Course Overview:
The purpose of this course is to engage the student in the chemistry research enterprise. This activity can take many forms, but typically involves exploratory laboratory work under the direction of a chemistry faculty member. The topic of the research will be agreed upon by the student and the faculty research advisor before the beginning of the semester, and may be either a stand-alone project or be a project performed in conjunction with other graduate or undergraduate students. A brief description (2-page, double spaced, including a few pertinent references) of the proposed project should be written within the first two weeks of the semester in which CHM 4800 is taken; it will be included in the student’s Chemistry Department file. Additionally, the faculty member will identify a Project Reviewer. The Project Reviewer will be another faculty member of the Chemistry Department who will review the written material produced for the course to ensure that it meets the standards outlined in this syllabus and associated documents. The faculty member and the student will informally agree on an appropriate amount of work to be completed at the beginning of the semester. The faculty member will assist the student in obtaining and understanding the requisite background material and laboratory techniques. It is expected that the student will perform a significant amount of work during the semester of this course. It is acceptable for the student to continue work for an ongoing research project to satisfy the requirements of this course, and for the previous work to be included in the descriptions included in the written and oral reports described herein. A timeline of important events required for this course is attached at the end of this syllabus.

Scheduling:
The scheduling of the laboratory time will be arranged on an informal basis between the advisor and the student. Since this is a three credit course, it is understood that the student will spend a minimum of six hours per week engaged in course-related activity.

Grading:
The grade for this course will be based on planning and conducting research (30%), a written report (50%), and an oral report (20%).

Project Proposal:
As described above, the student will spend the first two weeks of the semester writing a brief description of the proposed research. This proposal will be approximately 2 pages in length (double spaced) and may include a figure or two. The proposal should include a couple of pertinent references that the student has found in his or her literature review for the project. Also, as noted, the proposal will be included in the student’s Chemistry Department file. A copy of the proposal will be provided to the Project Reviewer. The proposal should have a cover sheet (included below) attached in front of the first page (with signatures). It is expected that the student will utilize the project proposal. The project proposal will also be used for Quality Enhancement Program assessment (see below).
Written Report:
A final written report is required at the end of the study. The report should be a carefully prepared, typed research report covering all aspects of the research study. It should generally follow the format and style described in the attached guide by the American Chemical Society Committee on Professional Training. The length of the report can vary, but should be at least 10 pages, double spaced, 12 point Times New Roman font, including all figures and references. The advisor will assist the student in determining the exact format and content for the final report. The final report will be reviewed by the Project Reviewer.

In some cases, the advisor may request that preliminary sections of the report be prepared during the first half of the study, while in other cases the student may be requested to submit all sections at one time. In either case, the full report must be submitted no later than the Monday of the second-to-last week of classes with all required revisions and corrections totally complete by the last day of regular classes. A copy of the final report should be provided to the Project Reviewer faculty member as well.

Oral Report:
The oral report portion of this course may be satisfied by one of the following: 1. The student may present a poster at the Science and Engineering Showcase. The poster must be prepared before the end of the course, even if the Showcase is the following semester; typically, the poster can be prepared easily by using text and figures from the report. 2. The student may present a poster at a local, regional or national scientific meeting; 3. The student may present an oral talk at a local, regional, or national scientific meeting. If the student and advisor elect options 2 or 3, it is acceptable for the oral presentation to have been given before the start of the semester in which this class is taken, on work performed previously by the student, of which the project agreed upon for this course is a continuation.

Quality Enhancement Program (QEP):
Since this course fulfills the QEP graduation prerequisite, the faculty advisor is required to complete an assessment review of the student’s performance (this is in addition to the normal grading procedure for the course). The standardized QEP assessment form is available either electronically from the departmental QEP representative, or in hard copy form in the repository of forms in the Chemistry Department office. Note that the QEP assessment reporting requirements are independent of grade reporting requirements.

General Safety and Laboratory Practices:
The student should follow the practices and guidelines learned in his or her previous coursework, as well as those additionally instructed by the advisor, including all appropriate safety and laboratory practices. In addition, the student is responsible for becoming familiar with and abiding by all special safety precautions and procedures pertinent to his or her work. No unauthorized work or unsupervised work during off hours is permitted. No unauthorized personnel are permitted in the laboratories. It is acceptable for a graduate student to supervise the student’s laboratory work.
In the space below, type or write the title of the proposal for the undergraduate research to be conducted for credit in CHM 4800.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Research project to begin _______________ semester, 20____.

