UMBC UGC New Course Request: CHEM 467 – Advanced Analytical Methods

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COURSE INFORMATION:

Course Number(s)	CHEM 467
Formal Title	Advanced Analytical Methods
Transcript Title (≤30c)	Advanced Analytical Methods
Recommended Course Preparation	CHEM 300
Prerequisite **NOTE:** Unless otherwise indicated, a prerequisite is assumed to be passed with a "D" or better.	CHEM 300
Credits	3
Repeatable?	☐ Yes X No
Max. Total Credits	3 This should be equal to the number of credits for courses that cannot be repeated for credit. For courses that may be repeated for credit, enter the maximum total number of credits a student can receive from this course. E.g., enter 6 credits for a 3 credit course that may be taken a second time for credit, but not for a third time. Please note that this does NOT refer to how many times a class may be retaken for a higher grade.
Grading Method(s)	X Reg (A-F) X Audit ☐ Pass-Fail

PROPOSED CATALOG DESCRIPTION (no longer than 75 words**):**

CHEM 467: Advanced Analytical Methods [3 credits]

This is an advanced survey of molecular characterization methodologies, and the information that can be obtained from each, as well as their application to current, real-world chemical/biochemical analyses. The course will consist of: (i) Data Handling and Chemical Transport Phenomena, (ii) Molecular Characterization Methods (fluorescence, Raman, Electrochemical, etc.), (iii) Chemical/Biochemical Imaging (fluorescence and Raman microscopy, atomic force microscopy, SEM, TEM, etc.). It will consist of lectures and discussions based on readings from current literature.

RATIONALE FOR NEW COURSE/WHY IS THERE A NEED FOR THE COURSE AT THIS TIME:

This course is being developed to provide advanced undergraduate chemistry students (with an interest in chemical, biochemical and materials characterization methods) a look at the recent significant advances in molecular analyses. With increased interest in the nano- and molecular-scale world, in numerous disciplines (biology, medicine, chemistry, energy science and materials science, etc.), a growing field of chemical/biochemical sensing and imaging is rapidly developing. This course aims to expose students to the recent advances in this area. With the continued growth in this area, there is an increasing need to better train the future workforce in characterizing samples at the molecular level. Many of the advances that have taken place in analytical methods for molecular characterization are applicable to many different fields ranging from medicine to materials science and engineering to energy science. Furthermore, the methodologies discussed in this course represent the future directions of molecular characterization that are increasingly necessary with materials development and biological characterization at the nano- and molecular scales and the inter-relation of chemical/biochemical species at this level. This will provide students will both a well-rounded exposure to new analysis methods that will likely be employed for decades to come while better preparing them for both the workforce as well as potential future graduate education.

HOW OFTEN WILL COURSE BE TAUGHT:
It is expected that this course will be taught during the Fall semester of every year, beginning Fall 2016. By providing it on a regular yearly basis, this will help address the issue of a limited number of regularly offered upper level elective options for B.S. and B.A. majors in Chemistry (which is currently very low) as well as potentially serve as an elective option for many other majors including Biochemistry, Chemical Engineering, Physics, etc.

HOW DOES THE COURSE FIT THE CURRENT CURRICULUM:
This course would represent an advanced elective to provide students interested in chemical characterization and analytical chemistry to explore recent advances that are seeing increasing adoption in the chemical and engineering worlds. With the prevalence of nano-materials and increased desire to understand biology at the molecular scale, this course will provide valuable training for new positions in industry as well as help train for graduate school. It will complement fundamental chemical analysis theories from CHEM 300 – Analytical Chemistry and build upon classical Instrumental Analysis techniques covered in CHEM 461 – Advanced Instrumental Analysis. It is designed to be able to take following CHEM 300 and independent or simultaneously with CHEM 461. A graduate level version of this class (CHEM 667) will also be offered that acts as an introductory graduate core course for Analytical Chemists, as can be seen from the syllabus, with the undergraduate students not needing to perform the class project but instead apply what they learned from the course during the semester to provide an insightful scientific critique of the graduate students projects.

