



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003051

Course/Subject Name: Analytical and Optical Instrumentation

| | |
|-------------------------|-----------------|
| w. e. f. Academic Year: | 2024-25 |
| Semester: | 3 rd |
| Category of the Course: | PCC |

| | |
|----------------------|--|
| Prerequisite: | Basic knowledge of Optical and Transducers |
| Rationale: | To study Analytical and Optical Instrumentation, students should have a solid understanding of basic electrical and electronic engineering concepts, including circuits and components. Familiarity with measurement techniques, transducers, and sensor principles is essential. A basic grasp of optics (like reflection, refraction, and light behavior) and fundamental chemistry (especially related to chemical analysis) is also important. |

Course Outcome:

After Completion of the Course, Student will be able to:

| No | Course Outcomes | RBT Level |
|------|--|-----------|
| CO-1 | Identify various elements and functional parameters of analytical instrumentation system | U |
| CO-2 | Identify different parts of absorption instrument. | U |
| CO-3 | Maintain different types of Spectrophotometers and Flame photometer. | A |
| CO-4 | Maintain different types of Blood gas analyzers. | A |
| CO-5 | Identify various types of chromatography and blood cell counter techniques. | U |

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

| Teaching Scheme (in Hours) | | | Total Credits L+T+ (PR/2) | Assessment Pattern and Marks | | | | Total Marks |
|----------------------------|---|----|---------------------------------|------------------------------|--------|--------|----------------------|-------------|
| L | T | PR | | C | Theory | | Tutorial / Practical | |
| | | | ESE (E) | | PA(M) | PA (I) | ESE (V) | |
| 3 | 0 | 2 | 4 | 70 | 30 | 20 | 30 | 150 |



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Course Content:

| Unit No. | Content | No. of Hours | % of Weightage |
|----------|---|--------------|----------------|
| 1. | Introduction | 07 | 15% |
| | 1.1 Elements of analytical Instrument. 1.2 Types of Instrumental methods 1.3 Classification of analytical instruments 1.4 Performance requirements of analytical instruments such as errors in chemical analysis, Accuracy and precision, SNR | | |
| 2. | Fundamentals of Absorption Instrument | 08 | 20% |
| | 2.1 Electromagnetic radiation: EM spectrum, 2.2 Interaction of Radiation with matter. 2.3 Laws related to absorption of Radiation: 2.3.1 Beer's law 2.3.2 Lambert's law 2.3.3 Beer-Lambert's law. 2.4 Block diagram of Absorption instruments 2.5 Various components of absorption Instruments like: 2.5.1 radiation source 2.5.2 different optical filters 2.5.3 monochromators 2.5.4 photosensitive detectors 2.5.5 slit Width 2.5.6 sample holders 2.6 Types of Absorption Instruments | | |
| 3. | Colorimeter, Spectrophotometer and Flame Photometer | 12 | 23% |
| | 3.1 Colorimeters (filter photometer): 3.1.1 single beam filter photometer 3.1.2 Double beam filter Photometer 3.2 Application of Colorimeter(photometer) in medical field 3.3 Optical diagram of Spectrophotometers 3.4 Application of Spectrophotometer in medical field 3.5 Principle of flame photometry 3.6 Block diagram of flame photometry 3.7 Essential parts of flame photometry 3.8 Constructional details: 3.8.1 emission system, 3.8.2 optical system, | | |



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|----|--|---------------|--------------|
| | 3.8.3 photosensitive detectors, 3.8.4 recording system 3.9 Clinical flame Photometer | | |
| 4. | Blood PH and Gas Analyzers | 08 | 20% |
| | 4.1 basic of acid base balance 4.2 blood pH measurement 4.3 principle of pH electrode with neat Sketch. 4.4 List the types of pH electrodes 4.5 Construction of Glass electrode 4.6 Measurement of O ₂ :Construction of O ₂ electrode 4.7 Measurement of CO ₂ : Construction of CO ₂ electrode | | |
| 5. | Blood cell Counter and Chromatography | 10 | 22% |
| | 5.1 blood cell counters measurement techniques 5.1.1 microscopic method 5.1.2 optical method 5.1.3 electrical conductivity method 5.1.4 coulter Counter method. 5.2 Chromatography: chromatography basics and Its techniques. 5.3 Gas chromatograph: block diagram 5.4 Liquid chromatographs: types of liquid chromatograph 5.4.1 Paper Chromatography 5.4.2 Thin layer chromatography 5.4.3 Column Chromatography | | |
| | Total | 45 Hrs | 100 % |

Suggested Specification Table with Marks (Theory):

| Distribution of Theory Marks (in %) | | | | | |
|-------------------------------------|---------|---------|---------|---------|---------|
| R Level | U Level | A Level | N Level | E Level | C Level |
| 37 % | 43 % | 20 % | -- | -- | -- |

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Handbook of Analytical Instruments by R.S. Khandpur, Tata McGraw Hill, New Delhi
2. Instrumental Methods of Analysis by Willard, Merritt, Dean, Settle, CBS Publishers & Distributors, New Delhi, Seventh edition.