Student
Name:_____________________________
Signature:_________________________
Date:_______________

Faculty Research Advisor
Name:_____________________________
Signature:_________________________
Date:_______________

Project Reviewer
Name:_____________________________
Signature:_________________________
Date:_______________

Distribution: Copy 1 – Student
Copy 2 – Student File (attached to the description of proposed research)
## CHM 4800 Course Timeline

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Activity</th>
</tr>
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| Before the start of the semester | • Student identifies a faculty research advisor  
• Student and advisor agree on a research project  
• Student registers for CHM4800                                                                 |
| First two weeks of the semester  | • Student engages in a brief literature review of the project  
• Student writes a project proposal  
• Student submits copies of the proposal to the advisor and Project Reviewer  
• Upon approval, a copy of the project proposal is placed in the student’s departmental file |
| Duration of the semester         | • Student engages in research activities as directed by the advisor  
• Student prepares portions of the final report as required by the advisor  
• Student prepares portions of the oral presentation as required by the advisor  
• Student presents their oral presentation (this may be completed before the start of the semester as described above) |
| Monday of second-to-last week of classes | • Student submits first draft of the full final report to the advisor                                                                                                                                 |
| Last two weeks of regular classes | • Student and advisor review and revise the final report                                                                                                                                 |
| Last day of regular classes      | • Student completes all revisions of the final report  
• Student provides copies of the final report to the advisor and the Project reviewer                                                                 |
| After the end of regular classes | • Advisor submits final letter grade for the course  
• Advisor completes and submits the QEP assessment evaluation form                                                                                                                                 |
Committee on Professional Training

Preparing a Research Report

Research experience is as close to a professional problem-solving activity as anything in the curriculum. It provides exposure to research methodology and an opportunity to work closely with a faculty advisor. It usually requires the use of advanced concepts, a variety of experimental techniques, and state-of-the-art instrumentation. Ideally, undergraduate research should focus on a well-defined project that stands a reasonable chance of completion in the time available. A literature survey alone is not a satisfactory research project. Neither is repetition of established procedures. The Committee on Professional Training (CPT) strongly supports efforts by departments to establish active and vibrant undergraduate research programs, recognizing the role that research can play in developing a wide range of student skills. The 2008 guidelines allow for the use of undergraduate research both as in-depth coursework, as well as a means of meeting 180 of the 400 laboratory hours required for certification provided that a well-written, comprehensive, and well-documented research report is prepared at the end of a project (samples of such research reports must be submitted with the periodic reports.) The CPT has a separate supplement outlining the components of successful research programs and projects.

Preparation of a comprehensive written research report is an essential part of a valid research experience, and the student should be aware of this requirement at the outset of the project. Interim reports may also be required, usually at the termination of the quarter or semester. Sufficient time should be allowed for satisfactory completion of reports, taking into account that initial drafts should be critiqued by the faculty advisor and corrected by the student at each stage. It may be expected that concrete outcomes of any research project would be student presentation of research results at a professional meeting and/or co-authorship on a journal publication. However, while this is a most desirable outcome, it is not a substitute for a well-written comprehensive report, produced by the student with substantive critique and correction by the faculty mentor, which demonstrates that the student has a full grasp of the scope of the problem, the techniques/instrumental methods used, and the ramifications of the results generated (much as might be expected for a capstone paper or a B.S. thesis). It is of paramount importance that any undergraduate research project culminates in a thorough well-documented written report.

Guidelines on how to prepare a professional-style research report are not always routinely available. For this reason, the following information on report writing and format is provided to be helpful to undergraduate researchers and to faculty advisors. Much of what follows is similar to what authors would find in many ‘guidelines to authors’ instructions for most journal submissions.

The most comprehensive reports examined by CPT have been those student reports reviewed by more faculty than just the supervising research advisor. In some cases, departments require an approval of the report by several faculty members; in such cases, student research reports are often of high quality.

Organization of the Research Report

Most scientific research reports, irrespective of the field, parallel the method of scientific reasoning. That is: the problem is defined, a hypothesis is created, experiments are devised to test the hypothesis, experiments are conducted, and conclusions are drawn. The exact format of scientific reports is often discipline dependent with variations in order and content. The student is encouraged to adopt the format that is most appropriate to the discipline of the research. Many journals offer a formatting template to aid the author. One example of such a framework is as follows:
Title and Title Page

The title should reflect the content and emphasis of the project described in the report. It should be as short as possible and include essential key words.

The author's name (e.g., Mary B. Chung) should follow the title on a separate line, followed by the author's affiliation (e.g., Department of Chemistry, Central State College, Central, AR 76123), the date, and possibly the origin of the report (e.g., In partial fulfillment of a Senior Thesis Project under the supervision of Professor Danielle F. Green, June, 1997).

All of the above could appear on a single cover page. Acknowledgments and a table of contents can be added as preface pages if desired.

