GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: ELECTRONIC AND PNEUMATIC INSTRUMENTATION
(COURSE CODE:3351701)

Diploma Programmers in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	5th semester

1. RATIONALE

In spite of the massive transition of the process control industry from the pneumatic to an electronic and digital age ,the study of pneumatic instrumentation is significantly essential since pneumatics are still widely used in the control valves of the control loops. Through this course the students will acquire sound theoretical and practical knowledge of the various pneumatic and electronic instruments widely deployed in the process industries.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in the students so that students are able to acquire following competency.

- **Operate and Maintain electronic and pneumatic instruments.**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes..

i. Classify and identify the instrument according to signal type.
ii. State standard signal units and ranges and perform signal conversion.
iii. Select and operate pneumatic and electronic instrument
iv. List application of electronics and pneumatic instrument
v. Differentiate pneumatic vs. electronic instrumentation and control systems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (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 Theory Practice; **P** - Practical; **C** – Credit **ESE** - End Semester Examination; **PA** - Progressive Assessment.

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (Outcomes in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals of Measurement	1a Classify and list electronic instrument based on laboratory/testing/ Field instruments. 1b Describe working principle, construction of electric meters/instruments with neat schematic diagram (1.2.1 to 1.2.4). 1c Enlist applications of electric meters/instruments (1.2.1 to 1.2.4). 1d Draw block diagram of basic instruments and explain operation in detail.(1.3.1 to 1.3.5) 1e Enlist application of listed test instruments (1.3.1 to 1.3.5) 1f Enlist additional features of DSO with reference to CRO. 1g Classify and list types of Measurement Bridge. 1h State Uses of bridges in Instrumentation 1i Explain the circuit diagram of Wheatstone bridge and derive the expression for unknown resistance. 1j Explain the circuit diagram of Kelvin Bridge. 1k Enlist applications of Wheatstone bridge and Kelvin Bridge. 1l Describe working principle and construction of AC bridge with neat diagram(1.4.2) 1m Discuss importance of isolation. 1n Describe isolation technique in detail.	1.1 Classification of electronic instruments as under • Laboratory- / Testing instruments. • Field instruments. 1.2 Electrical meters/Instruments 1.2.1 PMMC type 1.2.2 Rectifier type 1.2.3 Moving Iron type 1.2.4 Electro dynamic type 1.3 Test instruments 1.3.1 Standard signal generator (S.S.G.). 1.3.2 Ramp type DVM 1.3.3 CRO 1.3.4 Digital storage oscilloscope(DSO) 1.3.5 Electronic calibrator 1.4 Classification of measuring Bridge 1.4.1 DC bridges (for resistance measurement) • Wheatstone Bridge • Kelvin Bridge 1.4.2 AC bridges(for inductance/capacitance measurement) • Maxwell's Bridge • Anderson's bridge • Desauty's's bridge 1.5 Isolation and its techniques 1.6 Need for standardization of signals-Current, voltage, and pneumatic signal standards

	1o State need for standardization of signals. 1p State standard unit and range for pneumatic signal used in instrumentation. 1q State standard unit and range for electronic signal used in instrumentation.	
UNIT II Pneumatic Instrumentation	2a Enlist components of a self-balancing instruments. 2b Explain self-balancing principle of pneumatic instruments with neat schematic diagram. 2c Explain the construction and working of flapper nozzle system with neat diagram. 2d State the needs of Pilot relay. 2e Explain construction and working of Pilot relay with schematic diagram. 2f Describe construction and working of pressure regulator with neat sketch. 2g Explain different types of balancing principle with schematic diagram. 2h Explain construction and operation of various pneumatic controller with the help of neat sketch. (2.6.1 to 2.6.6).	2.1 Self-balancing instruments 2.2 Flapper Nozzle Mechanism (For Revision) 2.3 Pilot Relay Bleed & Non Bleed type 2.4 Pressure Regulator. 2.5 Different types of balancing Principles 2.5.1 Moment balance 2.5.2 Motion balance 2.5.3 Force balance 2.6 Pneumatic Controllers 2.6.1 On-Off Controller 2.6.2 P Controller 2.6.3 I Controller 2.6.4 P+I Controller 2.6.5 P+D Controller 2.6.6 P+I+D Controller
UNIT-III Electronic Instrumentation	3a Compare electronic and pneumatic instruments. 3b Describe function of electronics instruments. (3.2.1 To 3.2.5) in brief. 3c State uses of listed electronics instruments (3.2.1 to 3.2.3) 3d Draw general block diagram of different types of electronic controller and explain each block in detail. 3e Explain operation of various types of electronic controller with the help of op amp circuit diagram (3.6.1 to 3.6.6). 3f Define Proportional Band and	3.1 Electronic Instruments versus Pneumatic instruments 3.2 Electronics instruments 3.2.1 Instrumentation amplifier. 3.2.2 Integrator. 3.2.3 Differentiator. 3.3 Electronics controllers 3.6.1 On-Off Controller 3.6.2 P Controller 3.6.3 I Controller 3.6.4 P+I Controller 3.6.5 P+D Controller 3.6.6 P+I+D Controller 3.4 Controller tuning and alignment. 3.4.1 Tuning Methods:

	Offset Error. 3g Draw output response of P, I, D, P+I, P+D, P+I+D for step, pulse, ramp and sinusoid input. 3h State mathematical expression for P, I, D, P+I, P+D, P+I+D control action. 3i List out steps to be followed for controller tuning and alignment. 3j Explain in brief tuning methods for controller.	• Process Reaction Curve (open loop) • Ziegler Nichols (closed loop)
UNIT-IV Pneumatic and Electronic transmitters	4.a Describe need of transmitter. (Concept of field area & control room area). 4.b State types of transmitter. 4.c With the help of neat diagram, describe construction and working of force balance type pneumatic transmitter. 4.d With the help of neat diagram, describe construction and working of motion balance type pneumatic transmitter. 4.e Describe construction and working of force balance type electronic transmitter with the help of neat diagram. 4.f Describe construction and working of Motion balance type electronic transmitter with the help of neat diagram. 4.g State the features of intelligent transmitter. 4.h Draw and explain basic block diagram of smart transmitter. 4.i Compare conventional transmitter with smart transmitter.	4.1 Need of transmitter (concept of field area & control room area) 4.2 Types of transmitters • Pneumatic Transmitter • Electronic Transmitters 4.3 Pneumatic Transmitter 4.3.1 Force Balance Transmitter 4.3.2 Motion Balance Transmitter 4.4 Electronic Transmitters 4.4.1 Force Balance Transmitter 4.4.2 Motion Balance Transmitter 4.4.3 Intelligent and SMART Transmitter
UNIT-V Signal Converters and instrument transformer	5.a Explain the operation of current transformer with the schematic diagram. 5.b Explain the operation of potential transformer with schematic diagram. 5.c Describe the characteristics of current transformer and potential transformer.	5.1 Current Transformer. 5.2 Potential Transformer. 5.3 Converters 5.3.1 Electrical converter • Resistance to Current Converter • Resistance to Voltage Converter • Voltage to Current Converter

	5.d Enlist types of converter. 5.e Describe the construction and working of converters (5.3.1). 5.f Explain the working of Pneumatic to Electronic (P/I) converter with the schematic diagram. 5.g Explain the working of Electronic to pneumatic (I/P) converter with the schematic of diagram.	• mV to Current Converter for thermocouples • AC to DC Converter for mA 5.3.2 Pneumatic to Electronic (P/I) converter. 5.3.3 Electronic to Pneumatic (I/P) converter.

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

7.

