COURSE OUTLINE

Course Number	Course Title	Credits
MLT 200	Clinical Chemistry	**4**
Hours: Lecture/Lab/Other	**Co- or Pre-requisite**	**Semester & Year**
3/2	permission of program coordinator	**Summer 2023**

Catalog description: Principles and theory of chemical analysis performed on clinical specimens. In-depth study examines specimen processing, analysis, test interpretation, and quality control procedures used in routine manual and automated clinical chemistry testing. Laboratory exercises involve bench techniques, dilutions, and test procedures. Group presentations highlight various chemistry analyzers

General Education Category:
Not GenEd

Course coordinator:
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Required texts & Other materials:

Required:

i. Clinical Laboratory Chemistry Sunheimer R..(2017) 2nd Ed. Pearson ISBN-13: 978-0134413327
ii. Instructor-developed Lab Manual (purchase through the bookstore)
iii. MediaLab Subscription (provided by program budget) https://www.medialab.com/

Needed Lab Materials:

i. White lab coat- This must be a knee-length coat with a fitted wristband/cuff; it reduces the potential for splashes up the arm and fire hazards.
ii. Gloves - latex or nitrile, not vinyl 4. Pocket calculator
iii. Black or blue ink pen. (NO WORK IN PENCIL ACCEPTED)
iv. Sharpie or other permanent marker, fine point, black or blue
v. 3 ring binder w/Note pages:
√ Tabs or dividers are needed to identify and separate the following sections: Syllabus - including schedule and unit objectives, lecture PowerPoints, graded materials & other informative material.
√ Save all procedures, pre-labs, in-lab exercises, case studies and study questions.

Course Student Learning Outcomes (SLO):

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

1. Identify key elements of laboratory safety and universal precautions. (Supports ILG# 1,3,9; PLO#1, 2, 6, 7)
2. Demonstrate knowledge of the function and physiology of the body systems including renal, liver, cardiovascular, respiratory, digestive, endocrine, and reproductive. (Supports ILG# 3,11; PLO# 1, 2)
3. Correlate clinical chemistry laboratory results to conditions of health or disease in the human body. (Supports ILG# 3,4,11; PLO# 2, 6, 7)
4. Apply knowledge of general and physiological chemistry to manual and automated laboratory testing. (Supports ILG# 1,3; PLO#1, 2)
5. Apply knowledge of mathematics in the performance and analysis of statistical measurements used for quality assessment in the clinical laboratory. (Supports ILG# 1,2; PLO#1, 2, 4)
6. Discuss topics in relation to tumor markers, therapeutic drug monitoring and toxicology. (Supports ILG#1,3; PLO# 2, 6, 7)
7. Recognize differences in reference ranges for diverse populations. (Supports ILG# 3,8; PLO# 4, 5)

8. Demonstrate critical thinking skills in the evaluation of patient case studies relating data to a medical diagnosis and clinical conditions that occur as a result of disease processes. (Supports ILG# 3,4; PLO#3)
9. Perform basic laboratory techniques used in clinical chemistry. (Supports ILG# 3,4; PLO# 2)
10. Access information on a chemistry analyzer and present a classroom presentation on that instrument following designated guidelines. (Supports ILG# 1,4,10; PLO# 3, 5)

Course-specific Institutional Learning Goals (ILG):

Institutional Learning Goal 1. Written and Oral Communication in English. Students will communicate effectively in both speech and writing.
Institutional Learning Goal 2. Mathematics. Students will use appropriate mathematical and statistical concepts and operations to interpret data and to solve problems.
Institutional Learning Goal 3. Science. Students will use the scientific method of inquiry, through the acquisition of scientific knowledge.
Institutional Learning Goal 4. Technology. Students will use computer systems or other appropriate forms of technology to achieve educational and personal goals.
Institutional Learning Goal 8. Diversity and Global Perspective: Students will understand the importance of a global perspective and culturally diverse peoples
Institutional Learning Goal 9. Ethical Reasoning and Action. Students will understand ethical frameworks, issues, and situations.
Institutional Learning Goal 10. Information Literacy: Students will recognize when information is needed and have the knowledge and skills to locate, evaluate, and effectively use information for college level work.
Institutional Learning Goal 11. Critical Thinking: Students will use critical thinking skills understand, analyze, or apply information or solve problems.

