ENGR 105: Feedback Control Design
Winter 2013

Lecture 1 - Introduction to Feedback Control

Monday, January 7, 2013

Today's Objectives

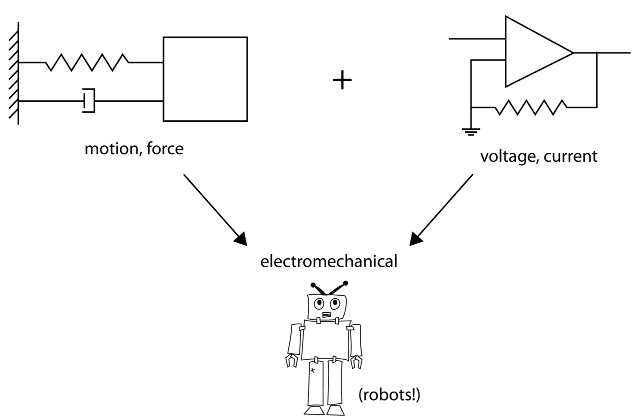
1. understand what you will get out of this course
2. get to know the teaching staff
3. learn course policies
4. define feedback control

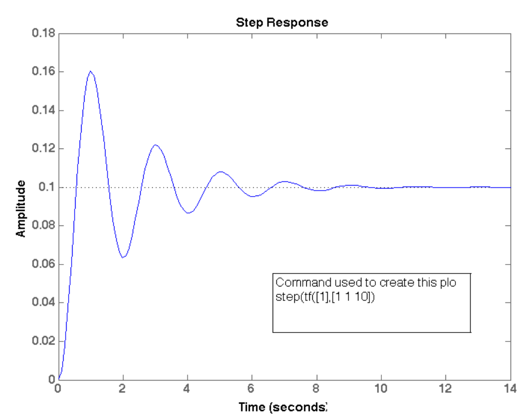
Reading: FPE Chapter 1

1 What is this course about?

The goal of this course is to use models of systems (equations of motion) to predict system response, and then change that response as desired using feedback control.

Models of systems $\Longrightarrow$ Behavior (depends on input)





In feedback control, we use *system behavior* to determine the new (artificial) inputs that we should apply to the system to get it to behave the way we want, in contrast to its natural behavior. We want to *predict* system behavior and *design* controllers accordingly. Prediction requires modeling and simulation – examine the quotes in your syllabus for inspiration (or at least context).

Control theory provides us with a powerful set of mathematical tools for changing system behavior. This theory can be abstract, but it is important to stay grounded in order to become a successful control designer. Review the course objectives in your syllabus for the path we will take through introductory control theory in this class.

2 Teaching Staff

- Instructor: Allison Okamura
- TAs: Nicholas Moehle, Sangram Patil, and Jared Muirhead

Office hours and problem session to be scheduled by Wednesday based on your response to this poll: `http://www.when2meet.com/?692266-7Yy1S`

3 Course Policies

Main components to the course:

- Lectures – Introduce and outline concepts, provide examples and context.
- Optional problem sessions – Detailed examples to enhance your problem-solving skills.
- Piazza Q&A – For discussion of concepts and problem-solving issues, particular to unstick you when you are stuck. Please participate as a question asker and answerer!
- Office hours – For one-on-one help to clear up conceptual issues.
- Assignments – Almost every week. Put concepts to practice. This is important to be successful on exams. (30%)
- Exams – A midterm (30%), and a comprehensive final (40%) to test your understanding of course concepts and your ability to use the acquired knowledge to solve problems.
- Participation – If your grade is borderline, attendance and involvement will help.

Course book: Gene F. Franklin, J. David Powell, and Abbas Emami-Naeini, Feedback Control of Dynamic Systems, 6th Ed.

Course notes: I will post notes before lectures as often as possible. The notes will have blank spaces for you to fill in relevant material during class. The completed notes will be available on piazza website before exams. The book is a much more detailed source of material.

Course website: `http://piazza.com/stanford/winter2013/engr105`
Grades will be posted to Coursework: `http://coursework.stanford.edu`

Review details of syllabus.

