MECH 6313
Nonlinear Systems

Same as	BMEN 6388, EECS 6336, SYSE 6324
Term	Spring Semester 2021
Lecture Time	Mondays & Wednesdays: 2:30pm – 3:45pm
Website	UT Dallas eLearning: https://elearning.utdallas.edu/

These descriptions and timelines are subject to change at the discretion of the Professor

Professor Contact Information

Dr. Armin Zare

Office location	ECSW 3.355C
Office hours	Online: set appointment by emailing professor
Email address	armin.zare@utdallas.edu

General Course Information

Semester Credit Hours 3

Pre-requisites An Introduction to Linear Systems at the level of MECH 6300 is necessary. Basic knowledge of linear algebra and differential equations are also required. Some knowledge of Matlab will be useful.

Other Restrictions None

Instructional Modality Remote/Virtual Learning

For additional details on instructional modalities, see the Spring 2021 Registration Information webpage.

Course Platform Class lectures will be live-streamed and recorded via Microsoft Teams during the scheduled lecture times. Course material including recorded lectures, homework assignments and solutions, and exams will be routinely posted on eLearning. **Please check it frequently.**

Asynchronous Learning Guidelines If you choose to follow the course asynchronously, you will need to inform your professor of this decision at the beginning of the semester. Please be aware that opting for asynchronous access **does not** mean that you can complete the course requirements at your own pace or discretion. You will still need to follow along at the pace of the class and meet the standards set forth by the instructor. For additional details, see the Asynchronous Access for Spring 2021 FAQ webpage.

Catalog Description Equilibria, phase portraits, linearization of nonlinear systems; periodic solutions; Poincare-Bendixson theorem; fundamental existence and uniqueness theorem for ODEs; Lyapunov stability theory; Invariance principle and LaSalle's theorem; converse theorems; singular perturbations; center manifold theorem; differential geometric tools, feedback linearization, input-output linearization, output injection, output tracking, passivity-based control; backstepping.

Course Outline	• Introduction and examples of nonlinear systems • State-space models, equilibrium points, and linearization • Range of nonlinear phenomena: finite escape time, multiple isolated equilibria, limit cycles, chaos. Bifurcations. Phase portraits. Bendixson and Poincare-Bendixson criteria. • Center manifold theory; Existence and uniqueness of solutions; Lipschitz continuity; Continuous dependence on initial conditions and parameters; sensitivity equations. • Lyapunov stability; Lyapunov's direct method; Lyapunov functions; LaSalle's invariance principle. • Stability via linearization; Estimating region of attraction; Comparison functions; uniform stability; exponential stability. • Stability of time-varying systems. Gradient algorithm for estimation of unknown parameters. Uniform observability and persistency of excitation. • Input-output and input-to-state stability. Small gain theorem. Passivity. • Perturbation theory and averaging. Singular perturbations. • Feedback and input-output linearization. Relative degree and zero dynamics; Backstepping design.
Learning Objectives	Upon successful completion of this course, students will: • have a basic understanding of the behavior of nonlinear systems described by ordinary differential equations; • have the ability to analyze the stability and performance of open and closed loop systems using Lyapunov theory; • have a basic understanding of nonlinear control methods such as feedback linearization, passivity-based control and robust control.
Reference Text	No required text. Lecture notes will be provided. Recommended text: Hasan Khalil, Nonlinear Systems, Third Edition, Prentice-Hall, 2002.

Course Policies

Grading Distribution	Homework (50%) Exam (25%) Quizzes (25%)
Homework Assignments	• Regular homework will be assigned via eLearning. You will receive an email announcing new assignments and their availability in the 'Homework' folder on eLearning. • Regular homework assignments are due on the date written at the top of the assignment and at the beginning of class. Late homework will not be accepted under any circumstances. To receive credit for homework, your solutions must be neat and organized. You will submit your completed homework via eLearning by attaching a single PDF file containing scans/pictures of your homework. • The lowest homework grade will be disregarded in the final grade.

- Moderate collaboration with your classmates is allowed. However, I expect you to spend time to understand homework problems and laboratory assignments and independently write the solutions and reports that you turn in. **Students are not allowed to use any homework solutions obtained from former students, online, or any other source. Cheating or plagiarizing are absolutely unacceptable and will be referred to the Office of Judicial Affairs** (see https://www.utdallas.edu/conduct/manage-dishonesty/) If it is determined that academic dishonesty occurred, you will receive a grade of **F** in this course.

