Government Polytechnic, Mumbai

(Academically Autonomous Institute, Government of Maharashtra)

Programme : Diploma in Instrumentation Engineering (Sandwich Pattern)

Learning and Assessment Scheme (P-23) **With Effect From Academic Year : 2023-24**

Duration of Programme : 6 Semester **Duration : 16 WEEKS**

Semester : Fourth **Scheme : P-23**

Sr. No.	Course Code	Course Title	Course Type	Total IKS Hrs. For Sem.	Learning Scheme					Credits	Assessment Scheme														
					Actual Contact Hrs./Week			Self-Learning (Term Work + Assignments) Hrs./Week	Notional Learning Hrs./Week		Paper Duration (Hrs.)	Theory					Based on LL & TL						Based On Self-Learning		Total Marks
																	Practical								
												FA-TH		SA-TH	Total		FA-PR		SA-PR				SLA		
												T1	T2	Max	Max	Min	Max	Min	Max		Min				
					CL	TL	LL	SLH	NLH			Max	Max						PR	OR			Max	Min	
1	IS23107	Process Control System	DSC	--	3	--	2	1	6	3	2:30	20	20	60	100	40	25	10	25#	-	10		25	10	175
2	IS23108	Unit Operation and Instrumentation	DSC	--	3	--	2	1	6	3	2:30	20	20	60	100	40	25	10	--	25#	10		25	10	175
3	IS23502	Embedded System Microcontrollers	AEC	--	3	--	4	1	8	4	2:30	20	20	60	100	40	25	10	25#	---	10		25	10	175
4	IS23201	Elective-I	Power Plant Instrumentation	DSE	--	3	--	2	1	6	3	2:30	20	20	60	100	40	25	10	--	--	--		25	10	150
	IS23202		Building Automation	DSE																					
	IS23203		Robotics and Automation	DSE																					
5	IS23109	Instrumentation Circuits Design	DSC	--	3	–	2	1	6	3	--	--	--	--	--	--	50	20	50#	--	20		25	10	125
6	IS23606	Industrial Data Communication	SEC	--	2	--	2	--	4	2	--	--	--	--	--	--	25	10	--	25@	10		--	--	50
7	IS23503	Basic Python Programing	AEC	--	--	–	2	2	4	2	--	--	--	--	--	--	25	10	--	–	--		25	10	50
				0	**17**	**–**	**16**	**7**	**40**	**20**	**10**	**80**	**80**	**240**	**400**	**160**	**200**	**80**	**100**	**50**	**60**		**150**	**60**	**900**

Abbreviations: CL-Classroom Learning, TL-Tutorial Learning, LL- Laboratory Learning, 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 addition of two-20 marks class tests 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+TL+LL+SL) hours X 16 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. *Self-learning hours shall not be reflected in the Time Table.

Course Category: Discipline Specific Core Course (DSC): 3, Discipline Specific Elective (DSE):0, Value Education Course (VEC):0, Intern. /Apprentice. /Project /Community (INP):0, Ability Enhancement Course (AEC): 1, Skill Enhancement Course (SEC): 1, Interdisciplinary Elective (IDE): 3

Department Coordinator, Curriculum Development, Dept. of Instrumentation Engineering

Head of Department, Dept. of Instrumentation Engineering

In-Charge Curriculum Development Cell

Principal, Government Polytechnic Mumbai

Programme: Diploma in Instrumentation Engineering (E &C) (Sandwich Pattern)													
Course Code: IS23107					**Course Title: Process Control System**								
Compulsory/ Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2.30 Hrs.)**	**FA-PR**	**SA-**		**SLA**	**Total**
										PR	**OR**		
03	--	02	01	06	03	20	20	60	25	25#	--	25	175

Total IKS Hrs. for course: -- Hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA-Formative Assessment, SA-Summative assessment, SLA-Self Learning Assessment

Legends: @InternalAssessment, #ExternalAssessment, *#On Line Examination, @$Internal Online Examination

Note:

1. FA-PR represents tutorial/practical term work of 25Marks.
2. SA-OR represents end term oral examination of 25Marks.
3. SLA represents self-learning Assessment of 25Marks.

I. Rationale

Process control in continuous production processes is a combination of control engineering and chemical engineering disciplines that uses industrial control systems to achieve a production level of consistency, economy and safety which could not be achieved purely by human manual control. It is implemented widely in industries such as oil refining, pulp and paper manufacturing, chemical processing and power generating plants. Process control technology allows manufacturers to keep their operations running within specified limits and to set more precise limits to maximize profitability, ensure quality and prioritize safety.

II. Industry/Employer Expected Outcome

The aim of this course is to help the student to achieve the following industry identified outcome through various learning experiences: "Understand and apply appropriate control scheme for the given industrial application".

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Identify different elements and variables for the given control system
CO2	Use different control modes to control the given process
CO3	Apply given control system in industrial application
CO4	Prepare project document for given process/project
CO5	Understand hazardous area classification and intrinsic safety in industry

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's)aligned to CO's	Topics/ Sub-topics
1	**TLO1.1** Define Process **TLO1.2** Describe the process control system **TLO1.3** Explain elements of process control system **TLO1.4** Describe the process control terminology **TLO1.5** Explanations Block Diagram and working of feedback control system **TLO1.6** List applications of feedback system	**Unit-I Introduction to Basic Process Control System:** 1.1 **Process-**Definition, types-continuous and batch, and their examples. 1.2 **Process Control System–**Definition, it's importance in process industries, Elements of Process Control System-Sensor/Transducer/ Transmitter, Controller, Final Control Element and other instruments that support a process control loop – Recorders, Indicators, Alarms, and Interlocks. 1.3 **Process Control Terminology-** Controlled variable/ Measured Variable, Set-point, Deviation, Manipulated Variable, Disturbance/Load Variables 1.4 **Familiarization of Basic Process Control System-** Feedback control system concepts its Advantages, limitations, and practical applications.
Course Outcome:CO1	**Teaching Hours:06**	**Marks:08**
2	**TLO2.1** Identify different modes of feedback controller **TLO2.2** Describe different modes of feedback controller. **TLO2.3** Compare different types of PID controller. **TLO2.4** Explain PID controller tuning **TLO2.5** Describe different methods of PID controller tuning	**Unit –II Modes of PID/Feedback Controllers and Tuning:** 2.1 **Modes of feedback controller –**ON-OFF, Proportional(P), Integral(I), Derivative, Proportional- Integral (PI), Proportional-Derivative (PD), three term controllers (PID). Control mode selection criteria for different processes. 2.2 **Types of PID controller-**Electronic and pneumatic type PID controllers and their comparison. 2.3 **PID controller tuning-**Definition, tuning criteria. 2.4 **PID controller tuning methods-**Ziegler Nichols open loop response and closed loop response methods.
Course Outcome: CO2	**Teaching Hours:07**	**Marks:11**
3	**TLO3.1** Understand the given advance control system **TLO3.2** Describe its operation **TLO3.3** List its advantages & disadvantages **TLO3.4** Illustrate industrial application for given control system **TLO3.5** Compare different control systems	**Unit-III Advanced Process Control Systems** 3.1 **Cascade control systems:** Block diagram, working, application, advantages, limitation 3.2 **Feed-forward control systems:** Block diagram, working, application, advantages, limitation 3.3 **Ratio control systems**-Types: Multiplier and Divider, Block diagram, working, application, advantages, Limitation 3.4 **Split-range control systems:** Block diagram, working, application, advantages, limitation

		3.5 **Override control systems:** Block diagram, working, application, advantages, Limitation
Course Outcome:CO3	**Teaching Hours:08**	**Marks:09**
4	**TLO4.1** Identify different ISA symbols. **TLO4.2** Understand Instrument identification system. **TLO4.3** Draw process control loop using ISA symbols. **TLO4.4** Describe project and activities at different phases of project **TLO4.5** Explain role of instrumentation engineers in project. **TLO4.6** Describe different project document **TLO4.7** Interpret project document **TLO4.8** Explain loop checking &Commissioning	**Unit-IV Project and Documentation** 4.1 **Symbol & Legend P&ID's:** General Notes & Index, Standard Symbols & Nomenclature Outline of Identification & Instrumentation Symbols - Instrument line, symbols, General instrument function symbols, Control valve body symbols, Primary element symbols. Motor Control Signal, Seal Plan Instrumentation 4.2 **Instrument identification:** Tag numbering, Front panel symbol, Auxiliary symbol, Field instrument symbols 4.3 **Process control loops using ISA symbols–** Temperature, Flow, Level, Pressure 4.4 **Project-**Types of Projects, typical life cycle of project, Role of process control/ instrumentation engineer in setting up a process control-based project. 4.5 **Front end and detailed engineering design documents-**Instrumentation Design Basis, Instrument index, I/O List, Instrument Data sheet, Loop diagrams, Instrument specification sheets, Hookup Drawing, Bill of materials. Cable scheduling, Cable trays. Process Flow Diagram (PFD), Piping and Instrumentation Diagrams (P&IDs), Equipment List, 4.6 **Loop checking & Commissioning**-Pre startup safety review (PSSR), Loop checking and commissioning –Logic Check, Control valve Checking, Safety Valve Checking.
Course Outcome:CO4	**Teaching Hours :18**	**Marks:25**
5	**TLO5.1** Define hazardous area. **TLO5.2** Explain hazardous area classification as per different standards. **TLO5.3** Describe ingress protection. **TLO5.4** Explain different protection methods against explosion. **TLO5.5** Describe Intrinsic safety **TLO5.6** Explain concept of ESD	**Unit-V Safety in Process Control Systems** 5.1 **Hazardous area classification**: Hazardous Area &Material classification as per NEC/IEC Standards. Introduction to Fire& Gas Detectors 5.2 **Enclosures:** Ingress protection IP classification, NEMA types 5.3 **Protection techniques used to reduce explosion hazards**: Explosion proof, oil immersion, purging, Flameproof 5.4 **Intrinsic Safety:** Definition, Intrinsically Safe (IS) barrier systems. 5.5 **DCS &Emergency shutdown (ESD)**–concept only
Course Outcome:CO5	**Teaching Hours :05**	**Marks:25**

V. Laboratory Learning Outcome and Aligned Practical/ Tutorial Experiences.

Sr No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment/Practical Titles / Tutorial Titles	Number of hrs.	Relevant Cos
1	**LLO1.1** Identify the process variables **LLO1.2** Explain the process variables	Identify the process variables- CV(PV), MV, SP, DVs for given process.	2	CO1
2	**LLO2.1** Understand operation of ON-OFF controller. **LLO2.2** Configure controller to operate in ON-OFF mode **LLO2.3** Understand its advantages & Limitation.	Implement the on-off controller for controlling given process	2	CO2
3	**LLO3.1** Understand feedback control system. **LLO3.2** Configure feedback controller **LLO3.3** Understand its advantages & Limitations.	Implement the feedback control system for given process	2	CO3
4	**LLO4.1** Understand ISA symbol. **LLO4.2** Draw ISA symbol for the lab instrument/equipment.	Draw ISA/ P&ID symbols for given field instruments/control room instruments.	2	CO4
5	**LLO5.1** Understand hazard, Hazardous area. **LLO5.2** Suggest appropriate protection technique	Identify hazardous area in process control laboratory and suggest protection method	2	CO5
6	**LLO6.1** Understand operation of P-Mode of controller **LLO6.2** Configure controller to operate in P-mode **LLO6.3** Understand advantages & limitations of P-mode.	Implement the P- controller for controlling given process	2	CO2
7	**LLO7.1** Understand operation of P-Mode of controller **LLO7.2** Configure controller to operate in PI mode **LLO7.3** Understand advantages & Limitations of P mode.	Implement the PI- controller for controlling given process	2	CO2
8	**LLO8.1** Understand operation of PID mode of controller **LLO8.2** Configure controller to operate in PID mode **LLO8.3** Understand advantages & Limitations of PID mode	Implement the PID-controller for controlling given process	2	CO2
9	**LLO9.1** Understand Cascade control system **LLO9.2** Configure Cascade controller **LLO9.3** Understand its advantages & limitation	Implement the cascade control system for given process to	2	CO3

10	**LLO10.1** Understand Ratio control system. **LLO10.2** Configure ratio controller **LLO10.3** Understand its advantages & limitations.	Implement the ratio control system for controlling given process	2	CO3
11	**LLO11.1** Understand PFD & PID documents. **LLO11.2** Draw PFD & PID sheet for the given application.	Develop Process Flow Diagram (PFD) and it's subsequent Piping & Instrumentation Diagram (P &ID) for given laboratory/ industrial application.	2	CO4
12	**LLO12.1** Understand instrument index sheet. **LLO12.2** Prepare instrument index sheet for given PID	Develop Piping & Instrumentation Diagram (P &ID) and prepare instrument index for given laboratory/ industrial process control application.	2	CO4
13	**LLO13.1** Understand loop diagram. **LLO13.2** Prepare loop diagram for given application.	Develop loop diagram for given process control loop/system.	2	CO4
14	**LLO14.1** Understand specification sheet **LLO14.2** Prepare specification sheet for given instrument.	Develop specification sheet for given process equipment.	2	CO4
15	**LLO15.1** Understand hook up diagram & Bill of material. **LLO15.2** Draw hookup diagram and prepare bill of material for given instrument.	Develop installation hookup of DP transmitter for liquid level measurement	2	CO4

Note: Minimum 12 experiments should be performed in a term for completion of TW (All Cos should be covered compulsorily).

VI. Suggested Micro Project/ Assignment/ Activities for Specific Learning/ Skills Development (Self Learning): (Minimum 05 Assignments)

1. Prepare a model of ratio control loop.
2. Develop feedback control loop for temperature control.
3. Build intrinsically safe Zener barrier circuit for the given application in hazardous area.
4. Visit nearby process industries, classify them in appropriate hazardous classes and prepare a report.
5. Sketch the typical ISA symbols with scale on half imperial size drawing sheet.

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Introduction to basic process control system	2	6	0	08
2	Modes of PID/Feedback controllers and tuning	2	3	6	11
3	Advanced process control systems	2	3	4	09
4	Project and Documentation	4	9	12	25
5	Safety in process control systems	2	3	2	07
Total		**12**	**24**	**24**	**60**

VIII. Assessment Methodologies/Tools

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (25 Marks)
- Rubrics for continuous assessment of self-learning assignments/ micro project/ activities based on process and product related performance indicators. (25 Marks)

Summative Assessment (Assessment of Learning)

- Rubrics for assessment based on laboratory process and product related performance indicators. (25 Marks)
- End of the term theory examination. (60 Marks)

IX. Suggested COs–POs Matrix Form

Course Out-comes(COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1 Basic and Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Develop-ment of Solutions	PO-4 Engi-neering Tools, Experime-ntation	PO-5 Engineering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Manage-ment	PO-7 Life Long Learn-ing	PSO -1	PSO -2
CO1	--	2	2	--	--	--	3	1	1
CO2	1	--	3	3	--	--	3	3	1
CO3	--	2	3	3	--	--	3	3	2
CO4	--	--	--	3	--	3	3	3	1
CO5	--	1	--	2	3	--	3	3	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

X. Suggested Learning Materials/ Books:

Sr. No	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Chemical process control: An introduction to theory and practice	Stephanopoulos, G. Prentice-Hall, New Delhi. PTR (1984)	978-0131286290
2	Process control & Instrumentation Technology	C. D. Johnson, Published by Wiley	978-0471057895
3	Instrument Engineers Handbook Vol.-II Process Control	Bela G. Liptak., Published by Chilton, Philadelphia (1969)	978-0801955198
4	Applied Instrumentation Vol 1-4	Andrew, William G., Published by DA Information Services (1982)	978-0872013841

XI. Learning Websites & Portals

Sr. No	Link/ Portal	Description
1	https://www.omega.co.uk/prodinfo/pid-controllers.html	--
2	http://instrumentationportal.com/	--
3	http://scholar.vimaru.edu.vn/sites/default/files/diemphd/files/isa_5-1_2009_0.pdf	--
4	https://www.academia.edu/29216379/P_and_ID_SYMBOLS_P_and_ID_SYMBOLS_ISA_Symbols_and_Loop_Diagrams	--
5	http://www.lesman.com/train/webinars/Webinar-Slides-Control-101.pdf	--

XII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr. Pravin Nalawade.	Associate Chief Engineer (Instrumentation & Control)	Technip Energies Mumbai
2	Mr. Saurabh Kharjule	Lecturer in Instrumentation Engg.	Government Polytechnic Ratnagiri
3	Mr. S.G. Thube	Selection grade Lecturer Instrumentation Engg..	Government Polytechnic, Mumbai
4	Mr. U.B. Shinde	Senior Lecturer Instrumentation Engg...	Government Polytechnic, Mumbai

Coordinator,
Curriculum Development,
Department of Instrumentation Engg.

