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SARVAJANIK UNIVERSITY
Sarvajani College of Engineering and Technology



Bachelor of Technology (B.Tech)

B. Tech. Semester VI

Subject Name: Process Control

Subject Code: BTCH13603

Type of course: Professional Core Course

Prerequisite: Material and Energy Balance Calculations, Mathematical Methods in Chem Engineering, Momentum and Mass Transfer, Chemical Reaction Engineering, Heat Transfer, Chemical Engineering Operations, Separation Processes

Rationale: In the real life environment, process is continuously subjected to various disturbances which deviates the operation from the designed steady state. This course specifically prepares students to assess the impact of disturbances and equip them with the tools available with the chemical engineer to tackle untoward situations.

Teaching and Examination Scheme:

TEACHING SCHEME				Theory Marks			Practical Marks		Total
L	T	P	C	TEE	CA1	CA2	TEP	CA3	150
3	0	2	4	60	25	15	30	20	

CA1: Continuous Assessment (assignments/projects/open book tests/closed book tests **CA2:** Sincerity in attending classes/class tests/ timely submissions of assignments/self-learning attitude/solving advanced problems **TEE:** Term End Examination **TEP:** Term End Practical Exam (Performance and viva on practical skills learned in course) **CA3:** Regular submission of Lab work/Quality of work submitted/Active participation in lab sessions/viva on practical skills learned in course

Content:

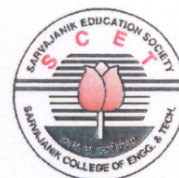
Sr. No.	Topics	Teaching Hrs.	Module Weightage %
1	INTRODUCTION Need for control and automation, Steady state and dynamic system, control logic, servo and regulatory, control, block diagrams, control structures (feedback vs. Feed forward). Laplace Transforms: Definition, Transforms of simple functions, Ramp functions, Sine 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.	5	10
2	RESPONSE OF FIRST ORDER SYSTEMS Mercury thermometer, Transient response of step functions, Sinusoidal input, Impulse functions. Physical Examples of First Order Systems: Liquid level, Mixing process, linearization. First Order System in Series: Non-interacting system of liquid level, Generalization of several non-interacting systems in series, Interacting systems.	4	9





3	SECOND ORDER SYSTEMS Development of transfer functions, Damped vibrator, Liquid manometer, Thermometer in thermo-pocket, Step response & impulse response, Overshoot, Decay ratio, Rise time, Response time, Period of oscillation, Natural period of oscillation, Sinusoidal response, Transportation lag.	4	9
4	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.	3	7
5	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.	3	7
6	TRANSIENT RESPONSE OF SIMPLE CONTROL SYSTEMS Proportional control for Set point change (Servo Problem), Proportional control for load change (Regulator Problem), Proportional integral control for load change, Proportional Integral control for set point change, Proportional control for system with measurement lag.	3	7
7	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.	4	9
8	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.	4	9





9	CONTROLLER TUNING AND ADVANCE CONTROLLERS Controller selection guidelines, controller design criteria, Ziegler-Nichols method, Cohen-Coon method, introduction to cascade control, feed forward control, ratio control, Smith-predictor, IMC, MPC, split range control, override control, adaptive control, inferential control, model predictive control, geometric control Dynamic matrix control, internal model control, dead-time compensation, digital control.	4	9
10	P & I DIAGRAMS (Piping & Instrumentation diagram) Symbols, P&I Diagram of reactors, Distillation column, Shell & tube heat exchanger, common control loops (level, pressure, flow, temperature), reactor control, distillation control loop	2	5
11	DISTRIBUTED CONTROL SYSTEM Distributed control system (DCS), Programmable Logical Control System (PLC).	2	5
12	INTRODUCTION TO PROCESS MEASUREMENT Elements of instruments, Parts of instruments, Static and dynamic characteristics. Measuring devices for flow, temperature, pressure level, pH, concentration, humidity, density, viscosity.	7	14

Suggested Specification table with Marks (Theory/Practical):

% Distribution of Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	25	30	10	05	00