Program Learning Outcomes (PLO) for Medical Laboratory Technology

1. Integrate knowledge learned and experienced in the disciplines of general education, mathematics, science, and medical laboratory science;
2. Achieve entry-level career competencies of a medical laboratory technician by testing biological samples using current technology to generate accurate, quality-assured laboratory results used for health and disease evaluation;
3. Utilize critical-thinking skills to assess and problem- solve laboratory data for patient diagnoses;
4. Maintain familiarity with the profession's code of ethics and consistently act within those standards during interactions with fellow classmates and working professionals in the clinical setting;
5. Describe the importance of continuing education in lifelong learning and in obtaining and upholding professional credentialing;
6. Demonstrate academic and technical competence in the professional courses of the curriculum through college and applied clinical education experiences;
7. Take the national ASCP certification exam.

Units of study in detail – Unit Student Learning Outcomes:

Unit I: Basic Laboratory Safety (Chapters 1-2) [Supports Course SLOs #1]
Laboratory Mathematics (Chapter 3 [Supports Course SLOs #5, 8]

Learning Objectives: The student should be able to:

1. Basic Laboratory Practices
2. Identify methods used to produce laboratory grade water for use in the clinical laboratory.
3. List 3 parameters that need to be monitored during the purification process.
4. Explain the purpose of different types of glassware used in clinical chemistry.
5. Identify different types of plasticware used in clinical chemistry.
6. Explain the proper use of pipettes when working with laboratory reagents and clinical specimens.
7. Define the following terms: to contain (TC) and to deliver (TD) in reference to types of pipettes, molarity, molality, normality, thermocouple, percent solution, and hydrates.
8. Explain the difference between air-displacement and positive-displacement micropipettes.
9. Distinguish swinging-bucket centrifuges, fixed-angle-head centrifuges, and ultracentrifuges from one another.
10. Cite three types of balances used to weigh substances in the laboratory.
11. Identify a source of calibration material for balances, thermometers, and pipettes.

12. Provide the correct words that correspond to the following abbreviations: OSHA, SDS, NFPA, HEPA, RACE, PASS, and CFR.
13. Describe the role of regulatory agencies in maintaining standards in laboratory testing.
14. List several responsibilities of employers and employees in maintaining a safe work environment.

Laboratory Mathematics

15. Define the terms: solution, solvent
16. Define the different measures for solution concentration including specific gravity, molarity, normality, molality and percent solution.
17. Convert results from one unit to another.
18. Convert temperatures from one system to another.
19. Calculate the volume of diluent needed to make up various dilutions.
20. Explain how a serial dilution is performed.
21. Explain how a Gaussian curve is used in laboratory quality assurance.
22. Differentiate the terms: precision, accuracy, sensitivity and specificity.
23. Identify five factors to consider when selecting quality-control material.
24. Select the appropriate statistic(s) for a given set of measurements.
25. Interpret a Levey–Jennings quality-control plot.
26. Compare random and systematic errors.
27. Identify Westgard rule violations and determine a course of action.
28. Identify and explain four factors that must be addressed before determining a reference interval.

<u>Psychomotor Performance Objectives:</u> [Supports Course SLO #9]

1. Exercise safety practices during laboratory sessions.
2. Demonstrate proper use of various pipettes in the clinical lab. ILG 4
3. Practice micropipetting using a testing kit that measures accuracy and precision.
4. Perform simple and serial dilutions using a variety of pipettes to look for consistency.

