Overview

Introductory Physics Lab is taught as a companion to the Foundation in Physics I sequence (PHYS 251-3), which covers the topics of mechanics, fluids, relativity, topics in modern physics, electricity & magnetism. During the Fall term we will concentrate on the topic of mechanics. While this course is designed to complement the material presented in PHYS251; this lab is a separate course with distinct goals.

Course Learning Goals

- Develop a better conceptual understanding of physical phenomenon through lab experimentation
- Gain initial experience with scientific method of observation, hypothesis construction, experimentation, and hypothesis refinement
- Learn laboratory documentation procedures
- Gain experimental skills in error analysis, error propagation, and estimation
- Gain familiarity with experimental equipment including Vernier probes, interface and software
- Technical presentation skills

Gaining a better understanding of physical phenomena is certainly one of the goals of this class, but so is learning something about the experimental process. As much as possible, the design and execution of the experiments in this course will be left up to you.

Schedule

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<td>Course Intro Willamette 110</td>
<td>Lab Sign up</td>
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<td>2 (Oct 3)</td>
<td>Motion and Forces</td>
<td>Prelude</td>
<td>Prelude Due Mon. 10/10 at Noon. Turn in your results sheet only!</td>
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<td>3 (Oct 10)</td>
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This schedule is tentative, and is subject to change as the quarter progresses. Please check the website for the latest information.

Grading

Course grades will be based on the completion of the three lab modules plus the prologue. Each lab module is worth 30%, with the prologue is an additional 10%. All lab modules will be graded based on your lab notebooks as described below. One of the fundamental goals of this course is to develop the experimental method, and much greater emphasis will be placed on the concepts, methodology, and presentation of the lab results than on the results themselves. Lab grades will be posted to the Blackboard website as soon as they are available.

Lab Information

Each lab has a handout, which contains formal instructions (such as they are) for completing the lab assignment. There may also be a page which provides some more detailed information and hints to help you along the way. Remember that one of the goals of this course is to encourage creative thinking and problem solving. You should take the information on these hint pages as advice to help you avoid common problems, not as definitive instructions for how to complete the lab. Also, feel free to try out your own ideas, particularly in consultation with a TA. There is no specific "right" way to complete one of these lab assignments, although there are a many things you can do which are certainly "wrong".
You should choose a lab partner from your lab session to work with for the quarter. It is far better for you to work in a group of either two or three people. Working alone or in a larger group will only be allowed in very special circumstances.

Lab Notebooks

As an experimentalist, you should see your lab notebook primarily as a resource for yourself. Your only hope of understanding what you did in an experiment is to have a clear, legible, and understandable record written down in a lab notebook.

Lab notebooks should constitute an honest record of:

- the purpose of an experiment (question addressed, physics “law” tested)
- what the experiment looked like and how it was done
- diagram of setup
- notes about how to do experiment
- any data taken, both raw and analyzed or refined
- analysis of data, including estimation of uncertainties
- comparison of analyzed data with hypothesis
- conclusions and speculations (particularly if things didn’t work as planned)

More details on producing a clear lab notebook and specific instructions on what should be included can be found here. Even though you are working in groups, each person is responsible, and will be graded on, the content of their own lab book. Data will certainly be shared amongst the lab partners, and you should work together on developing the analysis method, but the description and analysis narrative should be unique to each student. A good guide to what is expected concerning your experimental work can be found by reading the APS statement on scientific ethics.

Your notebooks will be due on Monday after each lab module, graded, and returned in time for your next scheduled lab session. Please do not be late. It is better for a report to be incomplete than to turn it in late. Late notebooks will receive an automatic 15% deduction, with potentially larger deductions for exceedingly late work.

Revisions

To allow you to correct errors made early in the term, you will be given the chance to revise one section of one lab writeup before the end of the term. This will be re-graded and any improvement will be reflected in your grade for that module. Your grade can only go up from a revision. Any revisions must be received by Monday Dec. 5th at 5PM, which means you cannot revise your final lab. Please clearly indicate at the start of the lab which is currently being graded that a revision has been made to a previous lab. Do not remove the previous page or otherwise cross-out the information. Simply make a note at the top of the page that this material has been revised, and give the page number where the revised version can be found. You should never remove or destroy information in your lab notebook. Sometimes understanding how you made a mistake can be just as useful as understanding how you got the right answer.

A final word

The challenge of experimentation is to remain both organized and on task on one hand, and to be creatively playing with science on the other. The Introductory Physics Labs are intended to be both challenging and fun, and have been designed to provide you with further insight into the material you will have been studying in the Foundations of Physics I course. As budding experimentalists, you are now colleagues. Please let us know what you think!

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Introductory Physics Lab

PHYS 290 - Fall 2005
Lab Notebooks

Updated Tuesday, September 21, 2004

Overview

Your labs will be graded entirely based on what is written down in your lab notebooks. These notebooks will be provided to you at the start of the term, please don't lose it. Your notebook should contain a record of everything which you do in your lab. The idea is that one of your peers (or yourself six months later) should be able to completely reproduce your research and verify your results starting from scratch. Thus is must contain a thorough description of your experiment and analysis (including objectives, process, diagrams, observations, and logs), be clearly written and legible, and contain all of the work you perform in arriving at your final results.

