Physics 648 - Nonlinear Dynamics - Spring 2020

Instructor	Renate Wackerbauer, Office Location: REIC 106 phone: 474-6108 e-mail: rawackerbauer@alaska.edu
Open office hours	Walk-ins are very welcome; appointments help; email is effective for straight-forward questions.
Course info	Phys648, 3 credits
Prerequisites	graduate standing or instructor's permission
Lectures	MWF 13:00 to 14:00 pm, REIC 203. The lectures will explore in depth material presented in the text.
Noyes Lab	Access to the Noyes Computer Lab (Rm 101 REIC is provided to all students enrolled in a Physics course. Your polar express card lets you in.
Text	**Required text**: *Nonlinear Dynamics and Chaos,* by S. Strogatz, Perseus Publishing. (book is available as hard copy and as electronic copy at Rasmuson library) **Supplementary readings**: *Chaotic dynamics,* by T. Tel and M. Gruiz, Cambridge (2007). many nice applications, and great explanations. *Chaos in dynamical systems,* by E. Ott, Cambridge (2002). also covers Hamiltonian chaos and quantum chaos. *Applied nonlinear dynamics*, by A. Nayfeh, B. Balachandran, Wiley (2004). covers analytical, computational and experimental methods in one book!! *An exploration of Chaos,* by Argyris, Faust, and Haase, Elsevier (1994). nice examples, some detailed calculations that are helpful for understanding *Nonlinear oscillations, dynamical systems, and bifurcations of vector fields*, by Guckenheimer and Holmes, Springer (1983). THE standard book in nonlinear dynamics from an applied mathematical sciences point of view *Synchronization, a universal concept in nonlinear science,* by Pikovsky, Rosenblum and Kurths, Cambridge (2001). a particular focus on synchronization, with many many examples across disciplines *Nonlinear time series analysis,* by Kantz and Schreiber, Cambridge (1998) focuses on NLD and its applications to the analysis of time series, discusses pitfalls, shows many applications *Mathematical Biology I and II,* by J.D. Murray, Springer (3rd edition, 2002) on nonlinear dynamics with particular focus on biological systems *Mathematical Geoscience,* by Andrew Fowler, Springer (2011) There are many books on nonlinear dynamics in the library. Please explore them to see different approaches to our topics.
Course Content Tentative course calendar	Introduction into the dynamics of nonlinear systems. Continuous and discrete dynamical systems, stability analysis, bifurcations, limit cycle, chaos and strange attractors, fractals and dimension algorithms, controlling chaos, synchronization processes, and stochastic dynamical systems.
	This course provides an introduction into nonlinear dynamics at the graduate level. Dynamical

