PHY474 Advanced Laboratory

Instructor: Tim Andeen (him/his, prefer "Tim")

January 20, 2020 v1.0

Class Meetings:	Unique number 56230. TTh 9:30-10:50 in PMA 5.120, TTh 9:30-5 in the lab PMA 7.220.
Office:	PMA 10.208
Office Hours:	Tu 3:00-4:00, Th 3:00-4:00 or by appointment.
Phone:	475-9575
Email:	tandeen@utexas.edu

Teaching Assistants :

Matt Dwyer :	matthew.sean.dwyer@gmail.com
Marc Tost:	marctost11@gmail.com

Prerequisites: PHY352K, Classical Electrodynamics, PHY355 Introduction to Modern Physics and PHY353L Modern Physics Labs. Note: you should be registered for at most one TTh class while taking PHY474.

Flags: This course has the Writing, II-Independent inquiry, and QR-quantative reasoning flags. Writing Flag courses are designed to give students experience with writing in an academic discipline. In particular, this course will focus on technical and professional writing for research publications. You can expect to write regularly during the semester, complete substantial writing projects, and receive feedback to help you improve your writing. You will also have the opportunity to revise one or more assignments, and you may be asked to read and discuss your peers work. Writing Flag classes meet the Core Communications objectives of Critical Thinking, Communication, Teamwork, and Personal Responsibility, established by the Texas Higher Education Coordinating Board.

Attendance: The lab will be open Tuesday and Thursday between 9:00 am and 5:00 pm following the class meeting on Tuesdays in **PMA 5.120**. You should be in the lab much of this time, but naturally lunch and other breaks are expected. Tuesdays and Thursdays may also be used for oral presentations. You are expected to attend all of the presentations. A record of your attendance will be maintained. There will be an attendance sheet for each day of class and it is your responsibility to provide the correct information. The laboratory attendance sheet reflects the actual hours you are in the laboratory. You should not have more than one other Tuesday/Thursday class scheduled. For some of the experiments it will be necessary to come to the lab after hours. Please see the TAs about access.

Course Requirements:

- You will perform the experiments with a lab partner. Collaboration is a critical aspect of experimental physics, however well-motivated exceptions to this may be allowed.
- The labs are categorized as either Group A or Group B. You are to do either three experiments from Group A, or one from Group A and one from Group B. Sign up for experiments is on a first come first serve basis. You must get approval from a lab instructor before starting on an experiment.

- An alternative is to work on an experiment in a research lab. This must be arranged at the very beginning of the semester and must be authorized by the instructor. All requirements in terms of attendance at the classroom sessions, progress reports, due dates for written reports and oral presentations will be in force. The only difference will be that the experiments will not be performed in the senior lab. Please see me as soon as possible if this is your plan.
- The list of labs given on the next page is not meant to limit you. If you want to propose a new experiment please let the instructor know.
- You will write a report for each lab you perform. If you are doing a group B experiment the second report will be a progress report. **These reports are to be prepared individually.**You may collaborate and discuss procedure, scientific concepts, analysis, etc, with anyone but you are to write your own report. Each report in PDF format must be submitted via Canvas by the due date (given below). The name of your report should include your name and the name of the experiment.
- You will submit a short progress report in Canvas at regular intervals during the semester. A LaTeX template is available on Canvas. You can use it as as guide if you want to use some other program. These should be uploaded by the end of the day on the following dates: **Feb. 2, Mar. 8, and Apr. 12**.
- You will give two oral reports to the class on your experiments (your choice). Sign up will be done using the Scheduler in Canvas. The reports will 10 minutes in length. They will be given individually and will be scheduled on Tuesdays and Thursdays: Feb. 20 and 22, Mar. 29 and April 3, May 1 and 3. The style will be that of an Am. Phys. Soc. conference talk and should be **well practiced** and include figures and plots. An electronic version of your presentation (Powerpoint or PDF) is to be submitted in Canvas before you give your talk.

Other: Tutorials, a LaTeX report template and a guide to report writing will be placed on the Canvas site. Generally, you are free to use whichever software you like to do data analysis and report preparation. Use of Python (with matplotlib, or other analysis libraries) is encouraged. No Excel graphs without prior approval of the instructor.