Head of Department
Department of Instrumentation Engg.

Incharge,
Curriculum Development Cell
Government Polytechnic, Mumbai

Principal
Government Polytechnic, Mumbai

Programme: Diploma in Instrumentation Engineering (E&C) (Sandwich Pattern)													
Course Code: IS23108					**Course Title: Unit Operations and Instrumentation**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2:30 Hrs.)**	**FA-PR**	**SA-**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	--	2	1	6	3	20	20	60	25	--	25#	25	175

Abbreviations: CL-Class Room Learning, TL-Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA-Formative Assessment, SA-Summative assessment, SLA-Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment,*# Online Examination, @$ Internal Online Examination

Note:

1. FA-TH represents addition of two class tests 20 marks each conducted during the term.
2. FA-PR represents tutorial/practical term work of 25 Marks.
3. SLA represents self-learning Assessment of 25 Marks.
4. SA-TH represents the end term theory examination of 60 Marks.
5. SA-OR represents the end term Oral examination of 25 Marks

I. Rationale:

Instrumentation diploma holders are expected to work in process industries such as petrochemical, power, chemical and fertilizer industries. Fundamental knowledge of different unit operations used in the process industries is essential. This course is introduced with the view that the students will be familiar with various processes and process equipment and instrumentation required for the unit operations.

II. Industry / Employer Expected Outcome:

The aim of this course is to encourage students to achieve knowledge, skills to work in process industries an identification of various unit operations.

1. Understand various operations & processes in industry.
2. Identify various equipment in process industry.

III. Course Outcome: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Identify various unit operations and processes in industries
CO2	Demonstrate operation of Boiler and Heat Exchanger equipment and its instrumentation and control
CO3	Explain the operation of Distillation equipment and its control schemes
CO4	Describe Evaporation and Drying equipment and associated instrumentation
CO5	Explain Crystallization equipment and associated controls

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics / Sub-topics
1	**TLO1.1** Define unit operation & unit process. **TLO1.2** Explain Batch & Continuous process. **TLO1.3** Describe Endothermic & Exothermic reaction. **TLO1.4** Explain Reversible & Irreversible process. **TLO1.5** Explain application of the various units in process industries with process flow diagram.	**Unit-I Introduction to Unit Operations** 1.1 Definition of unit operation and unit process. 1.2 Endothermic and Exothermic reaction. 1.3 Batch process & continuous process. 1.4 Reversible and Irreversible process. 1.5 Applications of the various units in process industries like: Thermal power plant, Oil refinery, Steel industry (process flow diagram and operation)
Course Outcome: CO1	**Teaching Hours: 06 hrs.**	**Marks: 10**
2	**TLO2.1** Explain basic concept and flow sheet symbol of heat exchanger and boilers. **TLO2.2** List types of heat exchanger equipment. **TLO2.3** Explain shell & tube heat exchanger. **TLO2.4** Enlist types of boilers. **TLO2.5** Explain water tube boiler. **TLO2.6** Explain different boiler control methods. **TLO2.7** List types of drum level control. **TLO2.8** Explain different drum level control methods.	**Unit-II Heat Exchangers and Boilers** 2.1 Basic concept & flow sheet symbol. 2.2 Types of heat exchange equipment. 2.3 Shell and tube heat exchanger: diagram, construction, operation, controls (Feedback,cascade, feed forward control). 2.4 Basic concept of boiler, flow sheet symbol & types: Water tube boiler Vs. Fire tube boiler. 2.5 Water tube & Fire tube boiler: diagram, construction and operation. 2.6 Boiler controls: safety interlocks, Steam Temperature control and Burner Management System (BMS). 2.7 Drum level control: swelling and shrinking phenomenon, single element control, two element control, and three element control
Course Outcome: CO2	**Teaching Hours: 14 hrs.**	**Marks: 16**
3	**TLO3.1** Define basic concept of distillation process. **TLO3.2** Enlist methods of distillation. **TLO3.3** Explain flash distillation **TLO3.4** Explain fractionating column distillation. **TLO3.5** Explain different controls for distillation. **TLO3.6** State applications of distillation. **TLO3.7** Describe process instrumentation data sheet & specifications.	**Unit-III Distillation** 3.1 Definition, basic concept of distillation process, flow sheet symbol 3.2 Methods of distillation – flash distillation, fractionating column distillation (Equipment setup, diagram & operation) 3.3 Different controls for distillation: Overload control & Bottom product control. 3.4 Applications.
Course Outcome: CO3	**Teaching Hours: 07 hrs.**	**Marks: 12**

4	**TLO4.1** Define evaporation process. **TLO4.2** Explain single & multiple effect evaporators. **TLO4.3** Enlist types of evaporators. **TLO4.4** Explain different types of evaporators. **TLO4.5** Explain methods of increasing economy & vapor recompression. **TLO4.6** Describe different controls for evaporation unit. **TLO4.7** Explain factors on which rate of drying depends. **TLO4.8** Explain different types of dryers. **TLO4.9** Explain methods of dryer control.	**Unit-IV Evaporation and Drying** 4.1 Definition, evaporation process, Capacity and economy of evaporator, flow sheet 4.2 Single & multiple effect evaporators: diagram & operation 4.3 Evaporator types: Natural vs. Forced circulation evaporators, Climbing film evaporator,Agitated film evaporator (diagrams and operation & application) 4.4 Methods of increasing economy, Vapor recompression operation. 4.5 Different controls for evaporation unit. 4.6 Introduction of Dryers. 4.7 Factors on which rate of drying depends. 4.8 Types of dryers: Tray dryer, rotary dryer, drum dryers: diagram, operation & advantages & disadvantages, application.
Course Outcome: CO4	**Teaching Hours: 12 hrs.**	**Marks: 14**
5	**TLO5.1** Define crystallization. **TLO5.2** Describe the concept Magma, crystallization process and importance of crystal size. **TLO5.3** Enlist types of crystallizer. **TLO5.4** Explain different types of crystallizer. **TLO5.5** Explain controls of crystallizer.	**Unit-V Crystallization** 5.1 Definition. 5.2 Magma, crystallization process, importance of crystal size 5.3 Crystallizer types: 5.3.1 Continuous crystallizer 5.3.2 Draft Tube Baffle (DTB) crystallizer (Diagram, operations, advantages & disadvantages, application.)
Course Outcome: CO5	**Teaching Hours: 06 hrs.**	**Marks: 08**

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Practical / Tutorial / Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of Hrs.	Relevant COs
1	**LLO1.1** Identify the ISA symbols of various units and process equipment.	Draw ISA symbols of various units and process equipment.	02	CO1
2	**LLO2.1** Prepare a drawing sheet for different types Heat Exchanger.	Different types Heat Exchanger.	02	CO2
3	**LLO3.1** Differentiate Fire tube & Water tube Boilers with help of diagram.	Fire tube & Water tube Boilers.	02	CO2
4	**LLO4.1** Prepare as well labelled diagram of Flash & Fractionating Distillation column setup.	Flash & Fractionating Distillation column setup.	02	CO3
5	**LLO5.1** Prepare a drawing sheet for Single effect & Multiple effect	Single effect & Multiple effect Evaporators.	02	CO4

	Evaporators.			
6	**LLO6.1** Identify different types of crystallization.	Sketch continuous crystallizer & Draft tube baffle (DTB) crystallizer.	02	CO5
7	**LLO7.1** Interpret process flow diagram of Thermal power plant.	Prepare a drawing sheet showing Process flow diagram of Thermal power plant.	02	CO2
8	**LLO8.1** Interpret the control schemes for a heat exchanger: Feedback control, Cascade control, and Feedforward control.	Prepare a drawing sheet showing Feedback, Cascade & Feedforward Heat Exchanger control scheme.	02	CO2
9	**LLO9.1** Interpret different boiler control scheme.	Prepare a drawing sheet for Single element, Two element & Three element Boiler control scheme.	02	CO2
10	**LLO10.1** Interpret different distillation column control	Prepare a drawing sheet for Overhead & Bottom product control scheme in Distillation column	02	CO3
11	**LLO11.1** Identify the different components of burner management system	Draw a well labelled Burner Management System (BMS).	02	CO2
12	**LLO12.1** Interpret Feedback, Cascade & Feedforward control scheme for Evaporator.	Prepare a drawing sheet showing Feedback, Cascade & Feedforward control scheme for Evaporator.	02	CO4
13	**LLO13.1** Interpret process flow diagram of oil refinery.	Prepare a drawing sheet showing process flow diagram of oil refinery.	02	CO1
14	**LLO14.1** Interpret process flow diagram of steel industry	Prepare a drawing sheet showing Process flow diagram of steel industry	02	CO1
15	**LLO15.1** Identify the different types of dryers.	Sketch Tray, Rotary & Drum dryer.	02	CO4

Note: Minimum 12 experiments are compulsory and should be chosen such that all COs will be covered, also Industry expert lecture and Industrial Visit should arrange.

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self-Learning):

Micro Project:

1. Prepare model of different types of boilers.
2. Prepare model of control scheme for boiler.
3. Prepare model of different types of heat exchangers.
4. Prepare model of different of Dryers.
5. Prepare model of Distillation column.

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Introduction to Unit Operations	2	4	4	10

2	Heat Exchangers and Boilers	4	6	6	16
3	Distillation	2	4	6	12
4	Evaporation and Drying	2	6	6	14
5	Crystallization	2	4	2	08
	Total Marks	**12**	**24**	**24**	**60**

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (25 Marks)
- Rubrics for continuous assessment of self-learning assignments/ micro project/ activities based on process and product related performance indicators. (25 Marks)

Summative Assessment (Assessment of Learning)

- Rubrics for assessment based on laboratory process and product related performance indicators. (25 Marks)
- End of the term theory examination. (60 Marks)

IX. Suggested COs - POs Matrix Form

Course Out-comes (COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1 Basic and Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools, Experimentation	PO-5 Engineering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Management	PO-7 Life Long Learn-ing	PSO - 1	PSO - 2
CO1	1	1	1	1	--	1	2	1	--
CO2	2	3	3	1	--	1	2	2	--
CO3	2	3	3	1	--	1	2	2	--
CO4	1	3	3	1	--	1	2	2	--
CO5	1	3	3	1	--	1	2	2	--
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

X. Suggested Learning Materials / Books:

Sr. No.	Title	Author, Publication, Edition and Year of Publication	ISBN NO.
1	Outline of chemicalTechnology	Gopala Rao & Sittiney, East West Press, 3rd edition, 1997	978-8185938790

2	Unit operations of chemical Engineering	MCcabe & Smith, McGraw Hill, 7th edition,2004	978-0072848236
3	Elementary Principles ofchemical processes	Bullard, Lisa G. Rousseau, Ronald W.Felder, Richard M. John Willey and Sons Publ.,4th edition, 2015	978-1118431221
4	Chemical Engineer'sHandbook	Green, Don, Perry, Robert, McGraw Hill publication ,8th edition,2007	978-0071422949
5	Unit operations -Vol 1& 2	K. A. Gawane, Nirali Prakashan, 2nd edition, 2014	978-8196396114 978-8196396121
6	Applied InstrumentationVol 1-4	W.G Andrew, H.B Williams, GulfPublishers, 3rd edition,1993	978-0872010475
7	Instrument Engineers Handbook Vol. –II Process Control	Bela G. Liptak.Taylor and Fransis pub ISA,4th edition,2013	978-0750622547

XI. Learning website and Portal:

Sr. No.	Link / Portal	Description
1	https://nptel.ac.in/courses/112/105/112105248/	Unit operation related nptel courses
2	https://nptel.ac.in/courses/112/107/112107216/	Unit operation related nptel courses
3	https://nptel.ac.in/courses/103/103/103103035/	Unit operation related nptel courses

XII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organization
1	Mr. Sandeepkumar Yadav	Assistance Manager	Assistant Manager Mahanagar Gas Pvt. Ltd.
2	Mr. J. K. Pohnerkar	Lecturer in Chemical Engg.	Govt. Polytechnic, Jalna
3	Mr. U. B. Shinde	Lecturer in Instrumentation	Govt. Polytechnic, Mumbai
4	Mr. M. K. Kulkarni	Lecturer in Instrumentation	Govt. Polytechnic, Mumbai

Coordinator,
Curriculum Development,
Department of Instrumentation Engg.

Head of Department
Department of Instrumentation Engg.

Incharge,
Curriculum Development Cell
Government Polytechnic, Mumbai

Principal
Government Polytechnic, Mumbai

Programme: Diploma in Instrumentation Engineering (E&C) (Sandwich Pattern)													
Course Code: IS23502					**Course Title: Embedded System Microcontrollers**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2:30 Hrs.)**	**FA-PR**	**SA-**		**SLA**	**Total**
										PR	**OR**		
3	--	4	1	8	4	20	20	60	25	25#	--	25	175

Total IKS Hrs. for course: -- Hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# Online Examination, @$ Internal Online Examination

Note:

1. FA-TH represents addition of two 20 marks class tests conducted during the term.
2. FA-PR represents tutorial/practical term work of 25 Marks.
3. SLA represents self-learning Assessment of 25 Marks.
4. SA-TH represents the end term theory examination of 60 Marks.
5. SA-PR represents the end term Practical examination of 25 Marks

I. Rationale:

Microcontroller is the key device in automation. It is being used in domestic, commercial, industrial and consumer goods from low end to high end applications. Microcontroller enhancing the pace of technology. Diploma engineers shall deal with various Microcontroller based systems and its maintenance. This course intends to develop skills to build and maintain the Microcontroller based systems.

II. Industry / Employer Expected Outcome:

The aim of this course is to help the student to achieve the following industry identified outcome through various learning experiences:

"Develop and maintain the microcontroller-based applications."

