Program Name : **Diploma in Instrumentation / Instrumentation & Control**

Program Code : **IS / IC**

Semester : **Fifth**

Course Title : **Analytical Instrumentation**

Course Code : **22543**

1. RATIONALE

The area of analytical instrumentation involves a multidisciplinary approach covering instruments used in medical, drugs and pharmaceutical , petroleum, chemical, water treatment, dairy, environmental pollution monitoring etc. for qualitative and quantitative analysis of given sample. The fundamental knowledge of this course will enable the student to select appropriate instrument for analysis of given sample. The objective of the course is to maintain, understand the working principle and operation of analytical instruments.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain industrial analytical instruments.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Select the relevant analytical instruments for various applications.
b. Maintain the instruments based on absorption spectroscopy.
c. Maintain the instruments based on separation techniques.
d. Use relevant analytical instrument for specified industrial gases.
e. Maintain analytical instruments to monitor environment pollutants.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment 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, ESE -End Semester Examination; PA - Progressive Assessment**

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the center of this map.

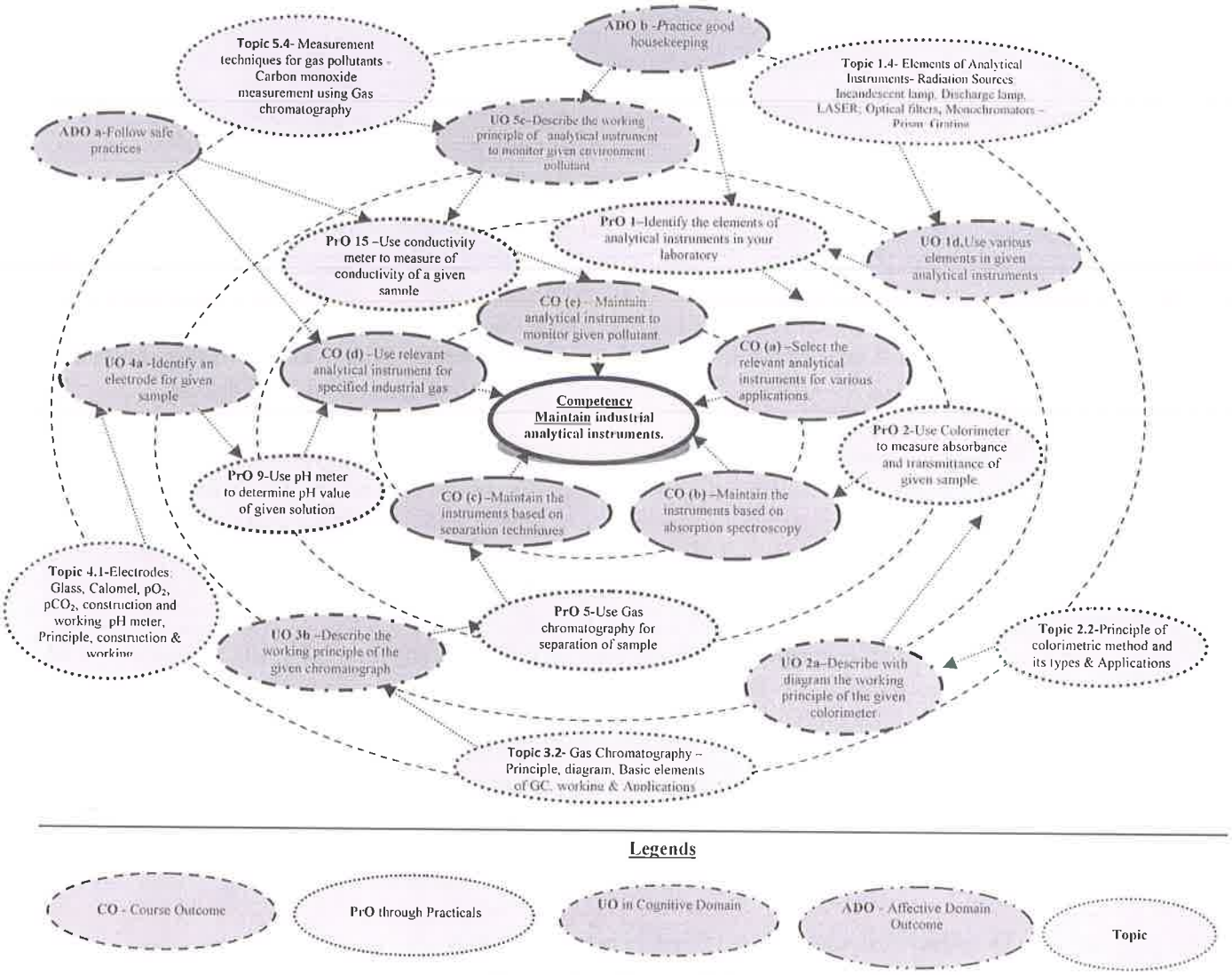

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the elements of analytical instruments in your laboratory	I	02*
2	Use Colorimeter to measure absorbance and transmittance of given sample	II	02*
3	Troubleshoot the given Colorimeter available in laboratory.	II	02
4	Use Spectrophotometer to Measure absorbance and transmittance of given sample	II	02*
5	Troubleshoot the given Spectrophotometer available in laboratory.	II	02
6	Use Flame photometer to Determine content of given sample	II	02*
7	Troubleshoot the given Flame Photometer available in laboratory	II	02

8	Use Gas chromatograph for separation of given sample contents	III	02*