UNIT NO.	TITLE	TEACHING HOURS	DISTRIBUTION OF THEORY MARKS			
			R LEVEL	U LEVEL	A LEVEL	TOTAL MARKS
I	Fundamentals of Measurement	10	02	08	04	**14**
II	Pneumatic Instrumentation	08	02	06	06	**14**
III	Electronic Instrumentation	08	02	06	06	**14**
IV	Pneumatic and Electronic transmitters	08	02	06	06	**14**
V	Signal Converters and instrument transformer	08	02	06	06	**14**
TOTAL		**42**	**10**	**32**	**28**	**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.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(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 outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as*

given in a common list at the beginning of curriculum document for this programme) would be assured.
Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

SR NO.	UNIT	PRACTICAL EXERCISE (outcomes in psychomotordomain)	APPROXIMATE HRS REQUIRED
1.	I	Measure controller output current using PMMC type instrument.	2
2.	I	Obtain wave form of S.S.G.	2
3.	I	Measure single phase ac voltage using DVM.	2
4.	I	Measure ac load current using DVM.	2
5.	I	Measure dc output voltage of thermocouple using DVM.	2
6.	I	Measure supply frequency using CRO.	2
7.	I	Measure output voltage using CRO.	2
8.	I	Compare two supply frequencies and phase using CRO.	2
9.	I	Compare amplitudes of two signals using CRO.	2
10.	I	Develop lissajous figures on CRO.	2
11.	I	Check function and features of DSO	2
12.	I	Find resistance of a RTD using Wheatstone bridge.	2
13.	I	Find resistance of a RTD using Kelvin double bridge.	2
14.	I	Find Inductance of a given inductor using Maxwell bridge.	2
15.	I	Find Inductance of a given inductor using Anderson bridge.	2
16.	I	Find capacitance of a given capacitor using Desauty's's bridge.	2
17.	II	Test flapper nozzle mechanism.	2
18.	II	Plot input-output characteristics of flapper nozzle system.	2
19.	II	Test output response of pilot relay.	2
20.	II	Set 20 psig Instrument air supply system using pressure regulator.	2
21.	II	Control pneumatic control valve using pneumatic P controller.	2
22.	II	Control pneumatic control valve using pneumatic P+I controller.	2
23.	II	Control pneumatic control valve using pneumatic P+D controller.	2
24.	II	Control pneumatic control valve using pneumatic P+I+D controller.	2

25.	III	Develop a circuit of an electronic integrator using op-amp.	2
26.	III	Develop a circuit of an electronic differentiator using op-amp.	2
27.	III	Build and test Instrumentation amplifier circuit using op-amp.	2
28.	III	Build circuit for instrumentation amplifier to convert for given input and output value.	2
29.	III	Build and test electronic on-off controller using operational amplifier for step input.	2
30.	III	Develop electronic P controller using operational amplifier for step input.	2
31.	III	Develop electronic I controller using operational amplifier for step input.	2
32.	III	Develop electronic P+I controller using operational amplifier for step input	2
33.	III	Develop electronic P+D controller using operational amplifier for step input	2
34.	III	Develop electronic P+I+D controller using op amp for step input.	2
35.	III	Tune given electronic controller for optimum output for step input.	2
36.	IV	Install and check functions of pneumatic transmitter	2
37.	IV	Install and check functions of electronic transmitter.	2
38.	IV	Install and check functions of SMART transmitter.	2
39.	V	Develop signal conditioning circuit to convert resistance to current.	2
40.	V	Develop signal conditioning circuit to convert resistance to voltage.	2
41.	V	Develop signal conditioning circuit to convert voltage to current.	2
42.	V	Develop signal conditioning circuit to convert thermocouple output mV into current.	2
43.	V	Plot characteristics of Pneumatic to Electronic converter.	2
44.	V	Observe the output response of Electronic to Pneumatic converter for a given input and plot its characteristics.	2
TOTAL Hrs. (practical for 56 hours from above representing each unit may be selected)			**88**

8. SUGGESTED LIST OF STUDENT ACTIVITIES:

i. Present a seminar on listed technical topics in EPI syllabus.
ii. Set up electronic apparatus on their own during practical hour under the guidance of lecturer as mini project.

iii. Debate on merits and demerits of pneumatic and electronic instruments.
iv. Prepare a poster on any one topic related of course.
v. Collect the extracurricular information related with the course from internet and share it with other students.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Display animation videos of controller response to different types of Standard inputs.
ii. Visit to nearby industry to observe realtime electronic and pneumatic loops.
iii. Facilitate the students to set up practical apparatus on their own.
iv. Compliment student for his/her work done during the practical in order to motivate him/her.
v. Regularly check the practical file maintained by student and instruct him/her remedies to improve the work if required.

10. SUGGESTED LEARNING RESOURCES

A.) LIST OF BOOKS

Sr No.	BOOK	AUTHOR	PUBLICATION
1	Instrument Engineers Handbook	Bela G Liptak	ISA
2	Applied Instrumentation in the process industries	W G Andrews H B Williams	ISA
3	Process Control Instrumentation Technology	Curtis D Johnson	PHI
4	A Course in Electrical and Electronic Measurements and Instrumentation	A K Sawhney	DHANPATRAI
5	Electronic Instrumentation Techniques	W D Cooper	PHI
6	Instrumentation Training Course	D B Taraporewala	D.B. Taraporevala Sons
7	Industrial Instrumentation and Control	S K Singh	TATA MCGRAW HILL
8	Process Instrumentation and Control	A P Kulkarni	Nirali Prakashan
9	Electronics measurement and instrumentation	K. Lal Kishore	Pearson
10	Process dynamics and control	Surekha bhanot	PHI

B.) LIST OF MAJOR EQUIPMENTS/INSTRUMENTS:

i. Electronic Controller Trainer Kit(on-off, P , I, D, P+I, P+D, P+I+D)
ii. Function generator(step, pulse, ramp, sine)
iii. CRO.
iv. DSO.
v. DVM
vi. SMART transmitter.
vii. mA / mV source.
viii. Electronic DP transmitter.

ix. Electronic temperature transmitter.
x. I to P converter
xi. P to I converter
xii. Pneumatic controller trainer Kit(on-off,P, P+I, P+D, P+I+D)
xiii. Compressor (cut off : 7 kg/cm2)(cut in:3.5 kg/cm2)
xiv. Pressure regulator (to maintain 20 psig)
xv. Quarter inch copper pipe (minimum 20 meter per semester)
xvi. Copper pipe bender and cutter
xvii. Teflon tape for sealing
xviii. Multi process control loop using pneumatic control.
xix. Multi process control loop using electronic control.
xx. Pneumatic & Electronic Calibrator

C.) LIST OF SOFTWARES/LEARNING WEBSITES

i. Multisim Software
ii. Ktechlab Software
iii. Logisim Software
iv. Jcircuits Software
v. Circuitmaker Software
vi. Coolspice Software
vii. Psimsoftware
viii. Simone Software
ix. Partsim Software
x. Docircuits Software
xi. www.nptel.ac.in
xii. logiccircuit software
xiii. http://www.deltapower.com/wpcontent/uploads/2013/12/pump.pdf
xiv. http://www.faa.gov/regulations_policies/handbooks_manual /aircraft/amt_airframe_handbook/media/ama_ch12.pdf

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

FACULTY MEMBERS FROM POLYTECHNICS

- **Prof. H. P. Patel** Lecturer(IC), Government Polytechnic, Ahmedabad.
- **Prof. N. J. Dehlvi** Lecturer(IC), Government Polytechnic, Gandhinagar
- **Prof. Manan Modi** Lecturer(IC), Government Polytechnic, Palanpur

CO ORDINATOR AND FACULTY MEMBER FROM NITTTR BHOPAL

- **Prof. Joshua Earnest.** Professor, Department of Electrical and Electronics Engineering
- **Prof. N.P.Patidar.** Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: PROCESS INSTRUMENTATION-II
(COURSE CODE: 3351702)

Diploma Programmers in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	5th Semester

1. RATIONALE

In the present industrial scenario, role of the process instrumentation is becoming more important day by day. More advanced, precise and complex instrumentations are being employed in the industry. Diploma engineers should therefore be able to identify, select , troubleshoot and maintain the different process instrumentation systems. Therefore, this course has been designed so that students will learn to build and test the different types of process instrumentation system required for the parameters such as temperature, level, force, torque, vibration etc.

