

Nonlinear Dynamics and Chaos

Professor:

Dr. Joanna Bieri
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Class:

May 2019
Monday - Thursday 9:00am-11:50am

Office Hours:

Please make an appointment.

About This Course

This course is an introduction to nonlinear dynamics and chaos. Our goal is to get as much information as possible from very difficult, or impossible to solve, nonlinear differential equations. We are going to think visually about what the solutions do, graph solution trends and fixed points, and think creatively to gain information about what solutions do as time moves dynamically forward.

PREREQUISITE: Passing grade of 1.7 in Calculus II (MATH 122)

Our course website can be found at:

NonlinearDynamics.JoannaBieri.com

Course Learning Objectives

By the end of this course you should have the ability to:

1. Improve your ability to think creatively about mathematics.
2. Learn new ways to analyze difficult mathematical problems.
3. Use technology to solve nonlinear programs, including computer programming and graphical analysis.
4. Learn new mathematical tools for nonlinear problems, including linear stability analysis, fixed points, bifurcations, phase portraits, limit cycles and mapping.
5. Explore applications of nonlinear dynamics to real world problems.

Required Texts

Please ensure that you have full-time access to all texts for the duration of the course. There are multiple editions of the book so please just make sure that you check that you are doing the correct assigned problems as posted on the website.

- Nonlinear Dynamics and Chaos with applications to physics, biology, chemistry and engineering 2E (second edition) - Steven Strogatz. (\$20 on Amazon)
- Other texts and articles made available via our course website.

Classwork

Consistent attendance and participation are crucial to your success in the class. Please read the following carefully:

i. Participation and Group Work:

It is imperative that students arrive to class on-time everyday. Class participation for all courses at the university level is vital to learning and understanding. It is also helpful to our fellow students, with whom we will collaborate. Aim to bring a positive and excited attitude to class each day and be prepared to engage in the course material.

In class homework problem presentations are required. It is your responsibility to make sure you participate in the presentations. You must also actively participate in all group work activities and presentations.

ii. Homework and Preparation:

Homework is assigned weekly on Monday and posted on the class website (worth 100 points) Additional essays, readings or other activities may be assigned daily and posted on the class website, so please check the website daily. **Homework is due the Following Monday BEFORE the beginning of class.** You may hand it in at my office or you may drop it in your Google

Folder (link on class website). It is very important that your homework is well written and neatly done. For each calculation, explain in words what you are doing and why you are doing it. I am more interested in the words than in the answer. Remember, homework is your chance to practice the techniques learned in class, it's ok if you do it wrong the first time (or tenth time) or if you need help. I am less interested in the correct answer and more interested in the thought and effort that you put into each problem. You should hand in individual homework and it should represent your individual understanding of the material, but it is okay to work with others on the homework problems.

You should do homework and class reading assignments daily to prepare for the next class. Students who fall behind not only have a hard time succeeding in the course, but also hurt their group's understanding of the material.

iii. Final Exam:

We will have a cumulative final exam on the last day of class.

Evaluation Procedures

There are five elements of the course which contribute to your overall grade, as follows:

Group Work and Participation	30 %
Individual Homework and Preparation	30 %
Final Exam	40 %

Grading Scales:

4.0	95-100%
3.7	90-94%
3.3	87-89%
3.0	83-86%
2.7	80-82%
2.3	77-79%
2.0	73-76%
1.7	70-72%
1.3	67-69%
1.0	63-66%
0.7	60-62%

Please note: According to the University Course Catalog (p. 13) 3.7 and 4.0 are reserved for "outstanding" work; 3.3 and 3.0 are both defined as "excellent," not mediocre.

Grading Criteria

All work for the course will be graded according following criteria.

- 4.0 **Exceptional:** Diligently completes assignments on time, explains ideas fully and clearly, writes assignments in a neat and professional way. Clearly shows a mastery of the material by explaining reasons behind the calculations. Connects ideas between this course and other mathematics or science courses. Makes few, if any, errors in basic calculations, can easily spot basic errors, and has a strong interest in expanding foundational skills.
- 3.0 **Very Good:** Diligently completes assignments on time, usually explains ideas fully and clearly, writes assignments in a neat and professional way. Shows an understanding of the material by explaining reasons behind each calculation, some explanations may be unclear or calculations hard to follow. Is working toward connecting ideas between this course and other mathematics or science courses. Sometimes makes small errors in basic calculations, occasionally has a hard time seeing where errors are, exhibits an interest in improving foundational skills.
- 2.0 **Acceptable:** Usually completes assignments on time, only occasionally explains ideas fully, often skips steps or arguments, writes assignments fairly neatly but does not show all steps, and has work that is hard to follow. Can explain reasons behind calculations when following the textbook, but some explanations are unclear and calculations hard to follow. Meets all the basic expectations within the class but does not connect ideas between this course and other mathematics or science courses. Makes many small errors in basic calculations, has a hard time seeing where errors are, and has an apathetic attitude toward improving foundational skills.
- 1.0 **Unacceptable:** Does not complete assignments on time, rarely explains ideas fully, writes assignments messily, and skips many steps making the calculations hard to follow. Cannot explain reasons behind calculations, has few to no explanations and calculations that are extremely hard to follow. Hands in homework unfinished, not meeting all basic expectations within the class, does not connect ideas between this course and other mathematics or science courses. Makes many errors in basic calculations, refuses to seek out errors when they happen, and has a negative attitude toward improving foundational skills.

