System Analysis

Spring 2009

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Lectures: Tu/Th 9:00-10:15 @301-105

Office hours: **After class or by appointment**

References: **1. Control Systems Engineering, Norman Nise, Wiley (purchase higly recommended)**
2. System Dynamics, William J. Palm, McGrawHill
3. MIT opencourseware: 2.004 spring 2008.

Objective: **Provide an overview of the system dynamics and control. Mathematical modeling and analysis of the devices and processes for the purpose of understanding their time-dependent behavior will be presented. Students will acquire skills to model and analyze dynamic systems which are the key skills required to design and build any kind of dynamic system.**

Grading: **Participation 5%** **Homework 10%**

Quiz 10% **Midterm Exam 1 20%**

Midterm Exam 2 20% **Final exam 35%**

Retakers will be downgraded. (A→ A-. B+ → B)

Participation: : **Uploading a Question or Answer on ETL counts as 0.5 point each.**

Questions will be asked during class

Correct answer 0.5 point

Wrong answer or answer in Korean 0point

No answer -0.5 point.

Late comers: **will be seated at the back, and will be asked questions intensively.**

Correct 0 point, Wrong -0.5point, No answer -1point.

Absent: **Coming to class after 9:30am will be counted as absence.**

Each absence →-1.5 point permanent deduction from Participation point.

If you are absent for more than 4 times, you will be given F.

Homework:

Problem sets will be given on Thursdays, and will be due next Thursday before class.

Late submission(only due to coming late) checked, and 0.5 point will be deducted from participation.

Will be On-Off checked. Please try your best to solve the problems on your own, instead of looking at the solutions.

Last homework will be one big problem, and will account for 5% of the grade. (Rest of the hw is 5%)

Quiz: One problem from homework that was due on Thursday will be given as a Quiz on the next Tuesday in class for 10 minutes. From 9:00am to 9:10am.

Midterm1: 75-minute on April 2 Thursday 9:00am -10:15am

Midterm2: 75-minute on May 14 Thursday 9:00am -10:15am

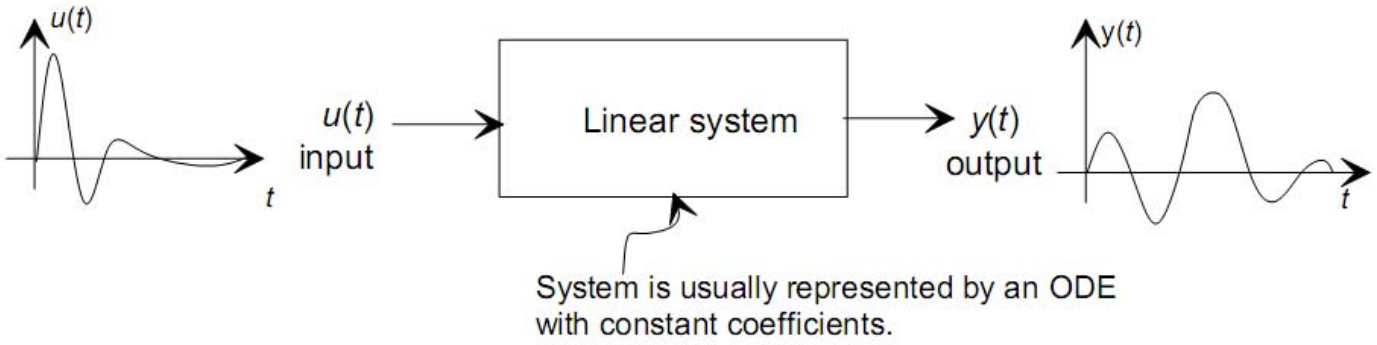
Final Exam: 2 hours on June 9 Tuesday 7:30pm-9:30pm

TA Hours: Wednesday 5:30pm-6:30pm (when there is a homework due)

English: Questions can be asked in Korean.

Upload a Picture by Next Thursday: 0 Attendance grade w/o picture

Why do you need to analyze a system?



usually represented by an ODE with constant coefficients.

