# Graduation Composition and Communication Requirement (GCCR)
## GCCR PROPOSAL AND CHANGE UNDERGRADUATE PROGRAM FORM

**I. General Information:**

| | | | | | |
|---|---|---|---|---|---|
| College: | Arts and Sciences | Department (Full name): | Physics and Astronomy | | |
| Major Name (full name please): | Physics | Degree Title: | BS, BA | | |
| Formal Option(s), if any: | ______ | Specialty Field w/in Formal Options, if any: | ______ | | |
| Requested Effective Date: | FALL 2014, ***IF*** RECEIVED BY SENATE COUNCIL BY MONDAY, APRIL 7. | | | | |
| Contact Person: | Kwok-Wai Ng | Phone: | 257-1782 | Email: | kwng@uky.edu |

**II. Parameters of the Graduation Composition and Communication Requirement (GCCR):**

The new GCCR replaces the old Graduation Writing Requirement. It is fulfilled by a course or courses specified within a B.A./B.S. degree program. As outlined in draft Senate Rule 5.4.3.1, the GCCR stipulates that students must successfully complete this requirement after achieving sophomore status and prior to graduation. To satisfy the GCCR, students must earn an average grade of C or better on the designated Composition and Communication (C&C) intensive assignments produced in any given course designated as fulfilling some or all of the GCCR. The requirements for GCCR courses include:

- at least 4500 words of English composition (approximately 15 pages total);
- a formal oral assignment *or* a visual assignment;
- an assignment demonstrating information literacy in the discipline;
- a draft/feedback/revision process on GCCR assignments.

The program requirements for the GCCR include:

- at least one specific Program Student Learning Outcome for C&C outcomes;
- a plan for assessing both the writing and oral *or* visual components of the GCCR;
- clear goals, rubrics, and revision plans for GCCR implementation.

Upon GCCR approval, each program will have a version of the following specification listed with its Program Description in the University Bulletin:

> *"**Graduation Composition and Communication Requirement.** Students must complete the Graduation Composition and Communication Requirement as designated for this program. Please consult a college advisor or program advisor for details. See also 'Graduation Composition and Communication Requirement' on p. XX of this Bulletin."*

**III. GCCR Information for this Program (by requirement):**

| |
|---|
| **A. *List the courses currently used to fulfill the old Graduation Writing Requirement:*** |
| PHY435 for BA or PHY535 for BS |
| |
| **B. *GCCR Program Outcomes and brief description:*** |
| 1. Please specify the Major/Program Student Learning Outcomes (SLOs) pertaining to Composition & Communication and the GCCR requirement. These are *program* outcomes, not *course* outcomes. Please specify the program-level SLOs for C&C in your program: |
| SLO #4 of BA/BS program: Ability to effectively communicate physical ideas in verbal and written presentations. |
| |
| 2. Please provide a short GCCR description for your majors (limit 1000 characters): Please explain the GCCR requirement in language appropriate for undergraduate majors to understand the specific parameters and justification of your program's GCCR implementation plan: |
| Effective communication is important for a successful scientific career. This includes writing of scientific papers and technical reports, presentation of results to an audience, and discussion with the peers. To prepare for these, all physics najors are requred to satisfy the GCCR requirementsby taking PHY435 for BA of PHY535 for BS students. This will involve the following learning outcomes and activities: 1. Write papers that are essentially free of mechanical errors (grammar, punctuation, spelling, and syntax) and awkwardness, using a style that is appropriate to the purpose and audience. 2. Be aware that composing a |

successful text frequently takes multiple drafts, with varying degrees of focus on generating, revising, editing, and proofreading. 3. Present your findings and results effectively to an audience, with different audio visual aids. 4. Answer questions from the audience and exchange idea through discussion.

**C. *Delivery and Content:***

| | |
|---|---|
| 1. **Delivery specification:** for your major/program, how will the GCCR be delivered? Please put an X next to the appropriate option. *(Note: it is strongly recommended that GCCR courses be housed within the degree program.)* | ☒ a. Single required course within program<br>☐ b. multiple required or optional courses within program<br>☐ c. course or courses outside program (i.e., in another program)<br>☐ d. combination of courses inside and outside program<br>☐ e. other (please specify): _ |

2. **Basic Course Information**: Please provide the following information for course(s) used to satisfy the GCCR, either in whole or in part:

**Course #1:** Dept. prefix, number, and course title: PHY435 or PHY535
- new or existing course? existing (*new courses should be accompanied by a New Course Proposal*)
  - ☐ *if a new course, check here that a New Course Proposal has been submitted for review via eCATS*
- required or optional? required
- shared or cross-listed course? No
- projected enrollment per semester: Total of 10 to 15 (PHY435 + PHY535)

**Course #2 (if applicable):** Dept. prefix, number, and course title: _____
- new or existing course? _____ (*new courses should be accompanied by a New Course Proposal*)
  - ☐ *if a new course, check here that a New Course Proposal has been submitted for review via eCATS*
- required or optional? _____
- shared or cross-listed course? _____
- projected enrollment per semester: _____

**Course #3 (if applicable):** Dept. prefix, number, and course title: _____
- new or existing course? _____ (*new courses should be accompanied by a New Course Proposal*)
  - ☐ *if a new course, check here that a New Course Proposal has been submitted for review via eCATS*
- required or optional? _____
- shared or cross-listed course? _____
- projected enrollment per semester: _____

3. **Shared courses:** If the GCCR course(s) is/are shared from *outside* the program, please specify the related department or program that will be delivering the course(s). Please provide the following:
- **Contact information of providing program:**

  _____
- **Resources:** what are the resource implications for the proposed GCCR course(s), including any projected budget or staffing needs? If multiple units/programs will collaborate in offering the GCCR course(s), please specify the resource contribution of each participating program.

  _____
- **Memorandum of Understanding/Letter of Agreement**: Attach formal documentation of agreement between the providing and receiving programs, specifying the delivery mechanisms and resources allocated for the specified GCCR course(s) in the respective programs (include with attachments).

