

Winter 2016

**FRS Title:** Computational Chaos

**Instructor:** Richard Scalettar, Department of Physics, College of Letters & Science

**CRN:** 25355 – 2 units

**Day/Time:** Wednesdays, 3:10-5:00 p.m.

**Location:** 2060 SciLab and Meeting Room B, and Student Community Center on 1/20, 2/17 & 3/9

**Course Description:** This course is open to first and second-year MURPPS students and consists of two components. The first is the study of a particular research area which spans many fields of science and engineering and which illustrates the sometimes accidental nature of scientific discovery.

Specifically, the first component examines the basic premise of most theoretical engineering and science studies that it is possible to take the current state of a system and use mathematical models to predict its future behavior. In fact, there exist many 'chaotic' systems for which such predictions are known to be impossible. We will explore some simple examples, and contrast how they differ from cases where one is able to determine the future state of a system from its past. The discovery of chaos is itself a fascinating story. We will learn the seemingly innocent process of restarting a previous simulation led to the mathematician /meteorologist Lorenz discovering the 'butterfly effect' -- the extreme sensitivity on initial conditions. To what extent are scientific discoveries 'planned' versus 'accidental?'

Classes will begin with a relatively brief introductory presentation, followed by student-led discussion and work on the current project, most typically a programming task. Students will be encouraged to work in small groups. The first several classes will develop background material both in writing C programs and in the history and theory of chaos. After this groundwork is established, the remainder of the course will explore how and why chaos occurs, using the computer to conduct appropriate simulations. No technical knowledge or mathematics is required.

The second component of the course consists of activities which encourage you to define the goals you have for your university education, based on your interests, values, and backgrounds, and to begin to see, through meetings with your academic advisor and a faculty member in your major, how you can excel in your coursework and become involved in research.

**Seminar Goals:** Students will learn, firstly: 1) the basic conceptual ideas and simple mathematical models of chaos; 2) how to write and use simple C programs to solve these models; 3) analysis of the properties of chaotic systems to illustrate their qualitative features. (No previous programming experience will be assumed); and 4) lessons from the discovery and study of chaos for the nature and practice of science generally. In addition, students will 5) attend presentations on academic integrity, campus resources and networking, and how to get involved in research and 6) undertake a personal reflection their college path.

**Format:** Class will meet for 120 minutes each week. The meetings will consist of classroom lectures and discussion, work on computational projects and presentations on university learning and research activities.

**Grading:** Students will be given a letter grade based on assignments (30%), participation in classroom discussions (30%), and a report on a pre-approved, relevant topic of their choosing (40%). There are no examinations or quizzes in this course.

**Homework Assignments:** Homework assignments are outlined below. These assignments are designed to stimulate thought and assist students in preparation for in-class discussions.

**#1 - Personal Mosaic** – Your first assignment is to create a personal mosaic that describes who you are. The mosaic should be creative. This is not a written assignment. Use magazines, drawings, photographs, and anything you wish to help visually describe who you are. The mosaic can take any shape but should not be larger than a standard poster board (22" x 28"). You will share your mosaic with the class, however you are

not expected to share all aspects – only what you wish. You may want to consider the following questions as you create your personal mosaic: Who are you? What characteristics describe you? What symbols express who you are? What are your personal and academic interests? What values shape your day-to-day interactions with others? Which individuals play an important role in your life? What elements of your personal background are important in understanding how and why you do the things you do? What do you want the instructors and other members of this class to know about you?

**#2 – Reading** – Chronicle Articles to be emailed to students and read prior to 1/20/2016.

- Berube, M. (October 1, 2004). Analyze, Don't Summarize. *The Chronicle of Higher Education*.
- Foster Segal, C. (September 15, 2006). Copy This. *The Chronicle of Higher Education*.
- Gleick, James (Author) (October 29, 1987). Chaos: Making a New Science

**#3 -Academic Advisor Meeting** – Your college/major advisor can help plan your academic path and ensure you meet all the requirements needed to receive your degree. Meet with your college/major advisor and construct your two-four year academic plan for graduation. Discuss your academic progress for last quarter or any concerns you may have regarding your courses. This would be a good time for you to ask questions regarding your major or possible interests if you are undeclared. In order to receive credit for this assignment, you submit a signed copy (from your academic advisor) of your course plan. CAMP/MURPPS counselors/advisors may not be used in this assignment.