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Comprehend the meaning of embedded system
CO2	Interpret the functions of different internal parts of microcontroller 8051
CO3	Interpret the basic functions of Arduino Uno
CO4	Interpret the basic use of memories and peripherals
CO5	Construct basic applications using input/output devices

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics / Sub-topics
1	**TLO1.1** Differentiate between microprocessor and microcontroller-based systems **TLO1.2** Differentiate between different embedded architectures **TLO1.3** Classify of embedded system **TLO1.4** Define embedded system characteristics **TLO1.5** Differentiate between different derivatives of 8051 **TLO1.6** List applications of embedded systems	**Unit-I Basics of Embedded System** 1.1 Embedded System definition, block diagram. 1.2 Microprocessor & microcontroller-based system, block diagrams. 1.3 Embedded system architectures: Von Neumann/ Harvard. RISC/CISC, DSP. 1.4 Classification of embedded systems. 1.5 Characteristics of embedded system. 1.6 Specifications of 8051 microcontroller. 1.7 Derivatives of microcontroller 8051 [from manufacturers Intel, Atmel, Microchip]. 1.8 Applications of embedded system.
Course Outcome: CO1	**Teaching Hours: 08hrs**	**Marks: 10**
2	**TLO2.1** Explain architecture of 8051 **TLO2.2** Explain pin function of 8051 **TLO2.3** Explain memory organization of 8051 **TLO2.4** Describe the function of SFRs and their bits **TLO2.5** Explain modes of timer modes and serial modes **TLO2.6** Describe software development tools	**Unit-II 8051 Architecture** 2.1 Architecture of 8051 microcontroller. 2.2 Pin diagram of 8051 microcontroller and function of each pin. 2.3 Boolean processor. 2.4 Input/ output ports, circuits & their alternate functions. 2.5 Internal memory organization [RAM & ROM]. 2.6 Program counter and stack pointer. 2.7 Flag and PSW register. 2.8 Timers/ counters– block diagram of timer control, TMOD, TCON, THx, TLx registers, modes of operation. 2.9 Interrupts- block diagram of interrupt control, vector addresses, priority, IE, IP registers. 2.10 Serial data: Modes, block diagram of serial control, SBUF, SCON, PCON registers 2.11 Software development tools: editor, assembler, compiler, cross compiler, linker, locator
Course Outcome: CO2	**Teaching Hours: 10hrs**	**Marks: 14**
3	**TLO3.1** Describe the features of At-mega 328P IC and Arduino uno **TLO3.2** Differentiate between various Arduino boards **TLO3.3** Explain block and pin diagram of Arduino **TLO3.4** Explain different Arduino functions	**Unit-III AVR Microcontroller** 3.1 Features of At-mega 328P and Arduino Uno board. 3.2 Arduino open-source community. 3.3 Arduino boards and their specifications. [Uno, Due, Lilypad, Robot, Esplora, Mega] 3.4 Block diagram of Arduino uno. 3.5 Function of pins on Arduino uno. 3.6 Arduino library functions 3.6.1 Data types, variables, operators

		3.6.2 I/O functions 3.6.3 PWM functions 3.6.4 Random functions 3.6.5 Serial functions: UART, I2C, SPI
Course Outcome: CO3	**Teaching Hours: 07hrs**	**Marks: 10**
4	**TLO4.1** Explain memory management and address translation **TLO4.2** Differentiate between various memories **TLO4.3** Draw and describe memory interfacing with 8051 **TLO4.4** Explain operation of different peripheral devices	**Unit-IV System Memory and Peripherals** 4.1 Memory System Architecture 4.1.1 Cache memory, virtual memory. 4.1.2 Memory management unit. 4.1.3 Address translation. 4.2 Memory Technology 4.2.1 SRAM, DRAM. 4.2.2 ROM, EPROM, E²PROM, NVROM. 4.3 External memory interfacing with 8051. 4.4 Peripheral Devices 4.4.1 Watchdog timer. 4.4.2 DMA controller.
Course Outcome: CO4	**Teaching Hours: 08hrs**	**Marks: 10**
5	**TLO5.1** Draw and describe interfacing of I/O devices with 8051 **TLO5.2** Write c codes for interfacing I/O devices with8051 **TLO5.3** Draw and describe interfacing of sensors with Arduino uno/nano **TLO5.4** Write c codes for interfacing of sensors with Arduino	**Unit-V I/O Interfacing** 5.1 Switch, LED, 7 segment display, LCD, relay, 4x4 matrix keyboard, DC motor, stepper motor, ADC and DAC interfacing with 8051. 5.2 Simple c programs for I/O control using 8051. 5.3 HC-04 ultrasonic module, HC-05 Bluetooth module, DHT11/22 humidity/ temperature, LPG detector module, DC motor, Servo motor, stepper motor interfacing with Arduino uno. 5.4 Simple c programs for I/O control using Arduino.
Course Outcome: CO5	**Teaching Hours: 12hrs**	**Marks: 16**

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Practical / Tutorial / Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of Hrs.	Relevant COs
1	**LLO1.1** Categorize the given microcontroller based on architecture **LLO1.2** Compare architectures of embedded system	Categorize the given microcontrollers based on architectures.	02	CO1
2	**LLO2.1** Interpret keil software **LLO2.2** Compare derivatives of 8051	Keil software, different windows [edit, project, output, memory, I/O ports etc.],	02	CO2

		functions and different directives.		
3	**LLO3.1** Write 'c' program to perform arithmetic and logical operations	Arithmetic and logical operations using Keil.	02	CO2
4	**LLO4.1** Write 'c' program to rearrange numbers	Rearrange nos. in ascending/ descending order located in internal data memory.	02	CO2
5	**LLO5.1** Write 'c' program to generate different time delays	Time delays in operation [1ms to 50ms] using T0 and T1 timers.	02	CO2
6	**LLO6.1** Write 'c' program to transfer data serially	Serial data transfer over serial port using serial interrupt.	02	CO2
7	**LLO7.1** Write 'c' program to transfer data serially	Receive data of various length serially over serial port.	02	CO2
8	**LLO8.1** Identify the different blocks and pins on Arduino uno **LLO8.2** Write functions of different blocks and pins on Arduino uno	Blocks and pins of Arduino Uno	02	CO3
9	**LLO9.1** Interface GSM module with Arduino using rs232 interface **LLO9.2** Write 'c' program to transfer data serially	Interface GSM module with Arduino board using RS 232	02	CO3
10	**LLO10.1** Write 'c' program to write and read internal E²PROM	Write and read data in internal E²PROM memory using Arduino.	02	CO4
11	**LLO11.1** Write 'c' program to write and read external RAM	Write and read data in external SRAM memory using Arduino.	02	CO4
12	**LLO12.1** Construct circuit to interface LCD **LLO12.2** Write 'c' program to print message on LCD	Interface LCD to 8051 Microcontroller. Display message in scrolling or stationary mode.	02	CO5
13	**LLO13.1** Construct circuit to interface 4x4 matrix keypad **LLO13.2** Write 'c' program to print keys on LCD	Interface 4x4 matrix keypad to 8051 microcontroller. Display keys on LCD.	02	CO5
14	**LLO14.1** Construct circuit to interface ADC **LLO14.2** Write 'c' program to display values on LCD	Interface ADC to 8051 microcontroller. Display potentiometer voltage on LCD.	02	CO5
15	**LLO15.1** Construct circuit to interface DAC **LLO15.2** Write 'c' program to generate wave patterns	Construct circuit to interface DAC to 8051 microcontroller. Generate square/ triangular wave and display on DSO.	02	CO5
16	**LLO16.1** Construct circuit to interface relay **LLO16.2** Write 'c' program to control relay switching	Interface relay to 8051 microcontroller. Control AC bulb ON/OFF using relay.	02	CO5
17	**LLO17.1** Construct circuit to interface DC motor **LLO17.2** Write 'c' program to control speed of DC motor	Interface DC motor to 8051 microcontroller. Control the speed of DC motor.	02	CO5
18	**LLO18.1** Construct circuit to interface stepper motor **LLO18.2** Write 'c' program to control speed of DC motor	Interface stepper motor to 8051 microcontrollers. Control speed/ direction/ step angle of stepper motor.	02	CO5

19	**LLO19.1** Construct circuit to interface DHT11/22 **LLO19.2** Write 'c' program to read data from module	Interface Humidity/ soil moisture sensor DHT11/22 module with Arduino.	02	CO5
20	**LLO20.1** Construct circuit to interface Ultrasonic module **LLO20.2** Write 'c' program to read data from module	Implement Ultrasonic Range Finder/level controller using Arduino Board.	02	CO5
21	**LLO21.1** Construct circuit to interface Bluetooth module **LLO21.2** Write 'c' program to read data from module	Interface Bluetooth module with Arduino board and transfer data to and fro.	02	CO5
22	**LLO22.1** Construct circuit to interface DC motor **LLO22.2** Write 'c' program to control speed of motor	Interface and control DC Motor Speed using Arduino Board.	02	CO5
23	**LLO23.1** Construct circuit to interface LPG module **LLO23.2** Write 'c' program to read data from module	Implement LPG Leakage Detector using Arduino Board.	02	CO5
24	**LLO24.1** Construct circuit to interface RTC module **LLO24.2** Write 'c' program to read data from module	Interface RTC module with Arduino board using I^2C to read time/date, also store data in SRAM.	02	CO5
25	**LLO25.1** Construct circuit to interface servo motor **LLO25.2** Write 'c' program to control position of servo motor	Interface and control servo Motor position using Arduino Board.	02	CO5
26	**LLO26.1** Interface GPS module with Arduino using **LLO26.2** Write 'c' program to receive location serially	Interface GPS module with Arduino board	02	CO5
27	**LLO27.1** Interface 8266 wifi module with Arduino using **LLO27.2** Write 'c' program to send/ receive data over wifi	Interface 8266 Wi-Fi module with Arduino board	02	CO5
28	**LLO28.1** Interface load cell with Arduino using **LLO28.2** Write 'c' program to measure and display weight	Interface load cell module with Arduino board	02	CO5
29	**LLO29.1** Interface RTD/TC with Arduino using **LLO29.2** Write 'c' program to measure and display temperature	Interface RTD/ thermocouple with Arduino board	02	CO5
30	**LLO30.1** Construct circuit to interface required for application **LLO30.2** Write 'c' program to read/write/display data and control **LLO30.3** Troubleshoot the circuit	Micro project on mentioned input/output/module-based applications.	02	CO5

Note: Minimum 20 experiments are compulsory and should be chosen such that all COs will be covered.

VI. Suggested Micro Project / Activities for Specific Learning / Skills Development (Self-Learning):

Microproject: - Students should select microproject in consultation with faculty.

Following are few topics for reference, students can choose any other applications.

1. Measure distance using ultrasonic module and 8051 microcontroller. Display distance on LCD.
2. Measure LPG gas concentration using LPG module and 8051 microcontroller. Display distance on LCD.
3. Transfer messages using Bluetooth module and 8051 microcontroller. Display distance on LCD.
4. Measure temperature using DHT11/22 module and 8051 microcontroller. Display distance on LCD.
5. Measure humidity using DHT11/22 module and 8051 microcontroller. Display distance on LCD.
6. Transfer messages using GSM module and 8051 microcontroller. Display distance on LCD.
7. Measure time/date using RTC module and 8051 microcontroller. Display distance on LCD.
8. Build digital watch using RTC module and Arduino uno/nano.
9. Build water level control system using Arduino.
10. Build temperature control system using Arduino.
11. Build automatic door opening/ closing system using Arduino.

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Basics of Embedded Systems	04	04	02	10
2	8051 Architecture	04	06	04	14
3	AVR Microcontroller	02	04	04	10
4	Memory System and Peripherals	02	04	04	10
5	I/O Interfacing	02	06	08	16
	Total Marks	**14**	**24**	**22**	**60**

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (25 Marks)
- Rubrics for continuous assessment of self-learning assignments/ micro project/ activities based on process and product related performance indicators. (25 Marks)

Summative Assessment (Assessment of Learning)

- Rubrics for assessment based on laboratory process and product related performance indicators. (25 Marks)
- End of the term theory examination. (60 Marks)

IX. Suggested COs - POs Matrix Form

Course Out-comes (COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1 Basic and Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Develop-ment of Solutions	PO-4 Engi-neering Tools, Experime-ntation	PO-5 Engi-neering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Manage-ment	PO-7 Life Long Learn-ing	PSO - 1	PSO - 2
CO1	1	--	--	--	--	--	1	2	--
CO2	1	--	--	1	1	2	1	--	2
CO3	1	--	--	1	1	2	1	--	2
CO4	1	--	1	1	1	2	1	2	--
CO5	1	3	2	2	3	3	1	--	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

X. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publication, Edition and Year of Publication	ISBN NO.
1	The 8051 Microcontroller: Architecture, programming and applications	Kenneth J. Ayala, Cengage Learning, 3rd edition, 2005	978-1401861582
2	The 8051Microcontroller and Embedded System using assembly and C	Muhammad Ali Mazidi, Janice Gillispe Mazidi, Rlin D. McKinlay, Pearson/ Prentice Hall New Delhi, 2nd edition, 2008	978-8131710265
3	Microcontroller Theory and application	Ajay V. Deshmukh, McGrawHill New Delhi, 1st edition, 2011	978-0070585959
4	Microprocessors and Microcontrollers: Architecture, Programming and System Design	Krishna Kant, PHI New Delhi, kindle edition, 2016	978-8120331914
5	An Embedded Software Primer	David E. Simon, Addison-Wesley Professional, 1st edition, 1999	978-0201615692
6	Introduction to Embedded Systems	Shibu K V, McGraw Hill Education India Private Limited; 2nd edition, 2017	978-9339219680
7	Embedded Systems	B Kanta Rao, Prentice Hall (I), 1st edition, 2011	978-8120340817
8	Embedded System Design	Steve Heath, Newnes, 2nd edition, 2002	978-0750655460
9	Arduino for Beginners: Essential Skills Every Maker Needs	John Baichtal, Que Publishing, 1st edition, 2013	978-0789748836
10	Introduction to Arduino: A piece of cake!	Alan G. Smith, CreateSpace Independent Publishing Platform, 1st edition, 2011	978-1463698348

XI. Learning Websites & Portals

Sr. No.	Link / Portal	Description
1	https://nptel.ac.in/courses/108105102/ [week 5 onwards video lectures]	Microprocessor and Microcontroller systems
2	http://www.circuitstoday.com/8051-microcontroller	8051 Microcontroller Basics
3	https://www.mikroe.com/ebooks/architecture-and-programming-of-8051-mcus/introduction	8051 Microcontroller Architecture
4	https://www.intorobotics.com/8051-microcontroller-programming-tutorials-simulatorscompilers-and-programmers	Current trends in embedded and robotics
5	https://nptel.ac.in/courses/108/105/108105057/	Embedded System Lectures
6	https://www.tutorialspoint.com/embedded_systems/index.htm	Embedded System overview/ notes
7	https://www.tutorialspoint.com/arduino/index.htm	Arduino Tutorials

XII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organization
1	Mr. Mudassar Khopatkar	Chief Executive Officer	PCE consulting and engineers LLP, Chandivali, Mumbai
2	Mr. Praveen Veer	Lecturer in Electronics	SNDT Polytechnic, Santacruz, Mumbai
3	Mr. S. G. Thube	Sr. Lecturer in Instrumentation	Government Polytechnic, Mumbai
4	Mr. Firoz S. Bagwan	Lecturer in Instrumentation	Government Polytechnic, Mumbai

Coordinator,
Curriculum Development,
Department of Instrumentation Engg.

Head of Department
Department of Instrumentation Engg.

Incharge,
Curriculum Development Cell
Government Polytechnic, Mumbai

Principal
Government Polytechnic, Mumbai

Programme: Diploma in Instrumentation Engineering (E&C) (Sandwich Pattern)													
Course Code:IS23201					**Course Title: Power Plant Instrumentation**								
Compulsory/Optional: Optional													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2:30 Hrs.)**	**FA-PR**	**SA-**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	--	2	1	6	3	20	20	60	25	--	--	25	150

Total IKS Hrs. for course: -- Hrs.

Abbreviations: CL-Class Room Learning, TL-Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA-Formative Assessment, SA-Summative assessment, SLA-Self Learning Assessment

Legends: @Internal Assessment, #External Assessment, *#Online Examination, @$Internal Online Examination

Note:

1. FA-TH represents addition of two class tests 20 marks each conducted during the term.
2. FA-PR represents tutorial/practical term work of 25 Marks.
3. SLA represents self-learning Assessment of 25 Marks.
4. SA-TH represents the end term theory examination of 60 Marks.

