MECH-430 Dynamic Systems II
Summer Term 2007

2001 Catalog Data: Credit (2-0-4-4)
Prerequisites: Dynamic Systems I
This is a second course; follow up course, in System Dynamics. The objective of this course is to provide an understanding into basic principles and methods underlying the steady state and dynamic characterization of **feedback** control systems. The focus is on multi-discipline approach as in the previous course. Construction of mathematical models of systems using Bond-graphs, block diagrams and development of transfer functions and state space models is emphasized. System performance is studied mainly using computer simulation (both in time and frequency domains) software tool(s). Design of control systems is attempted using the same computer simulation tools. Introduction to some advanced topics in control systems is also provided.

Suggested Textbooks: Dynamic Systems Workbook, R. Chandran and R. Lundstrom, Kettering University, 2005
Engineering System Dynamics-A unified Graph-Centered Approach, Forbes T. Brown, Taylor & FrancisInc, New York Second Edition, 2007.

References: *Modern Control Engineering*, Katsuhiko Ogata, Third edition, Prentice-Hall, Upper Saddle River, NJ, 1997.
System Dynamics-Modeling and Simulation of Mechatronic Systems, Dean C. Karnoop, Donald L. Margolis and Ronald C. Rosenberg, Third Edition, Wiley Interscience, New York, 2000.
Modern Control Systems, Richard C. Dorf and Robert H. Bishop, Tenth Edition, Addison-Wesley, Menlo Park, CA,2005.
Modeling, Analysis, and Control of Dynamic Systems, William J. Palm III, 2nd Edition, John Wiley & Sons, Inc., New York.
Mathematical Modeling of Mechanical and Multidiscipline Systems,Pinhas Barak, Wiley Custom Services, First edition, 2005.

Coordinator(s): Ram S. Chandran, Room 2243MC, 762-7839, rchandra@kettering.edu

Course Learning Objectives:
Upon completion of this course the student will be able to:

1. Model simple engineering systems involving multiple feedback loops. The system will include at least two disciplines, such as electrical-mechanical, electrical-fluid-mechanical combinations **[ME PO: A, B, C, E and L].**

2. Analyze the system performance in Time and Frequency domains-Laplace/inverse Laplace transform solution for simple cases, evaluate the system (response) characteristics using indices such as natural frequency, damping ratio, eigen value, time constant and band width. **[ME PO: A, B, C, E, L and N].**

3. Evaluate the system performance characteristics, such as stability and speed of response based on accepted metrics in time and frequency domains **[ME PO: A, B, E, L and N].**

4. Simulate the system performance in time and frequency domains using accepted professional simulation tools, such as MATLAB/SIMULINK **[ME PO: A, B, E, L and N].**

5. Design simple controllers, such as, P, PI, PD and PID, for systems to meet certain performance objectives using the modeling and simulation tools, such as MATLAB/SIMULINK, detailed in the course **[ME PO: A, B, C, E, K, L,M and N].**

Topics covered (suggested only):

Week	Topics
1	Introduction to first order systems (mechanical translation/rotation), modeling and simulation using software tools. Review of Bond graph techniques. CLO: 1 and 4.
2	Modeling and simulation/response of First order systems (step and ramp commands), additional examples in fluid and electrical domains. Development of block diagrams and its simplification. Simulation of system response using the software SIMULINK. CLO: 1 and 4.
3	Modeling of Second order systems. Solutions of Second order systems to step input commands. Discussion of second order system solution to under-damped, critically damped, over damped and no damping cases. Plotting of roots of characteristic equation and their significance to system transient response. Introduction of second order examples in mechanical and electrical domains. Introduction to evaluation of response characteristics of second order systems. Simulation of system response using the software SIMULINK. CLO: 1, 2 and 4. Examination Competencies 1 and 2
4	Introduction to modeling and simulation of higher order systems-Multi domain application, Electromechanical system. Development of bond graph, state equations, block diagram and transfer functions. Frequency repose analysis of simple first order systems and plot of Bode plots for the same using analytical methods. Development of bode plot, using MATLAB. Hard ware experiment on a mass-spring damper system and identifying system transfer function using input and response data. CLO: 1, 2, 3 and 4.
5	Continuation of frequency response (analysis) using bode plot for higher order systems including third and fourth order systems. Development of asymptotic plots for gains and phase angle and confirmation using MATLAB. Analytical evaluation of gain and phase angle of higher order transfer functions in frequency domain and output of a system given the frequency transfer function and input to a system. Evaluation of band width of a system. Evaluation of transfer function of a system given its bode plot(s). CLO: 1, 2, 3 and 4.
6	Introduction to feed back control systems, effect of feed back in first order systems. Improvement in speed of response, and identification of steady state error. Elimination of steady state error in systems using Integral controller in the forward loop. Simulation of these effects using software tools. Estimation of steady state error of closed loop systems using final value theorem, analytical method. Examination 2 Competencies 1, 2, 3 and 4.
7	Effect of feed back in second order systems, increase of natural frequency, and decrease of damping. Modeling, analysis and simulation of a higher order electromechanical position control system. System response simulation using the software SIMULINK. Damping improvement-using derivative feed back. Understanding reflected load inertia effects at the driver end. CLO: 1, 2, 3 and 4.
8	Stability of feed back control systems using Routh's criterion. Introduction to root locus techniques. Root locus plotting using MATLAB. Experimentation and simulation of response of a electromechanical angular position control system. Correlation studies. CLO: 3 and 4.
9	Continuation of Root locus study. Design of Controller using Zeigler-Nichols rules. CLO: 5
10	Design of a PI, PD and PID controller using root locus and Zeigler –Nichols rules. Assignment of a comprehensive Controller design project for a higher order electromechanical position control system. CLO: 5. Examination 3: Competencies 3,4,5 and 6
11	Design project and review. CLO 5; Final Examination. Competencies 1,2,3,4,5 and 6.

Schedule:

Two lab. sessions per week of 120 minutes, and
One lecture session per week of 120 minutes.

Computer usage:
Basic computer skills (MS Word, Excel) and some familiarity with MATLAB/SIMULINK.

Laboratory Projects:
two.

Relationship to professional component:
Three credits Engineering Science.
and one credit Engineering design.
Prepared by: Ram S. Chandran, Professor of Mechanical Engineering,