Nonlinear Control II: Adaptive Control

EML 6351 Sections 18161, 18162, 18163, and 22691
Class Periods: MWF, period 2, 8:30 AM - 9:20 AM
Location: NEB 0102 and online
Academic Term: Spring 2026

Instructor:
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Office Hours: WF, 9:30 AM – 10:30 AM, NEB 555 (or by appointment)

Course Description
Control methods for uncertain nonlinear systems. Lyapunov-based robust, adaptive, learning, and estimation-based methods

Course Pre-Requisites / Co-Requisites
EML 6350

Course Objectives
This course is intended to introduce students to control methods that can be applied to uncertain nonlinear systems. A Lyapunov-based framework is used as the baseline approach for the synthesis and analysis of the developed controllers. To compensate for uncertainty in the system, students will be introduced to topics including model reference adaptive control, Lyapunov-based adaptive control, neural network function approximation methods, composite and modular adaptive control, modifications for robustness, excitation and parameter convergence, and adaptive actor/critic-based reinforcement learning control. The content will be mathematical with illustrative examples taken from general engineering systems. EML 6350 Introduction to Nonlinear Control (or a baseline understanding of Lyapunov-based design and analysis methods) is a prerequisite. The students will also be expected to be able to use some simulation software (e.g., MATLAB) to complete class projects.

Recommended Materials
- Lecture notes by D. Liberzon, 2021 (http://liberzon.csl.illinois.edu/teaching/ece517notes-post.pdf)
- Robust and Adaptive Control with Aerospace Applications by E. Lavretsky and K. Wise, 2013 (available online through the UF library).
- Robust Adaptive Control by P. A. Ioannou and J. Sun, 2012 (preprint available online)
- Nonlinear Systems, 3rd Edition by H. Khalil, 2002.
- Nonlinear and Adaptive Control Design by M. Kristic, I. Kanellakopoulos, P. Kokotovic, 1995.
- Introduction to Nonlinear Control by C. M. Kellett and P. Braun, 2023.

Required Computer
The students will require a computer that meets the UF student computing requirements (*https://news.it.ufl.edu/education/student-computing-requirements-for-uf/* and the MAE student computing requirements (https://mae.ufl.edu/students/undergraduate/computer-requirements/). The course includes simulation assignments that can be completed using MATLAB (available through UFApps), Julia, or Python.

Course Schedule (tentative)

Week 1 (01/12):	Module 1: Introduction – Universal regulators, weak Lyapunov theorems
Week 2 (01/19):	Module 1: Introduction – Nussbaum gains, Backstepping, MRAC intro
Week 3 (01/26):	Module 2: Performance Enhancement – Composite Adaptive Control
Week 4 (02/02):	Module 2: Performance Enhancement – Least Squares, **HW 1 Due**
Week 5 (02/09):	Module 3: Parameter Convergence – Persistence of excitation
Week 6 (02/16):	Module 3: Parameter Convergence – Concurrent Learning, **HW 2 Due**
Week 7 (02/23):	Module 3: Parameter Convergence – Regressor mixing

Week 8 (03/02):	Module 4: Robustness – Sigma modification, Parameter Projection, **HW 3 Due**
Week 9 (03/09):	Module 4: Robustness – ISS Backstepping and Modular Adaptive Control, **Exam 1**
Spring break (03/16)	
Week 10 (03/23):	Module 5 - Iterative learning control
Week 11 (03/30):	Module 5 - Iterative learning control – nonsmooth systems, **HW 4 Due**
Week 12 (04/06):	Module 6 - Neural Network Adaptive Control
Week 13 (04/13):	Module 6 - Neural Network Adaptive Control, **HW 5 Due**
Week 14 (04/20):	Adaptive optimal control
Exam Week (04/27):	**Exam 2 Due on April 27, 2026 at 11:55 PM**

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance is not required but highly encouraged. I adjust the content delivered in the lectures based on questions asked by students in attendance. Asking questions in class is the best way for the students to ensure they understand the material. Excused absences must be consistent with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations) and require appropriate documentation. Additional information can be found here: https://gradcatalog.ufl.edu/graduate/regulations/

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Quizzes (10 – 12)	10 each	10%
Homework assignments (4 to 6)	100 each	50%
Exams (2)	100 each	40%
		100%

Grading Policy

Information on UF grading policy may be found in the UF Graduate Catalog and Grades and Grading Policies

Academic Policies & Resources

See https://go.ufl.edu/syllabuspolicies.

Generative AI

You **may** use generative AI (GenAI), such as large language models (e.g., GPT, Claude, Gemini), in this course to assist with your assignments, projects, and study materials. These tools can help generate ideas, provide explanations, and offer feedback. Ensure that all work submitted is your own by using GenAI as a supplementary tool rather than the main content source. For example, you can use GenAI to brainstorm ideas, outline your thoughts, or clarify complex concepts. However, the final writing, problem-solving, and/or analysis should be your original work. **Properly cite any AI-generated content to maintain transparency and academic integrity**. This responsible use of GenAI is meant to enhance your learning experience while ensuring that you develop and demonstrate your understanding and skills. When in doubt, ask your instructor for clarification.

Commitment to a Positive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University's core values.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Coordinator
- HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@ufl.edu