Exams & Quizzes
- Tentative Exam schedule: Monday, March 29th, 2021
  Quiz schedule: Wednesdays at the beginning of class.
- The lowest quiz grade will be disregarded in the final grade.
- No make-up exams/quizzes will be accepted without prior approval of the instructor. You must inform the instructor in advance if you will miss class for any reason.

COVID-19 Guidelines and Resources

The information contained in the following link lists the University's COVID-19 resources for students and instructors of record. Please see http://go.utdallas.edu/syllabus-policies.

Class Participation

Regular class participation is expected regardless of course modality. Students who fail to participate in class regularly are inviting scholastic difficulty. A portion of the grade for this course is directly tied to your participation in this class. It also includes engaging in group or other activities during class that solicit your feedback on homework assignments, readings, or materials covered in the lectures (and/or labs). Class participation is documented by faculty. Successful participation is defined as consistently adhering to University requirements, as presented in this syllabus. Failure to comply with these University requirements is a violation of the Student Code of Conduct.

Class Recordings

The instructor may record meetings of this course. Any recordings will be available to all students registered for this class as they are intended to supplement the classroom experience. Students are expected to follow appropriate University policies and maintain the security of passwords used to access recorded lectures. Unless the Office of Student AccessAbility has approved the student to record the instruction, students are expressly prohibited from recording any part of this course. Recordings may not be published, reproduced, or shared with those not in the class, or uploaded to other online environments except to implement an approved Office of Student AccessAbility accommodation. If the instructor or a UTD school/department/office plans any other uses for the recordings, consent of the students identifiable in the recordings is required prior to such use unless an exception is allowed by law. Failure to comply with these University requirements is a violation of the Student Code of Conduct.

Class Materials

The instructor may provide class materials that will be made available to all students registered for this class as they are intended to supplement the classroom experience. These materials may be downloaded during the course; however, these materials are for registered students' use only. Classroom materials may not be reproduced or shared with those not in class or uploaded to other online environments except to

implement an approved Office of Student Accessibility accommodation. Failure to comply with these University requirements is a violation of the [Student Code of Conduct](#).

Technical Requirements

In addition to a confident level of computer and Internet literacy, certain minimum technical requirements must be met to enable a successful learning experience. Please review the important technical requirements on the [Getting Started with eLearning](#) webpage.

Course Access and Navigation

This course can be accessed using your UT Dallas NetID account on the [eLearning](#) website. Please see the course access and navigation section of the [Getting Started with eLearning](#) webpage for more information. To become familiar with the eLearning tool, please see the [Student eLearning Tutorials](#) webpage. UT Dallas provides eLearning technical support 24 hours a day, 7 days a week. The [eLearning Support Center](#) includes a toll-free telephone number for immediate assistance (1-866-588-3192), email request service, and an online chat service.

Communication

This course utilizes online tools for interaction and communication. Some external communication tools such as regular email and a web conferencing tool may also be used during the semester. For more details, please visit the [Student eLearning Tutorials](#) webpage for video demonstrations on eLearning tools.

Student emails and discussion board messages will be answered within 3 working days under normal circumstances.

Distance Learning Student Resources

Online students have access to resources including the McDermott Library, Academic Advising, The Office of Student AccessAbility, and many others. Please see the [eLearning Current Students](#) webpage for more information.

Server Unavailability or Other Technical Difficulties

The University is committed to providing a reliable learning management system to all users. However, in the event of any unexpected server outage or any unusual technical difficulty which prevents students from completing a time sensitive assessment activity, the instructor will provide an appropriate accommodation based on the situation. Students should immediately report any problems to the instructor and also contact the online [eLearning Help Desk](#). The instructor and the eLearning Help Desk will work with the student to resolve any issues at the earliest possible time.

Comet Creed

This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

"As a Comet, I pledge honesty, integrity, and service in all that I do."

Additional Course Policies

The University of Texas at Dallas provides a number of policies and procedures designed to provide students with a safe and supportive learning environment. Brief summaries of the policies and procedures are provided for you at:

https://go.utdallas.edu/syllabus-policies

These include information about technical support, student conduct and discipline, academic integrity, copyright infringement, email use, withdrawal from class, student grievance procedures, incomplete grades, access to Disability Services, and religious holydays. You may also seek further information at these websites:

• https://www.utsystem.edu/offices/general-counsel/intellectual-property
• https://www.utdallas.edu/studentaccess/guidelines/