  **Date of agreement:** _____

4. **Syllabi: Please provide a sample syllabus for each course that will be designated to fulfill the GCCR.** Make sure the following things are clearly indicated on the syllabi for ease of review and approval (check off each):
- the GCCR assignments are highlighted in the syllabus and course calendar;
- the GCCR assignments meet the minimum workload requirements as specified by the Senate Rules for GCCR courses (see the draft Senate GCCR rule linked here);
- the elements are specified in the syllabus that fulfill the GCCR requirement for a clear draft/feedback/revision process;
- the grade level requirements for the GCCR are specified on the syllabus (i.e., an average of C or better is required on GCCR

assignments for credit);

- the course or sequence of courses are specified to be completed after the first year (i.e. to be completed after completing 30 credit hours) for GCCR credit;
- the course syllabus specifies "This course provides full/partial GCCR credit for the XXX major/program"
    - if the course provides partial GCCR credit, the fulfilled portion of the GCCR must be specified and the other components of the GCCR for the program must be specified: e.g. "This course provides partial credit for the written component of the GCCR for the XXX major/program in conjunction with Course 2"

**5. Instructional plan:** Summarize the instructional plan for teaching the C&C skills specified in the program SLOs and delivered in the course(s). Include the following information in **brief** statements (1000 characters or less). Information can be cut-and-pasted from the relevant sample syllabus with indications **where** on the syllabus it is found:

- overview of delivery model: summarize how the GCCR will be delivered for **all** program majors: explain how the delivery model is appropriate for the major/program and how it is offered at an appropriate level (e.g. required course(s), capstone course, skills practicum sequence of courses, etc.):

  PHY435 is required for BA Physics and PHY535 is required for BS Physics, these two courses are mostly taken by seniors before graduation.

- assignments: overview or list of the assignments to be required for the GCCR (e.g. papers, reports, presentations, videos, etc.), with a summary of how these GCCR assignments appropriately meet the disciplinary and professional expectations of the major/program:

  Each student will submit a laboratroy report after each experiment (about 5 in one semester). The student also has to prepare a five-minute oral presention on their project and present it to the class after each experiment.

- revision: description of the draft/feedback/revision plan for the GCCR assignments (e.g. peer review with instructor grading & feedback; essay drafting with mandatory revision; peer presentations; etc.):

  After the laboratory report is graded the first time, each student will have the opportunity to improve and revise the report according to the instructor's suggestions. After all changes and corrections are made, the student can resubmit the report for final grading.

- other information helpful for reviewing the proposal:

  PHY435 and PHY535 were used by the Physics and Astronomy Department to satisfy the old GWR requirements. This new GCCR proposal has been discussed and approved by the department UPCC. These two classes are taught at the same time in the same laboratory by the same instructor. However, students will do different sets of experiments with different level of difficulty.

***D. Assessment:***

In addition to providing the relevant program-level SLOs under III.B, please specify the assessment plan at the program level for the proposed course(s) and content. Provide the following:

- specify the assessment schedule (e.g., every 3 semesters; biennially):

  Once every three years.

- identify the internal assessment authority (e.g. curriculum committee, Undergraduate Studies Committee):

  Assesment will be conducted by the DUS, as part of the annual undergraduate program assessment. Assessment results will be reviewed by the UPCC, and problems will be addressed.

- if the GCCR course(s) is/are shared, specify the assessment relationship between the providing and receiving programs: explain how the assessment standards of the receiving program will be implemented for the provided course(s):

# Graduation Composition and Communication Requirement (GCCR)
# GCCR PROPOSAL AND CHANGE UNDERGRADUATE PROGRAM FORM

**Signature Routing Log**

**General Information:**

| | |
|---|---|
| GCCR Proposal Name<br>(course prefix & number, program major & degree): | PHY 435 for BA Physics, PHY 535 for BS Physics |
| Contact Person Name: | Kwok-Wai Ng |
| Phone: | 7-1782 |
| Email: | kwng@uky.edu |

**Instructions:**
Identify the groups or individuals reviewing the proposal; record the date of review; provide a contact person for each entry. On the approval process, please note:

- Proposals approved by Programs and Colleges will proceed to the GCCR Advisory Committee for expedited review and approval, and then they will be sent directly to the Senate Council Office. Program Changes will then be posted on a web transmittal for final Senate approval in time for inclusion in the Fall 2014 Course Bulletin.
- New Course Proposals for the GCCR will still require review and approval by the Undergraduate Council. This review will run parallel to GCCR Program Change review.
- In cases where new GCCR courses will be under review for implementation after Fall 2014, related GCCR Program Changes can still be approved for Fall 2014 as noted *"pending approval of appropriate GCCR courses."*

**Internal College Reviews and Course Sharing and Cross-listing Reviews:**

| Reviewing Group | Date Reviewed | Contact Person (name/phone/email) |
|---|---|---|
| Home Program<br>*review by Chair or DUS, etc.* | Feb 14, 2014 | Kwok-Wai Ng (DUS) / 4-1782 / kwng@uky.edu |
| Providing Program<br>*(if different from Home Program)* | | / / |
| Cross-listing Program<br>*(if applicable)* | | / / |
| College Dean | 4/1/14 | Ruth Beatties, Associate Dean / 3-9925 / rebeat1@uky.edu |
| | | / / |

**Administrative Reviews:**

| Reviewing Group | Date Approved | Approval of Revision/ Pending Approval[1] |
|---|---|---|
| GCCR Advisory Committee | 3/26/2014 | |

Comments:

| |
|---|
| |

[1] *Use this space to indicate approval of revisions made subsequent to that group's review, if deemed necessary by the revising group; and/or any Program Change approvals with GCCR course approvals pending.*

