CH 749: Analytical Spectroscopy

In Workflow
1. 17CH GR Director of Curriculum (shultz@ncsu.edu)
2. 17CH Grad Head (shultz@ncsu.edu; edmond_bowden@ncsu.edu)
3. COS CC Coordinator GR (alun_lloyd@ncsu.edu; clbowma2@ncsu.edu)
4. COS CC Meeting GR (alun_lloyd@ncsu.edu; clbowma2@ncsu.edu)
5. COS CC Chair GR ()
6. COS Final Review GR (clbowma2@ncsu.edu; alun_lloyd@ncsu.edu)
7. COS Dean GR (cohen@math.ncsu.edu)
8. ABGS Coordinator (george_hodge@ncsu.edu; lian_lynch@ncsu.edu; mlnosbis@ncsu.edu)
9. ABGS Meeting (george_hodge@ncsu.edu; lian_lynch@ncsu.edu; mlnosbis@ncsu.edu)
10. ABGS Chair (george_hodge@ncsu.edu; lian_lynch@ncsu.edu; mlnosbis@ncsu.edu)
11. Grad Final Review (george_hodge@ncsu.edu; lian_lynch@ncsu.edu; mlnosbis@ncsu.edu)
12. PeopleSoft (none)

Approval Path
1. Fri, 15 Apr 2016 16:50:10 GMT
   David Shultz (shultz): Approved for 17CH GR Director of Curriculum
2. Fri, 15 Apr 2016 16:51:53 GMT
   David Shultz (shultz): Approved for 17CH Grad Head
3. Fri, 15 Apr 2016 17:39:23 GMT
   Cheryll Bowman-Medhin (clbowma2): Approved for COS CC Coordinator GR
4. Fri, 15 Apr 2016 17:43:28 GMT
   Cheryll Bowman-Medhin (clbowma2): Approved for COS CC Meeting GR
5. Thu, 04 Aug 2016 14:26:44 GMT
   Alun Lloyd (alun_lloyd): Approved for COS CC Chair GR
6. Thu, 04 Aug 2016 14:35:30 GMT
   Alun Lloyd (alun_lloyd): Approved for COS Final Review GR
   Jo-Ann Cohen (cohen): Approved for COS Dean GR
8. Tue, 09 Aug 2016 19:13:14 GMT
   George Hodge (george_hodge): Approved for ABGS Coordinator
   George Hodge (george_hodge): Approved for ABGS Meeting

New Course Proposal

Date Submitted: Sat, 27 Feb 2016 22:01:47 GMT

Viewing: CH 749 : Analytical Spectroscopy

Changes proposed by: gwang10

Change Type

Major

Course Prefix

CH (Chemistry)

Course Number

749

Cross-listed Course
No

Title
Analytical Spectroscopy

Abbreviated Title
Analytical Spectroscopy

College
College of Sciences

Academic Org Code
Chemistry (17CH)

CIP Discipline Specialty Number
40.0501

CIP Discipline Specialty Title
Chemistry, General.

Term Offering
Fall Only

Year Offering
Offered Every Year

Effective Date
Fall 2016

Previously taught as Special Topics?
Yes

Number of Offerings within the past 5 years
3

<table>
<thead>
<tr>
<th>Course Prefix/Number</th>
<th>Semester/Term Offered</th>
<th>Enrollment</th>
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</thead>
<tbody>
<tr>
<td>CH795</td>
<td>2012 Spring</td>
<td>6</td>
</tr>
<tr>
<td>CH795</td>
<td>2014 Fall</td>
<td>9</td>
</tr>
<tr>
<td>CH795</td>
<td>2015 Fall</td>
<td>3</td>
</tr>
</tbody>
</table>

Course Delivery
Face-to-Face (On Campus)

Grading Method
Graded/Audit

Credit Hours
3

Course Length
16
weeks

Contact Hours
(Per Week)

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Contact Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>3</td>
</tr>
</tbody>
</table>

Course Is Repeatable for Credit
No

Instructor Name
Gufeng Wang

Instructor Title
Assistant Professor

Grad Faculty Status
Full

Anticipated On-Campus Enrollment
Open when course_delivery = campus OR course_delivery = blended OR course_delivery = flip

<table>
<thead>
<tr>
<th>Enrollment Component</th>
<th>Per Semester</th>
<th>Per Section</th>
<th>Multiple Sections?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>9</td>
<td>9</td>
<td>No</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Course Prerequisites, Corequisites, and Restrictive Statement
CH 315 &CH 316, or equivalent

Is the course required or an elective for a Curriculum?
No

Catalog Description
This is a graduate level course for analytical spectroscopy and instrumentation. The course covers the fundamentals of light-matter interaction, concepts and methodology of selected spectroscopic methods, components and working principles of optical instruments, and factors that affect the quality of optical measurements.