2. LIST OF COMPETENCY

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:

- **Operate and Maintain different types of process instrumentation systems.**

3. COURSE OUTCOMES:

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Selects measurement method for a process parameter by process instruments for temperature level, vibration, force and torque in a process plant.
ii. Specify instrumentation for temperature level, vibration, force and torque application.
iii. Identify, describe and Calibrate major instruments for temperature, level, vibration, force and torque in a process plant.
iv. Test & maintain the components of the main types instruments for temperature level, vibration, force and torque in a process plant.
v. Draw schematic diagram of process instrumentation for temperature level, vibration, force and torque in a process plant.

4. 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	4	7	70	30	40	60	200

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

5. COURSE DETAILS

Unit	Major Learning Outcomes (In cognitive domain)	Topics and Sub-topics
Unit – I Temperature Measurement Techniques	1a. Define heat, temperature. 1b. List various temperature scales and relate them. 1c. Enlist types of expansion thermometer. 1d. Enlist application, merits and demerits of expansion thermometer. 1e. Explain construction and working of following filled system thermometers: (1) Class I (2) Class II (3) Class III (4) Class V. 1f. Enlist applications, merits and demerits of filled system thermometers 1g. List sources of error in filled system thermometry. 1h. Explain head effect, radiation effect, immersion effect and dip effect. 1i. Describe Seebeck effect, Peltier effect and Thomson effect. 1j. State and explain thermoelectric laws. 1k. Describe protection, installation and importance of thermowell in thermometry 1l. State positive and negative extension wires used in following type of thermocouples: B, E, J, K, R, S, and T 1m.. Explain cold junction compensation method used in thermocouple. 1n. Enlist methods used for forming thermocouples ends. 1o. Define thermopile. 1p. State the criteria for selection of thermocouple. 1q.Classify various thermocouples as per ANSI standard 1r. Describe the output of thermocouple (mV) converted to corresponding temperature value using thermocouple calibration table. 1s. Describe construction of	1.1 Introduction: Heat, Temperature 1.2 Temperature scales. 1.3 Expansion thermometer 1.3.1 Solid Expansion Thermometer •Bimetallic thermometer ➢Spiral Bimetal element ➢ Helix Bimetal element 1.3.2 Liquid Expansion Thermometer- Mercury in Glass type. 1.4 Filled system thermometer 1.4.1 Class I-Liquid Filled Systems 1.4.2 Class II- Vapour Systems 1.4.3 Class III- Gas Filled Systems 1.4.4 Class V- Mercury Filled Systems 1.5 Thermocouples 1.5.1 Principle: Seebeck, Peltier, Thomson effect 1.5.2 Thermoelectric laws 1.5.3 Cold junction compensation 1.5.4 Thermowell 1.5.5 Thermocouple extension wires 1.5.6 Thermocouples selection criteria 1.6 Resistance Temperature Detector Industrial RTD 1.6.1 2-wire RTD 1.6.2 3-wire RTD 1.6.3 4-wire RTD 1.7 Thermistors 1.8 Integrated Circuit (IC) based Temperature sensors 1.9 Non-contact type thermometry 1.9.1 Radiation pyrometer 1.9.2 Optical pyrometer 1.9.3 Optical Fibre Thermometry 1.9.4 Ultrasonic thermometry 1.9.5 Laser thermometry 1.10 Temperature switches and thermostats

Unit	Major Learning Outcomes (In cognitive domain)	Topics and Sub-topics
	Industrial RTD. 1t. Explain resistance measuring circuit of RTD.(2-wire, 3-wire, 4-wire bridge circuit) 1u. State the need of lead wire compensation in RTD. 1v.Describe temperature measuring bridge circuit using thermistor. 1w. Describe performance of a thermistor. (Resistance-temperature graph). 1x. Compare output response of RTD, Thermistor and Thermocouple with sketch. 1y. Explain Integrated Circuit (IC) based temperature sensors. 1z.Define emissivity, Black body concept, Stefan Boltzmann Law. 1aa. Explain construction and working of non-contact type of thermometry(1.9.1 to 1.9.5) 1bb. State merits and demerits of non-contact type thermometer. 1cc. List sources of error in Non-contact type thermometry. 1dd. Describe operation of Temperature switches and thermostats.	
Unit – II Level Measurement Techniques	2a State units, importance of level measurement in process Industries 2b Classify methods of level measurement. 2c Describe working and construction of level measurement method (2.2 to 2.7). 2d Enlist Applications for various level measuring methods (2.2 to 2.7) 2e State merits and demerit of various level measuring methods(2.2 to 2.7) 2f Describe working and construction of various levels switches (2.8)	2.1Level measurement: Importance and Units. 2.2 Level measurement methods: 2.2.1Direct methods •Bob and Tape method •Sight glass method 2.2.2Indirect methods •Pressure gauge type •Air bellows. 2.3Capacitance type level measurement and Radiation type level measurement 2.4Differential pressure type level measurement 2.5 Ultrasonic level detector. 2.6 Laser Level Sensors 2.7 Optical Level detector 2.8 Level switches: 2.8.1 Float type level switch 2.8.2 Displacer level switch 2.8.3 conductivity level switch

Unit	Major Learning Outcomes (In cognitive domain)	Topics and Sub-topics
Unit – III Temperature and level Transmitters	3a Define transmitter. 3b Explain electronic temperature transmitter with neat schematic diagram. 3c List Differential pressure type level transmitters. 3d Explain working and construction of pressure type level transmitter with neat sketch (3.2.1-3.2.2). 3e Enlist applications of transmitters. 3f Describe concept of Zero suppression and Elevation for level transmitter.	3.1Electronic temperature transmitters 3.2 Level transmitter 3.2.1Differential pressure type level transmitter •Pneumatic type •Electronic type 3.2.2 Extended diaphragm level transmitter
Unit IV Force And Torque Measurement Techniques	4a Define Force and Torque 4b State units of Force and Torque 4c Explain working and construction of listed force transducers. 4d Explain working and construction of listed torque transducers.	4.1Force 4.1.1Elastic force meters. 4.1.2Load cells 4.2Torque 4.2.1 Strain gauge torsion meter 4.2.2 Electrical torsion meter 4.2.3 Mechanical torsion meter.
Unit – V Vibration Measurement Techniques	5a Define vibration 5b Explain working and construction of vibration sensor (5.2) 5c Enlist applications of vibration sensors (5.2) 5d Enlist merits and demerits of vibration sensors (5.2)	5.1 Vibration. 5.2 Vibration Sensors: 5.2.1. Mass spring seismic sensor 5.2.2 Piezo-electric sensor

6. 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 Marks
I	Temperature Measurement Techniques	14	4	12	5	21
II	Level Measurement Techniques	14	4	12	5	21
III	Temperature and level Transmitters	08	0	10	4	14
IV	Force And Torque Measurement Techniques	04	2	6	2	10
V	Vibration Measurement Techniques	02	0	2	2	04
	Total	**42**	**10**	**42**	**18**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's 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.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(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 outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
1	I	Use liquid in glass type filled system thermometers	02
2	I	Perform temperature measurement using expansion thermometer.	02
3	I	Measure temperature of given medium using given thermocouple with the help of corresponding thermocouple table.(Conversion of millivolt to temperature)	02
4	I	Verify the law of intermediate metal for available type of thermocouple.	02
5	I	Test the effect of reference junction temperature on given thermocouple.	02
6	I	Convert output of thermocouple (mV) into temperature(˚C) using corresponding thermocouple calibration table	02
7	I	Measure the temperature using RTD and Test.	02
8	I	Calculate temperature co-efficient of resistance using RTD	02
9	I	Measure the temperature using Thermistors and Plot the characteristic curve.	02
10	I	Measure the temperature using IC temperature sensor.	02
11	I	Measure the temperature of heating element using Optical Pyrometer.	02
12	I	Measure the temperature of heating element using radiation Pyrometer.	02
13	I	Measure the temperature using fiber Optic thermometer.	02

Sr. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
14	I	Measure the temperature using thermometer	02
15	I	Measure the temperature using thermometer	02
16	I	Test the operation of temperature switch at given temp	02
17	II	Measure the level of the tank with the help of the Sight glass	02
18	II	Measure the level of the tank with the help of the pressure gauge.	02
19	II	Measure level with the capacitance type transducer.	02
20	II	Test for the float type level switch	02
21	II	Use displacer level switch for given range & Test	02
22	II	Use capacitance type level switch for given range & Test	02
23	III	Use Electronic Temperature transmitters for given range & Test.	02
24	III	Use differential pressure type level transmitter for given range & Test.	02
25	IV	Measure torsion by electrical torsion meter	02
26	IV	Use load cell and test for perfomance	02
27	V	Measure vibration by vibration analyser.	02
* **Note: These experiments can be either conducted using hardware from covering all the Units .**		Total	54

8. SUGGESTED LIST OF STUDENT ACTIVITIES

i. Industrial Visit for students (chemical industries, petroleum industries, production industries)

ii. Small technical projects based on theory topic.