Grading Breakdown:

- Written Lab Reports 30%
- Oral/Poster Lab Reports 30%
- Progress reports 10%
- Peer Feedback 10%
- Attendance and performance evaluations by TA's 20%

Dates:

- First Lab Report is due on Sunday, February 23 by 11:59 pm.
- Second Lab Report (if you are doing 3 Group A experiments) or Progress Report (if you are doing a Group B experiment) is due on Sunday, March 29 by 11:59 pm.
- Third Lab Report (if you are doing 3 Group A experiments) or Final Report (if you are doing a Group B experiment) is due on Sunday, May 10 by 11:59 pm.
- Late reports are penalized 25% for the first late week (1hr. to 7 days late) and no credit thereafter. No incompletes will be given without just cause. In addition to the required printed report, you must email me a pdf version of the report.

Laboratory Procedures:

- SAFETY FIRST. We want zero accidents and zero injuries.
  - Never work alone!
  - Wear full length pants, or equivalent, and closed toe/heel shoes at all times in the laboratory.

  - DO NOT wear shorts, sandals or open-toed shoes. Proper shoes must be worn at all times in the laboratories.
  - DO NOT wear loose or torn clothing due to the potential for ignition, absorption of chemicals, and potential entanglement in machinery.
  - DO NOT wear loose or dangling jewelry and confine long hair to decrease the potential for entanglement in machinery.
- You will need to take University online safety training, follow the link on Canvas to the Hazard Communication course. Complete this ASAP. (You cannot begin experiments until you have completed the training). If you do an experiment using a laser or radioactive materials, take the appropriate course.
- Safety goggles are to be worn when working with lasers.
- Think about safety. There are many dangers: electrical, chemical, lasers, radiation. Always think about what you are doing, and if there is an element of risk, plan the work carefully. Lifting and climbing (both feet of the floor) should be planned rather than improvised. Also, there is zero tolerance for carelessness or fooling around in the Lab.
- On Thursday, January 28th and Thursday, January 30th a Radiation Safety course will be given in PMA 5.120 at 9:30 am. YOU MUST ATTEND.
- Protect laboratory equipment. Test circuits at low voltages before (preferably to avoid) burning out the meters. Read the manuals and note the safe operating conditions for the instruments. Know how to use an instrument before you try to use it. Do not be afraid to ask for help. Report broken equipment immediately. Again, ASK if you need help.
- Keep the lab clean. NO FOOD in the lab, ever. Always clean up your work space before leaving the lab.
- Read reports and literature in advance of the laboratory. Old reports and books can be signed out. Material is also on Canvas.
- You are required to have a lab notebook. This should be bound and not loose pages. You should develop the habit of writing in your notebook. A lot. Write all data, notes, original records in ink, and do not tear pages out. Date each entry. Tabulate and/or plot your data while accumulating it, and endeavor to understand it qualitatively while you are accumulating it, not when you are writing your reports. Take notes as you work, even if they seem trivial. Notebooks will be checked regularly during the lab.
- Work steadily. Do not try to do everything just before the report is due.
- All handling of radioactive sources must be done by the TAs (or instructors).

Wear protective clothing goggles and gloves when using chemicals. Look up each chemical in the MSDS reports (gives details of hazards of chemicals) which are on line at https://ehs.utexas.edu/programs/lab-safety/sds-chemicalinformation.php. If you do not know specifically about a chemical assume that it is highly toxic; just because they are commonly used does not make them safe. Contact a TA before disposing of any chemicals. Wear proper goggles when using lasers and protect bystanders from your beam. If you do not know how to safely handle high voltages talk with the instructor or a TA. Know how to properly handle radioactive sources before removing them from their lead vaults.

Communication: The instructor will sometimes communicate with the class through email, Quest, and/or Canvas. These are official communications and may include information that could affect your grade in the course. You are responsible for checking email, at least daily, at the address the University has on file for you. You are responsible for checking Canvas and Quest at least daily.

If Problems Arise: Sometimes, through no fault of your own, a circumstance may arise that hurts your ability to do well in class. Examples include, but are not limited to, the death or serious illness of a family member or close friend, your own serious illness (physical or mental), a serious accident or natural disaster. I hope nothing like this happens to you this semester. If it does, I want to help (and, likely, so do your professors in other courses). You should contact Student Emergency Services

(http://deanofstudents.utexas.edu/emergency/) and discuss your situation with them. If they decide it is warranted, based on information, and possibly documentation, that you provide, they will contact me and your other professors, and tell us that your circumstances are such that I would be justified in being flexible with the course requirements in your case. They will not give me any specifics about your situation, so your privacy will be protected. Then, you and I can have a conversation about what adaption would be most appropriate in your case.

