Programme Name/s : **Chemical Engineering**
Programme Code : **CH**
Semester : **Third**
Course Title : **PROCESS INSTRUMENTATION & CONTROL**
Course Code : **313338**

I. RATIONALE

Monitoring and control of the process are an important activity needs to perform by the Diploma Chemical Engineer. This course gives the knowledge of various instruments used to measure various process parameters. With the knowledge of this course, the Diploma Chemical Engineer will be able to handle various instruments and control the process parameter as per the desired value for the optimization of the process.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following identified industry relevant outcome through various teaching learning experiences:
• Apply appropriate control system for process variables in the chemical industry.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Identify applicable instruments for measuring process variables in the chemical industry.
- CO2 - Measure temperature using various temperature measuring instruments in the chemical industry.
- CO3 - Measure pressure using various pressure measuring instruments in the chemical industry.
- CO4 - Measure the flow and level using various flow and level measuring instruments in the chemical industry.
- CO5 - Integrate a control system with different controllers in the chemical industry.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313338	PROCESS INSTRUMENTATION & CONTROL	PIC	SEC	3	-	4	1	8	4	03	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the applications of Measurement and its aim. TLO 1.2 Differentiate between direct and indirect method of measurement. TLO 1.3 Explain functional elements of an instrument with neat sketch. TLO 1.4 Explain the causes of dead zone for the given instrument. TLO 1.5 Identify the static and dynamic characteristic of given instrument.	**Unit - I Introduction to Instrument Measurement System** 1.1 Measurement and its Aim: 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 Calibration, 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.	Lecture Using Chalkboard Video Demonstrations Presentations
2	TLO 2.1 List out temperature measuring scales used for temperature measurement. TLO 2.2 Explain the construction and working of given expansion thermometer with neat sketch. TLO 2.3 Describe the working principle of given electrical temperature sensors. TLO 2.4 Select the thermometer to measure high temperatures.	**Unit - II Temperature Measuring Instrument.** 2.1 Temperature Scales- Centigrade, Kelvin, Fahrenheit, Rankine and Reaumur. 2.2 Expansion thermometer: Principle, Construction, Working and Application of Spiral Bimetallic thermometer and Mercury in glass thermometer. 2.3 Electrical Temperature Sensor: Principle, Construction, Working and Application of Resistance Temperature Detector, Thermocouple and Thermister. 2.4 Pyrometer: Principle, Construction, Working and Application of Optical and Radiation pyrometer.	Lecture Using Chalkboard Model Demonstration Video Demonstrations Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Determine pressure in different units. TLO 3.2 Explain construction of given pressure gauge with neat sketch. TLO 3.3 Delineate the calibration process of pressure gauge by using dead weight tester. TLO 3.4 Describe the function of given electrical pressure transducer. TLO 3.5 Select pressure measuring instrument for low pressure measurement.	**Unit - III Pressure Measuring Instrument.** 3.1 Units of Pressure & Methods for Pressure Measurement. 3.2 C-type Bourdon tube and Bellows: Principle, Construction and Application. 3.3 Force balance pressure gauge – Principle, Construction, Workings and Application of Dead Weight Tester. 3.4 Electrical Pressure Transducer – Principle, Construction, Workings and Application of LVDT and Strain gauge. 3.5 Vacuum Measurement – Principle, Construction, Workings and Application of McLeod gauge.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations
4	TLO 4.1 Identify instrument to measure the flow rate of viscous fluid. TLO 4.2 Describe with sketches the working of the given flow meters. TLO 4.3 Explain construction of the given flow meters with neat sketch. TLO 4.4 Identify the instrument that will measure fluid flow based on temperature differences. TLO 4.5 Differentiate direct and indirect level measurement methods.. TLO 4.6 Explain indirect type level measurement system with neat sketch. TLO 4.7 Select method for non-contact type level measurement.	**Unit - IV Flow and Level Measuring Instrument.** 4.1 Piston type flow meter: Principle, Construction, Working and Application. 4.2 Electromagnetic flow meter, Ultrasonic flow meter, Turbine flow meter: Principle, Construction, Working and Application. 4.3 Positive displacement flow meter: Rotating vane meter- Principle, Construction, Working and Application. 4.4 Thermal mass flow meter: Heat transfer type- Principle, Construction, Working and Application. 4.5 Direct method for level measurement: Principle, Construction, Working and Application of High-pressure Sight glass level indicator. 4.6 Indirect method for level measurement: Principle, Construction, Working 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, Working and Application.	Lecture Using Chalk-Board Video Demonstrations Presentations Case Study

