

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester - IV

Course Title: Analytical and Optical Instrumentation

(Course Code: 4340303)

| | |
|--|----------------------------------|
| Diploma programme in which this course is offered | Semester in which offered |
| Biomedical Engineering | 4 th Semester |

1. RATIONALE

Now days use of analytical and optical instruments has become routine in Hospital and pathological laboratories for analysis of different body fluids in details. It is therefore expected that diploma biomedical engineers should have an understanding of analytical and optical instrumentation fundamentals. As a result, the students may be required to operate, maintain, and calibrate different analytical and optical instruments in the hospital and pathological laboratories. Therefore, this course tries to build knowledge and skills to the students and make them capable to maintain and operate different analytical and Optical instruments.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in students so that they are able to acquire following competency:

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

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

- Identify various elements and functional parameters of analytical instrumentation system
- Organize different parts of absorption instrument.
- Compare different types of photometer. (Spectrophotometer and Flame photometer)
- Demonstrate Blood gas analyzers and Blood Cell Counter
- Interpret various types of chromatography and pathological waste management**

4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme (In Hours) | | | Total Credits (L+T+P) | Examination Scheme | | | | Total Marks |
|-------------------------------|---|---|--------------------------|--------------------|-----|-----------------|-----|----------------|
| L | T | P | | Theory Marks | | Practical Marks | | |
| | | | C | CA | ESE | CA | ESE | |
| 3 | 0 | 4 | 5 | 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

The following practical outcomes (PrOs) that are the sub-components of the COs. Some of the **PrOs** marked ‘*’ are compulsory, as they are crucial for that particular CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. required |
|--------------|--|----------|-----------------------|
| 1 | Identify various elements of analytical instrumentation system. | 1 | 2 |
| 2 | Performance analysis and requirements of analytical instruments including errors in chemical analysis, Accuracy and precision, SNR | 1 | 4 |
| 3 | Identify wavelength and frequency in Electromagnetic spectrum. | 2 | 2 |
| 4 | Identify various Laws related to absorption of Radiation | 2 | 2 |
| 5 | Describe the principle of absorbance and transmittance. | 2 | 2 |
| 6 | Identify different components of absorption instruments | 2 | 2 |
| 7 | Demonstrate the working principle of Spectrophotometer. | 3 | 4 |
| 8 | Identify the various parts of clinical flame photometer | 3 | 2 |
| 9 | Demonstrate the working principle of flame photometer. | 3 | 4 |
| 10 | Determine the pH value of given solutions using pH meter. | 4 | 4 |
| 11 | Demonstrate the working principle of blood gas analyzer. | 4 | 4 |
| 12 | Demonstrate the working principle of blood cell counting. | 4 | 4 |
| 13 | Count the blood cell using coulter Counter method. | 4 | 4 |
| 14 | Understand the principle behind chromatography techniques. | 5 | 2 |
| 15 | Demonstrate the working principle of Gas chromatography | 5 | 4 |
| 16 | Demonstrate the working principle of column chromatography | 5 | 4 |
| 17 | Separate different colors by paper chromatography. | 5 | 2 |
| 18 | Identify different types of pathological waste | 5 | 2 |
| Total | | | 54 |

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.

| S. No. | Sample Performance Indicators for the PrOs | Weightage in % |
|--------|--|----------------|
| 1 | Preparation of experimental setup | 20 |
| 2 | Operate the equipment setup | 20 |
| 3 | Follow safe practices measures | 10 |

| S. No. | Sample Performance Indicators for the PrOs | Weightage in % |
|--------------|--|----------------|
| 4 | Record observations correctly | 20 |
| 5 | Interpret the result and conclusion | 30 |
| Total | | 100 |

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

- a) pH meter
- b) Colorimeter
- c) Spectrophotometer
- d) Flame photometer
- e) Chromatograph
- f) Blood cell counter
- g) Autoclave

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 competency.

