GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Instrumentation & Control Engineering / Automation and Robotics Engineering

Course / Subject Code: DI03000191

Course/Subject Name: Control Components

w. e. f. Academic Year:	2024-25
Semester:	3rd
Category of the Course:	PCC

Prerequisite:	Basic knowledge of electrical circuits and instrumentation fundamentals. Familiarity with process measurement techniques and industrial instrumentation is recommended.
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 understand the construction, working and applications of various control components. Therefore, this course has been designed to maintain control components of the instrumentation loop.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
CO-1	Demonstrate function of Control Valve and its Accessories.	R U A
CO-2	Test and select pneumatic components.	R U A
CO-3	Differentiate Gears based on their Application.	R U A
CO-4	Demonstrate the function and Application of Electrical Control Components.	R U A
CO-5	Demonstrate the working of Switches and Safety components.	R U A

**Revised Bloom's Taxonomy (RBT)*

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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(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Control Valve**	17	35
	1.1. **Control valve terminology:** Definition of Range ability, Hysteresis, Capacity and Linearity. 1.2. **Control Valve Parts:** Define Control Valve parts: Body, Trim, Stem, Plug, Seat and Bonnet. 1.3. **Classification of Control Valve:** 1.3.1 Based on construction: Globe valve, Ball valve, Butterfly valve, Needle valve, Pinch valve, Diaphragm valve, Solenoid valve. (Construction, working and Application) 1.3.2 Based on plug movement- Linear/Rotary. 1.3.3 Based on type of operation -Manually operated/ Remote operated. 1.3.4 Based on actuation signal- ATO/ATC. 1.3.5 Based on Failure of the Signal: Fail to Open, Fail to close **1.4 Signal Converter: Construction and working with diagram** 1.4.1 I to P converter 1.4.2 P to I converter **1.5 Actuator-Function, Classification Construction and working:**		

	Electric, Pneumatic, Hydraulic. **1.6. Positioner- Function, Classification and working:** Pneumatic, Electro pneumatic, **1.7. Flow characteristics of control valve:** Types, Definition and Application: Linear, Equal percentage and Quick opening. **1.8.Maintenance of Control valve:** Calibration procedure of Control Valve		
2	**Pneumatic Components**	05	11
	2.1 **Pneumatic Components:** Construction, working and application 2.1.1 Flapper Nozzle, Air Filter Regulator lubricator, Volume Booster 2.1.2 Pneumatic Relay types: Bleed/ Non-bleed, Direct / Reverse.		
3	**Introduction to Gears**	07	14
	3.1 Gears Terminology: Definition of Tooth, Pitch, Contact Ratio, Whole depth, Clearance, Addendum, Dedendum, Pitch of a Gear. **3.2 Gear Need, types working and application:** Spur Gear, Rack and Pinion, Helical Gear, Herringbone Gear, Bevel Gear and Worm Gear. **3.3 Relationship between speed, torque and number of teeth of two different connected gears.** **3.4 Backlash in Gears:** Phenomena and Solution.		
4	**Electrical Control Components**	08	20
	4.1 Synchro: Construction, working, application(As an error detector) **4.2Servo Motor: Classification, Construction, working and application:** 4.2.1 AC Servo Motor 4.2.2 DC Servo Motor 4.3 **Stepper Motor: Classification, Construction, working and application:** 4.3.1 Permanent Magnet 4.3.2 Variable reluctance 4.3.3 Hybrid		

5	**Safety Components**	08	20
	5.1 Relays: Classification, Construction, working and application: 5.1.1 Electromechanical Relay 5.1.2 Reed Relay 5.1.3 Solid State relay **5.2 Switches: Classification, Construction, working and application:** 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: Types, working and application** 5.3.1 Alarm Annunciator 5.3.2 Safety Valve, Relief, Valve, Safety Relief Valve. 5.3.3 Rupture Disc **5.4 SMART Devices: Features** 5.4.1 Control Valve Actuator 5.4.2 Control Valve Positioners. 5.4.3 Digital Control Valve		
	Total	**45**	**100 %**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
26	**34**	**40**	**-**	**-**	**-**

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:

Sr.	Title of Book	Author Name	Publication/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.,
7	ISA handbook of control valves	James W Hutchison	ISA

(b) Open-source software and website:

Educational Websites

Website	Description	Link
Emerson Process Management	Information on digital control valves and positioners.	https://www.emerson.com
Flowserve	Control valve specifications, operation, and selection guides.	https://www.flowserve.com
Pneumatics online	Tutorials, guides, and selection of pneumatic components.	https://www.pneumaticsonline.com
SMC Pneumatics	Pneumatic component catalogues, working principles.	https://www.smcusa.com
All About Circuits	Tutorials on motors, relays, and control systems.	https://www.allaboutcircuits.com
Instrumentation Tools	Information on smart actuators, control valves, and safety systems.	https://instrumentationtools.com

