INTRODUCTION TO ANALYTICAL INSTRUMENTS FOR CHEMICAL ANALYSIS

Course Code : 313017

Programme Name/s	**: Chemical Engineering**
Programme Code	**: CH**
Semester	**: Third**
Course Title	**: INTRODUCTION TO ANALYTICAL INSTRUMENTS FOR CHEMICAL ANALYSIS**
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I. RATIONALE

The analysis of materials is indispensable for monitoring and controlling the process/operations in the process industry. Nowadays use of analytical instruments for chemical analysis is increasing day by day. Therefore knowledge of different analytical instruments is desirable. Considering this requirement the curriculum is designed to provide an overview about the most common and important analytical instruments used.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The course should be taught and implemented with the aim to develop required skills in students so that they are able to acquire following industry outcome:
The course is expected to develop an ability to select suitable analytical instruments, interpret the results obtained by using the analytical instruments thereby monitor and control the progress of process/operation.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Differentiate between different instrumental methods of chemical analysis as per requirement.
- CO2 - Select relevant Spectroscopy based method of analysis based on nature of sample.
- CO3 - Select appropriate chromatography based analytical instruments for the given analyte.
- CO4 - Interpret the results of thermoanalytical method to decide the thermal stability of a material
- CO5 - Identify analytical instruments for composition and crystallographic study of a relevant sample.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												Total Marks
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313017	INTRODUCTION TO ANALYTICAL INSTRUMENTS FOR CHEMICAL ANALYSIS	IAIC	SEC	2	2	-	-	4	2	-	-	-	-	-	50	20	-	-	-	-	50

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Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain methods of chemical analysis. TLO 1.2 Differentiate between physical method and instrument based method of analysis. TLO 1.3 State the advantages and limitations of Chemical and Instrumental methods. TLO 1.4 Classify Instrumental methods of chemical analysis.	**Unit - I Introduction to Instrumental Methods of analysis** 1.1 Purpose/ Necessity of Chemical analysis and methods of analysis a. Quantitative Analysis b. Qualitative Analysis c. Chemical Methods d. Physical methods 1.2 Differentiate between physical properties and analytical methods of measurement. 1.3 Advantages and limitation of Chemical and Instrumental methods. 1.4 Classification of basic Instrumental method of chemical analysis : a. Electrochemical method b. Optical methods c. Radiometric method d. Mass Spectrometry e. Nuclear Magnetic Resonance.	Lecture Using Chalk-Board Presentations Case Study

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain electromagnetic spectrum and Parameters of electromagnetic radiations. TLO 2.2 Explain Principle and applications of Spectroscopy. TLO 2.3 Describe spectroscopy based analytical instruments.	**Unit - II Spectroscopy** 2.1 Electromagnetic Spectrum depicting wavelength, frequencies of electromagnetic radiations. Properties or parameters of electromagnetic radiations such as: a.Wavelength b.Frequency c.Velocity d.Wave Number. e. Definition of spectroscopy 2.2 UV-Visible spectrophotometer :Introduction, Principle, Construction, Working and Application. 2.3 Atomic Absorption Spectroscopy: Introduction, Principle, Construction, Working and Application. 2.4 Introduction, Principle and Application of Mass Spectroscopy.	Lecture Using Chalk-Board Video Demonstrations Presentations Site/Industry Visit
3	TLO 3.1 Explain chromatographic method of analysis. TLO 3.2 Distinguish between chromatography and spectroscopy. TLO 3.3 State different types of chromatographic methods. TLO 3.4 Explain typical features of commonly used chromatography based analytical instruments.	**Unit - III Chromatography** 3.1 Introduction of chromatography : Purpose and Principle. 3.2 Difference between spectroscopy and chromatographic based methods. 3.3 Introduction, Principle and Applications of following type of chromatography: a. Adsorption Chromatography b. Partition Chromatography c. Liquid - Liquid Chromatography d. Gas Chromatography(GC) e. Paper Chromatography f. Thin Layer Chromatography (TLC) g. High Performance Liquid Chromatography (HPLC) 3.4 Construction and Working of Gas Chromatography and High Performance Liquid Chromatography. 3.5 Introduction and Application of Gas Chromatography - Mass Spectrometry (GC-MS) and Liquid Chromatography - Mass Spectrometry (LC-MS)	Lecture Using Chalk-Board Video Demonstrations Site/Industry Visit Case Study
4	TLO 4.1 Select the analytical instrument for determining thermal stability of given material. TLO 4.2 Identify thermal characteristics of material.	**Unit - IV Thermoanalytical Methods** 4.1 Introduction, Principle and Applications of Thermogravimetric method of analysis (TGA). 4.2 Thermoanalytical methods based on thermal characteristics of material : a. Differential Scanning Calorimetry (DSC) b. Differential Thermal analysis (DTA).	Lecture Using Chalk-Board Video Demonstrations Case Study

