MECHANICAL ENGINEERING PROGRAM
ABET COURSE SYLLABUS

ME 322 Introduction to System Dynamics (4 Units) Required

Course Description: (2019-20 Catalog)	Unified approach for mathematical modeling and analytical and numerical analysis of dynamic physical systems that store energy in multiple domains. Emphasis on developing lumped-parameter linear models from primitive elements in a systematic manner. 3 lectures, 1 laboratory.
Prerequisite Courses:	CPE/CSC 101 or CSC 231 or CSC 234; EE 201; EE 251; ME 318; ME 341.
Prerequisites by Topic:	Lumped-parameter modeling and dynamic analysis of electrical circuits and mechanical systems Basic fluid mechanics Engineering computer programming (Matlab, FORTRAN, C, C++)
Textbook: (and/or other required material)	**System Dynamics: An Introduction**, by Derek Rowell and David N. Wormley, Prentice Hall, 1997.
References:	Course website, Matlab/Simulink on-line help.
Course Coordinator/Instructor:	William R. Murray, Professor of Mechanical Engineering

Course Learning Outcomes:

1. Students will understand energy storage in and the ideal energy transduction between the energy storage domains commonly encountered in engineering (e.g., mechanical translational, mechanical rotational, electrical, fluid and thermal).
2. Drawing on the above-mentioned understanding of ideal energy transduction, students can formulate realistic lumped-parameter linear and nonlinear models representing the dynamic behavior of a wide range of physical components such as gear trains, pulley assemblies, fluid tanks open to atmospheric pressure, accumulators in hydraulic and/or pneumatic systems, hydraulic and/or pneumatic cylinders, dc motors, ac motors, transformers, vehicle suspension components, and bearings.
3. Students will understand the analogies between the different energy storage domains. These analogies apply to energy storage elements and dissipaters, as well as the variables by which stored energy can be expressed.

4. Students can construct models describing the dynamic behavior of more complicated systems by combining models like those mentioned above that represent the dynamic behavior of components and subsystems.
5. Students can organize these models in a variety of different forms and can transform models from each form to any other form. For example, for an nth-order system, students can represent these models as a single nth-order differential equation, a block diagram, a transfer function, or as a state-space model, that is, as a set of n first-order nonlinear differential equations or a set of n first-order linear differential equations.
6. Students can assess the assumptions and potential errors involved in linearizing system models.
7. Students can apply causality to categorize energy storage elements as dependent or independent to accurately determine the order of a system.
8. Students can apply basic numerical methods to solve differential equations representing the dynamic behavior of a wide variety of physical systems.
9. Students can numerically solve for the time response and/or frequency response of any of these system models to a variety of inputs using modern computer applications (at this time, the likely applications would be Matlab and Simulink).
10. Students understand the typical time domain and frequency domain performance specifications (e.g., time to peak, rise time, settling time, damping ratio, natural frequency and damped natural frequency), and through simulation can evaluate how parameter changes in a system model affect these performance specifications for a system.
11. Students can analyze the results from laboratory simulations and write effective, professional reports conveying these results.

Relationship of Course to Mechanical Engineering Student Outcomes:

SO 1: Develop (D)
SO 2: Develop (D)
SO 3: Develop (D)
SO 4:
SO 5:
SO 6:
SO 7:

Topics Covered:

1. State determined systems.
2. Block diagrams and block diagram manipulation.

3. Dynamic response of systems.
4. Modeling of electrical, mechanical, fluid and thermal elements.
5. Linearization of nonlinear elements.
6. Causality.
7. Physical source modeling.
8. State-space representation of dynamic systems (linear and nonlinear).
9. Computer-based numerical simulation of the dynamic response of physical systems. Includes numerical solution of nonlinear and linear ordinary differential equations.
10. Linear graphs.
11. Multi-domain system models, with emphasis on the magnetic coupling between electrical and mechanical systems, which is the basis for all electro-mechanical systems, including electric motors.
12. Operational methods and block diagrams.

Laboratory Projects: During the laboratory period, students meet in a computer laboratory to model and simulate the dynamic response of a wide variety of engineering systems. Approximately six lab assignments are envisioned: three one-week introductory assignments followed by three two-week more significant assignments and a laboratory final exam. As possible, hardware and instrumentation will be brought to the lab to generate data to be compared to the simulated results from a model.

Class/Lab Schedule: Three 50-minute lectures per week, one 170-minute lab per week.

Contribution of Course to Meeting the Professional Component:

(a) College-level mathematics and basic sciences:	0 credits
(b) Engineering Topics:	4 credits
Design?	Yes
(c) General Education:	0 credits
(d) Other:	0 credits

Prepared by: William R. Murray

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