Syllabus and tentative schedule for Fall 2018
Intermediate Physics Laboratory (PHY 3802L-0001)
Class held in MSB 333A, Tuesday and Thursday 12:00-2:50 PM

Instructor: Dr Chris J. Bennett **Office:** PSB308 **Email:** Christopher.Bennett@ucf.edu
Office Hour: Wednesday 4:00 – 5:00 pm

Prerequisites: PHY 3101 or C.I. Laboratory work in basic measurements of physical constants; experiments in electronics, modern physics, nuclear physics, optics, and solid-state physics.

No textbook required. all the necessary manuals and guidelines will be uploaded to WebCourses within the first 2 weeks of class, as well as available at http://sciences.ucf.edu/physics/bennett-lab/teaching/3802l-intermediate-physics-laboratory/.

The following Reference books will be reserved in Library:

- The Art of Experimental Physics, D.W. Preston, E.R. Dietz, Wiley & Sons, Inc.
- Experimental Physics, Modern Methods, R.A. Dunlap, Oxford Univ. Press
- Experiments in Modern Physics, A.C. Melissinos, Academic Press
- Statistical Treatment of Experimental Data, H.D. Young, McGraw-Hill Book Co.

Grading:

Introductory quizzes/homework	15%
Laboratory interviews *(conducted each week of experiments)*	10%
Laboratory notebook and execution of experiments	10%
Laboratory write-ups (*5 as primary author, 5 as secondary author*)	50%
Final oral presentation	15%

Grading Scale:

Your final letter grade will be determined by your total score according to the following scale:

100% ≥ **A** ≥ 90%		90% > **A-** ≥ 85%
85% ≥ **B+** ≥ 80%	80% > **B** ≥ 75%	75% > **B-** ≥ 70%
70% ≥ **C+** ≥ 65%	65% > **C** ≥ 60%	60% > **C-** ≥ 55%
	55% > **D**	40 % > **F**

Note: As of Fall 2016, UCF is required to document students' academic activity at the beginning of each course. To document that you are actively participating in this course, **please complete the syllabus quiz on Webcourses by the end of the first week of classes (August 24th).** *Failure to do so will result in a delay in the disbursement of any financial aid students may be receiving.*

Course Objectives:

The fundamental objective of this course is to provide upper-level physics students with reinforcement of topics learnt during previous courses while gaining familiarity and proficiency with modern experimental methods and instrumentation. The main benefits to students, however, is that this course offers practical experience to gain proficiency in experimental design consideration, collection of scientific data, as well as performing statistical treatments and data manipulation/analysis techniques to appreciate potential limitations of the experiments performed.

For each of the 10 experiments, students will either be the primary or secondary author of scientific-style manuscripts, allowing students to become familiar with the scientific writing process. During the course, students are encouraged to work as independently as possible as a group (*i.e.*, without the instructors help) to accomplish the tasks, which often includes setting up and performing the experiments, potential troubleshooting, and are expected to perform a literature search to understand the significance and principles behind each experiment. Along with technical knowledge and skills, the student's ability to clearly and efficiently communicate basic principles of physics and their relations to experimental results will be developed. Lab reports will be graded not only on the quality of the results and subsequent analysis of results, but also on the succinctness, clarity and quality of writing to build on effective communication. Communication and learning skills will additionally be tested *via* quizzes/interviews pertaining to experiments to be performed on a given, or previous week. Each student will be expected to give an oral presentation at the end of the semester to develop communication skills on scientific topics to foster further comfort and experience with public speaking. Each of these skills are vital for the career of a Physicist.

Procedures:

The class will be divided into paired groups of two which will be set experiments each week during class-time (assigned during the initial meeting on Tue 21st Aug). On the occasions of an odd number of students, it is preferable to make one group of three members rather than a single grouping. The experiments will be circulated weekly among the groups according to the table given on the last page of the syllabus. *Although all students in the same group will work together on conducting each experiment, it is **required** that each student will obtain a bound lab notebook of his/her own and record all the pertinent data in his/her own notebook.* For each experiment, these notes should include the apparatus (including model, settings used, and manufacturer of chemicals used, if applicable), data, measurements and their conditions, preliminary graphs, working calculations, etc. Students in each group will be quizzed on the experiments being performed that week as well as the previous week for ~10 minutes to assess their understanding of the underlying principles and their completion of experiment and write-up. Note that both students are required to have knowledge and understanding of the experiments performed, even if they are not the primary author of the write-up on the given week.

