Analytical Instrumentation (INTC 1448)

Credit: 4 semester credit hours (3 hours lecture, 4 hours lab)

Prerequisite: CETT 1403/CETT 1405

Course Description

This course is a study of the application, installation, and calibration of numerous types of analytical instrumentation, along with study of continuous and non-continuous online analyzers. This includes oxygen analyzers, pH meters, infrared (IR), ultraviolet (UV), mass spectrometers, fiber optic, conductivity, and Chromatographic analyzers.

Required Textbook and Materials

1. *Analytical Instrumentation* by Bela G. Liptak, 1St edition, 1994
    a. The ISBN number is 9780801983979

Course Objectives

Upon completion of this course, the student will be able to:

1. Describe the functions, strengths, and limitations of various analytical instruments.
2. Describe the calibration method for various analytical instruments.
3. Operate numerous types of analytical instruments and analyzers.
4. Explain the function and importance of analyzer sample systems.

Course Outline

A. You and Your Analyzers

- Responsibilities as a Technician
- Analyzer Safety
- Glossary of Terms
- What is an Analyzer?
- Why do we need Analyzers?
- Analysis Frequency
- Discuss Quantitative and Qualitative Analysis

B. Analyzer Types

- Where do we find Analyzers?
- Why do we analyze?

C. Sensors and Detectors

- Photomultipliers
- Electron Capture Detector (ECD)
- Thermal Conductivity Detectors
- Electrochemical
- Flame Ionization Detector (FID)

D. Sample Systems

- Components
- Gas Sampling probes
- Filters
- Spargers, packed towers, and strippers.
- Separating liquid phases
- Removing gas bubbles from a liquid
- Slipstream and bypass filters
- Sampling high pressure condensate
- Homogenizers
- Solids Sampling
- Sample Conditioning
- Trace Analysis Sampling
- Multistream Switching
- Testing and Calibration

E. Analyzer Sampling - Stack Particulates

- Pitot Tube Assembly
- Installation
- Operation

F. Air Quality Monitoring

- Sampling of Ambient Air
- Gas and Vapor Sampling
- Absorption
- Adsorption
- Particulate Matter Sampling
- Air Quality Monitoring Systems

G. Calorimeter
- Terminology
- Water-Temperature-Rise Calorimeter (illustration)
- Air-Temperature-Rise Calorimeter (illustration)
- Airflow Calorimeter (illustration)
- Chromatographic Calorimeter (illustration)

H. Carbon Dioxide
- Ambient Air Measurement
- Source Measurement

I. Carbon Monoxide
- Calibration techniques
- Nondispersive Infrared Analyzers
- Gas Chromatograph Analyzer
- Electrochemical Analyzer
- Catalytic Analyzer

J. Chlorine
- Residual Chlorine Analyzer
- Colorimetric Analyzer
- Amperometric Analyzer
- Membrane Probes
- Buffers, Reagents, and Cleaners

K. Colorimeters
- Color Measurement
- Color vs. Wavelength Table
- Spectrophotometric Analyzers
- In-Line continuous Color Monitors

L. Combustible Analyzers
- Catalytic Combustion on a heated Filament
- Diffusion Head Analyzers
- Measurement Circuits
- Thermocouple Detector
- Wheatstone Bridge Detector

M. Conductivity Analyzers
- Theory of Operation
- The Cell Constant
- Two Electrode Cells
- Four Electrode Cells
- Electrodeless Cells
- Measurement Applications

N. Fiber Optic Probes and Cable
- Principle of Measurement
- Optical Fiber
- Probes
- Detectors
- Applications
- Absorption
- Fluorescence
- Scattering
- Refractive Index

O. Infrared Analyzers
- Principles of Infrared Analysis
- Infrared Analyzers for Laboratory Applications
- Grating Spectrometers
- Filter Spectrometers
- Infrared Analyzers for Process Applications
- Infrared Sources
- Tungsten Halogen Lamp
- Infrared Detectors

P. Ultra-violet light and Visible light Analyzers
- The Radiation Spectrum
- The Beer-Lambert Law
- UV-Absorbing Compounds
- Components of UV Analyzers
- Radiation Sources
- The Monochromator
- The Sample Cell
- Detectors
- Designs for UV analyzers
- Single beam
- Split beam
- Dual beam-single-detector
- Dual beam-dual-detector
- Flicker photometer
- Photodiode Array Spectrophotometers
- Retroreflector
- Near-Infrared Photometers

