

ECE 516: System Control Engineering

This course focuses on the analysis and design of systems control. This course will introduce time-domain systems dynamic control fundamentals and their design issues for electrical engineering applications. Emphasis will be on linear, time-invariant, multi-input multi-output continuous time systems. Topics include open and closed-loop state-space representations, analytical solutions, computer simulations, stability, controllability, observability, and controller/observer design. [ECE 301 \(Linear Systems\)](#) or equivalent is the *pre-requisite* for this course. A strong background in linear algebra and differential equations is not required but is highly recommended. The [MATLAB/SIMULINK](#) computer software package will be used extensively to assist in the understanding of concepts and fundamentals of system dynamics and control, and also to analyze and design control systems.

ECE 516 System Control Engineering
EB1 2015, MWF 11:45-12:35 pm, Spring, 2007, 3 Credit Hours

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BACKGROUND MATERIAL

Prerequisite Courses

ECE 301 **Linear Systems**

Recommended Background Courses

ECE 435 **Elements Control**

ECE 436 **Digital Control System**

Recommended Co-Requisite Courses

ECE 713 **Digital Signal Processing**

ECE 714 **Random Processes**

ECE 556/456 **Mechatronics**

GRADING SCHEME

The course materials can be classified into basic material (95%), recommended materials (4%), and optional materials (1%). Exams and homework will be based mainly on the basic material. Recommended materials will be presented once a while for your entertainment, and optional materials will be presented once a long while for your imaginations.

- A. Homework (approximately 6 – 9 assignments): 20%
- B. 1st Exam (February 24, 2006): 30%
- C. 2nd Exam (April 12, 2006): 30%
- D. Project presentation (May 8, 2006, 9:00 – 12:00 pm): 20%

The problems of exams will be based mainly on lecture materials and the textbook.

Your Class Grade = MAX {Relative standing, Absolute standing}, where

(a) Relative standing

The whole class grade will be “curved” and your grade will be based on your relative standing in the class.

(b) Absolute standing (AS – average score)

A+: AS ≥ 98%	A: 98% > AS ≥ 92%	A-: 92% > AS ≥ 90%
B+: 90% > AS ≥ 88%	B: 88% > AS ≥ 82%	B-: 82% > AS ≥ 80%
C+: 80% > AS ≥ 78%	C: 78% > AS ≥ 72%	C-: 72% > AS ≥ 70%
D+: 70% > AS ≥ 68%	D: 68% > AS ≥ 62%	D: 62% > AS ≥ 60%
F: 60% > AS		

TEXT BOOKS:

- A. [William L. Brogan, Modern Control Theory](#), 3rd Ed., Prentice Hall, ISBN: 0-13-589763-7. (Required)
- B. [MATLAB Student Version](#), latest version, Mathworks. (Recommended)

REFERENCES (Optional):

- A. Chi-Tsong Chen, [Linear System Theory and Design](#), HRW. (Advanced)
- B. Thomas Kailath, [Linear Systems](#), Prentice Hall. (Intermediate)
- C. Katsuhiko Ogata, [Modern Control Engineering](#), Prentice Hall. (Basic)

ECE 516 System Control Engineering Course Outline

A. General description of Systems and System Dynamics (Basic)

1. The Concepts of Systems, System Dynamics and Classifications
2. Control Theory
3. Systems Performance

Goal: After these lectures and studies, students should have a general concept and meaning of “dynamic” systems. Hopefully, you will be fascinated with “systems and control” and are interested to find *more*.

B. State Variables and State Space Description of Dynamic Systems (Basic)

1. The Concept of State
2. State Space Representation of Dynamic Systems
3. State Equation for Dynamic Systems
4. Obtaining State Equations from Input-Output Differential Equations

Goal: After these lectures, students should know how use state-space description to model simple linear electric circuits, dc motor dynamics, transfer functions, and high-order differential equations.

C. Analysis of the Equation of (Linear Time Invariant) Dynamical Systems (Basic)

1. Solution of State Equations — Time domain solutions
2. Solution of Nonlinear Equations

Goal: After these lectures, students should know how to apply some basic linear algebra such as matrix operations and eigenvalues to solve linear system and control problems directly in time domain – Yes! We do not need to go to frequency domain to find the solutions.

D. Controllability and Observability (Basic)

1. Concepts and Definitions
2. Time-Invariant Systems with Distinct Eigenvalues
3. Time-Invariant Systems with Arbitrary Eigenvalues (optional)

Goal: After these lectures, students should understand under what circumstance that they could solve the control problem. If so, how can they solve the problem in a professional manner.

E. Nonlinear Equations and Perturbation Theory (Basic)

1. Taylor Series
2. Linearization of Nonlinear Equations

Goal: After these lectures, students should know that most systems in the real-world are nonlinear, yet in most cases, we can linearize the nonlinear system and apply the linear control system design techniques learned in the class to a system to obtain good performance.

F. Stability for Linear and Nonlinear Systems (Basic)

1. Equilibrium Points

2. Stability Definitions
3. Linear Time-Invariant Stability
4. Nonlinear Time-Invariant Stability (Recommend)
5. Direct Method of Lyapunov (Optional)

Goal: After these lectures, students should feel comfortable and confident in using the word *stability* for control applications. They should also be able to use the techniques to test if the system is stable.

G. Design of Linear Feedback Systems (Basic)

1. Observer Design
2. Controller Design

Goal: After these lectures, students should be able to synthesize all the concepts and techniques learned in previous lectures to perform design work for applications.

H. Nonlinear Control Systems (Basic-Recommended)

1. Linearization
2. Dynamic Linearization Using State Feedback

Goal: This session has a strong tie with Topic E. Actually; they are in the same chapter of the text. After these lectures, students should be able to apply the techniques learned for linear system to a class of nonlinear system control.

I. Course Project (software simulation)

Unmanned vehicle observer-controller design for path tracking.

Goal: After this project, students should have a solid knowledge on how to apply the control materials learned in this course to solve control engineering problems.