

Engineering Systems Analysis: Systems

Course Description

Engineering Systems Analysis (ESA) involves building, developing, and practicing process-based quantitative analysis skills in the broad area comprising linear analysis of engineering systems. Concepts such as linearization, equilibrium, and stability will be applied to study the dynamic response of electrical and mechanical systems in both the time and frequency domains through time-integration and Laplace Transform analysis. Fundamentals of feedback control are introduced. The course project involves parameter identification and control of an unstable mechatronic system—an inverted pendulum on a translating cart.

Rationale for ESA: Linear system theory and feedback control are commonly included in the curricula of both Mechanical and Electrical and Computer Engineering programs. Both majors typically offer these subjects in similar, yet separate courses. ESA successfully integrates two subject-matter, specific content courses, Signals and Systems (ECE) and Dynamics (ME), into a single course that focuses on the development and application of general mathematical modeling and analysis tools to support the engineering design process. The efficacy and advantages of concept integration help build a shared language applicable to future academic projects and professional practice. Taught in a studio-setting, ESA serves as a prerequisite for advanced courses in either major.

Course Schedule

Class meetings	Topics	In-class assignments: T due Th, F due T
Day 1 F Jan 19	Intro. Input/Output systems. Review 1 st order systems in time domain. Analytical and numerical solns. for free, forced-step, and forced-harmonic	
Day 2 T Jan 23	Review free response of 2 nd order systems in the time domain. Analytical and numerical solutions. Connect parameters (e.g., damping ratio, natural/damped frequency) to system behavior.	
Day 3 F Jan 26	Review forced response of 2 nd order systems in time domain to step and harmonic excitation. Analytical and numerical solutions.	HW 1 Due F, 1/26
Day 4 T Jan 30	Intro to the s-plane and the Laplace transform (LT).	
Day 5 F Feb 2	Applying the LT to solve ODEs, e.g., 2 nd order ODE-output voltage of a circuit. Partial fraction expansions and the table lookup method.	HW 2 Due F, 2/2
Day 6 T Feb 6	Analytical Tools for 2 nd order systems: Poles, zeros, transfer functions, stability, ideal oscillators (LC circuits). Symbolic MATLAB tools.	
Day 7 F Feb 9	Block diagrams. LT analysis and solution of overdamped, critically, and underdamped systems. Poles of 2 nd order systems, their relationship to stability and response.	HW 3 Due F, 2/9
Day 8 T Feb 13	Intro to feedback control. Black's formula, Final value theorem. Proportional and PI feedback. Steady-state error.	
F Feb 16	NO CLASSES due to Candidates Weekend 1 !	

Day 9 T Feb 20	Analyzing feedback systems with MATLAB symbolic tools. PI control of a first order system.	HW 4 Due W , 2/21
Day 10 F Feb 23	Inverted pendulum (Rocky) eqns of motion. Formulating a feedback system for Rocky. Regulator problem	
Day 11 T Feb 27	Inverted pendulum (Rocky) project	HW 5 Due W , 2/28
Day 12 F Mar 1	Inverted pendulum (Rocky) project	
Day 13 T Mar 5	Inverted pendulum (Rocky) project	Quiz Due F , 3/8
Day 14 F Mar 8	Inverted pendulum (Rocky) project Demo Day	Final Project Deliverables Due F , 3/15