CHEM 552

California State University San Marcos • NEW COURSE • FORM C

ORIGINATOR'S SECTION:

1. College:

☐ CHABSS ☐ CoBA
☐ CoEHHS ☒ CSM

Desired Term and Year of Implementation (e.g., Fall 2008):

Fall 2017

2.Course is to be considered for G.E.? (If yes, also fill out appropriate GE form*) ☐ Yes ☒ No

3. Course will be a variable-topics (generic) course? ☐ Yes ☒ No
("generic" is a placeholder for topics)

4. Course abbreviation and Number:* CHEM 552

5. Title: ***(Titles using jargon, slang, copyrighted names, trade names, or any non-essential punctuation may not be used.)***
Single Molecule Spectroscopy

6. Abbreviated Title for PeopleSoft:
(no more than 25 characters, including spaces)
Single Molecule Spect.

7. Number of Units: 2

8. Catalog Description: ***(Not to exceed 80 words; language should conform to catalog copy. Please consult the catalog for models of style and format; include all necessary information regarding consent for enrollment, pre- and/or corequisites, repeated enrollment, crosslisting, as detailed below. Such information does not count toward the 80-word limit.)***

Introduces the development and application of single molecule (SM) detection to problems in biology and biochemistry. Topics covered include early pioneers of the field; the principles of instrument design; methods/approaches for sample preparation and probe attachment; single molecule fluorescence spectroscopy/microscopy; super-resolution imaging techniques; force spectroscopy/microscopy; hardware/software considerations for data acquisition and analysis; and a literature survey of current research applications. *Prerequisites*: *A minimum grade of C (2.0) in CHEM 341 or 351 and CHEM 401 or classified graduate standing.*

9. Why is this course being proposed?

This course is being proposed as part of the new Masters in Chemistry program. It is an elective course.

10. Mode of Instruction*

For definitions of the Course Classification Numbers:
http://www.csusm.edu/academic_programs/curriculumscheduling/catalogcurricula/DOCUMENTS/Curricular_Forms_Tab/Instructional%20Mode%20Conventions.pdf

Type of Instruction	Number of Credit Units	Instructional Mode (Course Classification Number)
Lecture	2	C-02
Activity		
Lab		

11. Grading Method:*
☒ Normal (N) *(Allows Letter Grade +/-, and Credit/No Credit)*
☐ Normal Plus Report-in-Progress (NP) *(Allows Letter Grade +/-, Credit/No Credit, and Report-in-Progress)*
☐ Credit/No Credit Only (C)
☐ Credit/No Credit or Report-in-Progress Only (CP)

12. If the (NP) or (CP) grading system was selected, please explain the need for this grade option.

13. Course Requires Consent for Enrollment? ☐ Yes ☒ No

☐ Faculty ☐ Credential Analyst ☐ Dean ☐ Program/Department - Director/Chair

14. Course Can be Taken for Credit More than Once? ☐ Yes ☒ No
If yes, how many times? (including first offering)

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15. Is Course Crosslisted: ☐ Yes ☒ No

If yes, indicate which course and check "yes" in item #22 below.

16. Prerequisite(s): ☒ Yes ☐ No CHEM 341 or 351 and 401 or classified graduate standing.

17. Corequisite(s): ☐ Yes ☒ No

* If Originator is uncertain of this entry, please consult with Program/Department Director/Chair.

18. Documentation attached:
☒ Syllabus ☒ Detailed Course Outline

19. If this course has been offered as a topic, please enter topic abbreviation, number, and suffix:*

20. How often will this course be offered once established?* In a 2.5 to 3-year rotation of elective courses

PROGRAM DIRECTOR/CHAIR - COLLEGE CURRICULUM COMMITTEE SECTION:
(Mandatory information – all items in this section must be completed.)

21. Does this course fulfill a requirement for any major (i.e., core course or elective for a major, majors in other departments, minors in other departments)? ☒ Yes ☐ No

If yes, please specify:
Elective course in the Masters of Science in Chemistry degree.

