Physics for Scientists and Engineers I Laboratory
PHY201 Fall 2024
Gustavus Adolphus College

Instructors:	Grace Kerber	Steve Mellema
Office:	Olin Hall 212	Olin Hall 210
E-Mail:	gkerber1@gustavus,.edu	mellema@gustavus.edu
	Chris Nolting	Paul Saulnier
	Olin Hall 213	Olin Hall 208
	nolting@gustavus.edu	psaul@gustavus.edu

Course Objectives

- Explore physical laws applicable to motion, energy, oscillations, waves, and fluid dynamics.
- Learn to formulate and test qualitative and quantitative hypotheses for physical systems
- Acquire experience and skills in making measurements, collecting and analyzing data, and reporting results
- Learn to apply basic error analysis and error propagation techniques
- Learn how to keep a good laboratory notebook

Course Policies and Evaluation

Lab Materials:

- Lab Manual: Physics for Scientists and Engineers I Laboratory Manual.
- Two quad-ruled laboratory notebooks (Ampad #26-251 or equivalent).
- A calculator.
- A flat straight edge or ruler for making charts and tables (optional).

Pre-Lab Exercises: WebAssign pre-lab quizzes will be assigned each week. Beginning with the second lab, students will complete the introduction, theory, and a brief outline of the procedure (as assigned) directly in the lab notebook before coming to lab. Both the WebAssign quizzes and notebook pre-labs engage the student in the material so that they are prepared when beginning the lab. The notebook pre-lab also teaches and models best practices for real scientific research. The notebook pre-labs will be checked by the instructor and/or lab assistants at the beginning of each lab session.

Lab notebook: In the laboratory, the lab notebook is a sequential journal of your data-collection procedure, observations, calculations, and analysis. In it you will record everything of significance that you do and observe. Your lab notebook should include a COMPLETE CHRONOLOGICAL RECORD of all of your important work conducted during the lab including experimental diagrams, data taken, calculations performed, graphs produced, etc. This RECORD should be of sufficient detail to allow a knowledgeable fellow student to reproduce your work without referring to the lab manual. Your lab notebook should be able to stand on its own.

Each lab/report in the lab notebook should follow the basic outline below. Sections 1-4 will usually be completed in advance (pre-lab, as discussed above). Sections 6-8 will often be done after lab, but there may be time in some lab periods to do portions of them.

1. Title, date, student name, and lab partner name
2. A one or two-paragraph introduction of the principles to be explored and why it is interesting
3. Theory to be tested
4. A one or two-paragraph description of the experimental methodology to be used
5. Detailed procedure, data, and observations
6. Analysis and answers to questions
7. Results (summary of findings)
8. Conclusions (Did it agree? If not, why?)

Each student will prepare their own individual lab notebook/report, even though the experiments were performed with partners. We encourage cooperative exchange and discussion outside of lab, but reports should reflect your individual effort (wording, answers, analysis, and derivations) and not be copied from your partner.

Section 5 will be completed in the lab. This portion of the report answers two questions:

What data did you collect?

- Data that are collected by hand should be recorded by hand and sufficiently described so that their meaning is understood.
- Numbers need to have units and descriptive phrases that act as labels.
- Sets of data are organized into tables with columns labeled and with units.
- Uncertainty estimates should be given for all measurements. The uncertainties of all measurements need to have a short description of how their value was determined.
- Data (charts and tables) that are collected via computer can be taped into the notebook. Again, descriptive information and units are essential. Computer data/files should be saved and kept for future analysis and the location and filename recorded in your notebook.

How did you collect the data?

- Record the procedure step-by-step as you do it.
- Sketches/diagrams are essential in conveying procedural information. Make a sketch of everything that is important.
- Procedure and data may be intermixed. It is most appropriate to record the procedure, then the data, or vice-versa, as long as it is clear.
- Data and procedure for each section should be kept together. If any calculations are done during the lab, they should be with the data and procedure. The same is true of any graphs you create as you are doing the lab.
- Deviations from what was expected should be discussed. For example, equipment malfunctions, mishaps, or procedural stumbles.

Sections 6-8: After the laboratory measurements are completed, you will also use the lab notebook for the calculations/analysis, results/conclusions, and answers to lab manual questions. This material should be handwritten. In most cases, some calculations using the data you collected, additional graphs, and fits to the data will be necessary to test a model of a theory. You will record this in a step-by-step manner in your notebook, just as you did the procedure and data in lab. Printed graphs must be taped into the lab notebook and annotated appropriately.

Conclusions are an important part of hypothesis testing. Did your measurements agree with the theory (within your estimated uncertainty)? If not, what are the possible reasons for the difference? (Do you think there might be characteristics of the physical system that the theory is not accounting for? Are there systematic measurement errors or shifts caused by limitations of the measurement method?) Depending on the lab, a question from the manual may ask you to make such a comparison; you can refer to your answer instead of repeating it in the conclusion.

Reports are due in class on the Friday (for Tuesday and Wednesday labs) or Monday (for the Thursday lab) following the completion of the lab. A penalty of 10% per day will be assessed each late lab report. They will be graded and returned at the beginning of the following lab period.

TA Grading: TAs are given the following outline for grading:

Lab (10 points, fractional (tenth point) values may be used where necessary)

- (0.1 pt) **Heading** (title, date, your name, **partner names),**
- (0.6 pt) **Theory and purpose**: a paragraph or two on the purpose of the lab and any relevant theory that is to be investigated.
- (0.3 pt) **Rough Sketch of Experimental Methodology**
- (5.5 pt) **Detailed Experimental Procedure and Data Collection:**
    - (2.5 pt) **General technique**: Proper use of significant figures, columns are labeled. All measurements have some estimate of uncertainty.
    - (0.5 pt) **Quality of their data**: How reliable is their data? Do their results appear reasonable, or is there any indication of possible errors due to oversight or lack of attention to detail?
    - (2.5 pt) **Charts, data tables, etc.**: Check for completeness. Figures should have descriptions, axes labeling, error bars, units, etc.
- (2.0 pt) **Analysis**:
    - (0.5 pt) **Data calculations**: Can you figure out what they did? Determine the coherence and clarity of the calculations presented.
    - (1.0 pt) **Questions from Manual**: Check for completeness and reasonable answers to any questions posed in the Lab Manual.
- (0.5 pt) **Results** (Summary of findings AND discussion):
  State the outcome of the lab. Reflect on the objective of the lab. List (or summary tables can work well here) key results including theoretical predictions and corresponding measurements (with uncertainty).
  Some sort of synthesis is good here, especially if there are different approaches

used to determine the same characteristic (like the spring constant in the oscillations lab); which approach did they think was best and why. Pull it all together in a discussion. Critical thinking about procedure and methodology is great here.

Note: Students may integrate the "Results/Findings" section with their conclusions or analysis, as long as it is clearly presented and comprehensive.

- (1.0 pt) **Conclusions:** Comparisons between measurement and theory; try to explain the difference (it is fine if they reference answers they have written to questions from the manual).
  - Measurements can have different kinds of associated errors:
    - Random **uncertainty**: Is the difference (from theory) within the uncertainty range on the measurement? Random uncertainties lead to fluctuations in individual measurements around the true value, but these variations should balance out over repeated measurements.
    - **Systematic error**: is there some problem or limitation with the measurement system that causes a **consistent offset** in the data?
  - Theory:
    - Is the theory too simple? Is there some change we could make to our model or fit to make it better represent the physical system we are observing?
  - Lessons learned or interesting observations (more than just restating the result).

Lab Groups: Students will work in groups of 2 or 3. It is essential that all members of the group share in the different aspects of the lab and become completely familiar with operating the equipment and computer, taking the measurements, and analyzing the data. Student roles should be changed from week to week.

Attendance: Students must arrange in advance to attend a lab at other than their scheduled time. It is the responsibility of the student to consult with the instructor during the first week of the semester regarding any anticipated absences due to field trips, athletic events, musical performances, or other activities. Because of equipment conflicts and other logistical reasons, in general, it may not be possible to make up a lab outside of a scheduled lab session. Lab equipment is dismantled, and next week's lab is set up typically on Friday afternoon.

Academic Accommodations:
Gustavus Adolphus College is committed to ensuring equitable and inclusive learning environments for all students. If you have a disability and anticipate or experience barriers to equal access, please speak with the accessibility resources staff about your needs. A disability may include mental health, attentional, learning, chronic health, sensory, physical, and/or short-term conditions. Students with a documented elevated risk of COVID-19 may also request academic accommodation. When appropriate, staff will guide students and professors in making accommodations to ensure equal access. Accommodations cannot be made retroactively; therefore, to maximize your academic

success at Gustavus, please contact them as early as possible. Accessibility resources staff are located in the Academic Support Center (https://gustavus.edu/care/accessibility/) (x7227).

Honesty: Students are expected to follow the Gustavus honor code.
On my honor, I pledge that I have not given, received, or tolerated others' use of unauthorized aid in completing this work.
Please ask if you have any questions about the appropriate use of another student's work.

Evaluation: Pre-Lab Exercises/Notebook 20%, Lab Notebooks 80%

Incompletes: A grade of incomplete will only be given for work not completed due to circumstances beyond the control of the student. [College policy.]

Final Grades: Final course grades will be assigned using the following scale as a guide only:

A	94-100	A-	90-94	B+	86-90
B	82-86	B-	78-82	C+	74-78
C	70-74	C-	66-70	D+	62-66
D	58-62				

Final grades may also take into account the instructor's evaluation of the student's attendance, participation, effort, and evidence of improvement or regression.