

## **SIO 216A Introduction to the Physics of Complex Systems**

Winter Quarter 2018 Tu/Th 2:00-3:20PM

(SIO has not assigned a classroom for SIOC 216A)

Initial Location: Mandeville Coffee Cart (Indoor seating at Mandeville Auditorium Lounge)

Optional Weekly Homework/Discussion meeting: TBD to meet everyone's schedule

Office Hours to be optimized to everyone's schedules

Instructor: brad werner [bwerner@ucsd.edu](mailto:bwerner@ucsd.edu)

20 Class Meetings

Weekly Homework problems in Octave (open source matlab)/Matlab

Group Project

30 min presentation plus 15 min questions at end of quarter on a topic related to complex systems

Graded S/U (except by exception - if you need a grade to satisfy a requirement)

### **Goals of SIOC 216A**

- acquire a solid understanding of the concepts and framework of the study of complex systems
- learn the practical methods used to model and analyze complex systems
- discuss modeling, measurement and data analysis strategies for complex systems
- survey the ways that complexity is applied in the physical, biological and social sciences.

### **Who should take SIOC 216A?**

Although the course emphasizes concepts and basic methodologies, it is primarily directed towards quantitatively oriented students in the physical, biological and social sciences with a research or general educational interest in ways to conceptualize, formulate and solve problems involving complicated systems. Students interested in more qualitative analysis approaches in the humanities and social sciences can benefit from this course, but might find some of the material on quantitative approaches to dynamics challenging.

### **Course Policies**

Respect for all participants in SIO 216 and their varying backgrounds, knowledge and life experience is required. SIO 216 is a safe zone for people of color, womxn, queers, alternately abled folks, economically disadvantaged people, youth, elders, those who have experienced violence, undocumented people, religious minorities and anyone, individually or as a group, who has been oppressed.

**Ground Rules:** The number one ground rule which we will all follow is to engage in respectful and considerate debate and discussion in the classroom. Follow the step up/step back rule.

**Broad Perspectives:** All participants in this class benefit from a broad range of perspectives, and the instructor of this course highly values these perspectives, especially appreciating those offered by recent immigrants and undocumented students. Support for students affected by political and legal restrictions on the free exchange of ideas and people can be sought from instructors, other students or the following:

<https://students.ucsd.edu/sponsor/undoc/> UCSD undocumented student services

<https://cgs.ucsd.edu/resources/For%20Undocumented%20Students.html> CGS undoc student services

**Accommodations:** If you need any accommodations for disability, illness, or other reason please see brad so we can create an accommodation plan for your success.

**English-language Learning Needs:** Some students will need to utilize office hours in order to get extra background and direction on the material. ELL students are highly encouraged to consult the resources at the OASIS center (858-534-3760).

**ADA Accommodation:** If you have a disability/alternate ability or condition that compromises your ability to complete the requirements of this course, please inform brad as soon as possible of your needs. brad will make all reasonable efforts to accommodate you. Contact the Office for Students with Disabilities (OSD)

<http://disabilities.ucsd.edu> for assistance.

**Cheating and Plagiarism:** Cheating and/or plagiarism are not tolerated behaviors at UCSD. If you are caught cheating or plagiarizing someone else's work, it will result in a failing grade and your infraction will be referred to your department, division or college for disciplinary action. Sharing and collaborative work is encouraged, but please write up your assignments on your own in your own words. Any questions? Contact brad.

**Class Discussions:** Everyone is encouraged to commit to and participate fully in class discussions and group projects, and to honor, respect and make space for the disparate intellectual perspectives that might emerge. If you find that you are talking a lot, please step back; if you find you aren't contributing as much as others, please step up.

**Technology:** Please turn off cell phones, tablets, laptops and other low dissipation communications devices during class discussions, except if you are using those devices specifically for taking notes. If you need to communicate or do other work during class time, please step outside the class to do so.

### **Grading**

- class participation and attendance 20%
- homework 30%
- group project(s) 15%
- final project/presentation 35%

### **Week 1 - INTRODUCTION**

1. What is Complexity? Approaches to and History of Complex Systems
2. The Tools and Concepts of Complexity

### **Week 2 - DYNAMICS APPROACH**

3. Nonlinearity, Dissipation, Phase Space, Attractors, Maps and Feedbacks
4. Stability of Attractors and Bifurcations

### **Week 3 - PATTERN FORMATION**

5. Patterns, Feedbacks and Emergent Behavior
6. Self-organization, Slaving and Modeling

### **Week 4 - SIMULATION FRAMEWORKS**

7. Cellular Automata
8. Complex Adaptive Systems and Artificial Life

### **Week 5 - OPTIMIZATION**

9. Nonlinear Optimization, Simulated Annealing and Genetic Algorithms
10. The Brain and Neural Networks

### **Week 6 - CHAOS**

11. Routes to Deterministic Chaos, Chaotic Systems
12. Nonlinear Time Series and Spatial Forecasting

### **Week 7 - MULTI-SCALE COMPLEX SYSTEMS**

13. Translations to Dynamics
14. Hierarchical Complex Systems

### **Week 8 - AGENT-BASED MODELING OF COMPLEX SYSTEMS**

15. Agent-Based Modeling
16. The Stock Market

### **Week 9 - SOCIAL AND ENVIRONMENTAL SYSTEMS**

17. Societal Institutions and Behavior
18. Human-Environmental Interactions

### **Week 10 - SUMMARY**

19. Course Summary
20. What's Next?