22. Does this course impact other discipline(s)? ***(If there is any uncertainty as to whether a particular discipline is affected, check "yes" and obtain signature.)*** ☐ Yes ☒ No

If yes, obtain signature(s). Any objections should be stated in writing and attached to this form.

Discipline ______________ Signature ______ Date ______Support ______Oppose

Discipline ______________ Signature ______ Date ______Support ______Oppose

SIGNATURES : (COLLEGE LEVEL) :

K. Hamadani 8/4/2016
1. Originator (please print or type name) Date

[signature] 8/9/16
2. Program Director/Chair Date

[signature] 12/14/16
3. College Curriculum Committee Date

[signature] 12/14/16
4. College Dean (or Designee) Date

(UNIVERSITY LEVEL)

5. UCC Committee Chair Date

6. Vice President for Academic Affairs (or Designee) Date

7. President (or Designee) Date

* If Originator is uncertain of this entry, please consult with Program/Department Director/Chair.

RP ✓ Tracker ✓

Course Outline: Chem 552 Single Molecule Spectroscopy

An introduction to the development and application of single molecule (SM) detection to problems in biology and biochemistry. Topics covered include a brief history of single molecule detection; the principles of instrumental design (signal-to-noise ratios, spatio-temporal resolution, and detector technologies); methods/approaches for biological sample preparation and probe attachment; single molecule fluorescence spectroscopy/microscopy; applications of time-correlated single photon counting; single-molecule localization-based super-resolution imaging techniques; single molecule force spectroscopy/microscopy; single-molecule surface-enhanced raman spectroscopy; single-molecule nucleic acid sequencing technologies and their applications; software platforms for data acquisition and analysis; and a literature survey of current research applications. Prerequisites: CHEM 341 or CHEM 351 and CHEM 401.

Learning Outcomes

- Appreciate the importance and interdependence of structure, dynamics, and function in biomolecular systems/processes.
- Appreciate the challenges involved in extracting mechanistic insight into inherently heterogeneous or asynchronous biochemical systems.
- Be able to compare and contrast various single-molecule spectroscopy and imaging modalities both technically (i.e. sensitivity, spatial/temporal/spectral resolution, ease of use) and with respect to biological applications.
- Be able to describe the operating principles of the most common single molecule detection platforms.
- Be familiar with the particular sample-preparation hurdles which must be overcome for typical single molecule biophysics assays.
- Be able to compare and contrast the different approaches to super-resolution microscopy (including single-molecule localization methods) and identify their strengths and weaknesses for various biological imaging applications.
- Be able to find, read, critically evaluate, and present for discussion research articles of interest within the field of single molecule biology/biophysics.

Text: Reader will be based on materials from current journals as well as selected texts, including

- "Principles of Fluorescence Spectroscopy" by Joseph R. Lakowicz, 3rd ed, 2011
- "Bioconjugate Techniques", by Greg T. Hermanson, 3rd ed. 2013
- "Fundamentals of Light Microscopy and Electronic Imaging", by Douglas B. Murphy, 2nd ed. 2012
- "The Becker & Hickl TCSPC Handbook", by Wolfgang Becker, 5th edition

Attendance: This course is discussion-based and relies heavily on the use of class notes for quizzes rather than texts. For these reasons, attendance is essential to do well in the class.

Examination: Two midterms and a final exam will be given to students in order to assess whether they have met the learning objectives of the course. These will both be primarily composed of free-response/essay questions.

Quizzes: There will be a series of 5 in-class pop quizzes throughout the semester on material that was recently covered in lecture. Lowest grade is dropped.

Literature Project/Presentation: At the end of the semester students will have the option of doing either an oral in-class presentation or a written presentation/analysis of a research article which they find interesting and which is related to a topic discussed in class. Students must obtain the approval of the instructor for the research article they intend to analyze/present.

