CATALOG DESCRIPTION:

*CTEC 1441 Applied Instrumental Analysis I. CIP 4103010003*
Overview of instrumental chemical analysis. Topics include statistical analysis, sampling, analytical separations, gravimetric and titrimetric analysis, gas chromatography, on-line process analyzers, and/or electroanalytical chemistry. (4 SCH, 3 lecture, 3 lab)  
Prerequisite: CHEM 1411 or CHEM 1405.  
Required skill level: College-level reading, writing and math.

_________________________________________  ____________________________________________
Judy Chu  Mickey McGaugh

_________________________________________  ____________________________________________
Bennett Willis  Gary Hicks

_________________________________________
Ken Tasa

August 2011
II. COURSE EVALUATION

Student Evaluation

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major exam average</td>
<td>10-40%</td>
</tr>
<tr>
<td>Lab average</td>
<td>20-60%</td>
</tr>
<tr>
<td>Final exam</td>
<td>15-25%</td>
</tr>
<tr>
<td>Attendance</td>
<td>0-10%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100%</td>
</tr>
</tbody>
</table>

Each instructor will announce the exact percentages to be used at the beginning of the course.

Instructor Evaluation

A. Students will be given an opportunity to evaluate their instructor and the course content.

B. Instructor will review and evaluate in terms of withdrawal rate.

C. Final grades given will be reviewed in an effort to determine if a pattern of high or low grades exists.

Department Evaluation

A. Faculty and the Division Chair will review student’s grade and withdrawal trends.

B. Faculty and the Division Chair will review the Course, Competencies, and Perspectives Assessment.
III. Course Content

Objectives

The course is designed to help the student:

A. Understand and apply common safety practices used in an industrial lab.
B. Understand and apply basic statistical methods used in an industrial lab.
C. Reinforce volumetric calculations and procedures presented in general chemistry.
D. Apply and understand standardization methods for analytical instruments.
E. Understand the operation and the theory that relates to the operation of the following instruments:
   1. Automatic Titrators
   2. ChemBox
   3. GC
   4. Automatic Distillation Apparatus
F. To acquire basic laboratory skills and carry out the laboratory objectives listed in section III.
Outline

