ME 360 COURSE PROFILE

DEGREE PROGRAM: Mechanical Engineering

COURSE NUMBER: ME 360	**COURSE TITLE:** Modeling, Analysis and Control of Dynamic Systems
REQUIRED COURSE OR ELECTIVE COURSE: Required	**TERMS OFFERED:** Fall, Winter
TEXTBOOK / REQUIRED MATERIAL: System Dynamics by Ogata	**PRE / CO-REQUISITES:** MECHENG 240 and P/A EECS 314. I, II (4 credits)
COGNIZANT FACULTY: K. Barton, J. Koller **BULLETIN DESCRIPTION:** Developing mathematical models of dynamic systems, including mechanical, electrical, electromechanical, and fluid/thermal systems, and representing these models in transfer function and state space form. Analysis of dynamic system models, including time and frequency responses. Introduction to linear feedback control techniques. Synthesis and analysis by analytical and computer methods. Four hours of lecture per week.	**COURSE TOPICS:** 1. MODELING: Mechanical, electrical, fluid/thermal and mixed-domain systems (e.g. DC motors) 2. MODELING: State space system equations; Numerical integration 3. ANALYSIS: Linearity (superposition) and linearization 4. ANALYSIS: Laplace transforms and transfer functions; block diagrams 5. ANALYSIS: Free and forced responses (impulse, step) of first and second order LTI systems 6. ANALYSIS: Frequency response; Bode plots 7. CONTROL: System performance measures in the time and frequency domains: time constant, natural frequency, damping ratio, steady-state behavior 8. CONTROL: Feedback control: P, PI, PD control; reference tracking and disturbance rejection
COURSE STRUCTURE/SCHEDULE: Lecture: 2 days per week at 2 hours	

COURSE OBJECTIVES: for each course objective, links to the Program Outcomes are identified in brackets.	1. To teach students elementary tools of modeling of mechanical, electrical, fluid, and thermofluid systems [1, 2, 6] 2. To teach a basic understanding of behavior of first- and second -order linear time invariant differential equations [1] 3. To teach basic concepts of Laplace transforms, transfer functions, and frequency response analysis [1, 6] 4. To introduce the concept of stability and the use of feedback control to actively control system behavior [1, 6] 5. To provide examples of real world systems to which modeling and analysis tools are applied (e.g., DC Motor) for the purpose of design [1, 2, 6] 6. To introduce an appreciation for decision making skills needed to devise models that adequately represent relevant behaviors yet remain simple [1] 7. To teach basic concepts in numerical integration and computer simulation of mathematical models [1, 2, 6]
COURSE OUTCOMES: for each course outcome, links to the Course Objectives are identified in brackets.	1. Given a description of a real world system, make educated decisions about how to model it in terms of idealized, lumped elements [1, 5, 6, 7] 2. Given a simple system containing some combination of mechanical, electrical, and/or thermofluid elements, write a differential equation describing its input/output behavior [1] 3. Given a first- or second-order LTI differential equation, predict its step response or free response [2] 4. Given a LTI differential equation and a sinusoidal input, predict the gain and phase of the steady-state output as a function of input frequency [3] 5. Given certain desired performance characteristics for a system (such as maximum overshoot due to a step input), translate specifications into design parameters (such as the dimensions of a coil spring) necessary to provide those characteristics [4, 5, 7] 6. Given a physical description of a system and a graphical representation of its time-domain response (step, frequency, etc.), estimate system parameters (i.e. friction or damping coefficient, spring constant) [3, 4, 5] 7. Given a LTI differential equation and an arbitrary input composed of steps, ramps, and other simple functions, set up the solution using Laplace transforms [3] 8. Describe basic applications of proportional, integral, and derivative feedback in control systems to improve performance or stability [4] 9. Given a system composed of mixed mechanical/electrical/thermofluid components, write the transfer function describing input-output behavior [1, 3] 10. Given a system with given performance, describe (qualitatively) how behavior can be improved according to specifications such as overshoot and settling time, using some combination of parameter tuning and feedback control [2, 4, 5, 7] 11. Describe how changes in parameter values will affect damping ratio and natural frequency for a system, and how these characteristics are manifested in the systems behavior [2,3,7] 12. Implement a mathematical model into commercial simulation software, and exercise the model to make engineering assessments [2, 5, 6, 7]
ASSESSMENT TOOLS: for each assessment tool, links to the course outcomes are identified	1. Regular homework problems 2. Exams

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