9. SPECIAL INSTRUCTIONAL STRATEGIES

i. Videos/Animation for different devices should be shown.

ii. Seminar on relevant topics.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

Sr. No.	Title of Book	Author	Publication
1.	Process Measurement and Analysis	Liptak, B. G.	I.S.A
2.	Industrial Instrumentation	Eckman, D. P.	Wiley Eastern Limited, New Delhi
3.	Industrial Instrumentation	Singh, S.K.	Tata Mc Graw Hill, New Delhi
4.	Mechanical Measurements	Kumar, D. S.	Metropolitan Book Company, New Delhi
5.	Process Instrumentation and Control	Kulkarni, A.P.	Nirali Prakashan, Pune

6.	Mechanical and Industrial measurements	Jain, R.K.	Khanna publication, New Delhi
7.	Industrial Instrumentation	Krishnaswamy, K. and S. Vijayachitra,	New Age International Publication, New Delhi

B) List of Major Equipment/ Instrument with Broad Specifications

i. Function generator(sine, square, triangle etc. with frequency range 10 Hz to 100 kHz)
ii. DC power supply (-30 →0→+30 V with at least 1A current capacity)
iii. Measuring equipments like CRO (preferably dual channel, 20Mhz)
iv. Multi meter
v. Electrical tool kit.
vi. Circuit/Trainer board/ Demonstration modules of Thermocouples , RTDs, Thermistors, IC temperature sensor.
vii. Temperature Switches, Optical Pyrometer, Radiation Pyrometer
viii. Sight Glass type Level Indicator
ix. Pressure Gauge type Level Indicator
x. Float type , Displacer type and Capacitance type Level Switches
xi. Fiber Optic Thermometer, Ultrasonic Thermometer, Laser Thermometer
xii. Capacitance type Level Transducer
xiii. Electronic Temperature transmitters
xiv. Differential pressure type Level Transmitter
xv. Universal Calibrator
xvi. Air Compressor
xvii. Load Cell
xviii. Vibration Analyzer
xix. Electrical Torsion Meter
xx. metal detector
xxi. ultrasonic flaw detector

C) List of Software/Learning Websites

i. http://www.pc-education.mcmaster.ca/Instrumentation/temperature.
ii. http://www.pc-education.mcmaster.ca/Instrumentation/level.
iii. http://www.dugantech.com/Product_Group-Temperature/Technical%20Articles/TE Criteria%20for%20Selection%20of%20RTD%20or%20TC%20industrial%20apps.pdf
iv. books.google.co.in/books?isbn=8122416691
v. Capacitive Displacement/Vibration Measurement Sensor Products
vi. Eddy-Current Displacement/Vibration Measurement Sensor Products

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. R. J. Dhruv** Sr. Lecturer , A.V.P.T.I. Rajkot
- **Prof. S. Z. Shyara** Sr. Lecturer, A.V.P.T.I. Rajkot
- **Prof. R. P. Raiyani** H.O.D I.C Christ Polytechnic Institute, Rajkot.
- **Prof. H. P. Patel** Lecturer, Government Polytechnic, Ahmedabad.

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. (Dr) Joshua Earnest.** Professor, Department of Electrical and Electronics Engineering
- **Prof. (Dr) N. P. Patidar.** Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: ANALYTICAL INSTRUMENTATION
(COURSE CODE: 3351703)

Diploma Programmers in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	5th Semester

1. RATIONALE

The use of Analytical instruments is increasing day by day in industries. Now a day's advanced, complex and precision analytical instruments are being used in most of the process industries. Diploma Instrumentation engineer are therefore also supposed to know about analytical instrumentation fundamentals, It is important as the students may get employment in the process plant, where they will have to operate, maintain and calibrate different analytical instruments. Hence this course has been designed to develop some of the basic skills in operation and maintenance of various analytical instruments.

2. LIST OF COMPETENCY

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

- **operate and maintain various analytical instruments.**

3. COURSE OUTCOMES:

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Observe and obtain the accurate reading of analytical instruments.
ii. Specify analytical instrumentation for different types of analysis.
iii. Identify and describe major analytical instruments.
iv. Describe the purpose and function of analytical instrumentation
v. Identify the main installed and laboratory analytical instruments.
vi. Identify sub components of the main analytical instruments
vii. Draw schematic diagram of analytical instrumentation
viii. Test and calibrate different analytical instruments

4. 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 Theory Practice; **P** - Practical; **C** – Credit **ESE** - End Semester Examination; **PA** - Progressive Assessment.

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (Outcomes in Cognitive Domain)	Topics and Sub-topics
Unit – I Fundamentals of Analytical Instruments	1a Define analytical instrumentation. 1b Explain importance of composition analysis in process industries. 1c Draw and explain elements of an analytical instrument. 1d List Application of composition analysis. 1e Classify analytical instruments based on properties that are utilized in the analysis.	1.1 Introduction 1.2 Elements of an analytical instruments 1.3 Applications of chemical composition measurement in industries 1.4 Classifications of analytical instruments based on properties
Unit – II Analysis using Mechanical and Thermal properties	2a Define the following terms: Viscosity, Fluidity, Kinematic Viscosity, Specific viscosity, Relative Viscosity and Viscosity Index. 2b State the units of viscosity. 2c State the methods of viscosity measurement techniques. 2d Explain principle, construction and working of Saybolt ' s viscometer. 2e Define density and specific gravity. 2f State the unit of density and specific gravity 2g Enlist types of density measurement techniques. 2h Describe working principle, construction with schematic diagram of Density and Specific Gravity measurement techniques . - pressure head type densitometer - displacer type densitometer - float type densitometer - buoyancy effect type densitometer	2.1 Viscosity measurement techniques. 2.1.1 Terminologies 2.1.2 Saybolt viscometer 2.2 Density and Specific Gravity measurement techniques. 2.2.1 Pressure head type densitometer 2.2.2 Displacer type densitometer 2.2.3 Float type densitometer 2.2.4 Buoyancy effect type densitometer 2.3 Thermal conductivity analysis. 2.3.1 Principle 2.3.2 Dual hot wire thermal conductivity cell.

