University of Waterloo
ECE 682: Multivariable Control Systems
Fall 2021
Tentative and subject to change

Lectures:  

Instructor: Prof. Christopher Nielsen.
Office hours: by appointment.
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Website: http://learn.uwaterloo.ca/

Calendar description: An introduction to control theory for linear time-invariant finite-dimensional systems from both the state-space and input-output viewpoints. State-space theory: the concepts of controllability, observability, stabilizability, and detectability; the pole-assignment theorem; observers and dynamic compensation; L.Q.R. regulators. Input-output theory: the ring of polynomials and the field of rational functions; the algebra of polynomial and rational matrices; coprime factorization of transfer matrices; Youla parametrization. Introduction to optimal control.

Prerequisites: ECE 380 (or equivalent) and familiarity with basic linear algebra.

Text: Course notes are available on the course website. The optional suggested textbook is Linear System Theory and Design, 3rd edition, C.T. Chen.

Additional references

- Finite-Dimensional Vector Spaces, P.R. Halmos.
- Robust and Optimal Control, K. Zhou, J.C. Doyle and K. Glover.
- Linear Systems, T. Kailath.

Evaluation:

25% Assignments (4 or 5 spread over the term).
25% Midterm (2 hrs).
35% Final exam (4 hrs).
15% Course Project.
Tentative Topics List:

1. Introduction to linear multivariable systems
   - Motivation, examples.

2. Linear state-space models
   - Deriving state models, Linearization, Solution of state equation, Realizations, Poles and zeros of a multivariable system.

3. Linear algebra
   - Vector spaces, Linear transformations, Quotient spaces, Invariant subspaces.

4. Controllability
   - Reachable states, Properties of controllability, PBH test, Equivalence of pole placement and controllability, Stabilizability.

5. Observability
   - The Kalman decomposition, Detectability, Observers, Observer based controllers.

6. Quadratic optimal control
   - Lyapunov equation, Riccati equation, The LQR problem and its solution.

7. Stability of feedback systems
   - Well-posedness, Feedback stability, Output feedback stabilization.

8. Regulation and tracking
   - Output regulation problem, Solution in the case of full information, Solution in the case of measurement feedback.

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Academic integrity, grievance, discipline, appeals and note for students with disabilities: see [www.uwaterloo.ca/accountability/documents/courseoutlinestmts.pdf](http://www.uwaterloo.ca/accountability/documents/courseoutlinestmts.pdf). The text on that web site is listed below.

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