

Eastern Illinois University  
**REVISED COURSE PROPOSAL**

This format is to be used for all courses submitted to the Council on Academic Affairs and/or the Council on Graduate Studies. (See <http://www.eiu.edu/~eiucaa/Directions.pdf> for directions on completing this form.)

**Please check one:** ☐ New course ☒ Revised course

**PART I: CATALOG DESCRIPTION**

1. **Course prefix and number, such as ART 1000:** CHM 4770
2. **Title (may not exceed 30 characters, including spaces):** Molecular Spectroscopy
3. **Long title, if any (may not exceed 100 characters, including spaces):** N/A
4. **Class hours per week, lab hours per week, and credit [e.g., (3-0-3)]:** 0-6-2
5. **Term(s) to be offered:** ☒ Fall ☐ Spring ☐ Summer ☐ On demand
6. **Initial term of offering:** ☒ Fall ☐ Spring ☐ Summer **Year:** 2010
7. **Course description (not to exceed four lines):** Application of spectroscopic techniques to study molecular structures, properties and dynamics. Methods used include vibrational and rotational spectroscopy, laser spectroscopy, and computational techniques.
8. **Registration restrictions:**
  - a. **Identify any equivalent courses** (e.g., cross-listed course, non-honors version of an honors course).  
No equivalent courses
  - b. **Prerequisite(s)**, including required test scores, courses, grades in courses, and technical skills. Indicate whether any prerequisite course(s) MAY be taken concurrently with the proposed/revised course.  
CHM3915 (with a grade of C or better) and CHM3920; or permission of instructor
  - c. **Who can waive the prerequisite(s)?**  
☐ No one ☒ Chair ☐ Instructor ☐ Advisor ☐ Other (Please specify)
  - d. **Co-requisites** (course(s) which MUST be taken concurrently with this one): N/A
  - e. **Repeat status:** ☒ Course may not be repeated.  
☐ Course may be repeated to a maximum of \_\_\_\_\_ hours or \_\_\_\_\_ times.
  - f. **Degree, college, major(s), level, or class** to which registration in the course is restricted, if any: none
9. **Special course attributes** [cultural diversity, general education (indicate component), honors, remedial, writing centered or writing intensive] writing intensive
10. **Grading methods** (check all that apply): ☒ Standard letter ☐ C/NC ☐ Audit ☐ ABC/NC ("Standard letter"—i.e., ABCDF—is assumed to be the default grading method unless the course description indicates otherwise.)
11. **Instructional delivery method:** ☐ lecture ☒ lab ☐ lecture/lab combined ☐ independent study/research  
☐ internship ☐ performance ☐ practicum or clinical ☐ study abroad ☐ other

## **PART II: ASSURANCE OF STUDENT LEARNING**

### **1. List the student learning objectives of this course:**

Students will demonstrate:

1. a thorough understanding of the application of quantum mechanics to spectroscopic problems, including:
  - a. molecular structure determination
  - b. electron spin interactions
  - c. molecular vibrations and rotations
  - d. the Born-Oppenheimer approximation
  - e. the Franck-Condon principle
  - f. application and structure of Hamiltonian operators
  - g. dynamics and relaxation times
  - h. electronic, vibrational and rotational energy levels
2. practical skills in using multiple different laboratory techniques and instruments such as:
  - a. Fourier-transform (FT) infrared spectrometer
  - b. Fourier-transform microwave spectrometer
  - c. monochromator
  - d. photomultiplier tube
  - e. oscilloscope
  - f. vacuum systems
  - g. virtual instruments (computerized data collection and analysis using LabVIEW software)
3. basic knowledge of laser operation and techniques, including laser safety, using lasers to solve spectroscopic problems, and determining what type of laser is appropriate for solving different types of problem.
4. a basic understanding of the relevance of computational chemistry to modern spectroscopic research, including demonstrating experience with accurate calculation of molecular properties and spectroscopic parameters.

