Problem-Solving Labs in Operation

Introduction:

These lab instructions are probably different than those you are used to. You will not find a detailed discussion of the principles explored by the lab; you will not find any algebraic derivations of the equation to be used in the lab; and you will not find step-by-step instructions telling the students what to do. Instead, our labs allow students to practice making decisions (problem solving) based on the physics presented in the other parts of the class: the discussion sections, the lecture, and the text.

The lab manuals are divided into 7 two-to-three-week units (labs), an equipment appendix, and technique appendices. The labs themselves are comprised of an introduction page and several "problems." Notice that we do not do experiments in our laboratory. The lab problems are similar to the ones found at the end of a textbook chapter or on a quiz, which the students solve and then compare their solution to nature. Typically a problem should take the students less than an hour to complete (if they have done their homework). They should analyze all the data and reach a conclusion in class before starting a new problem. The problems are further broken down into sections that represent the processes expert researchers use in a laboratory. The sections are: introduction to the problem, description of the equipment, a prediction of the outcome, method questions, exploration, measurement, analysis and conclusion.

Each lab problem begins by briefly describing a context in which a problem arises. The equipment is then described in enough detail to allow the students to predict the outcome of the problem. The questions in the next two sections (Prediction and Method Questions) are to be answered by the students **before** they come into lab, and will be checked by the lab instructor (you) *within the first five to ten minutes of class.* The Prediction is a qualitative or quantitative solution to the problem. The Methods Questions are designed to help the student either complete the prediction or plan the analysis of the data before they come to lab. Although the Prediction comes before the Methods Questions, the Methods Questions should typically be completed before the students make the prediction. The Prediction is given first so that the students will know the purpose of the Methods Questions. Students tend to do things in the order presented so they will have to be reminded to do the Methods Questions before struggling with the Prediction. Of course, if a student can do the prediction, the Methods Questions serve as a check of their knowledge leading to that prediction.

Typically, the introduction to each lab session will begin when you ask the members of each group to arrive at a consensus about the Prediction and one or more of the Method Questions. Make sure to give an explicit time limit for the process. If your students have prepared, and you should require them to do so, this should take no more than 10 minutes. While students are coming to a group consensus, you should go around and record if they have brought good written predictions to the class. At the end of the group discussion time, have one representative from each group put the answer to one of the questions they have just discussed on the board. This might be the Prediction or the Methods Question. Your choice should be governed by what you observed to have the greatest diversity when going around the class checking predictions. Then conduct a class discussion comparing and contrasting these answers. Remember that the purpose of the introduction is to get students to make an intellectual commitment to the physics of the lab. The discussion need not arrive at the correct answer to the questions. If there is unresolved disagreement, wait to resolve it in the closing discussion of that day after they have completed the laboratory problem.

The Exploration section encourages the students to become familiar with the apparatus so they will understand the range over which valid measurements can be made. This is perhaps the most important section of the laboratory and the one that students tend to skip. Don't let them. This is where they develop the "feel" for the real world that is a crucial guide in solving problems. This is also where students can qualitatively test their preconceptions about the physical process occurring. Give students a lot of encouragement to explore with the equipment. You and I know this is the essence of physics but many students view it as a "waste of time." The outcome of the exploration should be an organized plan for making the measurement.

The Measurement section asks the students to make the measurements needed to test the prediction. Here students need encouragement to pay attention to their measurements as they take them. They should be able to tell if their measurements "make sense" and why. If the measurements don't make sense to them this is an ideal coaching moment. Either they have a misconception of physics or a misconception of the measurement process. In either case you should work with them to set them straight.

In the Analysis section students process their data so that they can interpret their results in the Conclusions section. When students analyze their data by finding a function to represent the data, it is important that they understand the meaning of the constants in that function. By using some calculus and/or making measurements on the computer screen, students should be able to predict those constants reasonably precisely. Do not let your students get into the random guessing mode. This wastes a lot of time and eliminates some of the learning built into the lab. It is especially important that they should be able to tell you the units of those constants for the particular situation.

In the Conclusion section the students should reflect on their results and observations while solving the laboratory problem. This gives many students a great deal of difficulty especially at the beginning of the course. Make sure they write an outline of the conclusions for the problem before going on to the next one. The conclusion should go back to the original “realistic” problem and state a definite solution. It should also address the validity of the prediction and the measurement. Students love to give “human error” as a reason for a discrepancy. This is not an acceptable reason. Human error should always be corrected before a report is written.

