GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
I – Semester

Course Title: Fundamentals of Instrumentation and Control
(Course Code: 4311701)

Diploma programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	First

1. RATIONALE

The engineering diploma pass outs need to operate and maintain different types of instruments which are an integral part of any process industry.They are expected to apply basic principles of various sensing, measurement and control system to solvereal-time industrial problems by providing precise solutions adapting the safety measures and procedures preventing any harm to the personnel, system and environment. Moreover, this course is also a basic course which is a pre-requisite to pursue the other advance courses of instrumentation and control engineering. Therefore, this course is designed in such a way that the students will be able to acquire the desired fundamental knowledge and skill sets of Instrumentation and Control Engineering.

2. COMPETENCY

Thepurposeof this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Operate pneumatic and hydraulic instruments in process industries preciselyfollowing safety procedures.**

3. COURSE OUTCOMES (COs)

The practicalexercises, the underpinning knowledgeand the relevant soft skills associated with this competency are to be developed in the student to exhibitthe following COs:

a) Classify Instruments based on operation, function, output, nature of signals.
b) Apply the fundamentals of controls and automation to a given system.
c) Apply the basics of pneumatic and hydraulic instruments to a given system.
d) Practice safety measures to prevent accidents /hazards to personnel, system and environment.
e) Identify the basic architecture of the advanced industrial automation.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T/2+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	2	4	30*	70	25	25	150

(*):Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken

during the semester for the 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) that are thesub-components of the COs.*Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Classify various regularly used measuring devices according to MIMs (Measurement-Instrumentation-Meteorology)	I	02*
2	Calculate accuracy, resolution and precision for a given measuring instrument assuming you are given a standard instrument for comparison.	I	02*
3	Calculate mean and variance of error for given measuring devices.	I	02*
4	Calibrate range/span of a given instrument with the actual process parameters.	I	02
5	Identify which process parameters can be measured with given instrument/instruments	I	02
6	Map the given loop/ instrument with standard components of instrumentation system block diagram.	I	02*
7	Verify Bernouli's law using a simple experimental set up	II	02*
8	Verify Pascal's lawusing a simple experimental setup	II	02
9	Relate Reynold's number with type of flow.	II	02
10	Set up a basic hydraulic system.	II	02*
11	Trouble shoot hydraulic system.	II	02
12	Observe the operation of directional control valve and prepare a report	III	02
13	Identify and select components required to operate pneumatic cylinder.	III	02*
14	Troubleshoot the basic pneumatic system.	III	02
15	Observe the operation of pulley mechanism. (e.g. with the help of rod and rope set up.) and deduce the working principle with simple experimental set up.	IV	02*
16	Observe workingof the gear mechanism and relate with number of teeth Vs amplification of torque, speed with simple experimental set up.	IV	02
17	Illustrate moment balance principle with simple experimental set up (e.g. see-saw type arrangements)	IV	02
18	Illustrate motion balance principle with simple experimental set up.	IV	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
19	Illustrate force balance principle with simple experimental set up.	IV	02
20	Identify basic components of a Programmable Logic Controller (PLC)	IV	02*
21	Identify basic components of Distributed Control System (DCS)	IV	02
22	Identify basic components of Internet of Things (IoT)	IV	02*
			44

Note

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

ii. *The following are some **sample** '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..*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specificationsfor the PrOsis a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO.No.
1	Analog thermometer/ pressure gauge/ sight glass/ analog balancing insrument/	1-5
2	Hydraulic Trainer Kit	9-11
3	Pneumatic Trainer Kit	12-14
4	IoT Trainer Kit for different applications	22
5	Basic PLC kit	20
6	Simple experimental set up to explain force balance	19
7	Simple experimental set up set up to explain motion balance	18
8	Simple experimental set up to explain moment balance	17
9	Simple closed loop control loop (Water tank level or any)	6

7. AFFECTIVE DOMAIN OUTCOMES

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

a) Work as a leader/team membe.r
b) Always follow safety practices and procedure.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day to day observation.
e) Practiceenvironmental friendly methods and processes. (Environment related)

The ADOs are best developed through the 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.