9	Use video programs to demonstrate High performance liquid chromatograph for separation of given sample contents.	III	02*
10	Use video programs to demonstrate Mass spectrometer for separation of sample contents.	III	02*
11	Use video programs to demonstrate GCMS/LCMS for separation of sample contents.	III	02*
12	Use pH meter to determine pH value of given solution	IV	02*
13	Calibrate pH meter using standard buffer solution	IV	02*
14	Troubleshoot the given pH meter available in laboratory.	IV	02
15	Use IR gas analyzer to analyze given gas sample.	IV	02
16	Use thermal conductivity gas analyzer to analyze given gas sample. .	IV	02
17	Use oxygen analyzer to measure the concentration of oxygen.	IV	02*
18	Troubleshoot the given oxygen analyzer available in laboratory.	IV	02
19	Use video programs to demonstrate Complete blood gas analyzer for measurement of pO2, pCO2.	IV	02*
20	Use conductivity meter to measure of conductivity of a given sample	V	02*
	Total		**40**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of

practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Single beam filter Colorimeter: wavelength range- 340-900nm	II
2	Double beam Spectrophotometer: wavelength range- 190-2700nm	II
3	Flame photometer: Ranges Na: 1-100ppm, K: 1-100ppm, Li: 1-100ppm, Ca: 15-100ppm, Ba: 50-1000ppm.	II
4	Gas chromatography: Retention time repeatability - < 0.008% or < 0.0008 min Area repeatability - < 1% RSD, using 2ng tetradecane, Must support simultaneously: - two inlets - three detectors	III
5	High performance liquid chromatography: The flow rate should be within a range from 0.001 to 20 ml/min, Flow Accuracy: ± 1.0% or better	III
6	Mass spectrometer: Mass range (m/z) 10 – 1250 with unit mass resolution, Power 100 – 240 VAC, 50/60 Hz	III
7	pH meter, Range 0-14,Accuracy-0.1% of range ,Temp compensation-0 to 100^0 C	IV
8	IR gas analyzer:Range:CO_2-20%,CO-30%,H_2-30%,O_2-5%,CH_4-10%	IV
9	Thermal conductivity gas analyzer: Components:H_2, He ,Ar,CH_4,Output signal:4–20 mA DC, 0–1 V DC, or 0–10 mV DC	IV
10	Paramagnetic oxygen analyzer: Measurement range : Auto ranging from 0.01 to 100% Oxygen	IV
11	Conductivity meter:SO2-0 ... 20 ppm O_3-0 ... 1 ppm	V