Q. Hydrocarbon Analyzers
- Types of Hydrocarbons
- Methods of Analysis
- Analyzer Calibration
- Flame Ionization Detector

R. Hydrogen sulfide Analyzers
- Gold Film and Semiconductor Sensors
- Photometric Analysis
- Electrochemical Cells

S. Mass Spectrometers
- Principle of Operation

- Sample Ionization
- Types of Analyzers
- Magnetic Sector Instruments
- Quadrupole Instruments
- Time-of-Flight
- Ion-Trap Instruments

T. Mercury in Water Analyzers

- Total Mercury Detection
- Colorimetric Detection

U. Humidity and Dew Point analyzers (Air)

- Relative Humidity Sensors
- Wet and Dry Bulb Hygrometers
- Hair Hygrometers
- Cellulose Hygrometers
- Solution Resistance Elements (Dunmore Cells)
- Polystyrene Surface Resistivity (Pope Cells)
- Thin-Film Capacitance
- Dew point Hygrometers
- Condensation on Chilled Surface
- Surface Conductivity
- Moisture Indicators

V. Moisture in Gases and Liquids

- Process Analyzers and Sample Systems
- Electrolytic Hygrometer
- Capacitance Hygrometer
- Impedance Hygrometer
- Piezoelectric Hygrometer
- Heat-of-Adsorption Hygrometer
- Infrared Absorption Hygrometer
- Microwave Absorption Hygrometer

W. Moisture in Solids Analyzer

- Industrial Detectors
- Nuclear Moisture Gauge
- Infrared Adsorption or Reflection
- Microwave Attenuation
- Capacitance Moisture Gauge
- Resistance Moisture Gauge
- Impedance Moisture Gauge
- Nuclear Magnetic Resonance
- Radio Frequency Absorption

X. Nitrogen Oxide Analyzers

- Industrial Emission Monitoring
- Nondispersive Infrared and Ultraviolet Analyzers
- Chemiluminescent Determination
- Electrochemical Sensors
- Gas Chromatography
- Ambient Air Monitoring
- Calibration
- NO-NO2 Combination Analysis
- Calorimetric Determination

Y. Oil on or in water

- Process Industry Measurements
- Capacitance-Type Water-in-Oil Detectors
- Radio-Frequency (Microwave) Sensors
- Ultraviolet Oil-in-Water Analyzer
- On-Off Oil-on-Water Detector
- Oil Thickness on Water Detector

Z. Oxidation-Reduction Potential (ORP)

- Principles of Measurement
- Equipment for ORP Measurement
- Application of ORP
- Care of an ORP System
- ORP Control

AA. Oxygen in Gas Analyzers

- Paramagnetic Sensors
- Deflection-Type Analyzer (Deflection Design)
- Thermal-Type Analyzer (Thermal Design)
- Dual Gas Type Analyzer (Reference-Gas Design)
- Catalytic Combustion Detector
- Electrochemical Detectors (High Temperature Fuel Cell, Ambient Temperature Galvanic, and Polargraphic)

BB. Oxygen in Liquid Analyzers

- Polargraphic Cell
- Galvanic Cell
- Coulometric Sensor

CC. Particulate, Opacity, Dust, and Smoke Analyzers

- The Phenomenon of Light Attenuation
- Units and Definitions (Only Transmittance and Opacity)
- Light Attenuation/Transmissometer
- Double-Pass versus Single Pass Configurations
- Single-Beam, Double-Beam, or Dual-Beam Configurations
- Air Purge
- Ambient Air Opacity Monitoring
- High Volume Sampler

- Dichotomous Sampler
- Tape Sampler
- Light Scattering (Nephelometer)
- Piezoelectric Crystal Mass Balance
- Impaction Devices
- Radiometric Devices
- Charge Transfer (Triboelectricity)
- Surface Ionization
- Visual Observation
- Remote Sensing

DD. Particle Size and Distribution Monitors

- First Paragraph page 307
- Particle Size and Distribution
- Small Sample Quantities
- Optical Microscopy
- Electron Microscopy
- Image Analyzers
- Electrical Sensing Zone (Coulter Principle)
- Optical Scattering (Single Particles)
- Intermediate Loadings
- Light Scattering (Multiple Particle)
- Sedimentation (Photo and X-Ray)
- High Loading
- Sieving
- Optical Methods
- Ultrasonic Attenuation
- On-Line Particle Size Measurement