<u>Unit 2</u>: Instrumentation, Laboratory Automation and Informatics (Chapter 4) [Supports Course SLOs #2, 3]
Methodologies Continued (Immunoassays and Molecular Diagnostics) (Chapter 5-6) [Supports Course SLOs #2, 3]

<u>Learning Objectives</u>: The student should be able to:

Instrumentation, Laboratory Automation and Informatics

1. Explain how the measurement of light can be used to measure analytes in a solution.
2. Describe the technology used in the following analytical methods: Spectrophotometry, Reflectometry, Chemiluminescence, Fluorometry, Nephelometry, Refractometry, Electrochemistry, Electrophoresis and Chromatography
3. Identify terms associated with automated testing such as throughput, test menu, carryover, discrete testing, random access, open-reagent analyzer, closed-reagent analyzer, and LIS.
4. Describe the advantages and disadvantages of automated laboratory testing.
5. Explain the preanalytical, analytical and post analytical stages of laboratory testing.
6. Identify five laboratory tasks associated with the preanalytical stages of lab testing.
7. List four tasks associated with the analytical stage of laboratory testing
8. Identify three tasks associated with the postanalytical phase of testing.
9. State the two items required to interface computers.
10. State two ways of entering laboratory data into a computer.
11. Review the principles behind immunoassays.

Immunoassays and Molecular Diagnostics

12. Explain the fundamental differences among enzyme immunoassays, fluorescent immunoassays, and chemiluminescent immunoassays.
13. Compare and contrast the chemical structures of DNA and RNA.
14. Given a sequence of nucleotide bases in a DNA strand, deduce the sequence of nucleotide bases in the complementary RNA strand and protein product.
15. Discuss factors that may lead to reduced purity and yield following a DNA isolation procedure.
16. Compare and contrast agarose and polyacrylamide as matrices for gel electrophoresis.
17. Given a specific restriction endonuclease and DNA sequence, determine the number and size of the resulting fragments.

18. Recall the different techniques used in DNA analysis during molecular testing including the basic principles of the following techniques: liquid-phase hybridization, in situ hybridization, fluorescent in situ hybridization (FISH), Western blot, traditional polymerase chain reaction (PCR), real-time qPCR, and the Sanger method of DNA sequencing.

Psychomotor Performance Objectives: [Supports Course SLO #9]

1. Experiment with the functions of a spectrophotometer.
2. Calculate the concentration of a solution given the absorbent values for test and standard samples.
3. Calculate the following: coefficient of variation, mean, median, standard deviation.
4. Use statistical analyses to construct a Levey-Jennings chart.
5. Interpret Levey Jennings charts as it relates to Westgard rules.
   - Determine the ranges and investigate for random errors, shifts and trends.
6. Compute solutions and their concentrations using laboratory mathematical equations.

Unit 3: Carbohydrates & Lipids (Chapter 7 and 8)
Amino Acids, Peptides & Proteins (Chapter 9)
Enzymes (Chapter 10)
[Supports Course SLOs #2, 3, 7, 8]

Learning Objectives: The student should be able to:

Carbohydrates & Lipids

1. Discuss the molecular structure and function of carbohydrates.
2. Summarize the biochemical pathways of carbohydrate metabolism.
3. List the endocrine glands and hormones that affect carbohydrate metabolism.
4. Compare and contrast Type-1 and Type-2 diabetes.
5. Explain the physiological changes that occur with hyper- and hypoglycemia.
6. Describe the methodologies used to measure serum, urine and body fluid glucose levels.
7. Identify abnormal and critical levels of glucose.
8. Distinguish between cholesterol, lipids, triglycerides and fatty acids.
9. Explain the role of apolipoproteins.
10. Identify the risk factors associated with coronary heart disease
11. Explain the laboratory methodologies for measuring serum/plasma lipids.

Amino Acids, Proteins and Peptides

1. Describe the structure and function of proteins.
2. Explain the significance of the protein bands seen in serum protein electrophoresis.
3. Discuss causes of hyper- and hypoproteinemia.
4. Compare the methodologies used for measuring protein and albumin in clinical specimens.
5. Describe the methods used for protein screening in urine and the clinical significance of a positive test.
6. Explain the clinical significance of an elevated protein level in CSF and the methodologies used for measurement.
7. Define and calculate an A/G ratio.