# Modern Physics Lab
# Spring 2014

| | |
|---|---|
| Instructor: | Prof. Michael A. Kovash |
| Office: | CP-371, 257-1150 |
| Office Hours: | Thursday, 9-11 |
| email: | kovash@pa.uky.edu |
| | |
| Instructor: | Prof. Valdis Zeps |
| Office: | 246-6450 |
| Office Hours: | Tuesday & Thursday, 3-4 |
| email: | val.zeps@kctcs.edu |
| | |
| Assistant: | Mr. A. Sundararajan |
| email: | abhishek.s@uky.edu |

## COURSE GOALS

Physics 435 & 535 are upper-level laboratory courses which include projects spanning the fields of optics, spectroscopy, atomic and nuclear physics. In these largely self-directed courses, students will both learn laboratory skills and also gain valuable practice using statistical methods of data analysis. *There are no lectures, no hour exams, and no final exam. Our entire focus will be on your work in the laboratory, and on the proper analysis, interpretation, and presentation of the results of your experiments.*

The specific goals of PHY 535 include:

• To gain first-hand experience working in a laboratory setting by completing several "classic" physics experiments, many of which were instrumental in defining our modern, quantum-mechanical picture of atomic and nuclear systems;

• To learn numerical methods for evaluating the uncertainties associated with laboratory measurements, and for determining optimized parametric representations of measured data; and,

• To learn effective methods for recording and reporting the results of laboratory measurements.

## EXPERIMENTAL PROJECTS

The experimental projects can be grouped into three broad categories: Atomic Physics (the 'A' projects), Nuclear Physics (N), and Spectroscopy and Optics (SO). Every student will be assigned at least one project from each these areas, and each 535 student will also be assigned one of the five extended-length projects indicated by a star on the list of projects. A listing of the experiments which are available this semester is shown in Table 1.

## ORGANIZATION

In our first class we will review the techniques of data analysis, and present a discussion of the safe

| | |
|---|---|
| | *Atomic Physics* |
| A1 | Millikan Oil Drop: e |
| A2 | Electron Magnetic Deflection: e/m |
| A3 | Photoelectric Effect: h/e |
| A4 | Franck-Hertz: Hg Excited State |
| A5 | X-Ray Scattering and Absorption: Cu X-Rays, h, Moseley's Law |
| A6 | Noise Fundamentals |
| A7 | Electron Spin Resonance: g-factor |
| | |
| | *Nuclear Physics* |
| N1 | Gamma-Ray Absorption: Attenuation Coefficients, Counting Statistics |
| N2 | Gamma-Ray Spectroscopy: Energy Calibration, Resolution, Efficiency |
| N3 | Alpha-Particle Spectroscopy: Bragg Curve, Energy Straggling |
| $\star$N4 | Pulsed NMR: Spin Echo, Chemical Signatures |
| $\star$N5 | Compton Scattering: Kinematics, Angular Distribution, Recoil Energy |
| $\star$N6 | $^{60}$Co Decay: $\gamma\gamma$ Correlation |
| | |
| | *Spectroscopy and Optics* |
| SO1 | Microwave Optics: Refraction, Standing Waves, Interferometry |
| SO2 | Two-Slit Interference: Optical Waves and Photons |
| $\star$SO3 | Modern Interferometry |
| $\star$SO4 | Optical Pumping of Rubidium |
| SO5 | Optical Dispersion: Index of Refraction |

Table 1: List of avaiable projects.

handling of radioactive materials. Students will be given their schedule of experimental projects for the semester, and each of the lab projects will be briefly introduced. The set of project manuals as well as all of the course documentation will be made available on the PHY 435 & 535 BlackBoard web sites. *The project manuals are continually being revised, and for this reason you should access your project writeup only when it is time for you to begin a new experiment.*

Lab work will begin on the second meeting of the class, Tuesday, January 21, and continue through the remainder of the semester. Each project's lab manual contains a reading assignment which you are expected to study before you begin a project. Both your lab notebook and your written lab report will be collected for grading soon after each experiment is completed. The lab notebook as well as the graded report will be returned the following day. You will then have the opportunity to return to the lab apparatus to collect additional data, should that be necessary. Your final, revised and corrected, version of the written report will be due two days later. Each student will also prepare a five-minute oral presentation on their project and present it to the class on the same day their corrected report is due.

The extended projects are all scheduled to occur during the final two project periods of the semester. Note that the schedule for these special projects is slightly different from the norm: two extra days are scheduled for data collection, no oral presentation is given, and the written reports are not returned to you for corrections.

Graduate students enrolled in PHY 535 will complete the same number of laboratory projects as undergraduate students. However, the instructor will suggest additional work for graduate students to do in each of their projects. This may take the form of requiring additional measurements, or more sophisticated data analysis, or both.

## PROJECT ASSIGNMENTS

Students enrolled in PHY 435 will not do any of the extended projects, and their set of assigned projects will generally be more straightforward than those completed by the 535 students. Given the limited number of experiment setups and the large overall enrollment, it is necessary to pre-schedule the equipment for the entire semester. This has been done so as to provide each student with a broad mix of learning opportunities. Each student will be assigned an ID corresponding to one of the sets of five experimental projects shown in Table 2. Students in 435 will be given an ID starting with the number 4, while the 535 students will be assigned an ID that starts with a 5.

| ID | #1 | #2 | #3 | #4 | #5 |
|---|---|---|---|---|---|
| 41 | SO5 | SO1 | N1 | A3 | N2 |
| 42 | A7 | N2 | SO1 | N1 | A3 |
| 43 | N2 | A2 | A4 | SO1 | N1 |
| 44 | N2 | A3 | N1 | A1 | SO1 |
| 45 | A4 | N2 | A2 | SO5 | N1 |
| 51 | SO1 | A1 | N3 | ⋆SO3 | A5 |
| 52 | N1 | N3 | A1 | ⋆SO4 | A6 |
| 53 | A3 | A5 | SO2 | ⋆N4 | N3 |
| 54 | A1 | N2 | A5 | ⋆N5 | SO2 |
| 55 | A5 | SO2 | N2 | ⋆N6 | A1 |
| 56 | N2 | SO5 | A6 | N3 | ⋆SO4 |
| 57 | A2 | N1 | SO5 | A5 | ⋆N4 |
| 58 | SO2 | A6 | A3 | N2 | ⋆N5 |

Table 2: Project sets for each 435 student (IDs 41 - 45), and 535 student (IDs 51 - 58).