Scientific Ethics: You will be tempted many times in lab to tamper with the integrity of your scientific results. This is a mistake. You may also be tempted to plagiarize materials for your oral and written reports. Again, this is a mistake. All instances of academic misconduct in alb will be punished severely. It's simply not worth it. You are highly encouraged to review the materials on UT Austin's Student Conduct and Academic Integrity website. Please review the notes on scientific ethics on the Canvas page.

Classroom/Campus Climate: Scientific excellence derives from an environment in which the knowledge and perspectives of a diverse people are valued and dialog is encouraged at all times. Diversity is a strong reality in the scientific community and at UT Austin. On this campus and in this classroom and lab our goal is to foster a welcoming and inclusive environment. Please report any incidences of bias to myself and/or the Campus Climate Response Team at http://diversity.utexas.edu/ccrt/reportform, the Office of the Dean of Students at 512-471-5017, or the Office for Inclusion and Equity at 512-471-1849.

Facilities: You are free to have work done by the professional shops. Even though you will receive priority, there will be at least a 4 week delay so get your drawings in early. There is also a student machine shop and instructor available. To get supplies from the chemistry storeroom, get help from the TAs.

Administrative:
Details about adding and dropping courses can be found on: http://registrar.utexas.edu/calendars.

By UT Austin policy, you must notify me of a pending absence at least fourteen days prior to the date of observance of a holiday. If you must miss a class, an examination, a work assignment, or a project in order to observe a holiday you will be given an opportunity to complete the missed work within a reasonable time after the absence.

Upon request the University of Austin will provide appropriate academic accommodations for qualified students with disabilities. For more information, contact the Division of Diversity and Community Engagement, Services for Students with Disabilities, (512) 471-6259, http://ddce.utexas.edu/disability/current-students/ or ask me.

If you will miss class because of a religious holy day, you must notify the instructor of your pending absence at least fourteen days prior to the date of observance of a religious holy day and no later than the 12 th day of class. If you must miss a class, an examination, a work assignment, or a project in order to observe a religious holy day, you will be given an opportunity to complete the missed work within a reasonable time after the absence.

Safety in Emergency Situations:
Occupants of buildings on The University of Texas at Austin campus are required to evacuate buildings when a fire alarm is activated. Alarm activation or announcement requires exiting and assembling outside. Familiarize yourself with all exit doors of each classroom and building you may occupy. Remember that the nearest exit door may not be the one you used when entering the building. Students requiring assistance in evacuation shall inform their instructor in writing during the first week of class. In the event of an evacuation, follow the instruction of faculty or class instructors. Do not re-enter a building unless given instructions by the following: Austin Fire Department, The University of Texas at Austin Police Department, or Fire Prevention Services office. If you have concerns about the behavior of a

member of the campus community, you may call the Behavior Concerns Advice Line (BCAL): 512-232-5050. Link to information regarding emergency evacuation routes and emergency procedures can be found at: www.utexas.edu/emergency.

Experiments:

GROUP A	GROUP B
Neutron Activation	Compton Scattering
Zeeman Effect	Raman spectroscopy
Microwave interferometry in plasmas	Speed of light
Pulsed NMR	Plasma temperature
LEED of surface	Tunneling microscope
Noise fundamentals	Muon lifetime
X-ray fluorescence Josephson Junction	
Nonlinear mechanics	Temp. dep. LEED
Magnetic torque	Mossbauer Spec.
Optical pumping of Rb	
Acoustic Optic Modulator	
Berry Phase Experiment	
Optical Tweezers	

Experiments from Group A are briefer and more straightforward; hence one should obtain results fairly quickly. Experiments from Group B are more challenging (some may say impossible, with the given equipment). You may also do an experiment in Group B of your own design. Your must prove you have adequate resources and equipment to do the experiment. If you choose to do a Group B experiment of your own design you must turn in a proposal by February 28th. This proposal should convince me that you are capable of doing the experiment. It should include a list of equipment required, what results you anticipate, and estimates of expected signal strengths and equipment sensitivities.

Written Report Outline and Rubric:

Your reports should be written in a professional, scientific style. Find and read a *research* article that you find interesting in *Nature*, *Science* or *PRL* for good examples. Research papers in physics have a highly specialized style. The goal is a brief and engaging paper that conveys all the necessary details and results. Examples and a resources for writing are on the canvas page. The brief outline below is a rubric for grading as well. Each report is graded on a 100 point scale.