Enzymes

8. Explain the function of enzymes.
9. Describe enzymatic reactions including first and zero-order kinetics, cofactors and factors that affect reaction speed.
10. Summarize the clinical significance of the following enzymes: CK, LD, AST, ALT, ALP, GGT, 5'-NT, Amylase, Lipase and Trypsin.
11. Describe the methodologies used for measuring serum enzymes.

Psychomotor Performance Objectives: [Supports Course SLO #9]

1. Distinguish between the two types of diabetes using simulated urinalysis and ELISA tests.
2. Practice micropipetting using a testing kit that measures accuracy and precision.
3. Perform a protein electrophoresis.

Unit 4: Non-Protein Nitrogen and Renal Function (Chapter 11)
Electrolyte Balance (Chapter 12)

Blood Gases, pH, and Acid–Base Balance (Chapter 13)
[Supports Course SLOs #2, 3, 7, 8]

<u>Learning Objectives</u>: The student should be able to:

Non-protein Nitrogen and Renal Function

1. Describe the anatomy and physiology of the kidney.
2. Explain the source of blood urea nitrogen and creatinine and the role they play in the assessment of kidney function.
3. Define 'azotemia' and describe common causes of this condition.
4. Summarize the formation and excretion of uric acid.
5. Explain the condition of 'gout': its causes and treatments.
6. Describe how a 'creatinine clearance' is performed.
7. List other screening tests for renal disease.
8. Explain how dialysis helps in the treatment of renal disease.

Electrolytes

9. List the significant electrolytes routinely measured in the laboratory.
10. Define and calculate an 'anion gap'.
11. Explain the clinical significance of serum and urine osmolality.
12. Name the colligative properties of solutions used in measuring osmolality.

Blood gasses, pH, Acid-Base Balance

13. State the Henderson–Hasselbalch equation and identify the respiratory and metabolic components.
14. Define respiratory and metabolic alkalosis and acidosis.
15. Calculate various blood gas parameters given the appropriate equation(s)
16. Explain the role of the lungs, kidneys and physiological buffer system in acid-base balance.
17. Identify the five ways in which carbon dioxide is carried in blood.
18. Identify appropriate calibration materials to use for pH, PCO2, and PO2 measurements.
19. Describe the proper control material to use for blood pH, PCO2, and PO2 measurements.
20. Identify preanalytical sources of errors in blood-gas analysis.
21. Describe the collection method, testing methodologies and result parameters seen in blood gas analysis.

<u>Psychomotor Performance Objectives:</u> [Supports Course SLO #9]

1. Perform an enzyme assay and determine the rate of a biochemical reaction to better understand how enzymes are measured in patient samples.
2. Utilize an Advanced Instruments® osmometer to measure osmolality.
3. Challenge the procedure for a 'creatinine clearance' test and by performing calculations through examples.
4. Discuss the concepts of acid-base theory and apply it to real-life situations to determine acidosis and alkalosis, be it compensated or uncompensated.
5. Apply knowledge gained from the previous few weeks into solving clinical chemistry case studies.

<u>Unit 5</u>: Mineral and Bone Metabolism (Chapter 14)
Endocrinology (Chapters 15)
Digestive (GI, Liver Function, Pancreas) (Chapter 16-17; 19)
Cardiovascular (Chapter 18) [Supports SLOs #2, 3, 7, 8]

<u>Learning Objectives</u>: The student should be able to:

Endocrinology

1. List the function of the following hormones: thyroxine, cortisol, epinephrine, antidiuretic hormone, growth hormone, aldosterone, luteinizing hormone, FSH, estrogen, progesterone, testosterone, prolactin, oxytocin.
2. Discuss methodologies used to measure hormones in the laboratory.
3. Define the 'negative feedback system' as it relates to hormone regulation.
4. Associate abnormal hormone levels with various diseases and syndromes.

Iron and Heme Derivatives

1. Describe the physiology, transport and metabolism of iron.
2. Identify laboratory methods used to measure serum iron, porphyrins and hemoglobin.

Mineral and Bone Metabolism

1. Identify three forms of calcium as they exist in circulation.
2. Describe laboratory methods used for measuring serum calcium and phosphate.