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3. Principles of Instrumental Analysis by Skoog, Holler, Nieman, Thomson books-cole publications, 5th edition.
4. Instrumental Methods of Chemical Analysis by Galen W. Ewing, McGraw-Hill Book Company, Fifth edition
5. Introduction to Instrumental Analysis by Robert D. Braun, McGraw-Hill Book Company

(b) Open-source software and website:

1. pH Meter :
<https://phet.colorado.edu/en/simulations/ph-scale-basics>
<https://www.wikihow.com/Calibrate-and-Use-a-pH-Meter>
2. Beer's Law :
<https://phet.colorado.edu/en/simulations/beers-law-lab>
3. Spectrophotometer :
<https://vlab.amrita.edu/index.php?sub=2&brch=190&sim=338&cnt=1>
<https://www.slideshare.net/suniu/spectrophotometry-16091660>
4. Thin layer Chromatography
<https://vlab.amrita.edu/index.php?sub=3&brch=63&sim=154&cnt=1>

Suggested Course Practical List:

| Sr. No. | Practical Outcomes (PrOs) | Unit No. | Approx. hours required. |
|---------|--|----------|-------------------------|
| 1 | To study about analytical instrumentation. | 1 | 02 |
| 2 | To study about performance requirement of analytical instruments. | 1 | 02 |
| 3 | Identify wavelength and frequency in Electromagnetic spectrum. | 2 | 02 |
| 4 | Identify different components of absorption instruments | 2 | 02 |
| 5 | Demonstrate the working principle of Spectrophotometer. | 3 | 04 |
| 6 | To determine the concentration of alkali and alkaline earth metals in various samples using flame photometer. | 3 | 02 |
| 7 | To determine the pH value of given solutions using pH meter. | 4 | 02 |
| 8 | To find EMF of the cell. To calculate the Gibbs free energy change of the cell reaction. To calculate the Equilibrium constant. To predict the spontaneity of the cell reaction. | 4 | 04 |
| 9 | To understand Blood cell and its constituents using CBC Report learn various methods of blood cell counting. | 4 | 02 |
| 10 | Understand the principle behind chromatography techniques | 5 | 02 |
| 11 | Separate different colors by paper chromatography. | 5 | 02 |



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|----|--|---|----|
| 12 | Identify different types of pathological waste | 5 | 02 |
|----|--|---|----|

List of Laboratory/Learning Resources Required:

| Sr. No. | Equipment Name with Broad Specifications | PrO.No. |
|---------|--|---------|
| 1. | Analytical instrumentation model/Chart | 1 & 2 |
| 2. | Electromagnetic spectrum Chart/Model | 3 |
| 3. | Spectrophotometer | 4 & 5 |
| 4. | Flame photometer | 6 |
| 5. | pH meter | 7 & 8 |
| 6. | Blood cell Counter | 9 |
| 7. | Chromatography Model/Chart | 10 & 11 |
| 8. | Pathological Waste model/Chart | 12 |

Suggested Project List:

The projects serve as practical learning experiences for students in the field of Biomedical engineering. These projects integrate theoretical knowledge with hands-on application, fostering competency development across various Course Outcomes (COs). Below are guidelines for designing and executing projects:

- **Project Types:**
 - It can be industry-based, internet-based, workshop-based, laboratory-based, or field-based.
 - Each project should align with specific COs and address real-world challenges.
- **CO Integration:**
 - It should encompass two or more COs.
 - Integration involves aligning Program Outcomes (PrOs), Unit Outcomes (UOs), and Assessment and Design Outcomes (ADOs).
- **Project Duration:**
 - Students are encouraged to maintain a dated work diary to document their individual contributions and sufficient engagement time for each project should be allocated by faculty during the course.
- **Seminar Presentation:**
 - Before submission, students must give a seminar presentation on their project.
 - The presentation should highlight the project's objectives, methodology, results, and relevance to industry-oriented COs.



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Following are suggestive projects, and additional ones can be tailored to specific course objectives. Encourage students to explore innovative solutions and apply their engineering skills effectively.

1. Determine the pH of given solution
2. Prepare model to differentiate the different rays of electromagnetic Spectrum
3. Prepare model to execute beer-lambert's law.
4. Prepare model to perform thin layer/Paper chromatography
5. Prepare model to show Absorption Instruments.
6. To make effective charts of Blood cell counting techniques
7. Make a report on handling, recycling and disposal of wastes in Pathology laboratories and suggest some innovative strategies to overcome the problem if any.

Suggested Activities for Students:

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:

1. Visit to nearer pathology laboratory
2. Visit a nearby hospital where laboratory facilities are available
3. Prepare a chart of components currently used for analytical and optical instruments
4. Prepare mini/micro project
5. Participate in a seminar/workshop for learning new trends and technology in analytical and optical instrumentation
6. Prepare a poster for safety guidelines

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:

1. Massive open online courses (MOOCs) may be used to teach various topics/ subtopics.
2. Guide student(s) in undertaking micro-projects.
3. arrange to visit nearer Hospital/pathological laboratory
4. Video films/animation films on working of different types of analytical and Optical instruments.
5. Perform practical virtually on the various online website/software
6. Arrange expert lectures

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