4 Introduction to Feedback Control

Feedback Control Design

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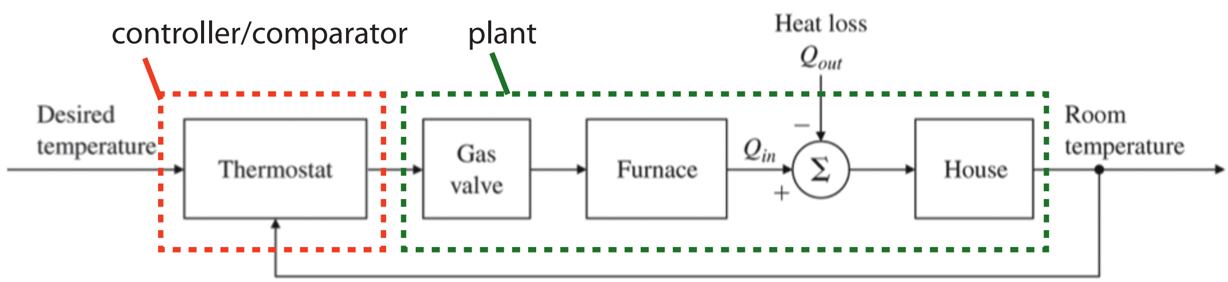
• measure	• change state	• conceive and form
• influence input	• predictable	• plan and fashion
	• desired outcome	• intend for a purpose

