

**CHE 420 INSTRUMENTAL ANALYSIS**  
**Spring 2007**  
**Marian College**  
**3200 Cold Spring Road, Indianapolis IN 46222**

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Office Hours: MWF 10.00-10.50 am W 2.00-4.00 pm  
Lecture: 3 semester hours 11.00-11.50 pm MWF Room 355  
Laboratory: 1 semester hour: schedule by agreement, room 356

Course Description: Study of the methods of modern chemical instrumental analysis including elementary electronics and microprocessors, optical spectroscopy, atomic absorption and emission spectroscopy, chromatographic methods, nuclear magnetic and electron paramagnetic resonance spectroscopies, and electroanalytical techniques.

Textbooks: Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler, Timothy A. Nieman, 5<sup>th</sup> Ed., Brooks/Cole, 1998.

Other needs: Hardbound laboratory notebook, scientific calculator.

Course Summary: CHE 420 is an upper division course recommended for chemistry majors and is also a recommended course for biology, medical technology, and mathematics majors. The course continues from the instrumental methods section of CHE 300 (which is a prerequisite), but focuses on the theory and practice of the operation of the various experimental tools, in particular the theory of spectroscopy, and on the methodology of data acquisition using electronics and computers.

CHE 420 contributes towards General Education objectives in the areas of Scientific and Quantitative Understanding and of Effective Communication. Particular areas include:

- Scientific (empirical) method of problem-solving and inquiry.
- Fundamental laws of nature and their significance.

- Mathematical reasoning, techniques of understanding numerical data, computer literacy.
- Critical, analytical, and creative thinking skills in written and oral communications.

Assessment of the Course Objectives is through (1) 2-3 semester tests and a comprehensive final examination, (2) written laboratory reports and an investigative project laboratory. Laboratory reports will be more detailed than those required for CHE 151 and CHE 152, and feedback will be available at the draft stage to help you produce the best report possible.

Course Objectives: The main goals of this course are to lay the groundwork for an understanding of the use of instrumentation to gather chemical data, to convey the theoretical principles upon which methods such as chromatography, spectroscopy, and electroanalytic techniques are based, and to cultivate relevant laboratory skills and data taking and data analysis methods. In more detail, you should:

1. Be able to enumerate the *data domains* characterizing an instrumental measurement.
2. Demonstrate an understanding of the principles of electronic circuitry by designing circuits for simple applications.
3. Be able to demonstrate the application of *operational amplifiers* to carry out mathematical operations on electronic signals.
4. Be able to describe the operational principles of a digital computer and the steps involved in the application of computers to chemical data acquisition and analysis.
5. Be able to discuss the sources of *noise* in instrumental analysis, together with the strategies appropriate to dealing with different types of noise.
6. Be able to apply the classical theory of wave motion to the propagation of electromagnetic radiation, and show knowledge of when such a treatment is appropriate.
7. Demonstrate an understanding of how the quantum-mechanical theory of electromagnetic radiation leads to the generation of spectra.
8. Be able to give a definition of emission, absorption, luminescence, and scattering methods.
9. Be able to describe the rôles and types of components found in typical optical instruments, including lasers, monochromators, and interferometers.

10. Show a knowledge of the specifics of infrared absorption, ultraviolet absorption, Raman scattering, and luminescence methods for the spectroscopic study of atoms and molecules.
11. Be able to explain the principles of mass spectrometry and its applications to the study of atoms and molecules.
12. Be able to give an account of how the interaction between nuclear magnetic moments and external magnetic fields leads to the phenomenon of nuclear magnetic resonance, and of how the phenomena of *chemical shift* and *spin-spin coupling* arise.
13. Be able to describe the operational principles of several types of electrode and electrochemical cell.
14. Show familiarity with the principles of chromatography and electrophoresis.
15. Keep a clear and accurate laboratory notebook.
16. Show the ability to design, and build an instrument to acquire specific chemical data.
17. Show facility in manipulation of symbolic expressions (algebraic and chemical equations).
18. Use relevant computer hardware and software to facilitate data acquisition and analysis.