Outside of the allocated class-time (although students are encouraged to work on write-ups during class), each paired group will need to prepare and submit full laboratory write-ups of the experiments, according to the data collected and notes taken during the class. It is your responsibility to make sure that you have a complete set of the data to work with before the group separates. This course is regarded as writing intensive since these write-ups are expected to follow the general guidelines for writing a scientific article. To make student work-load more reasonable, this year we will be making the laboratory write-ups more of a collaborative effort. Each week, only one student with a group (or two in a group of three) will be responsible for handing in the entire lab report (as primary author), with the other (secondary) author(s) only required to hand in their laboratory notebook for grading. The roles of the primary and secondary authors will rotate each week. The group receives joint grades for the execution of the experiments, the data collection, presentation, and analysis performed – as well as statistical analyses performed. The lead author each week is additionally graded for the introduction, background, and discussion sections of the paper as well as the clarity of the writing overall. It is therefore highly recommended that all members of the group contribute to the analysis and review the final paper prior to submission. The format of the lab report is defined clearly below, see "format specification". ***The lab reports are due every subsequent Thursday following the week the experiment was performed.***

Format of Lab report specification:

The lab reports (for primary authors) and notebooks (for secondary authors) should be submitted to webcourses in word format (pdf is also acceptable for those who prefer to use other software, such as LaTeX, for example). Each lab report should always consist two parts:

1. A word document. The name of the word document should be: ExpNumber_ExpName_LastNameFirstLetterofFirstName. For example, if the 7th experiment John Smith conducted was the Franck-Hertz experiment, then, his word document should be: 07*_FranckHertz_SmithJ.doc.* In the document, figures must be plotted by software such as excel, origin, or anything you have on your computer so long as it is legible. The original data from your lab note book must be present in table format in the word document. In the document, figures must be plotted using softwares such as Excel, Origin, Matlab, Python, etc. The original data from your lab notebook must be presented in table format in the document. **All lab reports may be screened by UCF *turnitin* system to detect potential plagiarism. If confirmed by the system, the student will get an F for the course and will be reported to UCF Office of Student Conduct.**

2. Pages of original notes from your lab note book, handwritten in blue/black pen, which can be a photocopy or digital photograph of the **authors own** original lab notes taken during class. It is permissible to use a smartphone to take pictures of the lab book pages and insert them into a document – however, marks will be deducted if the notebook images are not legible due to poor handwriting or badly scanned documents. Attach these images of the notebook at the end of their own submission, a word document as specified in 2, please place this information at the end of the Word document, titled as *Supplementary Information*. The *Supplementary Information* section can additionally include any other information that you don't think is appropriate or necessary for the main body of the report, for example, data collected that was not thrown out due to an error identified in the procedure used can be placed in this section.

We will go over how to write a scientific article in detail during one of the preliminary lectures, and it is advisable for students to pay attention to the feedback received during the first few weeks to improve upon scientific writing. Below are some brief guidelines. In general, regardless of the journal format you choose, the following elements should be present in your report:

1. Title, Experiment #, Week # and Group #, Authors, and Abstract. The *title* here should be the experiment being performed and should be accompanied by information on which week the experiment was performed as well as how many experiments have been performed at this point. The primary author should be provided as well as any secondary authors. **If you are a secondary author, you only need to submit this section and your notebook. The abstract is not required for the secondary authors.** The *abstract* should be part of the title page of the report, but it is a good idea to write it last. It should be a succinct summary of what the reader will find in the report. This usually consist of one or two sentences briefly explaining the purpose of the experiment, often putting it in additional details about the context, or specific problem at hand. This is followed by a description of the methods used, and then the most important results of your findings. Lastly, state your conclusions about whether the experiment was aligned with what was expected and how this may be significant, or potentially any reasons for deviations.
2. Introduction and Background. Give a summary of the research area that this experiment concerns and describe how the research described in this paper fits into that area, or helps solve a problem. The majority of theory/formulas relevant to the experiment and/or technique are

usually detailed or derived within the introduction along with numbered equations that can be referred to throughout the paper, but can be provided at a later stage if more appropriate (e.g., non-standard statistical analyses, if warranted). Often it is appropriate to describe the specific method chosen, the theory behind this and a comparison of this approach compared to others. In the experiments considered here, the outcome of these experiments is largely known, so one approach could be to provide some historical context as to what was known leading up to this time providing the opportunity to discuss why the experiments chosen for this experiment were significant and how this paved the way forward for future scientific developments, which can be discussed additionally in the introduction or discussion sections. There is no real set of rules here, but if you are struggling with what to put in an introductions/discussion, these suggestions may be a good place to start, but are not required. (It is however expected that equations used are defined at some point!).

3. Methods. Provide a diagram/schematic or labelled photograph of the experimental set-up. An overview of the underlying physics of the experiment is expected. Some instruments employed may deserve some exploration of its mechanism, for example, what is being measured for the *Nuclear Spectroscopy Experiment* and what information can this typically provide you with? Note that it is up to the primary author whether an in-depth description better belongs in the introduction or methods (or even discussion) section, but overall it should be demonstrated that the authors understand how the experiment being performed works. You are required to demonstrate knowledge of the working principles of the basic experiment set-up and can expect this to be part of the in-person interviews. Additional figures to explain concepts relating to the physics or experimental apparatus design are encouraged. If the experiment is described thoroughly in the introduction it is not necessary to go into depth again for the methods section, otherwise a description of how it works should be provided here. Next, detail the equipment that was used, including the settings, any chemicals or materials that were used, including sources and purity (and even batch numbers). Include the experimental procedure that was followed (this should be succinct if the instructions were simply followed verbatim, but if alterations to the procedure were made, then these should be explicitly stated here). **There should be enough information in the methods section of a paper that someone could follow this and repeat your experiment and they should obtain roughly the same result.** If there were any issues with the equipment used, such as trouble obtaining data, point that out in this section as well as where any data that was not used can be found (e.g., *Supplementary Information*).
4. Results: Data. Give a narrative how the data was acquired, be sure to note any deviations from the experimental procedure either here or in the methods section (not both). Although the original data is present in your lab note, this data must be reproduced in both tables, graphs, and figures how best the data can be represented for this experiment. Be sure to label graphs, label axes, give all appropriate units, etc. Please use SI units (if non-SI units are given, you can present both, for example for the slit spacing in the diffraction experiment).
5. Results: Data Analysis. Calculate whatever quantities are most appropriate for making comparison to theory or values available in literature for extracting useful information. For example, when you derived the electron charge mass ratio, how does your value compare with the value in literature? Another example is, after you measured the temperature dependent resistivity of Pt and semi-conductor, how do they compare to the standard value? Why do you see a larger/smaller value? How do you justify the size of deviation from the standard value (what are the potential factors caused this?) Be sure to include an error analysis starting with estimates and uncertainties of the measured quantities, and ending with estimates for the

precision of your final results. There must be sufficient information for the instructor to be able to follow your working, including error analysis performed, therefore sufficient information must be presented in tables as well as derivations, which can optionally be placed in the *Supplementary Information* section, if desired.

Note regarding sections 3, 4, and 5: In some cases, the flow of the document makes more sense if the *Methods, Results* and *Analysis* are presented for one section of the experiment at a time. This is fine, but in this case it is up to the author to provide section headings relevant to each experiment. For example, in the spectroscopy experiment (lab #7) it may be desirable to separately discuss the methods, tabled results, and analysis of the emission versus and then to repeat each of these sections for the absorbance experiments. The group is encouraged to decide how best to present the information logically, so long as each section can be identified for grading purposes.

6. Summary, Applications & Discussion. Surmise the main results of your experiment. List and discuss possible discrepancies between your experiment and theory, previous measurements, or initial expectations. It is expected to compare your results to those previously found in the literature with citations and reasons for differences in precision or accuracy. What improvements could be made to the experiment so that better results can be obtained in the future? In the discussion, you should try to evaluate the significance of the experiments in its historical context where possible. How do (or did) these results advance the field? *For example, the Franck-Hertz experiment discovered the quantization of excitation energy of Mercury, which led to proof for Bohr's model which was controversial at the time (why?).* You should discuss the significance of the results in a broader sense; are there applications that were born out of this experimental result? Was there a subsequent advancement in the knowledge of physics principles leading from this experiment? ***For this part of discussion, it is expected that the primary author presents their independent discussion in their lab reports; points will be awarded for originality and marked down for similarity with previous groups.***
7. References. Should come after the discussion section. For these lab reports, somewhere in the range of 5-15 references is expected (the laboratory guides should always be cited in each case). Acknowledge all sources throughout the report and refer to them by either author (e.g., Smith et al. (2012)) or as a numbered citation [1],[2],[3], etc. throughout your report. Consult the AIP style menu for format. For websites, you should include the date the content was accessed.
8. Supplementary Information: The laboratory notebook of the primary author is required here, as well as any additional information can be placed here. If Matlab or Python code is used, or any advanced analysis techniques then the code, or additional derivations/calculations can be provided here.

Criteria for lab report grading:

Each lab report will be marked out of 50 pts. Lab report are always due before midnight of the following Thursday. For example, if an experiment is conducted during the week of Sept 3rd - 7th, then its report is due by webcourses to the instructor ***by*** Sept 13th, the next Thursday night (12 am). Late submission of a lab report will suffer a **2pt penalty for every 24 hrs** behind the due date, or **10pts per week** past the due date. *The same late-rule penalties apply to the homeworks as well.*

Laboratory Notebook & Execution (10 pts total):

5 pts: Evidence of well-executed experiment, or documentation of sufficient attempts to recover the experiment if something went wrong.

5 pts: Clear presentation of the original data (photo image of the hand-written data page from your note book, must be your own version - *even if several students conduct an experiment together, each must have his/her own copy of the original data*).

Laboratory Write-up (50 pts):

5 pts (10%): Professional presentation of the word document (not sure what this means? Go to www.aps.org, find any paper to take a look). Write data in tables where appropriate. Use equation editor in word and number your equations for reference throughout the report, and preferably use a graphing program such as Excel (Origin, Python, R, Matlab, IDL, etc. also acceptable). Tables and Figures should be numbered and labeled. References well formated and cited throughout. Correct title, authors, etc. Papers should be checked for spelling, punctuation, and grammar.

10 pts (20%): Introduction covers sufficient background, including a concise literature review and sufficient theory required to understand how the experiment works, and the underlying physics principles. Typically this includes a demonstrated understanding of the phyiscs behind how the apparatus and/or experiment works.

10 pts (20%): Description of the apparatus (usually with annotated photograph and/or schematics). Model number, manufacturer, chemical suppliers, etc.

15 pts (30%): Clear presentation and derivation of your results and analysis of the data (see #5 *Analysis* in format specification above). The error/uncertainty analysis typically constitutes a significant fraction of the grading criteria for this section (*up to 50%*).

10 pts (20%): Discussion of the results, as well as relevant example/application/phenomena based on this experiment. I am expecting different contents for each write-up, which means you need to complete this part independently.

Because there is a strong emphasis on the quality of writing, the instructor reserves the right to return the reports for rewriting. If this happens on more than one occasion, I expect to meet the group/student during office hours to discuss improvements. It is encouraged for you to let other people read the report before you turn it in; they do not necessarily have to be physics majors (sometimes those people are the best reviewers). If the manuscript contains **new** material or additional work beyond the expectations of the instructor, **1-2 bonus points** may be awarded for a specific section, *one-time only*.

Primary *vs.* Secondary Author Break-down on Laboratory Report Write-ups:

You are required to hand in 5 reports as primary author and 5 reports as secondary author over the course of this course.

Primary authors are graded on:

- Everything (50 points lab report & 10 points Notebook/Execution)

Secondary authors will still be graded on:

- Laboratory Notebook & Execution (10 pts total)
- Results & Analysis (15 pts)

Note: This amounts to totals of 75 points out of 325 points (23%) of the total laboratory write-up grade, and ~11.5% of the total grade for the course.

Homework/Quizzes:

There will be a total of four sets of homework/quizzes for this course. The first is the syllabus quiz (10%) due on the 24th August (end of 1st week of class). The second is the lab safety quiz (20%) which will be taken during the class on Thu 24th August. Homework set #1 (due 9/20) will be based primarily on the statistical treatment of data, whereas Homework #2 (due 11/20) will cover topics more closely related to the experimental work throughout the course (both 35%).

Presentation:

A 15-minute oral presentation will be given by each student during the final exam period with a few minutes for questions and answers. The presentation style will be similar to a presentation that is given at a scientific conference. The topic of the presentation should be any experiment in physics history (that is different from what we do in this course) that led to the confirmation of a theory or discovery of a new physics law. You must propose and finalize your selected topic during the tenth experiment either in e-mail or in person, but the topic must be given instructor approval.

Attendance and Early Finish:

Students are required to read lab materials prior to the class and start the experiment early on Tuesday. **You will lose 20% of the credits for the execution of experiment if you are late for more than 30 minutes without good reason - it is not fair to expect your lab partner(s) to do the work on your behalf.** If you finish your experiment on Tuesday and pass the interview, you are not required to attend Thursday's class – however, it is strongly encouraged to spend some time working on your lab report in the classroom where help is available, or your lab partner is available to help go over the analysis.

Justified Absence:

I expect advanced notice if you miss class for an excused reason (for example, a medical situation), arrangements for making up the lab will be made.

Student Accessibility:

We aim to work with Student Accessibility Services to make sure that any needs/requirements can be met – please communicate with me during the first week of classes either in person or over WebCourses secure email so that we can make any necessary accommodations.

Experiments (a lab notebook is *required* for each student, *no data on loose pieces of paper*):

1. Frank-Hertz Experiment
2. Photoelectric Effect
3. Charge-to-Mass Ratio of Electrons
4. Temperature Dependence of Resistivity
5. Electron Spin Resonance
6. Superconducting Quantum Interference Device (SQUID)
7. Optical Experiment: Spectroscopy
8. Optical Experiment: Diffraction
9. Nuclear Spectroscopy
10. AC Electronics

Group Experiment Rotations and Scheduling of Experiments:
Group Assignment for 3802L, Fall 2018 (To be determined in the first class)

Group	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Wk13
A	1	2	3	4	5	6	7	8	9	10	-
B	2	3	4	5	6	7	8	9	10	1	-
C	3	4	5	6	7	8	9	10	1	2	-
D	4	5	6	7	8	9	10	1	2	3	-
E	5	6	7	8	9	10	1	2	3	4	-
F	6	7	8	9	10	1	2	3	4	5	-
G	7	8	9	10	1	2	3	4	5	6	-
H	8	9	10	1	2	3	4	5	6	7	-
I	9	10	1	2	3	4	5	6	7	8	-

(Tentative) Schedule:

Wk 1	08/21	Introduction to Syllabus & Experiments *(Lecture)*	What is Due this Week…
	08/23	Scientific Writing *(Lecture)*	Quiz #1 due on 08/24
Wk 2	08/28*	Lab safety *(Lecture by EHS)*	Quiz #2 taken on 08/23
	08/30*	Data Analysis *(Lecture)*	HW #1 released
Wk 3	09/04, 09/06	1st Experiment, A leads	
Wk 4	09/11, 09/13	2nd Experiment. B leads	1st Lab report due 9/13
Wk 5	09/18, 09/20	3rd Experiment, A leads	HW #1 & 2nd Lab report due 9/20
Wk 6	09/25, 09/27	4th Experiment, B leads	3rd Lab report due 9/27
Wk 7	10/02, 10/04	5th Experiment, A leads	4th Lab report due 10/04
Wk 8	10/09, 10/11	6th Experiment, B leads	5th Lab report due 10/11
Wk 9	10/16, 10/18	7th Experiment, A leads	6th Lab report due 10/18
Wk 10	10/23*, 10/25*	8th Experiment, B leads	7th Lab report due 10/25
Wk 11	10/30, 11/01	9th Experiment, A leads	8th Lab report due 11/01
Wk 12	11/06, 11/08	10th Experiment, B leads	HW #2 released 11/06 9th Lab report due 11/08
Wk 13	11/13, 11/15	Make-up week	10th Lab report due 11/15 Presentation topic decided
Wk 14	11/20	Prepare for presentations	HW #2 & last date for make-up lab reports.
Wk 15	11/27, 11/29	Final Student Presentations	

** May have a substitute instructor during this session as Dr Bennett is traveling. Class attendance will be taken.*