

ECE 7360: Optimal and Robust Control Course Syllabus - Fall 2001

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Office Hours: MW 1:00-2:30 PM.

Text: Kemin Zhou, with John Doyle, *Essentials of Robust Control*, Prentice-Hall, 1998.

Software: (1) MATLAB Control Systems Toolbox (2) MATLAB mu-synthesis Toolbox (3) RIOTS_95: MATLAB Toolbox for solving optimal control problems.

Prerequisites: Graduate course in multivariable linear control systems.

Course Requirements:

Homework	40 points
Mid-term take home exam	10 points
Focused Individual Study Project/presentation	10 points
Design project	40 points

Notes:

1. The course will follow the outline on the next page.
2. The course will cover material from most chapters of the text as well as some materials taken from the instructor's notes.
3. The course will be conducted as follows:
 - a) There will be lectures by the instructor on most Mondays/Wednesdays
 - b) Homework or project assignments will be given, via e-mail, on the weekly basis normally on Wednesday. The due is by the end of the next Wednesday.
 - c) There will be a midterm take-home exam.
 - d) For each student, a focused individual study project (FISP) is to be done with a literature survey and a class presentation. Topics can be chosen by the individual student, subject to the approval of the Instructor.
 - e) There are totally 4 design projects using MATLAB Simulink/Control Systems Toolbox/mu-Synthesis Toolbox/RIOTS_95 Toolbox. The Instructor will provide a free student edition of RIOTS_95 for solving general optimal control problems.
 - f) There is no final exam.

Course Description:

Robust control is concerned with the problem of designing control systems when there is uncertainty about the model of the system to be controlled or when there are (possibly uncertain) external disturbances influencing the behavior of the system. *Optimal control* is concerned with the design of control systems to achieve a prescribed performance (e.g., to find a controller for a given linear system that minimizes a quadratic cost function). While optimal control theory was originally derived using the techniques of calculus of variation, most robust control methodologies have been developed from an operator-theoretic perspective. In this course we will mainly use an operator approach to study the basic

results in robust control that have been developed over the last fifteen years. However, mathematical programming based techniques for solving optimal control problems will also be briefly covered. This course provides a unified treatment of multivariable control system design for systems subject to uncertainty and performance requirements.

Course Topics and Approximate Schedule:

wk #	Mondays	Wednesdays	Homework/Project
1	Aug. 27 – Chapter 1 Introduction/linear algebra	Aug. 29 – Chapter 2,3 Review /linear system theory	HW#1
2	Sept. 3 – No class Labor Day	Sept. 5 -- Chapter 4, 5 Norms, Stability	HW#2
3	Sept. 10 – Chapter 6 Performance Specs/Limitation	Sept. 12 – Chapter 6 More on performance limitations.	Proj.#1: Inverted Pendulum control revisited
4	Sept. 17 – Chapter 7 Balanced Model Reduction	Sept. 19 -- Chapter 8 Modelling Uncertainty	HW#3
5	Sept. 24 – Chapter 9 LFT: Linear Fractional Transform	Sept. 26 – Chapter 10 μ and μ synthesis	HW#4
6	Oct. 1 – Chapter 10 More on μ	Oct. 3 – Chapter 11 Controller parameterization (Youla-paramterization)	Project#2: Space- shuttle robustness analysis (stability and performance)
7	Oct. 8 – Chapter 12,13 LQR/H2 control	Oct. 10 – Lecturer's Notes LQG/LTR	HW#5
8	Oct. 15 – Chapter 14 H-infinity Control	Oct. 17 -- Chapter 14 H-infinity Control	mid-term take home exam
9	Oct. 22 – Chapter 14 H-infinity Control	Oct. 24 -- Chapter 15 H-infinity Controller order- reduction	HW#6
10	Oct. 29 – Chapter 16 H-infinity loop shaping	Oct. 31 – Chapter 16 H-infinity loop shaping	Project#3: H-infinity control (performance) design of high- maneuvering airplane
11	Nov. 5 -- Chapter 16 H-infinity loop shaping	Nov. 7 – Chapter 17 Gap metric	HW#7
12	Nov. 12 – Chapter 17 ν -Gap metric	Nov. 14 – Instructor's notes Mathematical foundation of RIOTS_95	HW#8

13	Nov. 19 – Instructor's notes Sample applications of RIOTS_95	Nov. 21 – No class. Thanksgiving	Project #4: Solving optimal control problems (you define it!) using RIOTS_95
14	Nov. 26 – FISP presentations (3 students)	Nov. 28 - FISP presentations (2 students)	
15	Dec. 3 - No class (IEEE CDC'01)	Dec. 5 – No class (IEEE CDC'01)	
16	Dec. 10 – exit interview	Dec. 12 – exit interview	

Possible Topics for FISP (not limited to the following, students may propose their own topic of interest)

1. l_1 - and l_∞ -optimal control (for rejection of unknown but bounded disturbances)
2. Structured perturbations, Kharitonov's Theorem
3. Quantitative feedback theory (QFT).
4. Linear matrix inequalities (LMI).
5. and many more ...