**SECOND SEMESTER 2022-2023**

# Course Handout Part II

Date: 16-01-2023

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : CHE F342

## Course Title : PROCESS DYNAMICS & CONTROL

## Instructor-in-Charge : Jaideep Chatterjee

**Scope and Objective of the Course:**

This course deals with the design of the continuous control systems for processes and automation, using the fundamental concepts of Dynamic Analysis. The course will introduce conventional analytical tools used to analyze the dynamic behavior of processes and the stability of controlled processes. The course will also introduce the several alternative control configurations possible for a given processing unit or a complete process plant. The course is intended to educate students to a level where they will be equipped to understand, analyze and ultimately design control systems for process plants of today and the future.

**Course Description:** Dynamic modeling and simulation of systems of relevance to engineering, and more specifically Chemical engineering; analysis of the dynamic behavior of such systems; analysis and design of simple feedback and advanced control loops; Classical feed-back control and estimation of controller parameters; Analytical tools for stability analysis; introduction to modern evolving control strategies.

**Textbooks:**

1. Coughanowr, D.R. and Steven E LeBlanc, Process Systems Analysis and Control, 3nd Ed., McGraw-Hill, 2009.
2. Seborg, D. E., Edgar, T. F. and Mellichamp, D.A., “Process Dynamics and Control”, 2nd Ed., John Wiley and Sons, 2004.

**Reference books**

R1 George Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall, 1984.

**Course Plan:**

| Lecture No. | Learning objectives | Topics to be covered | Chapter in the Text Book |
| --- | --- | --- | --- |
| 1 | Introduction to Process Dynamics | What is Process Dynamics with an example. Introduction to unsteady state modelling | T1-Chap 2 |
| 2-4 | Laplace Transforms | Laplace Transformations, Application to several types of time functions, | T1-Chap 2 |
| 5-7 | Inversion by partial fractions | Solution of differential equation using Laplace transforms and Inversion. Roots and Stability of Dynamic systems | T1-Chap 3 |
| 8-10 | Dynamic behavior of 1st order systems | Development and properties of transfer functions, linearization of non-linear models. Examples of 1st order systems. | T1-Chap. 4-5 |
| 11-13 | Dynamic behavior of 1st order systems in series | Dynamic Behavior of 1st order systems in series | T1-Chap. 6 |
| 14-16 | Dynamic response of higher order systems | Dynamic response of higher order systems. 2nd order systems, systems with transportation lag. | T1-Chap. 7 |
| 17-19 | The Control System | Closing the Loop. Introduction to feedback control. Closed loop transfer functions | T1-Chap. 8 |
| 20-21 | Control system instrumentation | Transducers, transmitters, final control elements | T1-Chap. 9 |
| 22-24 | Complete Analysis of a single closed-loop control system | Complete analysis of a single chemical reaction control system by looking at all elements in the loop | T1-Chap. 10 |
| 25 | Closed loop Transfer functions | Rules for obtaining the Input-output relations for set-point tracking and load rejection | T1-Chap. 11 |
| 26-28 | Dynamic Response of simple control systems | Effect of process and controller parameters on transient response of a closed loop system for set-point tracking and load rejection. | T1-Chap. 12 |
| 29 – 31 | Stability Analysis | Analysis of control system stability by Root Locus. Generating root locus plots and Design of Control Systems using Root Locus | T1-Chap. 13 & Chap 14 |
| 31-32 | Introduction to Frequency Response | Frequency Domain Transfer functions and Bode Plots of various open loop systems | T1-Chap. 15 |
| 33-35 | Control system Design by frequency Response | Use of Frequency response to determine limits for controller parameters. Gain Margin and Phase margin based determination of controller parameters. | T1-Chap. 16 |
| 36-37 | Feedforward and ratio control | Ratio control, feed forward controller design based on steady state and dynamics equation, feedforward-feed-back controller | T1-Chap. 17 |
| 38-40 | Advanced Control Strategies | Cascade control, time-delay compensation, Model Predictive control, adaptive control | T1-Chap. 17 |
| 41-42 | Process Identification and Controller tuning | Determination of optimal controller parameters and online identification of Process Parameters | T1-Chap. 18 |

**Evaluation Scheme:**

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| --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage (%)** | **Date & Time** | **Nature of Component** |
| Class Test 1 | 45 mins | 10 % | By 15/03 | OB |
| Mid-semester Exam | 90 mins | 25 % | 16/03 4.00 - 5.30PM | OB |
| Class Test 2 | 45 mins | 10 % | By 15/04 | OB |
| Assignments (1) | 1 week | 10 % | By 30/04 | OB |
| Comprehensive Exam. | 180 mins | 45 % | 16/05 AN | OB |

**Open Book Exam:** Use of any printed / written reference material (books and notebooks) will be permitted inside the exam hall. Use of calculators (no other electronic gadgets) will be allowed in all exams.

**Chamber Consultation Hour:** Wednesdays (5:00 - 6:00 PM)

**Academic Honesty and Integrity Policy:**

Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

**Notices:** All notices related to these courses will be displayed on the CMS system, with email to all registered students

**Make-up Policy:** Make-up for the Class tests may be granted only when one attends more than 80 % classes and valid justification and with prior permission from the Instructor-in-charge

Jaideep Chatterjee

**INSTRUCTOR-IN-CHARGE**