Syllabus for
Nonlinear Control
EML: 6350

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Remotely teaching from UF REEF

Office Hours: By virtual appointment only but email anytime

No teaching assistant

Grader: Patrick Amy (patrick.amy@ufl.edu)

Lecture Location and Hours:
Lectures will typically be recorded via Zoom Tuesday, Wednesday, and Thursday evening at 5pm ET; however, to minimize class interruption due to occasional travel, some lectures may be uploaded earlier.

Course Overview: The objective of this course is to introduce students to nonlinear control systems. Students will learn underlying theory derived from fundamental engineering science principles and will apply the theory to solve complex engineering problems using knowledge of mathematics. The objective will be achieved through:

- Uploaded lectures and examples
- Student completion of homework
- Student completion of projects/tests

Professional Component (ABET):
This course prepares graduates to have a knowledge of nonlinear Lyapunov-based control analysis and design methods and to have design competence that integrates covered topics.

Relation to Program Outcomes (ABET):

Outcome	**Coverage***
1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	High
2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3) an ability to communicate effectively with a range of audiences	
4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Medium

Coverage is given as high, medium, or low. An empty box indicates that this outcome significantly addressed by this course.

Strongly Recommended Textbook:
Nonlinear Systems: Third Edition by H. Khalil, 2002.

Supplemental Textbooks (not required but good references):

1. **Nonlinear Control of Engineering Systems: A Lyapunov-Based Approach** by W. E. Dixon, A. Behal, D. M. Dawson, and S. Nagarkatti, , Birkhäuser Boston, 2003.
2. **Applied Nonlinear Control** by Jean-Jacques Slotine, Weiping Li, Pearson Education, 1990.
3. **Nonlinear Dynamical Systems and Control: A Lyapunov-Based Approach** by Wassim Haddad and VijaySekhar Chellaboina, Princeton Press, 2008.
4. **Switching in Systems and Control** by Daniel Liberzon, Springer Science, 2003.

Course Overview: This course is intended to expose students to nonlinear analysis and control systems theory. The course is focused on Lyapunov-based analysis methods and associated design techniques. The first segment of the course introduces definitions of stability for autonomous and nonautonomous systems leading to a Lyapunov framework. Based on the developed Lyapunov-based analysis tools, basic and advanced design tools for contemporary engineering problems are presented including state-of-the-art techniques. Topics include: Solution Concepts for Nonlinear Differential Equations, Autonomous and Nonautonomous Systems, Integrator Backstepping, Input-Output Stability, Feedback Linearization, Observers and Filters, Switched and Hybrid Systems, and Robust and Adaptive Control. The content will be mathematical with illustrative examples taken from general engineering systems. The course is designed as an introductory course with no prerequisites, yet a general understanding of feedback systems, linear algebra, and exposure to differential equations will be beneficial. The student will also be expected to be able to use some simulation software (e.g., Python or Matlab) to complete class projects and tests.

Course Content:
1. Motivation for Nonlinear Control (Chapter 1 - Dixon)
2. Behavior of Nonlinear Dynamic Systems (Chapter 1,2 Khalil)
3. Lyapunov Stability (Chapters 3, 4 - Khalil)
4. Switched and Hybrid Systems (Chapter 1,3 – Liberzon and Supplemental)
5. Feedback Linearization (Chapter 13- Khalil)
6. Sliding Mode Control (Chapter 14- Khalil)
7. Integrator Backstepping (Chapter 14- Khalil)
8. Robust and Adaptive Control Applications (Chapter 2-6 - Dixon and Supplemental)

Exams: There will be three exams and a final project. The exams will be take home and will be cumulative but will emphasize the most recently covered material. The course will not include a final exam.

Exam 1: Friday September 17.
Exam 2: Friday October 22.
Exam 3: Friday November 26.
Final Project Due: Friday December 3.

Attendance: Not required. All students are responsible for all material presented in class. Office hours will not be used to compensate for class absence.

Late/Makeup Policy: Make-up exams will be given only for special circumstances that are pre-approved by the instructor.

Academic Honesty: All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a student at the University of Florida and to be honest in all work submitted and exams taken in this class and all others. All students should review the University's honor code policy you will be held to it.

For any exam or the final project where simulations are required, sharing of code is considered a direct violation of the academic honesty policy.

Course Grading: Homework may be assigned but not graded. Either you can work on the assigned project, or you can propose an alternative design project with consent of the instructor. The project will require a simulation of control design.

Exams (3) 90% (30% each)
Project 10%