## PROJECT MANUALS

A digitized manual for each experimental project can be found on the *Course Content* page in BlackBoard. Each manual is available as a pdf file, and contains a relatively complete, self-contained set of readings. Many of these are from the textbook *Experiments in Modern Physics*, by A.C. Melissinos, but other relevant readings are from apparatus manuals as well as from sections of other textbooks. Each listed resource is designated either as a primary (P) or secondary (S) reading on the ToDo list for the project. (The ToDo list is located at the front of each project manual.) All of the primary reading assignments must be read and understood before lab work can commence. The secondary readings are available as needed to provide you with a greater understanding of the physics content of your experiment.

The ToDo sheet in each manual lists activities which must be done to complete the project. This listing includes instructions on the set-up of the experiment, the data which should be collected, the kind of analysis which should be performed on your data to yield an interpretable result, and a listing of the relevant equipment manuals. The ToDo sheet also includes a set of questions. You should submit your answers to these questions separate from your report, but at the time your lab report is due. A laptop PC with Internet access is available at each experiment station. You can use these machines to access the manual as you work. Note that the lab contains both black-and-white and color laser printers with a wireless connection to your laptop. Please do not use these to make paper copies of the lab manuals.

To date, the manuals for projects A1, A2 and N1 have been extensively rewritten and do not contain most of the original source materials referred to above. Additional manuals will also be revised as the semester progresses.

At the start of the term you will be issued a USB memory stick. These should be used to transfer the data which you collect in the lab to the machine you will use to analyze your data and prepare your final report. *Please do not bring your personal laptop into the lab.*

## NOTEBOOKS, WRITTEN REPORTS, AND ORAL REPORTS

Everyone is required to use the laboratory notebook supplied by the instructor. The book contains *gridded paper* on which graphs can be easily constructed. No carbon paper is needed. This book will become a record of your preparations, methodologies, observations, graphs, and all other work completed before, during, and after the lab meeting times. Throughout the semester we will emphasize the appropriate construction of the notebook, and how it can be used to maintain an effective real-time record of your work.

The instructor will regularly check the data you have collected, as recorded in your lab notebook. *In order for a data set to be included in the final report it must be verified by the instructor on the day it is collected. Do not neglect to have the instructor check off each of your data sets, including data stored on a disk or flash memory!*

Students will submit their lab notebook for grading after each experiment. Note that each student's lab notebook will remain in the lab at the end of the semester.

We also will emphasize methods of writing a concise, coherent, and informative stand-alone lab report. Your written reports, along with your lab notebook, will be submitted for grading at the conclusion of each experiment. For example, the primary data collection phase of the first experiment concludes on Thursday, 30 January, so your notebook, first lab report, and answers to the project questions will be due the following Monday, 3 February, by noon. Reports may be submitted in the Physics Department office, or directly to Prof. Kovash. A complete listing of the report submission deadlines appears later in this syllabus.

At the conclusion of a project, every student will be expected to give a five-minute oral presentation to the class in which they briefly summarize their work. This requirement does not apply to both the first project and to the extended project, so each 435 student will give a total of four presentations, and each 535 student will give three. These oral reports will be evaluated based upon the accuracy and completeness of the presentation, and the communication skills of the presenter. Every student not working on a starred project is expected to attend the oral presentations.

**Graduation Composition and Communication Requirement**

Both 435 and 535 satisfy the University GCCR, which stipulates a minimum set of student activities in both oral and written communication. This requirement will not involve any additional work on your part, since the GCCR will be satisfied by the usual 435/535 syllabus which includes three oral presentations by 535 students and four by those in 435, as well as five written 4- to 5-page papers for all students. The GCCR stipulates that students receive feedback on their written and oral presentations. At the conclusion of each project every student will receive a report which evaluates their work in the following categories:

1. **Notebook** /15 (data tables, figures, graphs, procedures, insights, equipment, overall usefulness ...)

2. **Daily Work** /20 (attendance, preparedness, efficiency, diligence, pace ...)

3. **Written Report – Data Quality** /5 (completeness, accuracy ...)

4. **Written Report – Data Analysis** /15 (completeness, treatment of errors, $\chi^2$ ...)

5. **Written Report – Tables & Figures** /15 (labels, scales, legend, usefulness, completeness ...)

6. **Written Report – Writing** /15 (clarity, grammar, completeness, effectiveness ...)

7. **Interim score** /90

8. **Is a re-write necessary?**

9. **Oral Report** /15 (clarity, graphics, pace, timing, slides ...)

10. **Review of re-write** /5

11. **Total score** /100

As a result of this feedback, your oral and written work should evolve during the semester toward the goal of becoming a professional representation of the products of your research.

**ATTENDANCE**

All students are *required* to attend the Tuesday and Thursday lab sessions. The only exception is for students whose data set has been verified by the instructor to be complete.

Occasionally a student falls behind and is unable to complete the lab work in the allotted time. This is a potentially serious problem, and students who become ill or just "get stuck" on a lab project should discuss this with the instructor in a timely manner. In some cases it may be possible to schedule additional time for the student to be in the lab.

**GRADES**

A daily classwork grade of 0-10 points will be assigned by the instructor for work during each Tuesday and Thursday "data collection" lab period. Students who arrive on time and well prepared for class, and who are diligent, careful, accurate and effective in their lab work will receive a daily score of 10; students whose work in the lab is somewhat less than ideal will receive a score of 8; students who exhibit serious deficiencies in their lab work will receive a score of 6; and students with an unexcused absence will receive a daily score of 0. *Do not think that you will be penalized in your daily score for asking questions in class. Indeed, asking insightful questions can actually help you earn a 10-point score.* And don't worry if you don't have any questions; the instructor will usually have plenty for you. In particular, every student should be prepared to answer questions related to their project's reading assignment.

