Beginning-of-Course Assessment Memo

ECE 402 – Linear Control Systems (Fall 2007)

Course Description:
This course is to explore the modeling of linear dynamic systems via differential equations and transfer functions utilizing state-space and input-output representations; analysis of control systems in the time and frequency domains and using transfer function and state-space methods; study of the classical stability tests, such as the Routh-Hurwitz and Nyquist criterions, and design methods using root-locus plots and Bode plots; and the development of control techniques based on PID, lead and lag networks, using linear state or output feedback (3 credits).

Prerequisites:
ECE 323 – Signals and Systems (I), or equivalent.

Objectives:
Study the principles of system modeling, system analysis and feedback control, and use them to design and evaluate feedback control systems with desired performance; specifically, to acquire the related knowledge and techniques to meet the following course objectives:

1. *Control system modeling*: modeling of electric, mechanical and electromechanical systems, using differential equations, transfer functions, block diagrams, and state variables;
2. *Control system analysis*: analysis of properties of control systems, such as sensitivity, stability, controllability, tracking, in time and frequency domains; and
3. *Control system design*: design of feedback controllers, such as PID, lead and lag compensators, pole placement designs, to meet desired system performance specifications.

Course Objectives and Program Outcomes Map:
Objective 1: program outcomes 1.a (in depth); 1.b, 1.d (familiarity); 3.d (exposure)
Objective 2: program outcomes 2.b, 2.f (in depth); 1.b, 1.d, 2.c (familiarity); 3.a, 3.d (exposure)
Objective 3: program outcomes 2.d, 2.f (in depth); 1.b, 1.d (familiarity); 3.a, 3.d (exposure).

Textbook:
G. F. Franklin, J. D. Powell and A. Emani-Naeini, *Feedback Control of Dynamic Systems*, 5th ed., Pearson Prentice Hall, Upper Saddle River, NJ, 2006 (ISBN 0-13-149930-0).

Topics:
1. Mathematical models of control systems (2 lectures)
2. Transfer functions and block diagrams (2 lectures)
3. Time-domain responses (2 lectures)
4. The Routh-Hurwitz stability criterion (2 lectures)
5. Feedback control systems (2 lectures)
6. Root-locus techniques (4 lectures)
7. Bode plot techniques (2 lectures)
8. The Nyquist stability criterion (2 lectures)
9. Dynamic compensation in frequency-domain (3 lectures)
10. State space analysis and design (4 lectures).

Instructor:
Dr. Gang Tao, Thornton Hall, Room E311, 924-4586, gt9s@virginia.edu.

Lecture Hours:
11:00 - 12:15, Tuesdays and Thursdays, Room MEC 216.

Assessment Scheme:
There are totally 10 homeworks, 1 project and 2 tests for this course.

1.a: Application of calculus, differential equations, physical laws, complex variable theory in modeling of control systems (assignments in 4 homeworks, 2 tests, 1 project)

1.b: Procedure of technical developments in homeworks, tests and project

1.d: Standard of technical presentation in homeworks, tests and project

2.b: Use of matrix differential equations, Fourier transform, Laplace transform, matrix theory, and complex variable theory (assignments in 8 homeworks, two tests and 1 project)

2.c: Use of Matlab in control system analysis throughout homeworks

2.d: Study of system stability, sensitivity, transient and tracking performance, and design of control systems with desired performance specifications (assignments in 7 homeworks, two tests and 1 project)

2.f: Study of control system knowledge through homeworks, tests and project

3.a: Understanding of the need of learning more advanced topics in control systems, such as issues with nonlinearity and uncertainty

3.d: Practice of the UVa honor code in completing homeworks, tests and project.

Program Outcomes:
Program outcomes are the effectiveness measures of a course, which are grouped into three categories: 1. fundamentals, 2. specialists, and 3. citizenship.

Outcome 1.a: knowledge of mathematics (including differential equations), science, and engineering fundamentals.

Outcome 1.b: ability to identify, formulate, and solve engineering problems.

Outcome 1.d: ability to effectively communicate technical material.

Outcome 2.b: knowledge of advanced topics in mathematics including vector calculus, transform calculus, complex variables and probability and statistics.

Outcome 2.c: design of systems containing both hardware and software elements. Outcome 2.d: ability to specify, design, analyze and test an electrical/electronic system to meet a set of desired goals, within the context of a broader system application.

Outcome 2.f: specialized knowledge in one or more of the topical areas of electrical engineering: controls, communications, electrophysics, digital systems, or microelectronics.

Outcome 3.a: recognization of the need for and being capable of engaging in lifelong learning.

Outcome 3.d: understanding of the ethical and professional responsibilities of an engineering practitioner or researcher.