مدينة زويل للعلوم والتكنولوجيا
Zewail City of Science and Technology

SPC 318: System Modeling and Linear Systems

Lecture 0

Course Presentation

Dr. Ahmed Khalifa

Adjunct Lecturer
Space and Communication Engineering
Zewail City of Science and Technology

Spring 2017

Agenda

- Course Description
- Course Objectives
- Course Intended Learning Outcomes
- Course Topics
- Course Assessment
- Course Project
- Course Policy
- Course Resources

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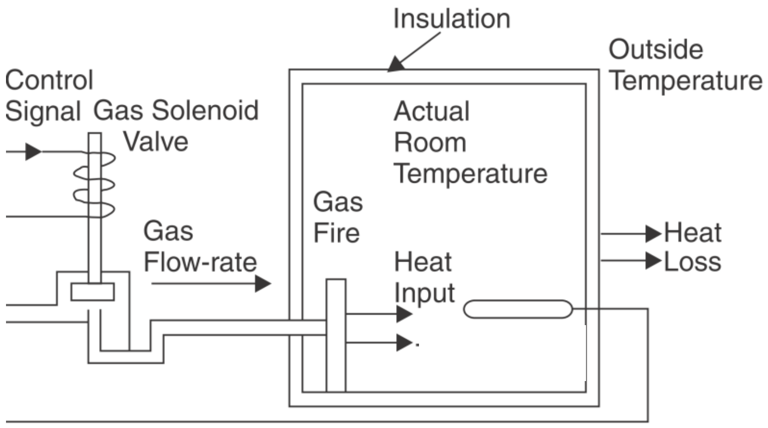
Course Description

- **Room Temperature (Objectives)**
  - **Accuracy:**
    - **Desired = Actual**
  - **Speed of response:**
    - **Time taken by the heater to reach desired**
  - **Protection:**
    - **From over temperature**



Oven

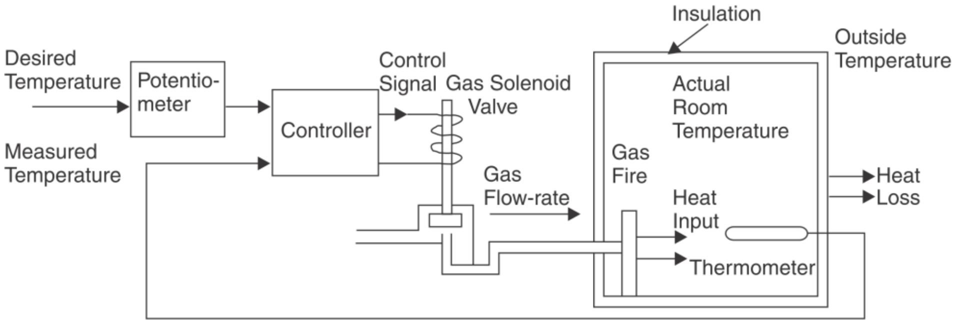
Open Loop

Impossible to achieve our objectives

Course Description

Solution: Use feedback

- **Room Temperature**
  - **Accuracy:**
    - **Desired = Actual**
  - **Speed of response:**
    - **Time taken by the heater to reach desired**
  - **Protection:**
    - **from over temperature**



