GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester- VI
Course Title: Instrumentation and Process Control
(Course Code: 4360504)

Diploma programme in which this course is offered	Semester in which offered
Chemical Engineering	6th Semester

1. RATIONALE

The course aims to provide students with a comprehensive understanding of process control and instrumentation. It covers the foundational principles of process control, including application of Laplace transform approach for single loop systems, analysis of dynamic responses in open and closed loop systems, Furthermore, the course delves into the practical application of various controllers, such as P, PI, PD and PID. In addition to control theory, the course emphasizes instrumentation for process control and offers hands-on experience. It covers the operational principles of different measuring devices for variables like temperature, level, pressure, and flow. The course also introduces students to the concept of PLC and DCS.

2. COMPETENCY

The course should be taught, and curriculum should be implemented with the aim to develop require skills so that students are able to acquire following competency: **Student will be able to apply the concept of process control and measure various process parameters in chemical industry.**

3. COURSE OUTCOMES (COs)

1) Apply the basic concept of process control in the chemical industry.
2) Apply basic concepts of various controllers in process control.
3) Select appropriate instruments to measure various process parameters in chemical plants.
4) Measure various process parameters in the chemical industry using relevant devices.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits [L+T+(P/2)]	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
2	0	2	3	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate the integration of COs, and the remaining 20 marks are the average of 2 tests to be taken during the semester for assessing the attainment of the cognitive domain UOs required for the attainment of the COs.
Legends: L-Lecture; T-Tutorial/Teacher Guided Theory Practice; P-Practical; C-Credit, CA -Continuous Assessment; ESE-End Semester Examination.

5.SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the subcomponents of the Cos.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Dynamics Of First Order System (Step and Impulse Response Of thermometer)	1	02
2	Dynamics Of First Order System (Step Response of Single Tank Liquid Level System)	1	02
3	Dynamics Of Two First Order Systems Connected in Series (Step Response Non-Interacting System)	1	02
4	Dynamics Of Two First Order Systems Connected in Series (Impulse Response Non- Interacting System)	1	02
5	Dynamics Of Two First Order Systems Connected in Series (Step Response of Interacting System)	1	02
6	Dynamics Of Second Order System (Step Response Of U-Tube Manometer)	1	02
7	Measure level using direct method	4	02
8	Measure temperature of fluid using bimetallic thermometer	4	02
9	Measure temperature of fluid using thermocouple	4	02
10	Prepare a chart of components of DCS system	2	02
11	Measure specific gravity by Hydrometer	4	02
12	Level controller trainer	2	02
13	Flow controller trainer	2	02
	Total		**26Hrs.**

NOTE: More Practical Exercises can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the Cos. The above table is only a suggestive list.

The following are some sample (suggested) 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed Practical Exercises of this course required which are embedded in the COs and ultimately the competency.

Sr. No	Sample Performance Indicators for the PrOs	Weightage in %
1	Handling of apparatus for precise measurements.	10
2	Record observations correctly	20
3	Practice and adapt good and safe measuring techniques	10
4	Calculations, Interpretation of results and their conclusion.	20
5	Prepare a practical report in prescribed format.	10
6	Solve assignment questions.	20
7	Viva-voce	10
	Total	100

6.MAJOR EQUIPMENTS/ INSTRUMENTS REQUIRED

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Interactive & Non-Interacting System Apparatus: Process Tank: Material Stainless Steel, Circular, with level scale (3 Nos.) Capacity: 2.5 to 3.5 liters. Supply Tank: Material Stainless steel, Capacity 20 liters. Overhead tank: Material Stainless steel, Capacity 5 liters. Water Circulation: FHP Pump, Tullu/Standard make. Piping: SS/PVC, size Flow Measurement: Rotameter. Instruction Manual: An ENGLISH instruction manual will be provided along with the Apparatus. The whole unit is assembled rigidly on a base plate. Most of the parts are powder coated and the rest are painted with auto paints. SERVICES REQUIRED Water supply Drain Electrical supply: 1 Phase, 220V AC, 0.5 kW. Table for set-up support. Processes when connected in interacting and non-interacting mode. It is a combined unit to study 1) Single capacity process. 2) Non interacting process different mode can be compared with mathematically predicted response. Setup consists of supply tank, pump for water circulation, Rota meter for flow measurement, process tanks with scales, which can be connected to interacting and non-interacting mode. The components are assembled on frame to form tabletop set-up. line-height:	3, 4, 5

7. AFFECTIVE DOMAIN OUTCOMES

The following *sample* Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.

b) Follow ethical practices

c) Observe safety measures
d) Good house keeping
e) Time management
f) Practice environmentally friendly methods and processes.