EE. Ion-Selective Electrodes

- Types of Electrodes
- Glass
- Solid State
- Liquid-Ion Exchange or Solid Matrix
- Calibrating Solutions

FF. pH Analyzers

- The Theory
- The Electrodes
- Shapes and Designs
- Fiber Optic pH Measurement
- The Reference Electrode
- The Differential Electrode
- Application Problems
- Installations
- Calibration

GG. Phosphorus Analyzers

- Colorimetric Analysis
- Flame Photometric Analysis
- Gas-Liquid Chromatography

HH. Refractometers

- Theory of Operation
- Differential Refractometers
- Critical Angle Refractometers
- Reflected Light Measurement

II. Sulfur in Oil Analyzers

- X-Ray Absorption Type (Theory of Operation)
- X-Ray Fluorescence

JJ. Sulfur Oxide Analyzers

- Nondispersive Infrared and Ultraviolet Analyzers
- Thermal Conductivity Analyzers
- Ambient Air analyzers
- Colorimetric, Conductimetric, Coulometric, Flame Photometric, and Electrochemical.

KK. Thermal Conductivity Detectors

- Measurement Ranges
- Principal Components
- Operation (Wheatstone Bridge)

LL. Total Carbon Analyzers

- Total Organic Carbon, Total Carbon, and Total Inorganic Carbon
- Catalytic Oxidation with a Nondispersive Infrared Detector
- Flame Ionization Detector
- Aqueous Conductivity
- Colorimetric Analysis

MM. Toxic Gas Monitoring

- Hazardous or Toxic Atmospheres
- Continuous Industrial Monitoring
- Electrochemical Sensors
- Discontinuous Dosage Sensors
- Color Change Badges
- Color Detector (Dosimeter) Tubes
- Sorption type Dosimeters
- Calibration of Electrochemical Sensors

NN. Turbidity, Sludge, and Suspended Solids

- Turbidity Units (NTU)
- Forward Scattering or Transmission Types
- Dual-Beam Design
- Laser type
- Suspended Solids and Sludge Density Sensors
- Scattered Light Detector (Nephelometer)
- Backscatter Turbidity Analyzers

- In-Line Units

OO. Viscometers

- Non-Newtonian Fluids
- Theory of Viscous Behavior
- Viscometer Applications

PP. Gas and Liquid Chromatographs

- Chromatograph Operation
- Components of a Process Gas Chromatograph
- Analyzer
- Oven
- Sample Valves
- Rotary Sample Valve
- Sliding Plate Valve
- Diaphragm Valve
- Columns
- Packed Columns
- Column and Valve Configuration
- Hardware
- Sample Injection
- Back Flush
- Heart-Cutting
- Detectors
- Thermal Conductivity Detector
- Flame Ionization Detector
- Flame Photometric Detector
- Orifice-Capillary Detector
- Photo ionization Detector
- Electron Capture Detector
- Helium Ionization Detector
- Carrier Gas Flow Control

Grade Scale

90 – 100	A
80 – 89	B
70 – 79	C
60 – 69	D
0 – 59	F

Course Evaluation

Final grades will be calculated according to the following criteria:

Activity	***Percentage***
Homework/Labs	20%
Exams	50%
Final Exam	30%
Total	***100%***

Late Penalties will be assessed on all work turned in late. 10 points per class period

Course Requirements:

1. Describe the functions, strengths, and limitations of various analytical instruments
2. Operate various analytical instruments.
3. Analyze samples.

Course Policies

1. No food, drinks, or use of tobacco products in class.
2. No foul language will be tolerated. The classroom will be a respectful environment.
3. No side conversations are allowed during lecture.
4. Ask questions. They are all important questions. There are no “Stupid Questions”.
5. Turn off all Cell Phones during lectures and Exams.
6. Headphones may be worn only upon Instructor approval.

