KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DEPARTMENT OF MATHEMATICS & STATISTICS
Math 642: Control and Stability of Linear Systems (Term 211)

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Office Hours: UTR 2:00 PM – 3:00 PM or by appointment

Check Blackboard Regularly for Announcements

Textbook: 1. Linear system theory and design by Chi-Tsong Chen, Fourth Edition.
2. Linear Systems Theory by Thomas Kailath, Prentice-Hall
3. Linear Systems Theory by Joao P. Hespanha, Princeton University Press

Review of systems of linear differential equations to include existence and uniqueness, contraction mappings, fixed points, transition matrix, matrix exponentials, the Laplace transform and stability. Linear control systems. Controllability, observability and duality. Weighting patterns and minimal realizations. Feedback. Linear regulator problem and matrix Riccati equations. Fixed-end point problems. Minimum cost and final-value problems in control theory. Stability of linear systems. Uniform stability. Exponential stability.

Learning Outcomes: Upon completion of this course, students should be able to

- Classify a system from the perspectives of dimension, causality, time dependence, and linearity.
- Learn fundamental linear algebraic concepts and normed spaces and apply them to Jordan normal form, singular value decomposition, positive definiteness, functions of a matrix.
- Learn the concept of state, the concept of state trajectory as the solution of a multivariable (time-invariant or time varying) state-variable representation, equivalence of representations, and in time-invariant case, its transfer matrix and the correspondence between eigenvalues and poles.
- Analyze the stability of a state-variable representation, know the difference between internal stability and input-output stability
- Test the controllability and observability of a (time varying or time-invariant) state-variable representation, learn their significance and applications
- Design state-feedback, state observers, and their combination to stabilize or to place the poles of a multivariable, time-invariant system
- Design a pole-placing output feedback controller using polynomial techniques for a single-input/single-output system.

Assessment

Activity	Weight
Quizzes	15%
Homeworks	10%
Midterm exam	30%
Projects	5%
Final Exam	40%

Academic Integrity: All KFUPM policies regarding ethics apply to this course.
For ***Important Dates*** and ***Academic Calendar***, check the Registrar's site: http://regweb.kfupm.edu.sa

SCEDULE and COVERAGE of MATERIAL

Week No. *(Dates)*	Sections	Topics
Week 1 *Aug. 29- Aug. 31*	2.1 2.2 2.3	Introduction Linear systems Linear time invariant (LTI) systems
Week 2 *Sep. 5- 7*	2.4 2.5 2.6	Linearization Examples Discrete-time LTI systems
Hwk1. Page 38, problems 2.2, 2.5, 2.8, 2.10, 2.13		
Week 3 *Sep. 12- 14*	3.1 3.2 3.3 3.4 3.5	Introducation Basis representation & orthonormalization Linear algebric equations Similarity Transformations Diagonal form & Jordan Form
Week 4 *Sep. 19- 21*	3.6 3.7 3.8 3.9 3.10	Funcations of a square matrix Lyapunov equation Some useful formulas Quadratic form & positive definiteness SVD
Hwk2. Page 79, problems 3.4, 3.11, 3.13, 3.14, 3.25, 3.26, 3.31, 3.34		
Sep 23: National Day Holiday		
Week 5 *Sep. 26- Sep. 28*	4.2 4.3	Solutions of LTI equations Equivlent state equations
Week 6 *Oct. 3- 5*	4.4 4.5	Realiations Solution of Linear Time-Varying (LTV) Equations
Week 7 *Oct. 10- 12*	4.6 5.2	Equivalent Time-Varying Equations Stability of input-output LTI systems
Hwk3. Page 117, problems, 4.2, 4.4, 4.6, 4.7, 4.9, 4.11, 4.15, 4.16, 4.26		
Oct. 17: Student Break		
Week 8 *Oct. 19*	5.3 5.4	Internal stability Lyapunov Theorem
Week 9 *Oct. 24- 26*	5.5 6.2 6.3	Stability of LTV Systems Controllability Observability
Hwk4. Page 140, problems, 5.4, 5.7, 5.11, 5.13, 5.16, 5.18, 5.23		
Week 10 *Oct. 31- Nov. 2*	6.4 6.5 6.6	Canonical Decomposition Conditions in Jordan-Form Equations Discrete-Time State Equations
Week 11 *Nov. 7- 9*	6.7 6.8	Controllability After Sampling LTV State Equations
Hwk5. Page 180, problems, 6.2, 6.4, 6.10, 6.14, 6.16, 6.21		
Week 12 *Nov. 14- 16*	8.1 8.2	Introduction State Feedback
Week 13 *Nov. 21- 23*	8.3 8.4	Regulation and Tracking State Estimator
Midterm Break Nov. 28- Dec 02		

Week 14 *Dec. 05- 07*	8.5 8.6	Feedback from Estimated States State Feedback—Multivariable Case
Week 15 *Dec. 12- Dec. 14*	8.7 8.8	State estimators—Multivariable Case Feedback from Estimated States—Multivariable Case
Hwk.6 Pages, problems 8.4, 8.5, 8.7,8.10, 8.13		
Week 16 *Dec. 19*	Suppl. Material	LQR
Dec 20	Normal Thursday Classes; Last day of classes for the term	
Final Exam (Comprehensive): TBA		