Find an input that can produce

Desired Output with Desired Performance(speed, overshoot, settling time…)

Design a system that can produce for a given input,

Desired Output with Desired Performance(speed, overshoot, settling time…)

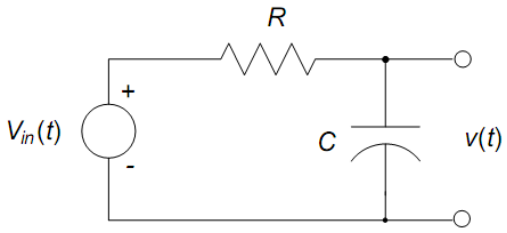
What do you do to analyze a system? or find a input to achieve desired output?

1. You build a system, give an input and see what happens!!

2. You model the system, and predict the output for a given input!!

How do you model a system?

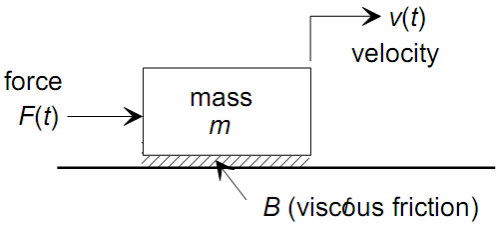
a) An electrical network:



Using KVL & KCL:

$$RC\frac{dv}{dt} + v = V_{in}(t)$$

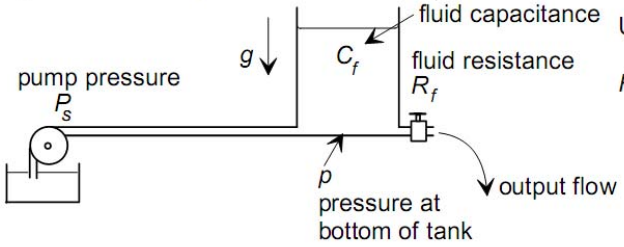
b) A simple mechanical system:



From a force balance:

$$\frac{m}{B}\frac{dv}{dt} + v = \frac{1}{B}F(t)$$

c) A fluidic system:



Using fluid junction equations

$$R_f C_f \frac{dp}{dt} + p = P(t)$$

We will learn,

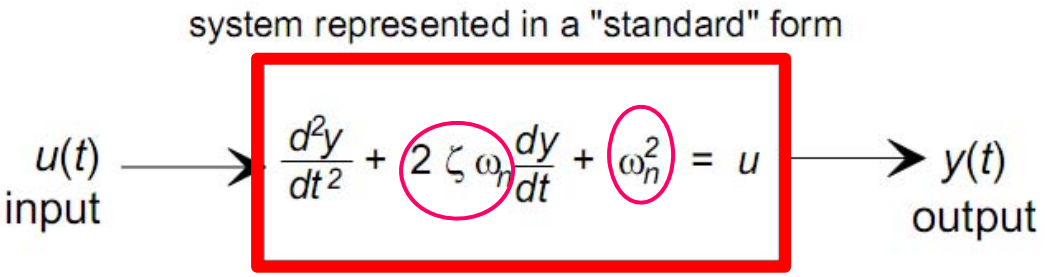
A unified approach to modeling the dynamic behavior of linear systems in many energy domains.

→ A Specific form!!

Linear System Theory

Generalized method for the description of the dynamic response of systems described by linear ODEs.

- Constant coefficients
- Without regard to particular energy domain



Models of systems from different domains will all be expressed using this standard form → (natural frequency, damping) or (m, c, k in mechanical domain)

Once a system is modeled using the above form, you will use standard analysis methods to quantify the performance of the system.

