AE 6530 – Multivariable Linear Systems and Control

HOURS: 3-0-3

CATALOG DESCRIPTION (25 words or fewer):
Techniques for analysis and description of multivariable linear systems. Tools for advanced feedback control design for these systems, including computational packages.

PREREQUISITES:
   AE 3531

TEXTBOOKS:
   Modern Control Theory - 3rd edition, William L. Brogan, Prentice Hall, 1991

COURSE OBJECTIVES:
The course is intended for graduate and advanced undergraduate students interested in modeling and control of linear, multi-variable systems. Emphasis will be given to the use of computer packages (e.g. Matlab) for the solution of these problems.

LEARNING OUTCOMES:
Students will be able to:
1. Model physical systems using linear, time-invariant (LTI) ordinary differential equations with multiple states, inputs and outputs (MIMO systems)
2. Learn to solve linear ordinary differential equations in the time-domain using matrix exponentials
3. Master the linear algebra concepts pertaining to the analysis and control synthesis of MIMO LTI systems
4. Design state-feedback stabilizing controllers for MIMO LTI systems
5. Investigate the controllability and observability properties of MIMO LTI systems
6. Understand the impact of noise in the dynamics and measurements and proposed methods to mitigate noise and other unwanted disturbances
7. Design observers to estimate the state of a system given a set of measurements
8. Use optimal control theory to design optimal controllers and estimators for LTI systems
9. Understand the theoretical properties and solution techniques for matrix linear equations (e.g., Lyapunov and Riccati matrix equations)
10. Combine state estimators with state feedback controllers to control MIMO systems
11. Learn how to implement these control and estimation techniques in a wide variety of engineering systems

GRADING:
Assignments:	15%
Midterm Exam:	35%
Final Exam:	50%

LEARNING ACCOMMODATIONS:
   If needed, we will make classroom accommodations for students with documented disabilities. These accommodations must be arranged in advance and in accordance with the ADAPTS office (http://www.adapts.gatech.edu).

TOPICAL OUTLINE:

Topic	Lecture Hours
I. Introduction	3
1. Models of physical systems	
2. Continuous systems, s-transform	
3. Equilibrium points, solutions and linearization	
II. Review of Linear/Matrix Algebra	16
1. Vectors and vector spaces	
2. Orthonormal bases, Gram-Schmidt procedure	
3. Linear mappings and adjoint operators	
4. Eigenvalues, eigenvectors, Jordan normal forms	
5. Spectral and singular value decompositions	
6. Null space and range of a matrix	
7. Linear matrix equations and least squares theory	
III. State-Space Linear Systems	10
1. State-space vs.transfer function matrix models	
2. Solution of linear differential equations, matrix exponential	
3. Signals and norms	
4. Realizations, Kalman canonical forms	
5. Stability, Lyapunov equations	
6. Controllability and observability grammians	
7. Stabilizability and detectability	
IV. Control Design	13
1. State feedback	
2. Eigenvalue and eigenstructure assignment	
3. Full-state and reduced-state observers	
4. Optimal regulation (LQR)	
5. Riccati equations	
6. Optimal state estimation, Kalman filter	
7. Output feedback, Linear-Quadratic Gaussian (LQG) controllers	
8. Applications of LQG control	
Exams and Review	3