GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Course Curriculum

SAFETY INSTRUMENTATED SYSTEMS AND SAFETY INTEGRATED LEVEL
(Code: 3331701)

Diploma Programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	3rd semester

1. RATIONALE

In the present industrial scenario, to avoid industrial accidents and hazards, many inbuilt checks and controls are provided by having "Safety Instrumented Systems". It is therefore desirable that a diploma engineer should be able to identify, classify and maintain the different 'Safety Instrumentated System's as well 'Safety Integrated Levels' applied to Safety Instrumented Systems. They are required to implement the planned safety Process Instrumentation maintenance schedules universally followed by the instrumentation and process industries. Therefore, this course has been designed to take care of this need, to make the students 'work ready'.

2. COMPETENCY ('Programme Outcome' according to NBA Terminology)

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Maintain the different types of "safety Instrumentated systems" as well as "safety integrated levels" associated with them in Process Instrumentation Application**

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** – Credit;; **ESE** - End Semester Examination; **PA** - Progressive Assessment.

4. COURSE DEATAIL

UNIT	MAJOR LEARNING OUTCOMES **('Course Outcomes' in Cognitive Domain according to NBA terminology)**	Topics/subtopics
UNIT-1 INSTRUMENTATION SAFETY IN PROCESS APPLICATIONS	1a.Classify the various types of zones with respect to hazard and safety of process in instrumentation and control 1b.Compare the specific Zones in Process Instrumentation	1.1 With guiding standard of IEC 61421.10 and IEC 60079.10 for Types of Zones of Processes in NFPA 497/API 500: Non-Hazardous Area, Division 2 or Zone 2 area, Division 1 or Zone 1 area, Zone 0 area
		a. Dust zones: Zone 20, Zone 21, Zone 22
		b. Gas / Vapour groups : Gas Group, Gas Group IIA, Gas Group IIB, Gas Group IIC
		c. Equipment Protection Level (EPL): Level - I (mines), II (gas) , III (dust) Equipment category: Category 1, Category 2, Category 3
		d. Common Materials within Associated Class and Group Ratings · Class I Areas: Group A: Acetylene / Group B: Hydrogen / Group C: Propane and Ethylene / Group D: Benzene, Butane, Methane and Propane · Class II Areas: Group E: Metal Dust / Group F: Carbon and Charcoal / Group G: Flour, Starch, Wood and Plastic · Class III Areas: NO GROUP: Cotton and Sawdust
		f. ANSI/NFPA areas description (Class I- Div. 1, Class I- Div. 2, Class II- Div. 1, Class II- Div. 2, Class III-Div. 1, Class III- Div. 2)

		g. Temperature classification: USA°C Type T1 - 450 , T2 – 300, T2A - 280, T2B – 260, T2C – 230, T2D – 215, T3 – 200, T3A - 180, T3B - 165, T3C - 160, T4 - 135, T4A – 120, T5 – 100, T6 – 85
		h. Type of protection: Ex Code d-Flameproof ,e- Increased Safety ,o- Oil Filled ,q-Sand/Powder/Quartz Filled ,m-Encapsulated ,p-Pressurised/purged ,i- Intrinsically safe ,n- Non Incendive ,s- Special
	1c. List out different system included in 1.2 in reference of safety instrumented system with application	1.2 Safety Instrumented Systems include: Equipment protection system, Emergency shutdown system, Safety critical system, Interlock (engineering)
	1d. Describe reliability regimes	1.3 Reliability regimes: regimes for life-critical systems, Fail-operational systems, Fail-safe systems, Fail-secure systems, Fail-Passive systems, Fault-tolerant systems 1.4 Software engineering for life-critical systems
UNIT-2 SAFETY INSTRUMENTED SYSTEM	2a.Define Safety Instrumentation Systems (terms)	2.1 safety instrumentation systems terms : Hazard and operability studies (HAZOP), failure modes, effects, and criticality analysis (FMECA), probability of failure on demand (PFD), failure mode and effects analysis (FMEA), SFF Safe Failure Fraction , , Safety Instrumented Function) SIF , Process Hazards Analysis PHA, , Process Hazards Analysis (PHA), Hardware Fault Tolerance , HIPPS (High Integrity Process Pressure System)

	2b.Describe safety life cycle	Safety Life Cycle: Concepts (safety acronyms), Safety Life Cycle, Safety Instrumented Function (SIF), Safety Requirement Specification(SRS)
UNIT-3 SAFETY INTEGRATED LEVEL(SIL)	3a.Define Risk with reference to safety integrated system.	3.1. Each SIF is assigned a Safety Integrity Level (SIL) during SIL analysis - risk assessment: i. SIL 0/none – lowest risk ii. SIL 1 – 95% of the SIFs iii. SIL 2 – 5% of SIFs iv. SIL 3 – < 1% (not likely in refineries, but possible in off-shore platforms or nuclear) v. SIL 4 – highest risk (only seen in nuclear industry) vi. RISK = Hazard Frequency X Hazard Consequence Event
	3b.Describe safety integrated level SIL-0 to SIL-4	
Unit– 4 SIF (Safety Instrumented Function) and SFF (Safe Failure Fraction) in Field , Utility and Safety Instrumentation Maintenance	4a. Compare SIF and SIS	4.1 SFF (Safe Failure Fraction)
	4b. Compare SIF and SIL	4.2 SIF (Safety Instrumented Function) i. Hazard, Mode of operation, Detection, Decision, Action, Safety integrity level (SIL), Safe state, Response time, Proof-test interval, Safety instrumented system (SIS), Spurious trip rate,
	4c. Define the terms of SIF	
Unit – 5 Operation, maintenance, testing, reporting and management of Protection System Maintenance Program (PSMP)	5a. Describe the working of various types of reports required for maintenance management.	5.1 Reports / Records i. Safety Instrument bin card ii. Safety Instrument log book iii. Safety Instrument Maintenance indent book(physical, human resource) iv. Safety Instrument complaint book
	5b. Define the terms context to Protection System Maintenance Program (PSMP)	5.2 Protection System Maintenance Program (PSMP) Terms : Verification ,Monitoring ,Testing, Physical Inspection , Calibration , Upkeep , Restoration i. Monitoring by Analysis of Fault Records ii. Performance-Based
	5c. List types of Protection System Maintenance Program PSMP - 5.2.1 to 5.2.7	
	5d. Describe the working of various types of PSMP 5.2.1 to 5.2.7 maintenance management	

	5e. Compare each other (PSMP – 5.2.1 to 5.2.7	Maintenance Process iii. Maximum Allowable Verification Intervals iv. Time Based versus Condition Based Maintenance
	5f. Identify maintenance activity and tasks in Time Based Maintenance.	
		v. Condition Based Maintenance (CBM) Programs vi. Time Based Maintenance (TBM) Programs vii. Overlapping the Verification of Segments of the Protection System
	5g. Describe Self-Monitoring Capabilities and Limitations of the system components	5.3 Self-Monitoring Capabilities and Limitations
	5h. Notify the Protection System failures as report and action	5.4 Notification of Protection System Failures

5. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total
I	Instrumentation Safety in Process Applications	5	3	2	2	7
II	safety instrumented systems (SIS)	10	4	5	5	14
III	safety integrated level (SIL)	10	4	5	5	14
IV	SIF (Safety Instrumented Function) and SFF (Safe Failure Fraction) in field, utility and Safety Instrumentation Maintenance	5	3	2	2	7
	Critical, Safety,	5	4	5	5	14

V	Protective Instrumented System					
VI	Operation, maintenance, testing reporting and management of Protection System Maintenance Program (PSMP)	7	4	5	5	14
Total		**42**	**22**	**24**	**24**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

4. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills (**Course Outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance.

Note: Here only course outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in *affective domain*** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Unit No.	Practical Exercise ('Course Outcomes' in Psychomotor Domain according to NBA terminology)	Approx Hours Required
1.	I	Identify the Instrumentation Safety in Process Applications continuous process from a textile industry.	02
2.	I	Identify the Instrumentation Safety in Process Applications continuous process from a chemical industry	02

3.	I	Prepare a daily maintenance schedule for a given safety instrumented systems in a textile process.	02
4.	I	Draw a control loop for a safety instrumented systems operated in a textile process.	02
5.	I	Draw a control loop for a safety instrumented systems operated in a chemical process boiler plant.	02
6.	I	Prepare a half-yearly maintenance schedule of activities for safety integrated level (SIL) 1 instrument used in a given chemical process.	02
7.	I	Prepare a list of activities for a yearly shut down maintenance for SIF (Safety Instrumented Function) schedule for a given chemical process.	02
8.	I	Maintain the indicating instruments for SIF (Safety Instrumented Function) in a given process.	02
9.	II	Maintain the Protective Instrumented System controlling instruments for a given chemical process boiler plant.	02
10.	II	Maintain the Protective Instrumented System recording instruments for a given process in a boiler.	02
11.	III	Maintain the Protective Instrumented System final control elements/instruments for a given textile dyeing process.	02
12.	IV	Test the performance of the final control	02

		elements/instruments of Protective Instrumented System for a given chemical process	
13.	V	Log the maintenance activity carried out for a given process in hard as well enter the data in computerized maintenance management software in appropriate log. Field.	02
14.	V	Carry out maintenance activity with Antivirus / Authorization/ Password for a given computerized maintenance management software.	02
Total		**28**	

7. SUGGESTED LIST OF STUDENT ACTIVITIES

i. Students may be given exercises based on various instrumentation devices and components to maintain related to above topics.

ii. Students may be asked to collect photographs using internet which is relevant to field application of various topics and have to prepare learning materials using it.

iii. Teachers guided self learning activities, Course/library/internet/lab based mini projects, industrial visit etc.

iv. Students activities like: course/ topic based seminars, Internet based assignments.

8. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Visits to Industries

ii. Bring small instrumentation components to the class when teaching

iii. Internet based home assignments

iv. Mini project

9. SUGGESTED LEARNING RESOURCES

A) List of Books S.No.	Author	Title of Books	Publication/Year
1	ld Goettsche.	ISA | Maintenance of Instruments and Systems,	2nd Edition Maintenance of Instruments and Systems, 2nd Edition ld Goettsche.ISA
2	Lindley R. Higgins, R. Keith Mobley, Darrin Wikoff	Maintenance Engineering Handbook,	Seventh Edition
3	W G Andrew	Applied Instrumentation to Process Industries	Vol. 1 to 4 Gulf Publication
4	Jones E. B.	Instrument Technology,	Vol - I, II, Hollywell
5	Williams M. Goble	Control system safety evaluation and reliability	ISA
6	Alan McMillan,	*Electrical Installations in Hazardous Areas*,	Butterworth-Heineman 1998
7	Harry Cheddie , William M. Goble	Safety Instrumented Systems Verification: Practical Probabilistic Calculation	ISA

B) List of Major Equipment/ Instrument with Broad Specifications

i. Instrument Maintenance Shop Tools

a) Dead weight tester / Comparison Guage,
b) Temp. Controlled Bath,
c) Temp. Controlled Oven,
d) Assorted Pneumatic and Hydraulic tubing/ piping tools,
e) Pneumatic Calibrator, Electronic Calibrator ,
f) Thermo Couple Calibrator, Indicator puller,
g) Impulse line bending and flaring tools, Allenkey set,
h) Open and Ring fix Spanner set,
i) Adjustable pipe wrench and Spanner,
j) Screw Driver set,
k) Digital Multimeters with True RMS 41/2 Digit,
l) Clip on meters,
m) Assorted Electrical Insulated Tools set ,
n) Soldering / Desoldering Station,

o) Drilling M/c ,
p) Mini Compressor,
q) Mechanical Vice,
r) Megger / insulation tester
s) Fibre Optic assorted tools – Splicer, Alignment tool , cutter , Splitting Tools, All assorted Magnetic tools,
t) All maintenance Consumables viz., Isopropyl Alcohol, Silicon Oil, Sprays ,CTC Thermic Fluids, Silicon Grease, Graphite based Grease, Clove Oil, Chart recorder Inks – Red/ Blue/ Black

ii. Standards Equipment Room

a) high precision dead weight tester (customs design)
b) high precision voltmeter
c) general purpose oscilloscope
d) stabilized power supply (high precision-high and low voltage)
e) high precision weighing balance
f) precision resistance thermometers
g) one set of glass thermometers (-5 to +250°C)
h) precision variable resistance (Decade box)
i) whetstone bridge
j) high precision barometer
k) high precision dew point hygrometer
l) standard platinum resistance
m) precision current source
n) flat bed recorder
o) standard thermocouples

iii. **Pneumatic 'Shop'**

a) precision pressure regulator
b) pneumatic test rig for controllers (depending on manufacturer)
c) set of precision gages
d) low pressure/vacuum calibration system
e) pneumatic calibration unit
f) digital pressure calibrator (300 mbar)
g) digital pressure calibrator (1.6 bar)
h) digital pressure calibrator (10 bar)
i) high pressure test kit (200 bar)
j) portable low pressure pump
k) portable calibrator
l) pneumatic calibrator- electro
m) pneumatic calibrator
n) absolute pressure unit

iv. **Electronic 'Shop'**

a) portable temperature indicator (6½ digits)
b) portable multivolt meter (6½ digits)
c) whetstone bridge
d) variable resistance (decade box)
e) analogic voltmeter multi-function
f) logic analyzer
g) electronic voltmeter
h) digit al counter frequency meter
i) universal impedance measuring bridge
j) adjustable and portable power supply (high + low voltage)
k) function generator
l) programmable pulse generator
m) general purpose oscillator
n) transistometer
o) stroboscopic tachometer
p) calibration set for vibration monitor
q) digital circuit tester
r) milli-ohm meter (in 0.001 ohm steps)
s) high resistance meter (500 kohms)
t) PT 100 simulator
u) flat bed recorder (dual bed)
v) portable tachometer
w) XY recorder (dual bed)
x) set of standard resistors (10 000 to 1 000 ohm)
y) set of standard platinum resistances
z) test oscilloscope microprocessor (to be kept in the control room, for integrated control systems)
aa) digital oscilloscope with memory
bb) low-voltage megger (50 Volts)
cc) high-voltage megger (500 Volts)
dd) earth fault detector
ee) specific 'manufacturers' calibrator
ff) cold junction reference
gg) computer peripherals.

v. **Special test-benches**

a) control valve
b) hydraulic (portable type)
c) temperature, pressure , flow , level & analytical instrumentation

vi. **Standard Test-Benches**
a) light duty
b) pneumatic
c) electronic
d) DCS and PLC
e) analyzer (general duty)
f) analyzer (specific duty)

vii. **Test Equipment**
a) set of precision pressure gages
b) low-pressure calibration unit (including vacuum)
c) set of digital pressure calibrators (300 mb to 10 bar)
d) pneumatic portable calibration unit (0.2 to 1 bar)
e) portable temperature indicator (TC simulator)
f) one or two electronic digital accurate voltmeters
g) variable resistance (decade box)
h) portable oscilloscope (general purpose)
i) PT 100 simulator calibrator
j) portable tachometer
k) manufacturer's' calibrator(s)
l) portable pulse and function generator
m) portable variable power supply (amps/volts).
n) -standard Voltage/frequency Sources

C. List of Software/Learning Websites
a) http://confirm.pbbiblogs.com/2009/11/28/8-types-of-maintenance-a-comparison/
b) www.maintenancephoenix.com/.../8-steps-to-success-in-maintenance-
c) www.reliabilityweb.com/.../Maintenance%20Scheduling%20101.pdf
d) Maintenance Event Builder (MEB). Soft ware
e) www.clicksoftware.com/service_schedule
f) www.mainpac.com/ Maintenance Software
g) http://www.mainpac.com.au/ Preventive Maintenance Software
h) www.clicksoftware.com/service_schedule SOFTWARE
i) Predictive maintenance software module of DCS, safety instrumentation preventive maintenance software.

- www.mainpac.com/ Maintenance Software
- http://en.wikipedia.org/wiki/Electrical_equipment_in_hazardous_areas
- http://en.wikipedia.org/wiki/Safety_instrumented_system
- http://en.wikipedia.org/wiki/Safety_critical_system
- http://en.wikipedia.org/wiki/Fail-safe

- http://en.wikipedia.org/wiki/Fail-secure
- http://en.wikipedia.org/wiki/Fault-tolerant_system
- Center for Chemical Process Safety book, Guidelines for Safe and Reliable Instrumented Protective Systems
- http://www.mpri.lsu.edu/workshop/Safety%20Instrumented%20Systems%20Angela%20Summers.ppt
- http://www.processengr.com/ppt_presentations/safety_instrumented_systems.pdf
- https://www.jlab.org/accel/ssg/safety/Understanding_sil.pdf
- http://www2.emersonprocess.com/siteadmincenter/PM%20DeltaV%20Documents/Articles/ControlMagazine/The-Safety-Instrumented-Function-An-S-Word-Worth-Knowing.pdf
- http://www.google.co.in/url?sa=tandrct=jand q=safety%20instrumented%20systems%20pptandsource=webandcd=3and cad=rjaandved=0CD0QFjACandurl=http%3A%2F%2Fwww.c-ad.bnl.gov%2FESSHQ%2FASW2009%2FPresentations%2FEtkin%2C%2520Asher%2520Tuesday%25208-18-09.pptxand ei=-NlfUf65GMPirAeR94CoBAand usg=AFQjCNFicYjLjSmRHXfjoXZTIhwQogfovgand bvm=bv.44770516,d.bmk
- http://www.cyber.st.dhs.gov/pcs/
- http://www.amazon.com/Safety-Instrumented-Systems-Verification-Probabilistic/dp/155617909X#reader_B0092WVBH8
- http://www.isa.org/Template.cfm?Section=books3and template=Ecommerce/FileDisplay.cfmandProductID=7915and file=ACFE503.pdf
- http://www.iec.ch/functionalsafety/
- www.siracertification.com
- http://www.hima-sella.co.uk/data/pp/pp054/docs/61508_overview_sira.pdf
- http://www.iamechatronics.com/notes/78-lessons-in-instrumentation/482-safety-instrumented-functions-and-systems
- http://www.nerc.com/docs/standards/sar/PSMT_Supplementary_Reference_Draft1_2009July23.pdf
- NERC/SPCTF/Relay_Maintenance_Tech_Ref_approved_by_PC.pdf

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnic

- **Prof. R.R. Manchiganti**, HOD IC Engineering, Govt. Polytechnic Gandhinagar
- **Prof. N.B. Mehta,** Lecturer IC Engineering, Government Polytechnic, Ahmedabad
- **Prof. H.P. Patel,** Lecturer IC Engineering, Government Polytechnic, Ahmedabad

Faculty Member from NITTTR Bhopal

- **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering
- **Dr. Shashikant Gupta**, Professor and Coordinator for State of Gujarat.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Course Curriculum

TELEMETRY SYSTEM
(Code: 3331702)

Diploma Programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	3rd semester

1. RATIONALE

In the process instrumentation, almost all the measurements are done remotely since data from one equipment is sent to other equipment for control. In some cases data from all the equipment is sent to centrally located control room for overall control. Telemetry is the science of measuring parameters and collecting data at remote or inaccessible points and transmitting them to receiving equipment for monitoring and taking action from optimum and safe operating point of view. The word 'telemetry' is derived from Greek roots: tele = remote and metron = measure. A diploma instrumentation engineer is therefore required to maintain telemetry systems in instrumentation used for monitoring and safe operations of the total system. Hence, it is essential for students to develop the associated skills by study this course deeply.

