Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Fourth**

Course Title : **Chemical Process Instrumentation and Control**

Course Code : **22407**

1. RATIONALE

Diploma chemical engineer have to perform monitoring and control of process in the chemical process industry. They have to deal with the instruments related to various process variables like temperature, pressure, level and flow. Diploma chemical engineer also deal with the control actions and implementation of control systems. They have to handle various instruments and control of various chemical engineering processes. This course is developed in the way by which the chemical process control can be performed and related instruments can be handled in safe and efficient manner.

2. COMPETENCY

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

- **Apply relevant process control parameter in chemical plants.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency.

a. Select the instrument for various chemical processes.
b. Use temperature measuring instruments in chemical industry.
c. Use pressure measuring instruments in chemical industry.
d. Measure the flow and level using various measuring instruments in chemical industry.
e. Select control system for various control action in chemical industry.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	2	2	8	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for 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 assessment 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, ESE - End Semester Examination; PA - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

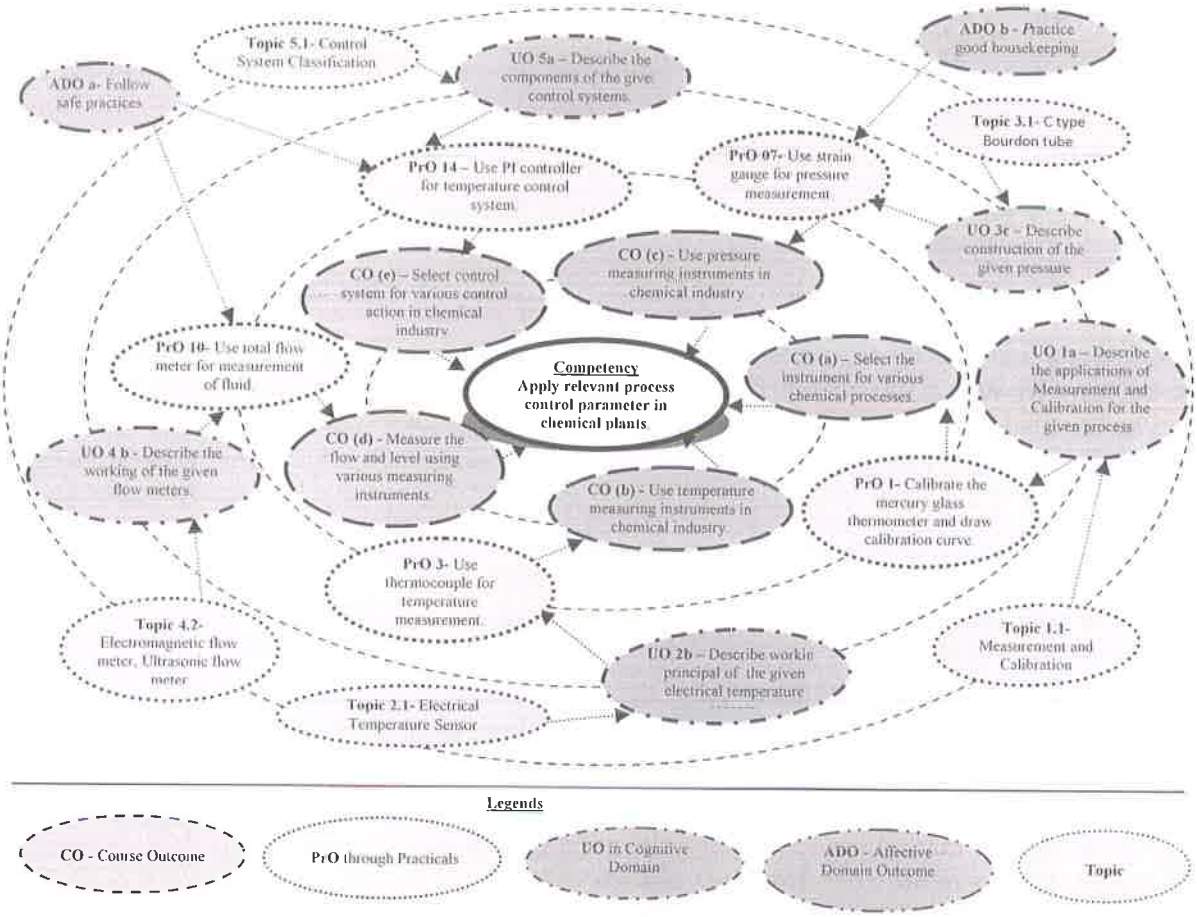

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Calibrate the mercury glass thermometer and draw calibration curve.	I	02
2.	Measure temperature using Resistance temperature detector.	II	02
3.	Use thermocouple for temperature measurement.	II	02
4.	Use pyrometer for high temperature measurement.	II	02
5.	Calibrate pressure gauge by using dead weight tester.	III	02
6.	Measure pressure by using Linear Variable Differential Transducer (LVDT).	III	02
7.	Use strain gauge for pressure measurement.	III	02
8.	Use McLeod gauge for measurement of low pressure.	III	02
9.	Measure the flow of fluid using electromagnetic flow meter.	IV	02
10.	Use turbine flow meter for measurement of fluid.	IV	02
11.	Use air purge method for level measurement of liquid in tank.	IV	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
12.	Use Capacitance probe method for level measurement of liquid in tank.	IV	02
13.	Use ON-OFF controller for temperature control system.	V	02
14.	Use PI controller for temperature control system.	V	02
15.	Use PID controller for temperature control system.	V	02
16.	Determine % flow and % valve opening of control valve and draw characteristics of control valve.	V	02
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment
f. Follow ethical practices

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Mercury in glass thermometer 0 °c to 200°c.	1
2	RTD Standard PT-100 RTD, Digital Voltmeter and ammeter, heater with regulator.	2
3	Thermocouple K type, Cr-Al thermocouple, heater with regulator, Digital temperature indicator.	2
4	Pyrometer (Infrared).	4
5	Dead weight tester, 0 to 40kg/cm^2 predetermined dead weight	5
6	LVDT, Bellows type pressure transducer, inlet pressure 2Kg/cm^2 maximum.	6
7	Strain gauge industrial grade pressure transducer , maximum pressure 10 Kg/cm^2	7
8	Mc Leod gauge	8
9	Electromagnatic flowmeter, size 1", fluid: water, complete assembly	9
10	Rotating vane meter, size 1", fluid: water, complete assembly	10
11	Air purge system, Pipe size 1", fluid: water and air supply	11
