Virginia Western Community College
MDL 260 Laboratory Instrumentation

Prerequisites

BIO 101 or equivalent

Course Description

Teaches the theory, principles of operation, methodologies, maintenance, and troubleshooting of the more common instrumentation used in the clinical laboratory.

Semester Credits: 2 Lecture Hours: 1 Lab/Clinical/ Internship Hours: 0

Required Materials

Textbook:

There is no required text for this course. The course instructor will provide handouts; information included would be from textbooks from previous MLT classes or from the following references:

- Chapters from textbooks utilized in prior courses
- Henry's Clinical Diagnosis and Management by Laboratory Methods, 23 Edition by Richard A. McPherson, MD, MSc; Matthew R. Pinus, MD, PhD; Elsevier
- Clinical Laboratory Instrumentation and Automation: Principles, Applications, and Selection, 1st Edition by Kory M. Ward PhD MT(ASCP) (Author), Craig A. Lehmann PhD CC(NRCC) (Author), Alan m. Leiken PhD (Author) • copies of select journal articles

Course Outcomes

At the completion of this course, the student should be able to:

- Describe the theory behind common instruments and their principles of operation.
- Apply knowledge from theories and methodologies to understand the principles of operation of currently and routinely used analyzers in clinical laboratories.
- Apply safety regulations relating to laboratory instrumentation.
- Properly prepare specimens for instrumentation analysis.
- Properly troubleshoot equipment, perform preventative maintenance, quality control and follow quality assurance guidelines.
- Apply knowledge and be able to perform basic maintenance on clinical laboratory analyzers.
- Apply knowledge and be able to understand requirements for procurement, installation, qualification/ validation and equipment upgrades.
- Recognize when and how pre-analytical, analytical, and post-analytical errors can affect instrument generated results.

Topic Outline

Topic		Objectives
Part 1	**Safety**	1. Explain the responsibility of laboratories to develop and publicize safety policies and procedures. 2. Identify and describe six types of safety risks that exist in the clinical laboratory. 3. Identify the components of the chain of infection and give examples of each, describe infection-control procedures used to break the chain, and identify four functions of infection-control programs. 4. Describe proper procedures for hand hygiene and putting on and removing protective clothing 5. Describe standard and transmission-based precautions and identify the organizations that developed them. 6. State safety rules to follow when working in the laboratory and in patient areas. 7. List examples of blood-borne pathogens and describe their means of transmission in a healthcare setting. 8. Discuss the major points of the blood-borne pathogens (BBP) standard, including changes required by the Needlestick Safety and Prevention Act, and identify key elements of a BBP exposure control plan. 9. Describe decontamination processes for equipment 10. Describe hazards, identify warning symbols, list actions to take if incidents occur, and specify rules to follow for proper biological, electrical, fire, radiation, and chemical safety. 11. Comply with standard precautions, proper use of PPE, handling of hazardous materials, and disposal of sharps in the laboratory. 12. Compare chemical labeling symbols. 13. Interpret the meaning of various safety symbols and pictograms
Quiz- Safety		
	Specimen Requirements and Processing	1. Describe the test request process, identify the types of requisitions used, and list the required requisition information. 2. List and define test status designations, identify status priorities, and describe the procedure to follow for each status designation. 3. Explain the importance of proper patient identification and describe what information is verified, how to handle discrepancies 4. List necessary information found on specimen tube lab 5. Identify, describe, and explain how to avoid or handle procedural error risks, specimen quality concerns 6. List general requirement for specimen collection and labeling for non-blood specimens 7. State at least 4 reasons for specimen rejection
	General Laboratory Supplies and Reagents: Considerations, Cautions, and Quality	1. List some uses of water in the laboratory and explain reasons why some uses require high purity water 2. State CLSI and CAP grades of water purity and general criteria for each 3. Describe methods of water purification that may be utilized in a laboratory 4. Explain the responsibility of laboratories to monitor water purifying methods 5. List types of balances that may be found in laboratories. 6. Discuss specifications and calibration for balances and weights. 7. List types of glassware and plasticware utilized by laboratories. 8. Describe limitations for use of glassware and plasticware 9. List other supplies that may be found in laboratories 10. Interpret Material Safety Sheets 11. Compare, contrast and interpret COA and COC (certificate of analysis and certificate of compliance)
Quiz – General Laboratory Considerations / Specimens		
	Review of QC, Accuracy, Precision, Levey-	1. Explain why quality is important to the hospital, patients and laboratory 2. Discuss principles of total quality management in the clinical laboratory. 3. Describe, discuss and compare the following terms: quality control reagents versus standards; accuracy versus precision; mean, standard deviation and