2. COMPETENCY ('Programme Outcome' according to NBA Terminology)

The course content should be taught and implemented with the aim to make the students competent enough

- **Maintain telemetry systems in instrumentation used for monitoring and safe operations of the total system**

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P - Practical; C - Credit; ESE - End Semester Examination; PA - Progressive Assessment

4. COURSE DETAILS

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Telemetry Principles	1a. Describe the block diagram a typical telemetry system 1b. Classify the different types of telemetry systems 1c. Describe each type of telemetry system with using relevant loop /block diagram 1d. Compare the merits and demerits of Hydraulic, Pneumatic and Electric Telemetry 1e. State standard output ranges of all types of telemetry systems	1.1 Telemetry System Overview: functional blocks of a telemetry system 1.2 Telemetry types: • Energy Medium – Pneumatic, Hydraulic • Electrical - Current, Pulse • Signal Type - Analog, Digital • Frequency Spectrum for telemetry application
UNIT II Hydraulic , Pneumatic and Electrical Telemetry Systems	2a. State strengths of fluid power with examples of hydraulic fluids 2b. With functions, state the components of a typical hydraulic telemetry system.	2.1 Strengths of fluid power with examples of hydraulic fluids 2.2 Components used in Hydraulic Transmissions: • Reservoir, Strainers, Filters, • Hydraulic Pumps- Centrifugal, reciprocating and Rotary • Lines -Types of tubes and pipes, fittings and connectors for impulse line tubing, • Sealing Devices • Types of Direction Control Valve 2.3 Types of Accumulators
	2c. With functions, state the components of a typical Pneumatic Telemetry system.	2.4 Components of Pneumatic Telemetry system: • Receiver tank, Strainers, Filters • Compressor - Centrifugal, reciprocating and Rotary • Lines -Types of Tubes and Pipes Fittings and connectors for Impulse Line tubing, • Sealing Devices • Junction boxes, Enclosures, clamps-P- U type, Numbering / Tagging system • Direction Control Valve - Types

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
	2d. With sketches label each component of the electrical telemetry system. State the steps to troubleshoot the electric telemetry loop	2.5 Electrical Telemetry Components of Electrical Telemetry: Cables, Junction boxes, Enclosures, connectors (Soldered/ Unsoldered – Screw/press fit), clamps-P- U type, Numbering/ Tagging system, Terminals Terminating types (Soldered-unsoldered (screwed , pressed, crimped)
Unit – III Process Data Multiplexing / Demultiplexing Techniques	3a. Justify the need of process data multiplexing and Demultiplexing in Telemetry 3b. Describe the working principle of the following: Multiplexers: TDM, FDM, WDM, CDM 3c. State merits and demerits of each type Multiplexer	3.1 Multiplexing in Telemetry Systems 3.2 Types of Multiplexing – Time Division Multiplexing (TDM) , Frequency Division Multiplexing (FDM), Wavelength Division Multiplexing (WDM), Code Division Multiplexing (CDM)
Unit – IV Process Signal Modulation and Demodulation Techniques	4a. Justify the need of Process Signal Modulation and Demodulation 4b. Describe the modulation with block diagrams. 4c. Describe the following types of modulation: AM, FM, PM, PAM, PPM. PWM, PCM.	4.1 Modulation for Telemetry - Carrier Signal, Process Signal as Information 4.2 Types of Modulation: Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM), Pulse Modulation (PM), Pulse Amplitude Modulation (PAM), Pulse Position Modulation (PPM), Pulse Width Modulation (PWM), Pulse Code Modulation (PCM) and Demodulation of all
Unit – V Process Data Transmission Standards and Buses	5a. Describe the modes of transmission. 5b. Differentiate between guided / unguided transmission media 5c. Describe the features of each type of guided transmission media 5d. Name the types of unguided transmission media 5e. State the steps to be taken to maintain various buses used for	5.1 Mode of transmission: simplex, half duplex, Full duplex 5.2 Transmission Media: Guided and Unguided 5.3 Guided Media: Twisted Pair, Coaxial Pair, Optical Fibre 5.4 Unguided Media: Radio, FM, sky wave, space wave, Infrared

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
	transmitting signals	
	5f. State the types and importance of Serial and parallel transmission standards for industrial data	5.5 Serial and parallel transmission standards,
	5g. Name the various Industrial Instrumentation Communication Buses with features their applications	5.6 Industrial Instrumentation Communication Buses: Foundation Field Bus, Profibus, IEEE488 (GPIB), HART, SCAN - Open Bus
Unit – VI Optical Telemetry and Safety Measures	6a. Compare the features of various types of Fibre optic cables 6b. Name the types and parts of optical fibre connectors 6c. Describe the steps for installing a fibre optical connector 6d. State the procedure to test an installed fibre optic connector 6e. Describe the effect of Back reflection and methods to minimise this using optical isolator 6f. With sketches state the functions of each components of the optical telemetry loop	6.1 Fibre optic Cable, Optical Fibre components: Types of Switches, Couplers, Splitters,, Fibre optic Connectors 6.2 Elements of Optical Telemetry
	6a. State the importance of incorporating safety measures in process telemetry 6b. List Safety Barrier Zones with their types 6c. State the procedure to test Safety Barriers 6d. Justify the need of isolation of process signals in control room to field and vice versa 6e. State the procedure to test electrical and optical Isolation	6.3 Safety Measures in Telemetry 6.4 Safety barrier(zone) 6.5 Isolation of signal (Electrical / optical)

5. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Telemetry Principles	4	3	5	0	08
II	Telemetry -Hydraulic and Pneumatic and Electric	12	2	10	7	19
III	Process Data Multiplexing / Demultiplexing Techniques	6	2	6	4	12
IV	Process Signal Modulation and demodulation Techniques	4	2	2	2	06
V	Data Transmission Standards and Buses	6	2	6	2	10
VI	Optical Telemetry and Safety Measures	10	3	8	4	15
Total		42	14	37	19	70

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as only general guideline for students and teachers. The actual distribution of marks in the question paper may vary from above table.

6. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course Outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance.

Note: Here only course outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of Programme Outcomes/Course Outcomes in ***affective domain*** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Unit No.	Practical/Exercise (Course Outcomes in Psychomotor Domain according to NBA terminology)	Approx Hrs. Required
1	II	Set up a Basic Hydraulic Telemetry System	4
2	II	Set up a Basic Pneumatic Telemetry System and demonstrate true and live zeroes	4
3	II	Connect a process signal to a given recorder/Indicator using 2-wire electric Telemetry	2
4	II	Connect a process signal to a given recorder/Indicator using 3-wire electric Telemetry	2
5	II	Connect a process signal to a given recorder/Indicator using 4-wire electric Telemetry	2
6	II	Tag a Process System by a tie warp/engraved number plate/painted for various process signals to a Junction Box and	4

S. No.	Unit No.	Practical/Exercise (Course Outcomes in Psychomotor Domain according to NBA terminology)	Approx Hrs. Required
		diversion of the field to the control panel.	
7	III	Test the operation of Analog-to-digital converter Digital-to-analog converter	2
8	III	Test a multiplexer and demultiplexer for multiprocess signal.	2
9	III	Build a frequency division multiplexing and demultiplexing circuit and to verify its operation for a temperature/pressure/level/flow process signal	2
10	IV	Determine the percentage modulation in a process signal for Amplitude Modulated System using CRO	2
11	IV	Determine the modulation index and bandwidth for various frequency modulating for a temperature/pressure/level/flow process signal	2
12	V	Implement RS 232 standards of serial transmission using hyper terminals of two computers	2
13	V	Implement RS 485 standards of serial transmission using hyper terminals of two computers	2
14	VI	Set up the digital optical channel for transmission of process signal with noise and observe the distortion of the output signal	2
15	VI	Determine the attenuation (dB/km) of optical fiber in transmitting for a temperature/pressure/level/flow process signal	2
16	VI	Test operation of an opto-coupler in transmitting a temperature/pressure/level/flow process signal	2
17	VI	Test safety barrier using Zener diode telemetry system.	2
Total			**42**

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. WEB Surfing for Advanced Techniques of Telemetry
ii. Presenting A Seminar
iii. Setting up Fibre Optic Control loop
iv. Setting up Pneumatic Control loop
v. Setting up Electrical Control loop

8. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Visits to Industries
ii. Take small instrumentation components to the class when teaching
iii. Video or animation films on working of different type of power stations from YouTube and other resources.
iv. Mini project

9. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Books	Author	Publication
1.	Telemetry Principles	D. Patranabis,	TMH, New Delhi latest Edition
2.	Telecontrol Methods and Applications of Telemetry and Remote Control	Swoboda G.,	Reinhold Publishing Corp., London, 1991
3.	Data Communication Networks	Sanjay Sharma	S.K.Kataria and Sons, New Delhi 2008 or latest Edition
4.	Mechanical and Industrial Measurements (Process Instrumentation and Control)	R.K. Jain	Khanna Publishers New Delhi Latest Edition
5.	Optical Fiber Communications, 3/E	John M. Senior	Pearson publications, New Delhi latest Edition
6.	Pneumatic Controls	Joji P.	Wiley India Edition, New Delhi latest Edition
7.	Instrumentation Reference Book	Edited by Walt Boyes	B H publications, latest edition