This course would represent an advanced molecular characterization methods course that would enhance incoming graduate students understanding of recent advances in chemical and biochemical analysis methods, beyond traditional techniques discussed in CHEM 300: Analytical Chemistry and CHEM 461/661: Advanced Instrumental Analysis which fundamental principles typically employed in macroscopic analyses. With increased needs to understand the chemical/biochemical composition, distribution and interaction in complex micro- and nano-environments, becoming increasingly important, there is an increasing need for a technique focused course that serves as a survey of new methods. The techniques discussed in this course will provide a strong fundamental basis for application to industrial analyses or future graduate studies that often focus on applications as opposed to the methodology used to obtain results. In order to provide a firm understanding of the limitations of such analyses and therefore their application to various fields, such a methods based course is critical.

WHAT PRIMARY STUDENT POPULATION WILL THE COURSE SERVE:
This course is aimed to serve upperclass STEM majors. As described previously, one major audience for this course will include Chemistry majors who currently have very few regularly offered upper level electives to take for their degree. While numerous approved upper level chemistry elective exist for the major, most cannot be offered regularly due current teaching loads, leading to only a couple options that students can reasonably plan for when undergraduate courses. Since this course will be offered annually (partly to fulfill graduate course requirements and program changes) it will allow students with an interest in this area of chemistry to reasonably expect to be able to take it as their advanced elective(s). Furthermore, many of the topics covered in this course are rapidly seeing increased use in many other STEM fields (e.g., biology, biochemistry, chemical engineering, physics, etc.) making it very likely that students in these fields will be interested. Following approval of the course, we are planning on contacting the biology, chemical engineering and physics departments to seek approval of this course as an upper level elective for their majors as well as the current Chemistry and Biochemistry majors.

WHY 400 – LEVEL:
This course was chosen to be a 400-level course as it is expected to be an advanced course for students in the final year of their degree. It requires significant knowledge gained from 300-level courses (namely CHEM 300 – Analytical Chemistry).

PREQUISITE APPROPRIATENESS:
The prerequisite for this course is CHEM 300 – Analytical Chemistry, in which students are exposed to fundamental principles associated with chemical measurement and how those measurements effect the sample

being measured. It also provide fundamental understanding of how to analyze data in a statistically meaningful way. These principles are essential before discussing advanced analytical analysis methods. In addition, CHEM 300 also provides students with a hands-on laboratory experience so that when describing real-world applications in this CHEM 467 course, they will have an understanding not only of the theory of what they are measuring but also the practical limitations associated with such advanced methods. In many ways, it is similar to CHEM 461 – Advanced Instrumental Analysis in terms of its necessary pre-requisites. In CHEM 461, classical instrumental analysis methods are taught whereas in the CHEM 467, newly evolving techniques that are based on the fundamental CHEM 300 principles are taught. After discussion among the faculty in the division who would teach it, it was believed that the topics outlined in the attached syllabus are not significantly overlapping with CHEM 461 to require it as either a pre- or co-requisite. Instead, they are simply two different complementary courses with different focuses.

GRADING METHOD REASONING:
The grading method selected for this course is either graded or audit depending on the choice of the student enrolled. With a large number of topics and a quite variable degree of mastery possible in those topics, it is believed that having an entire grading scale (i.e., A through F) for evaluation and rating of the student would serve both the student and any potential future employers/academic institutions best in terms of realizing what the student understood upon completion.

REPEATABILITY JUSTIFICATION:
N/A - since this course is not allowed for repeat and gaining additional credits.

ATTACH COURSE OUTLINE (mandatory):
See attached syllabus

COURSE CREDIT ASSIGNMENT/DETERMINATION:
The proposed course is requested to be a three credit course corresponding to three lecture/discussion hours a week for an entire semester.

CHEMISTRY 467/667: ADVANCED ANALYTICAL METHODS (Fall 2016)

Course Master: Dr. Brian M. Cullum – Regular Member Graduate Faculty
Other Potential Instructors: Dr. Ryan J. White – Regular Member Graduate Faculty
Dr. Minjoung Kyoung – Associate Member Graduate Faculty
Lecture: Time & Location TBD Office Hours: TBD, or by appointment

COURSE DESCRIPTION: In this course, students will be exposed to advanced, cutting-edge methods for chemical and biochemical analyses. The focus of this course will be on providing insight into the molecular information that can be obtained from the various methodologies discussed as well as current cutting edge advances in these areas. In addition to static and temporal local measurements (point measurements), the introduction of spatially resolved chemical/biochemical imaging via the various methodologies will also be discussed. Students will also a solid foundation in the theoretical basis for the various methods of analysis as well as timely, real-world scenarios in which they might be employed.

