GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)

Semester-III

Course Title: Control Components

(Course Code: 4331702)

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

1. RATIONALE

For a diploma Instrumentation engineer, before knowing the control engineering fundamentals, it is important to maintain and calibrate different process instruments and control components used for controlling the various process parameters. Hence the students will have to understand the construction, working and applications of various control components. Therefore, this course has been designed to maintain control components of the instrumentation loop.

2. COMPETENCY

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

- Operate, Test and Calibrate Various Control Components

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

a) Demonstrate function of Control Valve and its Accessories.
b) Operate pneumatic components.
c) Differentiate Gears based on their Application.
d) Demonstrate the function and Application of Electrical Control Components.
e) Demonstrate the working of switches, Safety and Auxiliary components.

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	
3	0	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 the subcomponents 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	Identify basic parts of the control valve.	I	2
2	Distinguish different types of globe valves as per their construction.	I	2
3	Examine Hysteresis in a given control valve.	I	2
4	Investigate linearity of given control valve.	I	2
5	Detect dead zone of given control valves.	I	2
6	Analyze the flow characteristics of linear type control valve.	I	2
7	Analyze the flow characteristics of equal percentage type control valve.	I	2
8	Analyze the flow characteristics of Quick opening type control valve.	I	2
9	Inspect the response of the diaphragm type pneumatic actuator.	I	2
10	Demonstrate the working of the positioner in a given control valve.	I	2
11	Test I to P converter and Plot the graph of mA versus PSIg.	I	2
12	Test P to I converter and Plot the graph of PSIg versus mA.	I	2
13	Plot the graph of Displacement v/s Back Pressure for a given Flapper nozzle system.	II	2
14	Test the air lock relay.	II	2

15	Check and observe the output reading of the air filter regulator.	II	2
16	Classify different Gears based on their Operation: Spur, Helical and Bevel Gears.	III	2
17	Calculate the relationship between speed ratio and teeth ratio of two different gears connected for motion transfer.	III	2
18	Control the step of stepper motor by varying the input pulse.	IV	2
19	Connect synchros as an Error Detector.	IV	2
20	Examine the working of synchronous motor.	IV	2
21	Examine the working of servo motor.	IV	2
22	Test SPST and SPDT Switch	V	2
23	Test DPST and DPDT Switch	V	2
24	Test inductive and capacitive proximity switch	V	2
25	Test the function of optical proximity switch	V	2
26	Demonstrate safety valve	V	2
27	Demonstrate different switches	V	2
28	Test the function of contactor	V	2
29	Test the given electrical relay by energizing its coil.	V	2
30	Test the given reed relay by energizing its coil.	V	2
31	Test the given solid state relay (SSR) by energizing its coil.	V	2
32	Test the operation of DIP switch	V	2
	Total		64

Note

i. *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.*

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..*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	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

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Control Valve trainer- with 3 valves having different types of flow characteristics. Positioner in any one valve. Rotameter showing flow through valve. Panel board with air lock relay, Pneumatic indicator and regulator as well as current source regulator and indicator.	3,4,5,6,7,8,9, 10,14,15
2	Cut section of control valve- globe type with diaphragm actuator	1,2
3	I to P converter Trainer Kit	12
4	P to I converter Trainer Kit	13
5	Flapper nozzle trainer kit	11
6	Gears demonstration kit (Which includes different types of Gears)	16,17
7	Synchro resolver Trainer	19,20
8	AC/DC Servomotor Trainer	21
9	Stepper Motor control Trainer	18
10	Proximity sensor Trainer	24,25

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 fulfil the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical appliances.
c) Practice environmental 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.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order 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 Control Valve	1a. Define control valve terminologies. 1b. Draw and label parts of Control valve. State function of each part. 1c. Describe function of various parts of control valve. 1d. With neat sketch explain construction and working of control valves based on their construction (1.3.1). State applications of each valve. 1e. Classify control valves 1f. Describe the construction of the control valve with the help of neat and clean diagram.	1.1. Control valve terminology: Rangeability, Hysteresis, Capacity, Linearity. 1.2. Basic Parts of Control valve : Body, Trim, Stem, Plug, Seat, Bonnet. 1.3. Classification of control valves 1.3.1 Based on construction: Globe valve, Ball valve, Butterfly valve, Needle valve, Pinch valve, Diaphragm valve, Solenoid valve 1.3.2 Based on plug movement- Linear/Rotary.

	1g. Explain construction and working of I to P converter and P to I converter with neat diagram. 1h. Describe the function of actuator. 1i. Classify actuators. 1j. Explain construction and working of electric actuator with neat diagram. 1k. Explain construction and working of pneumatic actuator and hydraulic actuator with neat diagram. 1l. Describe the function of positioner. 1m. Classify positioners. 1n. Explain construction and working of pneumatic positioner with a neat diagram. 1o. Explain construction and working of electro-pneumatic positioner with neat diagram. 1p. With neat sketch, explain flow characteristics of control valve. 1q. Describe maintenance procedure of control valve. 1r. State the procedure to calibrate control valve.	1.3.3 Based on type of operation -Manually operated/ Remote operated. 1.3.4 Based on actuation signal- ATO/ATC. 1.4 Signal Converter 1.4.1 I to P converter 1.4.2 P to I converter 1.5 Actuator-function Types- Electric, Pneumatic, Hydraulic. 1.6. Positioner- function Types- Pneumatic, Electropneumatic, 1.7. Flow characteristics of control valve - Linear, Equal percentage and Quick opening. 1.8. Maintenance of Control valve:- ● Calibration procedure
Unit – II Pneumatic Components	2a. State the need for pneumatic components. 2b. Explain the working of pneumatic components with sketches.	2.1 Pneumatic Components: Flapper Nozzle, Air Filter Regulator lubricator, Volume Booster, Pneumatic Cylinder (Single acting / Double acting) 2.2 Pneumatic Relay-Bleed/ Non-bleed, Direct / Reverse.