Abstract

The abstract should concisely describe the topic, the scope, the principal findings, and the conclusions. It should be written last to reflect accurately the content of the report. The length of abstracts varies but seldom exceeds 200 words.

A primary objective of an abstract is to communicate to the reader the essence of the paper. The reader will then be the judge of whether to read the full report or not. Were the report to appear in the primary literature, the abstract would serve as a key source of indexing terms and key words to be used in information retrieval. Author abstracts are often published verbatim in Chemical Abstracts.

Introduction

"A good introduction is a clear statement of the problem or project and the reasons for studying it." (The ACS Style Guide. American Chemical Society, Washington, DC, 2006.)

The nature of the problem and why it is of interest should be conveyed in the opening paragraphs. This section should describe clearly but briefly the background information on the problem, what has been done before (with proper literature citations), and the objectives of the current project. A clear relationship between the current project and the scope and limitations of earlier work should be made so that the reasons for the project and the approach used will be understood.

Experimental Details, Computation Procedures, or Theoretical Analysis

This section should describe what was actually done. It is a succinct exposition of the laboratory and computational details, describing procedures, techniques, instrumentation, special precautions, and so on. It should be sufficiently detailed that other experienced researchers would be able to repeat the work and obtain comparable results.

In theoretical reports, this section would include sufficient theoretical or mathematical analysis to enable derivations and numerical results to be checked. Computer programs from the public domain should be cited. New computer programs should be described in outline form.
If the experimental section is lengthy and detailed, as in synthetic work, it can be placed at the end of the report so that it does not interrupt the conceptual flow of the report. Its placement will depend on the nature of the project and the discretion of the writer.

Results

In this section, relevant data, observations, and findings are summarized. Tabulation of data, equations, charts, and figures can be used effectively to present results clearly and concisely. Schemes to show reaction sequences may be used here or elsewhere in the report.

Discussion

The crux of the report is the analysis and interpretation of the results. What do the results mean? How do they relate to the objectives of the project? To what extent have they resolved the problem? Because the "Results" and "Discussion" sections are interrelated, they can often be combined as one section.

Conclusions and Summary

A separate section outlining the main conclusions of the project is appropriate if conclusions have not already been stated in the "Discussion" section. Directions for future work are also suitably expressed here.

A lengthy report, or one in which the findings are complex, usually benefits from a paragraph summarizing the main features of the report - the objectives, the findings, and the conclusions.

The last paragraph of text in manuscripts prepared for publication is customarily dedicated to acknowledgments. However, there is no rule about this, and research reports or senior theses frequently place acknowledgments following the title page.

References

Thoroughness and currency of literature references acknowledge foundational work, direct the reader to published procedures, results, and interpretations, and play a critical role in establishing the overall scholarship of the report. The report should include in-text citations with the citations collated at the end of the report and formatted as described in The ACS Style Guide or using a standard established by an appropriate journal. The citation process can be facilitated by using one of several available citation software programs. In a well-documented report, the majority of the references should come from the primary chemical literature, with any citation of Internet sources kept to a bare minimum.

Preparing the Manuscript

The personal computer and word processing have made manuscript preparation and revision a great deal easier than it used to be. It is assumed that students will have access to word processing and to additional software that allows numerical data to be graphed, chemical structures to be drawn, and mathematical equations to be represented. These are essential tools of the technical writer. All manuscripts should be carefully proofread before being submitted. Preliminary drafts should be edited by the faculty advisor (and/or a supervising committee) before the report is presented in final form.

Useful Texts

Writing the Laboratory Notebook, Kanare, H. M., American Chemical Society, Washington, DC, 1985.

This book describes among other things the reasons for note keeping, organizing and writing the notebook with examples, and provides photographs from laboratory notebooks of famous scientists.

This volume is an invaluable writer's handbook in the field of chemistry. It contains a wealth of data on preparing any type of scientific report and is useful for both students and professional chemists. Every research laboratory should have a copy. It gives pointers on the organization of a scientific paper, correct grammar and style, and accepted formats in citing chemical names, chemical symbols, units, and references.

There are useful suggestions on constructing tables, preparing illustrations, using different fonts, and giving oral presentations. In addition, there is a brief overview of the chemical literature, the way in which it is organized and how information is disseminated and retrieved. A selected bibliography of other excellent guides and resources to technical writing is also provided. See also The Basics of Technical Communicating. Cain, B. E.; ACS Professional Reference Book American Chemical Society: Washington, DC, 1988.


This book addresses all aspects of scientific writing. The book provides a structured approach to writing a journal article, conference abstract, scientific poster and research proposal. The approach is designed to turn the complex process of writing into graduated, achievable tasks.