3. Discuss the clinical significance of measuring ionized magnesium.
4. Identify biochemical markers specific for bone formation and resorption.

Organ System Function (GI, Pancreas, Liver, Cardiac)

1. Outline the functions of the components of the GI system.
2. Explain laboratory tests used to assess diseases of the GI tract.
3. Summarize the endocrine and exocrine function of the pancreas.
4. List laboratory tests used to assess pancreatic function.
5. Explain the role that PTH and Vitamin D has on calcium and phosphate levels.
6. Describe the structure and function of the liver.
7. List the laboratory tests that are included in liver function assessment.
8. Summarize the breakdown of bilirubin.
9. State the differences between conjugated, unconjugated, direct, indirect and total bilirubin.
10. Briefly describe the pathology of the following liver disorders: Jaundice, Hepatitis, Cirrhosis, Bile duct obstruction, inherited metabolic disorders and enzyme deficiencies.
11. Explain the following laboratory tests used to assess cardiac function: Myoglobin, CK-MB, Troponin and BNP.

Psychomotor Performance Objectives: [Supports Course SLO #9-10]

1. Experimenting with levels of hCG via an ELISA test.
2. Manually perform preventative maintenance, calibration, quality control and different laboratory test panels on patient samples using a clinical chemistry analyzer.
3. Correlate laboratory diagnostic test findings with different disease states.
4. Access information on a chemistry analyzer and present a classroom presentation on that instrument following designated guidelines.

Unit 6: Therapeutic Drug Monitoring (TDM) and Toxic Substances (Chapters 21-22)
Nutrients (Chapter 23)
Tumor Markers (Chapter 24)
Geriatric and Pediatric Populations (Chapter 25) [Supports Course SLOs #6, 7, 8]

Learning Objectives: The student should be able to:

TDM and Toxic Substances

1. Define the term 'pharmacokinetics' and its implication in TDM.
2. Identify the four principle biological events associated with pharmacokinetics.
3. Explain the terms: elimination half-life, steady state, bioavailability, loading dose, peak & trough.
4. List therapeutic drugs that are commonly measured in the laboratory.
5. List several examples of toxic substances measured in clinical laboratories.
6. Identify laboratory methods used to measure selected toxic substances.
7. List six substances that are frequently used as adulterants in urine specimens for drug abuse testing.
8. Describe laboratory methods used for screening for drugs of abuse.
9. Identify the acidic or ketone metabolites of: ethanol, methanol, ethylene glycol, isopropyl alcohol, and salicylate.
10. List causes of high blood levels of lead.
11. Discuss the physiological role of trace elements in the body.
12. Identify specimen types and instrumentation used to measure trace elements in the laboratory.

Nutrients

1. Differentiate between fat and water soluble vitamins.
2. Identify laboratory methods for measuring vitamin levels.
3. Correlate abnormal levels of vitamins with various disease states.

Tumor Markers

1. List the tumor markers that are used in assessing cancer.
2. Explain the methodologies used in detecting tumor markers.
    a. Prostate disease
    b. Ovarian cancer
    c. Breast cancer
    d. Bladder cancer
    e. Pancreatic cancer

Geriatric and Pediatric Populations

3. Discuss briefly the changing demographics of the geriatric population
4. Describe briefly the physiological changes with aging.
5. Distinguish infant, child, and adolescent stages of life.
6. List five factors that should be considered when using peer review of pediatric reference intervals.
7. Summarize the changes that occur in infants, children, and adolescents regarding disorders of respiratory, liver, kidney, thyroid, calcium, diabetes mellitus, inborn errors of metabolism, and nutrition.
8. Identify specimen requirements and specimen integrity issues of selected laboratory tests.

Evaluation of student learning:

1. Lecture

a) Students will have weekly homework assignments through Blackboard LMS or via MediaLab Inc and must be completed to assess understanding of the theoretical concepts discussed in the lecture powerpoints.
b) Students will collaborate on a clinical chemistry analyzer presentation and present it to their classmates.
c) Students will complete a weekly quiz, midterm and final assessment through Blackboard LMS or via MediaLab Inc.