Oven

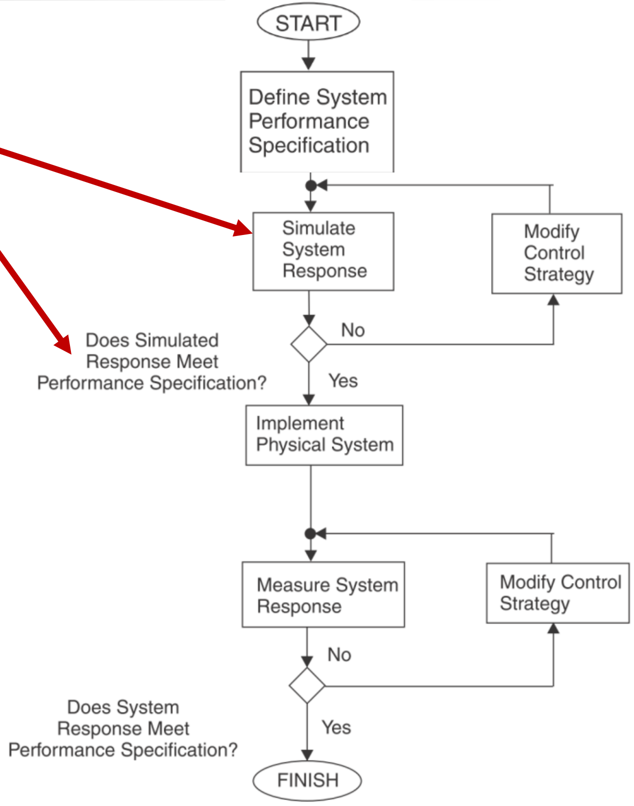
Feedback Controlled

Easy to achieve our objectives

Course Description

Main steps to design a control system

- **So, we need system model**
  - **To study relation btw input & output**
  - **To evaluate system performance (Our objectives)**
    - **Before control and after applying control technique**
    - **Before applying the control system in real time**
  - **Many control techniques are built based on system model**



Modeling ➔ Analysis ➔ Design

Main Tasks required to Design a Control System

Modeling
- Describe system I/O relationship

Analysis
- Evaluate system performance either before or after control

Design
- Achieve target performance

Implement
- Real time application of designed and tested control algorithm

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Course Objectives

- System modeling and Control are integral parts of all aerospace applications, from aircraft and spacecraft to robots and process control systems.
- Learning how to linearize and construct mathematical models for dynamical systems will help you to
  - Evaluate the behavior of the proposed system, and
  - Optimize system performance via controller design.
- Learning how to design and implement a simple control algorithm will help you to
  - Achieve the target performance of the system to be controlled.

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Course Intended Learning Outcomes

- Understand the construction and importance of feedback control systems.
- Model a system and represent it in the form of differential equations and transfer function
- Analyze system in the time domain and frequency domain
- Evaluate the behavior of LTI systems, both in the transient and steady-state regimes
- Study the system stability
- Design of a classical controller in the s-plane and frequency domain
- Understand and implement of a microprocessor-based control
- Analyze, design, simulate, implement, a control system in a modern computer language
- Coordinate working in a multifunctional team
- Prepare and present technical reports

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Course Topics

- Introduction to Control Systems
- System Modeling
- Time Domain Analysis
- Closed Loop Control Systems
- Classical Design in the s-plane
- Classical Design in the Frequency Domain
- Discrete-Time Control Systems

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Assessment

Weight	Evaluation Method
30%	**Final** (you must score at least **50% in final to pass**)
20%	**Midterms** (2 midterms, **all counted**)
10%	**Pop quizzes** (5 to 10 randomly distributed – **all counted**)
40%	**Project** (Incl. 2 x 2.5% follow up reports + 5% paper)

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Course Project

Topics

- The topics should include the modeling, analysis, control design, simulation, and experimental implementation of a physical system.
- The result of the course project will be a scientific paper (6 pages) along with part of the source code developed to solve a given problem.
    - IEEE Manuscript Template for conferences must be used.

Course Project

Teams

- **The team should include four to eight students who will divide themselves into sub-teams working on the software and hardware developments.**
- **To register in a project, the team must submit a file with the following items to your course instructor's email address before March 1, 2017:**
  - **Names of team members, IDs, email address**
  - **Project title**
  - **Project introduction (motivation and objective)**

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Course Policy

- **Late Submission Policy:**
  - **Anything submitted after 11:59PM on the due date will be penalized by 50% for each 24 hours of lateness.**
- **Absence Policy:**
  - **Attendance in all academic activities is mandatory.**
  - **Students who are absent more than 25% of the time in the course should not be permitted to attend the final examination and should receive a W grade.**
- **No makeup exams should be offered for missed exams.**
- **Projects and all other assignments will be submitted in electronic format.**
- **No homework need to be submitted, they are just for personal practice and solutions will be provided to you.**