9. UNDERPINNING THEORY

Only the major Underpinning Theory isformulatedashigher level UOs of *Revised Bloom's taxonomy* for development of the COs and competency is not missed out by the students and teachers.If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit – I **Basics of measurement and instrumentation**	1a. Justify the need for instrumentation 1b. Classify Instruments based on operation, function, output, nature of signals etc. 1c. Define various terminology related to Instrumentation and Control 1d. Compare Resolution-threshold 1e. Compare and contrast Accuracy with Errors 1f. List important process parameters. 1g. Define various terms of measurement instrumentation system. 1h. Identify various elements according to blocks of instrumentation system for measurement.	1.1 Concept and scope of instrumentation (work profile for instrument engineer) 1.2 History and evolution of instrumentation-Pneumatic, Hydraulic, Electrical, Computerized to Internet 1.3 Schematic representation of MIM Interactions: Measurement-Instrumentation-Meteorology 1.4 Types of instruments - Analog and Digital 1.5 Concept of standards and calibration 1.6 Characteristics of instruments - Static and Dynamic Characteristics, Major CharacteristicsRange,Span,Accuracy,Error, -Errors in Measurement, Resolution, Threshold, Linearity, Precision, Sensitivity, Drift(with

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
		example of analog thermometer/ sight glass) 1.7 Important process parameters 1.8 Basic block diagram of instrumentation system for measurement. 1.9 Definitions of terms-Input variable, manipulating variable, sensing element (Transducer), signal conditioning, output block, power supply (pneumatic, electric, hydraulic, magnetic, solar etc.)
Unit-II **Fundamentals of controls and automation**	2a. Explain the concept of control with examples. 2b. Identify various elements used in different blocks of control instrumentation system. 2c. list different methods of linking the system blocks. 2d. Explain given mechanical linkages. 2e. Explain given pneumatic concepts of passing signal to final control element.	2.1 Concept of controlwith day to day examples 2.2 Basic block diagram of control instrumentation system with definition of all terms e.g. input, output, controlled variable, manipulating variable, process, feedback, set point 2.3 Water tank level control system with all parameters identification. 2.4 Different methods of linking various blocks of system with each other. (mechanical, pneumatic, hydraulic, electrical, wireless etc) 2.5 Simple linkages and Terminology - link, lever, joint, DOF types of link 2.6 Basics of gears, pulleys 2.7 Basic principles of pneumatics 2.8 Flapper Nozzle Principle 2.9 Force Balance Principle 2.10 Moment Balance 2.11 Motion Balance Principle
Unit– III **Basics of pneumatic and hydraulic instrumentation**	3a. Explain Pneumatic Power and its scope. 3b. List important components of Pneumatic system 3c. State the function of each component in the block Diagram 3d. Choose the area of	3.1 Pneumatic power and its Scope 3.2 Essential components of a basic pneumatic system 3.3 Merits and Demerits of Pneumatic Systems 3.4 Applications of pneumatic systems 3.5 Checkpoints for failure of pneumatic systems

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
	application. 3e. Trouble shoot basic pneumatic system 3f. Explain principles of control mechanisms in Pneumatic Systems. 3g. Explain Hydraulic power and its scope 3h. List important components of hydraulic System 3i. State the functions of various components in the block diagram. 3j. Choose the area of application 3k. Trouble shoot a basic hydraulic System	3.6 Basic hydraulic theory 3.7 Hydrostatic and hydrodynamic systems. 3.8 Block diagram of basic hydraulic system 3.9 Advantages and disadvantages of hydraulic system 3.10 Applications of hydraulic systems 3.11 Checkpoints for failure of hydraulic systems
Unit– IV **Safety in instrumentation systems**	4a. Classify the various types of zones with respect to hazard and safety of process in instrumentation and control 4b. list applicationsof safetyinstrumented systems. 4c. listapplications of various safety regimes.	4.1 Types of Zones of Processes in Industry: Non-Hazardous Area, Division 2 or Zone 2 area, Division 1 or Zone 1 area, Zone 0 area, Dustzones, Gas /Vapour groups 4.2 Safety Instrumented - Equipment protection system, Emergency shutdown system, Safety critical system, Interlock (engineering) 4.3 Safety reliability regimes.
Unit– V **Introduction to advanced industrial instrumentation**	5a. Explain the basic components of a DCS, PLCand IoT with the help of a simple block diagram. 5b. List the Applications of DCS, PLC and IoT in Processes	5.1 Simple block diagram of DCS 5.2 Simple block diagram of PLC 5.3 Introduction to IoT,Key Features, advantages and disadvantages, Basic Components of IoT and Applications of IoT