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 State the applications of analytical instruments based on refraction and diffraction of light. TLO 5.2 Select the analytical instrument for determining composition of mixture and determine water content in given sample.	**Unit - V Miscellaneous Methods of Analysis** 5.1 Introduction, Principle, Construction, Working and Applications of Abbe's Refractometer. 5.2 Introduction, Principle and Applications of X- ray diffractometer (XRD). 5.3 Introduction, Principle and Applications of Elemental analyzer (CHN analyzer). 5.4 Introduction, Principle and Applications of Karl Fischer Titrator.	Lecture Using Chalk-Board Video Demonstrations Site/Industry Visit Presentations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Classify the analytical instruments.	1	* Explain the classification of analytical instruments based on following points: a. Method / Criteria of classification b. Phenomenon underlying method c. Quantity or property measured	2	CO1
LLO 2.1 List the different parts of UV- Visible Spectrophotometer. LLO 2.2 Explain the working of UV- Visible Spectrophotometer.	2	* Explain Principle, Construction, Working and Application of UV-Visible Spectrophotometer.	2	CO2
LLO 3.1 List the different parts of Atomic Absorption Spectrometer. LLO 3.2 Explain the working of Atomic Absorption Spectrometer.	3	* Explain Principle, Construction, Working and Application of Atomic Absorption Spectrometer (AAS).	2	CO2
LLO 4.1 List the applications of Atomic Absorption Spectrometer .	4	Visit soil and water testing labs / research lab in your area and prepare a report based on applications of Atomic Absorption Spectrometer .	2	CO2
LLO 5.1 Interpret the graphical data. LLO 5.2 Identify the appropriate sample for Chromatographic study.	5	* Use a virtual lab to prepare a report on interpretation of graphical data of given sample by Paper Chromatography.	2	CO3
LLO 6.1 List the different parts of Gas Chromatograph (GC). LLO 6.2 Explain the working of Gas Chromatograph (GC).	6	*Describe the Principle, Construction, Working and Applications of Gas Chromatography (GC).	2	CO3

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 7.1 List the different parts of High Performance Liquid Chromatography(HPLC). LLO 7.2 Explain the working of High Performance Liquid Chromatography(HPLC).	7	* Prepare a report stating Principle, Construction, Working and application of High Performance Liquid Chromatography(HPLC).	2	CO3
LLO 8.1 Describe methods of analysis of HPLC.	8	Refer journal papers and prepare a report based on HPLC based method of analysis of identified 3-5 compounds.	2	CO3
LLO 9.1 Differentiate the chromatograms of different samples based on the nature of the material.	9	Refer literature/journals. Collect the information about Chromatograph of any five Active Pharmaceutical Ingredients and prepare a report.	2	CO3
LLO 10.1 Explain the principle and applications of identified analytical instruments.	10	* Refer NPTEL website. Prepare a report / presentation based on any one relevant instrumental methods of analysis.	2	CO3
LLO 11.1 Differentiate spectrums of 5 compounds LLO 11.2 Differentiate chromatograms of 5 compounds	11	Use NIST Chemistry Webbook (https://webbook.nist.gov/chemistry) and prepare report for 5 compounds on the basis of Mass Spectrum, UV / Visible Spectrum and Gas Chromatograph.	2	CO2 CO3
LLO 12.1 Explain the different thermoanalytical methods of analysis.	12	Refer online resources, manufacturer websites to collect information about Thermoanalytical methods such as TGA/DSC/DTA.	2	CO4
LLO 13.1 List the different parts of refractometer. LLO 13.2 Explain the working of refractometer.	13	Use Virtual lab and perform experiments based on Abbe's Refractometer.	2	CO4
LLO 14.1 List the application of XRD analysis in industry.	14	Refer Journals / Magazine / Online resources to prepare a report on application of XRD analysis in industry.	2	CO5
LLO 15.1 List applications of various analytical instruments available. LLO 15.2 Write specifications of identified instruments.	15	* Visit Analytical / research lab available in nearby locations and Collect the information of analytical instruments available and prepare the list of relevant instruments, their applications along with specifications .	2	CO2 CO3 CO4 CO5
LLO 16.1 List the identified equipment along with specifications.	16	Visit the websites of different analytical instruments manufacturing companies (Perkin Elmer/Agilent/ThermoFisher/Shimadzu/Waters/Lab India, etc.). Prepare list of relevant equipments manufactured along with specifications.	2	CO2 CO3 CO4 CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Not Applicable

