EE 547 D Linear Systems Theory
Tuesdays 6:00pm - 9:50pm (lecture 6:00 – 8:00; laboratory 8:15 – 9:50)
Room: EEB 003

Instructor: Professor Linda Bushnell LB2@uw.edu
office hours: 5pm – 6pm Tuesdays, EEB M342

TA: Sang Sagong sagong@uw.edu
Office hours: 5pm – 6pm Tuesdays, room TBD

Textbooks/Software/Hardware:
Joao Hespanha, "Linear Systems Theory," Princeton University Press, 2009 or any other Linear Systems Theory book (recommended)
Matlab, Simulink, Control Systems Toolbox, Symbolic Math Toolbox (buy or use remote UW version)
Minseg robot based on Arduino (UW will provide this to each student for the quarter)

Grading:
Homework 40%, Take-home Midterm 20%, Project 40%

Topics Covered:
- System Representation: modeling, transfer function, state space, linearization, causality, time invariance, linearization
- System Response: LTV and LTI systems, impulse response, step response, frequency response, Bode Plots
- Stability: Lyapunov, Input-Output
- Controllability: concept of controllability, controllable subspaces, decompositions
- Observability: concept of observability, output feedback, minimal realizations
- State-variable Feedback: PID control, LQR control
- State Observers/Estimators: full-state observers, reduced-state observers
- Use of Matlab and Simulink to explore concepts covered above.
- Implementation of above concepts on a MinSeg robot.

Schedule:
Lecture 1: Introduction, physical system modeling, transfer function and state-space representation, linearization
Laboratory 1: Matlab: introduction to Matlab, linearization in state-space
Minseg: setting up laptops and connections to the Minseg, accessing the LED

Lecture 2: Basic properties of a system, impulse response, converting state-space to transfer function and vice versa, equivalent systems
Laboratory 2: Matlab: State-space and transfer function, Simulink
Minseg: Accessing the gyroscope

Lecture 3: Solutions to the LTV DE, solutions to the LTI DE, Fundamental matrix, State Transition matrix, matrix exponential, Cayley-Hamilton Theorem, characteristic polynomial
Laboratory 3: Matlab: Matrix exponential of LTI system
Minseg

Lecture 4: More ways to solve the DE: Similarity transformation, eigenvalues, eigenvectors, Jordan Form
Laboratory 4: Matlab: Eigenvalues and Jordan Form
Minseg

Lecture 5: Lyapunov Stability, Input/Output Stability
Laboratory 5: Matlab: Lyapunov stability
Minseg

Lecture 6: Controllability, Observability, Decomposition
Laboratory 6: Matlab: System controllability, observability, decomposition
Minseg

Lecture 7: State-variable feedback, SISO, MIMO; LQR controller
Laboratory 7: Matlab: System state feedback
Minseg

Lecture 8: Observers, full-order, reduced-order
Laboratory 8: Matlab: State estimators in Simulink
Minseg

Lecture 9: Combining feedback and observers, SISO, MIMO; applications of linear systems
Laboratory 9: Feedback with state observers
Minseg

Class 10: Project Presentations (PPT) and demos of balancing MinSeg robot