B) List of Major Equipment/Materials with Broad Specifications

i. 2 Nos. Of Computers with DACs & Printer
ii. Optical Fiber Testing Bench
iii. All Types of Modulating and Demodulating Cards for Process Signals
iv. All Types of Mulitplexing and Demultiplexing Cards for Process Signals
v. Tranreceiver Set for
vi. Hydraulic Telemetry Test Bench
vii. Pneumatic Telemetry Test Bench
viii. Electric Telemetry Test Bench
ix. Precision Measuring Instruments for a temperature/pressure/level/flow process signal
x. Safety Barrier Test Bench
xi. Test Bench for Industrial Buses

C) List of Software/Learning Websites

i. http://enginemechanics.tpub.com/14105/css/14105_31.htm for hydraulic transmission
ii. http://www.fiber-optics.info/articles/couplers_splitters for fiber optics system components
iii. http://www.becbapatla.ac.in/ece/lab/EC%20351%20AC.pdf --- for practical

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. R.R. Manchiganti**, HOD IC Engineering, Govt. Polytechnic Gandhinagar
- **Prof. R.P. Merchant**, HOD IC Engineering, Govt. Polytechnic Gandhinagar
- **Prof. M.N. Mulchandani**, OSD Continuing Education Centre, Ahmedabad
- **Prof. S. K. Raval**, Lecturer IC(SG) Engineering, Govt. Polytechnic Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Anjali Potnis**, Associate Professor, Department of Electrical and Electronics Engineering
- **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Course Curriculum

DIGITAL TECHNIQUES
(Code: 3331703)

Diploma Programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	3rd semester

1. RATIONALE

Digital electronics and techniques are almost part and parcel of any modern industrial equipment. Integrating industrial process signals for logical and mathematical operations, using combinational and sequential logic for process control components are some of the skills required in this area by IC engineers. This requires every diploma engineer to possess the basic skills of digital techniques to maintain various digitally controlled industrial process systems effectively and efficiently. Hence, this course has been designed to fulfill this purpose.

2. COMPETENCY ('Programme Outcome' according to NBA Terminology)

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Maintain various industrial process control systems which are digitally controlled.**

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
4	0	2	6	70	30	20	30	150

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

4. COURSE DETAILS

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Number Systems	1a. Represent given number in the other given number system.	1.1 Number systems: Decimal, Binary, Octal and Hexadecimal
	1b. Perform arithmetic operations on binary numbers.	1.2 Binary arithmetic Operation: addition, subtraction, multiplication and division
	1c. Obtain 1's and 2's compliment of given binary number. 1d. Subtract given binary numbers using 1's and 2's compliment method.	1.3 Compliments: 1's and 2's compliments, subtraction by 1's and 2's compliment method
	1c. Convert the given number from one number system to another number system.	1.4 Conversion: Binary to decimal, octal, hexadecimal conversion and vice versa. Octal to decimal, hexadecimal, binary conversion and vice-versa, hexadecimal to octal, decimal, Binary and vice versa.
Unit – II Logic Gates and Boolean Algebra	2a. Select electrical levels for '0' and '1' on and off Low and High logical operation. 2b. Differentiate between positive and negative logic system. 2c. State tri-state operation.	2.1 Two state operation 2.2 Positive and negative logic system 2.3 Tristate logic operation
	2d. Draw the symbol and equivalent electrical circuits of given gates. 2e. Explain functionality of any gate with the help of its truth table . 2f. Implement basic gates and other gates with the help of universal gate.	2.4 Basic gates : AND,OR, NOT Gate, universal gates: NAND and NOR, other gates:EX-OR, EX-NOR Equivalent electrical circuits, truth table and functional operation of each gates
	2g. State and verify First and Second De Morgan's theorem.	2.5 De Morgan's theorems
	2h. State Theorems of Boolean algebra.	2.6 Laws, theorems and postulates of Boolean algebra
	2i. Simplify the given expression using Boolean algebra and Karnaugh map method (up to 4 variables). 2j. Realise logic circuits of the simplified expression using truth table and AND-OR/ OR-AND/ NAND-NAND logic gates.	2.7 Boolean expression: Sum of products and product of sums 2.8 Karnaugh map method for simplification of Boolean expression

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – III Combinational Logic Circuits	3a. Define combinational logic circuit. 3b. Test the logic circuits with the help of truth table.	3.1 Combinational logic circuit. 3.2 Arithmetic Circuits: Half adder, full adder, half and full subtractor, 1's and 2's compliment subtractor circuit, 2's compliment subtractor/adder circuit.
	3c. Convert given numbers from binary to Gray and Gray to binary codes.	3.3 Code Converters: Binary to gray and gray to binary code converters (up to 4 bit).
	3d. Explain working of various given combinational circuits with logic diagram and truth table. 3e. List IC numbers of given combinational circuits.	3.4 Decoder (3 to 8), Encoder circuits (8 to 3). 3.5 Parity bit Generators and Checker circuits. 3.6 Multiplexer (4:1line), Demultiplexers (1:4 line).
Unit – IV Sequential Logic Circuits	4a. Define terms related to sequential logic circuits.	4.1 Digital clock signal, clock skew, duty cycle, synchronous and asynchronous circuit operation, Edge and Level triggered operation.
	4b. Differentiate between combinational and sequential circuit. 4c. Explain the truth tables of the given Flip flops. 4d. List the applications of Flip-Flop.	4.2 Flip-Flops: S-R, J-K, T and D. Truth table and logic circuits of each flip-flop
	4e. Define register and shift register. 4f. Describe with sketches the data movement in shift registers. 4g. List the applications of shift register in digital instruments.	4.3 Shift Registers: Series and parallel, shift, Serial in serial out, Shift Register.
	4h. List various counters. 4i. Explain the function of ripple counter (implemented using JK Flip flops) with the help of truth table.	4.4 Counters: Ripple counter, Mod counter, up – down counter, synchronous and asynchronous counters
	4j. Classify types of conversions. 4k. List applications of A/D and D/A Conversion in instrumentation 4l. Describe the block diagram of sensing motion.	4.5 A/D and D/A Converter 4.6 Digital Clock

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
	4m. Describe with block diagram working of a digital clock.	
Unit – V Control and Interfacing of process parameters	5a. Develop logic signals (0 and 1) 5b. Sketch the logic circuit for logical operations	5.1. Process Logic components for *level control* loop: Level Switch configuration: HL, HH, HHL, HHH, LL, LLL and LLH.
	5c. Develop logic signals (0 and 1) 5d. Sketch the logic circuit for logical and mathematical operations.	5.2. Process Logic components for *Temperature control* loop: Temperature Switch configuration: HL, HH, HHL, HHH, LL, LLL and LLH.
	5e. Develop logic signals (0 and 1) 5f. Sketch the logic circuit for logical operations	5.3. Process Logic components for *Pressure control* loop: Pressure Switch configuration: HL, HH, HHL, HHH, LL, LLL and LLH.
	5g. Develop logic signals (0 and 1) 5h. Sketch the logic circuit for logical and mathematical operations.	5.4. Process Logic components for *flow control* loop: Flow Switch configuration: HL, HH, HHL, HHH, LL, LLL and LLH.
	5i. Develop logic signals (0 and 1) 5j. Sketch the logic circuit ircuit for logical operations	5.5. Process Logic components for *Speed control* loop: Speed Switch configuration: HL, HH, HHL, HHH, LL, LLL and LLH.

5. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Number Systems	12	04	08	02	14
II	Logic Gates and Boolean Algebra	12	04	04	06	14
III	Combinational Logic Circuits	12	02	04	08	14
IV	Sequential Logic Circuits	08	02	02	03	07
V	Control and Interfacing of process parameters	12	03	06	12	21
Total		**56**	**15**	**24**	**31**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

6. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course Outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance.

Note: Here only course outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of Programme Outcomes/Course Outcomes in ***affective domain*** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Unit No.	Practical/Exercise ('Course Outcomes' in Psychomotor Domain according to NBA terminology)	Apprx. Hrs. Required
1.	II	Test the functionality of basic logic gates.	2
2.	II	Build/ test the functionality of exclusive-OR gate.	2
3.	II	Build/test the functionality of NAND gate as a universal logic gate.	2
4.	II	Build/test the functionality of NOR gate as a universal logic gate .	2
5.	III	Build/test the HALF ADDER circuit.	2
6.	III	Build/test the FULL ADDER circuit.	2
7.	III	Build/test HALF SUBTRACTOR circuit.	2
8.	III	Check the functionality of parity /generator checker circuit.	2
9.	IV	Build/ Test the Ripple counter(Four bit).	2
10.	IV	Check the performance of SEVEN SEGMENT display.	2
11.	IV	Build/ Test the functionality of SR flip-flop.	2
12.	IV	Build/ Test the functionality of JK flip-flop.	2
13.	IV	Build/ Test the shift register.	2
14.	IV	Determine the digital output for the given analog input signal through analog to digital converter circuit.	2
15.	IV	Determine the analog output for the given digital input the digital to analog converter circuit.	2
16.	V	Build/ Test AND, OR, EX-OR Logic circuits for temperature loop.	2
17.	V	Build/ Test AND,OR,EX-OR Logic for level loop.	2
18.	V	Build/ Test NAND,NOR Logic for temperature loop.	2
19.	V	Build/ Test NAND,NOR Logic for level loop.	2
20.	V	Build/ Test AND,OR,EX-OR Logic for flow loop.	2
21.	V	Build/ Test NAND,NOR Logic for flow loop.	2
		Total	**42**

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Students may be asked to collect photographs using internet which is relevant to field application of various topics and have to prepare learning materials using it.
ii. Teachers guided self learning activities, Course/library/internet/lab based mini projects, industrial visit etc.
iii. Students activities like: course/ topic based seminars, Internet based assignments.
iv. Students should deliver a seminar in groups on materials used in various Digital Techniques and advances/latest trends in Digital Techniques.

8. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Take small instrumentation components to the class when teaching
ii. Give simple numerical to students on Boolean Algebra
iii. Internet based home assignments
iv. Mini project

9. SUGGESTED LEARNING RESOURCES

A) List of Books:

S. No.	Title of Books	Author	Publication
1	Digital circuit	Kumar, Ananad	PHI Learning, New Delhi , Latest edition
2	Digital Electronics	Kharate, G.K.	Oxford University Press, Latest edition
3	Principles of digital electronics	Malvino and Leach	TMH, New Delhi , Latest edition
4	Digital Design	Mano ,M. Morris	Pearson, New Delhi , Latest edition
5	Digital electronics :Principles, devices and applications	Maini ,A .K.	John Willy and Sons, Latest edition
6	Digital Techniques	Godse ,A.P.	Technical publications, Latest edition
7	Applied Instrumentation in the Process Industries	William G. Andrews	Gulf Publication, London, Latest edition

B) List of Major Equipment/Materials with Broad Specifications

i. Bread boards
ii. DC Regulated power supply 0-30 volt DC (10 Nos.)
iii. Digital IC Tester (40 pins)
iv. Digital Logic trainer kit (10 Nos.)
v. Hardwired relay logic trainer (5 Nos.)
vi. Digital level switch, temperature switch, flow switch with logics HL, HH, HHL, HHH, LL, LLL and LLH.

C) List of Software/Learning Websites

i. www.nptel.com
ii. http://en.wikipedia.org/wiki/Digital_electronics
iii. http://my.safaribooksonline.com/book/electrical-engineering/computer-engineering/9780750645829/chapter-10dot-instrumentation-and-interfacing/
iv. http://www.hss.energy.gov/deprep/ftcp/directives/QSR-InstrumentationControl.pdf

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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- **Dr. Anjali Potnis**, Associate Professor, Department of Electrical and Electronics Engineering.
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GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Course Curriculum

CONTROL COMPONENTS
(Code: 3331704)

Diploma Programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	3rd semester

1. RATIONALE

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

2. COMPETENCY ('Programme Outcome' according to NBA Terminology)

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Maintain control components of instrumentation loop.**

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	200
3	0	4	7	70	30	40	60	

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

4. COURSE DETAILS

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Control Valve	1a. Define the valve parameters 1b. Name at least 7 types of control valve used in the industry. 1c. Describe the construction of at least 4 types of control valve 1d. Describe the functions of parts of control valves. 1e. State the procedure to test and calibrate	1.1. Control valve parameters: Rangeability, Hysteresis, Capacity, Linearity, etc. 1.2. Control valves in industries - Globe, Ball, Butterfly, Needle, Pinch, Diaphragm, Solenoid, Piston type valve (single acting/double acting). 1.3. Basic Parts of Control Valve: valve body, Trim, Stem, Plug, Cage, Seat, Bonnet, Actuator. 1.4. Flow characteristics of control valve 1.5. Calibration procedure
	1i. Classify control valves based on plug shapes and actuators 1j. Describe the working of a least 2 actuators and positioners with sketches and application 1k. Describe the characteristics of the actuators and positioners 1l. State the procedure to test and calibrate the actuators and positioners.	1.6. Classification of control valve as ATO/ATC, Linear/Rotary, Manually operated/Remote operated, Based on plug shapes, based on actuators 1.7. Valve actuators: Mechanical, Pneumatic (Diaphragm, piston), Hydraulic Electropneumatic, electrical 1.8. Valve Positioners: Mechanical, electrical 1.9. Calibration procedure
Unit – II Pneumatic Components	2a. State the need of pneumatic components 2b. Explain the working of pneumatic components with sketches	Pneumatic Components: Flapper-Nozzle, Air Filter Regulator lubricator, Volume Booster, Pneumatic Relay-Bleed/ Non-bleed, Direct/Reverse
Unit – III Piping Components	3a. Describe applications of each piping components with sketches	Piping component: Hydraulic Metallic, plastic) and Pneumatic (copper, steel, plastic) piping components- Mufflers, Reducers, Silencer, Bends, tees (equal, unequal), flanges, couplings (spring loaded\threaded),etc.
Unit – IV Control System Components	4a. Classify control system components 4b. Describe the construction of control system components with sketches 4c. Explain working principle	4.1. Control System Components: Synchros and Resolvers Servomotor-AC/DC 4.2. Stepper Motor-Variable reluctance, Permanent Magnet, Hybrid (CAV/CLV)

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
	control system components 4d. State the procedure to test the control system components 4e. Explain the working of a typical Gyroscope	4.3. Potentiometer and gyroscope: • Potentiometer- Linear and log (Linear, Rotary) • Potentiometer as an error detector 4.4. Gyroscope working principle
Unit V Safety and Auxiliary Components	5a. Identify the various types of relays, switches and auxiliary components from the list of given symbols. 5b. Classify the various types of safety and auxiliary components 5c. Explain the working of the various types of safety and auxiliary components 5d. State the testing procedure of the various types of safety and auxiliary components	**5** Safety and auxiliary components: a. Relays: Electromechanical, Reed, Solid state and Field Failure relay b. Switches i. Toggle switch: SPST, SPDT, DPST, DPDT ii. Push Button iii. DIP switch iv. Self illuminated resettable switch v. Rotary switch(Single pole/Multi pole) vi. Thumbwheel switch vii. Limit switch (mechanical lever type) viii. Proximity Switch: inductive, capacitive, optica ix. Flow switch: HHL, HL, LL, LLL x. Level switch: HHL, HL, LL, LLL xi. Pressure switch: HHL, HL, LL, LLL xii. Thermostat: HHL, HL, LL, LLL) xiii. Humidistat: HHL, HL, LL, LLL c. Auxillary Components: Alarm Annunciator, Square Root Extractor, Damper, Safety Valve, Relief Valve, Rupture Disc, Safety Relief Valve

5. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Control Valves	12	04	09	12	25
II	Pneumatic Components	04	01	02	02	05
III	Piping Components	04	01	02	02	05
IV	Control System Components	12	02	03	10	15
V	Safety and auxiliary components	10	02	04	14	20
Total		**42**	**10**	**20**	**40**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

6. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills (**Course Outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance.

Note: Here only course outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of Programme Outcomes/Course Outcomes in ***affective domain*** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Unit No.	Practical/Exercise ('Course Outcomes' in Psychomotor Domain according to NBA terminology)	Approx. Hrs. Required
1	I	Identify and Label basic parts of control valve.	2
2	I	Identify the type of valve from its construction.	2
3	I	Calibrate control valve.	2
4	I	Obtain the Globe valve characteristics .	2
5	I	Plot the graph of valve characteristics for given Ball valve.	2
6	I	Plot the graph of valve characteristics for given Butterfly valve.	2
7	I	Plot the graph of valve characteristics for given Needle valve.	2
8	I	Plot the graph of valve characteristics for given Pinch valve.	2
9	I	Plot the graph of valve characteristics for given Solenoid valve.	2
10	I	Plot the graph of valve characteristics for given Piston type valve.	2
11	I	Plot the graph of valve opening vs input air signal for given air to open type of valve.	2
12	I	Plot the graph of valve opening vs input air signal for given air to close type of valve.	2
13	I	Differentiate between the performance of rotary valve and linear valve.	2
14	I	Devise a plan to check working of electro pneumatic valve	2

		actuator.	
15	I	Observe the valve opening status at different pressure levels in pneumatic valve actuators.	2
16	I	Maintain pneumatic piston-cylinder actuator.	2
17	II	Plot the graph of voltage v/s pressure for given flapper nozzle system +	2
18	II	Analyze the effect of volume booster in line .	2
19	II	Test the air lock relay.	2
20	II	Check and observe the output reading of air filter regulator.	2
21	III	Check the effect of silencers,mufflers and reducers in hydraulic lines.	
22	IV	Examine the design of a 3-phase synchronous motor and learn how to connect it.	2
23	IV	Obtain Synchronous motor starting characteristic and determine the full-load and pull-off characteristic of a synchronous motor.	2
24	IV	Connect potentiometer as an error detector.	2
25	IV	Wire a servo motor and control it using labview program.	2
26	IV	Control the steps of stepper motor by varying the input pulse.	2
27	V	Test the given electro mechanical relay by energizing its coil.	2
28	V	Test the given reed relay by energizing its coil.	2
29	V	Test the given solid state relay(SSR) by energizing its coil.	2
30	V	Test the given Field failure relay by energizing its coil.	2
31	V	Test the operation of flow switch.	2
32	V	Test the operation of thermostat.	2
33	V	Test the operation of Pressure switch.	2
34	V	Test the operation of Humidistat.	2
35	V	Test the operation of Level switch.	2
36	V	Test the operation of given limit switch.	2
37	V	Test the operation of given proximity switch.	2
38	V	Test the operation of Toggle switch.	2
39	V	Test the operation of DIP switch.	2
40	V	Test the operation of Rotary switch.	2
41	V	Test the operation of Thumbwheel switch.	2
		Total	**84**

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Dismantle the control valve in order to recognize its internal parts.
ii. Calibrate the control Valve.
iii. Use proper piping elements for proposed hydraulic line.
iv. Control Temperature of given loop using thermostat.
v. Control Pressure of given loop using pressure switch.

8. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Visits to Industries
ii. Take small instrumentation components to the class when teaching
iii. Video films/animation films on working of different type of power stations from YouTube and other resources
iv. Mini project

9. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Books	Author	Publication
1	Control system components	B. Chatterjee	Khanna Publishers, latest edition
2	Control system components	M D Desai	PHI Learning,
3	Applied instrumentation in process industries	W. G Andrews	Gulf Publishing co., Houston
4	Instrumentation engineer's handbook	B.G Liptak	Chilton Book Co., Philadelphia
5	ISA handbook of control valves	James W Hutchison	ISA
6	Instrumentation and Control systems	D S Kumar	
7	Valve selection handbook	R W Zappe	Gulf Publishing Co., Houston

B) List of Major Equipment/Materials with Broad Specifications

i. Pliers,Screwdriver and other hand tools
ii. Multimeter
iii. Voltage Source
iv. pressure source
v. Air compressor

C) List of Software/Learning Websites

i. www.control.com
ii. En.wikipedia.org
iii. www.youtube.com
iv. www.valveinternational.co.za
v. books.google.com

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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- **Prof. A. M. Patel,** HOD IC Engineering, Govt. Polytechnic, Palanpur
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Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering
- **Dr. Shashikant Gupta**, Professor and Coordinator for State of Gujarat

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT
Course Curriculum

PROCESS APPLICATION AND INSTRUMENTATION MAINTENANCE MANAGEMENT

(Code: 3331705)

Diploma Programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	3rd semester

1. RATIONALE

In the present industrial scenario, it is desired that diploma engineering students should be able to identify, classify, troubleshoot and maintain the different Process Instrumentation systems. They are required to implement the planned Plant Process Instrumentation maintenance schedules. Therefore, this course has been designed so that students may learn to maintain the different types of Process Instrumentation Systems of Process Application.

2. COMPETENCY (Programme Outcome' according to NBA Terminology)

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:
Maintain the different types of Process Instrumentation Systems of Process Application

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Total Credits	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** – Credit;;
ESE - End Semester Examination; **PA** - Progressive Assessment.

4. COURSE DETAILS

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I **Process Applications using Instrumentation**	1a. Classify the various types of processes. 1b. Compare the specific need of Maintenance in batch process and continuous process of them	1.1 Types of Processes based on: 1.1.1 Period of operation of the process viz. Batch process , Continuous process 1.1.2 Type of Process: Unit operation /Unit Process/ Composite / Hybrid Processes
	1c. State Maintenance requirement for various process industries and state hazards (if not maintained)	1.2.1 For Food and Beverages industries(bottle filling plant-batch process) 1.2.2.For Thermal Power Plant(material feeding in boiler to turbine-continuous process)
Unit– II **Insrumentation Maintenance Engineering Techniques**	2a. Classify and define the types of maintenance	2.1 Time based Maintenance: a)Preventive (shift wise, daily, weekly, monthly, quarterly half yearly, yearly) b) Shutdown c) Break down 2.2 Event based Maintenance- a)Run to Failure or Reactive b)Event driven c)*Calendar based or Pre-planned or Routine* d)Statistical based e)Condition based f)Predictive Maintenance g)Reliability Centered Maintenance h)Financially Optimized Maintenance

	2b. Define terminology Related to Maintenance in Process industries.	2.3 List of terminology 2.3.1 Autonomous Maintenance, 2.3.2 Bill of Materials (BOM), 2.3.3 Computerized Maintenance Management System (CMMS), 2.3.4 Corrective Maintenance, 2.3.5 Failure Mode and Effects Analysis (FMEA), Frequency of Inspection, 2.3.6 Key performance Indicator (KPI), 2.3.7 Life Cycle Cost (LCC), 2.3.8 Maintenance, 2.3.9 Maintenance Engineering 2.3.10 Maintenance Management, 2.3.11 Mean Down Time (MDT), 2.3.12 Mean Time Between Failures (MTBF), 2.3.13 Mean Time To Repair (MTTR), 2.3.14 Purchase Order (PO, 2.3.15 Root Cause Failure Analysis (RCFA), Scheduling , 2.3.16 Uptime, 2.3.17 Work Order, 2.3.18 Work Request
Unit–III **Field, Utility and Safety Instrumentation Components Maintenance**	3a. Test each type of Instruments. 3b. Describe the calibration procedure for each type Of instruments. 3c. Describe the maintenance procedure for each type Of instruments.	Types of Instruments in the process plants: 3.1. Indicating instruments: 3.1.1. Analog Temp. indicator 3.2. Recorders: 3.2.1 Circular Chart, 3.2.2 Strip Chart 3.3. Transmitters :

		3.3.1Electronic Differential Pressure Transmitter 3.3.2 Pneumatic Differential Pressure Transmitter 3.4 Switches: 3.4.1.Pressure Limit Switch 3.4.2 Level Limit Switch 3.5. Valves: 3.5.1 Globe valve
Unit– IV Instrumentation Maintenance Hardware and Software	4a. Describe the application of each tools used for Maintaining Instruments. 4b. Describe the procedure to maintain and calibrate the tools used for Maintaining Instruments	4.1List of tools: 4.1.1 Dead weight Tester 4.1.2 Temp. Controlled Bath, 4.1.3 Temp. Controlled Oven 4.1.4 Assorted Pneumatic and Hydraulic tubing/ piping tools 4.1.5 Pnematic Calibrator, 4.1.6 Electronic Calibrator, 4.1.7 Thermo Couple Calibrator. 4.1.8 Digital Multimeters with True RMS, 4.1.9 Soldering / Desoldering Station, 4.1.10 Universal Calibrator
Unit – V Instrumentation maintenance reporting and management	5a. List and give various Types of reporting Formats with sample data Used in instrumentation Maintenance management System.	5.1. Reports: Instrument bin card, instrument log book, maintenance indent book (physical, human resource) instrument complaint book

5. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total
I	Process Applications using Instrumentation	6	3	3	2	8
II	Insrumentation Maintenance Engineering Techniques	6	6	6	0	12
III	Field Utility and Safety Instrumentation Components, Maintenance	12	5	5	10	20
IV	Insrumentatio Maintenance Hardware and Software	11	5	5	10	20
V	Instrumentaion maintainence reporting and managemen t	7	2	5	3	10
	Total	**42**	**21**	**24**	**25**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as only general guideline for students and teachers. The actual distribution of marks in the question paper may vary from above table.

6. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course Outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance.

Note:

Here only course outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in *affective domain*** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Unit No.	Practical Exercise('Course Outcomes' in Psychomotor Domain according to NBA terminology)	Approx Hours Required
1.	I	Identify the continuous process from a textile industry.	02
2.	I	Identify the batch process from a textile industry .	02
3.	I	Prepare a daily maintenance schedule for a given process.	02
4.	I	Prepare a weekly maintenance schedule for a given process.	02
5.	I	Prepare a monthly maintenance schedule for a given process.	02
6.	I	Prepare a half-yearly maintenance schedule for a given process.	02
7.	I	Prepare a yearly shut down maintenance schedule for a given process.	02
8.	I	Maintain the indicating instruments for a given process.	02
9.	II	Maintain the controlling instruments for a given process.	02
10.	II	Maintain the recording instruments for a given process.	02

11.	III	Maintain the final control elements/instruments for a given process.	02
12.	IV	Test the performance of the final control elements/instruments for a given process	02
13.	V	Log the maintenance activity carried out for a given process.	02
14.	V	Carry out maintainance activity with Antivirus / Authorization/ Password for a given computerized maintenance management software.	02
	Total		**28**

7. SUGGESTED LIST OF STUDENT ACTIVITIES

i. Students may be given exercises based on various instrumentation devices and components to maintain related to above topics.

ii. Students may be asked to collect photographs using internet which is relevant to field application of various topics and have to prepare learning materials using it.

iii. Teachers guided self learning activities, Course/library/internet/lab based mini projects, industrial visit etc.

iv. Students activities like: course/ topic based seminars, Internet based assignments.

8 SUGGESTED LEARNING RESOURCES

A) List of Books

S.No.	Author	Title of Books	Publication/Year
1	ld Goettsche.	Maintenance of Instruments and Systems,.	ISA 2nd Edition ld Goettsche
2	Lindley R. Higgins, R. Keith Mobley, Darrin Wikoff	Maintenance Engineering Handbook, Seventh Edition	
3	W G Andrew	Applied Instrumentation to Process Industries	Gulf Publication Vol 1 to 4
4	Jones E. B.	Instrument Technology,	Hollywell Vol - I, II
5	H. S Kalsi	Electronic Instrumentation	TMH New Delhi 2010

B. List of Major Equipment/ Instrument with Broad Specifications

1) **Instrument Maintenance Shop Tools**
   a) Dead weight tester / Comparison Guage,
   b) Temp. Controlled Bath ,
   c) Temp. Controlled Oven ,
   d) Assorted Pneumatic and Hydraulic tubing/ piping tools ,
   e) Pnematic Calibrator , Electronic Calibrator ,
   f) Thermo Couple Calbrator, Indicator puller,
   g) Impulse line bending and flaring tools,Allenkey set,
   h) Open and Ring fix Spanner set,
   i) Adjustable pipe wrench and Spanner,
   j) Screw Driver set,
   k) Digital Multimeters with True RMS 41/2 Digit ,
   l) Clip on meters ,
   m) Assorted Eletrical Insulated Tools set ,
   n) Soldering / Desoldering Station,
   o) Drilling M/c ,
   p) Mini Compressor,
   q) Mechanical Vice ,
   r) Megger / insulation tester,
   s) Fibre Optic assorted tools – Splicer , Alignment tool , cutter , Splitting Tools,All assorted
   t) Magnetic tools,
   u) All maintenance Consumables viz , Isopropyle Alcohol, Silicon Oil, Sprays ,CTC ,Thermic
   v) Fluids ,Silicon Grease, Graphite based Grease, Clove Oil, Chart recorder Inks – Red/ Blue/
   w) Black