Unit	Major Learning Outcomes (Outcomes in Cognitive Domain)	Topics and Sub-topics
	2i State principle of thermal conductivity for gas analysis. 2j Draw and explain the dual hot wire thermal conductivity cell. 2k List and explain different techniques of filling gas to thermal conductivity cell.	
Unit – III Analysis using Electrical properties	3a Define the following terms conductivity, conductance, cell constant. 3b Draw and explain null method of conductance measurement. 3c Draw and explain direct reading method of conductance measurement. 3d Explain working principle of conductivity cell. 3e Explain Temperature compensation in conductivity measurement. 3f Define pH, Dissociation constant Kw, pH range, Buffer solution, Slope factor. 3g Explain principle of pH measurement with neat diagram. 3h Draw relationship between pH and emf at different temperatures. 3i Describe measuring electrode (glass electrode) for pH measurement with schematic diagram. 3j Describe reference electrode (Calomel & $Ag/AgCl_2$ electrode) for pH measurement with schematic diagram. 3k Describe combination electrode for pH measurement with schematic diagram. 3l List and explain failures in ph meter. 3m List calibration & maintenance steps for pH meter 3n Explain electronics circuit for pH meter. 3o List techniques of O_2 analyzer. 3p Explain principle, working and construction of dumb-bell type paramagnetic O_2 analyzer. 3q Explain with schematic diagram the principle, working and construction of -wind type paramagnetic O_2	3.1Electrical Conductivity analyze 3.1.1 Introduction and applications. 3.1.2 Methods of measurement of conductance : • null method • direct reading method 3.1.3 Conductivity cell • Temperature compensation in conductivity measurement 3.2 pH analyzer 3.2.1 Principle of pH measurement. 3.2.2 Electrodes for pH measurement. 3.2.3 Electronics circuit for pH measurement. 3.2.4 Calibration 3.3 O2 Analyzer 3.3.1Paramagnetic O2 analyzer •dumb-bell type • wind type 3.3.2Heat of reaction analyzer 3.3.3Dissolved O2 analyzer. 3.4Polarography -electrodes DME (Dropping Mercury Electrode) , SCE (Saturated Calomel Electrode)

Unit	Major Learning Outcomes (Outcomes in Cognitive Domain)	Topics and Sub-topics
	analyzer -dissolved O2 analyzer . 3r List types of Polarography. 3s Explain basic polarographic set up. 3t Explain with schematic diagram the construction, working principle of electrodes DME , SCE	
Unit – IV **Analysis using radiant properties**	4a Define electromagnetic radiation, Absorption spectroscopy. 4b Draw electromagnetic spectrum. 4c Explain interaction of radiation with matter. 4d State Lambert's law 4e State Beer's law 4f State Beer- Lambert's law 4g Draw and explain working principle with schematic diagram in brief various components of absorption instruments 4h Draw and explain basic components of a filter colorimeter. 4i Explain working principle with schematic diagram the single beam optical null type spectrophotometer. 4j Explain principle construction and working of X-ray absorption scheme. 4k Enlist the application of X-ray absorption spectrometer. 4l Explain principle , construction and working of X-ray diffraction scheme. 4m Explain principle of NMR. 4n Explain block diagram of NMR spectrometer.	4.1 Electromagnetic radiation 4.1.1 Electromagnetic spectrum 4.1.2 Interaction of radiation with matter. 4.2 Laws relating to Absorption of radiation. 4.2.1 Lambert's law 4.2.2 Beer's law 4.2.3 Beer- Lambert's law 4.3 Absorption instruments 4.3.1Colorimeters (photometer) 4.3.2Spectrophotometer 4.3.3X-ray technique of analysis by absorption. 4.3.4 X-ray technique of analysis by diffraction. 4.4 Nuclear Magnetic Resonance(NMR) 4.4.1Principle. 4.4.2Block diagram.
Unit –V **Analysis using miscellaneous properties**	5a Define Gas chromatography. 5b List basic parts of Gas chromatograph. 5cDraw and explain block diagram of a Gas chromatograph. 5d List detectors used in Gas chromatograph. 5e Explain working principle with schematic diagram detectors for Gas chromatograph - thermal conductivity - flame ionization detector - flame photo detector - Electron Capture Detector 5f List applications of Gas	5.1 Gas chromatography 5.1.1 Basic parts 5.1.2 detectors •thermal conductivity detector •flame ionization detector(FID) •flame photo detector(FPD) •Electron Capture Detector (ECD) 5.2 Refractometer 5.2.1Theory of operation 5.2.2Classify Refractometer •Differential type ➢single pass refractometer ➢two pass refractometer

Unit	Major Learning Outcomes (Outcomes in Cognitive Domain)	Topics and Sub-topics
	chromatograph. 5g Explain theory of operation of refractometer. 5h Define refractive index, snell's law, critical angle. 5i Classify refractometer. 5j Describe single pass refractometer with neat sketch . 5k Describe two pass refractometer with neat sketch. 5l Describe critical angle refractometer with schematic diagram. 5m State the limitation of refractometer. 5n List applications of refractometer.	•critical angle refractometer

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

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Analytical Instruments	4	2	4	0	**06**
II	Analysis using Mechanical and Thermal properties	6	2	6	4	**12**
III	Analysis using Electrical properties	12	4	12	4	**20**
IV	Analysis using radiant properties	12	4	12	4	**20**
V	Analysis using miscellaneous properties	08	4	6	2	**12**
	Total	**42**	**16**	**40**	**14**	**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.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(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 outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes*** *(as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
1	II	Measure viscosity of given solution using viscometer.	02
2	II	Plot effect of temperature on viscosity of given solution by Saybolt viscometer.	02
3	II	Measure density of given solution using Pressure head type densitometer.	02
4	II	Measure density of given solution using displacer type densitometer.	02
5	II	Measure density of given solution using float type densitometer.	02
6	II	Measure density of given solution using buoyancy effect type densitometer.	02
7	III	Measure conductivity of given solution using analog multimeter.	02
8	III	Measure conductivity of given solution using digital conductivity meter.	02
9	III	Plot effect of temperature on conductivity of given aqueous solution	02
10	III	Test and calibrate pH meter.	02
11	III	Measure pH of given solution using double electrode method.	02
12	III	Measure pH of given solution using combination electrode method.	02
13	III	Plot the effect of temperature on pH of given aqueous solution	02
14	III	Test and calibrate dumb-bell type O_2 analyzer.	02
15	III	Test and calibrate wind type O2 analyzer.	02
16	III	Measure O_2 concentration in given gas mixture.	02
17	III	Prepare electrode and measure dissolved O_2 concentration in given sample.	02
18	III	Water analysis using water analyzer	02
19	IV	Verify Beer-Lambert's law using Trainer kit.	02
20	IV	Analyze given sample using colorimeter.	02
21	IV	Test and calibrate spectrophotometer.	02
22	IV	Measure % transmission, absorption and concentration of given sample using spectrophotometer.	02
23	V	Study of each part of gas chromatograph	02
24	V	Analyze given gas mixture using gas chromatograph.	02
25	V	Measure refractive index using refactometer.	02
26	V	Analyze given sample using refactometer.	02
TOTAL(practical for 28 hours from above representing each unit may be selected)			**52**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Prepare presentation on relevant topics.
ii. Prepare chart/model on relevant topic.

9. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

i. Visit to Industries/ Process and CSMRI type laboratories/ industries
ii. Video films/animation films on working of different types of analytical instruments.
iii. Mini project

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Hand book of Analytical Instruments	R.S. Khandpur	Tata McGraw Hill, New Delhi
2.	Analytical Instrumentation	Bela G. Lipkat	Chilton book company
3.	Principle of industrial instrumentation	D. Patranabis	Tata McGraw Hill, New Delhi
4.	Process instrumentation and control	A.P. Kulkarni	Nirali Prakashan,pune
5.	Instrumental methods of analysis	H.H. Willard	CBS Publishers & Distributers

B) List of Major Equipment/ Instrument with Broad Specifications

i. Saybolt viscometer
ii. Pressure head densitometer.
iii. Displacer type densitometer.
iv. Buoyancy effect type densitometer.
v. Float type densitometer.
vi. Conductivity meter.
vii. Double Electrode pH meter.
viii. Combination Electrode pH meter.
ix. Dumbbell type O2 analyzer
x. Wind type O2 analyzer
xi. Dissolved O2 analyzer.
xii. Trainer kit for Beer-Lambert's law
xiii. Ploarograph – with DME , SCE cells & Required Hg quantity
xiv. Gas Chromatograph
xv. Colorimeter
xvi. Laboratory Refractometer
xvii. Water analyzer
xviii. Spectrophotometer

C) List of Software/Learning Websites

Gas chromatography:

i. http://www.sigmaaldrich.com/analytical-chromatography

ii. http://www.slideshare.net/banuman35/applications-of-gas-chromatography-applications-of-gc-by-pravisankar

Rfractrometer :

iii. http://www.intercomir.it/laboratorio/rifrappl_en.html

iv. http://www.misco.com/refractometer-support/refractometer-forum/refractometer-applications

Spectrophotometer:

v. http://www.slideshare.net/suniu/spectrophotometry-16091660

pH meter

vi. http://www.wikihow.com/Calibrate-and-Use-a-pH-Meter

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof . R.P. Merchant**, HOD(IC) Govt. Polytechnic, Gandhinagar.
- **Prof . J. T. Patankar** Sr. lecturer IC Engineering, Govt. Polytechnic, Ahmedabad
- **Prof. A.K. Bula** Sr. lecturer IC Engineering, Govt. Polytechnic, Gandhinagar.

