PHYSICS 341L/342L Advanced Physics Laboratory, Spring 2024

INSTRUCTOR: Dr. Micky Holcomb
OFFICE: 434 White Hall
OFFICE PHONE: (304) 293-5196
E-MAIL: mikel.holcomb@mail.wvu.edu

OFFICE HOURS: Tuesday/Thursday 2:30 pm – 5:20 pm
(You may also make an appointment)
PRE/CO-REQ: PHYS 314 Modern Physics and PHYS 112 General Physics.
CREDIT HOURS: 2 credits
MEETINGS: White Hall 117 (with occasional meetings in the conference room as announced.) Tuesday/Thursday 2:30 – 5:20 PM

DESCRIPTION: This 2-semester lab course focuses on effective use of quantitative scientific knowledge in the area of basic mathematical skills and scientific inquiry. PHYS 341L seeks to introduce lab notebook documentation and technical report writing, concepts of uncertainty quantification (measurement uncertainty, least-squares fitting, and error propagation), and poster/focus-talk communication. At the end of this course, a student should be able to demonstrate competence in conducting research at the advanced undergraduate level.

CREDIT LEVELS: Students take this course for two credits and conduct and write up two experiments. All students will create and present, at the end of the course, one poster and one 10-minute talk each, reports on the methodology, evidence, and findings of one of the experiments. The point of doing both is two-fold: 1. To give you practice in presenting in different media. 2. To give you an opportunity to learn even more about your chosen lab and then include that new information in your talk. If I ever asked you questions previously, they are likely to come back up. Be ready.

METHOD OF INSTRUCTION: The student's primary activity is conducting laboratory experiments (prelab planning, data acquisition, post-lab analysis, technical report) alone or with a lab partner. In 341L, the instructor will supervise students and answer questions. Students are not expected to demonstrate the ability to work completely self-directed, but should lead the effort. For example, frequently when a student will ask a question, the instructor will instead ask the student what they think they should do or how could they check that. However, the instructor will guide the student if they are too far off, such that they can get back on task. Each student is responsible for completing two experiments documented in a lab notebook and in a technical report, plus one end-of-semester poster and one 10-minute oral presentation. There is a small but important homework component for first-semester students.

INDEPENDENT RESEARCH OPTION: PHYS 341L instructor approval and earning an A-, A or A+ PHYS 341L course grade in a previous semester makes one eligible for an independent-research project (in-class or supervised out-of-class by a physics-dept-approved project-specific substitute instructor), if desired and arranged in advance, which may substitute for the second Advanced Lab semester. The usual lab book documentation, error analysis, and presentation expectations of PHYS 341L apply. The student is responsible for working with a professor to plan research objectives and expected products, discussing those with the 342 instructor, getting their research advisor to send a note of acceptance to mentor you and getting 342 instructor approval.

LEARNING OUTCOMES:

- A student who completes this course will be able to perform advance-laboratory experiments that are customized in objective or procedure by the student under the supervision of the instructor.
- She/he will be able to solve homework problems on topic of uncertainty quantification.
- She/he will be able to justify the experimental approach and instrumentation necessary to document a finding based on the physics principles that link operating mechanism (cause) and measured quantity (effect).
- She/he will be able to apply uncertainty quantification methodology to accompany the experimental result with a documented formulation of precision.
- She/he will be able to demonstrate laboratory-notebook documentation practices at a junior-undergraduate level during a project centered on a controlled experiment.
- She/he will be able to quantitatively articulate the interpretation of her/his results, in written and oral forms, in the context of a student-formulated hypothesis within a journal-publication style technical report, a talk and a conference style poster exhibit using charts, graphs, tables, theory, and statistics.

SUPPLIES:

One USB flash memory stick (required)
One sturdy bound computation notebook with numbered quadrille-rule pages.
Examples: Roaring Spring, Quadrille Rule, 9.25" x 11.75", 75 Sheets (pages numbered to 152), Product ID: 77648 or National Brand Computation Notebook, 4x4 Quadrille, Product ID: 43648.