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Differentiate between SISO and MIMO. TLO 5.2 Draw the block diagram of the given control system. TLO 5.3 Identify controllers on the basis of control action. TLO 5.4 Differentiate cascade and ratio controllers. TLO 5.5 Explain the block diagram of PLC and DCS. TLO 5.6 Explain the architecture of SCADA. TLO 5.7 Differentiate between IoT and SCADA. TLO 5.8 Justify the control valve for the given system with its characteristics. TLO 5.9 Explain need of valve actuator and valve positioner in given control valve.	**Unit - V Automated Control System** 5.1 Types of system- single input system and multi-input system. 5.2 Control system classification- open loop and closed loop. 5.3 Control action- ON-OFF, P, PI, PID (Only Pneumatic Controller) 5.4 Cascade and Ratio controller- Diagram and Working. 5.5 Distributed control system and Programmable logic controller-principle and block diagram 5.6 SCADA- Definition, Architecture and application in chemical industry. 5.7 IoT-Definition, Characteristics of IoT, Features and Application of IoT 5.8 Types of control valve-air to open, air to close, Valve characteristics-linear, equal %, quick opening. 5.9 Valve actuator and valve positioner- Function in Control Valve.	Lecture Using Chalk-Board Video Demonstrations Presentations Site/Industry Visit

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Apply calibration process to the temperature measuring instrument.	1	*Calibrate mercury glass thermometer.	4	CO1 CO2
LLO 2.1 Measure temperature by using different thermometers.	2	*Measure temperature using Resistance Temperature Detector or Thermistor or Thermocouple	4	CO2
LLO 3.1 Use pyrometer for measurement of high temperature.	3	Measure high temperature by using Pyrometer.	4	CO2
LLO 4.1 Apply calibration process to the pressure measuring instrument.	4	*Calibrate pressure gauge by using dead weight tester.	4	CO3
LLO 5.1 Use LVDT for pressure measurement.	5	Measure pressure by using Linear Variable Differential Transducer (LVDT).	4	CO3
LLO 6.1 Use strain gauge for pressure measurement.	6	*Measure pressure by using strain gauge.	4	CO3
LLO 7.1 Utilize Mc Leod gauge for Vacuum measurement.	7	Measure low pressure by using Mc Leod gauge.	4	CO3
LLO 8.1 Apply electromagnetic flow meter for conductive fluid flow measurement.	8	*Measure the flow rate of fluid using Electromagnetic flow meter.	4	CO4
LLO 9.1 Use turbine flow meter for fluid flow measurement.	9	Measure the flow rate of fluid by using Turbine flow meter.	4	CO4
LLO 10.1 Use air purge method for the measurement of liquid level.	10	*Measure the level of liquid by using Bubbler Method	4	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 11.1 Use capacitance probe method for the measurement of liquid level.	11	Measure the level of liquid by using capacitance probe method.	4	CO4
LLO 12.1 Control the given process variable by using ON-OFF Controller.	12	*Use ON-OFF Controller to measure given process variable.	4	CO2 CO3 CO4 CO5
LLO 13.1 Control the given process variable by using PD Controller.	13	Use PD controller to measure given process variable.	4	CO2 CO3 CO4 CO5
LLO 14.1 Control the given process variable by using PI Controller	14	*Use PI Controller to measure given process variable.	4	CO2 CO3 CO4 CO5
LLO 15.1 Control the given process variable by using PID Controller.	15	Use PID Controller to measure given process variable.	4	CO2 CO3 CO4 CO5
LLO 16.1 Operate control valve to regulate the given process.	16	Calculate % flow and % valve opening of control valve and draw characteristics of control valve.	4	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Prepare calibration report of C-Type Bourdon tube pressure gauge/ Diaphragm pressure gauge/ Bellows pressure gauge.
- Collect data and prepare a report on the type of level measuring instruments used in the process industry.
- Prepare model of level measuring system by using waste material.
- Prepare model of control valve by using waste material.
- Collect data and prepare report of flow meters with specific use in refinery industry.
- Prepare report on different types of temperature measuring instruments used in chemical industry.

