

PHYS 233:

Intro to the Scientific Community Lab

(The following was created by the University of Maryland team, last edited by Kim Moore.)

These labs are different from what you might be used to. They are designed to model the actual process of science as an interactive, community-based experience.

If you have done science labs before, you were probably told exactly what to do. Such ‘cookbook’ labs showed you how to use equipment, tested your ability to follow instructions, and often were designed to test a theory learned in lecture. But that’s not the way real experimental science happens. In our lab course you will have an opportunity to develop your skills as an experimental scientist.

Some unusual features of our labs:

1. The main goal of these labs is to give you experience in designing an experiment to answer a question. We give you a question; you and your team think about how you can make a good measurement to answer the question. Additionally, you will need to consider how the design of the experiment affects the certainty of your result.

2. Sometimes the lab comes before the material appears in lecture.

In real life, you often have no idea what will happen and need to explore a phenomenon experimentally first. The idea here is to do an experiment to try to find out what the behavior is without knowing the answer beforehand—just like many real scientific experiments.

3. It’s not only your result that matters; it’s how good it is—quantitatively.

No experiment gives an exact result or the same result every time it is repeated. You will have to decide not just “the answer” but also what range of values you think is possible, given how you did the experiment.

4. You will have to present your results to the rest of the class, have them comment on your results, and

comment on theirs. Real science is a community process. Every experiment is considered by others and often challenged. The process of many people analyzing and thinking about everyone’s work helps clarify the real answer and purge the “wishful thinking” to which we all are prone.

What our labs are *not*:

1. These labs are not meant to demonstrate the perfect truth of some idealized theory.

Most of the rules you learn in physics are idealizations. They only work if certain assumptions are true (for example, there is no friction). When those assumptions are not true, we ask the question: are the results “almost true”? Can we correct them, either by changing our experiment or adding more to our theory?

2. These labs are not meant only to teach you some particular concepts in support of what you are learning in lecture. You are likely to have to use the concepts and equations you learn in lecture so it might help, but that is not their main point. You are also learning new ideas, relationships, and technical skills that can help you in your chosen professional career.

The Experiments

Before you come to lab:

Designing, carrying out, and presenting your results can be time consuming, so you will have two weeks to do most of the labs. Even with 4 hours, there is still a lot to do.

- *Read over the lab before you come in.*
- *Spend some time thinking about what is involved and how you might do the experiment.*

While you are in lab:

Since there is a lot to do, it is very important to keep to a schedule. The lab handouts suggest a time plan.

- *Focus on your goals and tasks in the lab. Don't waste time.*
- *If you take a lot of time on irrelevancies, you may have trouble finishing.*

You need to document what you are doing in a lab report created as you go. This will be facilitated by the division of labor described under "Roles" below.

When you leave the lab:

At the end of week one of a multi-week lab, be sure each team member has a copy of the data. You don't want to arrive in the second (or third) week and find the only person with your data has dropped the course (or is sick, or is away at a sports event, or forgot it, or ...).

At the end of a one-week lab or the last week of a multi-week lab, hand in your finished lab report before you leave. There is no out-of-class lab work required and no late-submissions are permitted.

Lab Reports

At the end of the experiment, your team will hand in a complete lab report. This is your chance to communicate your work in a style similar to what published scientific journals would require (with a little extra info for your TA). This report must include three components:

- *A Journal:* A clear and concise discussion of what you did, how you designed your experiment, and what results you got, written so that an absent student could understand and repeat your experiment. If you followed false trails that you gave up, you should explain them here with your reasons for giving them up.
- *Data and Interpretation:* A presentation of your data in a form that would be easy for an absent student to understand. Include a discussion of what your data means, what conclusions you've drawn from your data, and a persuasive *case* to convince your reader that your conclusion is valid. Keep in mind that a record of raw (un-manipulated) data would never be published by a scientific journal--what of the data that you have collected is *necessary* to make your case? Is this data sufficient and convincing?
- *Evaluation:* After you've had a chance to see what data and conclusions other groups have gotten, it's important to go back and reconsider what you've done. Here is where you discuss how you could improve upon your experiment (design or analysis), in light of what you learned during lab and during the class presentations. This is also the place to expand upon the interdisciplinary nature of these labs--how are the

things you have studied in other science classes connected to what you have done and learned here? Do you see other possible applications of these research ideas and experimental techniques?

