PHYSICS 274L — GENERAL PHYSICS III LAB

UH MANOA — Fall Semester 2015

Course Information & Policies

Lab Meetings Thursdays 1:30–4:20 p.m. (official lab times) in Watanabe Hall, Rm. 419
Mondays 2:00–4:00 p.m. (additional lab times)

Instructor Michael Nassir
E-mail: nassir@hawaii.edu
Office: Watanabe Hall, Rm. 426, (808) 956-2922
Help Hours: during above lab times, plus Fridays 1:30–4:00 p.m. drop-in to Wat 426
(*Note:* It is a good idea to call or e-mail first, during drop-in times.)

T.A. John Russell
E-mail: jwruss@hawaii.edu
Office: Watanabe Hall, Rm. 412, (808) 956-2978

Required Materials

- **notebook/binder or electronic journal** for recording measurements & observations
- **USB flash drive** for exporting data & files from lab instruments & computers
- **scientific calculator** with scientific (power-of-10) notation, trig functions, exponents and logarithms, but NO graphing necessary. (Good idea to bring to lab, but not mandatory.)

Optional Books your PHYS 274 textbook, or equivalent

Taylor, John R., *An Introduction to Error Analysis*, 2nd ed. (1997)
paperback: ISBN 0-935702-75-X (UH Bookstore: $44.50 new, $33.85 used)

Course Website http://www.phys.hawaii.edu/~phys274l
(*TO BE CONFIRMED… please stay tuned)*

Course Description

This course is intended to:

- Supplement the material of PHYS 274 (geometric and wave optics, special relativity, atomic and nuclear physics) by illustrating some of its concepts with hands-on experiments.
- Supply you with more advanced understanding of the mathematical/statistical tools and experimental techniques used by experimental physicists, beyond the simple techniques used in introductory labs. You will increase your skill using these tools and techniques via repeated practice with a variety of different experiments.
- Develop your formal scientific-writing skills. This course also satisfies a Writing-Intensive focus requirement (minimum 4000 words, although you should far exceed that amount over the course of your 7 lab reports).

Prerequisites: *PHYS 152L or 272L; and PHYS 274 (or concurrent).*

- This also implies satisfactory completion of PHYS 151, 151L, and 152; or of PHYS 170, 170L, and 272.
- MATH 243 or 253A (3rd-semester calculus) is a pre- or co-requisite for PHYS 274, and hence for this lab. While little calculus is required to understand the theory or to perform our experiments in 274L, you will regularly need to compute partial derivatives when performing error analysis.
- A grade of "C" or better is required in all prerequisite courses.

PHYS 274L Learning Outcomes

At the conclusion of this course, students should be able to:

- Define and use the terminology of selected important topics within wave optics & modern physics (current topics: wave diffraction & interference, deBroglie wavelength, photoelectric effect, Hall effect, atomic spectroscopy, semiconductors, superconductivity)
- Apply common theoretical equations and principles of wave optics & modern physics appropriately to physical experiments

- Gather experimental data, including initial estimation of, or calculation of, measurement errors on all values
- Within the constraints of prescribed experiments, exercise intermediate-level scientific judgment during data-gathering process and data analysis: identify important and unimportant quantities, choose frequency/number of measurements, devise unbiased measurement methods, choose when to reject outlying values, etc.
- Compile and analyze raw data to arrive at final calculated values with correctly propagated uncertainties (using partial derivatives)
- When appropriate, draw statistically valid scientific conclusions from final results & uncertainties
- Identify and employ important content and stylistic elements of scientific writing
- Compose a formal report similar in length and style to a scientific "letter" (short journal article)

Course Schedule — Fall 2015

Thu. Aug. 27	Introduction & Orientation to lab;
	Lecture & Homework Assignment on Error Analysis Principles
Thu. Sept. 3	Lecture on How to Write Scientific Papers;
	Lecture & Homework Assignment on Least-Squares Fitting
Thurs. Sept. 10 – Dec. 10	Lab Experiment Days — sign up to perform 7 experiments in 15 weeks
Thu. Dec. 17	Final deadline for last lab reports

Experiments

The PHYS 274L lab currently houses nine working experiments, of which you must complete **SEVEN** during the semester. The experiments are as follows, with the **five required experiments in boldface**. You may then choose any two of the remaining experiments:

1. One- and Two-Slit Diffraction	***Nassir***	
2. Bragg Diffraction	***Russell***	*lab partner recommended*
3. Michelson Interferometer	***Russell***	*lab partner recommended*
4. Photoelectric Effect	***Nassir***	
5. Electron Diffraction	***Nassir***	*prerequisite: Exp. #2 Bragg Diffraction*
(6. Hall Effect in p-type Ge — broken)		
(7. Franck-Hertz Experiment — retired)		
8. Atomic Spectra	*Nassir*	
9. Band Gap of Germanium	*Russell*	*lab partner recommended*
10. Superconducting Transition in YBCO	*Russell*	

Order of Experiments

If you are currently enrolled in PHYS 274 lecture:

We suggest that you sign up to complete the experiments **roughly in the order above**, since it approximates the order that the topics will be covered in lecture. For example, wave optics/interference is the first topic in PHYS 274 lecture, and it is the subject of our Experiments #1–3. Likewise, we suggest that you save Exp. #8 (Atomic Spectra), which deals with atomic structure and the quantum phenomenon of spin-orbit coupling, for last.

If you have already taken PHYS 274 lecture:

You may sign up to complete your experiments **in any order**.

- Everyone should complete #2 (Bragg Diffraction) **before** attempting #5 (Electron Diffraction).
- Exp. #6 (Hall Effect) uses only concepts from PHYS 272 (electromagnetism), so it can be performed at any time.

Pacing & Attendance

You will have approximately 14 weeks to complete seven experiments, which averages to **approximately one experiment every two weeks**. You may pace yourself accordingly when signing up for future experiments, although you are free to work faster if you wish. If you are not scheduled to perform an experiment or show your numerical analysis on a particular day, you do NOT need to attend lab on that day.

Partners

You may sign up **either alone or with ONE partner**. The partner does not need to be the same person for each experiment, but may be if you wish. (See section on "Collaboration" below for more information on working with a lab partner.) Given the large enrollment this semester, *we strongly encourage using partners while conducting experiments*.

Signups

You and a partner can sign up for experiments several weeks in advance. Details on how to sign up for experiments will be provided.

Oral Quizzes

You are required to take an oral quiz on the theory and objectives of each experiment before you begin taking data on that experiment. The oral quiz will be with your instructor or TA, will last 15 to 30 minutes, and will consist of:

(1) your instructor posing questions to you about the physics and theory of the phenomenon to be studied; and
(2) your instructor introducing and orienting you to the apparatus to be used.

Your quiz will be scored on a scale of 0 to 10 points.

If your oral quiz score is 5 points or lower, **you will be asked to re-study the lab writeup and theory, and to reschedule your experiment for a later date,** at which time you will be given a new oral quiz. Specific deficiencies in your preparation will be pointed out for you to remedy before your next attempt.

Lab Notebooks & Data-Taking

You are expected to keep a lab notebook, to be used before and during your experiments. You are welcome to choose a format — bound composition or engineering notebook, looseleaf binder (*not recommended!*), or electronic journal. If you choose anything other than a bound notebook, it should allow you to keep permanent, narrative journal of your experiment, just as a traditional bound lab notebook does.

Uses:

- Make pre-lab study notes, theory, and derivations before lab
- Paste in or tape in procedural steps before coming to lab (sometimes can be copied from lab manual)
- Draw sketches or schematics of apparatus layouts, and label important dimensions (sometimes can be copied from lab manual, or photos can be pasted in)
- Record measurements while taking data
- Record any departures or deviations from established lab manual procedure
- Make quick/scratch calculations
- Note any other observations that might prove useful while writing your formal lab report
- Calculate a rough result or make a quick-look graph of your data *in lab before leaving*, to "sanity-check" your results. If you discover a problem in your data, it can be remedied by taking fresh data the same day before you leave.

Important practices:

- Use pen, and neatly "line through" incorrect values or calculations
- Number your pages in advance, and create a Table of Contents
- Decide on a process (*example:* odd pages for most work, and even pages for scratch work or random notes)

Although this notebook does not need to be formally submitted as part of your grade, we will ask to view your notebook during lab or if you come to us with questions. You will need to draw from it while preparing your formal written lab reports.

Preliminary Results

We recommend that you commence work on your preliminary results *promptly* after taking your data for that particular experiment — the sooner that you do so, the better you will remember the peculiarities of your data and the circumstances of your observations.

WITHIN ONE WEEK (7 days) of conducting your experiment, you must visit your instructor/TA to show and discuss your preliminary results. This must include:

- Raw data, collected into tables or presented as graphs
- Preliminary calculation of final results, including any necessary graphical fitting
- Propagated errors/uncertainties on the final results

For this preliminary result check-in, **use of your lab notebook, handwritten calculations, and/or loose printouts of graphs are fine** — equations, tables, or graphs do NOT need to be formally prepared, as they will be in your final lab report.

Your instructor/TA will check that your data and results are reasonable, or if there are any obvious problems with your raw data or analysis. This is an important step before you invest the time and effort of writing your formal lab report.

A late penalty of –2 points/day will be deducted from your final lab report score for every day that these preliminary results are late**, up to a maximum of –10 points.**

Formal Lab Reports

We recommend that you commence work on your formal lab report *as soon as possible* after presenting your preliminary results — the sooner that you begin your writing, the better you will remember the details of your experiment.

• Lab reports *typically* contain **between five and 10 pages of double-spaced type**, depending strongly on the particular experiment — sometimes longer or shorter reports are appropriate. *Use as much space as needed to contain the relevant information and calculations*, while still being as economical as possible with your language.

- Developing your judgment about which information and details are "relevant" is part of this course.
- Scientific writing requires conciseness — saying things precisely, but with as few words as possible.

• Each lab report will be scored on a scale of **100 points,** following a predetermined scoring matrix.

• Although most details will be left up to you, all reports should follow a basic structure and writing style similar to that of a **short scientific paper**: Abstract, Introduction, Theory, Procedure, Raw Data, Calculations/Results, Conclusion, and References (plus Appendix or other sections, if necessary).

Typesetting

One of our aims is to help you develop and improve your scientific writing. Although tidy formatting and good organization are relevant to this goal, your reports do not need to be aesthetically beautiful — content is more important than appearance. Please **type** your lab reports using any standard word processor that can produce regular mathematical expressions and Greek letters. Graphs may be prepared using any graphing application that you are most familiar with: our computers in 274L lab have Graph, Graphical Analysis (both used in PHYS 170L & 272L), and GnuPlot installed. Many of our experiments require least-squares linear fits *including uncertainties*; see your instructor for how to do this when the time comes to prepare your first graphs.

Resubmission

You have the OPTION to **revise and resubmit** the FIRST TWO of your lab reports for better scores, if you wish: the first submitted to Mike Nassir, and the first submitted to John Russell. Your revisions should directly address the comments provided by the grader, and your revised report must be resubmitted *with the old report (and score sheet) attached*. Please discuss this with Mike Nassir or John Russell individually if you would like to exercise this option; revised reports will usually be due *one week* after the graded reports are returned to you.

Due Dates

The **due date** for any lab report is **TWO WEEKS (14 days) after you take your data**. Labs should be submitted to the person in charge of that particular experiment: either Mike Nassir or John Russell, either on paper or in PDF format.

Late reports will be **penalized by –2 points/day for each additional day** that they are late. If you encounter unusual problems with your report or analysis, please contact the instructor/TA for that experiment, as early as possible. Short extensions may be granted on a case-by-case basis, if substantial progress has already been completed.

Final Grade Determination

Total points possible in the course:

	700 points	= 7 Lab Reports × 100 points each
	70 points	= 7 Oral Quizzes × 10 points each
approx.	80 points	= Homework Assignments (weeks #1 & #2)
approx.	850 points	Total

Your **overall course percentage** will be computed as a simple fraction of your total points earned divided by the total points possible. An overall percentage of 90% will guarantee you at least a final grade of A–; 80% at least a B–; 70% at least a C–; and so forth. In the final determination of grades, these cutoffs may be lowered at the discretion of the instructor.

Collaboration

In this lab, you are welcome to conduct experiments and to take data **with a partner**. (Indeed, for Experiments #2, #3, and #9, working with a partner makes data-taking *much* easier.) Working in pairs or groups is common in science labs, and indeed is encouraged: teamwork can help you to make measurements and catch errors faster, and explaining something to another person is a great way to learn it yourself.

However, if you are "working with" a classmate while making a measurement, there are a few guidelines to follow:
(1) You should take turns occasionally and each ***make some of the measurements yourself***, so that each of you gets the educational value and experience of using the equipment and "seeing for yourself."
(2) All final lab reports should be written by you ***in your own words***, even if the raw measurements or data you are using are identical to your partner's. If you do perform the experiment with a lab partner, ***make a note in your lab report*** of the name of your partner for that particular experiment.

In the end, your submitted work should reflect ***your own understanding***. Any passages or calculations that are simply copied or plagiarized from another student, or from any other uncited source, will be given **no credit**. Serious cases of plagiarism may be referred to the Office of Judicial Affairs for disciplinary review.

Lab Conduct & Safety

Our experiments use a few lasers, a microwave transmitter, some high-voltage power supplies, and some exposed circuitry. While these items are safe to use with the protections provided, they are NOT completely harmless! Your instructor or TA will review **relevant safety tips** during your Oral Quiz for each experiment.

If any **equipment breaks or fails** during your experiment, please inform your instructor or TA; do NOT leave it to be discovered as a rude surprise by the next person who tries to use it. We have only one apparatus for each experiment, so non-working equipment must be fixed promptly.

Food is NOT allowed in lab. Beverages are permissible, but should be kept away from experimental apparatus and computers. Food or beverage containers should be thrown away OUTSIDE of our lab room.