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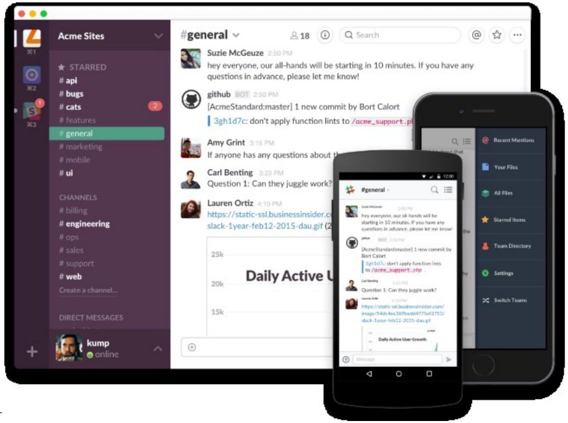
Course Resources

- **Course Website:** **Slack Page:** https://zc-spc318-spring2017.slack.com/
  - Course material - Course announcements – Discussions - etc. . .
  - Desktop/Mobile app:
    - https://zc-spc318-spring2017.slack.com/downloads/windows



- **Textbook:**
  - Dorf, Richard C., and Robert H. Bishop. "Modern control systems." (1
- **References:**
  - Ogata K, Yang Y. Modern control engineering.
  - Burns, Roland. Advanced control engineering. Butterworth-Heinemann, 2001.
  - Ibrahim, Dogan. Microcontroller based applied digital control. John Wiley, 2006.

Course Resources

- **Course Instructor**
  - **Dr. Ahmed Khalifa**
  - **Email: ahmed.khalifa0687@gmail.com**
  - **Office:** Adjunct Professors Room
  - **Office hours:** 2 hrs. after lecture
- **Course TAs**
  - **Eng. Salah Morsi**
    - **Email: smorsi@zewailcity.edu.eg**
    - **Office: 158**
    - **Office hours: TBD**
  - **Eng. Ahmed Khairy**
    - **Email: akhairy@zewailcity.edu.eg**
    - **Office: 158**
    - **Office hours: TBD**

Lecture End

Questions?

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SPC 318 – System Modeling and Linear Systems

Core Course: 3 Credits

Prerequisite(s): MATH 202 and SPC 218

Spring 2017

Instructor: Dr. Ahmed Khalifa

E-mail: ahmed.khalifa0687@gmail.com

Schedule: Wednesday 08:20 - 09:20 [114] and 10:40 – 11:40 [142]

Location: 114 and 142

Important Requirements

All students are required to

- Be able to perform simple programming tasks using any language (preferably MATLAB and C++)
- Homework, Projects, and all other assignments will be submitted in electronic format
- No homework assignments need to be submitted, they are just for personal practice and solutions will be provided.

Assessment Tools

T1: Examinations/Tests

T3: Group Projects

T6: Student Survey

Course Objectives

System modeling and Control are integral parts of all aerospace applications, from aircraft and spacecraft to robots and process control systems. Learning how to linearize and construct mathematical models for dynamical systems will help you qualitatively and quantitatively evaluate the behavior of the proposed system, and optimize system performance. Design and implementation of a simple control algorithm will help you to achieve the target performance of the system to be controlled.