CTEC 1441 – Schedule*

<table>
<thead>
<tr>
<th>WEEK</th>
<th>LECTURE</th>
<th>LAB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TT 5:35 – 6:50 PM</td>
<td>TUE 7 – 9:50 PM</td>
</tr>
<tr>
<td>1</td>
<td>Chapter 1 – Introduction to Analytical Science</td>
<td>Safety and check-in.</td>
</tr>
<tr>
<td></td>
<td>Chapter 2 – Sampling</td>
<td>Exp. 1 – Excel Spreadsheet</td>
</tr>
<tr>
<td>2</td>
<td>Chapter 2 – Sampling</td>
<td>Exp. 2 – Gravimetric Sulfate</td>
</tr>
<tr>
<td></td>
<td>Chapter 3 – Gravimetric Analysis</td>
<td>Exp. 2 – Gravimetric Sulfate</td>
</tr>
<tr>
<td>3</td>
<td>Chapter 3 – Gravimetric Analysis</td>
<td>Exp. 2 – Gravimetric Sulfate</td>
</tr>
<tr>
<td>4</td>
<td>Chapter 6 – Introduction to Instrumental Analysis</td>
<td>Exp 3a – GC of Beer</td>
</tr>
<tr>
<td>5</td>
<td>Chapter 11 – Analytical Separations</td>
<td>Exp 3a – GC of Beer</td>
</tr>
<tr>
<td>6</td>
<td>Chapter 11 – Analytical Separations</td>
<td>Exp. 3b- GC of Gasoline</td>
</tr>
<tr>
<td></td>
<td>Chapter 12 – Gas Chromatography</td>
<td>Exp. 3b- GC of Gasoline</td>
</tr>
<tr>
<td>7</td>
<td>Quiz 2</td>
<td>Exp. 3b- GC of Gasoline</td>
</tr>
<tr>
<td></td>
<td>Chapter 4– Introduction to Titrimetric Analysis</td>
<td>Exp. 4 – Esterification (Synthesis)</td>
</tr>
<tr>
<td>8</td>
<td>Chapter 5 – Applications of Titrimetric Analysis</td>
<td>Exp. 4 – Esterification (Extraction and GC Analysis)</td>
</tr>
<tr>
<td></td>
<td>Chapter 5.2 – Acid –Base Titrations</td>
<td>Exp. 5a – Titration (Standardization of NaOH)</td>
</tr>
<tr>
<td></td>
<td>Chapter 5.2 – Acid –Base Titrations</td>
<td>Exp. 5b – Standardization of HCl</td>
</tr>
<tr>
<td>11</td>
<td>Quiz 3</td>
<td>Exp. 5c – KHP unknown</td>
</tr>
<tr>
<td></td>
<td>Chapter 5 – (5.3 – Complex Ion Formation Reactions)</td>
<td>Exp. 5d – Soda Ash unknown</td>
</tr>
<tr>
<td>12</td>
<td>Chapter 5 – (5.3 – Complex Ion Formation Reactions)</td>
<td>Exp. 6 – EDTA Titration</td>
</tr>
<tr>
<td></td>
<td>Chapter 5 – (5.4 – Oxidation-Reduction Reactions)</td>
<td>Clean-up</td>
</tr>
<tr>
<td>13</td>
<td>Thanksgiving Holiday (no classes)</td>
<td>No Lab</td>
</tr>
<tr>
<td>14</td>
<td>Chapter 5 – (5.4 – Oxidation-Reduction Reactions)</td>
<td>Exp. 6 – EDTA Titration</td>
</tr>
<tr>
<td>15</td>
<td>Quiz 4</td>
<td>Clean-up</td>
</tr>
<tr>
<td>16</td>
<td>Review for Final</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Final – Tuesday, Dec. 15, 5:30-7:30 PM</td>
<td></td>
</tr>
</tbody>
</table>

*This schedule is subject to change.

The schedule will vary from semester to semester. The above schedule is based on a 16 week schedule where each week equates to 6 contact hours. In summer sessions the schedule will be adjusted to have more contact hours per week to accommodate the shorter semester.
A. Safety  
   1. Lab safety rules.  
   2. Industrial safety standards  
   3. MSDS  

B. Introduction to Analytical Sciences  
   1. Analytical Science Defined  
   2. Classification of Analysis  
   3. The Sample  
   4. The Analytical Strategy  
   5. Analytical Technique and Skills  
   6. The Laboratory Notebook  
   7. Errors, Statistics, and Statistical Control  
      a. Errors  
      b. Elementary Statistics  
      c. Normal Distribution  
      d. Precision, Accuracy, and Calibration  
      e. Statistical Control  

C. Sampling and Sample Preparation  
   1. Introduction  
   2. Obtaining the Sample  
   3. Statistics of Sampling  
   4. Sample Handling  
   5. Sample Preparation: Solid Materials  
   6. Sample Preparation: Liquid Samples, Extracts, and Solutions of Solids  
   7. Reagents  
   8. Labeling and Record Keeping  

D. Gravimetric Analysis  
   1. Weight vs. Mass  
   2. The Balance  
   3. Calibration of Care of Balances  
   4. When to Use Which Balance  
   5. The Gravimetric Method  
      a. Physical Separation Methods and Calculations  
      b. Chemical Alteration and Separation of the Analyte  
      c. Gravimetric Factors  
      d. Using Gravimetric Factors  
   6. Experimental Considerations  

E. Titrimetric Analysis  
   1. Solution Concentration  
      a. Percent concentration  
      b. Molarity  
      c. Normality  
   2. Solution Preparation  
      a. From Pure Solid
b. By Dilution
3. Stoichiometry of Titration Reactions
4. Standardization
   a. Using Standard Solution
   b. Using Primary Standard
   c. Titer
5. Percent Analyte Calculations
6. Volumetric Glassware
7. Pipetters, Automatic Titrators
8. Calibration of Glassware and Devices

