ELEN416 16

Course Summary

Course : RC706 **Title :** Control Systems Theory and Design
Length of Course : 16 Anne Venzon
Prerequisites : Credit Hours : 3

Description

Course Description: This course covers the basic principles of frequency- and time-domain design techniques. Classical methods covered include Laplace transforms and transfer functions; root locus design; Routh-Hurwitz stability analysis; frequency response methods including Bode, Nyquist, and Nichols; steady state error for standard test signals; second order system approximations; and phase and gain margin and bandwidth. In addition, the state variable method is investigated including full state feedback design, and limitations of state variable feedback. The student will learn to use computers in the analysis and design of control systems. NOTE: This course requires the student to purchase additional materials that are not covered by the book grant. Please refer to the Course Materials section for additional details. Prerequisites: ELEN310

Course Scope:

This course is delivered online and is organized around the concept of control systems theory in the frequency and time domains. It investigates classical control with root locus design and frequency response methods using Bode and Nyquist plots. It also covers modern control methods based on state variable models including pole placement design techniques with full-state feedback controllers and full-state observers. Students are given opportunities to apply the theory to the design and analysis of control systems by using examples presented in the text. The course also incorporates computer-aided design and analysis using MATLAB and LabVIEW MathScript.

Objectives

After completing the course, the student should be able to accomplish these Course Objectives (CO):

- CO-1 Classify the inputs, outputs, and components of a control system.
- CO-2 Differentiate between open-loop and closed-loop (feedback) control systems and the advantages of each.
- CO-3 Apply Laplace transforms and transfer functions to modeling complex interconnected systems.
- CO-4 Explain the significance of state variable modeling and the role of feedback in control system design.
- CO-5 Analyze the relationship of poles of a transfer function to the stability of a system, and how they

affect the physical behavior of a system.
- CO-6 Evaluate the stability of a dynamic system using the Routh-Hurwitz stability criterion.
- CO-7 Explain the role of integral control and why more than simple proportional control is often needed in a control system.
- CO-8 Illustrate the design of a controller that meets desired specifications using both the root locus method and the frequency response method and a full-state feedback controller and observer.
- CO-9 Analyze the relative stability and performance of feedback control systems using frequency response methods considering phase and gain margin and system bandwidth.
- CO-10 Demonstrate a working knowledge of reference inputs, optimal control, and internal model design.

Outline

Week 1: Introduction to Control Systems

Learning Objective(s)

- History of Automatic Control
- Examples of Control Systems
- Engineering Design
- Control System Design
- Mechatronic Systems
- Green Engineering
- The Future Evolution of Control Systems
- Design Examples
- Sequential Design Example: Disk Drive Read System (this example will be carried over to each Unit and discussed in the context of the subject covered

(CO-1) (CO-2)

Readings

Chapter 1

(Pages 1- 48)

Assignment(s)

Week 1 – Homework Assignment #1

Week 1 - Forum #1 Participation

Week 2: Mathematical Models

Learning Objective(s)

- Differential Equations of Physical Systems
- Linear Approximations of Physical Systems
- The Laplace Transform
- The Transfer Function of Linear Systems

(CO-3)

Readings

Chapter 2, Sections 2.1 – 2.5

(Pages 49- 79)

Assignment(s)

Week 2 – Homework Assignment #2

Week 2 - Forum #2 Participation

Optional Lab

Week 3: Block Diagram Models

Learning Objective(s)

- Block Diagram Models
- Signal-Flow Graph Model
- Design Examples
- The Simulation of Systems Using Control Design Software

(CO-1), (CO-2), (CO-3)

Readings

Chapter 2, Sections 2.6 – 2.11

(Pages 79- 160)

Assignment(s)

Week 3 – Homework Assignment #3

Week 3 - Forum #3 Participation

Optional Lab

Week 4: State Variable Models

Learning Objective(s)

- The State Variables of a Dynamic System
- The State Differential Equation
- Signal Flow Graph and Block Diagram Models
- The Transfer Function from the State Equation
- The Time Response and the State Transition Matrix
- Design Examples
- Analysis of State Variable Models Using Control Design Software

(CO-4)