I. Rationale:

A power plant instrumentation course teaches students about the instruments and control systems used to generate and control electricity. The course covers a range of topics, including - Power generation: The different methods of power generation, including thermal, hydro, nuclear, solar, tidal, bio-gas and wind. Instrumentation: The types of instruments used for measurement and analysis to monitor the electrical power generation process.

II. Industry/Employer Expected Outcome:

The aim of this course is to attain the following industry/ employer expected outcome through various teaching learning experiences:

"Describe the electrical power generation process with its Instrumentation and control to produce electricity effectively and efficiently".

III. Course Outcome:

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

CO1	Express the basics of thermodynamics / thermal process
CO2	Demonstrate Steam based electric power generation by various energy sources
CO3	Describe main auxiliaries of thermal power plant for e.g. boiler, turbine, Condenser and Cooling
CO4	Discuss the Nuclear Power generation, and its safety and non-conventional electric power generation
CO5	Identify an instrumentation required for steam power plants

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics/Sub-topics
1	**TLO1.1** Enlist and define various law of thermodynamics. **TLO1.2** Demonstrate the law of conservation of Energy **TLO1.3** Explain the various cycle use in electrical power generation	**Unit-I Introduction to basic thermal process** 1.1 Zeroth Law of Thermodynamics 1.1.1 Energy 1.1.2 Work 1.1.3 Specific heat 1.1.4 Perfect gas 1.2 Boyle's Law and Charles Law 1.2.1 Boyle's Law-1 and Law-2 1.2.2 General & Combined equation 1.2.3 Universal gas constant 1.2.4 Avogadro's Law 1.3 First Law of Thermodynamics 1.3.1 Internal Energy 1.3.2 Adiabatic work 1.4 Law of conservation of Energy 1.4.1 Constant Volume process 1.4.2 Constant pressure process 1.4.3 Constant temperature 1.4.4 Enthalpy 1.5 Second Law of thermodynamics 1.5.1 Heat Engine 1.6 Various Cycle: Carnot, Rankine, regenerative and reheat cycle
Course Outcome: CO1	**Teaching Hours: 08 hrs.**	**Marks: 10**
2	**TLO2.1** Define energy and power **TLO2.2** Classify and compare sources of energy **TLO2.3** Enlist and briefly write / explain the various principle of electrical power generation **TLO2.4** Describe combustion theory of coal. **TLO2.5** Draw the layout of steam power plant and requirement of it. **TLO2.6** Describe the site selection criteria of thermal power plant.	**Unit-II Basic of Electrical Power generation** 2.1 Introduction of Energy and Power 2.2 Sources of Energy: Fuels, Energy stored in water, nuclear energy, Wind power, Solar Energy, Tidal energy, Geothermal Energy, Thermoelectric power 2.3 Principal Types of Power Plant: Steam Power Plant, Internal Combustion Engine Plants, Gas Turbine Plant, Hydroelectric Plants 2.4 Combustion of Fuels: Combustion Chemistry, Coal Analysis, Measurement & control of air flow of combustion 2.5 Layout of steam Power Plants 2.6 Essential requirement of steam power plants 2.7 Selection of site of steam power plant
Course Outcome: CO2	**Teaching Hours: 12 hrs.**	**Marks: 14**
3	**TLO3.1** Describe the working principle of generator and exciter. **TLO3.2** Demonstrate the fuel and ash handling system. **TLO3.3** Enlist, define and describe boiler with its performance **TLO3.4** Enlist the turbine and condenser, its principle of working, construction & operation. **TLO3.5** Describe the cooling Ponds & tower	**Unit-III Major Auxiliaries of Thermal Power Plant and Introduction to Hydro-electric Power Plant** 3.1 Generator and Exciter 3.2 Fuel Handling, Fuel Flow measurement and Mill Control 3.3 Ash handling 3.4 Chimney draughtand Fan Control 3.5 Boiler: Furnace draft measurement & control and its performance

	TLO3.6 Value and use of water treatment **TLO3.7** Enlist the pros and cons of steam power plant **TLO3.8** Describe the working principle of Hydro-electric power plant.	3.6 Drum Level Measurement 3.7 Steam Nozzles 3.8 Turbine monitoring & control and condenser 3.9 Cooling Ponds and towers 3.10 Feed water treatments & Control 3.11 Advantages & disadvantages of steam power plants 3.12 Introduction of Hydro-electric Power Plant
Course Outcome: CO3	**Teaching Hours: 10 hrs.**	**Marks: 14**
4	**TLO4.1** Define terms and terminology of Nuclear Power generation **TLO4.2** Describe the working of Nuclear Power System **TLO4.3** Define, Enlist and describe nuclear reactors **TLO4.4** Enlist & describe the main components of Nuclear Power Plant **TLO4.5** Enlist the Site Selection and material selection criteria of Nuclear Power Plant. **TLO4.6** Compare the economics and safety measures of Nuclear Power plant with others **TLO4.7** List and describe working of non-conventional electrical power generation	**Unit-IV Nuclear Power Plant and Introduction Nonconventional Power generation** 4.1 General aspect of Nuclear Engineering 4.2 Nuclear power system 4.3 Nuclear reactors 4.4 Main components of Nuclear Power Plant 4.5 Selection of material for reactors components 4.6 Advantages of Nuclear Power Plants 4.7 Nuclear Power Plant site selection 4.8 Application & Economics of Nuclear Power plant 4.9 Safety measures of Nuclear Power plant 4.10 Introduction to nonconventional power generation such as Wind, Tidal, Solar and biogas.
Course Outcome: CO4	**Teaching Hours: 08 hrs**	**Marks: 12**
5	**TLO5.1** Value and use Instrumentation in steam power plant **TLO5.2** Demonstrate the vibration and turbo-visory instruments **TLO5.3** Demonstrate the significance of gas analyzer instruments **TLO5.4** Value and use of steam and water analysis instruments **TLO5.5** Demonstrate the significance of blown down and dosing control system **TLO5.6** Describe the analyzer to monitor and control the air pollution due to power plant	**Unit-V Special Instrumentation of Steam Power plant** 5.1 Introduction to Instrumentation in Power plant 5.2 Vibration and Turbo-visory Instruments 5.3 Gas Analyzers, Zirconium, Paramagnetic, Optical & Electrochemical 5.4 Steam and water analysis system 5.5 Sample conditioning system 5.6 Blow down and dosing control system 5.7 Analyzers for Air Pollution monitoring and control 5.8 NOx Reduction and Advance soot blower Control 5.9 Traditional Instrumentation Control system 5.10 Modern Instrumentation & Control system
Course Outcome: CO5	**Teaching Hours: 07 hrs**	**Marks: 10**

Note: Any one unit from 1 to 5 will be preferably taught by Alumni of Government Polytechnic Mumbai

V. Laboratory Learning Outcome and Aligned Practical/Tutorial Experiences.

Sr No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment/Practical Titles / Tutorial Titles	Number of Hrs.	Relevant Cos
1	**LLO1.1** Use the Rankine cycle to find the Rankine & relative efficiency by considering different pressure of steam	To find out the efficiency of Rankine Cycle	02	CO1
2	**LLO2.1** Demonstrate the function and significance of different auxiliary of	To study detailed layout of thermal power plant	02	CO2

	Coal based power plant			
3	**LLO3.1** Value and use the different formulae to find the efficiency of boiler and heat balance sheet.	To prepare heat balance sheet for a given Boiler	02	CO3
4	**LLO4.1** Demonstrate the function and significance of different auxiliary of nuclear power plant	To study detailed layout of nuclear power plant	02	CO4
5	**LLO5.1** Describe the vibration measurement of steam Turbine measurement	To Study vibration measurement of steam turbine	02	CO5
6	**LLO6.1** Value and use the different formulae to find the efficiency of Steam turbine	To find the power output and efficiency of a steam turbine.	02	CO 3
7	**LLO7.1** Draw the low-pressure boiler details schematics of coal base power plant	To study low pressure Boiler their mountings and accessories	02	CO 3
8	**LLO8.1** Distinguish two types of steam turbine based on construction	To study working of impulse and reaction Turbine.	02	CO 3
9	**LLO9.1** Demonstrate the function and significance of different auxiliary of Hydro-electric power plant	To study the detailed layout of Hydraulic power plant	02	CO 3
10	**LLO10.1** Demonstrate the function and significance of different Nuclear Reactors	To sketch the different types of nuclear reactors	02	CO 4
11	**LLO11.1** Demonstrate the function and significance of different auxiliary of Wind power plant.	To draw and study the detailed layout of Wind power plant	02	CO 4
12	**LLO12.1** Compare the different electric power generating plants.	To Prepare a comparison chart for power plants based on their types, location, and selection.	02	CO 2
13	**LLO13.1** Describe the various aspect of Electric Power generating plant.	To prepare technical report on any one power plant	02	All
14	**LLO14.1** Explain the principle of CO/CO_2 measurement in thermal power plant	TostudyCO/CO_2 measurementin thermal power station	02	CO 5
15	**LLO15.1** Value and use of oxygen measurement in thermal power station	To study oxygenmeasurement of thermal power plant.	05	CO 5

Note: Minimum 12 experiments are compulsory and should be chosen such that all COs will be covered.

VI. Suggested MicroProject/Assignment/ActivitiesforSpecificLearning/SkillsDevelopment (Self-Learning):

Micro Project:

i. Prepare model and chart of thermal process
ii. Preparation of model of thermal power Plant/boiler
iii. Preparation of Hydro-electric power plant model
iv. Preparation of wind mill model
v. Build and test Solar Power Plant circuit

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Introduction to basic thermal power plant	02	06	02	10

2	Basic of Electrical Power Generation	04	06	04	14
3	Major Auxiliaries of Thermal Power Plant and Introduction to Hydro-electric Power Plant	04	06	04	14
4	Nuclear Power Plant and Introduction to Non-conventional Power Generation	04	06	02	12
5	Special Instrumentation of Steam Power plant	02	06	02	10
	Total Marks	**16**	**30**	**14**	**60**

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (25 Marks)
- Rubrics for continuous assessment of self-learning assignments/ micro project/ activities based on process and product related performance indicators. (25 Marks)

Summative Assessment (Assessment of Learning)

- End of the term theory examination. (60 Marks)

IX. Suggested COs-Pos Matrix Form

Course Out-comes(COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1Basic and Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Develop-ment of Solutions	PO-4 Engi-neering Tools, Experim-entation	PO-5 Engineering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Manage-ment	PO-7 Life Long Learn-ing	PSO-1	PSO-2
CO1	1	1	1	1	--	--	--	--	--
CO2	2	1	2	1	--	--	--	2	2
CO3	2	1	2	--	--	--	--	2	2
CO4	2	1	1	--	--	--	--	--	--
CO5	3	2	1	--	--	--	--	3	1
Legends:- High:03,Medium:02,Low:01,NoMapping:--									

X. Suggested Learning Materials/Books

Sr. No.	Title	Author, Publication, Edition and Year of Publication	ISBN NO.
1	A text book of Power Plant Engineering	R.K. Rajput, Pearson Education, 11th edition, 2015	978-8131802557
2	Power Plant Instrumentation and Control Handbook	Swapan Basu and Ajay Kumar Debnath, Academic Press, Elsevier, Second Edition	978-0128195048

3	Power Plant Engineering	S. Domkundwar, S.C. Arora, and A.V. Domkundwar, Dhanpat Rai & Co.(P) Limited; Eighth edition (2016)	978-8177001952
4	Power Plant Engineering	P.K. Nag, McGraw Hill Education; Fourth edition (1 July 2017)	978-9339204044
5	Non-conventional energy resources	B. H. Khan, McGraw Hill Education India Private Limited; Third edition (1 July 2017)	978-9352601882

XI. Learning Websites & Portals

Sr. No.	Link/Portal	Description
1	https://archive.nptel.ac.in/courses/112/107/112107291/	This is NPTEL Video Link of IIT Roorki
2	https://onlinecourses.nptel.ac.in/noc24_me57/preview	This is NPTEL video Link of IIT Guwahatti
3	https://youtu.be/9njuNoLIADY?si=k3-ctPPaJWcLIdUz	Prof. Ravi Kumar, IIT Roorki, Lecture on PPI

XII.Academic Consultation Committee/Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organization
1	Er. Mrs. Kanchan Shiyale	Asstt Engineer (MSPGCL / Maha- Genco, Mumbai)	Maharashtra State Power Generation Company Ltd, Mumbai (M.S.)
2	Prof. Gaurav Dharme	Lecturer, Mechanical Engg.	Agnel Technical College, Bandra, Mumbai
3	Prof. K.U. Dawane	Lecturer in Instrumentation Engg	Government Polytechnic, Bandra
4	Dr. B. B. Sul	HOD, Instrumentation Engg	Government Polytechnic, Bandra

Coordinator,
Curriculum Development,
Department of Instrumentation Engg.

Head of Department
Department of Instrumentation Engg.

In-charge,
Curriculum Development Cell
Government Polytechnic, Mumbai

Principal
Government Polytechnic, Mumbai

Programme: Diploma in Instrumentation Engineering(E&C) (Sandwich Pattern)													
Course Code: IS23202					**Course Title: Building Automation**								
Compulsory / Optional: Optional													
Learning Scheme and Credits						**Assessment Scheme**							
						FA-TH		**SA-TH (2:30 Hrs.)**	**FA-PR**	**SA-**		**SLA**	**Total**
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**T1**	**T2**			**PR**	**OR**		
3	--	2	1	6	3	20	20	60	25	--	--	25	150

Total IKS Hrs. for course: -- Hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# Online Examination, @$ Internal Online Examination

Note:

1. FA-TH represents addition of two 20 marks class tests conducted during the term.
2. FA-PR represents tutorial/practical term work of 25 Marks.
3. SLA represents self-learning Assessment of 25 Marks.
4. SA-TH represents the end term theory examination of 60 Marks.

I. Rationale:

Building automation systems are essential for managing and optimizing the operation of various sub-systems in commercial, residential, and industrial buildings. There is a critical need for professionals who can ensure these systems work efficiently. This course will help the students to understand the various aspects of different automation systems involved in smart buildings.

II. Industry / Employer Expected Outcome:

The aim of this course is to help the students to attain the following industry related competency through various teaching learning experiences.

i. Demonstrate the functioning of various systems.

ii. Operate and maintain the systems involved in a building automation system.

III. Course Outcomes:

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

CO1	Identify various components of Building management system.
CO2	Explain the operation of various subsystems in BAS.
CO3	Demonstrate the operation of different types of HVAC equipment and system.

CO4	Understand DDC fundamentals of BMS.
CO5	Describe the advanced features used for effective facility control.

