BME 590-011
Introduction to Nonlinear Control Design

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Objective or Description: This course serves as an introduction to nonlinear system analysis and synthesis. Mainly, the course focuses on the Lyapunov-based control design for a nonlinear plant model. Application examples include controller design for robotic manipulators, rehabilitation robots, and functional electrical stimulation of the skeletal muscle.

Prerequisites: Linear algebra, Differential Equations, and Linear control methods or its equivalent. Students will use mathematical simulation software (e.g., MATLAB, SIMULINK, etc.).

Textbook: Nonlinear Systems: Third Edition by H. Khalil, Prentice Hall, 2002

Supplemental Textbooks:

- **Applied Nonlinear Control** by Jean-Jacques Slotine, Weiping Li, Pearson Education, 1990
- **Control of Robot Manipulators** by Frank L. Lewis, Chaouki T. Abdallah, D. M. Dawson, Macmillan Pub. Co., 1993

Tentative topics to be covered:

	Topic	**Reading**
1	Introduction to Nonlinear System Behaviour and Control	Chapter 1; Class Notes
2	Phase Plane Methods	Chapter 2; Class Notes; Chapter 13;
3	Fundamental of Lyapunov Theory	Chapter 3; Class Notes
4	Autonomous Systems; Invariance Principle	Chapter 4; Class Notes
5	Advanced Stability Analysis; Barbalat's Lemma; Uniform Ultimate Boundedness	Chapter 8; Class Notes
6	Robot Dynamics; Feedback Linearization	Class Notes; Chapter 13
7	Robust Control; Sliding Mode Control; Adaptive Control	Class Notes; Chapter 14
12	Integrator Backstepping	Class Notes; Chapter 14
13	Output Feedback Control	Class Notes; Chapter 14
14	Geometric Nonlinear Control (if Time)	Class Notes
15	Advanced Topic or Review	

Grading: Midterm exam- 30% Final Exam- 30% Project part 1- 15% Project part 2- 10% Homework 15%

Project part 1: The first part of the project is an individual effort. It will require doing simulations of 3-4 nonlinear control design techniques taught in the course.

Project part 2: The second part of the project is a team effort. It will require validating 3-4 control designs (same as in project part 1) by doing experiments on a 3-DOF robot in the lab.