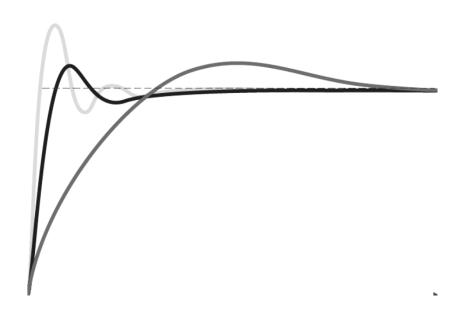
# MECH<sub>70022</sub> Advanced Control

Manab Shrestha



# Contents

1		Thursday Control Systems	1 4 5 5
	1.1	Mathematical Modelling Signals & Linear Dynamic Systems	2
		1.1.1 System Models Using Differential Equations	2
		1.1.2 Signal Representation in the Frequency Domain & Transfer Functions	2
	1.2	Frequency Response Analysis & Design	3
		1.2.1 System Models Using Differential Equations	3
		1.2.2 Signal Representation in the Frequency Domain & Transfer Functions	3
		<ul><li>1.2.3 Bode Diagrams</li><li>1.2.4 Design of Compensation</li></ul>	3 3
	1.3	Complex Frequency Analysis & Design	4
		1.3.1 Laplace Transforms & Complex Frequency Concepts	4
		1.3.2 Signal Representation in the Frequency Domain & Transfer Functions	4
		1.3.3 Root Locus Design Method	4
Chapter 2		Digital Control Systems	Page 5
_	2.1	Design of a Digital Controller Using Continuous System Theory	6
	2.1	2.1.1 CNC System Modelling	6
		2.1.2 CNC Controller Design for Transients, Disturbance Rejection & Multi-Axis Contouring	6
		2.1.3 Effects of Sampling	6
	2.2	Discrete System Analysis Using Z-Transforms	7
		2.2.1 Z-Transforms of Sampled Data Signals, Modified Z-Transforms & Fractional Time Delays	7
		<ul><li>2.2.2 Discrete Transfer Function</li><li>2.2.3 Digital Equivalent of a Continuous Transfer Function (Approx. Integration, MPZ, ZOH)</li></ul>	7
		<ul><li>2.2.3 Digital Equivalent of a Continuous Transfer Function (Approx. Integration, MPZ, ZOH)</li><li>2.2.4 Root Locus Design in the 'Z' Domain</li></ul>	7 7
		2.2.5 Jury's Stability Test	7
		2.2.6 Sampling Theorem	7
Chapter 3		State Variable Analysis	Page 8
	3.1	State Variable Analysis of Continuous Systems	9
	,	3.1.1 State Variable Modelling in Relation to Block Diagrams	9
		3.1.2 Eigenvalues, Eigenvectors & Characteristic Equation, Stability of State Variable Models	9
		3.1.3 Conversion Between Transfer Function & State Variable Models	9
		3.1.4 The State Transition Matrix 3.1.5 Closed Loop Systems	9
		3.1.5 Closed Loop Systems 3.1.6 State Variable Feedback	9 9
		3.1.7 Design of a Tracking Controller	9
		3.1.8 Controllability, Observability	9
	3.2	State Variable Representation of Discrete Systems	10
		3.2.1 Discrete State Variable Model from the Time Response of the Continuous Model	10
		3.2.2 Discrete State Variable Model from Discrete Transfer Function G(z)	10
	3.3	Extra Material	11
		3.3.1 Kalman Filtering 3.3.2 Optimal Control	11 11
		i	

### Chapter 1

# **Analogue Control Systems**

### 1.1 Mathematical Modelling Signals & Linear Dynamic Systems

- 1.1.1 System Models Using Differential Equations
- 1.1.2 Signal Representation in the Frequency Domain & Transfer Functions

### 1.2 Frequency Response Analysis & Design

- 1.2.1 System Models Using Differential Equations
- 1.2.2 Signal Representation in the Frequency Domain & Transfer Functions
- 1.2.3 Bode Diagrams
- 1.2.4 Design of Compensation

- 1.3 Complex Frequency Analysis & Design
- 1.3.1 Laplace Transforms & Complex Frequency Concepts
- 1.3.2 Signal Representation in the Frequency Domain & Transfer Functions
- 1.3.3 Root Locus Design Method

### Chapter 2

## **Digital Control Systems**

### 2.1 Design of a Digital Controller Using Continuous System Theory

- 2.1.1 CNC System Modelling
- 2.1.2 CNC Controller Design for Transients, Disturbance Rejection & Multi-Axis Contouring
- 2.1.3 Effects of Sampling

#### 2.2 Discrete System Analysis Using Z-Transforms

- 2.2.1 Z-Transforms of Sampled Data Signals, Modified Z-Transforms & Fractional Time Delays
- 2.2.2 Discrete Transfer Function
- 2.2.3 Digital Equivalent of a Continuous Transfer Function (Approx. Integration, MPZ, ZOH)
- 2.2.4 Root Locus Design in the 'Z' Domain
- 2.2.5 Jury's Stability Test
- 2.2.6 Sampling Theorem

### Chapter 3

### **State Variable Analysis**

#### 3.1 State Variable Analysis of Continuous Systems

- 3.1.1 State Variable Modelling in Relation to Block Diagrams
- 3.1.2 Eigenvalues, Eigenvectors & Characteristic Equation, Stability of State Variable Models
- 3.1.3 Conversion Between Transfer Function & State Variable Models
- 3.1.4 The State Transition Matrix
- 3.1.5 Closed Loop Systems
- 3.1.6 State Variable Feedback
- 3.1.7 Design of a Tracking Controller
- 3.1.8 Controllability, Observability

- 3.2 State Variable Representation of Discrete Systems
- 3.2.1 Discrete State Variable Model from the Time Response of the Continuous Model
- 3.2.2 Discrete State Variable Model from Discrete Transfer Function G(z)

- 3.3 Extra Material
- 3.3.1 Kalman Filtering
- 3.3.2 Optimal Control