Homework: Homework problems will be assigned from the textbook for each topic covered. 4 of these assignments will be collected randomly and graded for credit.

Class participation: Students will be expected to actively participate in class discussions and will be graded on the quality and regularity of their participation.

Grading :

	Pts.	% of grade
Pop Quizzes (10 points each)	40	8%
Literature Project/Presentation	100	20%
Homework	80	16%
Midterm I	70	14%
Midterm II	70	14%
Class Participation	40	8%
Final Examination	100	20%
Total	500	100%

Topics:

Section 1: Introduction to Single Molecule Detection: Developing the Tools

Week 1	Why detect single molecules?
Week 2	Single Molecule (SM) detection 70's and 80's: Non-fluorescence-based methods
Week 3	SM detection 70's and 80's: Fluorescence-based methods
Week 4	SM detection 90's: Paving the way for biological applications
Week 5	SM detection 00's: Methodology development and initial applications to biology

Section 2: Biological applications for single molecule detection

Week 6	High-throughput *in vitro* single molecule sequencing and screening
Week 7	Super-resolution *in vivo* imaging
Week 8	*In vivo* single molecule biochemistry
Week 9	Transient, unsynchronizable, heterogeneous systems/states I: Translation
Week 10	Transient, unsynchronizable, heterogeneous systems/states II: Protein Folding

Section 3: Future Directions and student presentations

Week 11	Dealing with the labeling problem
Week 12	Dealing with the bleaching problem
Week 13	Dealing with the throughput problem
Week 14-15	Student Presentations

CHEMISTRY 552: Single Molecule Spectroscopy

Term: Fall, 2016

Prerequisites: CHEM 341 or 351 and CHEM 401

Class time: TBD

Class location: TBD

Instructor: Kambiz Hamadani

Inst. Office: Science II-331

Inst. Office hours: TBD

Inst. Phone: (760)750-4189

Inst. E-mail: khamadani@csusm.edu

Course Description: An introduction to the development and application of single molecule (SM) detection to problems in biology and biochemistry. Topics covered include a brief history of single molecule detection; the principles of instrumental design (signal-to-noise ratios, spatio-temporal resolution, and detector technologies); methods/approaches for biological sample preparation and probe attachment; single molecule fluorescence spectroscopy/microscopy; applications of time-correlated single photon counting; single-molecule localization-based super-resolution imaging techniques; single molecule force spectroscopy/microscopy; single-molecule surface-enhanced raman spectroscopy; single-molecule nucleic acid sequencing technologies and their applications; software platforms for data acquisition and analysis; and a literature survey of current research applications. Prerequisites: CHEM 341 or CHEM 351 and CHEM 401.

Student Learning Outcomes: Upon completion of this course students should:

1. Appreciate the importance and interdependence of structure, dynamics, and function in biomolecular systems/processes.
2. Appreciate the challenges involved in extracting mechanistic insight into inherently heterogeneous or asynchronous biochemical systems.
3. Be able to compare and contrast various single-molecule spectroscopy and imaging modalities both technically (i.e. sensitivity, spatial/temporal/spectral resolution, ease of use) and with respect to biological applications.
4. Be able to describe the operating principles of the most common single molecule detection platforms.
5. Be familiar with the particular sample-preparation hurdles which must be overcome for typical single molecule biophysics assays.
6. Be able to compare and contrast the different approaches to super-resolution microscopy (including single-molecule localization methods) and identify their strengths and weaknesses for various biological imaging applications.
7. Be able to find, read, critically evaluate, and present for discussion research articles of interest within the field of single molecule biology/biophysics.

