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

Lectures: [redacted]

Instructor: Prof. Christopher Nielsen.
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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.

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

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