Readings

Chapter 3

(Pages 161-233)

Assignment(s)

Week 4 – Homework Assignment #4

Week 4 - Forum #4 Participation

Optional Lab

Week 5: Feedback Control Systems

Learning Objective(s)

- Error Signal Analysis
- Sensitivity of Control Systems to Parameter Variations
- Disturbance Signals in a Feedback Control System
- Control of the Transient Response
- Steady State Error
- The Cost of Feedback
- Design Examples
- Control System Characteristics Using Control Design Software

(CO-2), (CO-4)

Readings

Chapter 4

(Pages 234-303)

Assignment(s)

Week 5 – Homework Assignment #5

Exam 1 due end of week

Optional Lab

Week 6: Performance of Feedback Control Systems

Learning Objective(s)

- Test Input Signals
- Performance of Second- Order Systems
- Effects of a Third Pole and a Zero on the Second-Order System Response
- The Steady State Error of Feedback Control Systems
- Performance Indices
- The Simplification of Linear Systems
- Design Examples
- System Performance Using Control Design Software

(CO-5)

Readings

Chapter 5

(Pages 304-385)

Assignment(s)

Week 6 – Homework Assignment #6

Week 6 - Forum #5 Participation

Optional Lab

Week 7: Stability of Linear Feedback Systems

Learning Objective(s)

- The Concept of Stability
- Stability and the Routh- Hurwitz Stability Criterion
- The Relative Stability of Feedback Control Systems
- The Stability of State Variable Systems
- Design Examples
- System Stability Using Control Design Software

(CO-6)

Readings

Chapter 6

(Pages 386-442)

Assignment(s)

Week 7 – Homework Assignment #7

Week 7 - Forum #6 Participation

Optional Lab

Week 8: Root Locus Method I

Learning Objective(s)

- The Root Locus Concept
- The Root Locus Procedure
- Parameter Design by the Root Locus Method
- Sensitivity and the Root Locus

(CO-7), (CO-8)

Readings

Chapter 7, 7.1 – 7.5

(Pages 443-480)

Assignment(s)

Week 8 – Homework Assignment #8

Optional Lab

Week 9: Root Locus Method II

Learning Objective(s)

- PID Controllers
- Negative Gain Root Locus
- Design Examples
- The Root Locus Using Control Design Software

(CO-7), (CO-8)

Readings

Chapter 7, Sections 7.6 – 7.11

(Pages 480-552)

Assignment(s)

Week 9 – Homework Assignment #9

Week 9 – Forum #7 Participation

Optional Lab

Week 10: Frequency Response Methods

Learning Objective(s)

- Frequency Response Plots and Measurements
- Performance Specifications in the Frequency Domain
- Log Magnitude and Phase Diagrams
- Design Examples
- Frequency Response Methods Using Control Design Software

(CO-8), (CO-9)

Readings

Chapter 8

(Pages 553-633)

Assignment(s)

Week 10 – Homework Assignment #10

Week 10 – Forum #8 Participation

Optional Lab

Week 11: Stability in the Frequency Domain I

Learning Objective(s)

- Mapping Contours in the s-plane
- The Nyquist Criterion
- Relative Stability and the Nyquist Criterion
- Time-Domain Performance Criteria in the Frequency Domain
- System Bandwidth

(CO-8), (CO-9)

Readings

Chapter 9, Sections 9.1 - 9.6

(Pages 634-668)

Assignment(s)

Week 11 – Homework Assignment #11

Exam 2 due end of week

Optional Lab

Week 12: Stability in the Frequency Domain II

Learning Objective(s)

- Stability of Control Systems with Time Delays
- Design Examples
- PID Controllers in the Frequency Domain
- Stability in the Frequency Domain Using Control Design Software

(CO-8), (CO-9)

Readings

Chapter 9, Sections 9.7 - 9.12

(Pages 668-742)

Assignment(s)

Week 12 – Homework Assignment #12

Week 12 – Forum #9 Participation

Optional Lab

Week 13: Design of Feedback Control Systems I

Learning Objective(s)

- Approaches to System Design
- Cascade Compensation Networks
- Phase-Lead Design Using the Bode Diagram
- Phase-Lead Design Using the Root Locus
- System Design Using Integration Networks