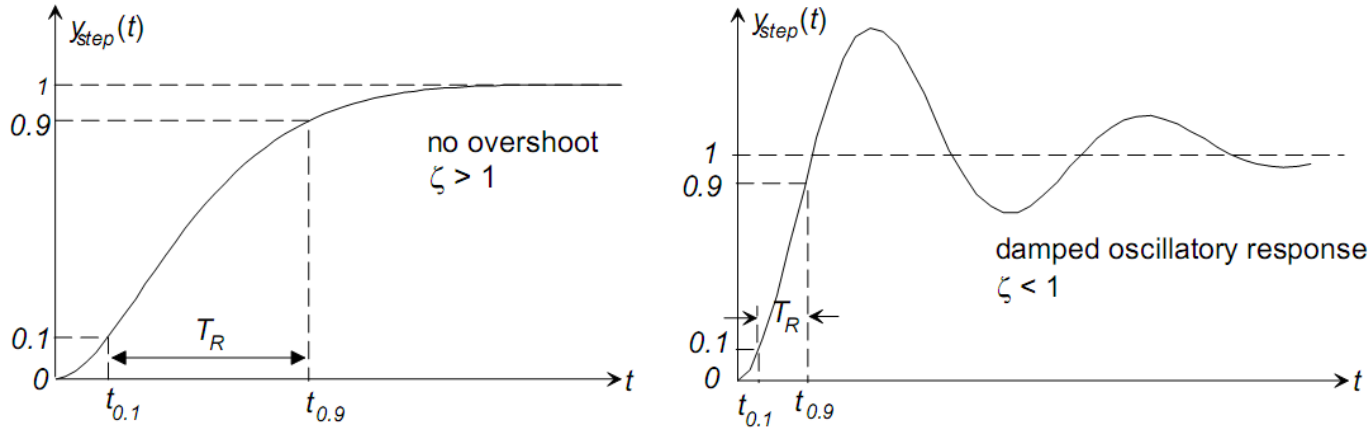
It's a powerful tool!
Think of all the different systems and reducing them into one single form, and you will know how they will respond to a given input!!

Can you predict the performance of the system if you know the model?

Two types of responses will be taught in this course.

Step input response. (Transient response)
Frequency response. (Sinusoidal input response)

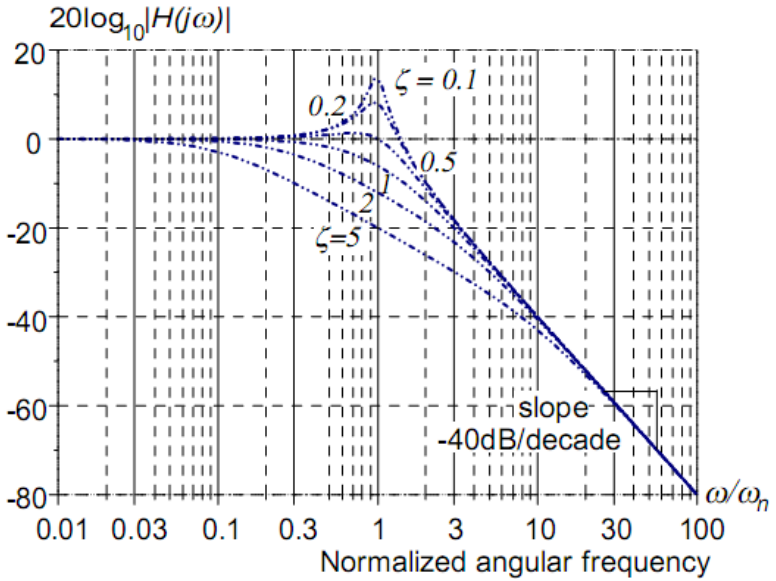
Step input response. (Transient response)