Roles

In order to facilitate the preparation of the lab report, you will be working in groups of *three* or *four*. There are four roles that your group members will fill; while each member takes primary responsibility for one role and for the portion of the lab report related to that role, please keep in mind that the experiment is a group effort and you should all be aware of the dilemmas faced by your peers and the decisions that they make. Also, except when writing the report, these lab experiments often involve "all hands on deck"--with every group member contributing to the construction, execution, and analysis of an experimental protocol. The division of labor will be as follows:

1. *The Journalist*: This person is primarily responsible for taking notes of everything that happens during the experiment and writing up the "Journal" section of the lab report.
2. *The Data Interpreter*: This person primarily deals with tabulating and displaying the data, operating the computer, and writing up the "Data and Interpretation" section of the lab report.
3. *The Critic*: This person is primarily responsible for taking notes during the class presentations and discussions and for writing the "Evaluation" section of the lab report.
4. *The Checker*: This person is primarily responsible for checking all sections of the lab report before it is turned in, reading the comments made by the grader on past lab reports, and suggesting ways to improve. This person also acts as a "manager" of the lab tasks, stepping in where help is needed and coordinating the group's efforts to ensure the lab is completed efficiently and on-time. In a group of three, the role of checker is shared by all group members.

You must rotate roles every lab unit so that each person gets a chance to do every task at least once (or, hopefully, twice). While the lab report is a group grade, it is necessary that you show that you are pulling your own weight in the group work. But working on lab reports is *group* work. Part of the goal is to give you practice working together in a group. Not every group works smoothly together at all times. Part of your task is to find ways to cooperate to cover difficulties. For example, if one person is having trouble with their particular task in a given week, the checker should serve as a support person and collaborator to help out.

Participation in Class Discussion

Writing the evaluation can be hard! It's difficult to see how you could improve your experiment. If you could do that, you would have done it the better way in the first place! That's why we have the class discussion—to help you think about your experiment again and write your evaluation.

A portion of your grade will depend on your participation in these class presentations and discussions at the end of the laboratory. Here, we are looking for you to make significant contributions to other groups' understanding of their lab, not just raising your hand and asking "why didn't you take more data?"

Grading

The lab grade makes up part of your total course grade. This grade will be based on your team's lab reports and your individual participation in the lab and the class discussions. *Your grade will not depend on whether or not your numerical results agree with some accepted standard but on how well you conceived and carried out the experiment.*

The grading for a typical lab is as follows:

<i>Criterion: Lab Report (as a team)</i>	<i>Points</i>
<u>Design and thoughtfulness.</u> Did your team do a careful and thoughtful job in creating your experiment, and was this thought reflected in the document?	7.5
<u>Clarity and completeness.</u> Did your team explain your experiment so that someone could reproduce it?	7.5
<u>Persuasiveness.</u> What conclusions did your team draw from your data and were you able to back up these conclusions with this data in a convincing way?	7.5
<u>Evaluation.</u> After observing the experiments of other groups, were you able to critique your own lab, propose constructive changes, or explain why your experiment was better than those of your classmates? (The question you are answering in your evaluation is, "If I got to re-do this experiment next week, how would I do it differently?")	variable
<i>Criterion: Participation (as an individual)</i>	
Contribution to team presentation: Did you participate constructively in your own group's work (protocol development and data collection)? Did you actively participate in both the preparation of the report/presentation and its delivery?	variable
Contribution of other teams' presentations: Did you ask useful questions or make comments that were valuable to the other teams' reports of their evaluations? Did you participate in both class and small group discussion?	variable

Attendance

Attendance at every lab is required. If you anticipate missing a lab session, try to arrange ahead of time to attend another lab section for that session (for a 1 week lab) or for the entire lab unit (for a 2 week lab). If it is not possible to attend a different lab session, contact your TA as soon as you are aware of your impending absence.