(CO-8), (CO-9)

Readings

Chapter 10, Sections 10.1 - 10.6

(Pages 743-767)

Assignment(s)

Week 13 – Homework Assignment #13

Optional Lab

Week 14: Design of Feedback Control Systems II

Learning Objective(s)

- Phase-Lag Design Using the Root Locus
- Phase-Lag Design Using the Bode Diagram
- Systems with a Prefilter
- Design with a Deadbeat Response
- Design Examples
- System Design Using Control Design Software

(CO-8), (CO-9)

Readings

Chapter 10, Sections 10.7 - 10.15

(Pages 767-833)

Assignment(s)

Week 14 – Homework Assignment #14

Week 14 – Forum #10 Participation

Optional Lab

Week 15: Design of State Variable Feedback Systems

Learning Objective(s)

- Controllability and Observability
- Full-State Feedback Control Design
- Integrated Full-State Feedback
- Optimal Control Systems
- Design Examples
- State Variable Design Using Control Design Software

(CO-8), (CO-10)

Readings

Chapter 11

(Pages 834-908)

Assignment(s)

Week 15 – Homework Assignment #15

Week 15 – Forum #11 Participation

Optional Lab

Week 16: Modern Digital Control, Wrap-up, Exam 3

Learning Objective(s)

- Digital Systems in Feedback Control

Readings

None

Assignment(s)

Week 16 – Forum #12 Participation

Final Design Technical Report Due

Exam 3 due end of week

Evaluation

Instructor announcements: Weekly announcements will be made on Monday of each week in the online classroom. These announcements will also be e-mailed to each student. The announcements will discuss the assignments for the week along with any other pertinent information for the week.

This is an upper level course; all students' work is to be presented as such in terms of quality and content. The grading system will be based on your introduction (2%), forums (8%), fifteen weekly assignments (60%) and three exams (30%).

Reading Assignments: Please refer to the Course Outline section of this syllabus for the weekly reading assignments.

Week 1 Introductions: Students must log into the classroom and post an introduction to the class during the first week of class. This assignment is worth 20 points or 2 percent of the course grade. Your response is due by Sunday of Week 1. The Week 1 introduction must be greater than 250 words (a requirement) and include the following information.

a. Your name

b. Your university major or program

c. Where you are in the program of study

d. Your academic goals, to include why you are taking this class

e. Information that you would like to share about yourself

Weekly Forums: The weekly discussion forum is for students to post their questions on course content for that week. This forum should not be used to discuss specific graded material questions prior to receiving feedback from the instructor. If there is a question on a specific graded question, find a similar problem in the book and ask a question on that problem or concept. Asking specific questions on graded questions creates an unfair advantage and defeats the purpose of the assessment tool.

Weekly Assignments: Weekly assignments are designed to help students apply the information that they have learned each week. Students are expected to submit course assignments by the posted due date unless prior approval is received from the instructor. A design project will be selected by the student on the first week of class and must be approved by the instructor. A final written technical report documenting that

design will be required and is due the last week of class as part of Assignment #15

Optional Lab Assignments: A lab is not required for this course, but is an option available for students wishing to use NI materials in the learning process. A companion book, Modern Control Systems with LabVIEW, will be used to guide the student through the computer applications that are available and may be used in solving homework and exam problems.

Exams: There will be three exams, each worth 10% of the final grade. They will be open book, open note exams and will be administered without a proctor. Students must complete numbered exams by the end of the week indicated in the syllabus and in the classroom.

Grading:

Name	Grade %

Materials

Book Title: Modern Control Systems, 12th ed. - VitalSource e-book is provided through the APUS Bookstore.