F. Acid-Base Titrations and Titration Curves
1. Indicators
2. pH Meters
3. Titration Curves
4. Automatic Titrators
5. Titration Experiments
6. Titration of Hydrochloric Acid
7. Titration of Weak Monoprotic Acids
8. Titration of Monobasic Strong and Weak Bases
9. Equivalence Point Detection
10. Titration of Polyprotic Acids: Sulfuric Acid and Phosphoric Acid
11. Titration of Potassium Biphthalate
12. Titration of TRIS and Sodium Carbonate
13. Alkalinity
14. Back Titrations
15. Buffering Effects and Buffer Solutions

G. Complex Ion Formation Reactions
1. Complex Ion Terminology
2. EDTA and Water Hardness
3. Expressing Concentration Using ppm
4. Water Hardness Calculations

H. Oxidation-Reduction Reactions
1. Review of Oxidation and Reduction Reaction
2. The Ion-Electron Method for Balancing Equations
3. Analytical Calculations
4. Applications

I. Introduction to Instrumental Methods
1. Review of Analytical Strategy
2. Instrumental Analysis Methods
3. Basics of Instrumental Measurement
4. Calibration
5. Preparation of Standards
6. Planks and Controls
7. Effects of Sample Pretreatment on Calculations
8. Laboratory Data Acquisition and Information Management
9. Standardization Curves
10. Laboratory Notebooks
11. Computer Functions

J. Analytical Separations
   1. Recrystallization
   2. Distillation
   3. Liquid-Liquid Extraction
   4. Solid-Liquid Extraction
   5. Chromatography
   6. Types of Chromatography
      a. Partition
      b. Adsorption
      c. Ion Exchange
      d. Size Exclusion
   7. Chromatography Configurations
      a. Paper and Thin-Layer
      b. Open-Column
      c. Instrumental
      d. The Chromatogram
      e. Quantitative Analysis with GC

8. Electrophoresis

K. Gas Chromatography
   1. Instrument Design
   2. Sample Injection
   3. Columns
   4. Other Variable Parameters
   5. Detectors
   6. Qualitative Analysis
   7. Quantitative Analysis
   8. Troubleshooting
   9. Mechanism of separation
  10. GC operation
  11. Resolution
  12. Theoretical plates
  13. Integration and calculation
  14. GC experiments
Laboratory Objectives

A. Safety

The student will:
1. Follow all safety guidelines given in lab.
2. Maintain a clean work area.
3. Properly handle all hazardous materials and waste.
4. Promote safety awareness among lab student.
5. Be familiar with material safety data sheets on chemicals used in the lab.

B. Lab Projects

Given the proper laboratory equipment and reagents, the student will:
1. Develop lab procedures including safety procedures for a given project given some general guidelines.
2. Conduct a literature search for a given project.
3. Requisition supplies for a given project.
4. Execute project activities.
5. Evaluate project data.
6. Summarize and report project results.
7. Perform statistical analysis on project data if needed.

C. Sample Analysis

Given the proper laboratory equipment and reagents, the student will:
1. Determine the concentration of each component of a given mixture using a gas chromatograph and the internal standard method.
2. Determine the concentration of each component of a given mixture using gas chromatography and the standard additions method.
3. Determine the normality of a given acid or base using an automatic titrator.
4. Determine the percent of KHP in an unknown sample through titrimetric analysis.
5. Determine the percent of sodium carbonate in an unknown soda ash sample through titrimetric analysis.
6. Determine the hardness of water through complexometric titrations.
7. Determine the percent of an unknown sulfate sample through gravimetric analysis.
8. Synthesize esters and analyze percent yield of products through GC analysis.
10. Prepare samples for a given analysis.
11. Calibrate instruments using various standardization methods such as internal standardization, external standardization, and standard addition.
12. Determine the reproducibility of a given instrument.