The ADOs are best developed through laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8.UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the Cos and competency. If required, more such higher-level UOs could be included by the course teacher to focus on the attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I Introduction of Process Control & Control Systems	1.Explain Need for control and automation in process control. 2.Explain Steady state and dynamic system. 3.Explain servo and regulatory system. 4.Development of Block diagram of process controller. 5.Apply basics of Laplace transform. 6.Explain Negative and positive feedback. 7. Explain First order system and second order system with examples of different systems.	1.1 Introduction of Process Control: Need for control and automation. 1.2 Steady state and dynamic system 1.3 Servo and regulatory control, Open and close loop block diagrams 1.4 The Control Systems: Block diagram, Standard block diagram symbols, Negative and positive feedback, Development of block diagrams, Process measuring element, Controller, Final control element. 1.5 Basic concept of Laplace transform. 1.6 First order system: Mercury thermometer, interacting and non-interacting liquid level system. 1.7 Second order system: U-Tube manometer.
Unit– II Controllers and Final Control Elements	1. Justify need for controllers. 2. Explain Pneumatic controller. mechanism of PI, PD, PID control. 3. Explain response of various modes of control. 4. Explain schematic of control loops. 5. Explain PLC, DCS system.	2.1 Controllers and Final Control Elements 2.1.1 Pneumatic controller mechanism of Proportional control, Proportional integral (PI) control, Proportional derivative (PD) control, Proportional integral derivative (PID) control. 2.1.2 Response of a typical control system showing the effects of various modes of control (no control, P, PI, PID) 2.1.3 Control loops: Temperature control, Pressure control, Flow control, Level control

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		2.1.4 PLC, DCS
Unit– III Introduction to Process Measurement	1. Justify need for instrumentation in chemical plant. 2. Classify instruments in chemical plant. 3. Describe Basic elements of instruments. 4. Compare Static and Dynamic Characteristics of instruments. 5. Select appropriate instrument for measurement based on instrument range.	3.1 Introduction of Process Measurement: Importance of instrumentation in chemical plant 3.2 Classification of instruments 3.3 Basic elements of instruments 3.4 Static and dynamic characteristics 3.5 Selection criteria for various measuring devices in chemical industry for: Temperature, Pressure, Level and Flow
Unit– IV Measuring Devices	1. Compare different types of temperature measurement devices. 2. Explain Principle, Construction & Working of: Bi-metallic, Resistance thermometers, Industrial thermocouple, Radiation and optical Pyrometers. 3. Describe principal construction, and working of Bourdon tube gauge, Dead weight Gauge. 4. Describe principle, construction, and working of Target meter. 5. Classify and explain level measuring devices.	4.1 Temperature Measurement: 4.1.1 Principle, Construction & Working of: 4.1.1.1 Bi-metallic thermometer 4.1.1.2 Resistance thermometer 4.1.1.3 Industrial thermocouple: their principle, construction, working range, lead wires. 4.1.1.4 Radiation and optical Pyrometers 4.2 Pressure Measurement: 4.2.1 Pressure gauges: Principle, construction and working: 4.2.2.1 Bourdon tube gauge 4.2.2.2 Dead weight gauge 4.3 Flow Measurement: Principle, construction and working of Target meter 4.4 Measurement of head & level: Principle, construction and working: 4.4.1 Direct level measuring devices 4.4.1.1 Probe and tape 4.4.1.2 Sight glass 4.4.2 Indirect level measuring devices: 4.4.2.1 Air trap box method 4.4.2.2 Diaphragm box method

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction of Process Control & Control Systems	11	7	7	3	17
II	Controllers and Final Control Elements	07	8	8	3	19
III	Introduction of Process Measurement	03	4	3	1	8
IV	Measuring Devices	07	10	10	6	26
Total		**28**	**29**	**28**	**13**	**70**

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from the above table.