- a) Work as a leader/a team member.
- b) Follow safety practices while using electrical appliances.
- c) Practice environmental friendly methods and processes. (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

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency

| Unit | Unit Outcomes (UOs) | Topics and Sub-topic |
|--|---|--|
| Unit – I Introduction to analytical instruments | 1.a Define analytical Instrumentation. 1.b Describe the different methods of analysis. 1.c Describe performance Requirements of Analytical Instruments. 1.d List out various analytical instrument used in laboratory. | 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 |

| | | |
|---|---|---|
| <p align="center">Unit – II Fundamentals of Absorption Instrument</p> | <p>2.a Describe Electromagnetic spectrum with Necessary diagram.</p> <p>2.b Explain interaction of radiation with matter</p> <p>2.c Explain beer Lambert’s law</p> <p>2.d Draw and explain block diagram of absorption Instrument.</p> <p>2.e List components of absorption instrument</p> <p>2.f List out the types of Absorption Instruments</p> | <p>2.1 Electromagnetic radiation: EM spectrum,</p> <p>2.2 Interaction of Radiation with matter.</p> <p>2.3 Laws related to absorption of Radiation:</p> <p>2.3.1 Beer’s law</p> <p>2.3.2 Lambert’s law</p> <p>2.3.3 Beer-Lambert’s law.</p> <p>2.4 Block diagram of absorption instruments</p> <p>2.6 Types of Absorption Instruments</p> |
| <p align="center">Unit– III Spectrophotometer and Flame Photometer</p> | <p>3.a Draw and explain optical diagram of Spectrophotometer.</p> <p>3.b List out the application Of spectrophotometer.</p> <p>3.c Draw and explain block diagram of Flame photometer.</p> <p>3.d State principle of clinical flame Photometer.</p> <p>3.e List out the application Of flame photometer in medical field</p> <p>3.f Differentiate different types of photometer</p> | <p>3.1 Optical diagram of Spectrophotometers</p> <p>3.2 Application of Spectrophotometer in medical field</p> <p>3.3 Principle of flame photometry</p> <p>3.4 Block diagram of flame photometry</p> <p>3.5 Essential parts of flame photometry</p> <p>3.6 Constructional details:</p> <p>3.6.1 emission system,</p> <p>3.6.2 optical system,</p> <p>3.6.3 photosensitive detectors</p> <p>3.6.4 Recording system</p> <p>3.7 Clinical Flame photometer</p> <p>3.8 Application of flame photometer in medical field</p> |
| <p align="center">Unit– IV Blood pH and Blood Cell Counter</p> | <p>4.a Define pH</p> <p>4.b Describe the principle of blood PH Measurement.</p> <p>4.c List the types of pH electrodes</p> <p>4.d Describe principle of pH electrode with neat Sketch.</p> <p>4.e List measurement techniques of blood cell counter</p> <p>4.f Draw and explain block diagram of coulter counter.</p> | <p>4.1 basic of acid base balance</p> <p>4.2 blood pH measurement</p> <p>4.3 Principle of pH electrode with neat Sketch.</p> <p>4.4 List the types of pH electrodes</p> <p>4.5 Construction of Glass electrode</p> <p>4.6 blood cell counters measurement techniques</p> <p>4.6.1 microscopic method</p> <p>4.6.2 optical method</p> <p>4.6.3 electrical conductivity method</p> <p>4.6.4 coulter Counter method.</p> |
| <p align="center">Unit– V Chromatography and Pathological Waste management</p> | <p>5.a Describe principle of Chromatography</p> <p>5.b List the types of chromatography</p> <p>5.c Explain the principle of Gas chromatograph</p> <p>5.d Explain block diagram of gas chromatograph</p> <p>5.e List the types of liquid chromatography</p> <p>5.f Describe principle of different liquid chromatography.</p> <p>5.g Define pathological waste.</p> <p>5.h Describe pathological waste</p> | <p>5.1 Chromatography: chromatography basics and its techniques.</p> <p>5.2 Gas chromatograph : block diagram</p> <p>5.3 Liquid chromatographs: types of liquid chromatograph</p> <p>5.3.1 Paper Chromatography</p> <p>5.3.2 Thin layer chromatography</p> <p>5.3.3 Column Chromatography</p> <p>5.4 Pathological Waste</p> <p>5.5 Waste Disposal Process</p> |

| | | |
|--|--------------------|--|
| | management process | |
| | | |

Note: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

| Unit No. | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|--------------|--|----------------|------------------------------|-----------|-----------|-------------|
| | | | R Level | U Level | A | Total Marks |
| 1 | Introduction to analytical instruments | 6 | 8 | 2 | 0 | 10 |
| 2 | Fundamentals of Absorption Instrument | 8 | 4 | 4 | 2 | 10 |
| 3 | Spectrophotometer and Flame Photometer | 8 | 6 | 8 | 4 | 18 |
| 4 | Blood PH and Blood cell Counter | 10 | 4 | 6 | 4 | 14 |
| 5 | Chromatography and Pathological Waste management | 10 | 6 | 8 | 4 | 18 |
| Total | | 42 | 28 | 28 | 14 | 70 |