*There will be no mid-term and no final exam in this course*; each student's accumulated score on their lab work will be the basis for their final grade assignment. The final Project Grade for each of the 5 experiments will be the weighted average of the scores for the lab notebook, the written report, the oral report (where available), and the in-class grade, with the following weightings:

| | |
|---|---|
| Written Report | 50% |
| Lab Notebook | 15% |
| Oral Report | 10% |
| In-Class | 25% |

Students with unexcused absences may be explicitly penalized when final grades are assigned. Also note that an "I" grade in this course will only be given in cases where a student is unable to complete the lab work because of illness or similarly debilitating personal circumstance. Other students will receive scores of zero for all uncompleted work, and a final course grade will be assigned.

Students with a documented disability that requires academic accommodations should contact the instructor as soon as possible. Students may obtain this documentation from the Disability Resource Center in room 2 of the Alumni Gym.

In assigning final course grades we will abide by the following University guidelines:

| | |
|---|---|
| A | Represents an exceptionally high achievement as a result of aptitude, effort, and intellectual initiative |
| B | Represents a high achievement as a result of ability and effort |
| C | Represents average achievement |
| D | Represents the minimum passing grade |
| E | Represents unsatisfactory performance and indicates a failure in the course |

## CHEATING

It is an unfortunate fact that a few students find it convenient to appropriate the work of others into their own lab notebooks and reports. Let's be very clear about this: A student who falsifies data or uses the work of others – including, but not limited to, relevant work found on the Internet – without proper attribution is guilty of cheating. The University rules on how to handle cheaters are unequivocal and very severe. Do not under any circumstances "borrow" either the data or the text from another source, including other student lab reports or textbooks and manuals, without making it very clear that this is what you are doing. You should collect your own data, maintain your own lab notebook, perform your own analysis, and write your own report. Unfortunately, one or more 435/535 students are found guilty of this crime every other year or so. Don't victimize yourself this semester!

## COURSE EVALUATIONS

An on-line course evaluation system was developed to allow each student ample time to evaluate each component of the course and instructor. The evaluation window for Spring 2014 will be open in April. To access the system simply go the Department of Physics web page at http://pa.as.uky.edu and click on the link for Course Evaluations; then follow the instructions.

**SCHEDULE**

| | | | | |
|---|---|---|---|---|
| R | 1/16 | | Introduction | |
| | | | | |
| T | 1/21 | | Data Collection, Project #1 | |
| R | 1/23 | | Data Collection, Project #1 | |
| T | 1/28 | | Data Collection, Project #1 | |
| R | 1/30 | | Data Collection, Project #1 | |
| M | 2/3 | Noon | Report #1 Due | |
| | | | | |
| T | 2/4 | | Data Collection, Project #2 | |
| R | 2/6 | | Data Collection, Project #2 | |
| T | 2/11 | | Data Collection, Project #2 | |
| R | 2/13 | | Data Collection, Project #2 | |
| M | 2/17 | Noon | Report #2 Due | |
| T | 2/18 | | Review Report #2 | |
| R | 2/20 | | Oral Presentation | |
| | | Noon | Corrected Report #2 Due | |
| | | | | |
| T | 2/25 | | Data Collection, Project #3 | |
| R | 2/27 | | Data Collection, Project #3 | |
| T | 3/4 | | Data Collection, Project #3 | |
| R | 3/6 | | Data Collection, Project #3 | |
| M | 3/10 | Noon | Report #3 Due | |
| T | 3/11 | | Review Report #3 | |
| R | 3/13 | | Oral Presentation | |
| | | Noon | Corrected Report #3 Due | |
| | | | | |
| T | 3/25 | | Data Collection, Project #4 | Data Collection, Project #4⋆ |
| R | 3/27 | | Data Collection, Project #4 | Data Collection, Project #4⋆ |
| T | 4/1 | | Data Collection, Project #4 | Data Collection, Project #4⋆ |
| R | 4/3 | | Data Collection, Project #4 | Data Collection, Project #4⋆ |
| M | 4/7 | Noon | Report #4 Due | |
| T | 4/8 | | Review Report #4 | Data Collection, Project #4⋆ |
| R | 4/10 | | Oral Presentation | Data Collection, Project #4⋆ |
| | | Noon | Corrected Report #4 Due | |
| M | 4/14 | Noon | | Report #4⋆ Due |
| | | | | |
| T | 4/15 | | Data Collection, Project #5 | Data Collection, Project #5⋆ |
| R | 4/17 | | Data Collection, Project #5 | Data Collection, Project #5⋆ |
| T | 4/22 | | Data Collection, Project #5 | Data Collection, Project #5⋆ |
| R | 4/24 | | Data Collection, Project #5 | Data Collection, Project #5⋆ |
| M | 4/28 | Noon | Report #5 Due | |
| T | 4/29 | | Review Report #5 | Data Collection, Project #5⋆ |
| R | 5/1 | | Oral Presentation | Data Collection, Project #5⋆ |
| | | Noon | Corrected Report #5 Due | |
| M | 5/5 | Noon | | Report #5⋆ Due |

# Maintaining a Laboratory Notebook

The laboratory notebook is *your personal record*, and to be useful it must be both complete and accurate.

Writing down your ideas for how to do an experiment can help you organize your thoughts, thereby allowing the measurements to be made more efficiently. While executing the experiment, your lab book is where you will record all of your observations and measurements as well as a complete description of the apparatus and measurement techniques. The comprehensive record which you maintain in the lab book will be invaluable during the analysis of the data, and in reconstructing any mistakes that were made. The lab book is an essential *organizational tool* for the laboratory scientist.