D. Instrument Operation and Report Generation

Given the proper laboratory equipment, the student will:
1. Perform basic operations required for sample analysis.
2. Enter data.
3. Retrieve data.
4. Provide a printout of analysis if instrument has printout capability.
5. Generate charts and graphs if needed.
6. Understand the basis for mathematical calculations done by computer or integrator.
7. Generate control charts.
8. Calculate errors and bias in data.

E. Trouble-Shooting

Given an instrument with a specific problem the student will:
1. Consult manuals for possible solutions.
2. Identify the problem or at least narrow the possible sources to 2 or 3.
3. Make basic repairs.
5. Ensure the integrity of the equipment once it is repaired.
6. Verify calibration standardization procedure if the problem is a standardization problem.
7. Verify the integrity of the standard reagents if the problem is a standardization problem.
8. Check sample identity.
9. Check calculations.
10. Consult with lab instructor.
### IV. LEARNING OUTCOMES

**CTEC 1441**

<table>
<thead>
<tr>
<th>OUTCOMES</th>
<th>METHOD OF ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand and apply basic statistical methods used in analytical labs.</td>
<td>Outcome 1: Student’s success on the following questions on the final exam which relate to basic statistical methods used in analytical labs will be evaluated: 6, 7.</td>
</tr>
<tr>
<td>2. Perform gravimetric analysis calculations and analyze unknowns using gravimetric techniques.</td>
<td>Outcome 2: Student’s success on the following questions on the final exam which relate to gravimetric analysis calculations and analyze unknowns using gravimetric techniques will be evaluated: 1.</td>
</tr>
<tr>
<td>3. Perform volumetric calculations necessary in the preparation of standard solutions.</td>
<td>Outcome 3: Student’s success on the following questions on the final exam which relate to volumetric calculations necessary in the preparation of standard solutions will be evaluated: 15, 25.</td>
</tr>
<tr>
<td>4. Apply and understand standardization methods used in titrimetric analysis, such as the use of primary standards, indicators, and the titration curve.</td>
<td>Outcome 4: Student’s success on the following questions on the final exam which relate to standardization methods used in titrimetric analysis, such as the use of primary standards, indicators, and the titration curve will be evaluated: 11, 19.</td>
</tr>
<tr>
<td>5. Understand the various methods of analytical separation, such as distillation, extraction and chromatography.</td>
<td>Outcome 5: Student’s success on the following questions on the final exam which relate to the various techniques of analytical separation, such as distillation and solvent – solvent extraction will be evaluated: 33, 34.</td>
</tr>
<tr>
<td>6. Understand the theory and operation of the gas chromatograph.</td>
<td>Outcome 6: Student’s success on the following questions on the final exam which relate to the theory and operation of the gas chromatograph, including the various analytical techniques used in GC analysis such as the internal standard method will be evaluated: 29, 36, 47.: 29, 36, 47.</td>
</tr>
<tr>
<td>7. Receive a grade of D or better in the laboratory portion of the course.</td>
<td>Outcome 7: Students’ success will be measured from their grade from the lab section of the course.</td>
</tr>
</tbody>
</table>
SCANS Competencies

The Secretary Commission on Achieving Necessary Skills (SCANS) identified competencies in the area of Resources, Interpersonal, Information, Systems, and Technology; and foundation skills in the areas of Basic Skills, Thinking Skills, and Personal Qualities. This course is part of a program in which each of these competencies and skills are integrated. The following is a list of applications of specific SCANS competencies and skills in this course.
## SCANS COMPETENCIES
### CTEC 1441