2) **Standards Equipment Room Equipment**
   a) High precision dead weight tester (customs design)
   b) High precision voltmeter
   c) General purpose oscilloscope
   d) Stabilized power supply (high precision-high and low voltage)
   e) High precision weighing balance
   f) Precision resistance thermometers
   g) One set of glass thermometers (-5 to +250°c)
   h) Precision variable resistance (decade box)
   i) Whetstone bridge
   j) High precision barometer
   k) High precision dew point hygrometer
   l) Standard platinum resistance
   m) Precision current source
   n) Flat bed recorder
   o) Standard thermocouples

3) **Pneumatic 'shop'**
   a) Precision pressure regulator
   b) Pneumatic test rig for controllers (depending on manufacturer)
   c) Set of precision gages
   d) Low pressure/vacuum calibration system
   e) Pneumatic calibration unit
   f) Digital pressure calibrator (300 mbar)
   g) Digital pressure calibrator (1.6 bar)
   h) Digital pressure calibrator (10 bar)
   i) High pressure test kit (200 bar)
   j) Portable low pressure pump
   k) Portable calibrator
   l) Pneumatic calibrator- electro
   m) Pneumatic calibrator
   n) Absolute pressure unit

4) **Electronic 'shop'**
   a) Portable temperature indicator (6½ digits)
   b) Portable multivolt meter (6½ digits)
   c) Whetstone bridge
   d) Variable resistance (decade box)
   e) Analogic voltmeter multi-function
   f) Logic analyzer
   g) Electronic voltmeter
   h) Digit al counter frequency meter
   i) Universal impedance measuring bridge
   j) Adjustable and portable power supply (high + low voltage)
   k) Function generator
   l) Programmable pulse generator
   m) General purpose oscillator
   n) Transistometer
   o) Stroboscopic tachometer
   p) Calibration set for vibration monitor
   q) Digital circuit tester
   r) Milli-ohm meter (in 0.001 ohm steps)
   s) High resistance meter (500 kohms)
   t) Pt 100 simulator
   u) Flat bed recorder (dual bed)
   v) Portable tachometer
   w) Xy recorder (dual bed)
   x) Set of standard resistors (10 000 to 1 000 ohm)

y) Set of standard platinum resistances
z) Test oscilloscope microprocessor (to be kept in the control room, for integrated control systems)
aa) Digital oscilloscope with memory
bb) Low-voltage megger (50 volts)
cc) High-voltage megger (500 volts)
dd) Earth fault detector
ee) Specific 'manufacturers' calibrator
ff) Cold junction reference
gg) Computer peripherals.

5) **Special Test-Benches**
   a) Control valve
   b) Hydraulic (portable type)
   c) Temperature.

6) **Standard Test-Benches**
   a) Light Duty
   b) Pneumatic
   c) Electronic
   d) Dcs And Plc
   e) Analyzer (General Duty)
   f) Analyzer (specific duty)

7) **Test equipment**
   a) Set Of Precision Pressure Gages
   b) Low-Pressure Calibration Unit (Including Vacuum)
   c) Set Of Digital Pressure Calibrators (300 Mb To 10 Bar)
   d) Pneumatic Portable Calibration Unit (0.2 To 1 Bar)
   e) Portable Temperature Indicator (Tc Simulator)
   f) One Or Two Electronic Digital Accurate Voltmeters
   g) Variable Resistance (Decade Box)
   h) Portable Oscilloscope (General Purpose)
   i) Pt 100 Simulator Calibrator
   j) Portable Tachometer
   k) Manufacturer's' Calibrator(S)
   l) Portable Pulse And Function Generator
   m) Portable Variable Power Supply (Amps/Volts).
      i) b) Standard Voltage/frequency Sources

8) **List of Software/Learning Websites**
   a) Predictive Maintenance software module of DCS
   b) Instrumentation Preventive Maintenance software.
   c) www.mainpac.com/ Maintenance Software

d) http://confirm.pbbiblogs.com/2009/11/28/8-types-of-maintenance-a-comparison/
e) www.maintenancephoenix.com/.../8-steps-to-success-in-maintenance-
f) www.reliabilityweb.com/.../Maintenance%20Scheduling%20101.pdf
g) Maintenance Event Builder (MEB). Soft ware
h) www.clicksoftware.com/service_schedule
i) www.mainpac.com/ Maintenance Software
j) http://www.mainpac.com.au/ Preventive Maintenance Software
k) www.clicksoftware.com/service_schedule SOFTWARE

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Visits to Industries
Take small instrumentation components to the class when teaching
Internet based home assignments
Mini project

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnic

1. **Prof.R.R. Manchiganti**, HOD IC Engineering, G. P. Gandhinagar

2. **Prof. N.B.Mehta,** Lecturer IC Engineering, Government Polytechnic Ahmedabad
3. **Prof. H.P.Patel,** Lecturer IC Engineering, Government Polytechnic Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

1. **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering.
2. **Dr. Shashikant Gupta**, Professor and Cordinator for State of Gujarat.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Course Curriculum

INSTRUMENTATION DRAWING
(Code: 3331706)

Diploma Programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	3rd semester

1. RATIONALE

For an Instrumentation and control diploma engineer, it is important to interpret relevant circuit diagrams with the symbols, draw circuit diagrams and identify the various components relevant to process and instrumentation. These drawings could be of process and instrumentation diagram, process flow sheets, instrument location plan and such others. Ability to document as per international codes and practices (ISA, IEEE, NEMA) is also an essential skill required by IC engineer. This course will therefore help the students to develop the skills to draw and interpret requisite process instrumentation loop diagrams (using knowledge of relevant symbols and standard conventions) and to document records properly.

2. COMPETENCY ('Programme Outcome' according to NBA Terminology)

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Draw requisite process instrumentation loop diagrams using standard symbols and conventions.**

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
0	0	4	4	0	0	40	60	100

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

4. COURSE DETAILS

Unit	Major Practical Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Process Flow Sheet Symbol	1a Identify the symbols 1b Draw the symbols 1c Label the symbols	1.1 Process line symbols 1.2 Symbols of valves (gate , globe, needle, ball valve, vee, three way, four way, angle, plug, check, butterfly valve) 1.3 Symbols of actuator with and without positioner or other pilot. 1.4 Furnace and boiler symbols("A" Frame, Box type, single coil Radiant type, Vertical, Boiler fired or waste heat) 1.5 Heat transfer symbols (Water cooled exchanger, Water cooled condenser, Shell and tube exchanger, Cooling tower, kettle – thermo siphon type Re-boiler , Super heater and re heater, Barometric condenser) 1.6 Pump and compressor(centrifugal, reciprocating, rotary, proportioning, lower or fan centrifugal) 1.7 Drivers(Motor, engine, turbine and steam piston) 1.8 Process pressure vessels (Horizontal, vertical, jacketed) 1.9 Dryers (Batch, Spray, Desiccant, rotary drum dryer or kiln) 1.10 Material handling equipments(Air lift, belt or shaker, Bucket or flight conveyor, screw conveyor, roller conveyor, feeder and hopper , rotary feeder) 1.11 Size reducing equipments(Ball mill, Grinder, Roller crusher, screener) 1.12 Process Equipment(Mixer, Settlers, autoclave, Kettle jacketed, rotary film dryer or floker, Jet mixer) 1.13 Separator (centrifuge, cyclone, electrical precipitator, drum settler, open settling tank, rotary vacuum filter, atmospheric tank, floating roof tank, pressure storage tank, cone bottom bin, open top-closed top bulk storage)
Unit – II Flow Sheet and Line Symbols	2a Identify the symbols 2b Draw the symbols 2c Label the symbols 2d Define letter identification	2.1 Flow sheet code letter service (letter A to letter V) 2.2 Symbol for Lines (Main process line, secondary process line, instrument air signal line, electrical leads, instrument capillary

Unit	Major Practical Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
		tubing, Battery limits, Existing lines, Vehicle or hand truck route , package unit by vendor, screwed cap, weld cap, blind flange, insulated line, hose connection , flexible hose connection , Removable pipe spool, steam trace line, steam jacketed line) 2.3 Utility symbols(duct, swage, spectacle blind, hammer blind, expansion joint, open drain to sewer, damper, utility rack, safety shower 'S' and eye wash'E', sample funnel, drain to sewer, steam trap – intermittent, steam trap-continuous 2.4 Drainer, strainer, filter, mixer, twin basket filter, spray nozzle, suction Tee, ejector-eductor-injector and exhauster, Horn, Air cleaner, steam separator, bootleg, seal legs, Hose reel, gage hatch, man-hole, flame arrester, diffuser, car sealed open-car sealed close-locked open-locked close, steam exhaust head winter type drain 2.5 Process and utility flow sheet for drives(centrifugal pump-electrical drive, centrifugal pump turbine drive, reciprocating pump steam drive, reciprocating pump-electric drive, rotary pump electric drive, rotary pump turbine drive, tandem pumps, compressor – single type engine drive, blower electric type, electric turbine drive
Unit – III Instrument Symbol and Identification	3a Identify the symbols 3b Draw the symbols 3c Label the symbols 3d Define letter identification	3.1 Instrument identification or tag number (6 letter code) 3.2 Identification of letter (A to Z) 3.3 Instrument line symbols(Instrument supply, undefined signal, Pneumatic signal , electric signal, hydraulic signal, capillary tube, guided – unguided EM or SONIC signal, internal system link, mechanical link, pneumatic and electric binary signal) 3.4 Symbols of function designations for relays 3.5 Symbols for primary location, field mounted, auxiliary location for discrete instruments, shared display and control, computer function and PLC 3.6 Symbols for self actuated regulators, valves