Legends: R: Remembrance, U: Understanding; A: Application, N: Analyze, E: Evaluate C: Create and above Levels (**Revised Bloom's Taxonomy**)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Text Books:

Sr. No.	Title of book /article	Author(s)	Publisher and details like ISBN	Year of publication	Publication Edition
1	Process System Analysis & Control	D. R. Coughanowr.	McGraw Hill Publishing Co	1991	2 nd Edition
2	Industrial Instrumentation	Donald P. Eckman	John Wiley & Sons	1999	2 nd Edition
3	Chemical Process Control	George Stephanopolous	Prentice-Hall India	2001	3 rd Edition
4	Essentials of Process Control	Luben W.L., Luben M.L	McGraw-Hill, New York,	1997	2 nd Edition





5	Process Industrial Instruments and Control Handbook	Considine D.M.	McGraw-Hill, New York,	2001	4 th Edition
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Course Outcome:

Sr. No.	CO Statement After learning this subject, students will be able to	Marks % weightage
CO-1	Understand the significance of process dynamics (unsteady state operation)	15
CO-2	Interpret various control configurations and remember the specific applications of control strategies	28
CO-3	Understand working principles of basic instruments available for flow, pressure, level and temperature measurement	27
CO-4	Design a control strategy for key unit operations in reactors, distillation column	12
CO-5	Interpret industrial control system architecture and tune a controller to reject disturbances	18

Mapping with POs:

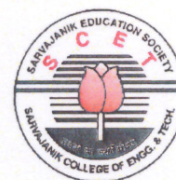
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO-1	3	2	1	3	2	2	3	1	1	2	3	3	3	2	1
CO-2	2	3	2	3	3	2	3	2	3	2	3	3	3	3	2
CO-3	2	2	3	3	3	1	2	1	1	3	2	3	3	3	1
CO-4	3	3	3	2	2	2	3	3	3	2	3	3	2	3	3
CO-5	3	2	1	3	3	1	3	3	3	1	3	3	3	2	2
Rationale*	13	12	10	14	13	8	14	10	11	10	14	15	14	13	9

Rationale*: All COs are satisfying the well-defined POs & PSOs

LIST OF PRACTICALS:

Sr no	Description
1	FIRST ORDER SYSTEM (Hg GLASS THERMOMETER ASSEMBLY)
2	MIXING PROCESS
3	TRANSPORTATION LAG
4	FIRST ORDER LINEARISED SYSTEM (TANK SET-UP)
5	RESPONSE OF FIRST ORDER SYSTEM Step and Pulse input (TANK SET-UP)





6	U TUBE MANOMETER (Change in applied forcing function, manometer fluid, geometric variables)
7	THERMOCOUPLE
8	RESISTANCE TEMPERATURE DETECTOR
9	RESPONSE OF SECOND ORDER SYSTEM (TANK SET-UP)
10	STUDY EXPERIMENTS

Reference Text Books:

Sr. No.	Title of book /article	Author(s)	Publisher and details like ISBN	Year of publication	Publication Edition
1	Process System Analysis & Control	D. R. Coughanowr.	McGraw Hill Publishing Co	1991	2 nd Edition
2	Industrial Instrumentation	Donald P. Eckman	John Wiley & Sons	1999	2 nd Edition
3	Chemical Process Control	George Stephanopolous	Prentice-Hall India	2001	3 rd Edition
4	Essentials of Process Control	Luben W.L., Luben M.L	McGraw-Hill, New York,	1997	2 nd Edition
5	Process Industrial Instruments and Control Handbook	Considine D.M.	McGraw-Hill, New York,	2001	4 th Edition

Major Equipment:

1. Process Tank system
2. Mixing Process

List of Open Source/learning website:

- <https://nptel.ac.in/courses/103/101/103101142/>
Introduction, process dynamics, principles
- <https://nptel.ac.in/courses/103/104/103104050/>
Plantwide control
- <https://nptel.ac.in/courses/103/101/103101003/>
Advanced process control
- <https://nptel.ac.in/courses/103/106/103106148/>
Process control design and analysis
- <https://nptel.ac.in/courses/103/105/103105064/>
Process control and Instrumentation