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Introduction to analytical instrumentation	1a. Describe function of given block(s) of the block diagram of the Analytical Instrument. 1b. Categorize the given analytical instrument based on property of analyte. 1c. Classify the given analytical instruments based on working principle. 1d. Use various elements in given analytical instruments.	1.1 Analytical Instrument: Block diagram, Explanation. 1.2 Properties of Analytes and techniques used in Analytical Instrument 1.3 Classification: Spectral, Electro-analytical, Separation method(Introduction to each method) 1.4 Elements of Analytical Instruments: Radiation Sources: Incandescent lamp, Discharge lamp, LASER; Optical filters:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Absorption Filters, Monochromators –Prism, Grating
Unit– II Absorption Spectrometer	2a. Describe with diagram the working principle of the given colorimeter. 2b. Describe the working principle of given Spectrophotometer. 2c. Explain the working principle of the given Flame photometer /NMR Spectrometer 2d. Describe the procedure to troubleshoot the given Absorption Spectrometer	2.1 Interaction of radiation with matter, Beer Lambert's Law 2.2 Principle of colorimetric method and its types : Single – Beam filter photometer, Double- Beam filter photometer, Multi-channel photometer , Applications 2.3 Spectrophotometer : Using Prism, Using Grating, Applications 2.4 Flame photometer : Principle, Constructional details of Flame photometer, Applications 2.5 Principle of NMR, Constructional details of NMR spectrometer, Applications
Unit-III Analytical Instruments based on separation Techniques	3a. Classify the chromatograph for the given techniques 3b. Describe the working principle of the given chromatograph. 3c. Identify the elements of the given chromatograph. 3d. Select the chromatograph for analyzing the given sample. 3e. Describe the working principle of the given mass spectrometer 3f. Select the mass spectrometer to analyze the given sample. 3g. Describe the procedure to troubleshoot the given separation technique based analytical instrument.	3.1 Principle of chromatography, Classification of chromatography, 3.2 Gas Chromatography: Principle, diagram, Basic elements of GC, working, Application 3.3 Liquid Chromatography : Principle, diagram , Basic elements of LC, working, Application 3.4 Mass Spectrometer : diagram, working Principle, types: Magnetic deflection (Nier 60^0sector)type, Time of flight type, diagram, working, Applications - (i) GCMS (ii) LCMS
Unit –IV Industrial gas Analyzer	4a. Identify an electrode for given sample. 4b. Describe the working principle of given gas analyzer. 4c. Select the gas analyzer for the given gas sample. 4d. Categorize the gas analyzer for given industrial application. 4e. Describe the procedure to troubleshoot the given Industrial gas Analyzer	4.1 Electrodes: Glass, Calomel, pO_2, pCO2, construction and working. pH meter, Principle, construction & working. 4.2 Complete Blood gas Analyzer for measurement of pH, pCO_2,pO_2, TCO_2,HCO_3,Base excess - Block diagram of complete blood gas analyzer, working. 4.3 Infrared gas Analyzer: Principle, Block diagram, working, applications 4.4 Thermal Conductivity Analyzer: Principle, diagram, working.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		applications. 4.5 Paramagnetic Oxygen Analyzer
Unit-V Environmental Pollution monitoring Instruments	5a. Identify the necessity of environmental pollutants analysis. 5b. Classify different pollutants and their concentration in environment. 5c. Describe the working principle of analytical instrument to monitor given environment pollutant. 5d. Select the analyzer to analyze the given environmental pollutant. 5e. Describe the procedure to troubleshoot the given Pollutant Monitoring Instrument	5.1 Necessity of monitoring pollutants for environmental sustainability. 5.2 Representation of concentration of gases 5.3 Types and concentration of various gas pollutants 5.4 Measurement techniques for gas pollutants - Carbon monoxide measurement using Gas chromatography, 5.5 SO2 measurement using Conductivity method, 5.6 Nitrogen Oxides measurement using (i) Chemiluminescence(ii) CO Laser, 5.7 Ozone measurement using Conductivity meter.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to analytical instrumentation	6	2	4	-	6
II	Absorption Spectrometer	12	4	8	4	16
III	Analytical Instruments based on separation Techniques	10	4	8	4	16
IV	Industrial gas Analyzer	10	4	8	4	16
V	Environmental Pollution monitoring Instruments	10	4	8	4	16
Total		**48**	**18**	**36**	**16**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