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics / Sub-topics
1	**TLO1.1** Understand the concept of building automation system **TLO1.2** Identify various components of building automation system **TLO1.3** Demonstrate the features of building automation system **TLO1.4** Discuss the benefits of building automation system	**Unit-I Introduction** **1.1** Concept of Building Automation. **1.2** Components and subsystems of building management system (BMS). **1.3** Features of Building management system. **1.4** Benefits of Building management system.
Course Outcome: CO1		**Teaching hours: 3 hrs.** **Marks:08**
2	**TLO2.1** List the types of fire alarm system. **TLO2.2** Draw the architecture of FAS, and explain the function of each block. **TLO2.3** Describe the working principle of sensors/detectors used in FAS. **TLO2.4** Draw the block diagram of CCTV System and explain function of each block. **TLO2.5** Differentiate between DVR and NVR systems. **TLO2.6** Draw block diagram of access control system and explain function of each block.	**Unit-II BAS Subsystems** **2.1** Fire Alarm System (FAS) -Introduction, types of fire alarm system and applications. Architecture of FAS, Working principle of FAS. Components - Fire and smoke detector sensors, Fire alarm control panel, annunciator panel, suppression systems, and Notification devices. **2.2** CCTV and Surveillance system - Overview of CCTV system and applications, Block diagram of CCTV system, Types of CCTV camera, Video management system -Digital video recorders (DVR) vs Network video recorders (NVR) **2.3** Access control systems - Overview of access control systems, features and applications. Block diagram of Access control systems, Basic components of an Access control systems.
Course Outcome: CO2		**Teaching hours: 14 hrs** **Marks:16**
3	**TLO3.1** Define various air properties **TLO3.2** Read the various air conditioning processes on psychrometric chart **TLO3.3** Classify and demonstrate the operation of various types of HVAC system	**Unit-III HVAC systems** **3.1** Air Properties: Dry bulb temperature, Wet bulb temperature, Relative humidity, Humidity ratio, Dew Point temperature, Enthalpy, Specific Volume. (definitions only) **3.2** Introduction to psychrometric chart: Construction of Psychometric chart, plotting the HVAC processes on the psychrometric chart,

	TLO3.4 Demonstrate the working of various units of HVAC system **TLO3.5** Discuss the control strategies used for HVAC control.	**3.3** Classification of HVAC system: Central air conditioning system, All Air system, All water system, Air – water system, (block diagram, working, advantages and disadvantages) **3.4** Components/ unit operations of HVAC system: Boiler, Chiller, Air-handling unit (AHU), Air terminal unit (ATU), Variable air volume equipment (VAV), HVAC Zones and Rooms (diagram and operation) **3.5** Control strategies for occupants comfort: Control methods, Zone control, temperature control, humidity control, fans volume and pressure control, pumps volume and pressure control.
Course Outcome: CO3	**Teaching hours: 14 hrs**	**Marks:16**
4	**TLO4.1** Draw and explain hierarchical configuration of controllers in BAS. **TLO4.2** Describe types of controllers and controller software used in DDC system. **TLO4.3** Describe energy management system **TLO4.4** Explain various DDC operators available in typical DDC systems.	**Unit - IV Direct digital control (DDC) Fundamentals of BMS** **4.1** Hierarchical system configuration. **4.2** Types of Controllers - Zone level controllers, system level controllers, operation level processor and management level processor. **4.3** Controller Software- operating Software, applications software, energy management software. **4.4** Typical DDC Operators: sequence, reversing, ratio, analog controlled digital output, digital controlled analog output, analog controlled analog output, Maximum input, Minimum input, Delay, Ramp.
Course Outcome: CO4	**Teaching hours: 7 hrs**	**Marks:10**
	TLO 5.1 Explain the concept of optimal control **TLO 5.2** Describe features for optimal control in FMS **TLO 5.3** State the significance of information management features available in BAS. **TLO 5.4** Describe features for information management in FMS	**Unit - V Advance Technology for effective facility Control** **5.1** Features for optimal Control: optimal START / optimal STOP (optimal run time), Load rolling, Demand limiting, Economizer switchover, Supply air reset (SAR), Condenser water reset, Chiller sequencing. **5.2** Information Management Features: Summaries, Password, Alarm Report, Time Scheduling, Trending, Totalization, Graphics.
Course Outcome: CO5	**Teaching hours: 7 hrs**	**Marks:10**

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Practical / Tutorial / Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of Hrs.	Relevant COs
1	**LLO1.1** Demonstrate the architecture of BMS	Architecture and components of BMS.	02	CO1
2	**LLO2.1** Install CCTV system	Closed-circuit television (CCTV) systems (connections of camera/DVR/NVR, installation of IP based camera.)	02	CO2
3	**LLO3.1** Troubleshoot the faults in CCTV system	Faults in the given CCTV system.	02	CO2
4	**LLO4.1** Demonstrate the operation of Fire alarm systems	Fire alarm systems.	02	CO2
5	**LLO5.1** Test the sensors and Fire/smoke detectors	Types of Fire/smoke detectors	02	CO2
6	**LLO6.1** Install a single door access control system.	Access control system: Access control deployment at a typical door.	02	CO2
7	**LLO7.1** Demonstrate the operation of HVAC system	Heating, Ventilation and Air-conditioning systems (HVAC)	02	CO2
8	**LLO8.1** Identify the type of HVAC system	Types of HVAC system	02	CO3
9	**LLO9.1** Test the Sensors used in HVAC System	Sensors used and maintenance of HVAC System	02	CO3
10	**LLO10.1** Identify the types of panels	BMS Control Panels and Alarm Monitors.	02	CO4
11	**LLO11.1** Demonstrate the operation of various DDC Operators in BMS	Typical DDC Operators in BMS.	02	CO4
12	**LLO12.1** Demonstrate the operation of energy Management system.	Energy Management system.	02	CO4
13	**LLO13.1** Test the features for optimal Control	Features for optimal Control.	02	CO5
14	**LLO14.1** Test the information management features	Information Management Features for effective facility Control.	02	CO5
15	**LLO15.1** Present the assigned topic	Preparation of power-point slides, by students, which may include videos, animations, pictures, graphics for better understanding of theory and practical work. The faculty will allocate chapters/ parts of chapters to groups of 3-4 students	02	ALL

Note: Minimum 12 experiments/assignments are compulsory and should be chosen such that all COs will be covered.

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self-

Learning):

Assignments:

i. Explain personal and equipment safety practices followed in your institutes.
ii. Prepare an instrument index sheet for sensors/instruments used in HVAC system.
iii. Prepare the specifications for boilers, chillers and humidifiers used for given industry/building.
iv. Identify various components of AHU used in the given application.
v. Visit a local mechanic shop of an AC mechanic and list out the tools he uses for AC maintenance.

Micro Project:

i. Make a survey report of top BMS providers in market.
ii. Build a circuit for fan motor (AC or DC) speed control.
iii. Build and construct model for boiler used in HVAC.
iv. Build a circuit for fire detection.
v. Build a circuit for fire and smoke alarm system.
vi. Build automatic door system for garage.
vii. Design a scheme for automatic lighting control of your institute building.
viii. Design a circuit for building safety using smoke detector.
ix. Build a RFID based access control system.

Activities:

i. Organize seminar on specific topic in the group of students and present in the class.
ii. Prepare model Charts of various subsystems in BMS.

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Introduction	2	4	2	08
2	BAS Subsystems	4	8	4	16
3	HVAC systems	4	8	4	16
4	DDC fundamentals of BMS	2	4	4	10
5	Advance Technology for effective facility Control	2	4	4	10
Total Marks		**14**	**28**	**18**	**60**

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (25 Marks)
- Rubrics for continuous assessment of self-learning assignments/ micro project/ activities based on process and product related performance indicators. (25 Marks)

Summative Assessment (Assessment of Learning)

- End of the term theory examination. (60 Marks)

IX. Suggested COs - POs Matrix Form

Course Out-comes (COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1 Basic and Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Develop-ment of Solutions	PO-4 Engi-neering Tools, Experime-ntation	Engi-neering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Manage-ment	PO-7 Life Long Learn-ing	PSO - 1	PSO - 2
CO1	2	1	1	1	2	--	3	1	1
CO2	2	3	3	3	2	2	3	2	1
CO3	2	3	3	3	2	2	3	2	1
CO4	2	3	3	3	2	1	3	2	1
CO5	2	2	2	1	2	1	3	1	1
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

X. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publication, Edition and Year of Publication	ISBN NO.
1	Smart Buildings	Jim Sinopoli, Butterworth-Heinemann imprint of Elsevier,2nd ed, 2010.	978-0978614409
2	Building Environment: HVAC Systems	AlanJ.Zajac, Johnson Controls, Inc.	978-0766821002
3	Understanding Building Automation system	Reinhold A. Carlson, Robert A.Di Giandomenico, First Edition	978-0876292112
4	Intelligent Building System	Albert Ting-pat So,Wai Lok Chan, Kluwer Academic, publisher, 3rd ed., 2012.	978-3319684611
5	Design of Special Hazards and Fire Alarm Systems	Robert Gagnon, Thomson Delmar Learning; 2nd edition, 2007	978-1418039509
6	HVAC Controls and Systems	Levenhagen, John I.Spethmann, Donald H McGraw-Hill Publication	978-0071786577
7	Process Control-Instrument Engineers Handbook	Bela G.Liptak, Chilton book co.	978-1483145020

XI. Learning Websites & Portals:

Sr. No.	Link / Portal	Description
1	https://nptel.ac.in/courses/108106022	Pdf notes
2	https://www.scribd.com/document/737283654/Automatic-Control-for-Commercial-Buildings- honeywell	Reference manual
3	https://pdfs.semanticscholar.org/presentation/11c9/9a40a4ff55687ada3b9a2a3a9f25b04b9631.pdf: HVAC	Research paper
4	https://customer.honeywell.com/resources/techlit/TechLitDocuments/77-0000s/77-E1100.pdf: HVAC, BAS basics, DDC,controllersoftwares.	Controller's information
5	https://www.nsdcindia.org/scmp/assets/image/1179656187-CCTV_Installation_TechnicianEnglish.pdf	Pdf notes
6	http://www.schneider-electric.com/b2b/en	Website
7	http://www.automation.siemens.com/	Website
8	https://nsdcindia.org/building-automation-specialist	Website

XII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organization
1	Mr. Shrikant Patil	Sr. Regional Manager	Source IT Group, Mumbai
2	Dr. P. D. Sarawade	I/C Head of department (Lecturer in Instrumentation)	Govt. Polytechnic, Karad
3	Mr. S. G. Thube	Lecturer in Instrumentation	Govt. Polytechnic, Mumbai
4	Mr. K. U. Dawane	Lecturer in Instrumentation	Govt. Polytechnic, Mumbai

Coordinator,
Curriculum Development,
Department of Instrumentation Engg.

Head of Department
Department of Instrumentation Engg.

In-charge,
Curriculum Development Cell
Government Polytechnic, Mumbai

Principal
Government Polytechnic, Mumbai

Programme: Diploma in Instrumentation Engineering (Sandwich Pattern)													
Course Code: IS23203					**Course Title: Robotics and Automation**								
Compulsory / Optional: Optional													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2:30 Hrs.)**	**FA-PR**	**SA-**		**SLA**	**Total**
										PR	**OR**		
3	--	2	1	6	3	20	20	60	25	--	--	25	150

Total IKS Hrs. for course: --Hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# Online Examination, @$ Internal Online Examination

Note:

1.FA-TH represents addition of two 20 marks class tests conducted during the term.
2.FA-PR represents tutorial/practical term work of 25 Marks.
3.SLA represents self-learning Assessment of 25 Marks.
4.SA-TH represents the end term theory examination of 60 Marks.
5.SA-PR represents the end term Practical examination of 25 Marks

I. Rationale:

Robotics and automation are at the forefront of the Fourth Industrial Revolution, driving innovation in areas such as artificial intelligence (AI), machine learning, the Internet of Things (IoT), and advanced manufacturing. Robotics and Automation are transformative fields shaping the future of process industries, healthcare, transportation, and daily life. A curriculum in this domain equips instrumentation engineering students with the theoretical knowledge, practical skills, and ethical considerations necessary to deploy intelligent systems that improve efficiency, safety, and quality of life.

II. Industry Employer Expected Outcome:

The aim of this course is to help the student to achieve the following industry identified outcome through various learning experiences:

"Develop and maintain the robotic-based applications."

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Interpret the basic terminology of robotic system
CO2	Select sensors for various robotic applications
CO3	Interpret the basic tools for vision signal processing
CO4	Develop simple programs for robot control

CO5	Maintain robotic system in various applications

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics / Sub-topics
1	**TLO1.1** Classify the robots **TLO1.2** Define robot terminologies **TLO1.3** Explain different transmission mechanisms **TLO1.4** Interpret different specifications of robot **TLO1.5** Explain need of automation	**Unit-I Basics of Robotics** 1.1 History of robots, Classification of robots, Present status and future trends. 1.2 Basic components of robotic system. 1.3 Basic terminology- Accuracy, Repeatability, Resolution, Degree of freedom, dexterity, compliance, RCC device. 1.4 Mechanisms and transmission, End effectors, Grippers- different methods of gripping, Mechanical grippers- Slider crank mechanism, Screw type, Cam type gripper, Magnetic grippers, Vacuum grippers, Air operated grippers. 1.5 Specifications of robot. 1.6 Introduction to Principles & Strategies of Automation, Types & Levels of Automations 1.7 Need of industrial applications of robot.
Course Outcome: CO1	**Teaching Hours: 07hrs**	**Marks: 10**
2	**TLO2.1** Explain robotic sensors **TLO2.2** Differentiate between different sensors **TLO2.3** Selection criterion for sensors in robotic system	**Unit-II Robotic Sensors** 2.1 Robotic Sensors: Introduction to robotic sensors 2.2 Tactile sensors- touch sensors, force sensors, force sensing wrist, joint sensors, tactile array sensors, proximity and range sensors. miscellaneous sensors. 2.3 Desirable features of sensors used in robotics. 2.4 Need for sensors and vision system in the working and control of a robot.
Course Outcome: CO2	**Teaching Hours: 07hrs**	**Marks: 10**
3	**TLO3.1** Explain vision control system **TLO3.2** Explain necessary image processing tools for robotics **TLO3.3** List applications of vision controlled robotic system	**Unit-III Signal Recognition and Processing** 3.1 Sensing and digitization function 3.1.1 Image devices 3.1.2 Lighting technics 3.1.3 Analog to digital signal conversions. (sampling, encoding and image storage) 3.2 Image processing and analysis 3.2.1 Image data reduction. 3.2.2 Segmentation. 3.2.3 Thresholding. 3.2.4 Region drawing. 3.2.5 Edge detection. 3.2.6 Feature extraction.