On most days it will be to your advantage to prepare a short summary of your intended lab activities *before you arrive in the lab.* This doesn't need to be particularly lengthy, but should reflect the ideas which you have developed as a result of going through the reading assignment and equipment manuals. It will be particularly helpful to have made a circuit sketch beforehand, if one is needed, since this can be a time-consuming job in the lab. You can also make special note of all of the variables which need to be recorded as the data are collected. Unfortunately, it is very common for experimentalists to find that they have 'finished' an experiment and neglected to record a value which is needed for the data analysis. Your lab book must also contain a sketch of the layout of the equipment you are using.

*Leave two blank pages at the front of the book and use these to maintain a Table of Contents showing the titles and page numbers for your experiments.* Fill in these entries as you accumulate your five projects during the semester.

Record the date and time on every page and record the model numbers for all of the equipment in use. It is advisable to make all entries in ink (legibly, please!) because of the greater longevity of the record. Any mistakes should simply be X'ed out and labeled a mistake. Do not try to remove errors by covering them up.

As you perform your measurements *all of the data must be recorded in the lab book.* Do not write on loose paper with the intention of transferring only the 'good parts' into the lab book at a later time. You will find that your data tables will contain a mixture of false-starts, good results, and errors. This is normal. Make sure that you try to organize your recorded results in a way that can be understood by someone else reading your notebook. Label any data tables that you make with the appropriate heading. For example: the label 'Collector Current (mA)' should be put at the top of a column of numbers representing your measured collector currents. As the data are collected it is useful to make a quick plot of the results to see if they are reasonable, or perhaps to see if they show the anticipated effect. All of this should be done in the lab book.

Be complete and comprehensive in keeping a record of your lab work. You will *never* be sorry that you did. (If you doubt this advice, just ask any practicing laboratory scientist!) If you are uncertain about what needs to be documented in the notebook, consider whether you would be able to repeat this experiment in 5 years – after you have forgotten the details of your work – using only the record in the lab book. If you could not, then that record is incomplete.

## Lab Etiquette

Please follow these simple guidelines to improve the workability and productivity of our laboratory space:

1. When entering the lab, put your coats and unused books at one of the coat racks.

2. If you are working in a dark space, use the curtains and low-level lighting to minimize the interference to other experimenters.

3. Do not bring food, drinks or audio equipment into the lab.

4. Put your stool under the bench at the end of the lab period.

5. Unless told otherwise by the instructor, make sure that your equipment power switch is turned off at the end of each lab period.

6. When you have completed your data taking with an apparatus, disconnect the cables, clean up the area, and leave it ready for the next experimenter. Do not do this until you have received the instructor's comments on the first version of your lab report. (You may have to collect more data!) Also, be sure to erase any data files which you have stored on the laptop.

7. Minimize the amount of time you spend talking and interacting with other students. While it's okay to occasionally ask a question or share a result with another student, remember that we all face similar time pressures in completing our work.

8. Make the instructor aware of any broken or missing equipment so that it can be dealt with before the next person needs to use it.

9. Sort cables as to type when putting them on a cable rack.

10. Return all radioactive sources to the source supply area at the end of each lab period. During a lab session, store your sources behind a lead brick when you are not collecting data.

11. Do not use the lab printer to make printouts of the lab manuals. Laptops in the lab can be used to read the manuals from the BlackBoard web site.

12. Throw away paper scraps after using the paper cutter, printer, etc. Close the paper cutter after use.

13. If you are the last person to leave the lab, make sure that all hallway doors are shut and locked.

14. Do not bring your personal computer into the lab room.

15. Do unto others ...

# The title of my paper

My Name
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February 12, 2014

A research paper begins with a brief abstract whose purpose is to summarize the goals, the methods, and the results of the investigation. An abstract should therefore contain a clear statement of the overall nature of the project, and include a summary of how the work was done. You might write, for example: We have determined the elementary unit of electrical charge, e, by measuring the terminal speed of ten charged oil drops in a uniform electric field. An abstract must also contain your estimate of the true value of the measured quantity and its error. For example, you could write: We find the charge of the electron to be -1.73 (0.22) x $10^{-19}$ Coulombs. Note that only 2 significant figures are given in the error, and the least significant digit (LSD) of the error corresponds to the LSD of the quoted mean value.

## 1. Introduction

The introductory section of your paper is intended to give the reader a clear picture of the scope and significance of your project. In most papers, the introduction includes a discussion of at least some of the previous relevant measurements, often commenting on their relative strengths and weaknesses. Since nearly all of the projects we will do have an historical significance, the introduction to your report can describe how the phenomena you are investigating have played a role in helping to define our present understanding of physics. And usually, an introductory section to a paper concludes with one or two sentences indicating the topics which are covered in each of the paper's subsequent sections. [1]

Most importantly, the introduction should present an overview of the entire project. A reader not familiar with the science will then be able to develop a broad picture of your work, before they delve into the more detailed discussion. By presenting the project's landscape early in the paper, the reader will be able to more readily comprehend the details of the project as they are subsequently offered.

As you prepare your paper, you should keep several other points in mind.

Strive to achieve clarity and accuracy in your writing. Scientists work hard in a laboratory to make precise measurements, and they value a written report which avoids misrepresentations, ambiguities, and outright errors.

Imagine that your reader is another physics major not enrolled in this course. Your goal will be to produce a document which they can readily comprehend -- or, at least one which they can understand after a second reading. This can most easily be achieved by "telling the story" of your lab work. Like all stories, yours will include a beginning, a middle, and an ending. The introduction serves as the beginning of the story, followed by the development section, which provides a detailed account of your work and the final results. The ending of your story will include an interpretation of the measured data within the context you have previously established earlier in your paper.

The first sentence of each paragraph should make a significant statement about one element of the project. The sentences which follow in each paragraph should amplify and clarify the information contained in the first. Someone should be able to read just the first sentence of each paragraph in the paper and glean a relatively thorough understanding of the project.