<table>
<thead>
<tr>
<th>Competency Reference</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Resource</strong></td>
<td>Students are required to complete labs in a limited time that requires managing their time. Students are trained in requisitioning supplies for a lab project.</td>
</tr>
<tr>
<td>Time Management</td>
<td></td>
</tr>
<tr>
<td>Facilities/Management</td>
<td></td>
</tr>
<tr>
<td>Human resources</td>
<td></td>
</tr>
<tr>
<td><strong>2. Interpersonal</strong></td>
<td>Students work in lab in pairs that allows them to develop interpersonal skills.</td>
</tr>
<tr>
<td>Leadership</td>
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</tr>
<tr>
<td>Participate as Team Member</td>
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<tr>
<td>Works with Diversity</td>
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</tr>
<tr>
<td><strong>3. Information</strong></td>
<td>Students collect analytical data during lab and are required to organize, and evaluate the data, then submit a written report.</td>
</tr>
<tr>
<td>Acquiring</td>
<td></td>
</tr>
<tr>
<td>Organizing</td>
<td></td>
</tr>
<tr>
<td>Interpreting</td>
<td></td>
</tr>
<tr>
<td><strong>4. Systems, Understanding</strong></td>
<td>Students are introduced to several analytical instruments. They are required to operate each instrument as well as perform maintenance on the instruments.</td>
</tr>
<tr>
<td>Organizational System</td>
<td></td>
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<tr>
<td>Technological Systems</td>
<td></td>
</tr>
<tr>
<td>Social Systems</td>
<td></td>
</tr>
<tr>
<td><strong>5. Technology</strong></td>
<td>Students will complete a project in which they will plan an analytical procedure and perform the analysis.</td>
</tr>
<tr>
<td>Selecting</td>
<td></td>
</tr>
<tr>
<td>Applying</td>
<td></td>
</tr>
<tr>
<td>Maintaining</td>
<td></td>
</tr>
<tr>
<td><strong>6. Basic Skills</strong></td>
<td>Students will follow written procedures as well as complete a project in which they will write their own procedures. Several of the analytical procedures will require some mathematics to interpret results. Oral communication skills are required since the students will work as partners in lab.</td>
</tr>
<tr>
<td>Reading, Writing</td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td></td>
</tr>
<tr>
<td>Speaking, Listening</td>
<td></td>
</tr>
<tr>
<td><strong>7. Thinking Skills</strong></td>
<td>Students will be presented with either an instrument or procedural problem and required to find the source of the problem and correct it.</td>
</tr>
<tr>
<td>Decision Making</td>
<td></td>
</tr>
<tr>
<td>Problem Solving</td>
<td></td>
</tr>
<tr>
<td>Learning Techniques</td>
<td></td>
</tr>
<tr>
<td><strong>8. Personal Qualities</strong></td>
<td>There will be some lab activities that will require sharing responsibilities among lab partners.</td>
</tr>
<tr>
<td>Responsibility</td>
<td></td>
</tr>
<tr>
<td>Sociability</td>
<td></td>
</tr>
<tr>
<td>Integrity/Honesty</td>
<td></td>
</tr>
</tbody>
</table>
V. INFORMATION FOR STUDENTS

COURSE DESCRIPTION
Knowledge of procedures, equipment, and techniques used in industrial laboratories will be gained by students through the performance of laboratory experiments and writing of laboratory reports. Students will perform calculations, prepare standard solutions, analyze unknown samples, and operate various analytical instruments. Topics to be covered include sampling and sample preparation, gravimetric and titrimetric analysis, introduction to instrumental analysis, analytical separations, gas chromatography, and electrochemical methods.

PREREQUISITES
CHEM 1411 or CHEM 1405.

COURSE GOALS
At the completion of CTEC 1441 the student should be able to:

8. Understand and apply basic statistical methods used in analytical labs.
9. Perform gravimetric analysis calculations and analyze unknowns using gravimetric techniques.
11. Apply and understand standardization methods used in titrimetric analysis, such as the use of primary standards, indicators, and the titration curve.
12. Understand the various methods of analytical separation, such as distillation, extraction and chromatography.
13. Understand the theory and operation of the gas chromatograph.
14. Receive a grade of D or better in the laboratory portion of the course.

TEXTBOOK OR COURSE MATERIAL INFORMATION
2. Organic Chemistry Lab Notebook, Published by Signature Labs.

LAB REQUIREMENTS
1. Visorgogs or safety goggles, must meet ANSI Z87.1-1989 certification.

