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