The table on the next page illustrates the different types of lab problems you will teach.

Grading:

The written laboratory report is one of your most important tools in coaching the student in physics. From a student's writing, you can usually tell if they have a firm grasp of the concepts being taught in the class, are confused about the concepts, or still have important misconceptions. After all, a student writing a laboratory report has time to think and can use the textbook, notes, or advice from other students. This truly represents the student's best expression of their knowledge on the subject matter. Based on your reading of the lab report, you may want to talk to that student during the next laboratory period or schedule an appointment with them. At the very least you should communicate forcefully to the student if there is a difficulty in physics understanding. Errors in understanding concepts of physics, problem solving, or measurement will seriously affect a student's ability to succeed in the course as time goes on. It is unfair to lull the student with a good grade on a lab report only to have them get a bad grade on the exams.

Because this course satisfies the University's Writing Intensive requirement, the grading of student laboratory reports takes on added significance. To be acceptable, a laboratory report must always be a coherent technical communication. It must be mechanically correct in spelling, grammar, and punctuation. It must be well organized with a logical presentation and purpose that is communicated clearly. It must have a content supported appropriately with neat and clearly labeled pictures, diagrams, equations, graphs, and tables. It must be expressed in a manner appropriate to a technical report written to an audience of the student's peers. Most importantly, the content must be correct. You can help your students achieve better writing by insisting on it. Students with serious communications problems can be referred to a central web based writing center. An added benefit is that a well-communicated laboratory report is easier for you to grade and enables you to give a student focused coaching on specific physics weaknesses.

Each student is required to write an individual lab report for one problem per laboratory topic (usually two weeks). You will assign each member of a group a different problem at the end of the two-to-three week lab period. Assigning the problem at the end of the laboratory period assures that all members of the group attend to every problem. Make your problem assignments based on your knowledge of the individual students. This is one of your opportunities to tailor the course to the needs of each individual student. Some students may need the challenge of the most difficult problem and some may need the consolidation offered by an easier problem. You might assign a student needing encouragement a problem you are confident they understand. On the other hand you might assign a problem to a student because you suspect that they were not adequately involved in the data acquisition or did not understand its point.

The grading criteria are briefly given on the laboratory cover sheet in the laboratory manual. This sheet is to accompany every laboratory report. Students are graded on a total point scale but a report that is not adequately communicated need not be accepted by you at all. Each week students receive points for having a logically written prediction and the answers to the Methods Questions. Also each week students receive points for keeping a competent lab journal. The report should be a concise and self-contained technical report that is essentially an elaboration of the student's lab journal. It should only be about four pages in length including graphs, tables, and figures. If you make sure that the students leave the laboratory with a well organized and complete laboratory journal, the laboratory report should not take them long to write.

To encourage students to use the powerful tool of peer learning, award bonus points if everyone in a group does well on the report. Typically, this has been defined as better than eighty percent. You may want to generate a little peer pressure for preparation by giving a bonus point if everyone in a group comes to lab with a complete set of answers for the prediction and methods questions (see the chapter by Karl Smith in your Reading Packet).

Frequently Asked Questions:

What goals do these labs address?

There are many possible reasons for doing a physics laboratory. For example, a lab could allow students to:

- confront their preconceptions of how the world works;
- practice their problem solving skills;
- learn how to use equipment;
- learn how to design an experiment;
- observe an event that does not have an easy explanation, so they realize new knowledge is needed;
- gain an appreciation of the difficulty and joy of doing and interpreting an experiment;
- experience what real scientists do; and
- have fun by doing something more active than sitting and listening.

It is impossible to satisfy all of these goals with a single laboratory design. Because this course follows the traditional structure of learning physics through solving problems, we have focused the laboratories toward **PROBLEM SOLVING**. Since one important reason that our students cannot solve physics problems is that they have misconceptions about the physics, our second goal is to confront some of those misconceptions in the laboratory.

Why this style of lab?