	Jennings Charts, Westgard Rules, etc.	coefficient of variation; systemic error, random error, trend versus shift, and reference range. 4. Given example results calculate the mean, the standard deviation and correctly plot results on Levey-Jennings charts. 5. Identify, describe, and explain how to apply Westgard Rules. 6. List strategies to utilize during investigation of a failed test system. 7. Compare sensitivity and specificity of a test and predictive values 8. List examples of pre-analytical, analytical and post analytical errors (pre-examination, examination, and post-examination) 9. Explain the importance of external quality assessment and proficiency testing.
Quiz – QC		
	Overview of Laboratory Instruments / Overview of Instrumentation Methodologies	1. List major analytic techniques and instrument types used in modern laboratories 2. Discuss essential principles of analytic instruments in the clinical laboratory. 3. State basic components of instruments in the clinical laboratory 4. Explain the importance of proper maintenance, quality control, and reagent integrity for accurate results 5. Compare and contrast standardization, calibration, and validation of equipment
TEST 1		
Part 2	**Spectrophotometry**	1. Describe and discuss the following terms: spectrometry, EMR, major role of spectrometry, some examples of applications of spectrometry. 2. Explain Beer- Lambert Law (or Beer's Law) 3. List possible reasons for deviations from Beer's Law 4. List the major components of a spectrometer and describe basic operation principles 5. Define the acronym LASER 6. Describe a blank and why it is used 7. List some parameters which should be monitored for quality assurance in spectroscopy
	Reflectometry - Reflectance Photometry	1. Describe / discuss reflectometry 2. List some examples of reflectometry uses in medicine 3. Describe the relationship between concentration and reflectance 4. List several other reflectometery methods
	Molecular Luminescence Spectrophotometry – Fluorometry	1. Define the terms: Luminescence spectroscopy. molecular fluorescence spectroscopy, molecular phosphorescence spectroscopy, chemiluminescence spectroscopy 2. Describe fluorescence, a fluorophore, incandescence, phosphofluorescence, chemiluminescence, bioluminescence 3. List some examples of fluorometric analyzers used in the modern laboratory 4. List factors that influence Fluorescence and Phosphorescence 5. List components of Fluorescence Spectrophotometers 6. List several advantages / disadvantages and applications of Fluorescence and Phosphorescence methods
	Nephelometry and Turbidimetry	1. Compare and contrast nephelometry and turbidity 2. List components of nephelometer and tubidometer 3. List some examples of analyzers used in the modern laboratory 4. List several advantages / disadvantages and applications of contrast nephelometry and turbidity methods
Quiz – Spectrophotometry / Reflectometry / Fluorometry / etc		
	Refractometry	1. Define refractive index 2. Describe principles of refractometry 3. List several types of refractometers 4. Describe use of refractometer to measure specific gravity 5. Differentiate between direct and indirect measurement of specific gravity 6. Compare and contrast specific gravity and osmolarity 7. List several advantages / disadvantages refractometer use

8. State normal range for specific gravity in urinalysis
9. State some possible reasons for increased or decreased specific gravity in urinalysis
10. List several advantages / disadvantages and applications of contrast nephelometry and turbidity methods
11. Describe routine care and maintenance of a refractometer
12. State calibration and quality control requirements for refractometers

Osmometry

1. Define osmosis, osmolarity, and osmolality
2. List colligative properties
3. Explain how freezing point depression, boiling point elevation and lowering of vapor pressure can be measured by instrumentation
4. Describe an osmometer and its principle components
5. State precautions that should be observed when using an osmometer
6. Define an osmolar gap
7. State the type of osmometer instrument most commonly found in laboratories