		3.2.7 Object detection. 3.3 Industrial application of vision controlled robotic control.
Course Outcome: CO3	**Teaching Hours: 09hrs**	**Marks: 12**
4	**TLO4.1** List different robot languages and its generation **TLO4.2** Enlist different robotic programming languages **TLO4.3** State capabilities and limitations of lead through programming **TLO4.4** Write simple programs to perform simple operation	**Unit-IV Robot Programming** 4.1 Introduction to robot languages 4.1.1 The textual robot languages. 4.1.2 Generation of robot programming languages. 4.1.3 Robot language structures 4.1.4 Constants, variables and other data objects. 4.1.5 Motion, end effector, sensor commands. 4.1.6 Communication and data processing. 4.1.7 Monitor mode commands 4.2 Robot coding introduction 4.2.1 Methods of programming. 4.2.2 Lead through programming, capabilities and limitations. 4.2.3 Path in space, motion interpolation. 4.2.4 WAIT, SIGNAL DELAY commands. 4.3 Introduction to teach pendant. 4.4 Simple program to pick and place. 4.5 Simple program to palletize the object. 4.6 Simple program for inspection. (bolt, bearing etc.)
Course Outcome: CO4	**Teaching Hours: 12hrs**	**Marks: 14**
5	**TLO5.1** Explain use of robot in material handling **TLO5.2** Explain use of robots in automated assemblies **TLO5.3** Explain procedure of robot maintenance **TLO5.4** List different safety rules in robot handling	**Unit-V Applications and Maintenance** 5.1 Material handling 5.1.1 Pick and place. 5.1.2 Palletizing. 5.2 Process operations 5.2.1 Spot welding, continuous arc welding. 5.2.2 Spray coating. 5.2.3 Die casting. 5.2.4 Plastic moulding. 5.2.5 Forging. 5.3 Automated assemblies. 5.4 Automated inspection. 5.5 Robot maintenance 5.5.1 Need and types of maintenance. 5.5.2 Common troubles and remedies. 5.5.3 Safety norms, aspects and precautions in robot handling. 5.5.4 Introduction to interlocking of robot.
Course Outcome: CO5	**Teaching Hours: 10hrs**	**Marks: 14**

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Practical / Tutorial / Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of Hrs.	Relevant COs
1	**LLO1.1** Select robot gripper for given application **LLO1.2** Demonstrate robot gripper for given application	Study and analysis of robotic gripper	02	CO1
2	**LLO2.1** Choose sensors for given part/ system in robot according to application **LLO2.2** Demonstrate sensor operation	Sensor interfacing for robot	02	CO2
3	**LLO3.1** Simulate system for given motion commands	Motion commands	02	CO2
4	**LLO4.1** Simulate system for given end effector commands	End effector command	02	CO3
5	**LLO5.1** Implement machine vision like edge, shape, location, color detection	Machine vision implementation	02	CO3
6	**LLO6.1** Develop code for vision operation **LLO6.2** Implement code to sync with robot operation	Robot operation with machine vision	02	CO3
7	**LLO7.1** Develop codes for vision operation using OpenCV source **LLO7.2** Develop codes for image processing operations	Open source computer vision programming	02	CO3
8	**LLO8.1** Simulate inspection command to test bolt and bearings	Inspection commands	02	CO3
9	**LLO9.1** Develop code for robot movement for given path	Robot movement	02	CO4
10	**LLO10.1** Develop code for palletizing given object	Palletizing the object	02	CO4
11	**LLO11.1** Develop code for robot movement for interrupted welding line path	Robot path creation	02	CO4
12	**LLO12.1** Develop code for robot movement for painting operation path	Robot path creation	04	CO4
13	**LLO13.1** Develop code for spot welding operation	Welding operation	04	CO5
14	**LLO14.1** Develop code for plastic molding operation	Plastic molding	04	CO5
15	**LLO15.1** Write standard procedure for robotic maintenance **LLO15.2** Perform basic maintenance of given robotic system	Maintenance of robot	04	CO5

Note: Minimum 12 experiments are compulsory and should be chosen such that all COs will be covered.

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self-Learning):

Microprojects:-

1. Visit robotic industry in nearby vicinity and prepare detailed report on operation and maintenance practices.
2. Develop robot program for performing various industrial operations.
3. Design a simulated robotic work cell.
4. Develop a low cost robotic prototype.
5. Develop IoT based robotic prototype.

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Basics of Robotics	4	4	2	10
2	Robotic Sensors	2	4	4	10
3	Signal Recognition and Processing	2	4	6	12
4	Robot Programming	2	6	6	14
5	Applications and Maintenance	2	6	6	14
	Total Marks	**12**	**24**	**24**	**60**

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (25 Marks)
- Rubrics for continuous assessment of self-learning assignments/ micro project/ activities based on process and product related performance indicators. (25 Marks)

Summative Assessment (Assessment of Learning)

- End of the term theory examination. (60 Marks)

IX. Suggested COs - POs Matrix Form

Course Out-comes (COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1 Basic and Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Develop-ment of Solutions	PO-4 Engi-neering Tools, Experime-ntation	PO-5 Engi-neering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Manage-ment	PO-7 Life Long Learn-ing	PSO - 1	PSO - 2
CO1	1	--	1	--	1	--	1	1	--
CO2	3	--	1	--	1	1	1	2	--
CO3	3	2	2	--	1	2	2	2	2
CO4	2	2	2	2	1	2	2	2	2
CO5	2	2	2	--	1	2	2	2	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

X. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publication, Edition and Year of Publication	ISBN NO.
1	Introduction to Robotics	Saha S. K., McGraw Hill Education Pvt. Ltd.	978-0070140011
2	Robotics Technology and Flexible Automation	Deb S. R., McGraw Hill Publication, New Delhi	978-0071331298
3	Introduction to Robotics (Mechanics and Controls)	Craig J. J., Pearson Education Ltd	978-9356062191
4	Robotics Fundamental Concepts and Analysis	Ghoshal, Ashitava, Oxford University press 2006	978-0195673913
5	Industrial Robotics	Mikell P. Grover, Mitchell Weiss, Rogger N. Nagel, Nicholas G. Ordey, Tata McGraw Hill Education Pvt. Ltd. New Delhi	978-0070265097

XI. Learning Websites & Portals

Sr. No.	Link / Portal	Description
1	https://www.roboanalyzer.com/virtual-experiments.html	Virtual Lab
2	https://www.vlab.iitkgp.ac.in/mr/	Virtual Lab
3	https://www.roboanalyzer.com/virtual-experiments.htm	Virtual Lab
4	https://www.robotshop.com/community/	Tutorials

XII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organization
1	Mr. Kiran Kulkarni	Director, Technical and Business Development	Denar Automation, Pune
2	Ms. Manju Kurien	Lecturer in Automation & Robotics	Vivekanand Education Society, Chembur
3	Dr. B. B. Sul	Head of Department, Instrumentation Engg.	Government Polytechnic, Mumbai
4	Mr. Firoz S. Bagwan	Lecturer in Instrumentation	Government Polytechnic, Mumbai

Coordinator,
Curriculum Development,
Department of Instrumentation Engg.

Head of Department
Department of Instrumentation Engg.

Incharge,
Curriculum Development Cell
Government Polytechnic, Mumbai

Principal
Government Polytechnic, Mumbai

Programme: Diploma in Instrumentation Engineering (E&C) (Sandwich Pattern)													
Course Code: IS23109					**Course Title: Instrumentation Circuits Design**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2:30 Hrs.)**	**FA-PR**	**SA-**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	--	2	1	6	3	--	--	--	50	50#	--	25	125

Total IKS Hrs. for course: --- Hrs.

Abbreviations: CL-Class Room Learning, TL-Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA-Formative Assessment, SA-Summative assessment, SLA-Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment,*# Online Examination, @$ Internal Online Examination

Note:

1. FA-PR represents tutorial/practical term work of 50 Marks.
2. SA-PR represents the end term practical examination of 50 Marks.
3. SLA represents self-learning Assessment of 25 Marks.

I. Rationale:

Operational amplifier is most adaptable IC used widely used to develop various circuits in electronic field, biomedical field and Industry. Students should develop skills to build, test, develop circuits based on op-amp and understand the working of various analog and digital signal conditioning circuits using op-amp for Industrial, consumer applications.

II. Industry / Employer Expected Outcome:

The aim of this course is to attain the following industry/ employer expected outcome through various teaching learning experiences:

"Develop various circuits using op-amp and special purpose IC's for industry applications".

III. Course Outcome: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Understand the basic parameters of op amp
CO2	Select op-amp in linear and non- linear applications
CO3	Develop signal conditioning circuits using instrumentation amplifier
CO4	Interpret different types of filters and their frequency response
CO5	Utilize IC's in various circuits for specific applications

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics / Sub-topics
1	**TLO1.1** Draw symbol and pin diagram of op amp **TLO1.2** Explain functions of each stage in block diagram of op-amp. **TLO1.3** Define op-amp parameters **TLO1.4** Describe open loop configuration of op-amp	**Unit-I Fundamental of operation amplifier(op-amp)** 1.1 Operational amplifier definition, symbol, pin diagram of Op-amp IC741 and OP-07. 1.2 Block Diagram of Op-amp and function of each stage 1.3 Ideal Op-amp electrical characteristic and Transfer characteristics. 1.4 Op-amp Parameter: Input offset voltage, input offset current, Input bias current, offset voltage adjustment range, Common mode rejection ratio (CMRR), supply voltage rejection ratio (SVRR), Slew rate, Differential Input resistance, Input capacitance, Input voltage range, Large Signal voltage gain, Gain Bandwidth product, output voltage swing, Output resistance 1.5 Virtual Short and virtual ground Concept. 1.6 Open loop configurations of Op-amp
Course Outcome: CO1	**Teaching Hours: 10 hrs.**	**Marks: --**
2	**TLO2.1** Draw and explain operation with output equation of closed loop configuration of op amp. **TLO2.2** Calculate the output equation of Arithmetic operation of op amp. **TLO2.3** Explain with sketches working of op amp for given application. **TLO2.4** Describe with sketch the nonlinear application of op amp.	**Unit-II Linear& Non-Linear Applications of Op-amp** 2.1 Linear applications of Op-amp 2.1.1. Close loop configuration: Inverting amplifier, non-Inverting amplifier and Unity gain amplifier 2.1.2. Arithmetic Operation: Adder/summing/scaling/ averaging amplifier, Subtractor/differential amplifier, Integrator, Differentiator, Multiplier and Divider 2.1.3. Voltage to current Converter with floating load. 2.1.4. Current to voltage converter. 2.1.5. Sample and hold circuit. 2.2 Non-Linear applications of Op-amp 2.2.1. Comparator: Inverting and Noninverting. 2.2.2. Comparator applications: Zero crossing detector, Schmitt trigger circuit. (Circuit diagram, working, output equation & waveform)
Course Outcome: CO2	**Teaching Hours: 09 hrs.**	**Marks: --**
3	**TLO3.1** State the need and features of Instrumentation amplifier. **TLO3.2** Explain with sketch, working and output equation of Instrumentation amplifier. **TLO3.3** Understand IC LM324 for different applications of instrumentation amplifier. **TLO3.4** Draw and Design signal conditioning circuit for sensor.	**Unit-III Instrumentation Amplifier** 3.1 Need and features of instrumentation amplifier 3.2 Two & Three op-amp Instrumentation amplifier Advantages and disadvantages of Instrumentation. 3.3 IC LM-324 pin configuration, specification 3.4 Sensor signal conditioning – design considerations and applications for RTD, LM35 thermocouple, Load cell

		3.5 Optical sensor signal conditioning – photo-conductor, photovoltaic amplifier 3.6 Successive approximation ADC and its resolution (Circuit diagram, circuit operation, output equation and applications)
Course Outcome: CO3	**Teaching Hours: 09 hrs.**	**Marks: ---**
4	**TLO4.1** Define filter and differentiate between Active filter and passive filter **TLO4.2** Understand different types of filter and their characteristics **TLO4.3** Draw frequency response curve for given filter with cut-off frequency equation **TLO4.4** Explain working of given type of filter with sketch **TLO4.5** Calculate cut-off frequency for LPF and HPF.	**Unit-IV Active filters** 4.1 Definition of filter, 4.2 Advantages of active filters over passive filters. 4.3 Filter Classification. 4.4 Filter Characteristic terms: order of filter, cut off frequency, pass band, stop band, centre frequency, roll off rate, Bandwidth, Q factor. 4.5 Types of filters: 4.5.1. Low pass (first order Butterworth) 4.5.2. High pass (first order Butterworth) 4.5.3. Band pass filter (first order): wide &Narrow 4.5.4. Band reject filters (first order): wide & Narrow 4.5.5. All pass filters (Circuit diagram, operation, frequency response, Applications)
Course Outcome: CO4	**Teaching Hours: 09 hrs**	**Marks: --**
5	**TLO5.1** State need of timer with pin diagram. **TLO5.2** Explain the operation of IC555 timer with sketch. **TLO5.3** Describe working of multivibrator using IC555. **TLO5.4** Calculate duty cycle of given multivibrator.	**Unit-V Specialized IC Applications** 5.1 IC555 timer: Need of Timer, features, block diagram and operation, Pin Diagram and function 5.2 IC555 timer as astable multivibrator and monostable multivibrator (circuit, operation, output wave form & output equation, applications) 5.3 Application: frequency Divider, Square Wave Generator (circuit diagram & operation)
Course Outcome: CO5	**Teaching Hours: 08 hrs**	**Marks: ---**

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Practical / Tutorial / Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of Hrs.	Relevant COs
1	**LLO1.1** Implement circuit to test the op-amp parameter	Measure the parameters of OP-Amp (input offset voltage, input offset current, input bias current & CMRR)	02	CO1
2	**LLO2.1** Implement circuit to measure output of Inverting and non-inverting amplifier	Test the Inverting & Non- Inverting amplifier usingIC741	02	CO2
3	**LLO3.1** Implement circuit to measure output voltage using Instrumentation amplifier	Measure the Gain of Instrumentation amplifier circuit.	02	CO3
4	**LLO4.1** Implement circuit to measure integrator using op amp	Test the output of Integrator circuit using IC741	02	CO2

5	**LLO5.1** Implement circuit to measure differentiator using op amp	Test the output of differentiator circuit using IC741	02	CO2
6	**LLO6.1** Implement circuit to measure V to I converter using op amp	Measure the output of V to I converter using IC741	02	CO2
7	**LLO7.1** Implement circuit to measure output of Adder / subtractor	Measure the output of adder/scaler/ averaging and subtractor using IC741	02	CO2
8	**LLO8.1** Implement circuit to determine time cycle of Monostable multivibrator	Construct Monostable multivibrator using IC555 timer and determine time cycle.	02	CO5
9	**LLO9.1** Implement circuit to calculate cut-off frequency of low pass filter	Observe the response of first order low pass Butterworth filter using OP- Amp	02	CO4
10	**LLO10.1** Implement circuit to measure output of comparator	Build to measure the output of Comparator using IC741	02	CO2
11	**LLO11.1** Implement circuit to measure output of Instrumentation amplifier using IC LM324	Construct Instrumentation amplifier circuit using IC LM324	02	CO3
12	**LLO12.1** Develop signal conditioning circuit for RTD using IC LM324	Test signal conditioning circuit for RTD using instrumentation amplifier	02	CO3
13	**LLO13.1** Implement circuit to calculate cut-off frequency of high pass filter using IC741	Observe the response of first order high pass Butterworth filter using op- amp	02	CO4
14	**LLO14.1** Implement circuit to test the zero -crossing detector using IC741	Measure the output of zero crossing detector using IC741	02	CO2
15	**LLO15.1** Implement circuit to test band pass filter using IC741	To observe the response of first order band pass filter using OP- Amp	02	CO4
16	**LLO16.1** Implement circuit to measure resolution of ADC	Construct circuit to measure resolution of ADC	02	CO3
17	**LLO17.1** Implement circuit to determine time cycle of astable multivibrator	To construct circuit of Astable multivibrator using IC555 timer to determine time cycle.	02	CO5
18	**LLO18.1** Implement circuit to test signal conditioning circuit for Load Cell using IC LM324	Built to measure signal conditioning circuit for Load cell using IC LM324	02	CO3

Note: Minimum 12 experiments are compulsory and should be chosen such that all COs will be covered.