TEXTS:

Measurements and their Uncertainties, Hughes and Hase (required)
Data Reduction and Error Analysis for the Physical Sciences, Bevington (in-room reference copy)
Methods in Experimental Physics, Melissinos (in-room reference copy available)
Building Scientific Apparatus, Moore, Davis, Coplan (in-room reference copy available)
The Art of Experimentation, D.W. Preston and E.R. Dietz (in-room reference copy available)
Description of each lab (provided by the instructor (often on the 117 front desk), it is the student's responsibility to remind the instructor if they have not yet received it)

SAFETY:

1. Attend the course-wide safety training offered in-class during the first week of the semester.
2. Open food and open drinks are prohibited in the lab. Re-closeable bottled drinks are allowed.
3. Be familiar with the course's safety-practices handout, available at each experiment table.
4. Please be considerate of your fellow students – clean up after yourself (stow tools and instruments where they belong, clean up spills, tidy up work area, etc.).

SNOW DAYS:

Speaking of safety, it is possible we could have a snow day or two. If so, you are still expected to be working on your experiments, even if at home. Note that if you need to talk to your partner, you can zoom. In most situations, I'll be available to discuss for zoom during class hours too. Note that a snow day will not necessarily change when things are due, and if it does, note that it's going to squeeze how much time you have somewhere else in the class. This class used to squeeze in three experiments over the same time, thus doing two in slightly less time is still feasible.

GRADING OVERVIEW (grade is based on %):

ITEM	**QUANTITY**	**VALUE**	**COURSE GRADE**
Lab Notebook	2 (one per exp.)	13 each	89.6% - 91.9% A-, A at 92
Technical Report	2 (one per exp.)	13 each	79.6% - 81.9% B-, B at 82
Check-ins	5	1 point each	69.6% - 71.9% C-, C at 72
End of Semester Poster	1	10 points	59.6% - 61.9% D-, D at 62
End of Semester Talk	1	10 points	
Total Points		First semester: 87 points (10 points for homework), Second semester: 77 points	

GRADING DETAILS:

Collaboration:

Each student is expected to work separately on pre-lab, apparatus set-up, and data-analysis during each experiment, although collaborating with a lab partner on instrument-scanning, measurement-observing, and acquisition/recording data is permitted. Seeking classmate advice is allowed only if cited in the lab notebook and kept secondary to one's own primary effort. Plagiarism is prohibited and receiving significant grade-influencing assistance from someone besides the instructor or teaching assistant is not permitted. (See general university academic integrity expectations for reference.)

Check-ins:

In real research, you go through many edits before you turn in a final product. As this is a one semester class, we have to speed that process up. We will do that by having graded check-ins before assignments are due. You are not required to have the assignment complete at the time of the check-in, however, the more complete it is the more likely I am to find any mistakes you have for which I would otherwise take off points at the due date. You are expected to have it at least halfway begun by check-in. (The instructor may not notice every single missing thing during check-in or even occasionally when grading the pre-lab. It is still the student's responsibility to verify that their assignment conforms to the rubric for every assignment.)

Lab Notebook Grading:

See the graded rubric for each assignment. While it may not encompass every important aspect of that is expected from the assignment, it does highlight the most important for your grade. For a complete list of expectations for each assignment, see below. Please ask questions if anything is unclear or if you are uncertain of the needed level of detail on any item.

Pre-lab (3 of 13 lab notebook points) Pre-data-taking preparation that provides a systematic plan for conducting the experiment: physics-understanding coherence, anticipated experimental approach specifics, methodology logic, sample calculations and analysis based on anticipated results, expectations for encountering and quantifying measurement uncertainty, literature/internet references, list of equipment with manufacturer-model#-serial#. This is a crucial element of successfully and efficiently performing the experiment.

<u>The postlab (10 points) is due at the same time your written report is due</u>. The post lab has three primary components, but see the rubric for the most critical items and some advice.

<u>Postlab Documentation</u> Experiment-performance documentation in the laboratory notebook: description completeness of step-by-step activity including pre-lab researching and raw data taking, trouble-shooting logic, calculation clarity, data/uncertainty analysis correctness and completeness, and informative figures, diagrams, graphs, and tables based on actual data and derived (fitted and non-fitted) results. Date each page of the lab notebook, label diagrams, and refer to pages and labels when detailing plans, documenting data acquisition and troubleshooting, and explaining data processing and interpretation.

<u>Postlab Analysis</u> Post-data-taking synthesis of results, uncertainty, and error for interpreting the experiment: conclusive reasoning, post-experiment repeat efforts to improve data, double checks of suspect information, conclusion, discussion, references, and quoting of results with uncertainty.