AutomationForum.co	Covers process control, automation, and PLC programming, electrical engineering, and control valves.	https://automationforum.co
NPTEL Virtual Lab – Process Control & Instrumentation	Interactive simulations for control valves, actuators, I/P converters, and process control loops.	https://vlab.co.in/broad-area-mechanical-engineering

Suggested Course Practical List:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	CO	Approx. hours required.
1	Identify basic parts of the control valve.	1	1	2
2	Distinguish different types of globe valves as per their construction.	1	1	2
3	Examine Hysteresis in a given control valve.	1	1	2
4	Investigate linearity of given control valve.	1	1	2
5	Detect dead zone of given control valves.	1	1	2
6	Analyze the flow characteristics of linear type control valve	1	1	2
7	Analyze the flow characteristics of equal percentage type control valve.	1	1	2
8	Analyze the flow characteristics of Quick opening type control valve.	1	1	2
9	Inspect the response of the diaphragm type pneumatic actuator.	1	1	2
10	Demonstrate the working of the positioner in a given control valve.	1	1	2
11	Test I to P converter and Plot the graph of mA versus PSIg.	1	1	2
12	Test P to I converter and Plot the graph of PSIg versus mA.	1	1	2
13	Plot the graph of Displacement v/s Back Pressure for a given Flapper nozzle system.	2	2	2
14	Test the air lock relay.	2	2	2
15	Check and observe the output reading of the air filter regulator.	2	2	2
16	Classify different Gears based on their Operation: Spur, Helical and Bevel Gears.	3	3	2

17	Calculate the relationship between speed ratio and teeth ratio of two different gears connected for motion transfer.	3	3	2
18	Control the step of stepper motor by varying the input pulse.	4	4	2
19	Connect synchro as an Error Detector.	4	4	2
20	Examine the working of AC Servomotor.	4	4	2
21	Examine the working of DC servo motor.	4	4	2
22	Test SPST and SPDT Switch	5	5	2
23	Test DPST and DPDT Switch	5	5	2
24	Test inductive and capacitive proximity switch	5	5	2
25	Test the function of optical proximity switch	5	5	2
26	Demonstrate safety valve.	5	5	2
27	Test the given electromechanical relay by energizing its coil.	5	5	2
28	Test the given reed relay by energizing its coil.	5	5	2
29	Test the given solid state relay (SSR) by energizing its coil.	5	5	2
30	Test the operation of DIP switch	5	5	2
Minimum 10 to 12 Practical to be performed.		**(Total 30 Hours.)**		

List of Laboratory / Learning Resources Required:

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.
2. Cut section of control valve- globe type with diaphragm actuator
3. I to P converter Trainer kit.
4. P to I converter Trainer kit.
5. Flapper nozzle trainer kit.
6. Gears demonstration kit (Which includes different types of Gears).
7. Synchro Trainer kit.
8. AC/DC Servomotor Trainer kit.
9. Stepper Motor Trainer kit.
10. Proximity sensor Trainer kit.

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 micro-projects:

1. Make a transparent working model of a control valve showing internal parts like body, plug, stem, seat, and bonnet using acrylic or 3D-printed parts.
2. Create a pneumatic actuator-operated valve setup controlled by a manual hand lever and pressure regulator.
3. Build a cut-section model of I to P and P to I converters with labeled parts and working flow diagram using lights/pressure gauges to simulate signals.
4. Construct a demo rig showing linear, equal percentage, and quick-opening valve characteristics.
5. Assemble a working model of a Flapper-Nozzle system using simple components (ruler as flapper, air pump, balloon or pressure gauge).
6. Build a gearbox demo model that shows different types of gears (spur, bevel, helical, worm) with labeled shafts and gear meshing.
7. Design a synchro and servo motor demo setup to visually demonstrate angular error using pointer indicators.
8. Prepare a mechanical relay and switch demo board with actual devices mounted and connected to bulbs for testing operation.
9. Create a safety valve, relief valve, and rupture disc demo unit using pressure cooker, balloons, and simple release mechanisms to show overpressure release.

Suggested Activities for Students:

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.

1. Industry Visits and Guest Lectures
2. Virtual Labs & Interactive Simulations
3. Workshops
4. Group Discussions & Problem-Solving Sessions
5. Mini Projects (Hands-on Prototyping)
6. Online Courses & Certifications

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