Your written description of the methods used to obtain and analyze the data should be written in the past tense. Use the present tense when you write the conclusions. Note that your paper will be evaluated for its use of proper grammar and spelling. Please also note that in printed text the word "data" is treated as a plural noun. The singular form is "datum."

You can use this file as the template of your paper. It can be downloaded from the Course Content section of our BlackBoard page. The LibreOffice word processing software used to create and edit this file is freely available for both PC and MAC machines at www.libreoffice.org. [2] If you choose not to use LibreOffice, then your word processing software should be set up so as to create a document with this format. Use 12-point font for the main text, and 0.7 inch margins on all sides. Your paper must be between 4 and 5 pages in length, excluding the references and appendix. [3]

## 2. Theory

In general, the single most important element of a research paper in our field is the physical insight which it conveys. In some cases, this is achieved by relating the results of our laboratory measurements to the predictions of an underlying theory. In other cases, our data provide information on one or more parameters which are elements of a physical theory. An example of the former is our study of the photoelectric effect, in which Einstein's very simple formula relating the work function, the frequency of light, and the maximum energy of the ejected electron is tested against measured data. Alternately, our experiment to measure the charge on the electron provides the value of e, which is not predicted by any theory.

The Theory section of your paper should provide a clear description of the physical phenomenon you are studying. It will typically include one or a few important mathematical results. For example, a paper on the photoelectric project will cite Einstein's result, [4]

$$T_{max} = hf - \phi \qquad (1)$$

where $T_{max}$ is the electron's maximum kinetic energy, $h$ is Planck's constant, $f$ is the frequency of the light, and $\phi$ is the work function. Notice first that each formula is separated from the text and sequentially numbered, and that each symbol appearing in the equation is defined in the text. (In LibreOffice, Greek letters can be placed in the text by switching to the Standard Symbols font.) Equation 1 could be used as the starting point for your description of the physical mechanism of the photoelectric effect.

Another example is provided by the oil drop experiment. In that case, equations are used to relate the measured rise and fall times of the drops to their charge. You should not derive these results, but instead they should simply be stated, with a citation, in this section of the paper.

Overall, the content of this section will form the basis for the interpretation you form of your measured data.

## 3. Experimental Description

In this section you should provide a description of your experimental equipment. Include enough detail so that your reader will know not only the physical layout of the equipment, but also how it was used.

Present a figure showing the essential features of the apparatus early in this section. This is usually shown as a schematic drawing, rather than as a photograph. Within your text, refer to this as Fig. 1. For example: A schematic representation of the apparatus used to measure the electron charge-to-mass ratio is shown in Fig. 1. [5] Then, locate this figure close to the text in which it is referenced. Notice that each figure contains a caption which provides a useful explanation of the figure's contents. Typically, figure and table captions use 10-point font.

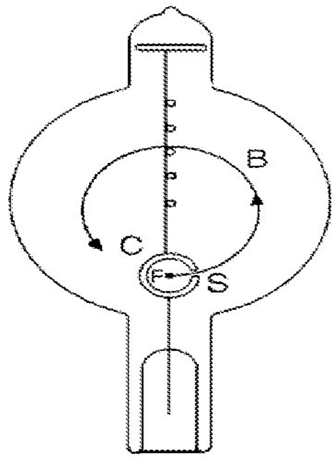


FIG. 1: The evacuated tube used to measure the orbit radius of the electron beam in an external magnetic field. Electrons emitted by the filament (F) are collimated by a slit (S) and form a narrow beam (B). The crossbar (C) contains five markers at known orbit radii.

If you are using the LibreOffice program, jpg figures can be easily included in the body of the document using the Insert/Picture/File menu option.

### 4. Results

Having already described both the apparatus and the method by which your data were acquired, it is now time to present your results.

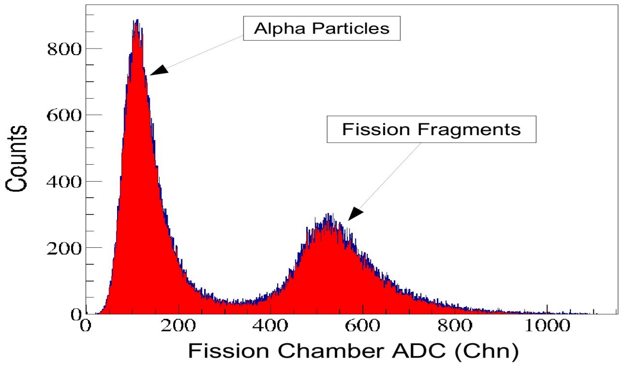


FIG. 2: The measured energy spectrum in the fission chamber. The separate peaks are from alpha particles emitted in the radioactive decay of $^{238}$U, and nuclear fragments created by neutron-induced fission.

In many experiments, the "raw data" consist of a measured spectrum of one form or another. In such a case, you should present just one example spectrum, such as the one shown in Fig. 2. [6] Either on this figure, or in its caption, make note of any important spectral features. The text of your paper will of course expand on the short description contained in the figure caption.

In many other experiments, the data consist of a set of measured x-y values. You might have used, for example, a digital voltmeter (DVM) to measure the photocurrent produced by the photoelectric effect as you illuminated a metal surface with a steady light source. The dependent variable is the measured current, while the independent variable is the applied retarding potential. Your measurements would then consist of a number of x-y data points, and these should be shown in your paper. (You may actually have collected several such data sets, but only one set should appear as a figure in the paper. You should, however, mention these additional data in the text.) We show in Fig. 3 an example plot of a complete x-y data set. [6]

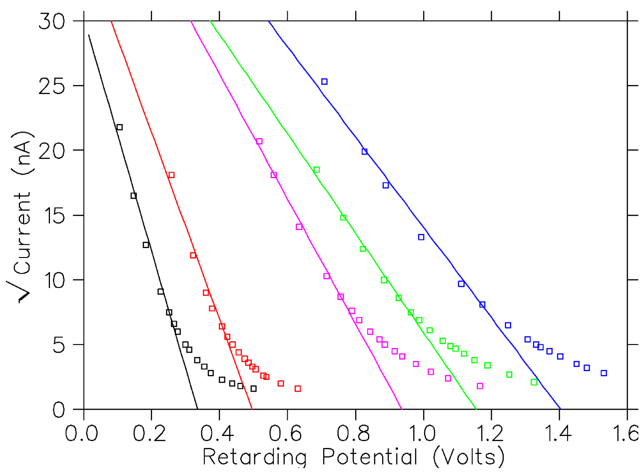


FIG. 3: Measured photocurrent as a function of retarding potential. The data sets shown above, reading from left to right, were collected at wavelengths of 577, 546, 436, 405, and 365 nm.