<u>Uncertainty Quantification</u> One of the key objectives in this class is helping you practice appropriate practices in uncertainty analysis. Explain clearly and quantitatively how 1) measurement uncertainty, 2) slope (and possibly intercept) uncertainty, and 3) propagation of measurement uncertainty into processed-result uncertainty are calculated based on observations, estimates, statistics, or assumptions. Except for the Franck-Hertz experiment that does not have propagation of errors, **all three** of these should be in each of your labs for full points! Assign and quote an uncertainty to the quantities being measured so that the precision of the experimental answer is unambiguous. For example, if the slope of a $y = mx + b$ relationship is relevant to arriving at the experiment result, then this slope and its uncertainty must be determined by least-squares methods. (A **common confusion** for students occurs when measurement error does not adequately define the error for a particular finding. For example, this occurs in the photoelectric, charge to mass and ESR labs. You will need to be clear about how you define the error in these cases. In the photoelectric lab, you should use more than one method to define the stopping potential; you'll need to explain why. This lack in clarity for a formal definition of how to define error occurs sometimes in research and what is important is that you well communicate how you will be defining it for your experiment.)

Technical Report Grading (13 points): Below discusses that expected components of your written lab report, which you will write for each of your two experiments. Post lab is due at the same time.

Presentation format and layout clarity and completeness

1. Title/Abstract
2. Introduction to and significance of the phenomena motivating the measurement
3. Theory and physics principles related to the measurement, including figures
4. Procedure/Methodology/Equipment/Schematics **beyond** manual-level detail
5. Raw results with uncertainty quoted (and it looks reasonable, meaning reasonably consistent with the scatter of your data—otherwise a clear discussion of what that isn't the case)
6. Analysis explicitly described and error propagation, processed results
7. Quantitative uncertainty analysis related to hypothesis and/or characterization of the phenomena

8. Conclusions w/quantitative reasoning and interpretation plus quoting of results
9. References with full citations, including specific page-chapter numbers for books
10. Tables with captions
11. Figures with captions. Graphs should include “uncertainty bars.”
12. Consistent and accurate capitalization. For example, unless at the beginning of a sentence, oscilloscope does not need to be capitalized. Another common acronym example: You do not need to capitalize full-width half-max, but you do to FWHM (applies to many acronyms). This applies to figure/table captions too.
13. Appendices, if needed

Technical writing clarity, logic, and flow (4 of the 13 points)
Correctness and sufficiency of data/uncertainty, analysis, and interpretation. Quantified discussion statements regarding sources of error/uncertainty and improvements. Only quantified discussion statements regarding how to improve precision or accuracy. (3 of the 13 points)
Uncertainty quantification. 1 point each for measurement uncertainty, slope uncertainty, and propagation of uncertainty. (3 of the 13 points)

ATTENDENCE POLICY: Attending class and reading relevant material in advance of the lecture are strongly correlated with success in this course. Students are expected to attend regularly and communicate with the instructor prior to any planned absences. Also inform your lab partner.

LATE WORK POLICY:
Assignments, whether complete or incomplete, must be submitted as a hardcopy. Work is due by 3:30 PM on the date indicated in the course schedule. If work is not complete on the due date, students should submit their incomplete work for “evaluation based on partial completion of the learning outcome goals” on the due dates, and I will grade on student progress. Even if an assignment is unfinished (e.g., prelab planning documentation, data acquisition and documentation, data analysis/uncertainty/interpretation, and evidenced-based interpretation), an evaluation can be made and the course pace can be sustained. Due dates are on the calendar.

FINAL PRESENTATIONS: Pick which of your two labs you want to do your poster and talk about. It is not necessarily better to pick the one you got the better grade on. I recommend that you pick the one with which you feel most comfortable. Remember that you can and should still fix some of your analysis based on any feedback you got or better understanding that you may now have.

A poster exhibit (10 points) on a student-selected assignment will be prepared and presented in the last two weeks of class. Typically, this is in a setting that simulates a conference poster session, and the department is invited to attend. Your poster could either be printed at the library, or you can print it from Powerpoint slides. I have mixed feelings on which is better. On the one hand, it is good practice to set up a nice-looking poster. On the other hand, if you use powerpoint slides, it will be easier to edit those based on any feedback you get at the poster session for your following talk.

A 10-min oral presentation (10 points) on a student-selected assignment is presented on the last day of class in an audience-attending session that simulates a conference contributed-talk session.