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. Joshua Earnest.** Professor, Department of Electrical and Electronics Engineering
- **Prof. N.P.Patidar.** Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: PLC PROGRAMMING
(COURSE CODE: 3351704)

Diploma Programmers in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	5th semester

1. RATIONALE

Different logical process automation is used for optimum controlling of the process parameters and hence Diploma Engineers should be able to maintain these instrumentation systems. This requires that they should know very well about logical control action fundamentals. Hence this curriculum has been designed so that the students will be able to develop, program and troubleshoot applications of various PLC based logical control strategies for automation.

2. LIST OF COMPETENCY

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

- **Maintain different types of PLC based process instrumentation systems.**

3. COURSE OUTCOMES:

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Identify logical process control in automation
ii. Connect the PLC peripherals with the PLC for logical functioning.
iii. Develop advance PLC programs.
iv. Able to develop PLC based automation system.
v. Troubleshoot PLC.

4. 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 Theory Practice; **P** - Practical; **C** – Credit **ESE** - End Semester Examination; **PA** - Progressive Assessment.

5. COURSE DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I **Basic PLC system**	1a Explain block diagram for PLC based automation system with sketch. 1b Draw block diagram various PLC modules and explain them in brief. 1c State steps to install PLC. 1d Describe PLC networking (master slave mode) with sketch.	**PLC system** 1.1.Over view of PLC system 1.2. PLC module 1.2.1.Intelligent module 1.2.2.PID module 1.2.3.Communication module 1.3.PLC Installation 1.4.PLC networking
Unit – II **Basic PLC function**	2a Describe the function of five common types of registers used in PLC. 2b Describe use of PLC registers in PLC operation. 2c Develop ladder logic for flip flops (R-S, ONE SHOT, D, T, and J-K) in PLC. 2d Describe module addressing for PLC. 2e Describe PLC retentive and delay timer functions 2f State types and instructions of timing functions used in PLC. 2g Draw ladder diagram and wiring diagram for each timer functions for PLC. 2h State types and instructions of PLC counter functions. 2i Draw ladder diagram for each counter functions for PLC. 2j Develop ladder logic for ON-OFF temperature control using timer, counter and limit switches.	2.1.PLC Registers and I/O addressing. 2.1.1.Register and flip-flop Characteristic. 2.1.2.Types of register(Holding, Input, Output register) 2.1.3.Module addressing 2.2. PLC timer function 2.2.1.Types and instructions of timer On Delay, Off Delay, Retentive ,Non Retentive timer 2.3.PLC counter function 2.3.1.Types and instructions of counter UP,DOWN,UP/DOWN counter
Unit – III **Arithmetic and logical function**	3a Describe arithmetic, comparison, square root, PLC functions. 3b Use PLC arithmetic functions to Add, subtract, multiply and divide numbers. 3c Derive square root by using PLC square root functions. 3d Describe each PLC Advanced comparison functions. 3e Describe each PLC logical functions. 3f Describe operation of the	**Arithmetic and logical function used in PLC** 3.1.PLC arithmetic function : Addition, Subtraction Multiplication, Division, Square root Negative, Average 3.2.PLC comparison function Basic comparison functions Equal, Not equal Greater than, Less than, Greater than equal to, Less than equal to 3.3.Advanced comparison functions LIMIT TEST, MASKED COMPARE, COMPARE EXPRESSION(CMP)

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	SKIP, MASTER CONTROL RELAY, JUMP, MOVE, FIFO, FAL, ONE SHOT (ONS), CLR, SWEEP functions. 3g Describe the PLC digital bit control functions. 3h Explain BIT SET, BIT CLEAR & BIT FOLLOW functions showing bit pattern in the registers. 3i Use shift register to move digital bits within registers. 3j Use shift register to move digital bits through registers.	3.4.PLC logical function 3.5.SKIP,MASTER CONTROL RELAY,JUMP with non return, JUMP with return 3.6.Data transfer function MOVE, BLOCK MOVE,TABLE AND REGISTER MOVE 3.7.FIFO, FAL, ONE SHOT, CLR and SWEEP functions 3.8.PLC Digital bit function 3.8.1 Bit patterns in registers 3.8.2 Changing register bit status 3.8.3 Shift register functions
Unit – IV Advanced PLC functions	4a Describe PLC sequencer. 4b Describe Sequencer output, input and load functions. 4c Develop ladder logic program using Sequencer output, input and load functions. 4d Differentiate between discrete and analog operation of PLC. 4e Convert input signals suitable to input module of PLC. 4f Convert output module signal to suitable values for output devices of PLC. 4g Describe the internal PLC operation for analog I/O systems. 4h List the different types of PID Tuning methods. 4i Discuss PID PLC function. 4j Describe PLC auxiliary functions.	4.1.Sequencer function 4.1.1. Sequencer output, input and load instruction. 4.2. PLC analog operation 4.2.1.analog signal processing 4.2.2. BCD or multibit data processing 4.3. PID function for continuous process 4.3.1.PID tuning (open loop transient system, ultimate cycle, frequency response) 4.3.2.PID function 4.4. PLC Auxiliary functions 4.4.1. Monitor mode function 4.4.2. Force mode function
Unit – V PLC Application and Troubleshooting	5a Draw neat sketches of PLC process applications for the given parameters of processes(5.1.1 to 5.1.4) 5b Identify Input and Output devices used for PLC process applications and assign proper addresses to each of them for the given parameters of processes. 5c Prepare sequence of events	5.1. PLC process Applications : 5.1.1.bottle filling plant 5.1.2.material handling elevator 5.1.3. 2-axis robot with PLC sequencer control 5.1.4. Process level control 5.2.Troubleshooting

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	for PLC process applications for the given parameters of processes 5d Develop Ladder Logic diagram for PLC process applications for the given parameters of processes 5e State the trouble shooting procedure for PLC system.	

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

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basic PLC system	04	2	4	1	07
II	Basic PLC function	10	4	8	2	14
III	Arithmetic and logical function	12	7	7	7	21
IV	Advanced PLC functions	10	4	8	2	14
V	PLC Application and Troubleshooting	06	0	4	10	14
	Total	**42**	**17**	**31**	**22**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's 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.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(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 outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
1	I	Install hardware and software components of Given PLC system. Check it's working by running a sample program	02
2	I	Identify intelligent, PID , Input , Output , Communication module	02