Self-Learning Activities

- Visit to nearby petrol pump and write a report on the measurement and control method used in Petrol Pump.
- Create a presentation that is based on the parameters needed for valve selection.
- Prepare list of different types of Thermometers, Pressure and Flow meters with their measurement ranges.
- Visit the different departments of the institute and compose a report about the available measuring instruments and their measuring parameters.
- Identify the control system employed in home appliances and categorize it according to the loop system and prepare a report on it.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Mercury in glass thermometer 0 ^{o}C to 200 ^{o}C.	1,2
2	RTD Standard PT-100 RTD, Digital Voltmeter and ammeter, heater with regulator.	1,2
3	Thermocouple K type, Cr-Al thermocouple, heater with regulator, Digital temperature indicator	1,2
4	Thermistor-NTC disc type, Temperature range- -25^{o}C to 80^{o}C. Digital Voltmeter and ammeter, heater with regulator	1,2
5	Air purge system, Pipe size 1", fluid: water and air supply.	10
6	Capacitance probe with parallel plate assembly.	11
7	ON-OFF controller kit, Supply voltage 1.6V to 5.5V max, operating temperature 0 ^{o}C to 100 ^{o}C, I/O response - high	12
8	PID Controller kit for measuring P, PI, PD, and PID	13,14,15
9	Pneumatic actuated diaphragm control valve, valve size 1", air to open, seat and plug, SS, complete assembly.	16
10	Pyrometer- RA-Red pyrometer 20 ^{o}C to 450^{o}C with special resource of 6-14 micrometer 2) Heating source-wooden box fitted with filament lamp rated 200 V, 200 W 3) Mercury in glass thermometer 0 ^{o}C to 50 ^{o}C.	3
11	Dead weight tester, 0 to 40 kg/cm2 predetermined dead weight.	4
12	LVDT, Bellows type pressure transducer, inlet pressure 2Kg/cm^{2} maximum.	5
13	Strain gauge industrial grade pressure transducer, maximum pressure 10 Kg/cm^{2}	6
14	Mc Leod gauge- Pressure range-12 Bar, Material-Glass, Measuring Parameter-Vacuum, Vacuum range-0.01 mmHg.	7
15	Electromagnetic flowmeter, size 1", fluid: water, complete assembly.	8
16	Turbine flow meter, size 1", fluid: water, complete assembly.	9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Instrument Measurement System	CO1	4	2	4	0	6
2	II	Temperature Measuring Instrument.	CO2	8	2	4	8	14
3	III	Pressure Measuring Instrument.	CO3	8	2	4	6	12

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
4	IV	Flow and Level Measuring Instrument.	CO4	10	4	4	8	16
5	V	Automated Control System	CO5	15	4	8	10	22
Grand Total				**45**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Each practical will be assessed considering: 60 % weightage to process, 40 % weightage to product.
- Two Class Test of 30 Marks

Summative Assessment (Assessment of Learning)

- End of Term Theory Examination
- End of Term Practical Examination

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	-	-	1	-	-	3			
CO2	3	2	1	2	2	1	3			
CO3	3	2	1	2	2	1	3			
CO4	3	2	1	2	2	1	3			
CO5	3	3	2	3	3	1	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	W. M. Morgan	Chemical Process Control: An Introduction to Theory and Practice	CBS Publishers & Distributors Pvt. Ltd, 2000 ISBN: 9788123904306
2	H. F. Payne	Industrial Instrumentation and Control	John Wiley & Sons Inc (1961) ISBN: 9780471673538
3	V.C. Malshe and Meenal Sikchi	Fundamental of Industrial Instrumentation	Antar Prakash Centre for Yoga, 2004 ISBN: 9788190329859
4	Dr. Swaraj Paul	Industrial Control and Instrumentation	John Wiley and Sons Ltd.2014 ISBN:9788126552559
5	S. K. Singh	Industrial Instrumentation & Control	ISBN: 9780070678200

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://nptel.ac.in/courses/103103037	Cascade and Ratio Controller
2	https://archive.nptel.ac.in/courses/103/105/103105064/	Pressure Measurement
3	https://archive.nptel.ac.in/courses/103/105/103105064/	Pneumatic Control System
4	https://archive.nptel.ac.in/courses/103/105/103105130/	General Principles and Representation of Instruments
5	https://archive.nptel.ac.in/courses/103/105/103105130/	Performance Characteristics of Instruments
6	https://archive.nptel.ac.in/courses/103/105/103105130/	Transducer Element
7	https://archive.nptel.ac.in/courses/103/105/103105130/	High Vacuum Measurement
8	https://archive.nptel.ac.in/courses/103/105/103105130/	Temperature Measurement
9	https://archive.nptel.ac.in/courses/103/105/103105130/	Flow Measurement
10	https://archive.nptel.ac.in/courses/103/105/103105130/	Level Measurement
11	https://archive.nptel.ac.in/courses/103/105/103105130/	Pneumatic Control Valve

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students