**ME 8282 Nonlinear Systems**
**Department of Mechanical Engineering**
**University of Minnesota**

**Spring 2007**

**Instructor**: Professor Perry Y. Li
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**Class schedule**:WF 1:25-3:15, ME 221
**Office Hours**: Th :1200-1:00pm, talk to me immediately after class, or by appointment.
**Course URL**: `http://www.me.umn.edu/education/courses/me8282/`

# Overview

This is a graduate level introductory course on analysis and control of nonlinear systems. Knowledge of mathematical linear systems theory (states space, controllability, observability etc.) and mathematical maturity are assumed.

The course will introduce the basic concepts and analysis tools for nonlinear systems, as well as several control design techniques. The goal is that after taking this course, students will be able to approach the literature on nonlinear systems on their own, and to apply the tools to their own applied and theoretical research problems. Approximately half to two thirds of the course will be on nonlinear systems analysis and the remainder on control design techniques.

Homework assignments will consist of theory (pen and paper) and design / simulation (using Matlab/Simulink). There will a significant term project, and a final. We will rely heavily on MATLAB for analysis, design and simulations throughout the course.

**Grades:** Homeworks - 40%, Midterm - 10%, Project - 20%, Final - 30%

# Course Outline

1. Introduction to nonlinear systems phenomena
2. 2nd order (planar) systems - phase plane analysis, Jacobian linearization, orbits and limit cycles;
3. Contraction mapping, sensitivity and continuous dependence on initial conditions
4. Lyapunov stability theory
5. Input-output stability analysis - Small Gain Theorem, Lure' problem, Popov and circle criteria, passivity etc.
6. Perturbed systems
7. Control of nonlinear mechanical systems
8. Exact Feedback linearization
9. Sliding mode and multiple surface control
10. Backstepping control
11. Lyapunov based adaptive control
12. { Nonlinear observers }

# Textbooks

### Main text

- H.K. Khailil "Nonlinear Systems"', 3rd Ed. Prentice Hall, 2002.

This text will be our guide, however, we may not follow the treatment of the topics or the sequence strictly. Supplementary reading materials will be handed out as appropriate.

### Other recommended references on nonlinear systems

1. S. S. Sastry, "Nonlinear systems - analysis and control", Springer-Verlag, 1999. *Fairly complete and very mathematical treatment of nonlinear systems.*

2. M. Vidyasagar, "Nonlinear systems analysis", 2nd Ed, Prentice Hall, 1993. *A mathematical treatment of nonlinear systems analysis.*

3. J.-J. Slotine, W. P. Li, "Applied Nonlinear Control", Prentice Hall. 1991. *Introductory book (i.e. readable) on nonlinear control.*

4. A. Isidori, "Nonlinear control systems", 3rd edition, Springer, 1995. *Good text, focusing on geometric aspect of nonlinear control design.*

5. M. Krstic, Kanellakopoulos, and Kokotovic, "Nonlinear and adaptive control design", Wiley, 1995. *Backstepping and related methods.*

### To brush up on your linear control systems ,

1. G. Goodwin, Graebe, Salgado, "Control System Design", Prentice Hall. 2001. *Good insights for control design, especially linear systems.*

2. C. A. Desoer and Callier, "Linear Systems Theory", Springer-Verlag, 1991. *Linear systems text using geometric ideas.*

3. C. T. Chen, "Linear System Theory and Design", Holt-Reinhart-Winston, 84. *Standard linear systems text*