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self-Learning):

Micro Project:

1. Prepare circuit and test square wave generator circuit as an application of Astable multivibrator
2. Prepare circuit of Notch Filter or band pass filter
3. Develop and test Frequency Divider circuit as an application of Monostable multivibrator
4. Develop signal conditioning of sensor (Load cell/strain gauge/ Photovoltaic cell)
5. Develop signal conditioning circuit of Photovoltaic cell

VII. Specification Table: ---NA----

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (50 Marks)
- Rubrics for continuous assessment of self-learning assignments/ micro project/ activities based on process and product related performance indicators. (25 Marks)

Summative Assessment (Assessment of Learning)

- Rubrics for assessment based on laboratory process and product related performance indicators. (50 Marks)

IX. Suggested COs - POs Matrix Form:

Course Out-comes (COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1 Basic and Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Develop-ment of Solutions	PO-4 Engi-neering Tools, Experim e-ntation	PO-5 Engineering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Manage-ment	PO-7 Life Long Learn-ing	PSO - 1	PSO - 2
CO1	3	2	1	2	1	1	-	2	1
CO2	3	2	2	2	1	1	-	2	1
CO3	3	2	2	2	1	1	-	2	1
CO4	3	2	2	2	1	1	-	2	1
CO5	3	2	2	2	1	1	-	2	1
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

X. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publication, Edition and Year of Publication	ISBN NO.
1	Op-Amp & Linear Integrated circuits	Ramakant A. Gayakwad, Third edition, Prentice Hall of India, 2011	9788120320581
2	Operational amplifiers with Linear integrated circuits	William Stanley, Pearson Education India, 2002	9788131708453
3	Integrated Circuits	K. R. Botkar, Khanna Publication, 1987	9788174092083
4	Linear Integrated Circuit	Roy Choudhary, D. Jain, New age International Publisher, New Delhi, 2003	9788122414707

5	Operational amplifier and Linear IC's	Bell, David A., Oxford University Press. New Delhi, 2011	9780195696134
6	Design with Operational Amplifier & Analog Integrated Circuit	Franco, Sergio, McGraw-Hill Education, New Delhi, 2014	9780078028168
7	Operational amplifier & Linear Integrated circuits	Coughlin & Driscoll Fourth Edition, Prentice Hall of India	9780136377856
8	Application and Design with Analog Integrated Circuit	J. Michael Jacob Second Edition, Reston Publishing co., 1982	9780835902458

XI. Learning Websites & Portals:

Sr. No.	Link / Portal	Description
1	https://www.electronicsforum.com	Op-amp basics
2	https://www.electronicshub.org	Op-amp applications
3	https://www.studyelectronics.in	Op-amp linear circuits
4	https://www.electronics-tutorials	Tutorial on op amp
5	https://www.electrical4u.com	Op-amp linear circuits

XII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organization
1	Mrs. Swapnali V. Latke	Senior Embedded Software	Paras defense and space technologies Ltd.
2	Mrs. Avanti Ghadge	Lecturer in Electronic engg.	Govt. Polytechnic, Thane
3	Mr. Firoz S. Bagwan	Lecturer in Instrumentation	Govt. Polytechnic, Mumbai
4	Ms. Kavita Waghmare	Lecturer in Instrumentation	Govt. Polytechnic, Mumbai

Coordinator,
Curriculum Development,
Department of Instrumentation Engg.

Head of Department
Department of Instrumentation Engg.

Incharge,
Curriculum Development Cell
Government Polytechnic, Mumbai

Principal
Government Polytechnic, Mumbai

Programme: Diploma Instrumentation Engineering (E&C) (Sandwich Pattern)

Course Code: IS23606 **Course Title: Industrial Data Communication**

Compulsory/Optional: Compulsory

Learning Scheme and Credits						Assessment Scheme							
						FA-TH		SA-TH (2:30 Hrs.)	FA-PR	SA-		SLA	Total
CL	TL	LL	SLH	NLH	Credits	T1	T2			PR	OR		
2	--	2	--	4	2	--	--	--	25	--	25@	--	50

Total IKS Hrs. for course: --- Hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @Internal Assessment, #External Assessment,*#Online Examination, @$ Internal Online Examination

Note:
1. FA-PR represents tutorial/practical term work of 25 Marks.
2. SA-OR represents the end term Practical examination of 25 Marks

I. Rationale:

The course aligns perfectly with the demands of Industry 4.0, where automation, data exchange, and Cyber-Physical Systems such as Networked control systems like PLC, SCADA and DCS are crucial. There's a significant gap in the workforce regarding industrial communication technologies. This course aims to bridge that gap and equip students with in-demand skills. Diploma Instrumentation Engineers with knowledge of industrial data communication will have better job prospects in various industries, including manufacturing, process control, energy, and more.

II. Industry/Employer Expected Outcome:

The aim of this course is to help the student to achieve the following industry identified outcome through various learning experiences:

"To design, implement, maintain, and troubleshoot industrial data communication networks of industrial automation".

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Select appropriate communication protocols for specific automation applications.
CO2	Configure and troubleshoot Serial communication interfaces
CO3	Configure, maintain, and troubleshoot Fieldbus networks.
CO4	Configure, maintain, and troubleshoot Ethernet based networks.
CO5	Configure, maintain, troubleshoot Wireless networks.

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's)aligned to CO's	Topics/Sub-topics
1	**TLO1.1** Describe the architecture of automation systems and their communication networks. **TLO1.2** Explain the OSI model and its relevance to industrial communication. **TLO1.3** Identify and compare various industrial communication protocols. **TLO1.4** Understand different network components, topologies, and transmission media used in industrial automation. **TLO1.5** Compare the digital modulation techniques- FSK and PSK	**Unit- I Introduction to Industrial Data Communication Networks for Automation** 1.1 Architecture of Automation Systems: Levels of automation systems (field, control, plant, management), Communication requirements at each level (bandwidth, reliability, security, latency) Resistive Displacement Transducers: Potentiometer, Strain gauge, types, Effect of temperature on strain gauge measurement, Simple Numerical on strain gauge factor. 1.2 OSI Model: Seven layers and their functions 1.3 Basic Concept of Industrial Communication Protocols: Fieldbus Protocols (Modbus, HART, Foundation, Fieldbus, Profibus), Ethernet-based Protocols(Ethernet, TCP/IP, Profinet), Wireless Protocols (Wi-Fi, Bluetooth, Zigbee, Wireless HART, ISA 100.11a)(Detailed study in later units) 1.4 Network Components, Topology, and Transmission Media: 1.4.1 Network components (router, bridge, gateway, repeater, hub, switch, connectors: BNC, DB9, DB15, RJ45) – functions of each 1.4.2 Network topologies (bus, star, ring, mesh)- advantages and disadvantages of each 1.4.3 Transmission media (twisted pair cables-shielded/unshielded, co-axial cables, fiber optic cables- Patch Cords, wireless-radio) – characteristics and applications 1.5 Digital Modulation Techniques- Introduction to FSK and PSK
CourseOutcome:CO1	**TeachingHours:08 hrs.**	**Marks:--**
2	**TLO2.1** Explain the characteristics of serial communication interfaces **TLO2.2** Describe various serial communication standards: RS-232 and RS-485. **TLO2.3** Describe various on-board serial interfaces/protocols	**Unit-II Serial Communication Interfaces/Protocols** 2.1 RS-232: Features, working, distances, and applications 2.2 RS-485: Features, working, distances, and applications 2.3 On-board Serial Interfaces/Protocols: I2C, CAN, USB, SPI (Architecture, working, features, data

	TLO2.4 Configure and troubleshoot serial communication links.	format and applications) 2.4 Configuring and troubleshooting the serial data communication networks
Course Outcome: CO2	**TeachingHours:04 hrs.**	**Marks:--**
3	**TLO3.1** Understand the concepts/operation and applications of fieldbus protocols. **TLO3.2** Compare the features of fieldbus protocols. **TLO3.3** Configure and troubleshoot the fieldbus protocols.	**Unit-III Fieldbus Protocols/Networks** Concept, features, definition, operation, and applications of following fieldbus protocols/networks: 3.1 Modbus 3.2 HART 3.3 Foundation Fieldbus 3.4 Profibus 3.5 Configuring and troubleshooting fieldbus protocols/networks
Course Outcome: CO3	**TeachingHours:07 hrs.**	**Marks:--**
4	**TLO4.1** Understand the concepts/operation and applications of industrial Ethernet protocols. **TLO4.2** Compare the features of industrial Ethernet protocols. **TLO4.3** Configure and troubleshoot industrial Ethernet networks.	**Unit-IV Industrial Ethernet** Concept, features, definition, operation, and applications of following industrial Ethernet networks: 4.1 Industrial Ethernet-10Mbps/100Mbps/Gigabit Industrial Ethernet 4.2 TCP/IP Protocol 4.3 Profinet 4.4 Configuring and troubleshooting Industrial ethernet
Course Outcome: CO4	**Teaching Hours: 04 hrs.**	**Marks:--**
5	**TLO5.1** Understand the concepts/operation and applications of industrial wireless networks. **TLO5.2** Compare the features of industrial wireless networks. **TLO5.3** Configure and troubleshoot industrial wireless networks	**Unit-V Industrial Wireless Networks** Architecture, components, applications of following industrial wireless networks: 5.1 Industrial Wireless Local Area Network (WLAN)-Wi-Fi 5.2 Bluetooth 5.3 Low-Rate Wireless Personal Area Networks (LRWPAN) - ZigBee, Wireless HART, ISA100.11a, 6LoWPAN 5.4 Satellite/Mobile Networks- GSM, GPRS, 5G/6G, 5.5 Configuring and troubleshooting wireless networks
Course Outcome: CO5	**Teaching Hours: 07 hrs.**	**Marks:--**

Note: Any one unit from 1 to 5 will be preferably taught by Alumni of Government Polytechnic Mumbai.

V. Laboratory Learning Outcome and Aligned Practical/ Tutorial Experiences.

Sr. No	Practical/ Tutorial/ Laboratory Learning Outcome (LLO)	Laboratory Experiment/ Practical Titles / Tutorial Titles	Number of Hrs.	Relevant COs
1	**LLO1.1** To identify the different levels of laboratory automation system (PLC/SCADA/DCS) and explore	Identification of different levels in the laboratory automation system and exploring their communication	02	CO1

		the communication requirements.	requirements		
2	**LLO2.1**	To simulate/build any one automation level (field, control, plant, management) over suitable communication network (Use PLC/SCADA /DCS-based process control trainer setup or Virtual lab simulator)	Simulation/ implementation of any one automation level (field, control, plant, management) over suitable communication network	02	CO1
3	**LLO3.1**	To simulate/implement different network topologies (bus, star, ring, mesh) using network simulation software (e.g., NS2/NS3/ Cisco Packet Tracer)	Simulation/implementation of different network topologies for various instruments/computer terminals, and test the data transfer	02	CO1
4	**LLO4.1**	To establish serial communication between a microcontroller and computer using RS232 cable and appropriate HyperTerminal like PuTTY	Establishing a RS232 based serial communication between a microcontroller and computer	02	CO2
5	**LLO5.1**	To configure DF1 protocol for establishing serial communication between PLC and PC using RS-232 /USB/Ethernet	Establishing the serial communication between PLC and computer using RS232 /USB/Ethernet cable and DF1 protocol	02	CO2
6	**LLO6.1**	To establish I2C type serial communication between two Arduinos	Establishing the serial communication between two Arduinos using I2C protocol	02	CO2
7	**LLO7.1**	To interface I2C type temperature sensor with Arduino controller.	Interfacing I2C type temperature sensor with Arduino controller for temperature measurement	02	CO2
8	**LLO8.1**	To establish SPI type serial communication between two Arduinos	Establishing the serial communication between two Arduinos using SPI protocol	02	CO2
9	**LLO9.1**	To interface SPI barometric sensor with Arduino controller	Interfacing barometric pressure sensor with Arduino using SPI protocol	02	CO2
10	**LLO10.1**	To interface car temperature sensor with Arduino controller using CAN module	Interfacing car temperature sensor with Arduino using CAN bus	02	CO2
11	**LLO11.1**	To interface windscreen wiper with Arduino controller using CAN module	Interfacing windscreen wiper with Arduino using CAN bus	02	CO2
12	**LLO12.1**	To interface PC with Arduino Uno using Serial Communication Port-USB	Interfacing PC with Arduino Uno using Serial Communication Port-USB	02	CO2
13	**LLO13.1**	To configure and troubleshoot a simple network of a PLC, VFD, and an HMI using MODBUS RS485 serial communication.	Design a simple network of a PLC, VFD, and an HMI using MODBUS RS485 serial communication.	02	CO3
14	**LLO14.1**	To configure HART enabled instrument using HART evaluation kit or HART communication software/simulator	Configuration of HART point-to-point communication network	02	CO3

15	**LLO15.1** To configure foundation fieldbus H1 device using FF evaluation kit or FF simulator	Configuration Foundation fieldbus H1	02	CO3
16	**LLO16.1** To set up a basic industrial Ethernet network using switches, routers, and network cables.	Industrial Ethernet Network Setup	02	CO4
17	**LLO17.1** To demonstrate TCP/IP communication between two devices on an industrial Ethernet network.	TCP/IP Communication	02	CO4
18	**LLO18.1** To connect Arduino UNO to a Laser with TCP/IP	Connect Arduino UNO to a Laser with TCP/IP	02	CO4
19	**LLO19.1** To capture and analyze network traffic using a packet analyzer (e.g. Wireshark or Cisco Packet Tracer)	Network Performance Analysis	02	CO4
20	**LLO20.1** To identify and troubleshoot common industrial Ethernet network problems (e.g., cable faults, device failures, network congestion).	Troubleshooting Network Problems	02	CO4
21	**LLO21.1** To set up and configure a basic Wi-Fi network for industrial applications.	Wi-Fi Network Setup and Configuration	02	CO5
22	**LLO22.1** To demonstrate Bluetooth communication between two devices (e.g., a microcontroller and a smartphone).	Bluetooth Communication	02	CO5
23	**LLO23.1** To set up a simple ZigBee sensor network for measurement of ambient temperature	Setting up ZigBee Sensor Network for ambient temperature monitoring	02	CO5
24	**LLO24.1** To set up two-hop Wireless HART Network sensor network for measurement of ambient temperature	Setting up two-hop WirelessHART Network for ambient temperature monitoring	02	CO5
25	**LLO25.1** To deploy a LoRaWAN sensor node in a real-world environment	LoRaWAN Sensor Deployment	02	CO5
26	**LLO26.1** To send and receive data using a GSM/GPRS modem	GSM/GPRS Communication	02	CO5

Note: Minimum 20 experiments are compulsory and should be chosen such that all COs will be covered.

VI. Suggested Micro Project/ Assignment/ Activities for Specific Learning/ Skills Development (Self-Learning): --NA--

VII. Specification Table: --NA--

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (25 Marks)

Summative Assessment (Assessment of Learning)

- Rubrics for assessment based on laboratory process and product related performance indicators. (25 Marks)

IX. Suggested COs-Pos Matrix Form

Course Out-comes(COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1 Basic and Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Develop-ment of Solutions	PO-4 Engi-neering Tools, Experime-ntation	PO-5 Engineering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Manage-ment	PO-7 Life Long Learn-ing	PSO -1	PSO -2
CO1	3	--	2	2	1	--	1	1	3
CO2	3	--	2	2	1	--	1	1	3
CO3	3	--	2	2	1	--	1	1	3
CO4	3	--	2	2	1	--	1	1	3
CO5	3	--	2	2	1	--	1	1	3
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

X. Suggested Learning Materials/Books

Sr. No.	Title	Author, Publication, Edition and Year of Publication	ISBN NO.
1.	Industrial Data Communication	Lawrence M Thompson, ISA, 2008	978-1934394243
2.	Practical Data Communications for Instrumentation and Control	Park, John; Mackay, Steve; Wright, Edwin Newnes An imprint of Elsevier, Linacre House, Jordan Hill, Oxford Wheeler Road, Burlington, MA, 2003	978-0750657976
3.	Practical Industrial Data Networks: Design, Installation and Troubleshooting	Steve Mackay, Edwin Wright, Deon Reynders, John Park Newnes An imprint of Elsevier, 2004	978-0080480213
4.	Industrial Communication Technology Handbook	Richard Zurawski, ISA Group, San Francisco, California, USA , CRC Press, 2015	978-1482207330
5.	Process Software and Digital Networks	Bela G. Liptak, Halit Eren , 3rd edition 2002, CRC Press	978-1439863435
6.	Industrial Wireless Sensor Networks: Monitoring, Control and Automation	Ramakrishna Budampati and Soumitri Kolavennu, Woodhead Publishing is an imprint of Elsevier, USA 2016	978-1782422303

XI. Learning Websites & Portals:

Sr. No.	Link/Portal	Description

1	https://forum.arduino.cc/t/communication-between-2-microcontrollers-with-i2c/1001863/4 https://in.mathworks.com/help/matlab/supportpkg/measure-temperature-from-i2c-device-on-arduino-hardware.html	I2C
2	https://circuitdigest.com/microcontroller-projects/arduino-spi-communication-tutorial https://docs.arduino.cc/tutorials/communication/BarometricPressureSensor/	SPI
3	https://how2electronics.com/interfacing-mcp2515-can-bus-module-with-arduino/#google_vignette https://diyprojectslab.com/vehicle-monitoring-mcp2515-can-bus-arduino/	CAN
4	https://playwithcircuit.com/interfacing-pc-with-arduino-uno-using-serial-	Serial interface
5	http://vlabs.iitkgp.ac.in/rtes/exp15/index.html	Virtual Lab IIT

XII.Academic Consultation Committee/ Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organization
1	Mr. Prathmesh Mulay	Project Engineer	Endress Houser, Mumbai
2	Mr. Sanjay Rajput	Lecturer in Instrumentation	Govt. Polytechnic, Ratnagiri
3	Mr. F. S. Bagwan	Lecturer in Instrumentation	Govt. Polytechnic, Mumbai
4	Mr. Shivaji G. Thube	Lecturer in Instrumentation	Govt. Polytechnic, Mumbai

Coordinator,
Curriculum Development,
Department of Instrumentation Engg.