**#4 - College Goals Reflection** – Write a 1-2 page reflection about your goals for your UC Davis experience. Why did you choose to attend UC Davis? What do you expect to learn, both inside and outside of the classroom, while you are here? Which major or discipline area do you think is the best for you to pursue? Why? Where do you hope to be in 5 years? 10 years? How do the people in your life (family, friends, etc.) impact the goals you have set and how you will achieve them? What can you do to ensure that you will achieve your goals? Incorporate some of the concepts from the reading into your reflection.

**#5 - Faculty Interview** – Look up the research of faculty members on the UCD campus: Pick ONE faculty in an area in which you are interested in conducting research (or something you are interested in exploring in your area) and make an appointment to talk to the faculty person about their research. Please note that for this assignment you must meet with an Assistant Professor or Associate Professor, Senior Lecturer or Full Professor. **The assignment will not serve its purpose if you interview a teaching assistant, temporary lecturer or writing specialist.** With your best professional and social etiquette, make contact with the professor as soon as possible and request an appointment or go to their office hours. The meeting with the faculty member need take no longer than 15 minutes, but it might be longer. Find out how the professor first became involved in research, how they chose a graduate school, where they had a post-doctoral appointment (if any), and the types of projects that are available to undergraduates working with them. Prepare interview questions in advance.

Write a **2-page** paper on your meeting with the faculty member. Please comment on what you discussed with the professor, and if you found the interaction valuable. Please comment on what you learned from the meeting about faculty and research in this area/discipline. Interview and summary is **to be completed by Wednesday, March 2, 2016.**

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**About the Instructor:** Richard Scalettar is a professor in the Department of Physics. His research interests are in computational approaches to metal-insulator transitions, quantum magnetism, and superconductivity. He is a Fellow of the American Physical Society and a recipient of the UC Davis Chancellor's Outstanding Undergraduate Mentor Award. In addition to his teaching in physics, he has been an instructor in the COSMOS summer high school science program and the Defense Advanced Projects Research Administration High School Apprenticeship Program.

## Schedule of Class Topics, Assignments and Readings

Class Meets Wednesday, 3:10-5:00 pm in 2060 SciLab

**On 1/20, 2/17 & 3/9 we will meet at Meeting Room B, Student Community Center (SCC)**

<i>Date</i>	Topic	<i>Assignment/Reading DUE</i>
Jan. 6	1. Introduction to Chaos and Iteration 2. Exercise: Computing $\sqrt{2}$ 3. Exercise: Computing $1 + 1/2 + 1/4 + 1/8 + \dots$ 4. Introduction to Programming 5. Coding Exercises: hello.c, add.c, count.c	
Jan. 13	Personal Mosaic Presentations This usually takes two hours	Personal Mosaic
Jan. 20	<b>Meet at Meeting Room B, SCC</b> 1. Introduction to Programming (cont'd) 2. Exercise: Computing arithmetic series 3. Exercise: Computing geometric series 4. Discussion of Reading  Academic Integrity and Plagiarism Don Dudley, Director - Student Judicial Affairs	Read Gleick, Chapter 1: The Butterfly Effect  Read "Copy This" Read "Analyze, Don't Summarize"
Jan. 27	1. Introduction to Programming (cont'd) 2. Exercise: Computing $\cos(\pi/4)$ 3. Exercise: Computing $e$ 4. Coding Exercises: arithmeticseries.c, geometricseries.c, exponential.c, cosine.c 5. Discussion of Reading	Read Gleick, Chapter 2: Revolution
Feb. 3	1. Introduction to Programming (cont'd) 2. Exercise: collatz.c 3. Discussion of Reading.	Academic Advisor Meeting  Read Gleick, Chapter 3: Life's Ups and Downs
Feb. 10	1. Introduction to Programming (cont'd) 2. Exercise: locker.c 3. Discussion of Reading	Read Gleick, Chapter 4: A Geometry of Nature
Feb. 17	<b>Meet at Meeting Room B, SCC</b> 1. Introduction to the Logistic Map 2. Exercise: logistic1.c  How to Get Involved in Research – Tammy Hoyer, Asst. Director – Undergraduate Research Center	College Goals Reflection
Feb. 24	1. The Logistic Map (cont'd) 2. Exercise: logistic2.c	Read Gleick, Chapter 5: Strange Attractors
Mar. 2	1. The Logistic Map (cont'd) 2. Exercise: logistic3.c	Faculty Interview and 2-page Summary
Mar. 9	<b>Meet at Meeting Room B, SCC</b>  Last Day of Class	Course Evaluation "Presentation of Reports"