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 conduct following activities in group and prepare

reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Visit to pathological laboratories to understand the operation of various analytical equipment.
b. Visit to industrial laboratories to understand the working of various analytical equipments.
c. Visit to PUC(Pollution under control) to measure the concentration of pollutants
d. Do internet survey and use various meters to calibrate analytical equipment
e. Read the safety precautions to operate various analytical equipment.
f. Library/Internet survey of advanced analytical equipment.
g. Prepare power point presentation or animation for understanding the concept of working of analytical instruments.

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/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Use proper equivalent analogy to explain different concepts.
g. Use Flash/Animations to explain working principle of analytical instrument.

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-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, 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 dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student 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. Similar micro-projects could be added by the concerned faculty:

a. Build an analogous model showing internal construction of Gas Chromatography/ Liquid Chromatography.
b. Build an analogous model showing internal construction of Colorimeter.
c. Build an analogous model showing internal construction of Spectrophotometer.
d. Build an analogous model showing internal construction of Flame photometer.
e. Analyze different environmental pollutant with the help of analytical instrument available in institute analytical instrumentation laboratory and prepare report on it.

f. Measure pH of different five water samples (drinking water, sewage water, Sea water etc.) with the help of pH meter and prepare a report on it.
g. Build a prism monochromator and prepare a report on it.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Handbook of Analytical Instrumentation	Khandpur R. S.	McGraw Hill Education, New Delhi, 2009, ISBN -13:978-0-07-060460-5 ISBN -10:0-07-060460-6
2	Analytical Instrumentation	Liptak Bela G.	CRC Press,1994,ISBN:9780801983979
3	Instrumental methods of analysis	Willard Merrit Dean	CRC Press ISBN-9780534290153
4	Instrumental method of chemical analysis	Ewing E. W.	McGraw Hill Education, New Delhi, ISBN-9780070198531
5	Introduction to instrumental analysis	Braun Robert D.	McGraw Hill Education, New Delhi, ISBN-978007100472
6	Principle of instrumental analysis	Skoog;Holler&Nieman	Sunder C ISBN-9781305577213
7	Bioinstrumentation	L. Veerakumari	MJP Publishers,Chennai2006, ISBN 81-8094-018-7

14. SOFTWARE/LEARNING WEBSITES

1. http://vlab.amrita.edu/?sub=1&brch=194&sim=802&cnt=4
2. http://vlab.amrita.edu/?sub=1&brch=192
3. http://ccnsb06-iiith.vlabs.ac.in/exp6_10/IR_Powder_exp6.swf
4. http://ccnsb06-iiith.vlabs.ac.in/exp7/index.php
5. http://ccnsb06-iiith.vlabs.ac.in/exp8/index.php
6. http://ccnsb06-iiith.vlabs.ac.in/exp9/index.php
7. http://ccnsb06-iiith.vlabs.ac.in/exp5/index.php
8. http://ccnsb06-iiith.vlabs.ac.in/exp10/index.php
9. http://vlab.amrita.edu/?sub=1&brch=195&sim=359&cnt=1
10. https://www.youtube.com/watch?v=bVKASwadjQY