ME 3253 – Linear Systems Theory

Credits and Contact Hours: 3 Credits. Three 50 minute or two 75 minute lectures per week.

Instructors: Chengyu Cao, Xu Chen, Jason Lee, Nejat Olgac, Jiong Tang

Textbook: *System Dynamics,* by K. Ogata, 4th Edition, Prentice Hall, 2004

Specific Course Information:

a. Catalog Description: Review of ODE solutions, mathematical modeling of dynamic systems, linearization of nonlinear behavior, Laplace domain representation of dynamics, transfer functions, block diagram algebra, signal-flow graphs, Mason's rule, transient analysis of system response, convolution integral, Duhamel's integral, Green's function, stability of linear systems, Routh-Hurwitz method, root locus, frequency response, Bode and polar representations, introduction to feedback systems.

b. Prerequisites: CE 2120, MATH 2410Q

c. Required, Elective or Selected Elective: Required

Specific Goals:

a. Course Outcomes:

After completing ME 3253 students should be able to:

1. Model first- and second-order linear dynamic systems such as mechanical, electrical and thermal-fluid systems, and analyze the linear responses.
2. Perform Laplace and inverse Laplace transformation, and to use Laplace transforms to solve ordinary differential equations.
3. Identify key characteristics of first- and second-order systems, and use block diagrams to analyze linear system performance.
4. Perform stability analysis for a dynamic system.

b. Relationship of Course Outcomes to Criterion 3 Student Outcomes:

1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.
   In this course students start with the linear ordinary differential equation solutions, Laplace transformations, and transfer function representations of dynamics, and continue with the broader understanding of dynamic responses. Using programming tools such as MATLAB and Simulink, students gain expertise in debugging numerical outcomes using engineering insight and mathematical functions. Students gain an understanding that every linear system can be broken into first and second order dynamics, and that these are the building blocks of more complex systems. Students learn how to assess the systems response to a set of conventional driving functions (such as step, impulse, ramp and sine functions). Based on this, students can troubleshoot and interpret the simulation results obtained through MATLAB/Simulink.

2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.
   Students are required to solve an open-ended design problem in one of the homework assignments using modeling, simulation, and animation tools.
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
   Through the use of modeling and simulation tools students are exposed to design alternatives and corresponding system response. Students learn to draw conclusions based on the response properties obtained.
4. An ability to communicate effectively with a range of audiences.
   Not Applicable
5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
   Not Applicable
6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.
   The need for life-long learning is reinforced by exposure to new developments in modeling and simulation tools, as emphasized by the changing popularity of the various commercial packages. Students learn to work with the underlying analytical tools which give them greater decision making abilities. Advanced modeling and simulation tools, such as MATLAB/Simulink are used in this course.
7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty.
   Not Applicable

Topics Covered:

- Ordinary differential equations
- Laplace domain representation of dynamics
- Mathematical modeling of dynamic systems
- Block diagram algebra
- Time domain analysis of system response
- Stability of linear systems
- Frequency domain analysis