Head of Department
Department of Instrumentation Engg.

Incharge,
Curriculum Development Cell
Government Polytechnic, Mumbai

Principal
Government Polytechnic, Mumbai

Programme: Diploma in Instrumentation Engineering (E&C) (Sandwich Pattern)													
Course Code: IS23503					**Course Title: Basic Python Programming**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2:30 Hrs.)**	**FA-PR**	**SA-**		**SLA**	**Total**
										PR	**OR**		
--	--	2	2	4	2	--	--	--	25	--	--	25	50

Total IKS Hrs. for course:-- Hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# Online Examination, @$ Internal Online Examination

Note:
1. FA-PR represents tutorial/practical term work of 25 Marks.
2. SLA represents self-learning Assessment of 25 Marks.

I. Rationale:

Python is a remarkably powerful dynamic programming language and known for its simple and easy-to-read syntax. Python is a versatile language that can be used for a wide range of tasks, including data analysis, visualization, automation, and control. For instrumentation engineers, who often work with data acquisition systems and control systems, Python has libraries and frameworks specifically tailored for data analysis, visualization, scientific computing and complex analysis. Python provides a powerful platform for developing custom solutions. Learning Python can greatly enhance the capabilities of instrumentation engineers and enable them to develop more efficient and innovative solutions for data acquisition, analysis, and control in their field.

II. Industry / Employer Expected Outcome:

The aim of this course is to help the student to achieve the following industry identified outcome through various learning experiences: **"Develop basic coding ability using python to solve problems."**

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Interpret basic tools of Python programming
CO2	Develop Python programs for conditional and looping statements
CO3	Develop Python programs for 1 and 2 dimensional arrays
CO4	Perform data structure operations in Python using functions, modules and packages
CO5	Develop Python programs using control system library

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics / Sub-topics
1	**TLO1.1** Interpret the features of Python **TLO1.2** Identify the given building blocks **TLO1.3** Use appropriate data types for given application **TLO1.4** Write simple program to display given message	**Unit-I Basics of Python Programming** 1.1 Features of python: Interactive, object oriented, Interpreted, platform independent 1.2 Building blocks of Python: Identifiers, keywords, Indention, Variables- Mutable and Immutable variable and comments 1.3 Data Types in Python: Numbers, Strings, Tuples, Lists, Dictionary 1.4 Declaration and use of data types 1.5 Running simple scripts in Python to display message
Course Outcome: CO1	**Teaching Hours: 04hrs**	**Marks: --**
2	**TLO2.1** Use appropriate operators for given problem statement **TLO2.2** Write simple programs for arithmetic logical expressions **TLO2.3** Write simple Python programs for I/O operations **TLO2.4** Write Python programs for decision making **TLO2.5** Write Python programs for looping **TLO2.6** Write Python programs for multiway branching and looping	**Unit-II Decision making and Looping** 2.1 Operators in Python: Arithmetic, relational assignment, logical, bitwise, membership and identity operators, Operator precedence, Expressions and Statements (Assignment statement) 2.2 I/O operations: Reading keyboard, printing on screen 2.3 Conditional programming: If - Else statement and nested if – else 2.4 Loops: While, do-while, for loops, use of range function in for 2.5 Loop manipulation: Nested loops, break, continue, pass, else, Use of compound expression in conditional constructs
Course Outcome: CO2	**Teaching Hours: 05hrs**	**Marks: --**
3	**TLO3.1** Write an array for given problem statement **TLO3.2** Develop python program for given matrix operations **TLO3.3** Write python program to manipulate lists **TLO3.4** Write python program to manipulate tuples **TLO3.5** Write python program to manipulate sets **TLO3.6** Write python program to manipulate dictionaries	**Unit-III Data Structures** 3.1 Basics of array, Array as abstract Data Type, two-dimensional array 3.2 Matrix: Implementation of matrix, Matrix operation like addition, subtraction, scaling, Multiplication, Transpose 3.3 Lists: Creating python list, Appending Items, extending a List, Inserting Items, Removing Items, List Slice 3.4 Tuple: Defining Tuple, accessing values from Tuple, Basic Tuple operations, Built in Tuple functions/methods 3.5 Set: Defining Sets, accessing values from set, deleting set values, Basic set operations, Built in set functions/methods 3.6 Dictionary: Defining Dictionary, accessing values from Dictionary, deleting Dictionary values, updating Dictionary, Basic Dictionary operations, Built in

		Dictionary functions/methods
Course Outcome: CO3	**Teaching Hours: 05hrs**	**Marks: --**
4	**TLO4.1** Use python standard functions for given problem statement **TLO4.2** Develop user defined functions for given problem statement **TLO4.3** Write python module for given problem statement **TLO4.4** Write python package for given problem statement	**Unit-IV Python Functions, Modules and packages** 4.1 Built-In Functions, invoking built in functions, Module (Importing entire module or selected objects, using from statement), Functions from math, random, time & date module. 4.2 User Defined Function: Defining, invoking functions, passing parameters (default parameter values, keyword arguments) 4.2.1 Scope of variables: void functions and functions returning values 4.3 Modules: Writing modules, importing modules, importing objects from modules, python built-in modules, namespace and scoping 4.4 Python Packages: Introduction, writing python packages, using standard (math, scipy, Numpy, matplotlib, pandas, seaborn, requests, scrapy etc.) and user defined packages
Course Outcome: CO4	**Teaching Hours: 06hrs**	**Marks: --**
5	**TLO5.1** Create classes and objects for given problem statement **TLO5.2** Interpret overloading, overriding of classes **TLO5.3** Interpret data hiding and abstraction **TLO5.4** Interpret inheritance and composition in classes **TLO5.5** Use appropriate functions for file handling and file exceptions	**Unit-V Object Oriented Programming** 5.1 Creating classes and objects 5.2 Method Overloading and Overriding 5.3 Data hiding and data abstraction 5.4 Inheritance and composition in classes 5.5 File handling: Opening files in different modes, accessing file contents, reading, writing, closing, renaming, deleting files and directories 5.6 Exception Handling
Course Outcome: CO4	**Teaching Hours: 05hrs**	**Marks: --**
6	**TLO6.1** Interpret control system library functions **TLO6.2** Create transfer functions using Python for given problem **TLO6.3** Use standard functions to derive poles and zeros of given transfer function **TLO6.4** Use standard functions to plot pole-zero plot for given transfer function **TLO6.5** Plot response of given system for given input **TLO6.6** Plot frequency response of given system	**Unit-VI Control System Applications** 6.1 Control system library functions 6.2 Transfer function for 1st and 2nd order systems 6.3 Poles- zeros, Pole- zero plot using python 6.4 Response of 1st and 2nd order system for step, ramp input 6.5 Plot gain and phase plots for 1st and 2nd order systems 6.6 Integrating python with LabView

	TLO6.7 Interpret the LabView and python integration	

Course Outcome: CO5 **Teaching Hours: 05hrs** **Marks: --**

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Practical / Tutorial / Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of Hrs.	Relev-ant CO
1	**LLO1.1** Write python program to display given message.	Write simple python program to display message on screen	02	CO1
2	**LLO2.1** Write python program to solve given expression	Implement python program using following operators: 1. Arithmetic 2. Relational & logical 3. Assignment 4. Bitwise 5. Membership 6. Identity	02	CO2
3	**LLO3.1** Write python program to solve given conditional problem	Implement python program to demonstrate the use of following conditional statements: 1. If statement 2. If-else statement 3. If-elseif-else statement 4. Nested if statement	02	CO2
4	**LLO4.1** Write python program for solving given problems using a while loop. **LLO4.2** Write python program for solving given problem using for loop	Implement python program to demonstrate the use of following looping statements: 1. while loop 2. for loop 3. nested loop	02	CO2
5	**LLO5.1** Write python program to perform operations on list	Implement a python program to perform following operations on the List: 1. Create a List 2. Access List 3. Update List 4. Delete List	02	CO3
6	**LLO6.1** Write python program to perform operations on tuple	Implement python program to perform following operations on the Tuple: 1. Create a Tuple 2. Access Tuple 3. Print Tuple 4. Delete Tuple 5. Convert tuple into list and vice-versa	02	CO3
7	**LLO7.1** Write python program to manipulate the set	Implement a python program to perform following operations on the Set: 1. Create a Set 2. Access Set 3. Update Set 4. Delete Set	02	CO3
8	**LLO8.1** Write python program to perform operations on dictionary	Implement a python program to perform following operations on the Dictionary: Create, Access Dictionary, Update Dictionary, Delete Dictionary, Looping through Dictionary, Create Dictionary from list	02	CO3
9	**LLO9.1** Write function to solve given problem	Write user defined function to implement following features: Function without argument, Function with argument, Function returning	02	CO4

		value		
10	**LLO10.1** Select appropriate module to solve given problem **LLO10.2** Use given module to solve problem	Write a python program to demonstrate the use of following module: 1. Math module 2. Random module 3. OS module	02	CO4
11	**LLO11.1** Write user defined package to solve given problem	Write python program to create and use a user defined package for a given problem.	02	CO4
12	**LLO12.1** Write python program using classes and objects to solve a given problem	Develop a python program to perform following operations: 1. Creating a Class with method 2. Creating Objects of class 3. Accessing method using object	02	CO4
13	**LLO13.1** Write a python program to implement polymorphism **LLO13.2** Write a python program use data hiding concept in python	Implement a python program to demonstrate Method Overloading, Method Overriding, Data hiding	02	CO4
14	**LLO14.1** Use control system library to plot pole-zero plot for given transfer function **LLO14.2** Use control system library to plot step response for given transfer function	Implement a python program to demonstrate pole-zero plot and step response for given transfer function	02	CO5
15	**LLO15.1** Use control system library to plot gain and phase plot for given transfer function	Implement a python program to demonstrate gain and phase plot	02	CO5

Note: Minimum 12 experiments are compulsory and should be chosen such that all COs will be covered.

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self-Learning):

1. Create a simple calculator program that allows the user to add, subtract, multiply, and divide two numbers.
2. Develop a basic quiz program that asks 3 multiple-choice questions and provides feedback on correct and incorrect answers.
3. Write a program that generates a random number and asks the user to guess it.
4. Build a Temperature Converter that takes a temperature in Celsius, Fahrenheit, or Kelvin and converts it into other temperature units.
5. Simulate a Simple Banking System that allows users to check their balance, deposit money, and withdraw money while ensuring the balance doesn't go negative.
6. Create a Password Generator that generates a random password containing letters, numbers, and symbols based on the user's preferred length.
7. Create an Expense Tracker that lets users enter daily expenses and displays total expenses for the month.
8. Build an Age Calculator that asks for the user's birth year and calculates their current age.
9. Develop a Simple Voting System that allows users to vote for predefined candidates and displays voting results.
10. Design a Fibonacci Series Generator that generates and displays the first N numbers in the Fibonacci sequence.

VII. Specification Table:----NA---

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on attendance, process and product related performance indicators. (25 Marks)
- Rubrics for continuous assessment of self-learning assignments/ micro project/ activities based on process and product related performance indicators. (25 Marks)

IX. Suggested COs - POs Matrix Form:

Course Out-comes (COs)	Programme Outcomes (POs)							Programme Outcomes (POs)	
	PO-1 Basi Discipline Specific Know-ledge	PO-2 Problem Analysis	PO-3 Design/ Develop-ment of Solutions	PO-4 Engi-neering Tools, Experime-ntation	PO-5 Engi-neering Practices For Society, Sustain-ability and Environ-ment	PO-6 Project Manage-ment	PO-7 Life Long Learn-ing	PSO - 1	PSO - 2
CO1	1	1	1	--	--	1	2	--	2
CO2	1	3	2	--	--	2	2	--	2
CO3	1	3	2	--	--	2	2	--	2
CO4	1	3	2	--	--	2	2	--	2
CO5	1	3	2	--	--	2	2	--	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

X. Suggested Learning Materials / Books:

Sr. No.	Title	Author, Publication, Edition and Year of Publication	ISBN NO.
1	Core Python Programming	R. Nageswara Rao, Dreamtech Press,	978-9390457151
2	Learning Python	Mark Lutz, O'Reilly Media, Inc,	978-1449355739
3	Python Basics	David Amos, Dan Bader, Joanna Jablonski, Fletcher Heisler, Real Python,	978-1775093329
4	Taming Python by Programming	Dr. Jeeva Jose, Khanna Book Publishing CO(P) LTD, New Delhi,	978-9386173348
5	Python Programming	Rupesh Nasre, AICTE, [Online available on AICTE e-Kumbh]	978-8195986354

XI. Learning Websites & Portals

Sr. No.	Link / Portal	Description
1	https://ekumbh.aicte-india.org/allbook.php	Python Programming
2	https://python-iitk.vlabs.ac.in/	Python Programming Lab

3	https://spoken-tutorial.org/tutorial-search/?search_foss=Python+3.4.3&search_language=English	Introduction to Python and control flow statements, Data Structures in Python, Function and module
4	https://onlinecourses.nptel.ac.in/noc19_cs41/preview	Python Programming Course
5	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013094437935001602592_shared/overview#error=login_required&state=5baee827-1544-4440-88bb-	Python for Beginners
6	https://wiki.python.org/moin/BeginnersGuide	Basics of Python
7	https://www.tutorialspoint.com/python_pandas/index.htm	Python pandas package
8	https://www.programiz.com/pythonprogramming/objectoriented-programming	OOP using Python
9	www.khanacademy.org	Chapter 3-5 theory topics
10	www.tinkercad.com	One can build and simulate the circuit

XII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organization
1	Ms. Priyanka Khadtare	Software development Engineer	Nykaa Pvt. Ltd.
2	Mr. Badshah Mulla	Lecturer in Computer Engg.	Government Polytechnic, Miraj
3	Mrs. Neha Vachhani	Lecturer in Computer Engg.	Government Polytechnic, Mumbai
4	Mrs. S.T. Shinde	Lecturer in Instrumentation	Government Polytechnic, Mumbai

Coordinator,
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Head of Department
Department of Instrumentation Engg.

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