7. Do not bring children to class.
8. No Cheating of any kind will be tolerated. Students caught cheating or helping someone to cheat can and will be removed from the class for the semester. Cheating can result from expulsion from LIT. **When you cheat, you are only cheating yourself!**
9. If you wish to drop a course, the student is responsible for initiating and completing the drop process. If you stop coming to class and fail to drop the course, you will earn an 'F' in the course.
10. Internet Usage
    a. Classroom computers have access to the internet.
    b. Student usage of the internet will be monitored.
    c. Proper usage of the internet will be allowed. Used for classroom research or as directed.
    d. Any unauthorized use of the internet will not be tolerated.
    e. Improper usage of the internet, such as profanity, pornography, gambling, etc… will result in disciplinary action not limited to expulsion from LIT.
11. Missing more than 20% of classes will result in an automatic "F" for the course.
12. Absences are counted for unexcused, excused and coming to class late.
13. Missing more than 20% of a class period will count as an absence.
14. Being tardy 3 times equals 1 absence.
15. Call or Email the instructor if you cannot attend a class.

Disabilities Statement

The Americans with Disabilities Act of 1992 and Section 504 of the Rehabilitation Act of 1973 are federal anti-discrimination statutes that provide comprehensive civil rights for persons with disabilities. Among other things, these statutes require that all students with documented disabilities be guaranteed a learning environment that provides for reasonable accommodations for their disabilities. If you believe you have a disability requiring an accommodation, please contact the Special Populations Coordinator at (409) 880-1737 or visit the office in Student Services, Cecil Beeson Building.

Student Code of Conduct Statement

It is the responsibility of all registered Lamar Institute of Technology students to access, read, understand and abide by all published policies, regulations, and procedures listed in the LIT Catalog and Student Handbook. The LIT Catalog and Student Handbook may be accessed at www.lit.edu or obtained in print upon request at the Student Services Office.

Course Schedule

Week	Topic	Reference
1	• Lecture: Responsibilities of a technician • Lab: Types of analyzer	Lecture Notes Lecture Notes
2	• Lecture: Sensors and Detectors • Lab: Sample Systems	Lecture Notes Chapter 2

3	• Lecture: Analyzer Sampling, Air Quality monitoring, Calorimeters, Carbon Dioxide, Carbon Monoxide, Chlorine • Lab: Sample systems	Chapter 3,4,7,8,9,10
4	• Lecture: Colorimeters, Combustible analyzers, Conductivity analyzers, • Lab: Sample systems	Chapter 14, 15,16
5	• Lecture: Review all previous information for exam • Administer Exam I	All of the above
6	• Lecture: Fiber Optic probes and cables, Infrared Analyzers • Lab: Detection	Chapters 22 and 26 Fiber optic analyzer
7	• Lecture: Ultra-Violet light and Visible light, Hydrocarbon, Hydrogen Sulfide, and Mass Spectrometers. • Lab: Detection	Chapters 57, 24, 25, 28
8	• Lecture: Mercury in Water analyzers, Humidity and Dew Point analyzers, Moisture in Gases and Liquids, and Moisture in Solids analyzer. • Lab: Hygrometers and Psychrometers	Chapters 30, 31, 33, 35,
9	Review for Exam II Administer Exam II	All chapters covered after Exam I
10	• Lecture: Nitrogen Oxide, Oil on or in water, Oxidation-Reduction Potential ORP), Oxygen in Gas analyzers, Oxygen in Liquid Analyzers. • Lab: Oxygen sensors and Hydrometers	Chapters 36, 38, 39, 40, 41
11	• Lecture: Particulate, Opacity, Dust, and smoke Analyzers, Particle size analyzers, Ion selective Electrodes, pH analyzers, • Lab: pH meters	Chapters 44, 45, 27, 46, Portable pH meters

12	• Lecture: Phosphorus, Refractometers, Sulfur in oil, Sulfur oxide, Thermal conductivity Detectors, Total Carbon analyzers • Lab: (TCD) Thermal Conductivity Detectors	Chapters 47, 49, 51, 52, 53, 54
13	• Lecture: Toxic Gas monitoring, Turbidity, sludge, Suspended Solids • Lab: Viscometers	Chapters 55, 56, 58, 59, 60
14	Review for Exam III Administer Exam III	All Chapters after Exam II
15	Lecture: Gas and liquid Chromatography Lab: Gas Chromatograph	Chapters 11 and 12
16	Review for Final Exam Administer Final Exam	Chapters 11 and 12