Course Policies

i. Absence and Tardiness

Students who attend every class have the best chance of doing exceptional work in the course. Missing even one class could put you far behind because many times one topic builds on the next and May term classes move at *Lightning Speed*. If you do need to miss a class, please let me know as soon as possible. Also, please note that I do not repeat lectures during office hours, you are responsible for learning, on your own, any material covered while you were absent. Tardiness can be very disruptive to class. If you do arrive late, please enter quietly and quickly so you do not disturb your classmates.

ii. Technology

You will need access to a laptop, computer, phone, or tablet capable of interacting with our course website. All course materials will be posted on the course website and accessed during class. However, cell phone ringers should be turned off during class and you should not be texting or accessing websites that are not productive to your learning in class..

iii. Academic Honesty

This syllabus assumes that all students have read and are familiar with the University of Redlands' policies on "Academic Honesty," as is written in the University Catalog. Any case of academic dishonesty will be processed through the official procedures.

iv. Other

The most reliable way to reach me is by email. Please note that my normal working hours are 9 a.m. to 5 p.m., Monday to Friday. I do not respond to emails after 5 p.m. or on weekends, except in an emergency.

Accommodations

If you have a disability that qualified for accommodations under the Americans with Disabilities Act and Section 504 of the Rehabilitation Act, you should contact Academic Success & Disability Services (ASDS). ASDS is located on the ground floor of the Armacost Library across from Human Resources and down the hall from the Jones Computer Center; their phone is 909-748-8069. The primary contact person is:

Amy Wilms

Assistant Dean of Academics and Student Life:

Phone: (909) 748-8069

amy_wilmsredlands.edu.

Discrimination, Harassment, Sexual Misconduct and Retaliation

The University of Redlands is committed to providing a safe learning environment for all students that is free of all forms of discrimination, sexual misconduct, and sexual harassment, including sexual assault, domestic violence, dating violence, and stalking. If you (or someone you know) has experienced or experienced any of these incidents, know that you are not alone. The University of Redlands has staff members trained to support you in navigating campus life, accessing health and counseling services, providing academic and housing accommodations, no contact orders, and more.

Please be aware all University of Redlands faculty members are "responsible employees," which means that if you tell me about a situation involving sexual harassment, sexual assault, dating violence, domestic violence, or stalking, I must share that information with the Title IX Coordinator. Although I have to make that notification, you will control how your case will be handled, including whether or not you wish to pursue a formal complaint. Our goal is to make sure you are aware of the range of options available to you and have access to the resources you need.

To report an incident related to discrimination, harassment, sexual misconduct, or retaliation, you can:

Report online at: www.redlands.edu/titleix -> Report

Contact the Title IX Office at 909-748-8916

Title IX Coordinator,
Pat Caudle,
pat_caudle@redlands.edu or 909-748-8171

Deputy Title IX Coordinator,
Erica Moorer,
erica_moorer@redlands.edu or 909-748-8916

**If you wish to speak to someone confidentially
(meaning not filing with the Title IX Office)
you can contact any of the following on-campus resources:**

Counseling Service
([http://www.redlands.edu/
student-life/health-and-psychological-services/counseling-center/](http://www.redlands.edu/student-life/health-and-psychological-services/counseling-center/))
Phone: 909-748-8108)
Crisis Line: 909-748-8960

Chaplain's Office
([http://www.redlands.edu/
student-life/campus-diversity-and-inclusion/religious-diversity/](http://www.redlands.edu/student-life/campus-diversity-and-inclusion/religious-diversity/))
Phone: 909-748-8368)

For more information, please visit www.redlands.edu/titleix

Course Schedule

The Course Schedule is provided below. The schedule is subject to change as we encounter new challenges and progress through the semester. You will be notified of any changes in class.

- Week 1: Integration Practice, Reduction to a First Order System, Separable ODEs, Flows on the Line, Existence and Uniqueness, Potentials, and Existence Thought Experiment, Numerical Methods.
- Week 2: Two Dimensional Systems, Love Affairs, Saddle-Node Bifurcations, Transcritical Bifurcations, Population Growth, Linear Stability Analysis.
- Week 3: Taylor Series, Pitchfork Bifurcations, General Bifurcations, Phase Portraits, PPLANE, Fixed Points and Linearization, Short Answer Essay Review.
- Week 4: Bifurcating Bunnies Project, Nonlinear Arms Race, Last Minute Fun with Fractals, Other fun topics!

Groups

This semester we will be working in teams in class. You will do individual homework but during in class explorations you will work with your groups. The goal of the groups is that you all work together to make sure that each member of the group completely understands the material.

RULES:

1. There are no stupid questions when it comes to math! Please ask questions of your group if you have them. The groups should be a safe place to explore mathematics.
2. Be kind and considerate of your group members and their questions. No matter what questions your group runs into, it is your responsibility to participate and help everyone understand the work. You don't really understand the material until you can explain it simply to another person.
3. You are responsible for your understanding of the material. Even though the group is working together it is your responsibility to make sure you understand the work. Remember you are handing in individual homework and the final exam will be an individual effort.