

University of Waterloo
ECE 682: Multivariable Control Systems
Fall 2023 (tentative)



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.

Recommended background: Undergraduate linear algebra; introductory course on feedback control (ECE380 or equivalent).

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

- Linear System Theory, F.M. Callier and C.A. Desoer.
- Control Theory for Linear Systems, H.L. Trentelman, A.A. Stoorvogel, M. Hautus.
- Linear Systems Theory, J.P. Hespanha.

Evaluation:

55% Final exam: open book.

40% Assignments: Four (4) assignments spread over the term.

5% Student delivered tutorials (if sufficient enrolment). Held outside lecture time. Schedule to be determined.

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, Structurally stable synthesis.

Academic integrity, grievance, discipline, appeals and note for students with disabilities:

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