Nonlinear Phenomena - Syllabus

Course Description:

An introduction to nonlinear phenomena. Flows and bifurcations (1D and 2D), chaos, fractals, strange attractors. Application to physics, engineering, chemistry, and biology.

Instructors:

Lecture:	Prof. Katie Byl (lecturer)	katiebyl@ece.ucsb.edu
Recitation:	Chelsea Lau	clau@umail.ucsb.edu
	Chris Steward	steward@umail.ucsb.edu

Prereq: Physics 105A; or ME 163; or upper-division standing in ECE.

Website: On Gauchospace. https://gauchospace.ucsb.edu/

Lecture: 11am-12:15pm Tues. and Thurs., in Phelps 3505.

Recitation: 1-hour session, once per week, led by a TA, which is REQUIRED.
Either: M 6-6:50 in ENG2 2243 or: F 12-12:50 in HSSB 4201

Required Text:

S. Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering, Westview Press, 2001.

Office Hours:

Prof. Byl: M-W 3:30-4:30pm in HFH 5115

Grading: This is a 4-unit course. Your grade will be the higher of the two options below.

- Homework (20%). There will be 6 homework assignments.
- Recitation (12%). Participation in recitation, with in-class (tutorial) quizzes.
- Midterm Exam (28%).
- Final Exam (40%).
- Option 1 is listed above. Option 2: HW 0%, Rec 15%, Midterm 35%, Final 50%.

Tools for Homework – MATLAB vs Mathematica:

Both MATLAB and Mathematica are excellent tools, and proficiency in using either is sufficient for this class. (From time to time, homework problems will require such numeric tools.)

Collaboration / Cheating / Grading Policy:

- Collaboration on homework is strongly encouraged. You should use Recitation as an opportunity to discuss upcoming homework questions, and you are encouraged to discuss problems with fellow students outside of class.

- Cheating by copying answers or "co-writing" a solution, etc., is not allowed, however. This means if you are collaborating outside of class, you must not "write together" what your entire solution is! (This should be obvious to everyone by now, for any class.)

- Grading emphasizes methodology over "The Right Answer". You must show work!

Course Schedule: Tentative

Lec	Date	Topic	Important Dates
	Wk 1	Recitation reading: 2.1-2.4	
1	4/2	(§1) Introduction, classification of dynamic systems.	
2	4/4	(§2.1-2.2, 8.7, 2.4) Phase portraits, fixed points, stability analyses, Poincaré maps.	
	Wk 2	Recitation reading: 2.5-2.8	
3	4/9	(§2.5-2.6) Existence and Uniqueness, oscillations.	
4	4/11	(§2.7-2.8) Potential fields, numerical methods.	HW 1 due (2.2,2.4,8.7,2.5)
	Wk 3	Recitation reading: 3.1-3.5	
5	4/16	(§3-3.2) Bifurcations in 1D: saddle-node, transcritical.	
6	4/18	(§3.4-3.5) Bifurcations in 1D: pitchfork, rotating hoop example.	
	Wk 4	Recitation reading: 5.1-5.2	
7	4/23	(§5.1) Linear systems in 2D: classification.	HW 2 due (2.5-2.8,3.1-3.2)
8	5/25	(§5.2) Linear systems in 2D: stability.	
	Wk 5	Recitation reading: 6.1-6.2	
9	4/30	(§6.1-6.2) Nonlinear 2D systems: fixed points, portraits, existence and uniqueness.	HW 3 due (3.4-3.4, 5.1-5.2)
-	5/2	**MIDTERM: Chapters 1-5 plus §8.7, in Strogatz**	**Midterm Exam**
	Wk 6	Recitation reading: 6.3-6.5	
10	5/7	(§6.3-6.4) Nonlin 2D sys analyses: linearization, examples	
11	5/9	(§6.5) Nonlin 2D sys analyses: conservative systems	
	Wk 7	Recitation reading: 6.6-6.7, 7.1-7.2	
12	5/14	(§6.6-6.7) Nonlin 2D sys analyses: reversibility, pendulums	
13	5/16	(§7.1-7.2) Limit cycles, Van der Pol oscillators, gradient systems	HW 4 due (6.1-6.5)
	Wk 8	Recitation reading: 7.3-7.6	
14	5/21	(§7.3-7.5) Poincare-Bendixson Thm, Lienard systems	
15	5/23	(§7.6) Weakly nonlinear oscillators	
	Wk 9	Recitation reading: 8.1-8.2, 10.3-10.5	
16	5/28	(§8.1-8.2) Bifurcations in 2D	HW 5 due (6.6-6.7, 7.1-7.5)
17	5/30	(§10.3-10.5) Logistic maps, chaos	
	Wk 10	Recitation reading: Review of all material	
18	6/4	(§10.3-10.5) Logistic maps, route to chaos	
19	6/6	Fractals, Lorenz systems, strange attractors	HW 6 due (7.6,8.2-8.2,10.3-10.5)
	6/12	**FINAL: All material**	**Final Exam**