Gyanmanjari Innovative University

Course Syllabus
Gyanmanjari Institute of Technology
Semester-7

Subject: Instrumentation and Process Control - BETCH17327

Type of course: Major (Core)

Prerequisite: Material and Energy Balance Calculations, Basics of differential equations.

Rationale: The course provides a fundamental understanding of process control and instrumentation, covering mathematical modeling using transfer functions for single-loop systems, dynamic response of open- and closed-loop systems, stability analysis, and controller tuning methods. It introduces P, PI, and PID controllers along with advanced strategies such as feed-forward, ratio control, model predictive control, and dead-time compensation. The course also focuses on practical aspects of instrumentation, including measuring devices for temperature, pressure, flow, level, pH, humidity, density, and viscosity, as well as components like transmitters, transducers, control valves, and systems such as PLC, DCS, and SCADA.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
				Theory Marks		Practical Marks		CA	
CI	T	P	C	ESE	MSE	V	P	ALA	
4	0	2	5	60	30	10	20	30	150

Legends: CI-Classroom Instructions; T – Tutorial; P - Practical; C – Credit; ESE – End Semester Examination; MSE- Mid Semester Examination; CA - Continuous Assessment; ALA-Active Learning Activities.

Course Content:

Sr. No	Course content	Hrs.	% Weightage
1	**Basics of Process Control and Laplace Transforms** Need for control and automation, steady-state and dynamic systems, control logic, servo and regulatory control, block diagrams, feedback and feedforward control structures, Laplace transforms, transforms of simple, ramp, sine, impulse and integral functions, solution of differential equations, inverse Laplace transforms using partial fractions, initial and final value theorems.	12	20

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2	**Dynamic Response of Systems** First and second order systems, mercury thermometer, liquid level systems, mixing process, damped vibrator, liquid manometer, thermowell thermometer, step response, impulse response, sinusoidal response, overshoot, decay ratio, rise time, response time, oscillation characteristics, interacting and non-interacting systems, linearization, transportation lag	12	15
3	**Control Systems and Controllers** Control systems basics, block diagrams and standard symbols, positive and negative feedback, servo and regulator problems, control system components such as measuring elements, controllers and final control elements, block diagram reduction, transfer functions for single loop, multi-loop and load changes, and process and instrumentation diagrams (P&ID). Controllers including P, PI, PD and PID, ideal vs actual controllers, pneumatic controllers, control valves and their characteristics, transfer functions of controllers, and the role of integral and derivative actions. Transient response of control systems including servo and regulator response, set point and load changes, and systems with measurement lag.	12	20
4	**Stability, Frequency Response and Advanced Control** Concept of stability, definition of stability for linear systems, stability criteria, characteristic equation, Routh test, Routh array, root locus method, Nyquist stability criterion, frequency response analysis, transportation lag, first order systems and systems in series, Bode diagrams, Bode stability criterion, graphical rules for Bode plots, phase margin, magnitude ratio, phase shift, open loop Bode diagrams of controllers, controller tuning methods such as Ziegler-Nichols and Cohen-Coon, and advanced control strategies including cascade control, feedforward control, ratio control, Smith predictor, IMC, MPC, dead-time compensation, and digital control.	12	15
5	**Process Measurement and Instrumentation** Introduction to process measurement, elements and parts of instruments, static and dynamic characteristics, temperature measurement including scales, expansion thermometers (constant volume gas, mercury in glass, bimetallic), filled system thermometers, thermocouples and pyrometers, errors and compensation methods, pressure measurement using manometers, Bourdon gauge, bellows and vacuum gauges, liquid level measurement methods such as float, bubbler, diaphragm and differential pressure systems, flow measurement using orifice plate, venturi, rotameter, pitot tube and positive displacement meters, flow control actuators and valves, humidity measurement using psychrometer and hygrometer methods, pH measurement using electrodes and reference electrodes, and density and viscosity measurement using hydrometers, displacement meters and viscometers.	12	30

Continuous Assessment:

Sr. No	Active Learning Activities	Marks
1	**Case Study on Process Control in Industry:** Students will select Individual a chemical/process industry (e.g., distillation column, reactor, heat exchanger) and prepare a short case study explaining the control strategy used (feedback, feedforward, PID), variables controlled, and challenges faced. Students will submit the report as a PDF on GMIU Web Portal.	10
2	**Controller Analysis and Comparison:** Students will prepare Individual a comparative table of P, PI, PD, and PID controllers including their characteristics, advantages, limitations, and industrial applications. Students will make report also include response graphs for better understanding. Submission will be in PDF format on GMIU Web Portal.	10
3	**Sources of Water Pollutants:** Students will Individually identify major sources of water pollutants (municipal, agricultural, industrial) and list examples of typical pollutants from each source. Students will upload report the PDF on the GMIU Web Portal.	10
Total		30

Suggested Specification table with Marks (Theory): 60

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage	14%	30%	20%	15%	15%	05%

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.

List of Suggested Practical

Sr. No	Suggested Practical	Unit No	Hrs.
1	Response of first order system: Thermometer	1	2
2	Response of first order liquid level system	2	2
3	Response of mixing process	2	2

4	Open loop system: Lagged thermometer	2	2
5	Response of second order system: U-tube manometer / damped vibrator	2	2
6	Response of interacting tanks	2	2
7	Response of non-interacting tanks	2	2
8	Characteristics of flow control valves	2	2
9	Temperature, level, flow and pressure control trainers	3	2
10	Flow-level cascade control	4	2
11	Calibration of thermocouple test rig	5	2
12	Temperature and pressure measuring devices	5	2
13	Level measuring devices (Bubble system)	5	2
14	Viscosity and pH measuring devices (pH control trainer)	5	2
15	Study of transmitters and transducers	5	2

Course Outcome:

After learning the course, the students should be able to:	
CO1	Understand concepts of open and close loop control system
CO2	Construct mathematical models of chemical process with its transfer function
CO3	Evaluate the performance of control system with controllers and control strategies along with instrumentation
CO4	Design control loop with appropriate controllers and control valve
CO5	Apply appropriate instruments for various application in chemical plant

Instructional Method:

The course delivery method will depend upon the requirement of content and the needs of students. The teacher, in addition to conventional teaching methods by black board, may also use any tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction. Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses. The internal evaluation will be done on the basis of Active Learning Assignment.

Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in the laboratory.

Reference Books:

[1] Coughanowr, D. R., LeBlanc, S. "Process Systems Analysis and Control", 3rd edition,McGraw-Hill (2008).
[2] Stephanopoulos, G. "Chemical Process Control: An Introduction to Theory and Practice", Pearson Education (1984)
[3] Seborg, D.E., Edgar, T.F., Mellichamp, D.A. "Process Dynamics and Control", 2nd edition, John Wiley (2003)
[4] William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, Mc-GrawHill (2005).
[5] S.K. Singh, Industrial Instrumentation and Control, 3rd edition, McGraw-Hill (2008).
[6] R. P. Vyas, "Process Control and Instrumentation", Denett & Co.
[7] Donald .P. Eckman, "Industrial Instrumentation", John Wiley & Sons Inc, New York.