Nothing should ever be erased from a logbook. If you make a mistake, or realize you have bad data, draw a single line through the parts to be ignored, and annotate the page with a comment to explain why. Ideally, you would write a description, potentially on another page, detailing just what mistake you made and what you have done to correct it. Often in experiments, documenting your mistakes is more important than documenting your successes. If you made a mistake, chances are somebody else would make this mistake as well.

Contents and Grading

We will not be requiring formal "lab reports" because I would rather you spend the time actually thinking about your lab. You will be required to have many of the elements of a lab report in your lab book for full credit, however. The rough grading scheme is as follows.

- 10% - Clearly stated introduction and objectives
- 15% - Description of equipment and experimental procedure
- 20% - Measurements recorded with uncertainties
- 20% - Analysis
- 10% - Conclusions
- 10% - Written descriptions of all diagrams, figures, tables, etc.
- 15% - Timeliness - you will loose 15% automatically if your notebook is late

The order in which these appear in your log book is sort of up to you, as long as they are clearly labelled an legible.

Introduction and Objectives

The introduction and objectives should describe exactly what you are trying to accomplish in this lab. It is probably worth writing the objectives before you begin so you understand at the start just what you are trying to do. Note that by design you will have to think a bit about how to design the lab yourself, so you need to spend some time (preferably before your scheduled lab session) coming up with some ideas. This section should also contain the following:

- a short paragraph (two at most) discussing the science under consideration that motivates what is to follow (think big picture!);
- a statement (in words as well as equations) of the theory and critical physics parameters under consideration (e.g., relationships governing the motion of a pendulum);
- if appropriate, figures depicting how those parameters act on the objects under study (e.g., force diagrams).

Equipment and Procedures

A detailed description of the equipment and procedure will probably need to be written after you are done, but you should try to explain roughly the procedure and equipment before you begin. As your procedure evolves during the course of your lab (ideally you will try out several ideas until you find one that really works well) you should be keeping a written record of what you are doing and what has changed. You should always date entries in your log book so you can reconstruct what you did when after the fact. After you have taken all of your data, you could additionally write a concise description of the final equipment and procedure if your running narrative is confusing. Remember, somebody else should be able to reproduce what you have done with nothing more than your log book. Helpful information can include the following:

- a brief introduction to the equipment;
- labeled drawings of the experimental apparatus;
- descriptions of how different parts of the data were acquired;
- an description of any non-obvious experimental techniques.
It is important to label your figures and drawings.

Measurements

Your measurements should be arranged into neat tables with units, uncertainties, and captions describing just what exactly is in each table. If you change the conditions or equipment during your lab, record that fact clearly and put the new data in a new table. If your data is taken by computer, you can either print out a copy of the data and paste it into your log book, or else save the data to some place you can find it again, and write down exactly where it is in your log book. The TA doesn't necessarily need to be able to find the data, but you do! You should include at least one example table of plot of your raw data for every lab, even if all of the data is stored on a computer. Computers crash, hard drives fail, laptops are stolen, and data will be lost. I have had all of these happen to me. If you have a paper record to at least indicate the type of data you acquired, you can always replace it at a later date.

Remember to include some estimate of the uncertainties on your measurements, along with an appropriate number of significant digits. A more detailed discussion of uncertainties can be included in the analysis section.

Analysis

This section will probably be written after the data is acquired, and should be organized around each of the experimental goals. For each goal, then:

- start with any predictions (hypotheses) you make as part of the lab;
- exposit, with writing and equations, how your experiment relates to each experiment goal;
- include and refer to graphs giving experimental data and their errors;
- include a brief explanations about how error was estimated/calculated for each experiment goal;
- analysis of results should speak clearly to whether the stated hypotheses were, indeed, confirmed.

Analysis sections without cogent explanations involving words will result in the deduction of points. In other words, don't just hand in a massive sprawl of equations. Try to relate your analysis to the objectives stated at the start of the lab, and use the questions in the lab handout as a guide to direct your analysis.

Summary and Conclusions

A short summary section listing the physics principles addressed by your investigation(s), the results of your investigation(s), any procedural problems you encountered and how you solved them, and a short statement giving your impression of the lab and what you might do differently next time.

Grading Criteria

Each report will be graded according to the clarity and conciseness of the writing, the organization and thought put into describing the experiment and assumptions made, the quality and pertinence of diagrams, and the appropriateness and correctness of the interpretation and analysis as presented in the last two sections.

Having perfect data is not the primary goal in these labs. Having a clearly thought out set of objectives and a rationally designed experiment to meet these objectives is the primary goal. Feel free to be creative, as long as your ideas and rationale are clearly described.

The analysis and conclusion sections are intended to be an extension of what you do during your lab sessions, and ideally will not take a huge investment of time. If you find yourself spending hours each week "writing up" your labs, you need to change your lab procedure. The stuff you write down during you lab session should cover the requirements for the majority of the notebook contents I listed above. Scribbling stuff down on a sheet of paper and transcribing it into your notebook later is simply not acceptable lab procedure.

Ultimately, everyone develops their own style of lab notebook management, and for most physicists, this style evolves throughout their professional career. The key thing to remember, however, is that you can never put enough detail into your notebook. You would be surprised at how quickly you forget things.