Notice how the axes on this and our other figures are scaled so as to fill the frame with the measured results. Each axis is labeled with the name of the displayed quantity, and its units. In MATLAB, you can easily add a legend to the figure, providing additional clarity for the reader. Note that error bars are not typically shown on data which are obtained with a DVM.

In addition to showing your unprocessed data in a figure, the Results section will also include a tabulation of the numerical values derived from an analysis of your measurements.

Consider the measurements shown in Fig. 3 as an example. The data collected at each wavelength are fit to a linear function over a range of retarding potentials that extends only up to the "knee" in the data. These fitted curves are shown overlaid on the data. Using the parameters derived from these fits, we determine the stopping potential at each wavelength, along with the estimated errors. (Recall that you can obtain an estimate of the error of any parameter value from the sample standard deviation of several data sets.) Since these stopping voltages are an important result of our experiment, they have been listed in Table 1.

| **$\lambda$ (nm)** | **$V_{stop}$ (Volts)** |
|---|---|
| 577 | 0.335 (0.034) |
| 546 | 0.496 (0.050) |
| 436 | 0.937 (0.094) |
| 405 | 1.15 (0.12) |
| 365 | 1.40 (0.14) |

TABLE 1: The fitted stopping voltage at each of the five wavelengths studied. The estimated errors are shown in parentheses. (Note the use of leading zeros.)

Finally, in most experiments our overall objective is to determine the numerical value of one or more physical parameters. Usually these values are determined by fitting our analyzed data and reporting the "best fit" parameters and their errors. Your paper should include a figure which shows this analysis. That figure should contain both your measured points, and the overlaid fitting function. For example: We show in Fig. 4 the results of a fit of our refractive index measurements at four wavelengths. [6] The resulting values of the dispersion constants for our glass sample are presented (say) in Table 2.

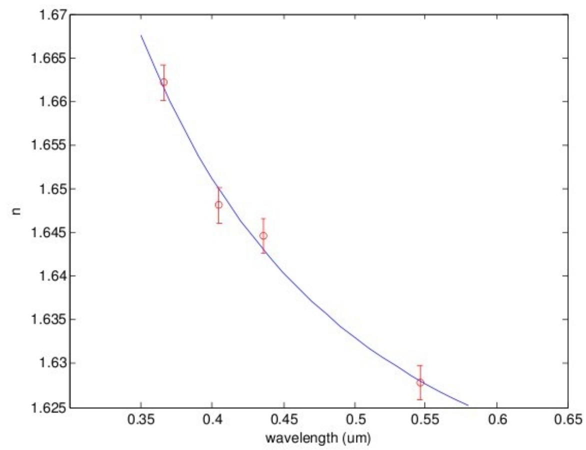


FIG 4.: The measured index of refraction for flint glass. The curve shows the results of a fit to the form (say) of equation 2.

## 5. Conclusions

The final section of the paper should summarize your findings and emphasize what has been learned as a result of your work. Compare the new results with what was already known, and discuss research which could lead to an improved future understanding.

The context for this part of the paper should be firmly rooted in the discussion which appeared in Theory section. There you have previously presented the case for obtaining a new and improved measurement of a physical constant, or testing the prediction of a physical theory. This is true even for work which is done as a student laboratory assignment!

Typically, a paper's concluding section does not emphasize the experimental aspects of the investigation, but rather how the measured results have advanced our state of knowledge. This is not to say that experimental issues are excluded from the Conclusions, just that they are not usually given an emphasis unless the project is primarily focused on a novel or significantly improved experimental method.

## Appendix

An appendix to a conventional journal article will typically contain either data in the form of one or more tables or figures, or additional explanatory text which may also include mathematical derivations. In our papers, only data tables and figures may be included, not text or mathematics.

When would you choose to put data in the Appendix, rather than in the Results section?

Typically, data tables that appear as part of the Results are of limited length and complexity. The data we show in Table 1 are "not too long," and "not too complex." But if our data instead consisted of the mean terminal velocity of each of 10 oil drops in each of three electric field settings, then those results should appear in a table in the Appendix. Tables which appear in the Appendix should contain only a limited set of "distilled" data.

In some cases it may be useful to show one or more plots of the data, beyond those which appear in the Results. We may, for example, elect to include a figure showing "raw" data in the Appendix.

Each data table and figure in the Appendix must have a caption.

## References

1. If you are generally unfamiliar with the style and content of journal articles, we recommend that you browse the American Journal of Physics, freely available for online download on a campus computer.

2. LibreOffice actually contains three programs: a text editor, a drawing program, and a slide editor. Use the slide editor to prepare your oral presentations. Text and slide files should be "exported" to pdf format for printing or projecting. This option appears under the MENU tab. Drawing files can be saved in jpg format, which then makes then easy to insert into your text file.

3. The Style and Notation Guide used by the Physical Review journals can be found at http://publish.aps.org/files/styleguide-pr.pdf. You should consult this document for answers to style and format questions not addressed in this template.

4. G. Margaritondo, Phys. Today **41**, 66 (1988). (This is the standard format for bibliographic citations used by Physical Review.)

5. This figure is taken from the Sargent-Welch manual.

6. M. A. Kovash, private communication (2014).