ME 3253 – Linear Systems Theory

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

Instructors: Chengyu Cao, Robert Gao, Kevin Murphy, 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:

a) an ability to apply knowledge of mathematics, science, and engineering:
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.

b) an ability to design and conduct experiments, as well as analyze and interpret data:
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.

c) an ability to design a system, component, or process to 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.

d) an ability to function on multi-disciplinary teams: *not applicable*

e) an ability to identify, formulate, and solve engineering problems:
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.

f) an understanding of professional and ethical responsibility: *not applicable*

g) an ability to communicate effectively: *not applicable*

h) the broad education necessary to understand the impact of engineering solutions in a global and societal context: *not applicable*

i) a recognition of the need for, and an ability to engage in life-long learning:
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.

j) a knowledge of contemporary issues: *not applicable*

k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice:
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.

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