3	I	Wire Inputs , Outputs via PLC input output modules	02
4	I	Wire intelligent, PID , Communication module with PLC	02
5	I	Connect master PLC with two slave PLCs	02
6	I	Study networking of PLC by means of simulation or appropriate video.	02
7	II	Develop ladder logic to realize D flipflop	02
8	II	Develop ladder logic to realize RS flipflop	02
9	II	Develop ladder logic to realize JK flipflop	02
10	II	Develop ladder logic to realize T flipflop	02
11	II	Simulate Industrial application of PLC On Delay Timer.	02
12	II	Verify On Delay timer operation using actual PLC	02
13	II	Simulate Industrial application of PLC Off Delay Timer.	02
14	II	Verify Off Delay timer operation usin actual PLC	02
15	II	Simulate Industrial application of PLC Retentive Timer.	02
16	II	Verify Retentive timer operation using PLC	02
17	II	Simulate Industrial application of PLC UP COUNTER.	02
18	II	Verify UP COUNTER operation using actual PLC	02
19	II	Simulate Industrial application of PLC UP/DOWN COUNTER.	02
20	II	Verify UP/DOWN COUNTER operation using actual PLC	02
21	II	Simulate Industrial application of PLC ADDITION Function.	02
22	III	Verify ADDITION Function using actual PLC	02
23	III	Simulate Industrial application of PLC SUBTRACTION Function.	02
24	III	Verify SUBTRACTION Function using actual PLC	02
25	III	Simulate Industrial application of PLC EQUAL TO Comparison Function.	02
26	III	Verify EQUAL TO Comparison Function using actual PLC	02
27	III	Simulate Industrial application of PLC LESS THAN and GREATER THAN Comparison Functions.	02
28	III	Verify LESS THAN and GREATER THAN Comparison Functions using actual PLC	02
29	III	Simulate Industrial application of PLC Advance Comparison Functions.	04
30	III	Verify the operation of Advance Comparison Functions using actual PLC	04
31	III	Simulate Industrial application of PLC SKIP and MCR Functions. Verify the same functions using actual PLC	02
32	III	Simulate Industrial application of PLC JUMP Functions. Verify the same functions using actual PLC	02
33	III	Simulate Industrial application of PLC Data Transfer Functions. Verify the same functions using actual PLC	02
34	III	Simulate Industrial application of PLC Data Transfer Functions. Verify the same functions using actual PLC	04
35	III	Simulate Industrial application of PLC SHIFT REGISTER Functions. Verify the same functions using actual PLC.	02
36	IV	Simulate Industrial/Domestic application of PLC SEQUENCER Function. Verify the same function using actual PLC.	04
37	IV	Control the level in a given level control loop using PID function of PLC. Obtain the response curves of PV, SP and Controller O/P. Tune the loop properly to obtain close control.	04
38	IV	Control the temperature in a given temperature control loop using PID function of PLC. Obtain the response curves of PV, SP and	04

		Controller O/P. Tune the loop properly to obtain close control.	
39	IV	Control the Pressure in a given pressure control loop using PID function of PLC. Obtain the response curves of PV, SP and Controller O/P. Tune the loop properly to obtain close control.	04
40	IV	Control the flow in a given flow control loop using PID function of PLC. Obtain the response curves of PV, SP and Controller O/P. Tune the loop properly to obtain close control.	04
41	V	Simulate Bottle filing process on PLC simulator. Verify operation of the same process using actual PLC. Draw connection details for the same process	04
42	V	Simulate material handling elevator operation on PLC simulator. Verify operation of the same process operation using actual PLC. Draw connection details for the same process.	04
Total Hours (practical for 28 hours from above representing each unit may be selected)			**102**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:
i. Assemble PLC power supply PLC, Input / Output and other module on mounting rack.

ii. Wire automatic level control system using various components.
iii. Wire automatic temperature control system using various components.
iv. Wire automatic flow control system using various components.
v. Connect personal computer using star topology.
vi. Connect personal computer using ring topology.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

I.**V**isits to Industries.
ii. Use free simulators for PLC programming in the class when teaching.
iii. Video films/animation films on working of different type automatic system such as bottle filling plant, material handling elevator, 2-axis robot with PLC sequencer control, Process level control, Process temperature control Troubleshooting of PLC from YouTube and other resources.
iv. Mini project based on 2 axis ROBOT, Designing of process control loop, PLC Industrial Application which is not covered in above Experiment list

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1	Programmable logic Controllers Principles and applications	John w. Webb Ronald A Reis	PHI Learning,
2	Programmable logic Controllers Programming methods and applications	John R Hackworth Frederick D. Hackworth Jr.	Pearson
3	Process Control Principles and applications	Surekha Bhanot	Oxford University press
4	Instrumentation engineer's handbook	B.G Liptak	Chilton Book Co., Philadelphia
5	Process control Instrumentation technology	Curtis D Johnson	PHI pvt. Ltd.

6.	Programmable Logic Control: Principles And Applications	NIIT	PHI EEE edition
7	Programmable Controllers	Thomas A. Hughes	ISA

B) List of Major Equipment/ Instrument with Broad Specifications

i. Electrical tool kit 3sets
ii. Multi-meter 3 No.
iii. Master PLC with Power supply and Hand held PLC programmer (touch screen teach pendent). 1 NO
iv. Slave PLC with Power supply and Hand held PLC programmer. 3 NO
v. 24 analog input module (8 analog input module 3NO.)
vi. 24 analog output module (8 analog input module 3NO.)
vii. 24 digital input module (8 digital input module 3 NO.)
viii. 24 digital output module (8 digital input module 3 NO.)
ix. PID module (3 NO.)
x. Communication module (3 NO.)
xi. Thermocouple module (3 NO.)
xii. 3 level switch
xiii. DP Transmitter (2 NO.)
xiv. Capacitive level transmitter
xv. 3NO Temperature switch
xvi. J and K thermocouple (5 NO each)
xvii. RTD (3 NO)
xviii. 3 NO flow switch
xix. 3" conveyor system operated 12V DC motor with digital shaft encoder
xx. 12 proximity switch(Inductive,Optical, motion , light)
xxi. 12 V DC motor with digital shaft encoder
xxii. PLC based Automatic bottle filling plant
xxiii. Flow, temperature, level control setup for PLC based automation using Flow, temperature, level switches.

B) List of Software

To run PLC compatible software should be purchased from the PLC supplier such as WINCC/ RS logix etc.

Learning Websites

i. www.control.com
ii. www.plcs.net
iii. www.pacontrol.com
iv. En.wikipedia.org
v. www.seimens.com
vi. www. ab.rockwellautomation.com › *Allen-Bradley*
vii. *www.abb.co.in*
viii. *www.tri**plc**.com*
ix. *http://plc-training-rslogix-simulator.soft32.com/free-download/*
x. www.youtube.com
xi. www.ourinstrumentationgroup.com
xii. for PLC networking in master-slave : http://www.automationdirect.com/static/manuals/dadnet/appxa.pdf
xiii. books.google.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof R. P. Merchant,** HOD IC Engineering, Govt. Polytechnic, Gandhinagar
- **Prof A. K. Bilakhia**, Lecturer IC Engineering, Govt. Polytechnic, Gandhinagar
- **Prof N. B. Mehta,** Lecturer IC Engineering, Govt. Polytechnic, Ahmedabad
- **Prof Manan Modi**, Lecturer IC Engineering, Govt. Polytechnic, Palanpur

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. (Mrs.) C. S. Rajeshwari,** Professor, and Head, Department of Electrical and Electronics Engineering
- **Prof. Joshua Earnest.** Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: MICROPROCESSOR AND MICROCONTROLLER IN INSTRUMENTATION
(COURSE CODE: 3351705)

Diploma Programmes in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	5th semester

1. RATIONALE

Microprocessors and Microcontrollers are being extensively used in the field of Instrumentation and Control Engineering. The students studying this subject are required to have a thorough knowledge of architecture of a typical Microprocessor and Microcontroller and also acquire fundamental programming skills in the assembly language. Students further need to be aware of various Microprocessors and Microcontrollers employed in industries. The course in addition, cover general hardware aspects along with some applications and interfacing of microcontrollers in instrumentation and control discipline which would equip the student with skills for designing an embedded microcontroller based instrumentation system .

