GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3153618
Semester – V
Subject Name: Process Instrumentation, Dynamics & Control

Type of course: Professional Core Course

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

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. 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
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction of Process Control :** Introduction to Industrial Process Control, Strategies for Control: Feedback/ Feed forward, Steady state system, Transient response, Block diagram, Parts of control system	3
2	**Laplace Transforms:** Definition, Transforms of simple functions, Ramp functions, Sine functions, Inversions of transform function by partial fractions, Solutions of differential equations, Final value and initial value theorems, Translation of transforms, Transforms of unit impulse functions, Transforms of integral.	5
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	7
4	**Second Order Systems:** Development of transfer functions, Liquid manometer, Step response & impulse response, Terms used to describe second order system like Overshoot, Decay ratio,Rise time, Response time, Period of oscillation, Natural period of oscillation, Sinusoidal response , Transportation lag.	7
5	**The Control Systems:** Block diagram, Negative and positive feedback, Servo problem v/s regulator problems,	7

	Development of block diagrams, Process measuring element, Controller, Final control element. Closed Loop Transfer Functions: Standard block diagram symbols, Overall transfer function for single loop system, Overall transfer function for change in load, Overall transfer function for multi loop control system.	
6	**Controllers:** Controller algorithms: P, PI, PD, PID control actions. Pneumatic controller mechanism of proportional control, Proportional integral (PI) control, Proportional derivative (PD) control, Proportional integral derivative (PID) control. Control valve, Control valve characteristics. 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.	**6**
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.	**7**
8	**Instrumentation:** Introduction of Process Measurement: Elements of instruments, Parts of instruments, Static and dynamic characteristics. **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.	**10**

Suggested Specification table with Marks (Theory): (For BE only)

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)

Reference Books:

1. "Process System Analysis & Control", Coughanower and Kappel, Mc-Graw Hill Book Company.
2. "Chemical Process Control", George Stephanopoulos, Prentice-Hall India
3. "Process Control: Modeling, Design and Simulation", Wayne Bequette, Prentice Hall
4. "Essentials of Process Control", Luyben and Luyben, Mc Graw Hill
5. "Industrial Instrumentation", Donald .P. Eckman, John Wiley & Sons Inc, New York.
6. "Process Instrumentation And Control", A. P. Kulkarni, Nirali Prakashan

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To gain knowledge on Process modelling fundamentals: Differential equation models, Laplace transforms, linearization, idealized dynamic behavior, transfer functions, block diagram, and process optimization.	10%
CO-2	To understand different aspects on control system context: safety, environmental concerns, product quality, and economical operation, instrumentation (valves, sensors, transmitters, and controllers).	15%
CO-3	To apply the fundamentals of process control in evaluating stability, frequency response, and other characteristics relevant to process control.	20%
CO-4	To analyze critically and make decisions, even if information is incomplete.	10%
CO-5	To evaluate for solving problems in process systems – in particular those dealing with equipment performance, fluid flow, and material and energy balances	25%
CO-6	To remember fundamental principles of equipment operation so they will know not just how equipment is operated but why it is operated that way	20%

List of Open Source Software/learning website:

- Literature available on Process Instrumentation, Dynamics & Control
- MIT Open course lecture on Process Instrumentation, Dynamics & Control
- NPTEL
- Delnet