#### Laboratory Experiments:

The laboratory sequence will be divided into several modules:

(I) Electronics – (i) elementary principles of circuits, (ii) measurements on AC circuits, (iii) time constant of an RC circuit, (iv) high-pass and low-pass filters, (v) semiconductor circuits and rectification, (vi) op amps and transducers.

(II) Computer workshops – (i) Crystallography and molecular modeling with Oscail, (ii) free induction decay and NMR spectroscopy using Mathcad.

(III) Instrumental analysis methods and experiments – (i) atomic absorption spectroscopy, (ii) UV-Vis spectrophotometry, (iii) fluorescence spectroscopy, (iv) FTIR spectroscopy, (v) high performance liquid chromatography, (vi) gas chromatography with mass-sensitive detection, (vii) polarimetry.

(IV) Research project – a research topic will be selected by the student after discussion with the instructor. Topics may be either in instrumental design or in chemical analysis using existing instrumentation. Topics must be discussed and approved before midterm recess, and the bulk of the remaining laboratory periods will be spent on the project.

### Course Requirements and Assessment Method:

1. Laboratory reports should be in ink or word processed and written assignments should be word processed (and spellchecked). Laboratory reports are due one week after the experiment.
2. Not all laboratory periods will be spent doing experiments *per se*. There will additionally be workshops in which techniques are learned or skills are acquired in a hands-on manner. No laboratory reports will be required for these sessions.
3. There will be approximately 2-3 tests and a comprehensive final exam, to be held on Wednesday, May 2, from 10.00 to 11.45 am. All exams must be taken on the scheduled days unless there is a valid reason not to take the exam at that time. If you miss an exam for a valid reason, the exam must be taken as soon as possible after the scheduled day.
4. You are expected to keep a laboratory notebook. This will be a dated record in ink of all work that you carry out in the laboratory. Keeping a notebook containing a full record of your data as you obtain them is considered to be an important part of your academic honesty as a scientist. Notebooks will be examined periodically throughout the semester, and a final notebook grade will be given based on organization, clarity, and completeness.
5. You are encouraged to participate actively in class by reading the relevant material beforehand, asking questions, and taking notes. Ideally, the class should form a fertile environment for mastery of chemical ideas. Chapter outlines and problem assignments for each chapter will be handed out beforehand. You are encouraged to form study groups and meet regularly and review the material.
6. Mathcad, LoggerPro, and other software will be used to assist data taking and analysis, and attention will be paid in the course to the theory of computer interfacing of experiments.
7. There will be an independent research laboratory on a topic based on a proposal by the student.
8. You are expected to understand and adhere to the College's policy on academic honesty. You should read the appropriate sections in the Code of Student Rights and Responsibilities (pp. 33-38) with care.

### Attendance:

Regular attendance in lecture and laboratory is important for your learning and for maximizing your interaction with the instructor and with others in the class. This will be reflected in a grade penalty of approximately one partial grade per two unexcused absences. If you are absent for more than 20% of the course, you will receive an F.

### Grading Criteria:

1. The overall grade is calculated as follows:

Homework, class tests, and assignments:	40%
Final exam:	30%
Laboratory:	30%

The letter grading scale follows common standards, with >90% corresponding to A, 80-89% corresponding to B, 70-79% corresponding to C, 60-69% corresponding to D, and <60% corresponding to F. The marks may be curved if needed. In the case of unsatisfactory marks in a semester test, it will be possible to retake the test within the same week, and the better of the two marks will count towards your grade.

2. Laboratory analyses will be presented in the form of reports.
3. The results of the research project must be presented in a written report, which should be word processed and should be checked by the Writing Center before being handed in. The data analysis should make use of computer-based methods. The report will be graded on the statement of the problem, the appropriate use of chemical literature, the presentation of the results, and the validity of the conclusions.