

# EE478 Control Systems (Fall 2009)

## Textbook:

N. S. Nise, *Control Systems Engineering*, 5/e, John Wiley & Sons, 2007.

## Reference Books:

G. F. Franklin, J. D. Powell and A. Emami-Naeini, *Feedback Control of Dynamic Systems*, Fifth Edition, Pearson Prentice-Hall, 2006.

J. Dorsey, *Continuous and Discrete Control Systems*, McGraw Hill, 2002.

K. Ogata, *Modern Control Engineering*, 4/e, Prentice-Hall, 2001.

B. C. Kuo, *Automatic Control Systems*, 7e, John Wiley & Sons, 1995.

## Instructor:

Yi Guo, Prof. of ECE

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Office Hours: Monday 2pm-3pm, Wednesday 3pm-4pm

## Course Web Site:

<http://personal.stevens.edu/~yguo1/teaching.html>

Solutions to homework will be posted regularly.

## Goals:

Control systems are an integral part of modern society. Numerous applications are all around us: The rockets fire, and the space shuttle lifts off to earth orbit; robots designed to compensate for human disability, such as picking up material in a radioactive environment; in process control industry, control systems designed to regulate liquid levels in tanks, chemical concentrations in vats, as well as the thickness of fabricated material. We are not the only creators of automatically controlled systems; these systems also exist in nature. Within our bodies are numerous control systems, such as the pancreas, which regulates our blood sugar.

For the purpose of control system design, analysis, test, and repair, the most important part of the very broad subject known as system theory is the theory of dynamic systems. All systems that can be described by ordinary differential or difference equations with real coefficients are indubitably dynamical systems. A system is a device that accepts an input signal and produces an output signal. A control system is dynamic: It responds to an input by undergoing a transient response before reaching a steady-state response that generally resembles the input. The central problem in control is to find a technically feasible way to act on a given process so that the process behaves, as closely as possible, to some desired behavior. Through the mechanism of feedback, a control system has the ability to compensate for disturbances.

In many modern systems, the controller (or compensator) is a digital computer. The advantage of using a computer is that many loops can be controlled or compensated by

the same computer through time sharing. Furthermore, any adjustments of the compensator parameters required to yield a desired response can be made by changes in software rather than hardware.

The knowledge of control cuts across numerous disciplines and numerous functions within those disciplines. As a result of this course, you will be able to take a top-down systems approach, that is, a high-level picture of the requirements is first formulated, and then the functions and hardware required to implement the system are determined. Benefited from the high-level of mathematics initially required for the systems approach, after completing this course, you will be able to think at the top level of large projects, engaged at the conceptual phase in determining or implementing overall system requirements. These requirements include total systems performance specifications, subsystem functions, and the interconnection of these function, including interface requirements, hardware and software design, and test plans and procedures. You will be able to stand back and see how your previous studies fit into the large picture. Your amplifier course and vibration course will take on new meanings as you begin to see the role the design work plays as part of product development. This course will clarify the analysis and design procedures and show you how the knowledge you acquired fits into the total picture of system design.

**Course Components:**

Engineering: 80%

Science and Math: 20%

**Grading:**

Homework 25%

Mid-term Exam 35%

Final Exam (comprehensive) 40%

Homework will be assigned regularly. The instructor may select a few homework to collect. It is the students' responsibility to keep track of homework assignment and due date. Possible revision of homework and test grades may be discussed immediately following the return of homework or the test papers (no later than a week from it). No make-up tests.

Any act of academic dishonesty will result in a failing grade.

**Software**

MATLAB is used in some of the homework assignments. The website <http://www.engin.umich.edu/class/ctms/> provides a tutorial for using MATLAB in the analysis and design of feedback control systems.

**Schedule of Topics (tentative):**

**Week 1:** Introduction to control, review of Laplace transform

Reading assignments: Chapter 1, Introduction  
Chapter 2: Sections 2.1-2.2

**Week 2:** Transfer function modeling, block diagram, state space representation

Reading assignments: Chapter 2: Sections 2.3-2.6  
Chapter 3: Sections 3.1-3.6

**Week 3:** Feedback, Mason's rule, closed-loop, poles and zeros

Reading assignments: Chapter 5: Sections 5.1-5.5  
Chapter 4: Sections 4.1-4.2

**Week 4:** Stability, Routh's stability criterion

Reading assignments: Chapter 6: Sections 6.1-6.4

**Week 5:** Transient behavior and steady-state error

Reading assignments: Chapter 4: Sections 4.3-4.8  
Chapter 7: Sections 7.1-7.4

**Week 6:** Review of complex numbers, root locus

Reading assignments: Chapter 8: Sections 8.1-8.6

**Week 7:** Root locus

Reading assignments: Chapter 8: Sections 8.6  
Mid-term Exam

**Week 8:** Root locus design

Reading assignments: Chapter 8: Sections 8.7

**Week 9:** PID control, lead/lag compensator

Reading assignments: Chapter 9: Sections 9.1-9.4

**Week 10:** Frequency response techniques, Bode plot

Reading assignments: Chapter 10: Sections 10.1-10.2, 10.13

**Week 11:** Nyquist diagram

Reading assignments: Chapter 10: Sections 10.3-10.4

**Week 12:** Nyquist criterion

Reading assignments: Chapter 10: Sections 10.5

**Week 13:** Gain margin and phase margin

Reading assignments: Chapter 10: Sections 10.6-10.7

**Week 14:** Review for final exam, Q&A