Author: Dorf & Bishop

Publication Info: Pearson

ISBN: 1269570986

Book Title: NI Student Software Suite - this item is not covered by the APUS Book Grant

Author: National Instruments

Publication Info: National Instruments

ISBN: 779252-3501

Book Title: NI Elvis Kit - this item is not covered by the APUS Book Grant

Author: National Instruments

Publication Info: National Instruments

ISBN: 780381-02

Book Title: NI myRIO Starter Accessory Kit - this item is not covered by the APUS Book Grant

Author: National Instruments

Publication Info: National Instruments

ISBN: 783068-01

Book Title: myParts Kit from Texas Instruments - this item is not covered by the APUS Book Grant

Author: National Instruments

Publication Info: National Instruments

ISBN: 783752-01

Book Title: Additional required items are available to order from the APUS Bookstore. If you buy these items from other vendors, you may not receive all the parts you need for your course. These items (as noted) are not covered by the APUS Book Grant.

Author: N/A

Publication Info: N/A

ISBN: N/A

Book Title: MATLAB and Simulink Student Suite-Not covered by the APUS Grant - available to purchase at https://www.mathworks.com/store/link/products/student/?s_tid=ac_buy_sv_cta

Author:

Publication Info:

ISBN: NTMO

Course Guidelines

Citation and Reference Style

- Attention Please: Students will follow the APA Format as the sole citation and reference style used in written work submitted as part of coursework to the University. Assignments completed in a narrative essay or composition format must follow the citation style cited in the APA Format.

Tutoring

- Tutor.com offers online homework help and learning resources by connecting students to certified tutors for one-on-one help. AMU and APU students are eligible for 10 free hours* of tutoring provided by APUS. Tutors are available 24/7 unless otherwise noted. Tutor.com also has a SkillCenter Resource Library offering educational resources, worksheets, videos, websites and career help. Accessing these resources does not count against tutoring hours and is also available 24/7. Please visit the APUS Library and search for 'Tutor' to create an account.

Late Assignments

- Students are expected to submit classroom assignments by the posted due date and to complete the course according to the published class schedule. The due date for each assignment is listed under each Assignment.
- Generally speaking, late work may result in a deduction up to 20% of the grade for each day late, not to exceed 5 days.
- As a working adult I know your time is limited and often out of your control. Faculty may be more flexible if they know ahead of time of any potential late assignments.

Turn It In

- Faculty may require assignments be submitted to Turnitin.com. Turnitin.com will analyze a paper and report instances of potential plagiarism for the student to edit before submitting it for a grade. In some cases professors may require students to use Turnitin.com. This is automatically processed through the Assignments

area of the course.

Academic Dishonesty

- Academic Dishonesty incorporates more than plagiarism, which is using the work of others without citation. Academic dishonesty includes any use of content purchased or retrieved from web services such as CourseHero.com. Additionally, allowing your work to be placed on such web services is academic dishonesty, as it is enabling the dishonesty of others. The copy and pasting of content from any web page, without citation as a direct quote, is academic dishonesty. When in doubt, do not copy/paste, and always cite.

Submission Guidelines

- Some assignments may have very specific requirements for formatting (such as font, margins, etc) and submission file type (such as .docx, .pdf, etc) See the assignment instructions for details. In general, standard file types such as those associated with Microsoft Office are preferred, unless otherwise specified.

Disclaimer Statement

- Course content may vary from the outline to meet the needs of this particular group.

Communicating on the Forum

- Forums are the heart of the interaction in this course. The more engaged and lively the exchanges, the more interesting and fun the course will be. Only substantive comments will receive credit. Although there is a final posting time after which the instructor will grade comments, it is not sufficient to wait until the last day to contribute your comments/questions on the forum. The purpose of the forums is to actively participate in an on-going discussion about the assigned content.
- "Substantive" means comments that contribute something new and hopefully important to the discussion. Thus a message that simply says "I agree" is not substantive. A substantive comment contributes a new idea or perspective, a good follow-up question to a point made, offers a response to a question, provides an example or illustration of a key point, points out an inconsistency in an argument, etc.
- As a class, if we run into conflicting view points, we must respect each individual's own opinion. Hateful and hurtful comments towards other individuals, students, groups, peoples, and/or societies will not be tolerated.

University Policies

Student Handbook

- Drop/Withdrawal policy
- Extension Requests
- Academic Probation
- Appeals
- Disability Accommodations

The mission of American Public University System is to provide high quality higher education with emphasis on educating the nation's military and public service communities by offering respected, relevant, accessible, affordable, and student-focused online programs that prepare students for service and leadership in a diverse, global society.