- 1. 5 pts. Title Page: experimental title, your name, your partner's name, semester and supervisor's name.
- 2. 15 pts. Abstract: Concise summary of your experiment, 100 words or less.
- 3. 5 pts. Introduction: State succinctly the goal or motivation of your experiment. This should include the basic theory of your experiment.
- 4. 10 pts. Experimental Procedure and Apparatus: Describe your experiment in sufficient detail that someone unfamiliar with the experiment could perform it from reading your report alone. Do not simply list equipment and model numbers; but describe the operation and procedure and show equipment in the form of block diagrams. Point out experimental difficulties and observations.
- 5. 15 pts. Experimental Data: Show data in the form of tables or graphs. Error bars are essential: "a measurement with out an error is not a measurement."
- 6. 10 pts. Analysis: Extract quantities of interest (speed of light, transition energies, etc) from your data.
- 7. 10 pts. Error/uncertainty: present the systematic and statistical uncertainties of the experiment and discuss the limitations of the method.
- 8. 5 pts. Conclusion: Compare your result with theory and previous experimenters. Summarize the major results, suggesting any improvements.
- 9. 5 pts. References.

- 10. 20 pts. Correct spelling, punctuation and style.

Oral Report/Poster Outline and Rubric:
Each student will prepare and give one 12-minute oral report on the theoretical and experimental aspects

of a portion of the experiment to the class. This is a short time, so it is essential that you rehearse your presentation as you would if you were giving a 12-minute presentation at a meeting of the American Physical Society. Please review the Speaker Tips and Guidelines linked in Canvas.

You must prepare your visual aids electronically (e.g. slides in the LaTeX beamer class or MS PowerPoint) for use with a digital projector in a professional-style presentation. We suggest a maximum of ten slides. Written and Oral Report Resources have detailed instructions and templates for generating your own presentations.

The theoretical section should briefly demonstrate a mastery of some portion of theory relevant to understanding the significance of the experimental results. The experimental section should dominate the discussion and demonstrate an understanding of how the equipment works, what was measured, how the data were reduced, and how the random and systematic errors were estimated. Each student must discuss different aspects of the motivating theory and experiment. Furthermore, it is not acceptable to discuss theory only or experiment only; every presentation should contain a balance. Full cooperation with lab partners and others in preparing for the oral reports is encouraged and required. This latter aspect is particularly important to ensure that both partners report the same results.

Orals reports will be graded using the following criteria (out of 100):

- Theoretical and/or experimental motivation: 15%
- Description of experiment: 35%
- Analysis of data and results: 35%
- Style and English: 15%

Each student will prepare and make and present one poster on the theoretical and experimental aspects of a portion of the experiment to the class. You will have 5 minutes to present your poster to the class, followed by 5 minutes for questions. Again this follows in the same format as a poster session at a meeting of the American Physical Society. Please review the Poster Tips and Guidelines linked in Canvas.

Posters exams will be graded using the following criteria (out of 100):

- Theoretical and/or experimental motivation: 15%
- Description of experiment: 35%
- Analysis of data and results: 35%
- Style and English: 15%

Peer Evaluations:
In scientists are asked to evaluate each other constantly. The art of constructive, detailed, helpful and

respectful criticism is a vital skill. You will each be assigned a poster and a presentation to serve as the peer reviewer. In class you will lead the questioning and provide a short (2-4 sentences) critic of the work. This will be turned in to me, and we'll discuss the report with the reviewee in a short meeting in lab.

Week	Tues.		Thur.		Sunday	
1	21-Jan	Intro.	23-Jan			
2	28-Jan	Rad Safety	30-Jan	Rad Safety	2-Feb	Progress Report
3	4-Feb	Lab Safety	6-Feb	-		
4	11-Feb	Vacuum S. (?)	13-Feb	-		
5	18-Feb	Sci. Writing 1	20-Feb	Instrumentation 1	23-Feb	Lab 1 Due
6	25-Feb	Uncert. 1	27-Feb	Presentation		
7	3-Mar	Presentation	5-Mar		8-Mar	Progress Report
8	10-Mar	Sci. Writing 2	12-Mar	-		
	17-Mar	BREAK	19-Mar	BREAK		
9	24-Mar	Uncert. 2	26-Mar			
10	31-Mar	Uncert. 3.	2-Apr		29-Mar	Lab 2 Due
11	7-Apr	Presentation	9-Apr	Presentation		
12	14-Apr	Analysis 1	16-Apr	Presentation	12-Apr	Progress Report
13	21-Apr	Electronics 1	23-Apr			
14	28-Apr	Electronics 2	30-Apr	Presentation		
15	5-May	Presentation	7-May	Presentation	10-May	Lab 3 Due