North Carolina State University
Department of Mechanical and Aerospace Engineering

MAE 521 Linear Control and Design For MIMO Systems
Syllabus
Spring Semester 2024

Schedule: TuTh 4:30-5:45pm
Classroom: EBIII 2232
Website: wolfware.ncsu.edu

Instructor: Dr. Fen Wu, Professor
Office: EBIII 3254
Office Hours: TuTh 1-3:30pm
E-mail: fwu@ncsu.edu

COURSE OBJECTIVE:

This course introduces linear multivariable control and design for engineering systems such as robotics and aircraft. Emphasis on multi-input and multi-output (MIMO) system analysis and design using state-space approach. Controllability and observability, transmission zeros and pole-zero cancellation, stability analysis of MIMO systems in time-domain, state-feedback control and state estimation, optimal control.

REQUIRED TEXTBOOK:

Linear System Theory and Design (4th Ed.), by C.-T. Chen, Oxford University Press, 2013.

REFERENCES:

- R.L. Willams II and D.A. Lawrence, *Linear State-Space Control Systems*, John Wiley and Sons, 1999.

- J.M. Maciejowski, *Multivariable Feedback Design*, Addison-Wesley, 1989.

- G. Strang, *Linear Algebra and its Applications* (5th ed.), Wellesley-Cambridge Press, 2016 (Linear Algebra Reference).

PREREQUISITE:

A good background in linear algebra and classical control techniques.

HOMEWORK POLICY:

Problems are normally assigned every other week and due two weeks later. The completed homeworks should be submitted to the course website on time. Since assigned homeworks are an integral part of transferring course content to students, they are to be completed through 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 (Mar. 7) during the semester. The final exam will be comprehensive and is scheduled on Apr. 30, 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.*

GRADING POLICY:

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

Homework 30%
Midterm 30%
Final Exam 40%

The grading scale is:

A_+	> 95	C_+	$73.33 - 76.66$
A	$90 - 95$	C	$70 - 73.33$
A_-	$86.66 - 90$	C_-	$66.66 - 70$
B_+	$83.33 - 86.66$	D_+	$63.33 - 66.66$
B	$80 - 83.33$	D	$60 - 63.33$
B_-	$76.66 - 80$	D_-	$55 - 60$
		F	< 55

TENTATIVE SCHEDULE:

Date	Topics
Jan. 9	Introduction to linear systems
Jan. 11, 16	Linear system properties
Jan. 18, 23, 25	Linear algebra
Jan. 30, Feb. 1	Canonical forms
Feb. 6, 8	Functions of a matrix
Feb. 15	State-space solution
Feb. 20	Realization and stability
Feb. 22, 27	Controllability and observability
Feb. 29, Mar. 5	Kalman decomposition
Mar. 7	Midterm
Mar. 19, 21	State-feedback control
Mar. 26, 28, Apr. 2	State estimation
Apr. 4	Poles and zeros
Apr. 9	Robust stability
Apr. 11, 16	Linear optimal control
Apr. 18	Extension to LTV systems
Apr. 23	Review
Apr. 30	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`

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`

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`

4. Online class evaluation will be available for students to complete at end of the semester. Evaluation website is at `classeval.ncsu.edu`