Course Intended Learning Outcomes

By the end of this course, the student will be able to:

ILO#	Description	Assessment Tool	Program ILO
1	Understand the construction and importance of feedback control systems.	T1,T6	1,5
2	Model a system and represent it in the form of differential	T1,T6	1,5

	equations and transfer function		
3	Analyze system in the time domain and frequency domain	T1,T6	1,5
4	Evaluate the behavior of LTI systems qualitatively and quantitatively, both in the transient and steady-state regimes	T1,T6	1,5
5	Study the system stability	T1,T6	1,5
6	Design of a classical controller in the s-plane and frequency domain	T1,T6	1,5
7	Understand and implement of a microprocessor-based control	T1,T6	1,3,5
8	Analyze, design, simulate, implement, a control system in a modern computer language	T3	5,11
9	Coordinate working in a multifunctional team	T3	4,10
10	Prepare and present technical reports	T3	4,6,7,11

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References

- Dorf, Richard C., and Robert H. Bishop. "Modern control systems." (1998).
- Burns, Roland. Advanced control engineering. Butterworth-Heinemann, 2001.
- Ibrahim, Dogan. Microcontroller based applied digital control. John Wiley, 2006.

Topics and Schedule

Week #	Topic	Practice and Assessment
1 8/2/2017	Course Presentation Introduction to Control Systems • Basic Definitions • Types of Control Systems • Examples	HW #01 How to Write a Paper: Abstract
2 15/2/2017	System Modeling • Mathematical Modeling of Physical Systems. • Mathematical Modeling of Mechanical Systems. • Mathematical Modeling of Electrical Systems. • Mathematical Modeling of Electromechanical Systems. • Linearization of Non-linear Systems.	HW #02 How to Write a Paper: I. Introduction
3 22/2/2107	Time Domain Analysis • Laplace Transforms • Transfer Function • Common Time Domain Input Functions	HW #03 How to Write a Paper: II. Related Work

	• Time Response of 1st Order Systems. • Identification of the 1st Order Transfer Function.	
4 1/3/2017	Time Domain Analysis • Time Domain Analysis of 2nd Order System. • Step Response of Second Order Systems. • Second Order System Time Domain Specifications.	HW #04 How to Write a Paper: III. Problem Formulation and Modeling
5 8/3/2017	Closed Loop Control Systems • Block Diagram Representation. • Block Diagram Reduction Techniques. • Superposition of Multiple Inputs.	HW #05 How to Write a Paper: IV. Proposed Approach
6 15/3/2017	Closed Loop Control Systems • The generalized control problem • P-, PI-, and PID-controller • Analog Implementation of PID • PID Tuning: Ziegler- Nichols method	HW #06 How to Write a Paper: V. Performance Evaluation
7 22/3/2017	**Midterm #1**	
8 29/3/2017	Classical Design in the s-plane • Stability of the dynamic systems. • Routh-Hurwitz Stability Criterion. • The Final Value Theorem. • The Steady State Error.	HW #08 **Follow up #01 due**
9 5/4/2017	Classical Design in the s-plane: Root Locus Analysis • Procedures for Root Locus. • Controller Design with Root Locus.	HW #09 How to Write a Paper: VI. Conclusion
10 12/4/2017	Classical Design in the Frequency Domain • The Concept of Frequency Response. • Bode Plot. • Relation between time and frequency domains • Stability Analysis with Bode Plot.	HW #10 How to Write a Paper: References
11 19/4/2017	**Spring Break**	
12 26/4/2017	**Midterm #02**	

13 3/5/2017	Discrete-Time Control Systems • Microprocessor-based control • Sampling Theorem • z-transform • Mapping the s-Plane into the z-Plane • Stability in z-plane	HW #13 **Follow up #02 due**
14 10/5/2017	Discrete-Time Control Systems • Digital Implementation of PID Controller • Practical considerations during PID Implementation • Case Study on Digital Control System design	HW #14 How to Write a Paper: **Case study**
15 17/5/2017	**Project Evaluation**	
16 24/5/2017	**Final Exam**	

Assessment

30% Final (you must score at least 50% in final to pass)
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Course Project

Topics

- The topics should include the modeling, analysis, control design, simulation, and experimental implementation of a physical system.
- The result of the course project will be a scientific paper (6 pages) along with part of the source code developed to solve a given problem. IEEE Manuscript Template for conferences must be used.

