Math 309
Complexity and Emergence
CSULB
Fall 2022

Scott Crass
FO3-211
scrass@csulb.edu
Office: Mon/Wed 5:15-5:45; Tue 4:15-4:45

Overview

Welcome to *Complexity and Emergence*!

The science of complex systems has developed into a framework rooted in math for interrogating a broad variety of problems; examples include biological and ecological processes, social interactions, neurological structures, and economic behavior. Complexity and emergence provide a unifying conceptual scheme for studying phenomena that follow simple rules that govern the interactions among elements. Knowledge of complexity theory will deepen your level of understanding and especially prepares you to connect topics across distinct disciplines, such as the mathematics of dynamical systems and the behavior of a social or biological network.

Geometry and Symmetry Project

Our course is running as part of the **Long Beach Project in Geometry and Symmetry**, an initiative that promotes thinking that's rooted in perception and experimentation. The project's centerpiece is *The Geometry Studio* which we'll be using as a classroom. Your critical comments—signed or anonymous—on the project or studio experience are welcome at all times.

Getting involved

A typical class session will consist of activities, experiments, and explorations that are part of a developing class discussion. You'll work in groups of two or three. Following group work we'll discuss matters as an entire class. The key to success in this course is **initiative**—a willingness to try things and contribute.

Much of our work will be *open-ended* in the sense that you won't figure out something *completely*. Chances are that I won't have all the answers either. Deep thinking really works this way—you're able to make sense of some things out, but there's still more to understand. This is like hiking in the mountains—you reach one peak and gain a nice view, but there are more peaks around you.

Classes will meet on Zoom at the scheduled times. In addition, the lecture-discussion sessions will be recorded and posted online with access through the class website.

Lab explorations

Class will meet regularly (nine times) as a computer lab. Working in groups of 2-3, we'll explore models that simulate the behavior of complex systems. We'll use the freely available program *NetLogo* which has a user-friendly interface and requires no background in programming. See the class website for a link to the *NetLogo* download page.

Required technology. A device that can run *NetLogo*.

Reading, writing, and speaking

Text for recommended reading. Melanie Mitchell, *Complexity: A Guided Tour*

Essays. There will be regular assignments of reading from the text. Exploratory exercises and essay questions will be distributed around week eight. You'll have two to three weeks to write up responses to selected items. The content of this material will depend somewhat upon the directions taken by the course. However, the overall emphasis will be on continuing the explorations we conduct in class. A typical assignment will consist of questions that require essay responses (500-700 words) that students write individually. The questions will address issues that arise in the readings and class activities. Written work will be submitted and returned with comments.

Submit pdf files to a class dropbox. **Late essays** will be accepted only in case of personal emergency.

Lab journal. Each lab exploration will be guided by a handout. You will be asked to conduct experiments and then write brief journal entries (200-400 words) regarding the outcomes. You're encouraged to work in teams (two is best, three might be okay). A team should submit one journal entry.

Submit pdf files to a class dropbox. **Late entries** will be accepted only in case of personal emergency.

Project. A third piece of coursework is the written work and presentation that result from the course project. Emphasis will be placed on clarity of exposition, insightful perspectives, and creativity. A list of sample topics will appear mid-semester, but you're encouraged to originate a project. Please chat with me if you're wondering about a topic or struggling with finding one.

Teamwork (preferably, two members) is encouraged. Submit one paper (1200-1500 words) for the group. On the day of the final exam, we'll hold a **Complexity Fair** in which projects will be displayed and explained.

Submit pdf files to a class dropbox. **Late papers** will be accepted only in case of personal emergency.

On writing

Everything that you submit should be written in concise, clear sentences. Experiment with various styles in developing one that works. A style sheet and content rubric is available on the class website. For further help with writing, take a look at

S. Pinker. *The Sense of Style: The Thinking Person's Guide to Writing in the 21st Century.* Penguin (2015).

W. Strunk and E. White. The Elements of Style. Longman (1999).

W. Zinsser. *On Writing Well.* Harper (2006).

Prior to submission of the essay assignment, a class session can be dedicated to a **writing workshop** in which preliminary drafts will be exchanged, read, and critiqued. Also, writing assistance is available at the **University Writing Center**, located on the second floor of the Student Success Center.

WWW

Materials related to the course (course description, assignments, reference materials) will appear at the class website, a link to which appears at

<div align="center">

`geomsymm.cnsm.csulb.edu`

</div>

Please make recommendations for things that you'd like to see on the site.

Planned itinerary

Weeks	Topics	Coursework
1-3	What is complexity? Dynamical systems, fractals, chaos	
3-5	Information, randomness, entropy	
5-7	Evolution, selection, adaptation	
7-9	Algorithms	
9-12	Self-organization	Essay due
12-15	Networks	
16	Complexity Fair	Project paper due

Assessment

Grades will be determined by the following factors.

Essay	25%
Lab journal	35%
Project	30%
Contribution to class activities and discussion	10%

Here's a *rough* indication of how grades will be assigned. 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 assign a mark 0-10. See below for an *indication* of what these marks mean.

10 . . . .   Clear, elegant, mathematically and scientifically correct, shows depth of
             understanding, insight, or creativity
9 . . . . . .   Clear, shows understanding and some elegance, insight, or creativity;
             mathematically and scientifically correct
8 . . . . . .   Mathematically and scientifically correct, little elegance, insight, or creativity
7 . . . . . .   Mostly mathematically and scientifically correct;
             little elegance, insight, or creativity
6 . . . . . .   Some significant misconceptions
5 . . . . . .   Quite significant misconceptions
0-4 . . . .   Deep misconceptions—shows little effort.

Let me know if you're happy or unhappy about something.

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.
f↓   Text does not **flow** well.
h?   **How** did you get this?
i   **Illustrate** what your talking about—give an example, a picture, etc.
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.
√   This is right—you have the idea.

Fine Print

The CNSM is committed to providing a safe and positive learning environment and has established a zero-tolerance policy for any sexual/gender-based misconduct, including, but not limited to sexual harassment, assault, relationship violence or stalking for all faculty, staff, and students.

As members of The Beach community, we practice tolerance and denounce hate and prejudice. Our classroom will strive to be a place of mutual respect where the focus is on learning and student success.

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.