GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL TECHNOLOGY (36)
PROCESS INSTRUMENTATION, DYNAMICS & CONTROL
SUBJECT CODE: 2183607
B.E. 8TH SEMESTER

Type of Course: Chemical Technology

Prerequisite. Students are expected to have a background in mathematics through differential equations, Laplace transformation, material and energy balance concepts, and unit operations.

Rationale: The main objective of this subject is to cover basics of process control and the instrumentation used in industries. The process control part begins with the introductory concepts, and mathematical modeling and its use for control purposes. Subsequently, the dynamic behavior of chemical processes will be discussed. This course goes deeper into the design of feedback controllers. A special emphasis will be placed on the controller tuning and stability analysis. The instrumentation part will elaborate the valve characteristics along with the working principle, specifications, design and selection aspects of various measuring instruments.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	3	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	Introduction of Process Control : Introduction to Industrial Process Control, Strategies for Control: Feedback/ Feed forward Steady state system, Process control, Feedback control, Transient response, Block diagram, Parts of control system	03	10
2.	Laplace Transforms: Definition, Transforms of simple functions, Ramp functions, Sine functions, Inversions of transform function by partial fractions, Final value and initial value theorems, Translation of transforms, Transforms of unit impulse functions, Transforms of integral.	03	05
3.	First Order Systems: Mercury thermometer, Transient response of step functions, Sinusoidal input, Impulse functions. Physical Examples of First Order Systems such as Liquid level, Mixing process, linearization. Response of First Order System in Series: Non-interacting system of liquid level, Generalization of several non-interacting systems in series, Interacting systems	07	15
4.	Second Order Systems: Development of transfer functions, Liquid manometer, Step response & impulse response, Terms used to describe second order system, Transportation lag.	07	15

5	**The Control Systems:** Block diagram, Negative and positive feedback, Servo problem v/s regulator problems, Development of block diagrams, Process measuring element, Controller, Final control element. Controller algorithms: P, PI, PD, PID control actions. 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. Selection of Controller & Control Criteria. Introduction to DCS, PLC and SCADA.	07	20
6	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.	07	15
7	Instrumentation: Introduction of Process Measurement: Elements of instruments, Parts of instruments, Static and dynamic characteristics. Mechanism & working of instrumentation for: Temperature Measurement: Scales, Expansion thermometers like constant volume gas, Mercury in glass, Bimetallic, Filled system thermometer like pressure spring thermometer, Static accuracy of thermometer, Dip effect in thermometer, Errors in thermometer of liquid and gas filled type like cross ambient effect, Head effect, Methods of compensation, Thermoelectric temperature measurement: Thermo couples, Laws of thermo electricity, Pyrometers: Laws of radiation, Radiation pyrometer, Photo electric pyrometers, Optical pyrometers, Errors in optical pyrometers. Pressure Measurement: Liquid column manometer, Enlarged lag manometer, Inclined tube manometer, Ring manometer, Tilting U tube manometer, Bourdon gauge, Bellows, Bellows differential pressure gauge, Vacuum Measurement: Ionization gauge, Pirani vacuum gauge, Thermocouple vacuum gauge, McLeod gauge Liquid Level Measurement: Direct measurement, Float and tap, Float and shaft, Hydraulic remote transmission, Bubbler system, Diaphragm & air trap system, Differential pressure manometer, Float and spring pneumatic balance, Displacement float, Magnetic float gauge Flow Measurement: Head flow meter, Orifice plate, Flow nozzle, Venturi tube, pitot tube, Differential pressure meter, Electric type head flow meter, Bellows type meter, Rotameter, Piston type area meter, Positive displacement meter.	08	20

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
58	**12**	**13**	**9**	**8**	**-**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and 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 Books:

1. Process systems analysis and control, Donald Coughanowr and Lowell Koppel,Mc Graw Hill, 2005
2. Process Control: Modeling, Design and Simulation, Wayne Bequette, Prentice Hall, 2003
3. Process Dynamics and Control, Seaborg, Edger, Millichemp, John Wiley & Sons, 3rd Ed., 2010
4. Process Control: Theory and Applications, Corriou, Springer, 2004
5. Process Dynamics Process, Modeling and Control, Ogunnaike and H Ray, Oxford University, 1994
6. Essentials of Process Control, Luyben and Luyben, Mc Graw Hill, 1997
7. Plantwide Process Control, Ericson and Hedrick, Wiley, 1999
8. Chemical Process Control: An Introduction to Theory and Practice, G Stephanopoulos, Prentice Hall, 1994

Course Outcomes:

At the end of this course students will gain knowledge on

1. Process modeling fundamentals: Differential equation models, Laplace transforms, linearization, idealized dynamic behavior, transfer functions, block diagram, and process optimization.
2. Control system context: safety, environmental concerns, product quality, and economical operation, instrumentation (valves, sensors, transmitters, and controllers).
3. Evaluate stability, frequency response, and other characteristics relevant to process control.

At the end of the course students will be able to

1. Think critically and make decisions, even if information is incomplete.
2. Analyze and solve problems in process systems – in particular those dealing with equipment performance, fluid flow, and material and energy balances.
3. Understand the fundamental principles of equipment operation so they will know not just how equipment is operated but why it is operated that way

List of Experiments:

1.	To study and determine the time constant of first order system. (Mercury in glass Thermometer
2.	To calibrate a Resistance Temperature Detector (RTD) and a thermistor
3	To study the pneumatic valve characteristics.
4.	To study the response of first order system in series using two tank liquid level system (Non-interacting system and Interacting system)
5.	To Study the closed loop feedback Temperature control system using temperature Transmitter i.e. RTD & Heater Control Card.

Major Equipment: Response of Interacting and Non interacting system, Level/ Flow cascade control trainer, Pressure/temperature control system trainer, Thermocouple, RTD, Control valve characteristics trainer.

Open Ended Project fields:-

Students are free to select any topic based on process control or instrumentation

List of Open Source Software/learning website:

1. Literature available on Journals, internet
2. NPTEL
3. Delnet

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.