- a. **If this is a general education course, indicate which objectives are designed to help students achieve one or more of the following goals of general education and university-wide assessment:**
  - **EIU graduates will write and speak effectively.**
  - **EIU graduates will think critically.**
  - **EIU graduates will function as responsible citizens.**
- b. **If this is a graduate-level course, indicate which objectives are designed to help students achieve established goals for learning at the graduate level:**
  - **Depth of content knowledge** Graduate students will demonstrate a deeper understanding of the topics in 1.1 – 1.4.
  - **Effective critical thinking and problem solving** Graduate students will combine concepts from section 1.1 in order to solve spectroscopic problems – this requires an understanding of the interrelationships of these concepts.
  - **Effective oral and written communication** Most theoretical/conceptual material is to be interwoven into laboratory periods, allowing for an interactive approach to the course. Graduate students will contribute to discussions on topics in 1.1 – 1.4 and will communicate an understanding of the interconnected topics of the individual laboratory experiments in their written laboratory reports.

- **Advanced scholarship through research or creative activity** Graduate students will write a paper critically assessing data from the chemical literature and/or analyzing a novel spectroscopic problem and assessing the suitability of different techniques for solving it.

## 2. Identify the assignments/activities the instructor will use to determine how well students attained the learning objectives:

Students will perform five 1-3 week laboratory experiments. For each experiment, the connection between theory and application will be emphasized, as well as introduction to the use and function of numerous instruments. A summary of the planned experiments is given below:

1. Atomic emission spectroscopy of sodium (**key concepts:** electron spin interactions, term symbols, electronic energy levels; **key skills:** monochromator and photomultiplier tube operation, computer controlled data acquisition and analysis).
2. Fourier transform (FT) infrared spectroscopy of carbon dioxide (**key concepts:** vibrational energy levels, connection between molecular structure and spectra, nuclear spin statistics, transition dipole moment, vibrational selection rules, vibrational and rotational quantum numbers, computational prediction of molecular properties; **key skills:** operation of FT infrared spectrometer, gas-handling techniques, data analysis and graphing)
3. FT microwave spectroscopy of carbonyl sulfide (**key concepts:** rotational energy levels, connection between molecular structure and spectra, supersonic jets, Stark effects and dipole moment determination, isotopic substitution, rotational selection rules, angular momentum in chemistry, rotational quantum numbers, computational prediction of molecular properties; **key skills:** operation of FT microwave spectrometer, supersonic expansions, ab initio structure optimizations, prediction of molecular properties, UNIX/LINUX)
4. Laser-induced fluorescence and ultraviolet-visible spectroscopy of iodine (**key concepts:** principles of laser operation, molecular dynamics, fluorescence, kinetics of fluorescence quenching, lifetime measurements on the nanosecond timescale, electronic transitions, Franck-Condon principle, electronic energy levels of diatomic molecules, molecular term symbols; **key skills:** oscilloscope operation, alignment of optics, laser operation and safety, pulsed discharge nozzle and modern spectroscopic techniques, computer controlled data acquisition, analysis and graphing, sample temperature control and monitoring)
5. Vibrational Raman spectroscopy of tetrachloromethane (**key concepts:** Raman spectroscopy, polarizability, rule of mutual exclusion, normal modes of vibration, complementary nature of different spectroscopic techniques; **key skills:** vibrational frequency calculations, laser and optical alignment, computerized data acquisition and analysis)

## 3. Explain how the instructor will determine students' grades for the course:

Graded Item	Percent of Grade	Learning Objectives
Written Laboratory Report	14% each (five reports)	1, 2, 3, 4
Quiz on Theory and Interpretation	4% each (five quizzes)	1, 2, 3, 4
Participation and Literature Analysis	10%	1, 2, 3

For each of the five laboratory experiments, the grade will be distributed as follows, with all experiments weighted equally:

70% written laboratory report (one report may be replaced (partially or in full) with an oral or poster presentation) – emphasizing presentation of results, clear explanation of calculations, and interpretation of data (**Objectives 1 – 4**)

20% quiz on theoretical background and interpretation (**Objectives 1 – 4**)

10% of the grade will be devoted to a participation score, including literature analysis (**Objectives 1 – 3**)

