Math 456	Scott Crass
Dynamics & Geometry of Chaos	FO3-232
CSULB	scrass@csulb.edu
Fall 2024	Office: Tue/Thu 11-11:45

Overview. Systems that change relative to time, space, or other parameters have long been the objects of mathematical study. However, the complexity of *dynamical systems* thwarted efforts at exploration. With the recent advent of inexpensive high-performance computing, research could occur at an experimental level. Following a familiar model in the history of science, the empirical work gave impetus to theoretical development that, in turn, led to further experiment, etc. Recapitulating its history, we will examine dynamical systems both experimentally and theoretically. A chief goal for us will be to "see" general features in specific examples.

Text. K. Alligood, T. Sauer, and J. Yorke, *Chaos: An Introduction to Dynamical Systems*

Exercises. There will be regular assignments of reading and exercises. Written work is due by class Wednesday in weeks 4, 9, and 13 (estimated). A complete list of exercises for each assignment will appear at least two weeks before the due date.

I urge you to **work with others** and to consider the problems at some length before asking about them in class. I also urge you to ask about the problems. The work represented in what you submit should be *your own.* Everything that you submit should be written in concise, clear sentences.

Typed work is preferred—this is an opportunity to learn LaTeX. (See the class website for LaTeX help.) Submissions of pdf files will be made on a class dropbox. Late work will be accepted only in case of personal emergency.

Problem talk. You will present to the class a solution of a selected exercise that's structured to take 10-15 minutes. Your grade will reflect your understanding of and insight into the math and your effectiveness in their communication. There will be a sign-up sheet for each assignment. Groups of two are encouraged.

Course project. Find a topic to be examined independently. One possibility is to work out an especially challenging unassigned problem in the text. A list of other ideas will appear shortly. A number of useful items will be held on reserve for you to consult. Computational work is especially suitable. You might come up with your own topic. Bear in mind that your project should have a *narrow focus.* The project **should not be a summary** of a piece of theory. The goal is explore a topic or problem in some depth.

I encourage you to work with someone. Be advised that the standards for group work will be proportionally higher. You will give a talk on your findings to the class (10-15 minutes) during the final exam time. If you work in a group, each member must make some contribution during the presentation.

By the 11th week you should submit a brief proposal (or chat with me) that describes what you working on and planning to do. If you're having difficulty, please see me.

Lab work. On three occasions (tentatively, weeks 3, 7, and 11) we'll meet as a computer lab to explore the experimental side of things. For each session there will be a lab handout to work through.

Our computational tool will be *Mathematica*—available free to students through the university's Software Depot. Typically, you will write some smallish programs for creating useful numerical or graphical data. If you're unfamiliar with *Mathematica*, there's an introductory handout on the class website as well as online tutorials built in to the software. Your work for each lab—which will consist of a **commented** *Mathematica* notebook–will be **due by 12N Friday** three weeks hence (weeks 6, 10, and 14). The lab notebook should be submitted via email. You can write and submit **one** notebook with a partner.

Topics we'll explore include

- One-dimensional iteration
- Trajectory plots
- Chaotic behavior and periodic points
- Period-doubling and bifurcation diagrams

WWW. Materials related to the course (course description, assignments, list of reference materials) will appear at

`home.csulb.edu/~scrass/teaching`

Please recommend things that you'd like to see on the site.

Evaluation.

Exercises	25%
Labs	30%
Problem talk	20%
Course project	25%

Here's an indication of how I will assign grades. These are **minimum** standards. The actual boundaries between grades might be lower than these, but won't be higher.

85-100%	A
75-85%	B
65-75%	C
50-65%	D

To each individual part of your work I will assign a mark 0-10. See below for an *indication* of what these marks mean.

10	Clear, elegant, shows depth of understanding and special insight or creativity
9.....	Clear, shows understanding and some elegance and insight
8.....	Mostly clear, shows understanding, little elegance and insight
7.....	Somewhat clear, lacking depth of understanding, little elegance and insight
6.....	Some significant misconceptions or shortcomings
5.....	Highly significant misconceptions
0-4....	Shows little effort.

Key to comments on marked papers.

- a This needs a supporting **argument**.
- a? What's the **argument**—the line of reasoning—here?
- d **Describe** what's going on here.
- e **Explain** what you're doing here.
- h? **How** did you get this?
- i **Illustrate** what your talking about—give an example, a picture, etc.
- m The **meaning** here isn't clear.
- p A **picture** would help here.
- s This is not a **sentence**.
- w **Wording** is awkward, confusing, etc. Meaning is unclear.
- y? **Why** is this so? What's the connection to what you've already said?
- ! Very nice. Something especially clear, insightful
- ? What this means or what you're doing is **unclear**. Where does this come from?
- X Something's wrong here—in concept or calculation.
- $\surd$ This is right—you have the idea.

Fine Print

Withdrawal A copy of the School of Natural Sciences withdrawal policy is available from the Department Office. Note that it's different from the University withdrawal policy and the deadlines are earlier. Deadlines to which you should pay particular attention to appear below. Withdrawals from this course will be allowed only in accordance with University and College policies. Please be aware of the more specific and restrictive withdrawal policy for the College of Natural Sciences and Mathematics.

Weeks 1-2. Withdrawals will not appear on the student's permanent record.

Weeks 3-8. Withdrawals are permissible only for serious and compelling reasons. Academic progress unsatisfactory to the student is considered a serious and compelling reason during this period. Instructor and Department Chair signatures on the drop form are required.

Weeks 9-12. Withdrawals are permissible for serious and compelling reasons, but during this period, unsatisfactory academic progress is not considered a serious and compelling basis to drop a course. Circumstances must be shown that preclude the student from attending class or from any effective opportunities to study. In addition to the normal withdrawal form, a special form must be completed, and instructor and department chair signatures are required.

Weeks 13-15. Withdrawals are permissible only for serious accident or illness and involve a total withdrawal from the University. Detailed written documentation must accompany withdrawal forms. Instructor, chair, and college dean signatures are required.

Disability It is the student's responsibility to notify the instructor in advance of their need for accommodation of a disability that has been verified by the University.

Cheating/Plagiarism Cheating and plagiarism are in violation of the California Administrative Code, Title 5, Section 41301. CSULB has adopted a specific policy with respect to the violations of this nature (see the Bulletin or Schedule of Classes). Any student in violation of this code and policy in any assignment or examination related to this course shall be subject to the options specified in the policy statement. This may result in the student receiving a failing grade in the course or, in certain circumstances, being expelled from the University.