BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

SECOND SEMESTER 2020-21
COURSE HANDOUT

Date: 18.01.2021

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 and Control**
Instructor-in-Charge : **HARE KRISHNA MOHANTA**
Instructor(s) (Tut/Prac) : **Srinivas Appari, Venkata Vijayan S**

1. Course Description:

Dynamic modeling and simulation of momentum, energy, mass transfer and reacting systems; analysis of the dynamic behaviour of lumped and distributed parameter systems; analysis and design of simple feedback and advanced control systems; design of control systems with multiple input and multiple output; introduction to computer control.

2. Scope and Objective of the Course:

This course deals with the design of the control systems for chemical processes, not as a mathematical problem, but as an engineering task with all its attractive challenges and practical shortcomings using the fundamental concepts of process dynamics as the basis. The course aims to help the student in the selection of the best among the several alternative control configurations usually possible for a given processing unit or a complete plant. Finally the course will familiarize the student with a plethora of analytical tools and design methodologies to be understood before attempting the process control problems.

3. Text Books:

- Seborg, D. E., Edgar, T. F. and Mellichamp, D.A., Doyle, F.J., "Process Dynamics and Control: An Indian Adaptation", 4th ed., (Feb., 2021), John Wiley and Sons.

4. Reference Books:

- Coughanowr, D.R., and LeBlanc S.E., "Process Systems Analysis and Control", 3rd Ed., McGraw-Hill Education (India), 2013.
- George Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall, 1984.

5. Course Plan:

Module No.	Lecture Session	Ref.	Learning outcomes
1. Introduction to Process Control (1-2)	L1.1 Need of process control, process control strategies, process control activities	Ch. 1	Understanding of the need of process control and overview of control system design.
	L1.2 An overview of control system design		
2.Theoretical Models of Chemical Processes (3-5)	L2.1 Modeling principles,	Ch. 2	Understanding the principles of modeling a system.
	L2.2 Degrees of freedom analysis		
	L2.3 Dynamic models of representative processes.		
3.Laplace Transforms (6-7)	L3.1 The Laplace transform of representative functions	Ch. 3	Understanding the use of Laplace Transforms for simulating a dynamic system expressed with transfer function models
	L3.2. Solution of differential equation		

4.Transfer Function Models (8-10)	L4.1 Development and properties of transfer functions	Ch. 4	Transfer function models and State-Space Models
	L4.2. Linearization of non-linear models		
	L4.3. State-space and transfer function matrix models		
	L4.4 Poles and Zeros and their effect on process response		
5.Dynamic Behavior of First- and Second-Order Processes (11-13)	L5.1 Standard process inputs	Ch. 5	Understanding the dynamic behavior of first and second order processes when subjected to different inputs.
	L5.2. Response of first order processes		
	L5.3. Response of second order processes		
	T5. Exercise problems on First and Second Order processes		
6. Dynamics Behavior of Higher-Order Processes (14-19)	L6.1. Effect of time delays	Ch. 6	Understanding the importance of poles and zeros, approximation of higher order systems, state and process transfer function matrices.
	L6.2. Approximation of higher order systems		
	L6.3. Interacting and Non-interacting processes		
	L6.4. Multiple-Input, Multiple-Output (MIMO) Processes		
	L6.5. Fitting First- and Second –Order Models using Step Tests.		
7.Feedback Controllers (20-25)	L7.1. Basic Control Models	Ch. 7	Understanding basics of classical feedback control systems – P, PI and PID Controllers.
	L7.2. Features of PID Controllers		
	L7.3. On-Off Controllers		
	L7.4. Typical Response of Feedback Control Systems		
	L7.5. Digital Versions of PID Controllers		
8.Control System Instrumentation (26-27)	L8.1. Sensors, Transmitters and Transducers	Ch. 8	Understanding how Instrumentation is important in process control.
	L8.2. Final Control Elements and control valve characteristics		
	L8.3. Piping and Instrumentation Diagrams		
9. Dynamic Behavior and Stability of Closed-Loop Control Systems (28-31)	L9.1. Block Diagram Representation and Closed-Loop Transfer Functions	Ch. 9	Understanding closed-loop response and stability of control systems.
	L9.2. Closed-Loop Response of Simple Control Systems		
	L9.3. Stability of Closed-Loop Control Systems		
	L9.4. Root Locus Diagrams		
10.Frequency Response Analysis and Control System Design (32-34)	L10.1. Sinusoidal Response of First- and nth-Order Process	Ch. 10	Understanding Frequency Response Analysis of closed-loop control systems, their design and stability analysis.
	L10.2. Frequency Response Characteristics of Feedback Controllers		
	L10.3. Bode Stability Criterion		
	L10.4. Controller Design using Gain and Phase Margins. Nyquist Plot.		
11. PID Controller Design, Tuning and Troubleshooting (35-38)	L11.1. Performance Criteria for Closed-Loop Systems	Ch. 11	Understanding various tuning and designing methods for PID controllers
	L11.2. Model-Based Controller Design Methods		
	L11.3. Controller Tuning		
12. Enhanced Single-loop control strategies (39-40)	L12.1. Introduction to Feedforward Control	Ch. 12	Understanding the concepts behind feedforward and ratio control
	L12.2. Ratio Control		
	L12.3 Cascade Control		

After completing this course the students will be able to

- Perform the Degrees of Freedom Analysis for a System/Control System.
- Make the Time-Domain Dynamic Model of the System.
- Make the Transfer Function Model of the System.
- Design and Tune Classical PID Controllers for the System.
- Make the Stability Analysis of the System.
- Perform Frequency Response Analysis of the System
- Draw Bode and Nyquist Diagrams.
- Design Control Systems using Gain Margin and Phase Margin.
- Design Feedforward, Ratio and Cascade Controllers.

6. Evaluation Scheme:

EC No.	Component	Duration (Minutes)	Weightage (%)	Date & Time	Nature of Component
1.	Mid-Semester Test	90	90 (30%)	-	CB/OB
2.	Tutorial Tests (Best 4 of 6)	-	60 (20%)	-	CB/OB
3.	Comprehensive Examination	120	120 (40%)	08/05 FN	CB/OB
4.	Home Assignments (Total 2)	-	30 (10%)	-	OB

7. Chamber Consultation Hour: (To be decided)

8. Notices: All notices concerning this course will be shared in the Google Classroom for Process Dynamics and Control. All the students are required to join the Google Classroom.

9. Make-up Policy: Make-up will be granted only for genuine cases.

10. Note (if any): Contact No. +91-1596-255754.

(Hare Krishna Mohanta)
Instructor-in-charge
CHE F342