Teams

- The team should include four to eight students who will divide themselves into sub-teams working on the software and hardware developments.
- To register in a project, the team must submit a file with the following items to your course instructor's email address before March 1, 2017:
  - Names of team members, IDs, email address.
  - Project title
  - Project introduction (motivation and objective)

Project Delivery: May 15, 2017

- Before the presentation and to complete evaluating the project, each team must prepare a CD/Memory stick for the course instructor containing all materials related to the project (project paper according to the course policy mentioned above + a well-documented project technical report).

Project Presentation: May 17, 2017

Project Evaluation:

- The project team presents the developed project in 10 minutes plus 5 minutes for a question period.
- The other teams view the presentation and ask questions.
- Each presentation is attended by the course instructor as chair, course TA, critiquers (other teams), and the project team.
- During the presentation, one or two members can do all the speaking, or three or four members can share the speaking equally.
- All team members must be on the stage. Absent members need to provide documentation excusing their participation, e.g., a doctor's note.
- The critiquers will mark the presentation.
- The critiquers should provide clear, relevant and professional comments.
- The critiquers comments do not need to agree with the instructors' comments, but must be well justified.
- The classmates' critique questions and results do not affect the presentation marks directly, but may help the instructors to clarify their own rationale, especially in evaluating the team's responses to questions.
- The project evaluation will be based on the following criteria:
  - Project management (15%)
    - Planning
    - Follow up
    - Corrective actions and re-planning
  - Software (20%)
    - Open source or your own
    - Ease of use and operability
    - Accuracy
    - Output graphics
  - Experimental Hardware (20%)
    - Packaging
    - Stability and reusability
    - Precision
    - Cost optimization
  - Final Report (30%)

    - Technical report format (Cover, TOC, Introduction and literature survey, mathematical background, results, conclusions, reference, appendices)
    - Rigor of literature survey
    - Details of the model derivation and analysis
    - Numerical results and experimental verification
  - Final presentation (15%)
    - Public decimation of knowledge (Website. Wiki, videos, public slides, public reports, design graphics and charts, etc...)
    - Presentation graphics and appeal
    - Accuracy of presentation content
    - Comprehensibility of presentation content
    - Audience capturing
    - Audience participation and reply to questions
    - Timing

Course Policies

Late Submission Policy:

- Anything submitted after 11:59PM on the due date will be penalized by 50% for each 24 hours of lateness.

Absence Policy:

- Attendance in all academic activities is mandatory.
- Students who are absent more than 25% of the time in the course should not be permitted to attend the final examination and should receive a W grade.
- No makeup exams should be offered for missed exams.

Academic Integrity Policy:

Students are required to refrain from all forms of dishonorable or unethical conduct related to their academic work including.

- **Plagiarism**:

Submitting material that is in part or whole is not entirely one's own work without properly citing sources. Plagiarism includes, but is not limited to:

1. Submitting a copied piece of writing as original work
2. The quotation or other use of another person's words, ideas, opinions, thoughts, or theories (even if paraphrased into one's own words) without acknowledgment of the source
3. The quotation or other use of facts, statistics, or other data or materials (including images) that are not clearly common knowledge without acknowledgment of the source.

Fabrication:

Falsifying or inventing any information, data, or citation; presenting data that were not gathered in accordance with standard guidelines defining the appropriate methods for collecting or generating data and failing to include an accurate account of the method by which the data were gathered or collected including the incorrect documentation of a source;

1. The citation, in a bibliography or other list of references, of sources that were not used to prepare the academic work.
2. The inclusion in an academic work of falsified, invented, or fictitious data or information, or the deliberate and knowing concealment or distortion of the true nature, origin, or function of such data or information.
3. The unauthorized submission of an academic work prepared totally or in part by another.

Cheating:

Cheating is defined as fraud, deceit, or dishonesty in an academic assignment, or using or attempting to use materials, or assisting others in using materials that are prohibited or inappropriate in the context of the academic assignment in question.