Course Goals, Student Learning Outcomes	systems that are characterized with coupling and feedback processes often show dynamical or spatiotemporal patterns that need to be described at the systems level; a reductionist approach is not suited for complex systems, since the entire system behaves different to the sum of its part. Complex systems can be high-dimensional but must not. A necessary requirement for complex dynamics is nonlinear equations of motion. Students learn, *how to analyze the stability of complex systems *how nonlinear systems differ from linear systems regarding dynamical properties *how sensitivity of system dynamics is related to predictability, determinism, and control *to explore dynamical systems analytically and with computer simulations
Homework homework assignments	Homework will be assigned weekly and will be due by 3:00 pm on the following Friday, unless explicitely altered at the time of assignment. *Late homework will not be accepted*. Finished homework should be placed in my mailbox, or given to me in class. Homework assignments and solutions will be posted in the glass case in the Physics Department hallway. I HIGHLY appreciate it if you RECYCLE paper for your homeworks!
Project: Paper & Presentation	Explore nonlinear dynamics with a project that includes a computational component! For example a bifurcation analysis of a dynamical system, the calculation of fractal dimensions of certain cracks; nonlinear time series analysis of an ECG, or other biological, financial, physical measurement series; correlations between two time series (synchronization); phase space analysis and quantification. Explore a topic related to this course on your own. *The project needs to be based on a published paper or text book, online sources like Wikipedia are not allowed.* A list of possible topics is given here: topics. You can also choose a topic of your interest in agreement with the instructor. **All topics should be discussed with the instructor at least 5 days before the topic is due.** **Project on track:** 1) project topics [20points]: submit tentative project title and a pdf file of the main literature source (paper, text book) that you use in your project. *topics are due on Feb. 19.* 2) project outline [30points]: submit a one page paper proposal that includes a) scientific background, b) hypothesis to test, and c) scientific approach and methods to be used. *outline is due on March 4*. 3) project simulation [50points]: submit one page that describes a) computational methods used, b) a first simulation result that demonstrates that you have a basic working computer program towards your project [this can be done through a figure and its description; figures don't count towards page requirements], and c) a brief outline of the remaining computational study to be done. *project simulation is due march 25.* **Project paper:** The results of your project should be turned in as a paper, like an article in the journal "Physics Today". It should consist of 5 pages [11pt, standard margins (not larger than 1inch) and spacing, **single column**), including introduction, NLD background, results and discussion, summary, and about 5 references. *figures and references do not count towards the 5 pages. The paper needs to be turned in as a PDF-file and as a HARD COPY.* The grade is determined from physics (60%) and style (40%) of the paper. The physics part includes correct physics, level covered, computational results, how explained, how introduced, understanding, terms defined. The style part includes organization and structure, title, references given, figures referenced, good to read, grammar. *the paper is due Wednesday, April 8.* **Presentation:** The paper will be presented to the class in a 15 minutes talk (excluding discussions) the week before finals; *an electronic copy of the presentation needs to be turned in on the day of the presentation.* The grade is determined from clarity of presentation (50%) and content (50%). The clarity of presentation includes board/transparency use, clarity of writing/slides, references used, blocking board/screen, speaking clearly and loud, speed of speach, facing class and eye contact, dealing with questions. The content includes appropriate level, enough details, terms introduced before used, correct physics, how explained.
Examinations	A one-hour in-term examinations and a two hour final examination will be held during the semester.

In-term exams will be held in the classroom. The exams will be closed books and closed notes.

Midterm exam	Friday, Feb 28	Strogatz, approx chapt 1-7
Final exam	Wed, April 29, 1-3pm	Strogatz, approx chapt 1-12

Grading

The maximum score for each homework will be 100 points. A solution (homework, exam) that presents nothing more than a restatement of the problem will receive zero credit. Credit will be given for clarity of presentation, *illegible work will not be graded.* **Grades are assigned as follows: A+ (>97.5%), A (>87.5%), A- (>85%), B+ (>82.5%), B (> 72.5%), B- (>70%), C+ (> 67.5%), C (> 57.5%), C- (> 55%), D+ (> 52.5%), D (> 42.5%), D- (> 40%), else F.** For the final grade homework, exams, etc. will be weighted as follows:

Homework	25%
Presentation	15%
Paper	15%
Project on track	5%
Midterm	20%
Final exam	20%

Course policies

Attendance at lectures is expected. Active class participation, questions, comments on newspaper articles on modern physics are extremely welcome in the lectures. A missed exam will receive 0 credit unless the instructor is notified by email, phone, etc before the exam starts. Make-up exams will be individually scheduled with the student.

Student Obligations

As students of UAF, you are bound by the policies and regulations of the University of Alaska, UAF rules and procedures, and the Student Honor Code. You are obligated to make yourselves familiar with all conditions presented in the UAF Catalog. *Plagiarism on homework, or on exam, or on presentation or on paper will result in a failing grade.*

Disabilities Services

The Office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials. If you have any kind of dissability, please ensure that you go to the dissabilities services program coordinator. I will work with the office of disabilities services (208 WHIT, 474-5655) to provide reasonable accomodations to students with disabilities.

Title IX

University of Alaska Board of Regents have clearly stated in BOR Policy that discrimination, harassment and violence will not be tolerated on any campus of the University of Alaska If you believe you are experiencing discrimination or any form of harassment including sexual harassment/misconduct/assault, you are encouraged to report that behavior. If you report to a faculty member or any university employee, they must notify the UAF Title IX Coordinator about the basic facts of the incident. Your choices for reporting include: 1) You may access confidential counseling by contacting the UAF Health & Counseling Center at 474-7043; 2) You may access support and file a Title IX report by contacting the UAF Title IX Coordinator at 474-6600; 3) You may file a criminal complaint by contacting the University Police Department at 474-7721.