**Summary of experiments and which learning objective(s) each addresses:**

<b>Experiment</b>	<b>Learning Objective(s)</b>
1. Atomic emission spectroscopy	1.b., 1.h., 2.c., 2.d., 2.g.
2. FT infrared spectroscopy of carbon dioxide	1.a., 1.b., 1.c., 1.d., 1.f., 2.a., 2.f., 2.g.
3. FT microwave spectroscopy of carbonyl sulfide	1.a., 1.c., 1.f., 2.b., 2.f., 2.g., 4
4. Laser-induced fluorescence spectroscopy of iodine	1.c., 1.d., 1.e., 1.g., 1.h., 2.e., 2.g., 3
5. Vibrational Raman spectroscopy of methane	1.c., 1.d., 1.h., 2.c., 2.d., 2.g., 3, 4

4. **For technology-delivered and other nontraditional-delivered courses/sections, address the following:**
  - a. **Describe how the format/technology will be used to support and assess students' achievement of the specified learning objectives:**
  - b. **Describe how the integrity of student work will be assured:**
  - c. **Describe provisions for and requirements of instructor-student and student-student interaction, including the kinds of technologies that will be used to support the interaction (e.g., e-mail, web-based discussions, computer conferences, etc.):**
5. **For courses numbered 4750-4999, specify additional or more stringent requirements for students enrolling for graduate credit. These include:**
  - a. **course objectives;**  
Graduate students will also develop the ability to search and interpret spectroscopic literature independently, as well as to assimilate and present information.
  - b. **projects that require application and analysis of the course content; and**  
Graduate students will communicate an understanding of the interconnected topics of the individual laboratory experiments by writing a paper in which they interpret and critically analyze the data in several related articles from the literature.
  - c. **separate methods of evaluation for undergraduate and graduate students.**  
For graduate students, the added writing assignment will be worth 10% of the course grade; thus, the sum of the laboratory reports will only be worth 60% of the final grade.
6. **If applicable, indicate whether this course is writing-active, writing-intensive, or writing-centered, and describe how the course satisfies the criteria for the type of writing course identified. (See Appendix \*.)**

This course will be writing intensive. The primary method of grading (70%) is through five written reports. In addition, students will have the opportunity to rewrite one of the reports after obtaining written feedback from the instructor on a first draft. Emphasis is on accurate and efficient communication of scientific information and its interpretation in terms of basic chemical ideas and concepts.

### **PART III: OUTLINE OF THE COURSE**

**Provide a week-by-week outline of the course's content. Specify units of time (e.g., for a 3-0-3 course, 45 fifty-minute class periods over 15 weeks) for each major topic in the outline. Provide clear and sufficient details about content and procedures so that possible questions of overlap with other courses can be addressed. For technology-delivered or other nontraditional-delivered courses/sections, explain how the course content "units" are sufficiently equivalent to the traditional on-campus semester hour units of time described above.**

Students will perform five laboratory experiments. A summary of the planned experiments is given below. Presentation of related theoretical material will be integrated with hands-on experimentation, with emphasis on learning proper data-collection and analysis techniques while assimilating theory through application:

Weeks 1-3: Atomic emission spectroscopy of sodium

Weeks 4-6: FT infrared spectroscopy of carbon dioxide

Weeks 7-8: FT microwave spectroscopy of carbonyl sulfide

Week 9: Theory of laser operation, laser safety, introduction to different types of lasers

Weeks 10-11: Laser-induced fluorescence and UV-vis spectroscopy of iodine

Weeks 12-14: Vibrational Raman spectroscopy of tetrachloromethane

Week 15: Analysis of a paper from the literature, highlighting recent spectroscopic advances

### **PART IV: PURPOSE AND NEED**

#### **1. Explain the department's rationale for developing and proposing the course.**

This course is being decreased from 3 to 2 credits to fit better within our recently changed undergraduate program requirements which only require 2 additional hours of advanced lab work beyond currently required courses to obtain American Chemical Society certification. In the current course, students take one lecture hour and six lab hours per week; the revision drops the lecture hour. Two fewer experiments will be performed than in the previous version of this course, with the remaining experiments retaining the key concepts for study. Background material to provide a firm theoretical foundation for the experiments will primarily be integrated within the laboratory environment, leading to greater understanding of the application of the theory covered in the class and more efficient use of lab time.