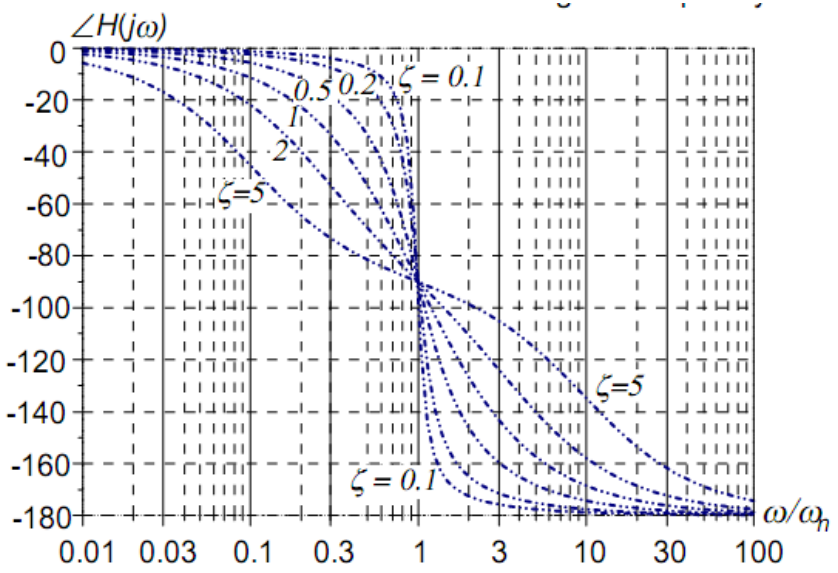


This response will be determined by just two parameters.
Natural frequency and damping!!

Can you predict the performance of the system if you know the model?

Frequency response. (Sinusoidal input response)





This response will be determined by just two parameters.
Natural frequency and damping!!

What do you do to analyze a system? or find a input to achieve desired output?

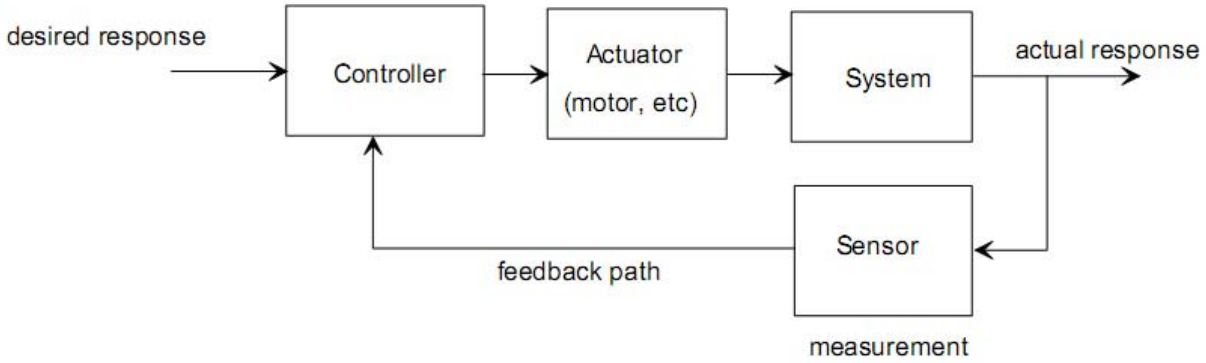
1. You build a system, give an input and see what happens!!

   Do this and plot the graph, and find the model!!!!

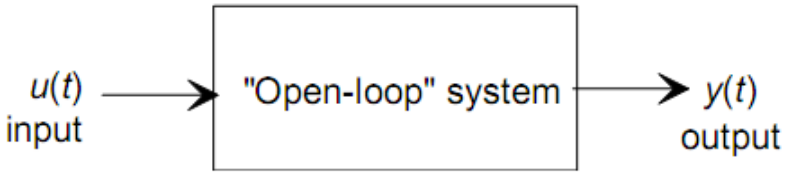
2. You model the system, and predict the output for a given input!!

Feedback Control

Monitor the system response(output) – compare with the desired behavior and generate a system input so as to drive the system toward the desired response.



Problems of Open Loop control



- Response might be unstable
- Response might be too slow
- Response might be affected by external influences
- Component properties might change

Major Course Contents

Part 1: *Introduction*

Introduction, Concepts, Terminology

Part 2: *Laplace Transform*

Laplace Transform: Why is this so powerful? Changes DE into algebraic equation!

Part 3: *Modeling*

Mathematical Model of Dynamic Systems

Transfer Function Approach to Modeling Dynamic Systems

State space Approach to Modeling Dynamic Systems

Electrical Systems

Fluid Systems and Thermal Systems

Major Course Contents (contd.)

Part 4: *Analysis*

Time Domain Analysis of Dynamic Systems

First Order / Second Order Systems

Transient Analysis

Analysis with MATLAB

Frequency Domain Analysis of Dynamic Systems

Understanding the underlying physics and being able to construct models of dynamic systems to analyze (and,) predict (and control) engineering systems