COURSE PREREQUISITES: CHEM 300(ANALYTICAL CHEMISTRY)

COURSE OBJECTIVE: Upon successful completion of this course, students will exhibit a thorough understanding of the principles and theory behind current cutting-edge molecular characterization methodologies for analyses from the atomic scale to micro- and macro-scopic scale as well as the type of information each provides. They will be able to determine the most applicable method for analysis for real-world applications of interest in chemistry, biochemistry, biology and materials science as well as how to implement them.

TENTATIVE LECTURE SCHEDULE

WEEK OF TOPIC EXAM

Module 1: DATA HANDLING AND CHEMICAL PHENOMENA

08/31 Introduction/Error Propagation/Quantitation Methods & Regression 09/05
Statistical Tests (t-tests, F-tests)/Sources of Noise/Signal-to-Noise 09/12 Molecular
Transport Phenomena/Diffusion

Module 2: ADVANCED POINT CHARACTERIZATION METHODS

09/19 Luminescence Principles/Quenching Exam I
09/26 Time Resolved Luminescence (stop flow, FRAP, lifetimes, correlation)
10/03 Scattering (Raman, Rayleigh)
10/10 Time Resolved Raman(pump-probe)/Non-Linear Raman 10/17
Electrochemical (macro- & micro-electrodes)
10/24 Voltammetry/Amperometry/Temporal Analysis
10/31 Mass Spectrometry (adv. sampling & ionization)/SPR & TIR (surface analyses) Exam II

Module 3: CHEMICAL & BIOCHEMICAL IMAGING

11/07 Topological Imaging (microscopy/scanning probe methods (AFM/SEM/TEM)) 11/14
Concept of Chemical/Biochemical Imaging (scanning methods vs. wide field)
11/21 Spectroscopic Chemical/Biochemical Imaging (fluorescence microscopy, Raman, etc.) 11/28
Mass Spectral Imaging/Electrochemical Imaging/Elemental Imaging (auger/XPS)
12/05 Class Review/ Class Project Presentations Exam III
12/12 Class Project Presentations

Textbook: No textbook will be required for this course, handouts and materials will be made available to the students as necessary (including excerpts from various texts and scientific journal articles).

Exam Schedule: There will be three exams given in the course as well as a comprehensive final exam. All exams are tentatively scheduled as indicated above.

Final Exam: TBD (Check on-line university final exam schedule for any updates or changes)

Important Dates: TBD – Last Day to Add a Class
TBD – Last Day to Drop without a "W"
TBD – Last Day to Drop a Class
TBD – Last Day of Class

Grading: Final grades for each course (both CHEM 4*67* and CHEM 66*7*) will be comprised of three one-hour exams, one final exam, and classroom participation (active involvement in class

discussion, etc.). For graduate students (those enrolled in CHEM 667), a class project/presentation (described in detail below) in which students will be given complicated real-world analysis scenarios that they will be asked to provide the optimal solution to and present that solution will make up the final component of their grade. For undergraduate students (those enrolled in CHEM 467), the final component of their grade will consist of reasonable scientific critiques of the graduate students projects/presentations. These critiques will be evaluated based on the scientific validity/merit of the criticisms provided. The weighting of these various components are described below.

CHEM 467	**% of Grade**	**CHEM 667**	**% of Grade**
Three one Hour Exams	70	Three one Hour Exams	70
Final Exam	15	Final Exam	15
Presentation Critiques	5	Class Project/Presentation	10
Class Participation	10	Class Participation	5
TOTAL	**100**	**TOTAL**	**100**

Letter Grades for the class will be assigned based upon the following distribution.