12	Capacitance probe with parallel plate assembly	12
13	ON-OFF controller kit, Supply voltage 1.6V to 5.5V max, operating temperature 0 to 100°C,I/O response - high	13
14	PID Controller kit for measuring P, PI, PD, and PID	14,15
15	Pneumatic actuated diaphragm control valve, valve size 1", air to open, seat and plug, SS, complete assembly	16

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Measurement and	1a. Describe the applications of Measurement and Calibration for the given process. 1b. Describe with sketches the direct and indirect method of measurement for the given process. 1c. Describe with sketches the the use of functional elements of the given system. 1d. Explain the causes of dead zone for the given instrument. 1e. Interpret the dynamic characteristic of the given	1.1 Measurement and Calibration: Definition and application 1.2 Measurement methods – Direct and Indirect method 1.3 Functional elements - Primary, secondary, manipulating element , data transferring element 1.4 Static characteristics – definition of Accuracy, Precision, Repeatability, Drift, Sensitivity, Dead zone, causes of dead zone and Static error 1.5 Dynamic characteristics – Speed of Response, Time lag, Dynamic Error

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	instrument.	
Unit-II Temperature Measurement	2a. Explain with sketches the working of the given type of thermometer 2b. Explain with sketches the working principle of the given type of electrical temperature sensors. 2c. Describe with sketches the construction of the given type of pyrometer. 2d. Explain with sketches the working of the given type of pyrometer	2.1 Expansion thermometer : Principle, construction and application, spiral bimetallic thermometer, mercury in glass thermometer 2.2 Electrical Temperature Sensor: principle, construction and application, resistance temperature detector, thermocouple and themister 2.3 Pyrometer: Principle , construction and application, optical and radiation pyrometer
Unit– III Pressure Measurement	3a. Describe with sketches the construction of the given type of pressure gauge. 3b. Explain with sketches the use of dead weight tester for calibration of the given pressure gauges. 3c. Describe with sketches the function of the given type of electrical Pressure Transducer. 3d. Explain with sketches the use of the given type of low pressure measurement.	3.1 C type Bourdon tube, bellows and metallic diaphragm gauge : principle, construction and application 3.2 Force balance pressure gauge – principle, construction and application, dead weight tester 3.3 Electrical Pressure Transducer – principle, construction and application, LVDT and Strain gauge 3.4 Vacuum Measurement – principle, construction and application, McLeod gauge
Unit– IV Flow Viscosity and Level Measurement	4a. Classify flow measurement instruments on the basis of the given characteristics. 4b. Explain with sketches the working of the given flow meters. 4c. Describe with sketches the construction of the given flow measuring devices. 4d. Explain with sketches the use of direct/indirect method for level measurement of the given liquid. 4e. Explain with sketches the	4.1 Variable area flow meter (Piston type): principle, application 4.2 Electromagnetic flow meter, Ultrasonic flow meter turbine flow meter: principle, construction and application, 4.3 Positive displacement flow meter: Principle, Construction and application, Rotating vane meter 4.4 Thermal Mass Flow meter: principle, construction and application, Heat Transfer type 4.5 Direct method for level measurement : principle, construction and application of High Pressure sight glass level indicator 4.6 Indirect method for level measurement :