Unit	Major Practical Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
		and other devices for: Flow, Level, Pressure, Temperature, Traps, Multiple way valves, Primary element symbols (A to Z), Function symbols (A to Z)
Unit – IV Logic Function , PLC and Distributed Control Display Symbols	4a Identify the symbols 4b Draw the symbols as per ISA, NEMA standard 4c Label the symbols 4d Define letter identification	4.1 Logical function symbols i. Gates (AND , OR, NOT, NOR, NAND,EX-OR, EX-NOR, transmission gate, Gate isolated, Gate non isolated) ii. Transmission and Switching symbols(Flip-flop, single shot flip flop, level /schmett trigger flip flop, Amplifier , switching amplifier, signal converter) iii. Timer (Signal time delay, adjustable time delay, Time delay ON, Time delay OFF, time delay energizing, time delay de energizing) 4.2 Switching symbols for PLC i. Push buttons (single circuit normally ON , single circuit normally OFF, double circuit , Double circuit with mushroom head) ii. Foot switch (Normally open/OFF, Normally close/ON) iii. Limit switch (Normally open/OFF, Normally close/ON) iv. Process parameter switch(liquid level Normally open/OFF, liquid level Normally close/ON ,Vacuum-pressure Normally open/OFF, Vacuum-pressure Normally close/ON, Temperature switch Normally open/OFF, Temperature switch Normally close/ON, Air-Water-gas etc. Flow Normally open/OFF, Air-Water-gas etc. Flow Normally close/ON) v. Output device(coil, motor, lamp, solenoid, optocoupler) 4.3 Distributed control / shared display symbols(As per ISA) i. Normally accessible to operator ii. Not Normally accessible to operator iii. Auxiliary operator's interface device 4.4 Distributed control Computer symbols i. Normally accessible to operator ii. Not normally accessible to operator

Unit	Major Practical Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
		4.5 Distributed control logic/sequential Control symbols i. Normally accessible to operator ii. Not normally accessible to operator 4.6 Miscellaneous symbols i. Computing/signal conditioning ii. software system link
Unit – V Piping and Fluid Power Symbols	5a Identify the symbols 5b Draw the symbols flanged, screwed, welded, soldered 5c Label the symbols 5d Define letter identification	5.1 Piping symbols for Bushing, Cap, reducing cross, straight size cross, Cross over, 45˚ Elbow, 90˚ Elbow, long radius double branch , reducing double branch, Connecting pipe joint, Expansion pipe joint, Lateral, reducing flange, bull plug, pipe plug, sleeve, reducing tee, straight size tee, output up tee, output down tee, union, 5.2 Flow Obstruction symbols(orifice flange, Check angle valve, Gate (elevation) angle valve, Gate(plan) angle Valve, By-pass automatic valve, Governor operated automatic valve, reducing automatic valve, cock, float valve, diaphragm valve, motor operated gate valve, hose valve, safety valve 5.3 Fluid power symbols i. Line technique(Main line conductor, Pilot line, Exhaust/drain line, enclosure outline, line crossing at 90˚ line joining) ii. Flow direction of pneumatic, hydraulic iii. Rotating coupling, vented reservoir, pressurized reservoir, reservoir with connecting line for above fluid level, reservoir with connecting line for below fluid level, vented manifold, Accumulator, Spring loaded accumulator Gas charged accumulator, Air/Gas receiver, fluid conditioners iv. Heater, Cooler, Temperature controller, filter-strainer, manual drain separator, automatic drain separator, manual drain filter-separator, automatic drain filter-separator, chemical dryer, lubricator with less drain, Lubricator with manual drain v. Hydraulic and pneumatic Cylinders (single acting, single end rod double acting, double

Unit	Major Practical Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
		end rod double acting, fixed/adjustable/ non cushion double acting) vi. Pressure insentifier, servo positioner, discreate positioner vii. Actuator and control: a. Contact type(Spring , Manual operated push button, lever, Pedal, mechanical, detent, pressure compensated) b. Electrical / hydraulic, pneumatic Motors and pumps(Uni-bi directional) c. Instruments(pressure /temperature / flow indicator-recorder) d. Sensing(Venturi, orifice plate, pitot tube, nozzle) e. Valve (two way ON-OFF Valve, two way pilot- operated to open check valve, two way pilot- operated to close check valve, two position normally open two way valves, two position normally close two way valves, infinite position normally open two way valves, infinite position normally close two way valves, two position normally open three way valves, two position normally close three way valves, two position normal four way valves, two position actuated four way valves, three position normal four way valves , three position right actuated four way valves, three position left actuated four way valves f. Pressure control valves(pressure relief valve, sequence valve, pressure reducing valvepressure reducing and relieving valve, air line pressure regulator g. Flow control valves (adjustable, Adjustable with bypass, Adjustable and pressure compensated with bypass, temperature and pressure compensated adjustable)

5. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Not Applicable

6. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills (**Course Outcomes in psychomotor and affective domain**) so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance.

Note: Here only course outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in affective domain** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Unit No.	Practical/Exercise ('Course Outcomes' in Psychomotor Domain according to NBA terminology)	Apprx. Hrs. Required
1	I	Sketch the process line symbols	2
2	I	Sketch the different valve symbols	2
3	I	Sketch the different heat transfer equipment symbols	2
4	I	Sketch the different process equipment symbols	2
5	II	Sketch the different flow sheet code letter service	2
6	II	Sketch the different Symbol for Lines	2
7	II	Sketch the different Utility symbols	2
8	II	Sketch the different process and utility flow sheet for drives symbols	2
9	III	Sketch the different instrument identification or tag number (6 letter code) schemes	1
10	III	Sketch the different identification of letter (A to Z)	2
11	III	Sketch the different instrument line symbols	2
12	III	Sketch the different symbols of function designations for relays	2
13	III	Sketch the different symbols for primary location, field mounted, auxiliary location for discrete instruments	2
14	III	Sketch the different symbols for self actuated regulators, valves and other devices for flow , level, pressure, temperature	2
15	III	Sketch the different symbols for self actuated regulators, valves and other devices for traps, multiple way valves	2
16	III	Sketch the different symbols for self actuated regulators, valves and other devices for primary element symbols(A to Z)	4
17	III	Sketch the different symbols for self actuated regulators, valves and other devices for function symbols(A to Z)	4
18	IV	Sketch the different Logical function symbols for different gates, transmission - switching , timers	2
19	IV	Sketch the different push buttons, foot, limit switches	1
20	IV	Sketch the different process parameter switches used for PLC	2
21	IV	Sketch the different graphical symbols used for distributed control system	2
22	V	Sketch the different graphical symbols for piping and joints	2

S. No.	Unit No.	Practical/Exercise ('Course Outcomes' in Psychomotor Domain according to NBA terminology)	Apprx. Hrs. Required
23	V	Sketch the different graphical symbols for flow obstruction	2
24	V	Sketch the different graphical symbols for fluid power transmission and storage	1
25	V	Sketch the different graphical symbols for hydraulic and pneumatic cylinders	2
26	V	Sketch the different graphical symbols for different electric, hydraulic and pneumatic motor and pumps	2
27	V	Sketch the different graphical symbols for sensing elements and 2,3,4 way valves	2
28	V	Sketch the different graphical symbols for pressure and flow control valves	2
	Total		**56**

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Study P & I diagram of given chemical process.
ii. Study P & I diagram of given textile process.
iii. Study P & I diagram of given automobile manufacturing.
iv. Prepare chart for different categories of symbols.
v. Study colour code for different zone/electric/piping fluid.

8. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Demonstration using Power Point Presentation
ii. CBT based self learning session
iii. Display of Industrial Drawings for Interpretation
iv. Visit to Industry and correlating drawing with the actual systems
v. Practical exercises both manually and on computer using different drawing software.
vi. Mini project

9. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Books	Author	Publication
1	Applied Instrumentation in the process industries vol.3	W.G. Andrew/ H.B.Williams	Gulf publishing co. Kuwait 2012
2	DOE Fundamental handbook engineering symbology, prints and drawing	Department of energy	Department of energy USA 2012
3	Instrumentation and control system documentation	Frederick A. Meier and Clifford A. Meier	ISA USA year 2004 awarded best selling ISA book
4	Process control principles and applications	Bhanot Surekha	Oxford University Press year 2011

B) List of Major Equipment/Materials with Broad Specifications

i. High end computers (22 No) with enhanced graphic card & 20 inch Display
ii. Media Projector -3000 lumens
iii. Electrical CAD software
iv. AutoCAD software
v. Chemsketch software
vi. Three colour plotter
vii. Instrumentation component stencil
viii. Drawing tools.

C) List of Software/Learning Websites

i. www.isa.org
ii. www.nema.org
iii. www.ieee.org
iv. www.ourinstrumentationgroup.com
v. www.chemsketch.en.malavida.com

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Mr. R. R. Manchiganti**, Head of IC Engineering Department, GPGandhianagar
- **Mr. A. K. Bilakhia**, Lecturer, IC Engineering Department, GP Gandhinagar
- **Mr. M. B. Vanara**, Lecturer, IC Engineering Department, GP Gandhinagar
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- **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering.
- **Dr. Shashikant Gupta**, Professor and Coordinator for State of Gujarat. .