ENAE 743 APPLIED NONLINEAR CONTROL
SPRING 2016 SYLLABUS

DEPARTMENT OF AEROSPACE ENGINEERING, UNIVERSITY OF MARYLAND
LAST UPDATED: JANUARY 21, 2016

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. *Prereq: ENAE 641*

Instructors
Dr. Derek A. Paley, 3150 Glenn L. Martin Hall, 301-405-5757, dpaley@umd.edu
Office Hours: Walk-in or by appointment
Francis D. Lagor (Frank), Future Faculty Fellow, 3247 Kim Building, flagor@umd.edu
Office Hours: Tu, Th 1-2pm, or by appointment

Lectures
Tu, Th 11:00–12:15 in CHE 2116

Textbook
[1] H. Khalil, *Nonlinear Control*, Prentice Hall, 2014.
http://www.egr.msu.edu/∼khalil/NonlinearControl/

Additional references on reserve in Engineering Library
[1] H. Khalil, *Nonlinear Systems*, 3rd edition, Prentice Hall, 2002.
[2] S. Sastry, *Nonlinear Systems Analysis, Stability, and Control*, Springer-Verlag, 1999.
[3] M. Hirsch, S. Smale, R. Devaney, *Differential Equations, Dynamical Systems, & An Introduction to Chaos*, 2nd edition, Elsevier Academic Press, 2004.
[4] L. Perko, *Differential Equations and Dynamical Systems*, Springer, 2001.
[5] B. Schutz, *Geometrical methods of mathematical physics*, Cambridge University Press, 1980.
[6] W. Rugh, *Linear Systems Theory*, 2nd edition, Prentice-Hall, 1996.
[7] R. Horn and C. Johnson, *Matrix Analysis*, Cambridge University Press, 1985.
[8] R. Sepulchre, M. Janković, P. Kokotović, *Constructive Nonlinear Control*, Springer, 1997.
[9] A. Tewari, *Modern Control Design*, Wiley, 2002.
[10] A. Isidori, *Nonlinear Control Systems*, 3rd edition, Springer, 1995.
[11] H. Nijmeijer and A. J. van der Schaft, *Nonlinear Dynamical Control Systems*, Springer-Verlag, 1990.

Grading
Your final grade will be based on short, weekly homework assignments (30%), a final take-home exam (30%), a midterm take-home exam (20%), a project (20%), and attendance and participation.

Policies
You are encouraged to collaborate on the homework, but you must submit original work. Collaboration is not permitted on the midterm, final, or project (except with permission of the instructor). Assignments and exams will not be accepted after the deadline, except with prior permission.

Course materials

Course materials will be available through ELMS, `http://elms.umd.edu`.

Course outline by week

[1] Mathematical Review & Examples
[2] Introduction to Nonlinear Models & Behavior of Two-Dimensional Systems
[3] Stability of Equilibrium Points
[4] Time-Varying and Perturbed Systems
[5] Passivity Theory
[6] Input-Output Stability
Midterm exam, March 10
[7] Stability of Feedback Systems
[8] Special Nonlinear Forms
[9] State Feedback Stabilization
[10] Robust State Feedback Stabilization
[11] Nonlinear Observers
[12] Output Feedback Stabilization
[13] Tracking and Regulation
Final exam, May 10

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 10–15 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 include the following:

- 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. Short *project topic* description due after spring break (March 22)
2. *Oral presentation* held during one of the last three days of class (May 3, 5, 10)
3. *Written report* due at the start of the last class (May 10)