GUJARAT TECHNOLOGICAL UNIVERSITY

BIOTECHNOLOGY (04)
INSTRUMENTATION & CONTROL FOR BIOENGINEERING
SUBJECT CODE: 2160407
B.E. 6th SEMESTER

Type of course: BE

Prerequisite: Basics of differential equations, material and energy balance.

Rationale: This course introduces dynamic processes and the engineering tasks of process operations and control. Subject covers modeling the static and dynamic behavior of processes; control strategies; design of feedback, feed forward, and other control structures; and applications to process equipment.

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		
4	0	3	7	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	**Introduction of Process Control:** Steady state system, Process control, Feedback control, Transient response, Proportional control, Integral control, Block diagram, Parts of control system.	1	2
2.	**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	8
3.	**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, RC circuit, linearization. First Order System in Series: Non-interacting system of liquid level, Generalization of several non-interacting systems in series, Interacting systems.	6	9
4.	**Second Order Systems:** Development of transfer functions, Damped vibrator, Liquid manometer, Thermometer in thermo pocket, Step response & impulse response for $\zeta<1$, $\zeta>1$& $\zeta=1$, Overshoot, Decay ratio, Rise time, Response time, Period of oscillation, Natural period of oscillation, Sinusoidal response, Transportation lag.	5	8
5.	**The Control Systems:** Block diagram, Standard block diagram symbols, Negative and positive feedback, Servo problem v/s regulator	6	9

	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.		
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.	**4**	**6**
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 for load change, Proportional Integral control for set point change, Proportional control for system with measurement lag.	**4**	**6**
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.	**6**	**9**
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. Ziegler Nicholas controller settings,	**6**	**9**
10.	**Introduction of Process Measurement:** Elements of instruments, Parts of instruments, Static and dynamic characteristics.	**2**	**3**
11.	**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, Pyrometers: Radiation pyrometer, Photo electric pyrometers, Optical pyrometers, Errors in optical pyrometers.	**4**	**6**
12.	**Pressure Measurement:** Liquid column manometer, Enlarged leg 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	**3**	**5**
13.	**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	**3**	**5**

	pneumatic balance, Displacement float, Magnetic float gauge.		
14.	**Flow Measurement:** Head flow meter, Orifice plate, Flow nozzle, Venturi tube, Pitot tube, Differential pressure meter, Electric type head flow meter, Bellows type meter, Rota meter, Piston type area meter and Positive displacement meter.	**3**	**5**
15.	**Humidity measurement & pH Measurement:** Psychometer method, wet bulb and dry bulb thermometer, hygrometer method, dead point method, electrolytic water analyzer. Electrode for pH measurement, calomel reference electrode, measuring circuits.	**3**	**5**
16.	**Density & Viscosity Measurement:** Liquid level method, displacement meters, hydrometer. Viscosity meter, continuous viscosity meters, capillary type viscometers, rotating bowl type viscometer.	**3**	**5**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**20**	**15**	**10**	**5**	**5**

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 System Analysis & Control", Coughanower and Kappel, Mc-Graw Hill Book Company.
2. "Process Control and Instrumentation", R. P. Vyas, Denett & Co.
3. "Chemical Process Control", George Stephanopoulos, Prentice-Hall India
4. "Industrial Instrumentation", Donald .P. Eckman, John Wiley & Sons Inc, New York.
5. "Industrial Instrumentation & Control", S. K. Singh, Tata McGraw-Hill Education.
6. "Process Instrumentation And Control", A. P. Kulkarni, Nirali Prakashan

Course Outcome:

After learning the course the students should be able to:

- Understand concepts of process dynamics and various forms of mathematical models to express them, including differential equations, Laplace transfer functions, and frequency response plots.
- Develop mathematical models of chemical and processes by writing unsteady-state mass and energy balances.
- Analyze, design and tune feedback / feedforward controllers in the context of various control strategies used to control chemical and biological processes.
- Recognize and fit various simple empirical models that are used for designing controllers.
- Understand and design basic control strategies.

List of Experiments:

Experiments based on above topics.

Design based Problems (DP)/Open Ended Problem:

- Non working models of control systems for exemplary chemical processes
- Projects based on advanced control strategies
- Mathematical models of simple physical systems
- Studies related to modern hardware and instrumentation needed to implement process control

Major Equipment:

- Interacting and non interacting liquid level tanks
- Equipment for non linear process
- Temperature trainer
- Pneumatic control valve, etc

List of Open Source Software/learning website:

- NPTEL lecture series
- Literature available on Instrumentation & Process Control
- MIT Open course lecture on Instrumentation & Process Control

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.