ENGR 4220: CONTROL SYSTEMS

University of Detroit Mercy
Term III, 2012-2013

Course Description: Modeling of chemical, electrical, mechanical and hydraulic systems. Analytic solution of open loop and feedback type systems. Routh criteria. Root Locus methods in design of systems and evaluation of system performance. Time and frequency domain design of control systems.

Prerequisites: MTH 3720, Differential Equations

Instructor: Dr. Rick Hill, Assistant Professor
Department of Mechanical Engineering
Room E274
hillrc@udmercy.edu

Class meetings: TR 3:00-4:21 pm, Room E224

Office hours: M 10:00-11:00am, T 4:21-5:30pm, W 2:00-4:00pm, R 1:30-3:00pm, others by appointment

Course homepage: http://knowledge.udmercy.edu

Required text:
Ogata, K., *System Dynamics*. 4th Ed., Pearson Prentice Hall, 2004.

Additional References:
Control Tutorials for `MATLAB` *and* `Simulink` [http://ctms.engin.umich.edu]
Franklin, G., Powell, J.D., and Emami-Naeini, A., *Feedback Control of Dynamic Systems*.
Nise, Norman S., *Control Systems Engineering*.

Class Elements: Homework - Problem sets will be assigned approximately weekly over the course of the semester.

Quizzes - Short in-class quizzes will be given often. Quizzes cannot be made-up if you miss class.

Laboratory - One laboratory assignments will be given during the semester.

Exams - One midterm will be given during the semester in addition to a cumulative final.

Class Policies: Late work - Homework must be turned in at the beginning of class. Late homework is not accepted.

Emergencies - Your lowest homework and lowest quiz score will be dropped, thereby allowing for emergencies. If there are further extenuating circumstances they can be discussed on a case-by-case basis.

Exams - Exams will in general be closed-book and closed-note. You may be allowed an equation sheet. Make-up exams will only be given if prior arrangements have been made with me.

Regrades - If you feel a mistake has been made in the grading of an assignment or exam, you have one week from the date of its return to submit the item for a regrade.

Academic Integrity - Any suspected cheating will be dealt with according to the College policy - see the Engineering Science Student Handbook. In the case of homework, working together is encouraged, but you must write your own solutions that reflect your own understanding of the material.

Grading:

Homework	20%
Quizzes	10%
In-class activities	5%
Midterm Exam	30%
Final Exam	35%

Grade Scale:

Percentage	93-100	90-92	87-89	83-86	80-82	77-79	73-76	70-72	67-69	60-66	< 60
Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	F

Course Topics:

1. Linear Time-Invariant (LTI) differential equations (natural and forced response)
2. Laplace transforms and transfer function models
3. Block diagrams and their manipulation
4. Modeling of mechanical, electrical, and interconnected systems
5. Time response analysis
6. Stability
7. Properties of linear systems and linearization
8. State-space models
9. Controller specification and design
10. PID control
11. Root locus analysis and design
12. Frequency response analysis and design (Bode plots)
13. Numerical integration and computer simulation of mathematical models

Course Outcomes: After taking this course, students will be able to:

1. Derive mathematical models for mechanical, electrical, and electromechanical systems (differential equations, transfer functions). [EE Outcome a and e]
2. Describe and evaluate simplifying assumptions made in the modeling process. [EE Outcome e]
3. Apply Laplace transform techniques to determining the time response of physical systems (solution of differential equations, initial value theorem, final value theorem). Demonstrate understanding of connection between poles of transfer function (roots of characteristic equation) to transient time response. [EE Outcomes a]

4. Determine and describe quantitatively the time response of first and second order systems (transient and steady state). [EE Outcome b]

5. Model a system of components by block diagram and determine the input/output behavior of the system based on such a model. [EE Outcome a]

6. Generate the linear approximation of a nonlinear model. [EE Outcome a]

7. Generate state-space models for linear systems. [EE Outcome a]

8. Determine and describe the robustness properties of a system based on its frequency response. [EE Outcome b]

9. Use time domain techniques (pole placement, root locus) to analyze systems and to design controllers that achieve prescribed requirements. [EE Outcome c, e, and k]

10. Use frequency domain techniques (Bode plot) to analyze systems and to design controllers that achieve prescribed requirements. [EE Outcome c, e, and k]

11. Describe and tune the effect of the three terms of a PID controller. [EE Outcome c and e]

12. Evaluate the advantages and disadvantages of a chosen type of system representation or controller design technique. [EE Outcome c, e and k]

13. Evaluate the trade-offs inherent in the design of a controller. [EE Outcome c and e]

14. Use `MATLAB/Simulink` for the analysis and design of control systems. [EE Outcome k]