UCONN
UNIVERSITY OF CONNECTICUT

Course and Instructor Information

Course Title: Nonlinear Systems
Credits: 3
Mode/Format: In person
Location: Ell 321
Time: 11:00 AM – 12:15 PM Tuesday and Thursday, 2024/8/26 - 2024/12/6
Prerequisites: No prerequisites. In particular, ME 3253 Linear Systems Theory is NOT a pre-requisite.

Professor/Instructor/Facilitator: Chang Liu
Pronouns: he/him/his
Email: chang_liu@uconn.edu
Telephone: (410) 369-6999
Office Hours/Availability: TBD

Course Materials

Required course materials should be obtained before the first day of class.

Required textbook:

Khalil H.K. Nonlinear Systems, Third Edition, Prentice Hall, 2002, ISBN 0-13-067389-7

Please also check the errata for this textbook in the link
https://www.egr.msu.edu/~khalil/NonlinearSystems/

Required software: MATLAB. Please follow the instructions on https://software.uconn.edu/software/matlab/ to install.

Course Description

Nonlinear systems analysis techniques: linearization, bifurcation, nonlinear stability, feedback systems and harmonic balance method. Numerical software for bifurcation analysis and nonlinear stability analysis will also be introduced. Application examples in fluid dynamics will be discussed.

Course Objectives

Learn analysis techniques for nonlinear systems to characterize the nonlinear solutions and stability. Learn numerical software for nonlinear system analysis and how to apply them in practical applications such as fluid dynamics.

Course Requirements and Grading

Summary of Course Grading:

Course Components	Weight
Homework	50%
Project	50%

Homework (50%)
For undergraduate students, one homework with the lowest grade will be automatically dropped and the grade will be averaged based on other homework. For graduate students, grades will be averaged on all homework.

Course project (50%)
One project proposal (10%) is due in the middle of the semester. The last class will be a final presentation (20%) and the final report (20%) will be due one week after the last class. A list of suggested projects with references will be provided. All students are welcome to design a project based on existing research but need to distinguish the work within this course project. All students will be graded in the same rubric, but undergraduate's course project grades will

be curved as $New = 10\sqrt{Old}$.

Grading Scale:

Grade	Letter Grade	GPA
93-100	A	4.0
90-92	A-	3.7
87-89	B+	3.3
83-86	B	3.0
80-82	B-	2.7
77-79	C+	2.3
73-76	C	2.0
70-72	C-	1.7
67-69	D+	1.3
63-66	D	1.0
60-62	D-	0.7
<60	F	0.0

Due Dates and Late Policy: Please contact me if you need an extension on homework and I will try to accommodate your request. If you do not contact me in advance, expect your grade to be lowered due to lateness (reduced by 25%). HW submission one week after the due date will not be graded.

Weekly Time Commitment: 6 hours outside of the classroom.

Course Outline

The tentative outline of the class is below, and they are subject to change based on the progress.

Dates	Sections in the textbook (Khalil)	Course content
Week 1	Chapter 1, Sections 2.1-2.5	Introduction and linearization
Week 2	Sections 2.6-2.7 and others	Bifurcation analysis
Week 3	https://www.staff.uni-oldenburg.de/hannes.uecker/pde2path/	Numerical software pde2path for bifurcation and stability analysis
Week 4	Sections 4.1-4.4	Nonlinear stability I: Lyapunov method
Week 5	Sections 8.1-8.3	Nonlinear stability II: Region of attraction
Week 6	https://yalmip.github.io/ https://www.cds.caltech.edu/sostools/	Numerical software YALMIP and SOSTOOLS for finding the Lyapunov function
Week 7 Proposal due	Sections 4.8-4.9, Chapter 5	Feedback systems I: input-output analysis
Week 8	Chapter 6	Feedback systems II: Passivity
Week 9	Section 7.1	Feedback systems III: Absolute stability
Week 10	https://doi.org/10.1103/PhysRevE.102.063108 https://doi.org/10.1017/jfm.2021.762	Application in fluid dynamics I: transition to turbulence in wall-bounded shear flows
Week 11	Section 7.2	Harmonic balance method
Week 12	https://doi.org/10.3390/fluids7120373 https://doi.org/10.1017/jfm.2022.865	Application in fluid dynamics II: reduced-order modeling of convection
Week 13	Sections 4.5-4.6 and others	Non-autonomous systems or data-driven modeling (TBD)
Week 14	Final presentation TBD	Final presentation TBD

Calendar and/or Class Meeting Schedule

11:00 AM – 12:15 PM Tuesday and Thursday at EII 321, 2024/8/26 - 2024/12/6

Accommodations for Illness or Extended Absences

Please contact me if you need other accommodation and it will be evaluated case by case.

How to Succeed in this Course

All students can succeed in this course and we are here to help you along the way. Please do not hesitate to ask questions or attend office hours. All questions are important here. Success in this course program depends heavily on your personal health and well-being. Recognize that stress is an expected part of the college experience, and it often can be compounded by unexpected setbacks or life changes outside the classroom. Your teaching assistants and I strongly encourage you to reframe challenges as an unavoidable pathway to success. Reflect on your role in taking care of yourself throughout the semester, before the demands of exams and projects reach their peak. Please feel free to reach out to me about any difficulty you may be having that may impact your performance in your courses

or campus life as soon as it occurs and before it becomes too overwhelming. In addition to your academic advisor, I strongly encourage you to contact the many other support services on campus that stand ready to assist you.

Academic Integrity

Cheating of any kind on examinations and/or plagiarism of homework is strictly prohibited. Students may work together on homework but submitted work should be your own. Any student work that is found to be in violation of the university policy regarding academic misconduct will be assigned a grade of zero. Read and understand The UConn Student Code of Conduct Academic, Scholarly, and Professional Integrity and Misconduct Policy..

Resources for Students Experiencing Distress

The University of Connecticut is committed to supporting students in their mental health, their psychological and social well-being, and their connection to their academic experience and overall wellness. The University believes that academic, personal, and professional development can flourish only when each member of our community is assured equitable access to mental health services. The University aims to make access to mental health attainable while fostering a community reflecting equity and diversity and understands that good mental health may lead to personal and professional growth, greater self-awareness, increased social engagement, enhanced academic success, and campus and community involvement.

Students who feel they may benefit from speaking with a mental health professional can find support and resources through the **Student Health and Wellness-Mental Health** (SHaW-MH) office. Through SHaW-MH, students can make an appointment with a mental health professional and engage in confidential conversations or seek recommendations or referrals for any mental health or psychological concern.

Mental health services are included as part of the university's student health insurance plan and also partially funded through university fees. If you do not have UConn's student health insurance plan, most major insurance plans are also accepted. Students can visit the **Student Health and Wellness-Mental Health located in Storrs on the main campus in the Arjona Building, 4th Floor,** or contact the office at **(860) 486-4705, or https://studenthealth.uconn.edu/** for services or questions**.**