Fall 2002

ME 559 and EE 559. NONLINEAR CONTROL AND STABILITY
(Schedule Nos. 950076 AND 943704)

Instructor: Professor Asok Ray; **Tel**: 5-6377; **email**: axr2@psu.edu

Web Page Address: **http://www.me.psu.edu/ray**

Office Location: 329 Reber Building;

Office Hours: To be announced

Lecture Class Time and Location: T R 11:15 AM to 12:30 PM at 106 SACKETT

Recitation Class Time and Location: To be announced

Instructional Objectives:

This course is offered at the second year graduate level and its objective is to provide a comprehensive introduction to the theory of nonlinear systems modeling, analysis and control with applications to process control, aeronautics, and robotics. Graduate students the different disciplines of Engineering should find this course useful for their research.

Course Outline:

Review of fundamentals of linear and nonlinear dynamical systems including chaotic motion and fractional dimension. Concepts of equilibrium points and autonomy. Examples of nonlinear and time-varying differential equations including Van der Pol oscillator, Duffing equation, and Mathieu equation.

The Lipshitz condition for existence and uniqueness of nonlinear differential equations. Stability definitions for nonlinear and time-varying systems in continuous-time and discrete-time settings. Lyapunov's direct and indirect methods. The Lure' problem. Treatment of slowly varying systems. Two-time scale problems and singular perturbations. Popov's stability test. Introduction to input-output (I/O)stability. The relationship between I/O and Lyapunov stability.

Analytical approximation techniques like Krylov Boguliubov's method and power series method. Periodic solutions. Analysis of limit cycle problems. Describing function analysis and engineering design of nonlinear systems using the describing function approach.

Introduction to differential geometric methods. Notions of reachability and observability in nonlinear systems. Feedback linearization including input-state linearization and input-output linearization.

Selected topics of nonlinear control systems design such as the sliding control method. Practical examples in control of aircraft, ship, and undersea autonomous vehicles. Use of computer-aided design techniques.

Prerequisites:

Automatic Control (ME 555) or Linear Control Systems (EE527).

Text Book:

H. Khalil, *Nonlinear Systems*, 3rd ed., Prentice Hall, 2002.

Reference Books:

K. Falconer, *Fractal Geometry: Mathematical Foundations and Applications*, John Wiley, Chichester, 1999.

A. Isidori, *Nonlinear Control Systems*, 3rd ed., Springer-Verlag, Berlin, 1995.

E. Ott, *Chaos in Dynamical Systems*, Cambridge University Press, Cambridge, U.K., 1993.

S. Sastry, Nonlinear Systems: Analysis, Stability, and Control, Springer, New York, 1999.

M. Vidyasagar, *Nonlinear Systems Analysis*, 2nd ed., Prentice-Hall, 1993.