Justification for new course:
Analytical Spectroscopy is one of the main areas in chemical measurements and chemical analysis. Modern optical spectroscopic instruments can be found nearly in every research lab in both academia and industry. In most of the other major research universities, Analytical Spectroscopy (or Spectrochemical Analysis) is listed as one of the “core” courses for Analytical Chemistry programs. For most of the graduate students, this is the only course that prepares them with the advanced knowledge about instrumentation and working principles of spectroscopic methods, as well as factors that affect the quality of optical measurements.

This course fills a void in the graduate programs offered by NC-State University. It introduces the students to modern analytical methods and chemical analysis using optical spectroscopic methods. It covers the fundamentals and the state-of-art optical spectroscopic techniques that are useful for chemical, biological and material sciences. A course offered at the graduate level will help the Chemistry students understand the fundamentals of the most used instruments and establish connections between chemicals and real-world optical measurements. In addition, I expect that students from Physics, Biomedical Engineering, Chemical & Biomolecular Engineering, Biochemistry, Biological Sciences, Material Science and Engineering, as well as the Chemistry undergraduate program would be interested in this course.

Does this course have a fee?
No

Consultation
### College(s) and Contact Names

<table>
<thead>
<tr>
<th>College (s)</th>
<th>Contact Name</th>
<th>Statement Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>College of Agriculture and Life Sciences</td>
<td>Mike Goshe (BCH)</td>
<td>I looked over both course action forms and they are fine. The BIO/CH 727 cross-listing and title upgrade are appropriate, and CH 749 is an appropriate addition to the Chemistry graduate program. These courses do not conflict with anything we currently offer.</td>
</tr>
<tr>
<td>College of Engineering</td>
<td>Saad Khan (CHE)</td>
<td>We are good here</td>
</tr>
</tbody>
</table>

### Instructional Resources Statement

This course has previously been taught as a Special Topics course and is part of a faculty member’s regular teaching load. There is no lab associated with this course. No new resources are required.

### Course Objectives/Goals

The goal of this course is for students to gain an in-depth understanding of the principles of spectrochemical analysis. The course will prepare the graduate student by providing an understanding of the fundamental processes behind molecular methods of spectroscopic analysis and the design of spectroscopic instrumentation. The course will cover the principles of light-matter interaction, the methodology of selected spectroscopic methods, instrumentation of these spectroscopic methods, and factors that affect the quality of optical measurements. A student will leave this class with the ability to understand spectrometric concepts in the literature and apply spectroscopic analysis method in their own research.

### Student Learning Outcomes

The goal of this course is for students to gain an understanding of the principles of spectrochemical analysis. The course will prepare the graduate students by providing an understanding of the fundamental processes behind molecular methods of spectroscopic analysis and the design of spectroscopic instrumentation.

After learning the course, the students should be able to:

1. Describe the scientific principles underlying optical measurements
2. Describe the operation of the instrument components required to make spectroscopic measurements
3. Evaluate results of measurements in terms of signals and noises/interferences
4. Critique (orally and in writing) scientific literature that describes measurements utilizing the elements covered in the course
5. Design and evaluate spectroscopic methods for specific chemical problems

### Student Evaluation Methods

<table>
<thead>
<tr>
<th>Evaluation Method</th>
<th>Weighting/Points for Each</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple exams</td>
<td>50%</td>
<td>There will be two exams in the course. The first one will be closed-book (20%). The second one will be open book (30%).</td>
</tr>
<tr>
<td>Homework</td>
<td>30%</td>
<td>Three problem sets will be given during the semester. The problem sets will be based on either the lecture material or assigned research articles from the literature.</td>
</tr>
<tr>
<td>Major Paper</td>
<td>10%</td>
<td>Term paper and Presentation: Each student will pick one topic that is relevant to using optical measurement to acquire chemical information, write a 3-page review paper on the topic, and give a fifteen-minute presentation to the class at the end of the semester. Please talk to the instructor before you finalize your topic to make sure no overlaps between student presentations. The grading will be based on the assessment of students’ written and oral communication of scientific data.</td>
</tr>
</tbody>
</table>
Oral Presentation 10%

Term paper and Presentation: Each student will pick one topic that is relevant to using optical measurement to acquire chemical information, write a 3-page review paper on the topic, and give a fifteen-minute presentation to the class at the end of the semester. Please talk to the instructor before you finalize your topic to make sure no overlaps between student presentations. The grading will be based on the assessment of students’ written and oral communication of scientific data.

