. If cheating has been detected, the student will receive a zero grade for that assignment. Further disciplinary procedures may also be considered.

Policies: Students with documented disabilities may be entitled to specific accommodations. SUNY Brockport's Office for Students with Disabilities makes this determination. Please contact the Office for Students with Disabilities at 395-5409 to inquire about obtaining an official letter to the course instructor detailing approved accommodations. The student is responsible for providing the course instructor with the official letter. Faculty and staff work as a team with the Office for Students with Disabilities to meet the needs of students with disabilities