ECE 6744/ ME 6544/ AOE 6744: Linear Control Theory
Course Syllabus

Instructor: Mazen Farhood
224-10 Randolph Hall
E-mail: farhood@vt.edu
Phone: 231-2983

Meeting Time: Tuesdays and Thursdays, 3:30 to 4:45 PM

Meeting Place: Whittemore 257

Office Hours: Tuesdays and Thursdays, 2:00 to 3:20 PM

Grader: Jean-Michel Fahmi (fahmi@vt.edu)

Description: This course covers optimal controller and observer design for multi-input, multi-output linear systems. Major course topics include a review of linear system theory, linear-quadratic optimal control theory, linear-quadratic Gaussian (optimal controller/observer) theory, and methods for ensuring robustness to model uncertainty and time delays.

References: Texts Focusing on Linear Optimal Control

P. Dorato, C. T Abdallah, and V. Cerone. *Linear Quadratic Control: An Introduction*, Krieger Publishing.

B. D. O. Anderson and J. B. Moore. *Linear Optimal Control*, Prentice Hall, Englewood Cliffs, NJ, 1971.

R. W. Brockett. *Finite Dimensional Linear Systems*, John Wiley and Sons, New York, NY, 1970.

H. Kwakernaak and R. Sivan. *Linear Optimal Control Systems*, John Wiley and Sons, New York, NY 1972.

More General Texts on Optimal Control

A. E. Bryson, Jr. and Y.-C. Ho. *Applied Optimal Control: Optimization, Estimation, and Control*, (Revised Printing) Taylor and Francis, New York, NY 1975.

R. F. Stengel. *Optimal Control and Estimation*, Dover, New York, NY 1986.

Grade:		
	20%	Homework
	40%	Midterm Exam (24-hour take-home exam)
	40%	Final Exam (24-hour take-home exam)

Course Topics:

I. Linear System Theory
    A. Linear Algebra
        i. Vector spaces and norms
        ii. Linear maps; range and null space
        iii. Existence and uniqueness of solutions to linear algebraic equations
        iv. The eigenvalue problem
        v. Symmetric matrices and quadratic forms
        vi. Similarity transformations and the Jordan form
    B. Linear ODEs
        i. Linearization of nonlinear ODEs
        ii. The state transition matrix
    C. System Structural Properties
        i. Controllability
        ii. Observability
        iii. Stability
II. The Linear-Quadratic Controller
    A. Derivation of the LQ controller by dynamic programming
        i. Solution for time-varying systems
        ii. Solution for time-invariant systems
        iii. Steady-state (infinite horizon) solution for time-invariant systems (The Linear-Quadratic Regulator)
            1. Penalty matrix selection
            2. Guaranteed degree of stability
        iv. LQ optimal trajectory tracking
    B. Robustness of the LQR state feedback controller
        i. Nyquist plots
        ii. Stability (gain and phase) margins
III. State Estimation and Output Feedback
    A. Introduction to stochastic systems
    B. The Kalman-Bucy filter
    C. The LQG controller and the separation principle
    D. Loss of robustness and loop transfer recovery