Topical Outline/Course Schedule

<table>
<thead>
<tr>
<th>Topic</th>
<th>Time Devoted to Each Topic</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course introduction</td>
<td>1 lecture</td>
<td>Course introduction; history of spectrochemical analysis</td>
</tr>
<tr>
<td>Light-matter interactions</td>
<td>2 lectures</td>
<td>Radiation; optical intensity; types of light-matter interactions;</td>
</tr>
<tr>
<td>Spectrometers and geometric optics</td>
<td>2 lectures</td>
<td>Spectrochemical measurements and analytical information</td>
</tr>
<tr>
<td>Spectrometers and wave optics</td>
<td>3 lectures</td>
<td>Frequently used optics in spectrometers – an understanding using geometric optics rules: light propagation; imaging rules, etc.</td>
</tr>
<tr>
<td>Polarization</td>
<td>1 lecture</td>
<td>Design and optical path in spectrometers; numerical aperture and photon collection efficiency; aberrations and their impact on measurements</td>
</tr>
<tr>
<td>Other optics</td>
<td>1 lecture</td>
<td>Wave optics - Wave properties of light; diffraction and interference; Huygens-Fresnel principle; math behind diffraction and interference</td>
</tr>
<tr>
<td>Light sources</td>
<td>2 lectures</td>
<td>Light dispersion - Math behind diffraction and interference (continued); single slit, double slit, and multi-slit diffraction; gratings and grating equations</td>
</tr>
<tr>
<td>Detectors</td>
<td>2 lectures</td>
<td>Light dispersion device - Monochromators, spectrographs, and spectral resolution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Polarization of light - Chemical information behind polarization; methods to generate polarized light</td>
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<tr>
<td></td>
<td></td>
<td>Other optics - Color selection; intensity modulation techniques; fiber optics etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light sources - Blackbody radiation; gas discharge lamps; other lamps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light sources – Lasers and stimulated emission; semiconductor-based light sources (LEDs and semiconductor lasers)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optical transducers - General properties; thermal detectors; photon detectors; photomultiplier tubes (PMT); analog mode and single photon counting mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optical transducers - Photodiodes; array detectors, CCD and CMOS detectors</td>
</tr>
<tr>
<td>Topic</td>
<td>Lectures</td>
<td>Overview</td>
</tr>
<tr>
<td>------------------------------</td>
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<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Signal and noises</td>
<td>2 lectures</td>
<td>Signal-to-noise ratio - Sensitivity and LOD; characterization of noises; noise classification; interference; thermal noise; bandwidth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Signal-to-noise ratio - Shot noise and Poisson distribution; 1/f noise; methods to combat noises (software and hardware)</td>
</tr>
<tr>
<td>Atomic spectroscopy</td>
<td>2 lectures</td>
<td>Atomic spectroscopy - Spectral line width broadening; peak profiles under different broadening conditions (Gaussian and Lorentzian); characteristics of different peak profiles; practical peak profiles (Voigt)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Atomic spectroscopy - Methods and instrument components</td>
</tr>
<tr>
<td>Molecular spectroscopy</td>
<td>5 lectures</td>
<td>Molecular spectroscopy - Types of molecular spectroscopy; Born-Oppenheimer approximation; Franck-Condon principle; chemical information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molecular luminescence - Introduction; Jablonski diagram; time scales of molecular processes; fluorescence lifetime and rate constant measurements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molecular luminescence - Excited states and excited state processes; quenching; energy transfer; anisotropy; excited reactions</td>
</tr>
<tr>
<td>Scattering</td>
<td>1 lecture</td>
<td>Scattering - molecular Raman scattering; scattering from metal nanoparticles; Localized surface plasmon resonances; SERS</td>
</tr>
<tr>
<td>Optical microscopy</td>
<td>1 lecture</td>
<td>Optical imaging and spectroscopy – Microscopes; spatial resolution; frequently used microscopy (bright field, dark field, phase contrast, epi- and confocal fluorescence, etc.)</td>
</tr>
<tr>
<td>Outlook</td>
<td>1 lecture</td>
<td>State-of-the-art techniques - Single molecule spectroscopy and imaging; super resolution techniques; outlook of future techniques</td>
</tr>
<tr>
<td>Exams and student presentations</td>
<td>3 lectures</td>
<td>Exam 1: mid-way through semester. Student presentations: last two class meetings</td>
</tr>
</tbody>
</table>

**Syllabus**

Analytical_Spectroscopy_Syllabus_2016_Fall.docx

**Additional Documentation**

CH_727_749_consults.pdf

**Additional Comments**

minosbis 8/4/2016: See consultation notes above. No further consultation required.

ghodge 8/9/2016 Ready for ABGS reviewers

ABGS Reviewer Comments:
- It has very low enrollments and from the projects, it will cap at 9?
- No price is on the textbook in the syllabus
- Syllabus mentions lab visits as well, will these visits be on campus? If not, a note is needed for travel off campus.
ghodge 8/16/2016 there is no set number for enrollment. Would ask that department add textbook pricing to the syllabus when the course is taught and add a note to syllabus when field trips are required.

Course Reviewer Comments

alloyd (Thu, 04 Aug 2016 14:26:41 GMT): Approved by college committee

Key: 9536