GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Instrumentation & Control Engineering

Course / Subject Code: DI01C17011(Only for C to D Students)

Course/Subject Name: Fundamentals of Instrumentation & Control Engineering

w. e. f. Academic Year:	2024-25
Semester:	1st
Category of the Course:	PCC-01

Prerequisite:	Basic knowledge of Physics
Rationale:	The course on Fundamentals of Instrumentation and Control Engineering equips engineering diploma students with essential knowledge and skills to operate, maintain, and troubleshoot various instruments integral to process industries. Students learn to apply fundamental principles of sensing, measurement, and control systems to address real-time industrial challenges while prioritizing safety and sustainability.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level
CO-1	Utilize foundational understanding of instrumentation principles to accurately measure process parameters in practical scenarios.	A
CO-2	Identify an appropriate sensor or transducer based on the specific process parameter being measured.	R
CO-3	Opt for a suitable power supply that aligns with the requirements of the instrumentation system.	U
CO-4	Differentiate between various control systems commonly employed in industrial settings, considering their features and applications.	U
CO-5	Understand the safety aspects in industrial instrumentation and implement safety protocols to prevent accidents, ensure personnel safety, protect equipment, and maintain environmental integrity.	A

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Introduction to Measurement system**	12	30
	1.1.Measurement: • The need for measurement • Methods of measurement • Block diagram of measurement system • Examples of measurement system 1.2.Units of measurement • Fundamental & Derived units • CGS, MKS and SI system of measurement 1.3.Standards of measurement • International, Primary, Secondary and Working standards 1.4.Instrument • Classification based on operation, function, output, nature of signals. • Selection criteria of instruments 1.5.Performance characteristics • Static and dynamic behavior of instruments. • Types of errors (i.e., systematic, random) 1.6.Transducers & Sensors		

	• Definition & its examples
	• Classification of transducer & sensors
	  ○ Based on principle of operation
	  ○ Primary & Secondary transducer
	  ○ Externally powered & Self generating type
	  ○ Analog & Digital transducer
	• Difference between transducer & sensor
	• Selection of sensor / transducer
	1.7.Important process parameters
	• Definitions & Units
	  ○ Temperature, Pressure, Flow and Level
	  ○ Displacement and Speed
	  ○ Dimension measurement (Thickness, Width and Length)
	  ○ Force and Torque
	  ○ Vibration and Acceleration.
	  ○ Density, Viscosity, Humidity and pH
	• List of sensors/ instruments/ devices for measurement of above-mentioned process parameters
	• List of day-to-day & industrial applications of sensors/transducers
	1.8.Concept of calibration, its significance		

2.	**Basics of Instrumentation & Control system**	9	20
	2.1 History and evolution of instrumentation • From pneumatic and hydraulic systems to electrical and computerized control. • The transition to the Internet of Things (IoT) revolutionizes instrumentation 2.2 Scope of instrumentation 2.3 Role of instrumentation in industries & benefits 2.4 Work profile of an instrument engineer 2.5 Terminologies related to instrumentation		

	• Instrumentation, Control system, Process, Sensors, Transducers, Transmitter, Final control element, Controller 2.6 Concept of control with day-to-day examples 2.7 Control system basics • Definition, block diagram, elements, terminologies and examples ○ Manual control system & Automation ○ Open loop system & Closed loop system ○ Feedback control system & Feedforward control system • Examples: Tank water level control system, Boiler drum level control system, Chemical reactor temperature control		
3	**Pneumatic, Hydraulic and Electronic instrumentation**	6	10
	3.1. Introduction to power sources, its classification and scope 3.2. Pneumatic control system • Essential components of a basic pneumatic control system • Merits and demerits of pneumatic control systems • Applications of pneumatic control systems • Checkpoints for failure of pneumatic control systems 3.3. Hydraulic control system • Essential components of a basic hydraulic control system • Merits and demerits of hydraulic control systems • Applications of hydraulic control systems • Checkpoints for failure of hydraulic control systems 3.4. Electronic control system • Essential components of a basic electronic control system • Merits and Demerits of electronic control systems • Applications of electronic control systems • Checkpoints for failure of electronic control systems 3.5. Comparison (pneumatic v/s hydraulic v/s electronic)		
4.	**Advancements in Industrial Instrumentation for Automation**	9	20

	4.1.Evolution of Industrial automation (Industrial Revolutions i.e. from IR 1.0 to IR 4.0) 4.2.Significance of advanced industrial instrumentation in the era of Industrial Revolution 4.0 4.3.PLC, DCS and SCADA • Block diagram • Components • Advantages and disadvantages • Industrial applications 4.4.Internet of Things (IoT) • Introduction to IoT • Key features of IoT • Block diagram • Basic components • Advantages and disadvantages • Industrial & Real-life applications of IoT		
5.	**Safety and Sustainability in Industrial Instrumentation**	9	20
	5.1. Safety Aspects in Industrial Instrumentation: • Industrial Hazards and Instrumentation • Classification of hazardous area (as per IEC) ○ Area classification ○ Apparatus (Gas) classification ○ Temperature classification • Role of Instrumentation & Control in industrial safety • Safety Instrumented System ○ Equipment protection system ○ Emergency shutdown system ○ Safety critical system ○ Interlock system (engineering) 5.2. Environmental impact and sustainability:		