Unit– III Introduction to Gears	3a. State need of a Gear in industries. 3b. Define various terminologies related to Gear. 3c. Explain different types of Gears used in industries. 3d. Explain backlash phenomena in Gears. 3e. Study the relationship between speed, torque and number of teeth of two different gears connected for motion transfer. 3f. Write applications of Gears.	3.1 IntroductionTerms: Tooth, Pitch, Contact Ratio, Whole depth, Clearance, Addendum, dedendum, Pitch of a Gear. 3.2 Type of Gears: Spur Gear, Rack and Pinion, Helical Gear, Herringbone Gear, Bevel Gear, Worm Gear. 3.3 Relationship between speed, torque and number of teeth of two different connected gears. 3.4 Backlash in Gears. 3.5 Application of Gears
Unit– IV Electrical Control Components	4a. Classify electrical control components. 4b. Describe the construction of electrical control components with sketches. 4c. Explain the working principle of electrical control components with a diagram. 4d. Outline the applications of each electrical Control components.	4.1. Electrical Control System Components: 4.1.1 Synchros and Resolvers 4.1.2 Synchro as an error detector 4.2 Servo Motor- 4.2.1 AC servo motor 4.2.2 DC servo motor 4.3.Stepper Motor 4.3.1 Variable reluctance 4.3.2 Permanent Magnet 4.3.3 Hybrid

Unit– V Safety & Auxiliary Components	5a. Identify the various types of relays, Contactors, switches and auxiliary components from the list of given symbols. 5b. Classify the various types of safety and auxiliary components 5c. Explain the working of the various types of safety and auxiliary components 5d. State the testing procedure of the various types of safety and auxiliary components 5e. Explain basic features of SMART devices	5.1Relays: 5.1.1Electromechanical, Reed 5.1.2 Solid state relay, Contactors 5.2 Switches 5.2.1 Toggle switch: SPST, SPDT, DPST, DPDT 5.2.2 Push Button 5.2.3 DIP switch 5.2.4 Rotary switch (Single pole/Multi pole) 5.2.5 Thumbwheel switch 5.2.6 Limit switch (mechanical lever type) 5.2.7 Proximity Switch: Inductive, Capacitive, Optical 5.3 Safety Components 5.3.1 Alarm Annunciator 5.3.2 Safety Valve, Relief Valve, Safety Relief Valve. 5.3.3 Rupture Disc 5.4 Auxiliary Components: 5.4.1 Square Root Extractor 5.4.2 Seismic Damper 5.5. SMART devices 5.5.1 Features of SMART Actuators 5.5.2 Features of SMART valve 5.5.3 Features of Digital valve

***Note**: The UOs 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.*

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	Control Valves	16	6	8	10	24
II	Pneumatic Components	4	2	2	4	8
III	Introduction to Gears	6	4	4	2	10
IV	Electrical control components	8	4	4	6	14
V	Safety and Auxiliary Components	8	2	6	6	14
Total		**42**	**18**	**24**	**28**	**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 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 vary slightly 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 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) Industrial visit should be arranged by department for students so that students can have exposure to the real industrial realm.

b) Department should arrange a workshop/seminar where students can have interaction with industry personnel.

c) Download videos of different industries from various youtube channels like how it's made, how stuff works and show in class and discuss instrumentation used in that industry.

d) Dismantle the control valve in order to recognize its internal parts.

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.

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.

12. 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 a dated work diary consisting of individual contributions 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 a micro-project by the end of the semester to develop the industry oriented COs.

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) Prepare Robotic Car using DPDT Switch

b) Develop object detection system using appropriate sensor

c) Develop home automation system using control components

d) Demonstrate speed control system using different control components

e) Demonstrate system for the detection of the metallic and nonmetallic objects using control components

f) Trigger pump using electromechanical relay

g) Chart / Model Preparation of Various Control Components.

h) Prepare Presentation of Various Control Components.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN

1	Control System Components	Gibson & Tutor	McGraw-Hill Inc. ISBN-13 1258649036-978 :
2	Control System Components	M.D.Desai	PHI India, ISBN-978-81-203-3605-6
3	Servomechanism Practice	Ahrendt & Savant	McGraw-Hill Inc. ISBN-130070006874-978 :
4	Control System Components	B. Chatterjee	Khanna publishers
5	Applied Instrumentation in Process Industries	W. G Andrews	Gulf Publishing co., Houston
6	Valve selection handbook	R W Zappe	Gulf Publishing Co., Houston
7	ISA handbook of control valves	James W Hutchison	ISA

14. SOFTWARE/LEARNING WEBSITES

1. www.instrumentationtools.com
2. www.automationforum.com

15. PO-COMPETENCY-CO MAPPING

Semester III	**CONTROL COMPONENTS (Course Code: 4331702)**						
	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, Test and Calibrate Various Control Components***						
CO1- Demonstrate function of Control Valve and its Accessories.	2	2	-	3	-	1	3

CO2 - Operate Pneumatic Components.	2	-	-	1	-	-	2
C03 - Differentiate Gears based on their Application	2	-	-	-	-	-	1
CO4- Demonstrate the function and Application of Electrical Control Components	2	-	-	1	1	1	1
CO 5 Demonstrate the working of switches, Safety and Auxiliary components.	2	2	1	2	3	1	2

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

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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