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Ultrasonic and Radioactive methods for the given liquid and solid level measurement	principle, construction and application of hydrostatic level measurement (pressure gauge, differential pressure and air purge) 4.7 Ultrasonic, Radioactive and Capacitance probe type level measurement : principle, construction and application,
Unit –V Process Control System and Control Valve	5a. Describe with sketches the function of the components of the given control systems. 5b. Draw the block diagram of the given control system. 5c. Interpret the control action for the given process. 5d. Describe the characteristics of the given valve. 5e. Identify the valve on the basis of the given sizing parameter with justification.	5.1 Control System Classification – open loop and closed loop 5.2 Servo and regulatory process, comparison 5.3 Automatic control system: block diagram 5.4 Control action – ON-OFF, P, PI, PID (only Pneumatic controller) 5.5 Cascade and Ratio controller: Working 5.6 Distributed Control System and Programmable Logic Controller – principle and block diagram 5.7 Types of control valve – air to open, air to close, Valve characteristics –linear, equal%, quick opening, Valve actuators 5.8 Valve sizing – Range ability and turndown, pressure drop across valve, cavitation 5.9 Valve selection – load variations, pressure drop across valve, system non-linearities 5.10 Solenoid valve – Principle, Construction, working and industrial applications

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.

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	Concept of Measurement	04	04	02	00	06
II	Temperature Measurement	08	02	04	06	12
III	Pressure Measurement	08	02	04	06	12
IV	Flow and Level Measurement	12	02	06	08	16
V	Process Control System and Control Valve	16	04	06	14	24
Total		**48**	**14**	**22**	**34**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual*

distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from 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. Prepare journals based on practical performed in laboratory.
b. Follow the safety precautions.
c. Use various instruments to measure variables.
d. Library / Internet survey of instruments used for various parameters
e. Prepare power point presentation or animation for understanding different control action and systems

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/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the LOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Use Flash/Animations to explain various instruments for measurement
f. Guide student(s) in undertaking micro-projects

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 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 oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **Prepare report**: Prepare report on different temperature measuring instruments used by different industries.

b. **Prepare model**: Prepare working model of control valve.
c. **Prepare charts**: Prepare charts displaying pressure measurement instruments with industrial applications.
d. **Prepare List:** Prepare the list of different flow meters with specific use in process industry.
e. **Prepare the report**: Collect information regarding different level measuring instruments used in industry and prepare report of the same.
f. **Visit of chemical process plant**: Visit nearby industry to observe operation of DCS/PLC control system and prepare the report.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Chemical Process Control: An Introduction to Theory and Practice	Stephanopoulos, George.	Pearson Education India; New Delhi, 2015, ISBN-13: 978-9332549463
2	Process System Analysis and Control	Coughanowr, Donald R. ; LeBlanc, Steven E.	McGraw Hill International, New York, 2009, ISBN-13: 978-0073397894
3	Industrial Instrumentation and Control	Singh, S. K.	McGraw Hill, New Delhi, 2010 ISBN-13 : 978-0070678200
4	Fundamental of Industrial Instrumentation	Barua, Alok	Wiley India Pvt. Ltd. New Delhi, 2011, ISBN-13 : 978-8126528820
5	Industrial Control and Instrumentation	Bolton, W.	Longman, New York, 1991 ISBN-13 : 978-0582068025
6	Instrumentation	Kirk, Franklyn W.; Weedon, Thomas A.; Kirk, Phillip	American Technical Pub; Orland Park, 2010, ISBN: 978-0826934307

14. SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/103103037/1
b. https://ocw.mit.edu/courses/chemical-engineering/10-450-process-dynamics-operations-and-control-spring-2006/lecture-notes/
c. http://textofvideo.nptel.iitm.ac.in/103105064/lec1.pdf
d. http://www.engmatl.com/home/finish/21-manufacturing/186-fundamentals-of-industrial-instrumentation-and-process-control
e. http://www.learnerstv.com/Free-Engineering-Video-lectures-ltv689-Page1.htm
f. http://www.freeengineeringbooks.com/chemical-books-download/Process-dynamics-and-control-Lecture-Notes.php
g. http://www.slideshare.net/CHINTTANPUBLICATIONS/process-dynamics-and-control-53793238
h. http://home.iitk.ac.in/~amandg/Babatunde_A._Ogunnaike,_W._Harmon_Ray_Process_Dynamics,_Modeling,_and_Control___1994.pdf