	• Instrumentation's role in sustainability. • Role of energy-efficient sensors, smart transmitters, and low-power designs to reduce resource consumption. • Proper disposal of old instruments (e-waste management) is crucial for sustainability.		
	Total	**45 Hrs.**	**100 %**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
40 %	**40 %**	**20 %**	--	--	--

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Industrial Instrumentation and Control by S. K. Singh, 3rd Edition, Tata McGraw-Hill Publication, New Delhi, ISBN: 9780070262225
2. Basic Instrumentation System & Programmable Logic Controller by Umesh Rathore, KATSON Books, S. K. Kataria & Sons, ISBN: 9789350140093.
3. Process Control, Principles and Applications by Surekha Bhanot, Oxford Publication, ISBN: 9780195693348
4. Instrumentation & Process Measurements by W. Bolton, 1st edition, Orient Longman Publication.
5. Introduction to Measurements and Instrumentation by Arun K. Ghosh, 4th edition, PHI Publication, 2012, ISBN: 978-8120346253.
6. Hydraulics and Pneumatics A Technician's and Engineer's Guide Third edition Andrew Parr, Third edition 2011Elsevier Publication.
7. Industrial Automation Using PLC SCADA & DCS, by Rajesh G Jamkar,2nd edition, Global Education Limited Publication, ISBN:978-8193579954
8. Basic Instrumentation by Will L. McNair, 4th edition, The University of Texas at Austin Publication, ISBN: 978-0886981976
9. Lessons in Industrial Instrumentation by Tony R. Kuphaldt, Samurai Media Limited Publication, ISBN: 9789888407088
10. Environmental Instrumentation and Analysis Handbook, by Randy D. Down, Jay H. Lehr, WILEY publication. 2009 edition. ISBN: 978-0-471-47332-9.

(b) Open-source software and website:

1. https://instrumentationtools.com
2. https://instrumentationandcontrol.net/
3. https://www.vlab.co.in/
4. https://control.com/
5. https://sustainability.yale.edu/blog
6. Sustainable E-Waste Management & Its Importance| GEP Blog
7. How instrumentation technology is making a world of difference for a cleaner and greener world - ABB Measurement & Analytics Blog
8. https://www.ourmechanicalcenter.com/
9. https://www.controleng.com/articles/how-the-control-engineering-profession-helps-sustainability/
10. https://nptel.ac.in/courses/108102191

Suggested Course Practical List: If any

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. hours required.
1	Classify various regularly used measuring devices.	1	2
2	Identify which process parameters can be measured with given instrument/ instruments.	1	2
3	Calculate accuracy, resolution and precision for a given measuring instrument assuming you are given a standard instrument for comparison.	1	4
4	Calculate mean and variance of error for given measuring devices.	1	4
5	Calibrate range/span of a given instrument with the actual process parameters.	1	4
6	Map the given loop/ instrument with standard components of instrumentation system block diagram	2	2
7	Prepare a feedback control system for tank water level control.	2	4
8	Prepare a feedforward control system for tank water level control.	2	4
9	Set up a basic hydraulic system.	3	2
10	Trouble shoot hydraulic system.	3	2
11	Set up a basic pneumatic system.	3	2
12	Identify and select components required to operate pneumatic cylinder.	3	2
13	Troubleshoot the basic pneumatic system.	3	2

14	To study about evolution of industrial automation from IR 1.0 to IR 4.0	4	2
15	Identify basic components of a Programmable Logic Controller (PLC)	4	2
16	Identify basic components of Distributed Control System (DCS)	4	2
17	Identify basic components of Supervisory Control and Data Acquisition (SCADA)	4	2
18	Identify basic components of Internet of Things (IoT)	4	2
19	To understand the concept of hazardous areas and apply safety measures.	5	2
20	To study about various disposal methods of electronic waste (e-waste) and role of instrumentation in sustainable practices.	5	2
Minimum 12 Practical Exercises			**30 Hrs**

List of Laboratory/Learning Resources Required:

1. Classifying Measuring Devices:
    - Various devices such as
        - Thermometers, Sight glass, Dial gauges etc.
2. Identifying Process Parameters:
    - Various measuring sensors/devices
        - Flow meters, Pressure transducers, RTD, Thermocouples, Level sensors etc.
3. Calculating Accuracy, Resolution, and Precision:
    - Standard reference instruments (e.g., calibrated weights, rulers)
    - Calculator or spreadsheet software
4. Mapping Instrumentation System Block Diagram:
    - Process control trainers or simulation software
    - Components: Sensors, transmitters, controllers, actuators
5. Feedback Control System (Tank Water Level):
    - Water tank setup equipped with level sensor, controller, actuator (pump or valve)
6. Feedforward Control System (Tank Water Level):
    - Similar setup as feedback control with additional feedforward element (e.g., flow rate prediction)
7. Hydraulic System Setup and Troubleshooting:
    - Hydraulic trainer kit

- Hydraulic components (pumps, valves, cylinders)

8. Pneumatic System Setup and Troubleshooting:
   - Pneumatic trainer kit
   - Pneumatic components (compressors, valves, actuators)
9. Understanding Industrial Automation Evolution (IR 1.0 to IR 4.0):
   - Reference materials or presentations on each industrial revolution
10. Identifying PLC, DCS, SCADA, and IoT Components:
    - Study materials or hands-on experience with these systems
11. Hazardous Area Safety:
    - Safety manuals
12. E-Waste Awareness and Role of Instrumentation:
    - Educational materials on e-waste management

Suggested Project List:

The projects serve as practical learning experiences for students in the field of Instrumentation and Control Engineering. These projects integrate theoretical knowledge with hands-on application, fostering competency development across various Course Outcomes (COs). Below are guidelines for designing and executing projects:

- **Project Types:**
  - It can be industry-based, internet-based, workshop-based, laboratory-based, or field-based.
  - Each project should align with specific COs and address real-world challenges.
- **CO Integration:**
  - It should encompass two or more COs.
  - Integration involves aligning Program Outcomes (PrOs), Unit Outcomes (UOs), and Assessment and Design Outcomes (ADOs).
- **Project Duration:**
  - Students are encouraged to maintain a dated work diary to document their individual contributions and sufficient engagement time for each project should be allocated by faculty during the course.
- **Seminar Presentation:**
  - Before submission, students must give a seminar presentation on their project.

- The presentation should highlight the project's objectives, methodology, results, and relevance to industry-oriented COs.

Following are suggestive projects, and additional ones can be tailored to specific course objectives. Encourage students to explore innovative solutions and apply their engineering skills effectively.

1. **Industrial Hazard Analysis:**
   - Research and compile information about past industrial accidents (both nationally and globally).
   - Analyse the causes, effects, and consequences of these accidents.
   - Investigate strategies used to prevent such incidents.
   - Present your findings in a seminar or report.
   - Students can also explore case studies related to specific industries (e.g., chemical plants, oil refineries, nuclear facilities) and discuss safety measures.
2. **IoT Model Making:**
   - Choose an innovative IoT project related to instrumentation or control systems.
   - Create a physical model or prototype that demonstrates the concept.
   - Explain how the IoT components (sensors, actuators, communication modules) work together.
   - Consider projects like smart home automation, environmental monitoring, or industrial process optimization.
3. **Instrument Selection Simulation:**
   - Simulate the process of selecting instruments for a given application.
   - Define process parameters (e.g., temperature, pressure, flow rate) for a specific scenario.
   - Research and recommend suitable instruments (sensors, transmitters, controllers).
   - Discuss factors like accuracy, range, response time, and compatibility.
   - Prepare a detailed report summarizing your choices.
4. **PLC/DCS/SCADA Market Survey:**
   - Choose a specific type of PLC/DCS/SCADA.
   - Conduct a market survey to compare available options from different manufacturers.
   - Evaluate features, scalability, reliability, and ease of integration.
   - Consider factors like programming languages, I/O modules, and communication protocols.
   - Provide recommendations based on your analysis.

Suggested Activities for Students: If any

In addition to classroom and laboratory learning, students are encouraged to engage in co-curricular activities that enhance their understanding and practical skills. These activities can be conducted in groups and should be documented in 5-page reports. Collecting physical evidence of their work will also contribute to their portfolio, which can be valuable during placement interviews.

- Collaborate in groups to create detailed specifications for various industrial measuring devices. Consider accuracy, range, resolution, and environmental factors.
- Form teams and work on small-scale instrumentation projects. Apply theoretical knowledge to practical scenarios, such as designing a temperature control system or flow measurement setup.
- Deliver a seminar on safety practices specific to instrumentation systems. Cover topics like hazard identification, risk assessment, and emergency protocols.
- Organize a seminar focusing on cutting-edge instrumentation technologies. Discuss trends, innovations, and their applications in industry.
- Conduct a comprehensive market survey to explore available industrial components (sensors, transducers, controllers, etc.). Analyze their features, costs, and suitability for different applications.
- Prepare portfolios showcasing your instrumentation-related work. Include project reports, photographs, and evidence of practical implementation.

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