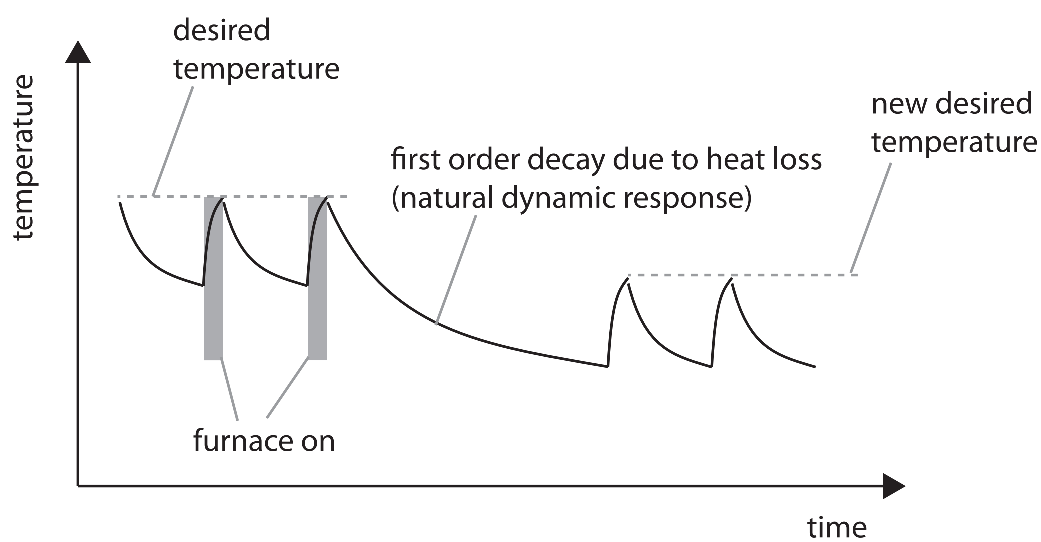
Example systems

- thermostat
- heat regulation in animals
- cruise control
- teleoperation

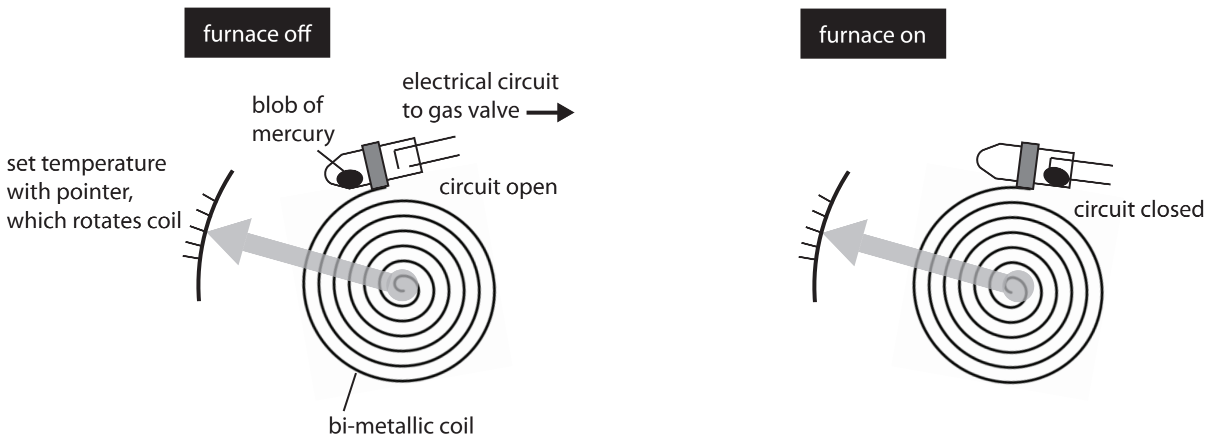
Thermostat



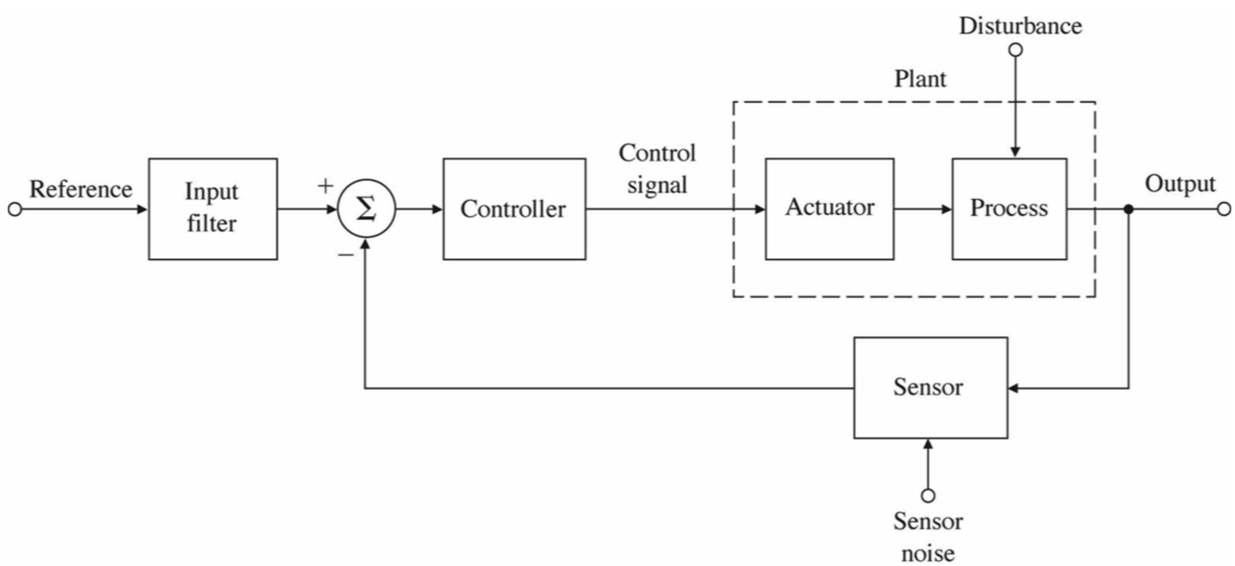
Closed-loop system response:



An old-fashioned mercury thermometer accomplishes the control mechanically:



General form of feedback control system



Purpose of each block:

- *process*: central component, output is to be controlled
- *disturbance*: uncontrollable, unpredictable inputs to the process
- *actuator*: device that can influence the controlled variable of the process
- *sensor*: measures output (the location matters!)
- *controller*: computes desired signal (analog circuit, digital circuit, or computer program)
- *comparator*: measures difference between reference and sensor output (measure of error)
- *input filter*: may be needed to convert reference to electrical form

What is good control?

- closed loop system must be stable (think about the Segway)
- system output tracks command input
- system output does not respond much to disturbance inputs
- these goals met even if:
  - model is not completely accurate
  - plant changes over time

More specific criteria may also include:

- response time
- disturbance recovery
- overshoot
- cost
- response to initial conditions
- well-defined output (calibration)