# ECE 680 Modern Control Theory Spring, 2008

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| Instructor: | Sarah Koskie |
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| Prerequisites: | ECE 602 or permission of instructor. |
| Credits: | 3 |
| Office Hrs: | tbd |
| Text: | (Required) Stanislaw H. Zak, Systems and Control, Oxford University Press, New York, 2003, ISBN 0-19-515011-2 |
| Description: | An introduction to modeling, analysis, and design of dynamical control systems. Stability; Lyapunov's second method and its applications to the control system design. Sliding modes. Optimal control methods; linear quadratic regulator, dynamic programming, Pontryagin's minimum principle. Robust feedback control of dynamic systems. |
| Assignments: | Homework assignments will be given on a regular basis. Matlab will be used to obtain numerical solutions to some complex problems. Late homework will not be accepted. |
| Exams: | A take-home midterm and a take-home final exam will be given. |
| Grading: | Homework (30%), Midterm (30%), Final (40%). |

# Lecture Outline

1. Introduction and background review (Zak Chs. 1–2, 2 lectures)
   (a) Dynamical system concept
   (b) Formulation of the control problem
   (c) Modeling—the design model and the simulation model
   (d) Analysis of modeling equations: State-plane analysis, linearization
2. Controllability and observability of linear systems (Zak Ch. 3, 1 lecture)
   (a) Controllability and reachability, controllability tests
   (b) Observability and constructability, observability tests
   (c) Duality
   (d) Stabilizability and detectability
   (e) Canonical forms: controller form, observer form
3. Controller synthesis (Zak Ch. 3, 1 lecture)
   (a) Linear state feedback
   (b) Pole assignment and stabilization via linear state feedback
4. State estimators, combined controller-estimator compensators (Zak Ch. 3, 1 lecture)
5. Stability (Zak Ch. 4, 3 lectures)
6. Robust feedback control design using Lyapunov's method (1 lecture)
7. Sliding mode controller design (Zak Ch. 6, 3 lectures)
8. Static optimization: an overview (notes, 2 lectures)
9. Optimal control (Zak Ch. 5 and notes, 14 lectures)
   (a) Basic concepts and examples (1 lecture)
   (b) The calculus of variations (2 lectures)
   (c) Optimization of functionals (1 lecture)
   (d) Linear quadratic regulator (LQR) problem (2 lectures)
   (e) Algebraic Riccati equation (ARE) (1 lecture)
   (f) Design of optimal control systems with prescribed poles (1 lecture)
   (g) Dynamic programming (2 lectures)
   (h) The Hamilton-Jacobi-Bellman (HJB) equation (1 lecture)

(i) Pontryagin's minimum principle (1 lecture)

(j) Minimum-time control (1 lecture)

(k) Minimum-fuel/energy control (1 lecture)

(l) Weighted optimal control (1 lecture)

(m) Two-point boundary-value problem (2 lectures)

10. Advanced topics (notes, 1 lecture)