GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2022 (COGC-2022)

Semester – IV

Course Title: Analytical Instrumentation

(Course Code: 4341703)

Diploma programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	4th semester

1. RATIONALE

There is a growing trend in industries to use analytical instruments. Now a days most process industries use advanced, complex, and precision analytical instruments. It is therefore expected that diploma instrumentation engineers have an understanding of analytical instrumentation fundamentals. As a result, the students may be required to operate, maintain, and calibrate different analytical instruments in the process plant. Therefore, this course aims to provide students with a basic understanding of analytical instruments operation and maintenance.

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

As part of the course content, the following skills should be developed so that students acquire the following competency:

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

3. COURSE OUTCOMES (COs)

On completion of this course, the student should be able to:

a) Describe different types of Analytical Instruments.
b) Demonstrate Analytical Instruments according to mechanical, thermal and electrical properties of sample.
c) Test Radiant properties of sample using appropriate Analytical Instruments.
d) Demonstrate miscellaneous instruments for Analysis.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

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

5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PrOs) are the subcomponents of the Course Outcomes (Cos).

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	To study various components of analytical instruments.	I	2
2	Measure viscosity of a given solution using a viscometer.	II	4
3	Measure viscosity of a given solution using Zahn Cup/Ford Cup viscometer.	II	2
4	Measure density of a given solution using Pressure head type densitometer.	II	2
5	Measure density of a given solution using float type densitometer.	II	2
6	Measure density of a given solution using displacer type densitometer.	II	4
7	Test and calibrate pH meter	III	4
8	Measure conductivity of given solution using digital conductivity meter.	III	4
9	Plot effect of temperature on conductivity of given aqueous solution	III	4
10	Test and calibrate conductivity meter.	III	2
11	Measure pH of given solution using double electrode method.	III	4
12	Measure pH of given solution using combination electrode method.	III	2
13	Plot the effect of temperature on pH of given aqueous solution	III	2
14	To study dumb-bell type O2 analyzer.	III	2
15	To study wind type O2 analyzer.	III	2
16	Measure O2 concentration in given gas mixture.	III	2
17	Prepare electrode and measure dissolved O2 concentration in given sample.	IV	2
18	Water analysis using water analyzer	IV	4
19	Verify Beer-Lambert's law using Trainer kit.	IV	4
20	Analyze given sample using colorimeter.	IV	4
21	Test and calibrate spectrophotometer.	IV	2
22	Measure % transmission, absorption and concentration of given sample using spectrophotometer.	V	4
23	Study of each part of gas chromatograph	V	2
24	Analyze given gas mixture using gas chromatograph.	V	2
25	Measure refractive index using refractometer.	V	2

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical***

Exercises *of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to the user in uniformity of practical's in all institutions across the state.

I. CONDUCTIVITY METER
II. PH METER
III. WATER ANALYZER

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical, electronics, pneumatic instruments and tools.
c) Realize the importance of E-waste management. (Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that is formulated for the development of COs and competency. If required, more such UOs could be included by the course teacher to focus on the attainment of COs and competency

Unit	Unit Outcomes (UOs)	Topics and Sub-topics

Unit-I Fundamentals of Analytical Instruments	1a Define analytical instrumentation. 1b Explain the 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.	1a Define analytical instrumentation. 1b Explain the 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.
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 Viscometer, Zahn Cup Viscometer and Ford Cup Viscometer. 2e Define Density. 2f State the units of Density. 2g Enlist types of density measurement techniques. 2h Describe working principle and construction with schematic diagram of density measurement techniques. -Pressure head type densitometer -Displacer type densitometer -Float type densitometer -Float type densitometer -Buoyancy effect type densitometer 2i State principle of Thermal	2.1 Viscosity measurement techniques. 2.1.1 Terminologies 2.1.2 Saybolt viscometer 2.1.3 Zahn Cup viscometer 2.1.4 Ford Cup viscometer 2.2 Density 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

	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/AgCl2 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 &	3.1 Introduction and application 3.2 Methods of measurement of conductance : 3.2.1null method 3.2.2 direct reading method 3.3 Conductivity cell 3.3.1Temperature compensation in conductivity measurement 3.4 pH analyzer 3.4.1 Principle of pH measurement 3.4.2 Electrodes for pH measurement 3.4.3 Electronics circuit for pH measurement 3.4.4 Calibration 3.5 O2 Analyzer 3.5.1Paramagnetic O2 analyzer 3.5.1.1dumb-bell type O2 analyzer 3.5.1.2 wind type O2 analyzer 3.5.2Heat of reaction analyzer 3.5.3Dissolved O2 analyzer 3.6Polarography

	maintenance steps for pH meter 3n Explain electronics circuit for pH meter. 3o List techniques of O2 analyzer. 3p Explain principle, working and construction of dumb-bell type paramagnetic O2 analyzer. 3q Explain with schematic diagram the principle, working and construction of -wind type paramagnetic O2 3r Explain working principal of polarography	
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.	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 4.3.1 Colorimeters (photometer) 4.3.2 Spectrophotometer 4.3.3 X-ray technique of analysis by absorption. 4.3.4 X-ray technique of analysis by diffraction. 4.4 Nuclear Magnetic Resonance(NMR) 4.4.1 Principle. 4.4.2 Block diagram.