2. Lab

a) Students will complete weekly quizzes (pre-lab and/or post-lab) and complete weekly homework assignments that pertain to the laboratory exercises.
b) There will be written and hands-on practical assessments at the halfway point and at the end of the course to assess competency level.
c) Students will work through case studies for patients with different etiologies and teach their fellow classmates.
d) Laboratory Session Professional Performance- Students' professional performances will be evaluated during each of the laboratory sessions and weekly feedback will be given on how to improve. The grading scale is for each of the categories below is that a student can score between 0-2 points (0= Unsatisfactory, 1=Satisfactory, 2=Exceeds Expectations).
    i) PROFESSIONAL PERFROMANCE EVALUATION:
        1. DEPENDABILITY
            - The student arrives in the laboratory with adequate time to start lab session as scheduled. The student comes with appropriate manual and supplies, and wearing required laboratory attire. The student shows evidence of having reviewed the assigned topic before coming to the laboratory. The student completes assignments (lab reports, homework assignments, etc) on time.
        2. ATTENTIVENESS
            - The student is attentive to the instructor, takes complete notes and proceeds with laboratory work without repeated instructions. The student follows verbal and written instructions, asks pertinent questions when necessary, and seeks the instructor's assistance when needed. The student neither distracts others nor allows distractions to affect completion of laboratory exercises.
        3. ORGANIZATION
            - The student demonstrates the ability to organize work to be done within the available laboratory time. The student is able to perform multiple tasks without jeopardizing accuracy and precision.
        4. INDEPENDENCE
            - The student demonstrates the ability to work independently by exercising independent judgement and thinking logically in using the protocols and instructions given. The student draws on previously gained information to solve problems without prompting from instructor. The student seeks activities to expand knowledge, ability and performance.
        5. RECORD KEEPING
            - The student demonstrates the importance or proper record keeping by accurately and legibly labeling/recording laboratory work and reports (i.e. sample containers, reagents and worksheets).
        6. MANAGEMENT AND ECONOMY
            - The student conserves reagents and supplies. The student maintains an adequate supply of common use items at their appropriate workstation. The student takes proper care of equipment
        7. SAFETY
            - The student works in an orderly and safe manner, enabling others to safely work in the same general area. The student adheres to the guidelines of the Laboratory Safety Regulations (e.g. wearing eye protection, keeping long hair tied back, and properly storing hazardous materials).

8. INTERPERSONAL SKILLS
   - The student communicates in a professional, positive, tactful manner with peers and instructors. The student consistently shows common courtesy (e.e. restocks supplies) and contributes towards achieving an environment conducive to work and learning for self and others.

9. Composure
   - The student maintains composure and work quality under stressful conditions and adapts quickly to new situations. The student recognizes his/her own personal strengths and weaknesses and works positively within that framework. The student accepts evaluation of performance as constructive when offered by instructors and follows through with suggestions made.

10. INTEGRITY
   - The student accepts accountability for work performed. The student readily admits errors, follows procedures (including quality control) as written, and maintains confidentiality of patient results, if applicable. Student exhibits perseverance to obtain accurate results

Course Grading

A	93-100%	B-	80-82
A-	90-92	**C+**	**77-79 <- minimum grade needed for total course grade**
B+	87-89	**C**	**70-76 <- minimum grade needed in Laboratory**
B	83-86	D	60-69
F	0-59%		

Lecture

Analyzer Presentation	10%
Homework	20%
Quizzes	20%
Midterm	20%
Final	30%

100% x .65 = _____ Lecture Percentage

Laboratory

Pre-Lab Quizzes	10%
Homework	20%
Case Study Instruction	20%
Midterm	20%
Final Exam	30%

100% x .30 = _____ Lab Percentage

Professionalism (Affective)

Attendance _____*/600 points possible (100% for presence, 50% if tardy, & 0% if absent for each week)*

*Professionalism** _____*/120 points*

_____/720 = x .05 = _____ Affective Percentage

_____Final Total Grade= Lecture Percentage + Lab Percentage + Professionalism