

ENAE743 APPLIED NONLINEAR CONTROL SPRING 2009 SYLLABUS

DEPARTMENT OF AEROSPACE ENGINEERING, UNIVERSITY OF MARYLAND
LAST UPDATED: JANUARY 21, 2009

Description

This course introduces the mathematics and methods of nonlinear systems analysis and nonlinear control design, including dynamical systems theory, Lyapunov theory, input-output stability, passivity theory, frequency-domain analysis, and nonlinear feedback. 3 credits. *Prerequisite: ENAE641*

Instructor

Dr. Derek A. Paley
3150 Glenn L. Martin Hall
301-405-5757, dpaley@umd.edu
Office Hours: Walk-in or by appointment

Lectures

Tu, Th 11:00–12:15 in ITV 1100

Textbooks

- [1] H. Khalil, *Nonlinear Systems*, 3rd edition, Prentice Hall, 2002. **HK** (main text)
- [2] S. Sastry, *Nonlinear Systems Analysis, Stability, and Control*, Springer-Verlag, 1999. **SS**

References

- [1] M. Hirsch, S. Smale, R. Devaney, *Differential Equations, Dynamical Systems, & An Introduction to Chaos*, 2nd edition, Elsevier Academic Press, 2004.
- [2] L. Perko, *Differential Equations and Dynamical Systems*, Springer, 2001.
- [3] B. Schutz, *Geometrical methods of mathematical physics*, Cambridge University Press, 1980.
- [4] W. Rugh, *Linear Systems Theory*, 2nd edition, Prentice-Hall, 1996.
- [5] R. Horn and C. Johnson, *Matrix Analysis*, Cambridge University Press, 1985.
- [6] R. Sepulchre, M. Janković, P. Kokotović, *Constructive Nonlinear Control*, Springer, 1997.
- [7] A. Tewari, *Modern Control Design*, Wiley, 2002.
- [8] A. Isidori, *Nonlinear Control Systems*, 3rd edition, Springer, 1995.
- [9] H. Nijmeijer and A. J. van der Schaft, *Nonlinear Dynamical Control Systems*, Springer-Verlag, 1990.

Grading

Homework Assignments 30%, Final Take-home Exam 25%, Midterm Take-home Exam 20%, Project 20%, Attendance & Participation 5%

Policies

You are encouraged to collaborate on the homework assignments. Collaboration is not permitted on the midterm exam or final exam. Collaboration is not permitted on the project, except by permission of the instructor. Assignments and exams will not be accepted after the deadline, except by permission of the instructor.

Course Materials

Course materials will be available through the Blackboard website, <https://bb.eng.umd.edu>.

Course Outline

I. *Basic Analysis*

- a. Nonlinear Models and Nonlinear Phenomena (**HK** Ch. 1, **SS** Ch. 1)
- b. Mathematical Preliminaries (**HK** App. A, **SS** Ch. 3)
- c. Qualitative Behavior and Phase Portraits (**HK** Ch. 2, **SS** Ch. 2)
- d. Existence and Uniqueness (**HK** Ch. 3, **SS** Ch. 3)

II. *Analysis of Feedback Systems*

- a. Lyapunov Stability Theory (**HK** Ch. 4, **SS** Ch. 5)
- b. Input-Output Stability (**HK** Ch. 5, **SS** Ch. 4)
- c. Passivity Theory (**HK** Ch. 6)
- d. Frequency-Domain Analysis (**HK** Ch. 7, **SS** Ch. 6)

III. *Nonlinear Feedback Control*

- a. Stabilization and Linearization (**HK** Ch. 12)
- b. Feedback Linearization (**HK** Ch. 13, **SS** Ch. 9)
- c. Geometric Nonlinear Control (**SS** Ch. 11)
- d. Nonlinear Design Tools (**HK** Ch. 14)

Project

The project will consist of an oral presentation to the class and a written report provided to the instructor. The oral presentation should be 15–20 minutes long and should summarize your project in a way that is accessible to the whole class. The written report should be 5–10 typed pages and should contain reference citations, relevant calculations, computer simulations, etc.

You are free to choose a topic for your project according to your interest. The project should make use of, or build on, nonlinear systems analysis and/or nonlinear control design. Your project may complement your current research but it should not be a repeat of something you have already done in your research. Possible project types:

An **application project** applies the theory of nonlinear systems and control to an application of interest. This type of project could involve a problem that you define and study. Alternatively, you could investigate a problem studied in the literature by reading and working through a paper.

An **advanced topic project** investigates an advanced topic that goes beyond what we have studied in class. This could be completely independent work or it may involve reading, understanding and being able to explain the results of a paper from the literature.

Project deadlines:

1. *Project topic* due at the start of the first class after spring break (March 24)
2. *Oral presentation* held during one of the last three days of class (May 5, 7, or 12)
3. *Written report* due at the start of the last class (May 12)