Flow Cytometry

1. State principles of flow cytometry
2. Define fluorochrome
3. List cell characteristics that can be measured using flow cytometry
4. Identify sample requirements and sample preparation for analysis using a flow cytometer
5. List the systems that comprise a flow cytometer and the major components of each system
6. List parameters that measured
7. Compare and contrast histogram and dual dimensional dot plot
8. Discuss fluidics system and hydrodynamic focusing
9. Discuss use of monoclonal antibodies and fluorescence in detection of abnormal / aberrant cells
10. Discuss flow cytometer data in terms of parameters, histograms, and dot plot
11. Discuss the concept of gating and how it can be used in analysis of data from flow cytometry
12. Define sorting and discuss how it is used in flow cytometry
13. List applications for flow cytometry for clinical hematology, blood bank, clinical microbiology, and DNA analysis
14. Explain quality control in flow cytometry

Quiz- Flow Cytometry

Electrochemistry

1. State the fundamental principles of electrochemistry and chemical sensors
2. Describe potentiometry and list types of electrodes
3. List some clinical analysis procedures based no electrochemical sensors
4. Define the term biosensor

Test 2

Part 3 Conductance and Impedance

1. Define conductance or conductometry and list several applications
2. Define electrical impedance
3. State the fundamental principles of hematology analyzers currently in use in clinical laboratories
4. Compare and contrast impedance and flow cytometry methodologies in hematology analyzers
5. Describe bases for CBC parameters measured by impedance methods (Colter Cell Counter)
6. State sources of errors in measurements performed by cell counters
7. Correlate Hemoglobin and hematocrit values obtained
8. Define MCV, MCH, MCHC, RDW, and MPV
9. Interpret printed results and histograms
10. Explain region flags and abnormalities that they may represent
11. State normal and critical CBC values
12. Explain what is meant by linearity
13. Discuss interferences that may cause erroneous results

Quiz- Conductance /Impedance

	Electrophoresis and Densitometry / Capillary Electrophoresis / Isoelectric Focusing	1. Define densitometry and state components of a densitometer 2. Explain electrophoresis, capillary electrophoresis, isoelectric focusing 3. List applications for this instrumentation 4. Interpret peaks (bands) on serum electrophoresis and state some clinical reasons for abnormal results 5. Define electrical impedance 6. State the fundamental principles of hematology analyzers currently in use in clinical laboratories 7. Compare and contrast impedance and flow cytometry methodologies in hematology analyzers 8. Describe bases for CBC parameters measured by impedance methods (Colter Cell Counter) 9. State sources of errors in measurements performed by cell counters

Quiz- Electrophoresis

	Biotechnology Techniques	1. Describe PCR and applications of PCR 2. Define RADP, RT-PCR, Quantitative (real-time) PCR (qPCR), FISH, and FACS 3. Explain ELISA, Competitive ELISA, Direct ELISA, Indirect ELISA and Sandwich ELISA 4. List several applications of ELISA tests

Test 3

Part 4	**Chromatography**	1. Describe principle of chromatography 2. Identify terms which may be associated with a chromatograph: injection point, baseline, peak width, baseline nose, peak fronting, peak tailing, peak with poor resolution, baseline drift 3. List different chromatography methods/ techniques 4. List the basic components for a gas chromatography instrument
	Mass spectrometry	1. Describe principle of mass Spectrometry 2. List applications of mass spectrometry 3. Identify basic components of a mass spectrometer 4. Define MALDI, MALDI-TOF 5. List different chromatography methods/ techniques
	Troubleshooting Equipment	1. Explain the importance of scheduled equipment maintenance and service 2. Describe “troubleshooting” as it applies to laboratory equipment and processes 3. Identify basic concepts, cautions and tools for troubleshooting laboratory equipment and processes 4. Explain how maintenance records, documentation of non-scheduled maintenance or troubleshooting steps can help laboratory instrument reliability and decrease downtime

Final Exam – cumulative

Notes:

- **This outline is tentative and subject to change**
- **Study guides/ questions are provided at the discretion of the instructor**
- **The final exam is cumulative and may include some questions from past quizzes and exams, as well as questions on new material**