GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor/Master of Engineering Syllabus

Subject Code : 3174401

Subject Name : Chemical Process Control

WEF Academic Year:	2023-24
Semester:	VII
Category of the Course:	**Professional Core course**

Prerequisite :	Basics of differential equations, Material and Energy Balance Calculations.
Rationale :	This course has been crafted to provide students with a comprehensive understanding of process control and their practical applications. Throughout the course, students will delve into the foundational aspects of control systems, learning about mathematical models using the transfer function approach for single-loop systems. They will acquire the skills necessary to analyze the dynamic responses of open-loop and closed-loop systems, both in transient and frequency domains, with a focus on stability assessment. Additionally, the course covers controller tuning techniques. As the course progresses, students will be introduced to various types of controllers, including Proportional (P), Proportional-Integral (PI), and Proportional-Integral-Derivative (PID) controllers, exploring their real-world applications

Course Scheme:

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	P	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Introduction of Process Control:** Introduction to process control, process variables, degree of freedom , Steady state and dynamic system, control logic, servo and regulatory, control, block diagrams, control structures . control valves , characteristics of control valves,	4	6
2	**Laplace Transforms:** Definition, Transforms of simple functions, Ramp functions, Sine	6	10

	functions, Solutions of differential equations. Inversions of transform function by partial fractions, qualitative nature of solutions, Final value and initial value theorems, Translation of transforms, Transforms of unit impulse functions, Transforms of integral.		
3	**First Order Systems:** Physical examples of first order systems, Linearization technique for a non linear valve, Derivation of the transfer function for a standard first order system, Response of a first order system to pulse, step and sinusoidal inputs, Self regulating and non self regulating first order systems, First order systems in series, Non interacting and interacting systems. Derivation of transfer functions of these systems	6	10
4	**Second Order Systems:** General form of the transfer functions of a second order system, Response of a second order system to pulse, step and sinusoidal inputs.	5	10
5	**The Control Systems:** Block diagram, Standard block diagram symbols, Negative and positive feedback, Servo problem v/s regulator problems, Development of block diagrams, Process measuring element, Controller, Final control element. Closed Loop Transfer Functions: Block diagram reduction, Overall transfer function for single loop system, Overall transfer function for change in load, Overall transfer function for multi loop control system, process and instrumentation diagrams , parts of control system.	6	10
6	**Controllers and Final Control Elements:** Actual v/s Ideal controller, Pneumatic controller mechanism of proportional control, Proportional integral (PI) control, Proportional derivative (PD) control, Proportional integral derivative (PID) control. Control valve, Control valve characteristics. Transfer functions of P, On-off, PI, PD, and PID control, Motivation for addition of integral and derivative modes, Block diagram of chemical reactor control system.	5	10
7	**Transient Response of Simple Control Systems:** Proportional control for Set point change (Servo Problem), Proportional control for load change (Regulator Problem), Proportional integral control	4	10

	for load change, Proportional Integral control for set point change, Proportional control for system with measurement lag.		
8	**Stability:** Concept of stability, Definition of stability (linear system), Stability criterion, Characteristic equation, Routh test for stability, Routh array, Method of Root Locus for stability analysis, Nyquist stability criterion.	5	8
9	**Frequency Response analysis:** Fortunate circumstances, Transportation lag, First order system, First order system in series, Bode diagrams, Bode stability criterion, Graphical rules for Bode diagrams. Transient response phase margin, magnitude ratio, phase shift, open loop bode diagrams of various controllers.	5	10
10	**Controller tuning and advance controllers:** Ziegler-Nichols method, Cohen-Coon method, introduction to cascade control, feed forward control, ratio control, Smith predictor, IMC, MPC, dead-time compensation, digital control.	4	8
11	Introduction to advance topics like Electrical and pneumatic signal conditioning and transmission, Computer process control, PLC, DCS, and SCADA.	4	8
	Total	**54**	**100**

Reference Book:

1. Stephanopoulos, G. “Chemical Process Control: An Introduction to Theory and Practice”, Pearson Education (1984).
2. R. P. Vyas, “Process Control and Instrumentation”, Denett & Co.
3. Seborg, D.E., Edgar, T.F., Mellichamp, D.A. “Process Dynamics and Control”, 2nd edition, John Wiley (2003).

Course Outcome:

After Completion of the Course, Student will able to :

No	Course Outcomes	RBT Level*
CO-1	Understand concepts of open and close loop control system	10
CO-2	Construct mathematical models of chemical process with its transfer function	25
CO-3	Evaluate the performance of control system with controllers and control strategies along with instrumentation	25
CO-4	Design control loop with appropriate controllers and control valve	20
CO-5	Apply appropriate instruments for various application in chemical plant	20

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

Suggested Course Practical List:

1. Calibration of thermocouple
2. Dynamics of liquid level system - single tank
3. Reponses of second order system: U-tube manometer or damped vibrator
4. Dynamics of liquid level system - non-interacting tanks in series
5. Dynamics of liquid level system - interacting tanks in series
6. Dynamics of mixing process
7. Dynamics of thermometer with thermo well
8. Comparative study of P, PI and PID controllers for temperature process system
9. Characteristics of flow control valves
10. Study of Electro-pneumatic converter

List of Laboratory/Learning Resources Required:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can perform experiments on Virtual lab by IITs.

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