10.SUGGESTED STUDENT ACTIVITIES:

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidence for their (student's) portfolio which may be useful for their placement interviews:

Following is the list of proposed student activities like:

1. Assignments
2. Technical Quiz/MCQ Test
3. Presentation on some course topic
4. I-net based assignments
5. Undertake micro-Project in team/individually

11.SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (MOOCs) may be used to teach various topics/subtopics.

b) Guide student(s) in undertaking micro-projects/activities.
c) Different types of teaching methods i.e., video demonstration, activity-based learning, case study, m-learning need to be employed by teachers to develop the outcomes.
d) Some of the topics/sub-topics which are relatively simpler or descriptive are to be given to the students for self-learning but to be assessed using different assessment methods.
e) Teachers need to ensure to create opportunities and provisions for co-curricular activities.
f) Guide students to address issues on environment and sustainability with reference to using the knowledge of this course.
g) OERs and Vlab may be used to teach for the teaching of different concepts.

12.SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, in the fifth and sixth semesters, the number of students in the group should not exceed three. The micro-project could be industry application-based, internet-based, workshop-based, laboratory-based, or field-based. Each micro-project should encompass two or more COs which are the integration of PrOs, UOs, and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions to the project work and give a seminar presentation of it before submission. The duration of the microproject should be about 14-16 (fourteen to sixteen) student engagement hours during the course. The student sought to submit micro-project by the end of the semester (so that they develop industry-oriented COs).
A suggested list of micro-projects is given here. This should relate highly to the competency of the course and the COs. Similar micro-projects could be added by the concerned course teacher.

1) Prepare chart on working of PLC and DCS system.
2) Predict accuracy and precision of a standard measurement equipment
3) Prepare charts on First order dynamics for mixing process, temperature measurement, liquid level measurement etc.
4) Prepare a chart on liquid level equipment.
5) Prepare a PowerPoint presentation on a topic “P, PI, PD, PID controllers.”
6) Interpret PID diagram of a chemical industrial process.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year, and ISBN
1	Process Systems Analysis and Control	Donald Coughanowr, Steven E. LeBlanc	3rd edition, McGraw-Hill (2009)
2	Fundamentals of Industrial Instrumentation and Process Control	William C. Dunn	Mc-Graw-Hill (2005)
3	Industrial Instrumentation and Control	S.K. Singh	3rd edition, McGraw-Hill (2008)

Sr. No.	Title of Book	Author	Publication with place, year, and ISBN
4	Process Control and Instrumentation	R. P. Vyas	Denett & Co. (2015)
5	Industrial Instrumentation	Donald P. Eckman	John Wiley & Sons Inc, New York (2019)
6	Practical Process Control for Engineers and Technicians	Wolfgang Altmann	Elsevier Science (2005)
7	Chemical Process Control: An Introduction to Theory and Practice	George Stephanopoulos	Pearson Education India (2015)
8	Instrument Engineers' Handbook, Volume 1: Process Measurement and Analysis	Bela G. Liptak (Editor)	5th edition, CRC Press (2016)

14.SOFTWARE/LEARNING WEBSITES

Students can refer to video lectures available on websites including NPTEL.

- https://nptel.ac.in/courses/103103037
- https://www.tec-science.com/thermodynamics/temperature/how-does-a-bimetallic-strip-thermometer-work/ (Bimetallic thermometer animation)
- http://users.telenet.be/instrumentatie/temperature/temperature-scales.html (Temperature scales)
- https://en.wikipedia.org/wiki/Thermometer (Thermometer)
- https://instrumentationtools.com/bimetallic-thermometer/ (Bimetallic thermometer)

15.PO-COMPETENCY-CO MAPPING

Semester-VI	Instrumentation and Process Control (4360504)						
	Pos						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & Environment	PO 6 Project Management	PO 7 Life- long learning
Competency	**Student will be able to apply the concept of process control and measure various process parameters in chemical industry.**						
4360504.1	3	2	-	3	2	1	2
4360504.2	2	3	2	1	2	2	2
4360504.3	2	3	2	2	2	2	2
4360504.4	3	2	2	3	2	2	3

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16.COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
1	Mr. M.P Deshpande (Lecturer in chemical Engineering)	G.P Valsad	-	mehuldeshpande@gpvalsad.ac.in
2	Mr. J.D Rathod (Lecturer in chemical Engineering)	G.P Valsad	-	Jdrathod94@gmail.com