Course Reader and Reserve Textbooks:

A collection of research articles and excerpts from selected texts will be made available in the form of a course reader. The following textbooks will also be made available to the class by the instructor:

"Principles of Fluorescence Spectroscopy" by Joseph R. Lakowicz, 3rd ed, 2011

"Bioconjugate Techniques", by Greg T. Hermanson, 3rd ed. 2013

"Fundamentals of Light Microscopy and Electronic Imaging", by Douglas B. Murphy, 2nd ed. 2012

"The Becker & Hickl TCSPC Handbook", by Wolfgang Becker, 5th edition

Cougar Courses: The course website can be accessed via cougar courses. The following will be available or done through the site:

- **(i).** Posting of all research articles and additional reading assignments.
- **(ii).** Public e-mail communication with the instructor, receiving notices from the instructor (make sure you are receiving the "test message" sent at the beginning o the semester).
- **(iii).** The syllabus
- **(iv).** Lecture notes (*also see below*).

If you are not already familiar with the use of Cougar Courses please consult the IITS help desk or the instructor as soon as possible.

Lecture Notes: PDF files of the slides that I use during the lecture will be available online via the campus Cougar Courses system. It is highly recommended that you print a copy of these files and bring it to class with you and take your own notes on them during lecture.

Topic Schedule: Given below is the topic list. Although every attempt will be made to adhere to this list the instructor reserves the right to adjust the time spent on each topic as well as the order of the topics.

Week	Topic	Readings (background, proof of principle, application)
Introduction to Single Molecule Detection: Development of the Tools		
1	**Why detect single molecules?** Static/Dynamic heterogeneity. Time/Ensemble Avg. The importance of transient events and intermediates in biology/biochemistry. Single molecule sequencing and molecular evolution. How to excite and detect single molecules. Maximizing signal-to-noise. Minimizing the observation volume.	Weiss '99, 00 Kapanidis '09 Rigler '94
2	**SM detection 70's and 80's: Non-fluorescence-based methods**. Single-particle Reconstruction EM, single-channel patch clamp, low-temp SM absorbance in crystalline-hosts, Atomic Force Microscopy, Optical tweezers.	Glaeser '08, Frank '09, Neher '76, Chu '86, Moerner '89, Fernandez Gaub,
3	**SM detection 70's and 80's: Fluorescence-based methods.** Fluorescence Correlation Spectroscopy, low-temp SM fluorescence of doped crystals, RT SM fluorescence in flowing liquids. Problems.	Webb '74, Oritt '90, Mathies '89, Keller '84, Keller '87
4	**SM detection 90's: Paving the way for SM Biology.** Near-field excitation, confocal detection, TCSPC/lifetime analysis, TIRF, GFP, spFRET, polarization anisotropy, magnetic tweezers, trajectories from immobilized molecules, multi-spot detection. Problems.	Betzig '93, Zare '94 Ha '96, Strick '98, Deniz '99, Moerner-Goodwin '99, Eigen '99, Tsien '94

5	**SM detection 00's:** Vesicle trapping, single molecule mixing, alternating laser excitation, PDA analysis, surface passivation methods, zero-mode waveguides, click-chemistry bioconjugation, super-resolution imaging (sm localization vs. structured illumination vs. stimulated emission depletion). Outstanding problems yet to be resolved.	Haran '03, Schuler '03, Kapanidis '04, Groll '05, Levene '03, Deniz '08, Seidel '06, Betzig '06, Hell '00, Gustaffson '00
Important biological applications for single molecule detection		
6	**High-throughput single molecule sequencing and screening**	
7	**Super-resolution *in vivo* imaging**	
8	***In vivo* single molecule biochemistry**	
9	**Studying transient states and unsynchronizable systems: Translation**	
10	**Studying transient states and unsynchronizable systems: Protein Folding**	
Future Directions and student presentations		
11	**Dealing with the labeling problem**	
12	**Dealing with the bleaching problem**	
13	**Dealing with the throughput problem**	
14	**Student Presentations**	
15	**Student Presentations**	

Exams:

There will be 2 mid-term exams and a final examination. The two mid-term exams are scheduled as follows:

1st mid-semester exam – XX
2nd mid-semester exam – XX

This is a tentative exam schedule and may change.