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Not Applicable	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Instrumental Methods of analysis	CO1	4	0	0	0	0
2	II	Spectroscopy	CO2	8	0	0	0	0
3	III	Chromatography	CO3	10	0	0	0	0
4	IV	Thermoanalytical Methods	CO4	4	0	0	0	0
5	V	Miscellaneous Methods of Analysis	CO5	4	0	0	0	0
Grand Total				**30**	**0**	**0**	**0**	**0**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Term work as Continuous Assessment.

Summative Assessment (Assessment of Learning)

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	1	1	1	1	1			
CO2	3	2	1	1	-	1	1			
CO3	3	2	1	1	1	1	1			
CO4	3	2	1	1	1	1	1			
CO5	3	2	1	1	-	1	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	B. K. Sharma	Instrumental Method of Chemical Analysis	GOEL Publishing House, Meerut (India) ISBN -81-87224-98-3
2	Douglas A. Skoog F. James Holler Stanley R. Crouch	Principle of Instrumental Analysis	Cengage ISBN 9789353506193
3	P. C. Jain, Monika Jain	Engineering Chemistry	Dhanpat Rai Publishing Company,17th Edition ISBN 978-9352160006
4	Gurdeep R. Chatwal and Sham K. Anand	Instrumental Methods of Chemical Analysis (5th Edition)	Himalaya Publishing House ISBN 978-9351420880
5	R.Gopalan R., K. Rangarajan K., P.S.Subramanian	Elements of Analytical Chemistry (3rd Edition)	S. Chand & Sons ISBN: 978-81-8054-765-2

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://nptel.ac.in/courses/103108100 https://www.youtube.com/watch?v=UHYfgwjE2i4	Introduction to the Modern Instrumental Methods of Analysis by Dr. J.R. Mudakavi
2	https://www.youtube.com/watch?v=R_tgHUUXiE4	Common Analytical Instruments
3	https://www.youtube.com/watch?v=O39avevqndU	Ultraviolet / Visible Spectroscopy (UV-Vis)
4	https://www.youtube.com/watch?v=P9iAV-x5y-w	The Science Behind UV Vis Spectroscopy: Everything You Need To Know

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Sr.No	Link / Portal	Description
5	https://www.youtube.com/watch?v=uSG8ANBTaN0	Gas Chromatography- Explainer Video
6	https://www.youtube.com/watch?v=Wap9pQEN4gE	Atomic Absorption Spectroscopy (AAS) Explained
7	https://www.youtube.com/watch?v=UycPljfrnWo	Quickly Understand Gas Chromatography
8	https://www.petro-online.com/news/analytical-instrumentation/11/gr-scientific/water-content-determination-of-crude-oils-and-petroleum-products-by-coulometric-karl-fischer-titration/34652	Water Content Determination of Crude Oils and Petroleum Products by Coulometric Karl Fischer Titration
9	https://www.youtube.com/watch?v=QHMzFUo0NL8	What is X-ray Diffraction?
10	https://www.iitk.ac.in/che/PG_research_lab/pdf/resources/TGA-DSC-reading-material.pdf	Thermal Analysis Thermogravimetry (TG) & Differential Scanning Calorimetry (DSC)
11	https://webbook.nist.gov/chemistry	NIST chemistry workbook

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students