	4m Explain principle of NMR. 4n Explain block diagram of NMR spectrometer	
Unit-V Demonstrate miscellaneous devices for Analysis.	5a Define Gas chromatography. 5b List basic parts of Gas chromatograph. 5c Draw 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 5f Explain theory of operation of refractometer. 5g Define refractive index, snell's law, critical angle. 5h Classify refractometer. 5i Describe single pass refractometer with neat sketch. 5j State the limitation of refractometer. 5k List applications of refractometer. 5l Stack air Quality analyzers, CO2 analyzers, NO and H2S types, IR analyzers, 5m Air pollution due to carbon monoxide, hydrocarbons, nitrogen oxides, sulphur dioxide 5n Concepts of Dust and smoke measurements.	5.1 Gas chromatography 5.1.1 Basic parts 5.1.2 detectors 5.1.2.1thermal conductivity detector 5.1.2.2flame ionization detector(FID) 5.1.2.3flame photo detector(FPD) 5.1.2.4Electron capture detector (ECD) 5.2 Refractometer 5.2.1 Theory of operation 5.2.2 Classify Refractometer 5.2.3 Single pass refractometer 5.3 Miscellaneous Analyzers 5.3.1stack air quality analyzers 5.3.1.1 co2 analyzer 5.3.1.2 NO and H2S types 5.3.1.3 IR analyzers 5.3.2 Air pollution 5.3.3 Concepts of Dust and smoke measurements

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Fundamentals of Analytical Instruments**	4	8	0	0	**8**
II	**Analysis using Mechanical and Thermal Properties**	6	4	10	2	**16**
III	**Analysis using Electrical properties**	12	4	10	2	**16**
IV	**Analysis using radiant properties**	8	3	7	4	**14**
V	**Demonstrate miscellaneous devices for Analysis.**	12	4	10	2	**16**
	Total	**42**	**23**	**37**	**10**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a) Prepare a chart of components currently used for analytical instruments
b) Prepare a chart that displays the different types of analyzers
c) Prepare mini/micro project
d) Participate in a seminar/workshop for learning new trends and technology in analytical instrumentation
e) Prepare a poster for safety guidelines

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (MOOCs) may be used to teach various topics/ subtopics.
b) Guide student(s) in undertaking micro-projects.
c) Visit to Industries/ Process and CSMRI type laboratories/ industries
d) Video films/animation films on working of different types of analytical instruments.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Air quality monitoring system .
b) Water quality measurement using appropriate instrument.
c) Alarm system for pollution control.
d) Smoke alarm system in industry
e) Determine the pH of given solution

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of book	Author	Publication with place, year and ISBN
1	Handbook of Analytical Instruments	R.S. Khandpur	Tata McGraw Hill, New Delhi
2	Analytical Instrumentation	Bela G. Liptak	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 & Distributors

14. SOFTWARE/ LEARNING WEBSITES

- Gas chromatography:
  http://www.sigmaaldrich.com/analytical-chromatography
  http://www.slideshare.net/banuman35/applications-of-gas-chromatography-applications-of-gc-by-pravisankar

- Refractometer :
  http://www.intercomir.it/laboratorio/rifrappl_en.html
  http://www.misco.com/refractometer-support/refractometer-forum/refractometer-application

- Spectrophotometer:
  http://www.slideshare.net/suniu/spectrophotometry-16091660
  https://vlab.amrita.edu/index.php?sub=2&brch=190&sim=338&cnt=1

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

https://phet.colorado.edu/sims/html/ph-scale/latest/ph-scale_en.html
https://phet.colorado.edu/en/simulations/ph-scale

- Concentration
  https://phet.colorado.edu/sims/html/concentration/latest/concentration_en.html
- Density
  https://phet.colorado.edu/en/simulations/density
- acid-base-solutions
  https://phet.colorado.edu/en/simulations/acid-base-solutions
- Beers-law-lab
  https://phet.colorado.edu/en/simulations/beers-law-labL
- Molecules-and-light
  https://phet.colorado.edu/en/simulations/molecules-and-light

15. PO-COMPETENCY-CO MAPPING

Semester IV	ANALYTICAL INSTRUMENTATION (Course Code: 4341703)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ develop-ment of solutions	PO 4 Engineering Tools, Experimen-tation& Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Operate and maintain various analytical instruments.**						
Course Outcomes CO 1) Describe different types of Analytical Instruments	2	-	-	1	-	-	1
CO 2) Demonstrate Analytical Instruments according to mechanical, thermal and electrical properties of sample	2	1	1	2	1	1	1

CO 3)	**Test Radiant properties of sample using appropriate Analytical Instruments**	2	2	2	2	2	2	1
CO 4)	**Demonstrate miscellaneous instruments for Analysis**	2	2	2	2	3	2	2

*Legend: '**3'** for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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