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in students so that they are able to acquire following competency:

- **Design, Operate and Maintain microcontroller based process instruments**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Identify the different block of microprocessor and microcontroller.
ii. Use microcontrollers in instrumentation applications
iii. Develop simple assembly language program using above instructions for given application.
iv. Program 8051 microcontroller for various for internal organization use
v. Interface peripheral devices with 8051 microcontroller for instrumentation applications

4. 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	05	70	30	20	30	

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

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Overview of 8085 Microprocessor and microcontroller	1a. Describe basic architecture of microprocessor of 8085. 1b. Draw and describe block diagram of microprocessor 8085. 1c. Describe functional block diagram of 8051 microcontroller with sketches and pin diagram 1d. Compare microprocessor and microcontroller.	1.1 Microprocessor Architecture 1.2 8085 Microprocessor: Block Diagram 1.3 Microcontroller 8051
Unit– II 8051 Microcontroller	2a. State functions of following in microcontroller: Oscillator, Clock and Reset circuit. Program counter and data pointer. A and B CPU register and PSW. 2b. Describe functions of internal RAM organization. 2c. State applications of stack operation and function registers 2d. Describe functions of internal RAM and ROM organization with sketches.	2.1 8051 microcontroller hardware 2.2Programming Model: Oscillator and Reset circuit, Program Counter, Data Pointer, A and B CPU registers, Flags and program status word (PSW) 2.3Memory organization: Internal RAM, The stack and stack pointer, Special function registers, Internal ROM and External memory connections 2.4 Input/output pins, ports and Circuits.
Unit– III 8051 Assembly Language	3a State the applications of addressing modes. 3b List the instruction set. 3c Explain application of Instructions	3.1 Addressing modes: immediate, Register, Direct, Indirect, Indexed, Relative and bit addressing

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Programming	with suitable example. 3d Formulate simple assembly language program using above instructions for given application.	3.2 Instructions: Moving data, Arithmetic operation, Logical operation, Jump and Call instructions 3.3 Simple programs
Unit – IV Application programming of 8051	4a State applications of TCON and TMOD register of timer. 4b List various timer modes of 8051. 4c Develop simple programs on timers which include square wave generation and delay. 4d State application of serial communication, SBUF, SCON and PCON registers, 4e Develop program for transmitting and receiving single word. 4f List interrupts of 8051 4g State the application of IP and IE registers.	4.1 8051 Timer/counter:TCON, TMOD, Modes of timer 4.2 Simple Programs on timer 4.3 Serial Communication of 8051: Basics, SBUF register, SCON and PCON registers, Modes of operation 4.4 Simple program of serial communication 4.5 8051 Interrupts: Interrupt priority and interrupt vector, IP and IE register
Unit – V Microcontroller Applications in Instrumentation	5a. Describe Applications of 8051 microcontroller in Instrumentation - Room Temperature Indicator, Level detection, car parking -(Motion and obstacle sensing), frequency counter, RPM meter , SMART instruments 5b.Explain interfacing of 8051 for the instrumentation listed: relay, DC Motor, stepper motor and temperature sensor LM35/LM 34, Analog Output devices for Damper and Hopper Control 5c. State the steps to maintain the above instrumentation applications and interfaced devices	5.1 Application s in Instrumentation - Room Temperature Indicator, Level detection application, car parking - (Motion and obstacle sensing), frequency counter RPM meter, SMART Instruments ,DC Motor, stepper motor, relay, Analog Output devices for Damper and Hopper Control, Analog Multiplexer 4051
	5d..Draw interfacing diagram of 8051 with devices listed: LED, LCD, ON/OFF switch, Hex keyboard, A/D converter with ADC 0804 and D/A converter 0808.	5.2Interfacing of 8051 with devices : LED, LCD, Switch: Pushbutton, DIP, ON/OFF, Thumbwheel, Tilt Hex keyboard, A/D converter with ADC 0804 and D/A converter 0808

6. 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 Marks
I	Overview of Microprocessor and microcontroller	02	03	04	00	07
II	8051 Microcontroller.	10	07	10	04	21
III	8051 assembly language programming	12	03	04	07	14
IV	Application programming of 8051	10	03	04	07	14
V	Microcontroller Applications in Instrumentation.	08	03	04	07	14
	Total	42	**19**	**26**	**25**	**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.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

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

Note*: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty members should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Approx Hrs. required
1	I	Demonstrate Hardware and Software development tool for 8085.	02
2	I	Demonstrate Hardware and Software development tool for 8051.	02
3	I	Study family of microprocessor and microcontroller.	02
4	II	Develop and Execute Programs on 8 bit data transfer.	02
5	III	Develop and Execute Programs on 16 bit data transfer instructions	02
6	III	Develop and Execute Programs on 8 bit data transfer for a block of data from external memory.	02

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Approx Hrs. required
7	III	Develop and Execute Programs on 8 bit Arithmetic instructions.	02
8	III	Develop and Execute Programs on 16 bit Arithmetic instructions.	02
9	III	Develop and Execute Programs on Byte level Logical instructions.	02
10	III	Develop and Execute Programs on Bit level Logical instructions.	02
11	III	Develop and Execute Programs on Rotate and SWAP instruction.	02
12	III	Check status of given registers after execution of given programs.	02
13	III	Develop and Execute Programs on branching instructions.	02
14	III	Develop and execute program for delay (without using timers).	02
15	IV	Develop and execute program for delay using timers.	02
16	IV	Develop and execute program for generating square wave using timers.	02
17	IV	Develop and execute programs on serial transmission with different baud rates.	02
18	IV	Develop and execute programs on interrupts handling.	02
19	V	Interface 8051 with external memory.*	02
20	V	Interface 8051with LED.*	02
21	V	Interface 8051 with Seven Segment LED.*	02
22	V	Interface 8051with LCD.*	02
23	V	Interface 8051 with input switches.*	02
24	V	Interface 8051 with Hex Key board.*	02
25	V	Interface 8051with ADC 0804/ADC0808/ any available.*	02
26	V	Interface 8051with DAC 0808/ any available.*	02
27	V	Interface 8051 with relay.*	02
28	V	Interface 8051with stepper motor.*	02
29	V	Interface 8051 with temperature sensor / any available linear sensor.*	02
Total (practical for 28 hours from above representing each unit may be selected)			**58**
* **Note:** These experiments can be either conducted using hardware interfacing modules or using simulated software like Labview.			

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Student should develop a small application related to micro controller as a mini project in laboratory.

ii. Prepare evolution chart for microprocessor and microcontroller families.

iii. Students should explore internet for keeping themselves up-to-date with latest upgraded versions and facilities related with micro controllers and make presentations in seminars.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Class Test
ii. Assignment
iii. Seminar/Symposium
iv. Collection/Records
v. Group discussion/Debate for continuous evaluation of lab activity
vi. Mini project

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	The 8051 microcontroller	Ayala, Kenneth	Cengage learning, New Delhi
2.	Microcontroller and embedded systems	Mazidi and Mazidi	Pearson, New Delhi
3.	The 8051 microcontroller	Mackenzie, I.S.	Pearson¸ New Delhi
4.	Microprocessor 8085: architecture, programming and application	GAONKAR, R.S.	Peneram International Publishing (India), New Delhi
5.	8051 Microcontroller: Internals, Instructions, Programming and Interfacing	Ghoshal, Subrata	Pearson Education, New Delhi
6.	The 8051 Microcontrollers: Architecture, Programming and Applications	Rao, K. Uma Andhe Pallavi	Pearson Education, New Delhi

B) List of Major Equipment/ Instrument with Broad Specification

i. Microprocessor trainer kit
ii. Microcontroller 8051 Trainer kit
iii. Computers
iv. Microcontroller Simulators
v. Microcontroller 8051 based interfacing study cards with components listed in Unit-5.

C) List of Software/Learning Websites

i. ce.kashanu.ac.ir/sabaghian/download/micro/6.ppt
ii. www.engineersgarage.com/.../8051projects/interface-lcd-at89c51-circuit
iii. courses.cs.washington.edu/courses/cse477/.../ppt/.../MicrocontrollersII.pp.
iv. nptel.iitk.ac.in/courses/.../IIT.../microcontrollers/.../Course_home2_13.ht...
v. seminarprojects.com/s/microcontroller-8051-ppt-by-iit
vi. freevideolectures.com › Electronics › IIT Kharagpur
vii. www.youtube.com/watch?v=0SZPr4iGACg

viii. www.vlab.co.in/ba_labs_all.php?id=1
ix. 59.181.142.81/Virtual Labs (Electronics), IIT Bombay.. Microcontrollers
x. nptel.ac.in/courses/Webcourse-contents/IIT.../Course_home2_5.htm
xi. cse.iitkgp.ac.in/~soumya/.../the-8051-microcontroller-0314772782.pdf
xii. http://www.bipom.com/documents/lectures/Microcontroller%20to%20Sensor%20Interfacing%20Techniques.pdf
xiii. NI Lab view evaluation version

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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