

ME451: Control Systems

Lecture 0 Introduction

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Spring 2010

1

Instructor

- **Class Instructor:** Dr. Jongeun Choi,
 - Website: <http://www.egr.msu.edu/~jchoi/>
 - Assistant Professor at ME department,
 - 2459 Engineering Building,
 - Email: jchoi@egr.msu.edu
- **Office Hours**
 - 2459 EB, **MWF** 10:10-11:00am, Extra hours by appointment
- **Laboratory Instructor:** Dr. C. J. Radcliffe,
 - 2445 Engineering Building
 - Email: radcliff@egr.msu.edu

Spring 2010

2

Course information

- **Lecture:**
 - When: MWF: 12:40pm-1:30pm,
 - Where: 2245 Engineering Building
- **Class website:**
<http://www.egr.msu.edu/classes/me451/jchoi/2010/>
- **Laboratory website:**
<http://www.egr.msu.edu/classes/me451/radcliff/lab>
- **Required Text:**
 - Feedback Control Systems, C. L. Phillips and R. D. Harbor, Prentice Hall, 4th edition, 2000

Spring 2010

3

Main components of the course

- Lectures (about 40 lectures)
- Old Math Quiz
- Midterm1, Midterm2
- Final (Final exam period)
- Laboratory work
- Grading:
 - Homework (10%), Math Quiz (5%), Exam 1 (17.5%), Exam 2 (17.5%), Final Exam (comprehensive) (25%), Laboratory work (25%)
 - Homework will be due in one week from the day it is assigned

Spring 2010

4

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

$$s := x + jy \in \mathcal{C}, \text{ where } x, y \in \mathcal{R}, j = \sqrt{-1}$$

- 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

$$\begin{aligned} s_1 s_2 &= (x_1 + jy_1)(x_2 + jy_2) \\ &= (x_1 x_2 - y_1 y_2) + j(y_1 x_2 + x_1 y_2) \end{aligned}$$

$$s s^* = |s|^2 = x^2 + y^2$$

Complex Numbers

- Euler’s identity $e^{j\theta} := \cos \theta + j \sin \theta$

$$\cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}, \sin \theta = \frac{e^{j\theta} - e^{-j\theta}}{2j}$$

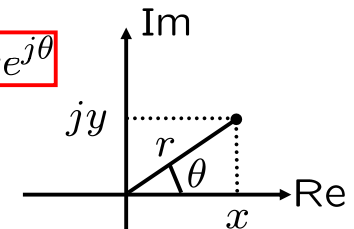
- Polar form $s := x + jy = r e^{j\theta}$

- Magnitude $r = \sqrt{x^2 + y^2}$
- Phase $\theta = \tan^{-1}(y/x)$

$$s_1 = r_1 e^{j\theta_1}, s_2 = r_2 e^{j\theta_2}$$

$$s_1 s_2 = r_1 r_2 e^{j(\theta_1 + \theta_2)}$$

$$\frac{s_1}{s_2} = \frac{r_1}{r_2} e^{j(\theta_1 - \theta_2)}$$



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:

$$b^{\log_b(x)} = x \quad \log_b(x^y) = y \log_b x$$

$$\log_b(xy) = \log_b x + \log_b y$$

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

$$\log_b\left(\frac{x}{y}\right) = \log_b x - \log_b y : \frac{b^x}{b^y} = b^{x-y}$$

Spring 20

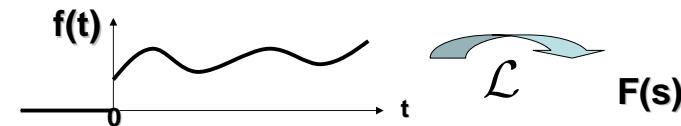
9

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 $F(s)$.

Spring 2010

10

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 Appendix A, B of the textbook.

Spring 2010

11