Class Percentage	Letter Grade
90 – 100	A
80 – 89	B
69 – 79	C
56 – 68	D
0 – 55	F

ACADEMIC CONDUCT: students are required to comply with the University rules of conduct, as described at http://www.umbc.edu/NewsEvents/Student/oldstconduct.html and related links. Students found to be violating these rules (e.g., plagiarizing on assignments, cheating on exams, etc.) will immediately receive a grade of "0" for that assignment, be reported to the Provost's Office of Academic Conduct as well as potentially be dismissed from the course and receive a grade of "F".

MAKEUP ASSIGNMENTS AND EXAMS: will be given in accordance with University policy: a signed and readable note on letterhead paper from a physician, a police report, a certificate from a funeral home, *etc.* are required to be on file.

CLASS PROJECTS (CHEM 667 STUDENTS ONLY):

A 20 minute presentation will be given to the class by each graduate student (CHEM 667 students). This presentation will propose a solution to a complex problem assigned to the teams by the instructor at the beginning of the semester that will require determination of the optimal analytical analysis method for analysis as well as describe the procedure proposed. The "real-world" problems will be taken from current requests for proposals from federal, state and industrial agencies as well as similar alternatives provided by the instructor. Students will be able to choose from a series of topics/problems at the beginning of the semester and will continue to develop the optimal solution all semester long before culminating in a presentation to the class at the end of the semester. The presentation will include a detailed description of the proposed analysis method(s) that should be employed and a detailed procedure on how to obtained the desired results. Students should consider alternative techniques that might also be applied and describe the advantages of the proposed method over those alternative methods.

This presentation will be a critical analysis of a "real-world" analysis issue, and involves the development and application of an analytical technique and methodology based upon principles discussed in class.

Presentations should include:

1) Background to the specific problem/task to be accomplished
2) Theoretical background on how the selected method works (including a detailed procedure)

3) Summary of the results that should be capable of being obtained with the proposed system or methodology

Grades for this project will assigned using the following rubric:

(i) *Quality of Presentation* (is it presented in a coherent, logical order) (0 – 15 pts)
(ii) *Clarity of Audio Visual* (is the presentation media legible) (0 – 10 pts) (iii)*Was Solution to Problem the Best/Knowledge of Subject Matter* (0 – 55 pts) (iv)*Ability to Answer Questions* (0 – 20 pts)

CLASS PROJECT CRITIQUES (CHEM 467 STUDENTS ONLY):

Students enrolled in the advanced undergraduate elective version of the class (CHEM 4*67*) are required to show up for the presentations and ask questions as well as provide well-thought out critiques of the positives and negatives of each of the projects presented by the graduate students. These critiques should provide a scientific analysis of the proposed method and the detailed procedure given during each graduate student presentation and should evaluate any shortcomings or advantages that the proposed analysis method would have over the current state-of-the-art. The critiques should employ the appropriate terminologies (those discussed in class) and be professional in nature.

Grading for the critiques will be based on the following rubric:

(i) *Validity of Critique* (are valid issues/compliments raised based on presentation) (0 – 60 pts)
(ii) *Appropriate Usage of Terminology* (does the critique use the appropriate terminology covered in class) (0 – 20 pts)
(iii) *Clarity of Critique* (ability to concisely and coherently convey their assessment) (0 – 20 pts)

Each undergraduate will be responsible for grading every graduate presentation and the average of all of the critiques will be used as the Presentation Critiques grade.

CLASS PARTICIPATION:

Class participation grades will be assigned based upon the quality and quantity of classroom interactions provided by the student to discussions. The grading rubric for class participation will be evaluated using the following scale:

90 - 100 pts (out of 100) – Student comes to class routinely, is well prepared for class and actively contributes to the discussion but does not dominate it, making thoughtful contributions when possible and demonstrating a clear understanding of the topic discussed.

70 – 89 pts (out of 100) – Student comes to class regularly and is well prepared, participates when asked upon and provides a clear understanding of the topic being discussed.

50 – 69 pts (out of 100) – Student comes to class prepared but only minimally contributes to the discussion.

30 – 49 pts (out of 100) – Student does not come to class regularly prepared and provides minimal contribution to discussion even when called upon.

0 – 30 pts (out of 100) – Student does not come to class regularly or prepared, provides no meaningful contribution to discussions. Is disrespectful to students and/or faculty during classroom discussions.