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

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may varies lightly 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 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:

- Visit to nearer pathology laboratory
- Visit nearer Hospital where laboratory facility available
- Prepare a chart of components currently used for analytical and optical instruments
- Prepare mini/micro project
- Participate in a seminar/workshop for learning new trends and technology in analytical and optical instrumentation
- 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) arrange to visit nearer Hospital/pathological laboratory
- d) Video films/animation films on working of different types of analytical and Optical instruments.
- e) Perform practical virtually on the various online website/software
- f) Arrange expert lectures

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:

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.

13. SUGGESTED LEARNING RESOURCES

| S. 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 | Instrumental Methods of Analysis | Willard, Merritt, Dean, Settle, | CBS Publishers & Distributors, New Delhi, Seventh edition. |
| 3 | Principles of Instrumental Analysis | Skoog, Holler, Nieman | Thomson books-cole publications, 5th edition. |
| 4 | Instrumental Methods of Chemical Analysis | Galen W. Ewing, | McGraw-Hill Book Company, Fifth edition |
| 5 | Introduction to Instrumental Analysis | Robert D. Braun | McGraw-Hill Book Company |

14. SOFTWARE/LEARNING WEBSITES

- pH Meter :
<https://phet.colorado.edu/en/simulations/ph-scale-basics>
<https://www.wikihow.com/Calibrate-and-Use-a-pH-Meter>
- Beer's Law :
<https://phet.colorado.edu/en/simulations/beers-law-lab>
- Spectrophotometer :
<https://vlab.amrita.edu/index.php?sub=2&brch=190&sim=338&cnt=1>
<https://www.slideshare.net/suniu/spectrophotometry-16091660>
- Thin layer Chromatography
<https://vlab.amrita.edu/index.php?sub=3&brch=63&sim=154&cnt=1>
- Gas Chromatography :
<https://www.youtube.com/watch?v=939N9JFQXY>
<https://www.youtube.com/watch?v=iX25exzwKhl>
- Microscope :
https://javalab.org/en/microscope_en/
http://cbi-au.vlabs.ac.in/cell-biology-1/Light_Microscope/#
- Electromagnetic Wave :
https://javalab.org/en/category/electricity_en/electromagnetic_wave_en/
- Coulter Counter :
<https://bitesizebio.com/48384/coulter-counter-works/>

15. PO-COMPETENCY-CO MAPPING

| Semester III | Pos | | | | | | |
|---|--|-----------------------------|--|---|---|-----------------------------------|-------------------------------|
| | PO 1 Basic & Discipline specific knowledge | PO 2 Problem Analysis | PO 3 Design/ developmen t of solutions | PO 4 Engineerin g Tools, Experiment ation &Testing | PO 5 Engineering practices for society, sustainabilit y & environmen t | PO 6 Project Managemen t | PO 7 Life-long learning |
| Competency & Course Outcomes | | | | | | | |
| Competency | | | | | | | |
| CO-1 Identify various elements and functional parameters of analytical instrumentation system | 2 | 2 | - | - | 2 | - | 3 |
| CO-2 Organize different parts of absorption instrument. | 3 | - | 1 | 3 | - | 2 | 2 |
| CO-3 Compare different types of photometer. (Spectrophotometer and Flame photometer) | 3 | - | 1 | 3 | - | - | 2 |
| CO-4 Demonstrate Blood gas analyzers and Blood Cell Counter | 3 | - | 2 | 3 | - | - | 2 |

| | | | | | | | |
|--|---|---|---|---|---|---|---|
| CO-5 Interpret various types of chromatography and pathological waste management | 3 | - | 2 | 3 | 2 | 3 | 3 |
|--|---|---|---|---|---|---|---|

Legend: '3' for high, '2' for medium, '1' for low or '-' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

| S. No. | Name and Designation | Institute | Contact No. | Email |
|--------|----------------------|---|-------------|---------------------------|
| 1 | Mr. S. R. Jain | Government Polytechnic Gandhinagar | 9016796602 | ersrj22@yahoo.com |
| 2 | Ms. A. R. Dalwadi | Government Polytechnic for Girls, Ahmedabad | 9099314217 | ankitadalwadi98@gmail.com |
| 3 | Ms. P.G.Lakhani | Government Polytechnic Gandhinagar | 9898645087 | poonamlakhani17@gmail.com |