The final exam is scheduled for XX from XX (note the time of the final is different from the normal class time) in room XX

Make up examinations will only be given if the student has a valid excuse (e.g. severe illness, death in the family) and notifies the instructor prior to test time (if possible). No make-up examination will be given unless the instructor is notified of the emergency within two (2) days of the test.

Please bring a green scantron and a scientific calculator without wireless communication capabilities to each examination.

Pop Quizzes:

There will be a series of 5 in-class pop quizzes throughout the semester on material that was recently covered in lecture. You will have 15 minutes to complete each quiz. Your lowest score on one of the quizzes will be dropped.

Literature Project: At the end of the semester students will have the option of doing either an oral in-class presentation or a written presentation/analysis of a research article which they find interesting and which is related to a topic discussed in class. Students must get the approval of the instructor for the research article they choose.

Homework: Homework problems will be assigned from the textbook for each chapter covered. 4 of these assignments will be collected randomly and graded for credit.

Class participation: Students will be expected to actively participate in class discussions and will be graded on the quality and regularity of their participation.

Grading (points):

	Pts.	**% of grade**
Pop Quizzes (10 points each)	40	8%
Literature Project/Presentation	100	20%
Homework	80	16%
Midterm I	70	14%
Midterm II	70	14%
Class Participation	40	8%
Final Examination	100	20%
Total	500	100%

Letter grades: Letter grades will be assigned based on the following cutoff values:

Percentage	**Grade**
92% and above	A
90 - 91.9%	A-
88 – 89.9%	B+
82 – 87.9%	B
80 – 82.9%	B-
78 – 79.9%	C+
70 – 77.9%	C
68 – 69.9%	D+
62 – 67.9%	D
60 – 62.9%	D-
59.9% and below	F

Writing Requirement: The University Writing Requirement will be satisfied by the written assignments.

Use of Electronic Devices:

The use of cell phones, PDAs, or any other electronic device during exams is not allowed. Scientific calculators are permitted.

Use of Cellular Phones:

All cellular phones must be set to the silent mode. Please refrain from using your cellular phone during class. If you **must** answer your phone, due to an emergency, please leave the classroom.

Students with Disabilities:

Students with disabilities who require accommodation must be approved by the Office of Disabled Student Services (DSS). Please contact this office as soon as possible and meet with the instructor during office hours (or at some other mutually agreeable time). The DSS office is located in Craven hall 5205. Their telephone number is (760) 750-4905 or TTY (760) 750-4909.

Academic Honesty: All students are expected to maintain academic honesty. This is especially true with regards to the completion of assignments and homework. **All submitted work must be your own and must be written in your own words.**

All students should be familiar with the university policies and procedures concerning academic honesty as detailed in the university catalog. An online version of these polices and procedures can also be found at: http://lynx.csusm.edu/policies/procedure_online.asp?ID=187

Cheating, plagiarism, and other forms of academic dishonesty will not be tolerated. If you are caught cheating on an exam you will receive a grade of zero. All cases of academic dishonesty will be reported to the dean of students for appropriate action.

Use of Plagiarism Detection Software:

Where appropriate the instructor will use software (TURNITIN) for the detection of plagiarism. Plagiarized work will not be graded (see above).

Classroom Behavior and Student Code of Conduct:

Students are expected to respect and follow standards of student conduct while in class and on the campus. As your instructor, I have the following expectations concerning your behavior in this class:

1. Promote a courteous learning atmosphere by exhibiting mutual respect and consideration of the feelings, ideas, and contributions of others.
2. Practice consideration for others by maintaining a clean and orderly classroom.
3. Recognize everyone's opportunity to contribute information in a relevant and meaningful manner by not monopolizing discussions, interrupting, interjecting irrelevant, illogical or inappropriate questions or comments.
4. Do not dominate class discussion—give others a chance to contribute!
5. If you must eat in class do so discreetly.