ME451: Control Systems

Lecture 0
Introduction

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Instructor

- **Class Instructor:** Dr. Jongeun Choi,
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**Office Hours**
- 2459 EB, MWF 11:30-12:20am, Extra hours by appointment

- **Laboratory Instructor:** Dr. Ranjan Mukherjee,
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Course information

- **Lecture:**
  - When: MWF: 12:40pm-1:30pm
  - Where: 2243 Engineering Building
  - Class and Laboratory website: [http://www.egr.msu.edu/classes/me451/jchoi/2012/](http://www.egr.msu.edu/classes/me451/jchoi/2012/)

- **Required Textbook:**

Main components of the course

- **Lectures (about 40 lectures)**
- Old Math Quiz
- Midterm1, Midterm2
- Final (Final exam period)
- Laboratory work
- **Grading:**
  - Homework plus Math Quiz (10%), Exam 1 (20%), Exam 2 (20%), Final Exam (comprehensive) (25%), Laboratory work (25%)
  - Homework will be due in one week from the day it is assigned
Tips to pass this course

- Come to the lectures as many times as you can.
- Print out and bring lecture slides to the lecture.
- Do “Exercises” given at the end of each lecture.
- Do homework every week.
- Read the textbook and the slides.
- Make use of instructor’s office hours.
- If you want to get a very good grade...
  - Read the textbook thoroughly.
  - Read optional references too.
  - Do more than given “Exercises”.
  - Use and be familiar with Matlab.

Math Prerequisites

- Complex Numbers
  - Add, Subtract, Multiply, Divide
- Linear Algebra
  - Matrix Multiply, Inverse, Sets of Linear Eq.
- Linear Ordinary Differential Equations
- Laplace Transform to Solve ODE’s
- Linearization
- Logarithms
- Modeling of Physical Systems
  - Mechanical, Electrical, Thermal, Fluid
- Dynamic Responses
  - 1st and 2nd Order Systems of ODE’s

Prerequisites: Complex Numbers

- Ordered pair of two real numbers
  \[ s : = x + jy \in \mathbb{C}, \text{where } x, y \in \mathbb{R}, j = \sqrt{-1} \]
- Conjugate \( \bar{s} = s^* : = x - jy \)
- Addition \( s_1 = x_1 + jy_1, s_2 = x_2 + jy_2 \)
  \[ s_1 + s_2 = (x_1 + x_2) + j(y_1 + y_2) \]
- Multiplication \( s_1s_2 = (x_1 + jy_1)(x_2 + jy_2) \)
  \[ = (x_1x_2 - y_1y_2) + j(y_1x_2 + x_1y_2) \]
  \[ s_s^* = |s|^2 = x^2 + y^2 \]

Complex Numbers

- Euler’s identity
  \[ e^{j\theta} := \cos \theta + j \sin \theta \]
  \[ \cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}, \quad \sin \theta = \frac{e^{j\theta} - e^{-j\theta}}{2j} \]
- Polar form
  \[ s := x + jy = re^{j\theta} \]
- Magnitude
  \[ r = \sqrt{x^2 + y^2} \]
- Phase
  \[ \theta = \tan^{-1}(y/x) \]
- Multiplication
  \[ s_1 = r_1e^{j\theta_1}, s_2 = r_2e^{j\theta_2} \]
  \[ s_1s_2 = r_1r_2e^{j(\theta_1 + \theta_2)} \]
Logarithm

- The logarithm of $x$ to the base $b$ is written $\log_b x$.
- The logarithm of 1000 to the base 10 is 3, i.e., $\log_{10} 1000 = 3$.
- $\log_{10} 10 = 1$, $\log_{10} 1 = 0$.
- Properties:
  
  $b \log_b(x) = x$  
  $\log_b(x^y) = y \log_b x$  
  $\log_b(xy) = \log_b x + \log_b y$  

  Why?  
  
  $x := b^z$, $y := b^w$, $\log_b(b^z b^w) = \log_b(b^{z+w})$  
  
  $\log_b \left(\frac{x}{y}\right) = \log_b x - \log_b y : b^x = b^{x-y}$

Laplace transform

- One of most important math tools in the course!
- Definition: For a function $f(t)$ ($f(t)=0$ for $t<0$),
  
  $$F(s) = \mathcal{L}\{f(t)\} := \int_0^\infty f(t) e^{-st} dt$$

  (s: complex variable)

- We denote Laplace transform of $f(t)$ by $F(s)$.

Summary & Exercises

- Prerequisites
  - Complex numbers, Linear Algebra, Logarithm, Laplace transform
  - Dynamics

- Next
  - Introduction

- Exercises
  - Buy the course textbook and keep it!
  - Review today’s slides on complex numbers and logarithm
  - Read Chapter 1 and 2 of the textbook.