Nonlinear Dynamics and Chaos II (MATH 722) Course Syllabus

Instructor: Paul J. Hurtado (email: `phurtado (at unr.edu)`) **Spring 2017**
Lectures: Monday and Wednesday, 9:30 - 10:45AM
Office: 220 DMSC. **Phone:** 775-784-4655 (Math Office: 775-784-6773)
Office hours are as listed on the course website, or by appointment in **220 DMSC**.
Text: Kuznetsov, Yuri A. *Elements of aPplied Bifurcation Theory*, 3rd ed.

Course Websites: The main website is http://www.pauljhurtado.com/teaching/SP17/
Students are also responsible for checking Web Campus (wcl.unr.edu) and their email, and are assumed to be aware of all information posted to these sources prior to each meeting.

Description: This is the second part of a two-semester sequence of courses (MATH 721 & 722). This course starts with an introduction to a mix of topics from analysis and topology followed by a general definition of a dynamical system and the stability of invariant sets. Topological equivalence and the concept of bifurcations are then discussed, followed by an in depth look at various types of bifurcations in continues and discrete time dynamical systems, including global bifurcations, bifurcations leading to chaos, and methods for proving the existence of such phenomena (e.g., Melnikov's method). Students will also read primary literature related to the theory and applications of dynamical systems and chaos.

Course Pre-requisites: MATH 721 or instructor approval.

Course content: This course is an advanced treatment of the analysis of nonlinear dynamical systems models, with an emphasis on bifurcation theory. We will cover much of the material addressed in the textbook. Students will also be introduced other advanced topics that build on this material, e.g., statistical properties of dynamic models and algebra-based methods.

Course Objectives: Students will obtain familiarity with methods for analyzing dynamical systems, will be familiar with the theoretical foundations of popular computational tools used for bifurcation analysis, and will learn how to interpret and critically evaluate the application of these methods.

Student Learning Outcomes: Upon successful course completion, a student will be able to:

- Demonstrate understanding of the concepts that underly the study of dynamical systems.
- Apply insights and methods from the course to the study of a focal dynamical system.
- Critically evaluate and discuss similar results in the primary literature.

General Rules: I (the instructor) come to class to help you learn, and I expect you will come to class to learn **and help others learn**. Everyone in class, myself included, is expected to be respectful to one another. Disruptions during class will not be well tolerated, and are to be kept to a minimum.

Homework: Some homework may be graded on completion only. Solutions will be provided or discussed in class. Please write or type solutions legibly, preferably using LaTeX. Solutions should show all relevant work, and be a clear explanation of your reasoning (the same applies for all written work submitted to the instructor). Supplementary electronic files (e.g. R scripts) are to be emailed to the instructor in a single document or as a single zip file with a file name that begins with your last name, e.g., **hurtado-homework1.zip**.

Exams: There will be one mid-terms, and no final exam.

Project: Each student will complete a project and submit a term paper at the end of the course. The instructor will help students identify a good topic, and will consult closely with them during the semester. Additionally students will present their results to the class at the end of the semester.

Computing Resources: This course may use mathematical software, which is either free or is available to students through UNR. Students are assumed to have access to a computer with, e.g., Matlab, the

free software R (www.r-project.org) or similar software (e.g., Python), and Maple or Maxima (http://wxmaxima.sourceforge.net). Students using R are strongly encouraged to use the front-end RStudio (www.rstudio.com). These applications are available in DMSC 106.

Course Topics: Below is a tentative list topics for the course. See the course website for a more detailed list of topics, and updated schedule.

1. General Definition of a Dynamical System
2. Stability concepts
3. Poincaré maps
4. Topological Equivalence
5. Classification of equilibria and Bifurcations
6. Structural Stability
7. One-parameter Bifurcations in continuous- and discrete-time systems
8. Normal forms and Center manifolds
9. Higher Codimension and Global Bifurcations
10. Chaos
11. Numerical tools for bifurcation analysis
12. Statistical tools for dynamical systems

Final Grades: Your grade for the course will be determined as follows:

60% Assignments, 25% Exam, 15% Project.

The grading scale that will be used may be curved, and the cutoffs will be no higher than the those given below (i.e., for a given final score, letter grades will be as follows, or better):

A	A-	B+	B	B-	C+	C	D	F
≥93%	≥90%	≥87%	≥83%	≥80%	≥77%	≥70%	≥55%	55%>

Makeup, Late Policy: Late homework will not be graded, unless you had previously notified the instructor. If you need to miss an exam due to participation in official university activities, you must make arrangements with the instructor at least two weeks prior to the exam.

Academic Dishonesty: Cheating, plagiarism or otherwise obtaining grades under false pretenses constitute academic dishonesty according to the Student Code of Conduct. Students are assumed to know what plagiarism is (for a definition, see wpacouncil.org/positions/WPAplagiarism.pdf) and how to avoid it. Academic dishonesty will not be tolerated and penalties can include canceling a student's enrollment without a grade or receiving an F for the course or assignment. For more details, see the UNR General Catalog.

Disability Services: Any student with a disability needing academic adjustments or accommodations is requested to speak with the Disability Resource Center (Thompson Building, Suite 101) and then me, as soon as possible, to arrange for appropriate accommodations.

Academic Success Services: A common habit among successful students is to seek help outside of the classroom. Your student fees cover use of the Math Center (784-4433 or www.unr.edu/mathcenter), Tutoring Center (784-6801 or www.unr.edu/tutoring-center), and University Writing Center (784-6030 or www.unr.edu/writing-center). These centers support your classroom learning; it is your responsibility to take advantage of their services.

Statement on Audio and Video Recording: Written permission of the instructor is required to video or audio recorded class lectures. In order to accommodate students with disabilities, some students may have been allowed to record class lectures and discussions. Therefore, your comments and actions during class may be recorded. Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy.