PHY 451: Advanced Laboratory

Department of Physics and Astronomy, College of Natural Science, Michigan State University

COURSE SYLLABUS

Instructor:	Dr. Chih-Wei (C.W.) Lai	Term:	Spring 2014
Office:	4238 BPS	Class Days:	Tues. (Sec. 1 Lab), Thurs. (Sec. 3 Lab), Wed. Lecture (all)
Phone:	(517) 884-5675	Class Hours:	9:10-12:00, 6:00-8:50 (Lab) 5:10-6:00 pm (Lecture)
E-Mail:	cwlai@msu.edu		
		Location:	1245 BPS (Lab)
Office Hours:	by appointment		1308 BPS (Lecture)

Teaching Assistants:
Ian Dayton daytoni1@msu.edu
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Email:

When sending e-mail to the instructor and TAs, please begin the "Subject:" of the message with the following: PHY 451

Course websites:

http://quantum.pa.msu.edu/advlab/ (handouts, manuals, and references)

https://mynotebook.labarchives.com/login (electronic lab notebook system)

I. Course Description

As described in the MSU Description of Courses catalog, the focus of PHY 451 is "general research techniques, design of experiments and the analysis of results based on historical experiments in modern physics." Our approach is to study a small number of experimental systems and techniques in depth, so that you learn how experimental physics is done. As oral conference presentations and written scientific reports are the primary means by which new findings are communicated, students will develop skills in both forms of scientific communication. In the process, this course fulfills the Tier II writing requirement (assuming completion of PHY 431 and PHY 440 as well).

Required Text:
Experiments in Modern Physics (2nd Ed), by Melissionos and Napolitano (Academic Press).
Experiments in Modern Physics (1st Ed), by Melissionos.
(download link: https://archive.org/details/ExperimentsInModernPhysics)

II. Course Credits: 3 credits

III. Course Prerequisites

The listed prerequisites are PHY 440 and completion of Tier I writing requirement. However, you should be familiar with electricity and magnetism and quantum mechanics as well.

IV. Course Objectives

- To allow you to reproduce and understand the experimental results that are the underpinnings of modern physics.
- To enable you to design, assemble, and perform experiments.
- To familiarize you with experimental techniques employed in contemporary research and industrial laboratories.
- To allow you to develop skills in laboratory redord keeping, data analysis, and scientific graphing.
  - You will record your observations, collect reliable data, and organize your measurements.
- To provide you with an opportunity to develop critical writing skills and understand how to effectively present your scientific work to a larger audience.
  - You will write a professional laboratory report.
  - You will prepare a paper in the style of a scientific journal report.
- To give you a survey, via experimenting, of the sub-fields of modern physics, and the pertinent experimental issues in each.
- To expose you to the realities of the laboratory experience, where things don't always work, where the issues are not always clear, and where progress depends on perseverance, ingenuity, and judgment.
- To learn and appreciate the ethical and social issues that are involved in scientific research. These include the handling of proprietary information, respect for colleagues and adherence to high standards of honesty in reporting scientific results.

V. Class Operation and Requirements

Students work in pairs, and perform **three** distinct sets of experiments (4 weeks each) during the course of the semester.

The experiments include:

1. computerized Cavendish balance,
2. diode laser spectroscopy,
3. nuclear magnetic resonance,
4. nuclear physics (gamma ray spectroscopy and muon lifetime),
5. optical pumping,
6. photoelectric effect and determination of Plank's constant,
7. sonoluminescence,
8. superconductivity and superconducting tunneling junction,
9. superfluidity of liquid helium

You may only do one of experiments 2 and 5 and one of experiments 6 and 7. We encourage you to think about and discuss the experiments with the instructors throughout the course, so that you not only learn basic techniques of experimental physics, but also hone your ability to learn through discussions. Lab handouts and supplementary information for each experiment can be downloaded from the course website.

In accordance with MSU's general regulations, as a three-credit course, PHY 451 requires a *minimum* of 9 hours of work per week. With this in mind, there are three weeks that are set aside at the beginning, middle, and end of semester that are not required lab time but are intended to allow for the time needed to prepare for future experiments and complete high quality oral and written reports.

Preparation and Pre-Labs: As laboratory time is limited, you must read the experimental handouts before class. You will be asked questions by your instructors at the beginning of your laboratory sessions, especially before

starting new experiments. These questions will focus on your understanding of what you will measure and how you will perform such measurements before you begin your experiments.

Pre-Labs: The experiments are all described in the laboratory instructions (available as pdf files on the course website). You are expected to print and read the material and prepare yourself before coming to class as there will not be sufficient time to start from scratch during the six-hour laboratory session. You will be given a lab notebook for the labs in this course. You are expected to demonstrate your pre-lab preparation in your lab book. The laboratory period for new experiments will start with we examining the pre-lab preparation on your lab notebook.

Lab Performance: The lab performance will be evaluated based on the coordination with our team members, the questions you raise, your skill in setting up the instruments and collecting meaningful data, and your problem solving skills in particular when something is "NOT working".

Class Time and Attendance: This is a laboratory course with only a limited number of lectures. The class meets one hour each week for lectures or to discuss laboratory problems students are having and their possible solutions. The lectures will cover such topics as cryogenics, optics, nuclear magnetic resonance, data acquisition and measurement methods, noise, scientific presentations, and ethics in research. Attendance at these lectures is mandatory. Attendance of each laboratory session is also mandatory unless you have been excused by your instructor, in which case you will make-up the missed laboratory time during the make-up week following each experiment. **Please be on time to class.**

Lab Attendance: One unexcused absence from lab will result in a drop of 2 point for your course grade. If you are absent from TWO labs without a legitimate reason, your course grade will drop by 5 points. If you are absent from more than three labs, you will receive another drop of 5 points for each additional lab you miss.

Class Attendance and Participation: Regular class attendance is strongly advised and is necessary for students to fully grasp many of the concepts. Students in attendance are expected to be active participants in the course. This participation includes: contribution to class discussions, providing insights into the class discussion topics, raising questions, and relating class material to personal experiences and other course topics. I will reward extra credit to in-class participation throughout the semester. If you miss a class session, it will be your responsibility to find out the materials that were covered.

Laboratory Notebooks: Each student will keep an electronic laboratory notebook in which all of your ideas, designs, data analysis, graphs and mistakes will be recorded. (See the handout on lab notebooks for more details.) While you will collaborate in the laboratory, each student will keep his/her own notebook with his/her own analysis. After each experiment is completed, we will grade your lab notebook.

A bound laboratory notebook is also provided for you to document your pre-lab preparation and to take notes. However, you should convert the experimental notes to electronic format for grading.

Lab Report for Experiment #1: By the end of the experiment #1, each student will turn in a lab report.

Term Paper (Final Report): By the end of the last week of classes, each student will turn in a term paper on experiment #2 for #3. The paper will be presented in the style of a report in a scientific journal such as *Physical Review Letters*. The content of the paper should be based on your work in the lab as reflected in your notebook but with a broader perspective. It should include a literature survey with proper citations, in-depth analysis, and conclusions, in addition to reporting the main techniques and experimental results obtained. The paper should be 3,000 ± 500 words, double-spaced, with one-inch margins.

A draft of the paper will be prepared by **Friday, April 11, 2014** and will be reviewed by two classmates and your instructors and TAs akin to the refereeing process for papers submitted to scientific journals. The paper will then be rewritten with this feedback in mind.

In-Class Presentation: Each group will deliver an in-class PowerPoint presentation on one of your completed experiments. The presentation should be 15 minutes including time for questions.

Everyone must take part for the presentation. All members of a group will receive the same score for the presentation; that is, the presentation is assessed as a whole and everyone receives this score.

Your presentations will be 'peer reviewed'. The average score after dropping the lowest and highest ones will account for 30% of your group project grade. The grade given by the instructor and TAs will account for 70%. In addition, extra credits will be given to individuals with outstanding performance.

VI. Course Grading

Course Item		Points
Pre-labs (preparation)		10
Laboratory Performance (independence, quality and quantity of work, experimental skills, attendance, etc.)		20
Laboratory Notebook (quality of your record data analysis)		20
Lab Report for Experiment #1		10
Term Paper		25
First draft	7	
Referee Report on Classmates' Papers	3	
Final draft	10	
Presentation		15
Extra Credits		5
Total accumulated points		105

Grading Scale (points)

>=90 4.0

85 - 90 3.5

80 - 85 3.0

70 - 80 2.5

60 - 70 2.0

50 - 60 1.5

40 - 50 1.0

<40 0

Reporting of Final Grades:

Michigan State University takes seriously the opinion of students in the evaluation of the effectiveness of instruction, and has implemented the SIRS (Student Instructional Rating System) process to gather student feedback. This course utilizes the "online SIRS" system. You will receive an e-mail sometime during the last two weeks of class asking you to fill out the SIRS online form at your convenience. Please note the final grade for this course will not be accessible on STUINFO for seven days following the University grade submission deadline published by the Office of the Registrar unless the SIRS online form has been filled out. You will have the option in the online SIRS form to decline to participate in the evaluation of the course – we hope, however, that you will be willing to give us your frank and constructive feedback so that we may instruct students even better in the future.

VII. Course Policies

Late Assignment Policy: If an emergency arises and you cannot submit your notebook or paper on or before the scheduled due data, you MUST inform your instructor and obtain approval NO LESS than 24 HOURS BEFORE the scheduled date/time.

Academic Conduct Policy: Academic dishonesty in any form will not be tolerated. Academic dishonesty at Michigan State University is defined by the General Student Regulations (http://splife.studentlife.msu.edu/regulations) as conduct that violates the fundamental principles of truth and honesty.

If you are uncertain as to what constitutes academic dishonesty, please consult the General Student Regulations for further details. Violations of these rules will result in a record of the infraction being placed in your file and receiving a zero on the work in question AT A MINIMUM. At the instructor's discretion, you may also receive a failing grade for the course.

VIII. Course Schedule

All assignments are due at 5:00 PM on the specified dates.

Experiment 1

Section	Laboratory Dates	Notebooks Due
1	Jan. 14, 21, 28, Feb. 4, 11	Jan 28 (notebook) Feb. 12 (report/notebook)
3	Jan. 16, 23, 30, Feb. 6, 13	Jan 31 (notebook) Feb. 14 (report/notebook)

Experiment 2

Section	Laboratory Dates	Notebooks Due
1	Feb. 18, 25, Mar. 11, 18	March 19
3	Feb. 20, 27, Mar. 13, 20	March 21

Experiment 3

Section	Laboratory Dates	Notebooks Due
1	Mar. 25, Apr. 1, 8, 15	April 16
3	Mar. 27, Apr. 3, 10, 17	April 18

Final Reports

Draft	Referee Reports	Final Report (Term Paper)
April 11	April 18	April 25

Feb 11 & 13: lab open for make ups and report writing (mandatory, but you may leave after submitting your lab report).

March 3 – 7: **Spring Break**

April 9, 16, and 23: student in-class presentations

April 22 & 24: lab open for make-ups and report writing (optional).