***Note**:TheUOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

10. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A	Total Marks
I	Basics of measurements and instrumentation	12	5	7	2	14
II	Fundamentals of controls and automation	8	5	7	2	14
III	Basics of pneumatic and hydraulic instrumentation	10	5	14	2	21
IV	Safety in instrumentation systems	06	2	4	1	07
V	Introduction to advanced Industrial instrumentation	06	7	5	2	14
Total		**42**	**24**	**37**	**09**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of theUOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may varyslightly from above table.*

11. 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 conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare specification of some Industrial measuring devices.
b) Undertake micro-projects in teams
c) Give seminar on safety in instrumentation system
d) Give seminar on advanced industrial instrumentation
e) Undertake a market survey of different Industrial components.
f) Prepare showcase portfolios.

12. 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/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.11***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

f) Guide students on how to address issues on environment and sustainability
g) Guide students for using data manuals.

13. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, 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 in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry orientedCOs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs.Similar micro-projects could be added by the concerned course teacher:

a) **Industrial Hazard**: Compile the reports of past industrial massive accidents, their causes, effects, and strategies used and suggested to prevent such incidentsand present the same in a seminar.
b) Model making of some innovative IoT projects
c) Carry out mock selection of instrument for given process parameters. (Measuring / controlling/ signal transmission/safety)and prepare a report.
d) Carry out market survey for a given type of PLC/DCS

14. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Industrial Instrumentation and Control	S.K.Singh	Tata, McGraw-Hill,New Delhi ISBN: 9789351340102, 9789351340102
2	Hydraulics and Pneumatics	S.Sameer, K.Iliyas	R K Publications (1 January 2010) ISBN-10: 9352689054 ISBN-13: 978-9352689057
3	Mechanical and Industrial Measurements (Process Instrumentation and Control)	Er. R.K. Jain	Khanna Publishers New Delhi Latest Edition ISBN: 9788174091918, 9788174091918
4	Basic Pneumatic Systems, Principle and Maintenance	S R Majumdar	Tata, McGraw-Hill,New Delhi, 2002 or Latest Edition ISBN-13: 978-0074602317 ISBN-10: 0074602314
5	A textbook of Engineering Mechanics	R.S.Khurmi	S Chand and Company, 22 edition (1 January 2008)

S. No.	Title of Book	Author	Publication with place, year and ISBN
			ISBN-10: 9352833961 ISBN-13: 978-9352833962
6	Industrial Automation Using PLC SCADA & DCS	by R. G. Jamkar	Global Education Limited, second edition (1 January 2018) ISBN-10:819357995X ISBN-13:978-8193579954

15. SOFTWARE/LEARNING WEBSITES

a) www.datasheetcafe.com
b) www.wikipedia.com
c) www.virtuallabs.iit
d) www.nptel.iitm.ac.in
e) www.khanacademy

16. PO-COMPETENCY-CO MAPPING

Semester I	Fundamentals of Instrumentation and Control (Course Code: .....)						
	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	*Operate simple pneumatic and hydraulic instruments in process industries correctly and safely*						
Course Outcomes CO a) Classify Instruments based on operation, function, output, nature of signals	3	2	1	2	1	1	3
CO b) Apply the fundamentals of controls and automation to a given system.	2	1	1	2	1	1	2
CO c) . Apply the basics of pneumatic and hydraulic instruments to a given system.	2	1	1	2	1	1	2
CO d) Practice safety measures to prevent accidents /hazards to personnel, system and environment.	2	1	1	-	2	-	2
CO e) Identify the basic architecture of the advanced industrial automation.	2	-	-	2	-	1	2

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO

17. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1	Ms. M.N.Mulchandani	A.V.P.T.I. Rajkot	9106518990	manna4mala@gmail.com
2	Ms. S.K.Raval	Govt.Polytechnic, Ahmedabad	9427952040	sejalr73@gmail.com

NITTTR Resource Persons

S. No.	Name and Designation	Department	Contact No.	Email
1	Dr. C. S. Rajeshwari, Professor	Electrical and Electronics Engineering	9340068700	csrajeshwari@nitttrbpl.ac.in
2	Prof. Sanjeet Kumar Assistant Professor	Electrical and Electronics Engineering	9039210521	skumar@nitttrbpl.ac.in