

NORTH CAROLINA STATE UNIVERSITY  
Department of Mechanical and Aerospace Engineering

**MAE 721 Robust Control with Convex Methods**  
SYLLABUS  
Fall Semester 2024

**Schedule:** TuTh 11:45am-1pm  
**Classroom:** EBI 1010  
**Website:** [wolfware.ncsu.edu](http://wolfware.ncsu.edu)

Dr. Fen Wu, Professor  
**Office:** EBIII 3254  
**Office Hours:** TuTh 9:30-11:30am  
**E-mail:** [fwu@ncsu.edu](mailto:fwu@ncsu.edu)

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**COURSE OBJECTIVE:**

This course emphasizes on control design techniques which result in closed-loop systems that are insensitive to modeling errors and which achieve a pre-specified level of performance. Robustness margins against model uncertainty. Robust control design techniques based on linear matrix inequalities. Topics include uncertainty modeling, robust stability and performance,  $H_\infty$  control, convex optimization technique (LMI), mu-analysis and synthesis, computer-aided analysis and control design.

**REQUIRED TEXTBOOK:**

*Essentials of Robust Control*, by Kemin Zhou and John C. Doyle, Prentice Hall, 1998.

**REFERENCES:**

- *A Course in Robust Control Theory—A Convex Approach*, G.E. Dullerud and F. Paganini, Springer-Verlag, Texts in Applied Mathematics, **36**, 2000.
- *Multivariable Feedback Control*, S. Skogestad and I. Postlethwaite, John Wiley and Sons, 1996.
- *A Course in  $\mathcal{H}_\infty$  Control Theory*, B.A. Francis, Springer-Verlag, Lecture Notes in Control and Information Sciences, **88**, 1987.
- *Linear Matrix Inequalities in System and Control Theory*, S. Boyd, L.E. Ghaoui, E. Feron and V. Balakrishnan, SIAM, 1994.

**PREREQUISITE:**

Linear system theory (MAE 521 or ECE 516) and background knowledge of linear algebra and complex analysis.

**HOMEWORK POLICY:**

Problems are normally assigned every other week and due two weeks later. The assignments split approximately 70% theoretical, and 30% computer based. Since assigned homeworks are an integral part of transferring course content to students, they are to be individual effort. Each new homework problem must begin on a new page. *Late submission of homework assignments will not be accepted without prior approval by the instructor.*

### EXAMINATIONS:

There will be one midterm (Oct. 17) during the semester. The final exam will be comprehensive and is scheduled on Dec. 5, 2024. All exams will be open books and open notes. Graded exams will be returned as soon as possible. *There will be no makeup examinations except for extreme circumstances.*

### DESIGN PROJECT:

You will be given four weeks to work on the design project. The due date of the project will be the last day of instruction (Dec. 3, 2024). The project should be a group effort with preferable size of no more than 2 persons for each group. Your results should be summarized in a formal report.

### GRADING POLICY:

For the course grade assignment, the following weighting basis will be applied:

Homework 20%  
 Midterm 25%  
 Project 20%  
 Final Exam 35%

### TENTATIVE SCHEDULE:

Date	Topics
Aug. 20	Introduction
Aug. 22, 27, 29, Sept. 3	Review linear algebra linear system theory
Sept. 5, 10	Functional space and norms
Sept. 12, 19	Internal stability
Sept. 24, 26	Performance specification
Oct. 1, 3	LFT
Oct. 8, 10	Controller parametrization
Oct. 17	Midterm
Oct. 22, 24	Uncertainty modeling and robustness
Oct. 29, 31	Riccati equation
Nov. 5, 7	Convex optimization (LMI)
Nov. 12, 14	$\mathcal{H}_\infty$ control
Nov. 19, 21, 26	$\mu$ analysis and synthesis
Dec. 3	Class review
Dec. 5	Final Exam

## MISCELLANEOUS:

1. Attendance is expected at all class meetings. The attendance policy is consistent with the Academic Regulation.  
See [www.ncsu.edu/policies/academic\\_affairs/pols\\_regs/REG205.00.4.php](http://www.ncsu.edu/policies/academic_affairs/pols_regs/REG205.00.4.php)
2. It is responsibility of each student to be familiar with the NCSU Code of Student Conduct and in particular with those portions pertaining to academic dishonesty.  
See [www.ncsu.edu/policies/student\\_services/student\\_discipline/POL11.35.1.php](http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php)
3. Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantages of available accommodations, students must register with Disability Services for Students  
See [www.ncsu.edu/policies/student\\_services/courses\\_undergrad/REG02.20.1.php](http://www.ncsu.edu/policies/student_services/courses_undergrad/REG02.20.1.php)
4. Online class evaluation will be available for students to complete at end of the semester. Evaluation website is at [classeval.ncsu.edu](http://classeval.ncsu.edu)