- a. **If this is a general education course, you also must indicate the segment of the general education program into which it will be placed, and describe how the course meets the requirements of that segment.**
- b. **If the course or some sections of the course may be technology delivered, explain why.**

#### **2. Justify the level of the course and any course prerequisites, co-requisites, or registration restrictions.**

This course requires an understanding of basic physical chemistry principles, as presented in CHM 3920 and the introductory CHM 3915 lab.

#### **3. If the course is similar to an existing course or courses, justify its development and offering.**

**If the contents substantially duplicate those of an existing course, the new proposal should be discussed with the appropriate chairpersons, deans, or curriculum committees and their responses noted in the proposal.**

- a. **Cite course(s) to be deleted if the new course is approved. If no deletions are planned, note the exceptional need to be met or the curricular gap to be filled.**

**4. Impact on Program(s):**

- a. **For undergraduate programs, specify whether this course will be required for a major or minor or used as an approved elective.**

Students in the Chemistry major may choose this course as an approved elective in all tracks.

- b. **For graduate programs, specify whether this course will be a core requirement for all candidates in a degree or certificate program or an approved elective.**

This course is an approved elective for all graduate students.

**If the proposed course changes a major, minor, or certificate program in or outside of the department, you must submit a separate proposal requesting that change along with the course proposal. Provide a copy of the existing program in the current catalog with the requested changes noted.**

## **PART V: IMPLEMENTATION**

**1. Faculty member(s) to whom the course may be assigned:**

Drs. S. Peebles, B. Lawrence and R. Peebles are qualified to teach the course.

**If this is a graduate course and the department does not currently offer a graduate program, it must document that it employs faculty qualified to teach graduate courses.**

**2. Additional costs to students:**

A course fee of \$30 is requested, as is the case for the current course. This will cover chemicals and other supplies as well as the maintenance of the equipment used for the experiments.

**Include those for supplemental packets, hardware/software, or any other additional instructional, technical, or technological requirements. (Course fees must be approved by the President's Council.)**

**3. Text and supplementary materials to be used (Include publication dates):**

*Modern Spectroscopy*, J.M. Hollas (1996); *Quantum Chemistry*, D.A. McQuarrie (2008); *ACS Style Guide* (2005)

## PART VI: COMMUNITY COLLEGE TRANSFER

If the proposed course is a 1000- or 2000-level course, state either, "A community college course may be judged equivalent to this course" OR "A community college course will not be judged equivalent to this course." A community college course will not be judged equivalent to a 3000- or 4000-level course but may be accepted as a substitute; however, upper-division credit will not be awarded.

## PART VII: APPROVALS

Date approved by the department or school: 8/28/2009

Date approved by the college curriculum committee: 9/18/09

Date approved by the Honors Council (*if this is an honors course*):

Date approved by CAA: 10/1/09 CGS:

\*In **writing-active courses**, frequent, brief writing activities and assignments are required. Such activities -- some of which are to be graded -- might include five-minute in-class writing assignments, journal keeping, lab reports, essay examinations, short papers, longer papers, or a variety of other writing-to-learn activities of the instructor's invention. Writing assignments and activities in writing-active courses are designed primarily to assist students in mastering course content, secondarily to strengthen students' writing skills. In **writing-intensive courses**, several writing assignments and writing activities are required. These assignments and activities, which are to be spread over the course of the semester, serve the dual purpose of strengthening writing skills and deepening understanding of course content. At least one writing assignment is to be revised by the student after it has been read and commented on by the instructor. In writing-intensive courses, students' writing should constitute no less than 35% of the final course grade. In **writing-centered courses** (English 1001G, English 1002G, and their honors equivalents), students learn the principles and the process of writing in all of its stages, from inception to completion. The quality of students' writing is the principal determinant of the course grade. The minimum writing requirement is 20 pages (5,000 words).

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