Students must prepare and present a slideshow that clearly explains the scientific motivation, approach, main experimental results and uncertainties, and conclusions.

See detailed rubrics on the class website to see how the posters and talks (and any other assignment) are graded.

MIDTERM ASSESSMENT: Midterm course-progress assessment is determined one week before the midterm-check deadline and typically consists of all of Experiment 1 (26 points+2 check-ins) and the pre-lab for Experiment 2 (3 points+1 check-in). This is 41.5% of the points in the course.

SYLLABUS STATMENTS: This course adheres to all university policies as described here: https://tlcommons.wvu.edu/syllabus-policies-and-statements

CAUTION: Some of you will feel tempted to use artificial intelligence, such as chatgpt. I feel a lot of similarities of the invent of ChatGPT and other similar AI to when calculators were first getting popular. Many teachers said you won't always have a calculator with you, and now we have them on our phones. Thus, I am not outlawing it, because maybe it's not a bad idea to learn how to use it wisely. However, buyer beware. I must point out that it gets things incorrectly frequently, and thus you run the risk of falling victim to this and mislearning things. AI will also "hallucinate," meaning if you tell it to write something, it will write it whether it is correct or incorrect. There is a famous law case where a lawyer lost their law license because they used it and it made up cases. I once tried to use it to write some pieces of an education grant, which I thankfully checked as it was all made up. A useful prompt to include is "if you don't know say so." There are many things that AI will not be good at helping you with, and I still honestly think you are better off doing all of these writing activities without AI; you will learn more. I also do not think AI gives you much of an advantage for this class, as I do not grade based on pretty language (I will count off some for terrible grammar/spelling/etc though, as impressions matter), which is what current AI is best at. If you do decide to use AI, make sure you check it and you understand it. Your understanding and completeness are ultimately what this class is assessing. You are responsible for the correctness of what you turn in, even if ChatGPT writes it, just as I would point out if you got false information from an untrustworthy website. This is partly why we reference things, as it is possible to get false information even from a trustworthy source (Wikipedia used to be littered with errors).

Spring 2024	Experiment (**Bolded** items mean something is due or you must be present for)
9-Jan	**Introduction to Advanced Lab and Uncertainty** (Virtual due to covid/student conference)
11-Jan	Homework (and/or Pre-lab); Ask Homework Questions Today!!! (Experiments Assigned)
16-Jan	Example Lab (**Photoelectric) Walk-Thru**; What is Expected from Other Assignments
18-Jan	Pre-lab and Work on Homework; Ideally More Focused on Pre-lab
23-Jan	Pre-lab; **Homework Part 1 due**; **Chalk Talk**
25-Jan	Pre-lab/Homework 2; Ideally More Focused on Pre-lab
30-Jan	Pre-lab; **Pre-lab Check-In**; **Homework Part 2 due**
1-Feb	**Pre-lab 1 due @ 3:30 pm** (you may keep notebooks until finish data taking for day); Data Taking
6-Feb	Data Taking
8-Feb	Data Taking; **How to Write a Good Abstract and Lab Report**
13-Feb	Post Lab: Data Analysis, Improvements, Conclusions
15-Feb	Post Lab: Data Analysis, Improvements, Conclusions
20-Feb	Tech Report
22-Feb	Tech Report; **Notebook/Report Check-In**
27-Feb	**Notebook and Lab Report due** @ 3:30 pm; **Pre-lab 2 begins**
29-Feb	Pre-lab 2
5-Mar	Pre-lab 2; **Chalk Talk**
7-Mar	Pre-lab 2; **Pre-lab Check-In**
19-Mar	**Pre-lab 2 due @ 3:30 pm** (you may keep notebooks until finish data taking for day); Data Taking
21-Mar	Data Taking
26-Mar	Post Lab: Data Analysis, Improvements, Conclusions
28-Mar	Post Lab: Data Analysis, Improvements, Conclusions
2-Apr	Tech Report
4-Apr	Tech Report; **Notebook/Report Check-In**
9-Apr	**Notebook and Lab Report due @ 3:30 pm**; **How to Make A Good Poster**; Poster/Talk Prep
11-Apr	**Poster Abstract Due**; Poster/Talk Prep
16-Apr	Poster/Talk Prep; **Poster Check-In**
18-Apr	**Poster Exhibit**
23-Apr	Talk Prep; **How to Make/Give a Good Talk**
25-Apr	**Talk Presentation in 105; The Department Will Be Invited**