STUDENTS WITH DISABILITIES
Brazosport College is committed to providing equal education opportunities to every student. Brazosport College offers services for individuals with special needs and capabilities including counseling, tutoring, equipment, and software to assist students with special needs. Please contact the Special Populations Counselor, 979-230-3236, for further information.
ACADEMIC HONESTY
Brazosport College assumes that students eligible to perform on the college level are familiar with the ordinary rules governing proper conduct including academic honesty. The principle of academic honesty is that all work presented by you is yours alone. Academic dishonesty including, but not limited to, cheating, plagiarism, and collusion shall be treated appropriately. Please refer to the Brazosport College Student Guide for more information; this is available online at http://www.brazosport.edu/Web%20Part%20Pages/Sched.aspx.

ATTENDANCE AND WITHDRAWAL POLICIES
Class attendance is not graded, but you must attend class to successfully complete the course. If you are unable to complete this course, you must complete and submit a withdrawal form with the registrar. If you stop attending class and do not withdraw, you will receive a performance grade, usually an “F”.

COURSE REQUIREMENTS AND GRADING POLICY
For this class you complete the following:

Exams: There will be a total of four exams. Each exam will last approximately one hour during class. The exact date of each Exam will be announced in class prior to the actual date of the exam.

Homework: As assigned by the instructor. Due date for homework is the day of the exam.

Lab: The laboratory portion of the course consists of weekly 3 hour labs which the student must attend. To pass the course, the student must successfully complete the laboratory experiments with a grade of D or better.

Final Exam: The final will be given at the end of the course. The final exam is comprehensive.

Each of the above requirements counts toward your final grade as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams</td>
<td>40%</td>
</tr>
<tr>
<td>Attendance</td>
<td>5%</td>
</tr>
<tr>
<td>Lab</td>
<td>40%</td>
</tr>
<tr>
<td>Final</td>
<td>15%</td>
</tr>
</tbody>
</table>

TESTING
See the class calendar for the chapters and dates of the tests. Students are allowed to bring one page of hand written notes, containing equations, etc., to the exams. The material to be covered on each exam is as follows:

<table>
<thead>
<tr>
<th>Exam</th>
<th>Chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intro to Analytical Science, Sampling, Gravimetric Analysis</td>
</tr>
<tr>
<td>2</td>
<td>Intro to Instrumental Analysis, Analytical Separations, GC</td>
</tr>
<tr>
<td>3</td>
<td>Titrimetric Analysis, Acid-Base Titrations</td>
</tr>
<tr>
<td>4</td>
<td>Complex Ion Formation, Redox Reactions and Titrations</td>
</tr>
<tr>
<td>Final</td>
<td>Comprehensive Exam</td>
</tr>
</tbody>
</table>

MAKE-UP POLICY
There will be no make-up exams. The lowest exam grade will be replaced by the final exam grade, if higher. The final exam grade will replace one missed exam grade.
STUDENT RESPONSIBILITIES
Students are expected to fully participate in this course. The following criteria are intended to assist you in being successful in this course:
1. understand the syllabus requirements
2. use appropriate time management skills
3. communicate with the instructor
4. complete course work on time, and
5. utilize online components (such as Desire2Learn) as required.

PROJECTS, ASSIGNMENTS, PORTFOLIOS, SERVICE LEARNING, INTERNSHIPS, ETC.
None.

OTHER STUDENT SERVICES INFORMATION
Information about the Library is available at www.brazosport.edu/sites/CurrentStudents/Library/default.aspx or by calling 979-230-3310.

Information about study skills and tutoring for math, reading, writing, biology, chemistry, and other subjects is available in the Learning Assistance Center (LAC); see www.brazosport.edu/sites/CurrentStudents/LAC/default.aspx or call 979-230-3253.

To contact the Physical Sciences and Process Technology Department call 979-230-3427.

The Student Services provides assistance in the following:

- Counseling and Advising 979-230-3040
- Financial Aid 979-230-3294
- Student Activities 979-230-3355

To reach the Information Technology Department for computer, email, or other technical assistance call the Helpdesk at 979-230-3266.