Most physicists feel that labs are an essential part of a physics course because physics is reality. Some have gone so far as to state that all physics instruction should take place in the laboratory. Nevertheless, labs are the most expensive way to teach physics. Research to determine the benefit of labs in teaching physics has consistently shown that labs which give students explicit instructions in a “cookbook” style, have little value, particularly to address a problem-solving goal. The research also shows that "hands-on" experience coupled with directed peer and instructor coaching can be an efficient way of overcoming misconceptions. In our teaching environment, the laboratory is the only opportunity for you to interact with small groups of students during an extended time period. Because the students have specific and visible goals, it is easier for the instructor (you) to determine their physics difficulties by observing them. Solving a problem in the laboratory requires the student to make a chain of decisions based on their physics knowledge. Wrong decisions based on wrong physics lead to experimental difficulties that you can observe and correct. For a comparison of our problem-solving labs with traditional and inquiry labs, see the chart on the next page.

How can I make my students like and value the labs?

Instructor attitude is the most important factor in determining what the students like. If the instructor likes the labs and thinks they are valuable, then the students will tend to like the labs. The converse is also true. Even before starting the class, many students consider labs as "busy work" which have nothing to do with the content of the course. Labs have required attendance, so some students see their object as getting a task done as fast as possible so they can leave — the "take-the-data-and-run" approach. This view is reinforced when: (a) students are given step-by-step instructions focused on doing the task as efficiently as possible; (b) the lab instructor spends a majority of the lab time helping groups get their apparatus working so they can get done; (c) the lab instructions have all necessary information so that no use of the textbook or the lectures is needed; (d) the problems are not seen as challenging; and (e) there is no reference to the labs in the lectures or on tests.

The physical appearance of the lab is also very important in determining student attitude. Students will also dislike the labs if they are overly frustrated in their attempts to operate in the laboratory environment. An instructor who takes time to assure that the lab is neat and orderly *before* the students enter gives the message that the student's lab work is important.

Why have students work in groups?

The simplest answer is that a well-functioning group is the most efficient way to solve any problem. However, in this class we have more definite educational reasons. Students working in groups must discuss what their thoughts are -- they get practice in "talking physics." This discussion tends to bring their physics preconceptions (alternative conceptions) to the surface so they can deal with them. It is a cliché that the "best way to learn is to teach," but it is true. Working in the same groups in both laboratory and discussion section allows students to become more familiar with each other so that they feel comfortable enough to discuss their physics difficulties. Having the same groups and instructor for both the laboratory and discussion section also explicitly connects the lab to the rest of the course. In addition, group work makes teaching more manageable for the instructor. Instead of trying to serve 15 individual students, you interact with 5 groups, so you can be their "coach" to help them become better problem solvers. By pooling their knowledge and experiences, members of a group will get "stuck" less often, which leaves the instructor more freedom to concentrate on coaching to remediate serious physics or procedural difficulties.

Why are there so many problems in each lab?

Our labs have been written so that there are more problems than the typical group can complete in the time allotted. This emphasizes that the function of the lab is to learn the physics rather than just to get the problems "done." The teaching team for each course section can then choose a preferred order of problems and the minimum number of problems to be completed to match the emphasis of the lectures. In addition, the extra problems allow each lab instructor (you) the flexibility to select the material to meet the needs of each particular group. Some of your groups may understand the material and need to be challenged with more difficult problems to deepen their knowledge. This also keeps these groups from becoming bored. On the other hand, some groups will have difficulty in understanding the basic physics being presented and may need to concentrate on a specific difficulty by doing a second very similar problem.

What is the function of the pre-lab computer check-out?

This set of questions is available in selected computer labs around campus. They are designed to make sure that students have read the relevant sections of the text ***before*** they come to your laboratory. There is nothing more wasteful of both your time and that of your students than their having to read the text during the laboratory period for the first time. The questions require minimal understanding of the concepts in the text and are a good preparation for the lectures as well as the laboratory. Students are required to score at least 70% to pass. If a student misses a question, the test is expanded to give them another chance to answer a similar question correctly. The more questions that the student misses, the longer the test. Student can take the check-out as many times as they wish. They can use their textbook, their notes, and consult with other students when they take the check-out. The important thing is that they come to lab prepared. When a student keeps getting the same question wrong even though they are sure they put in the right answer, it is almost never a computer glitch -- usually the student has an alternative conception. This is an excellent opportunity for instruction. Each student's score, questions missed, the number of times the check-out is taken, and the time for each test is all recorded in a file for your use. A student who has read the material with some understanding should pass the check-out in less than 15 minutes. Of course, this rarely happens. Typically students read their text *for the first time* while they are taking the check-out, so they can take from 30 - 45 minutes to learn the information. If a student is taking more than 60 minutes to pass the check-out, this is probably too much time and you should discuss the difficulty with the student.

Why don't the lab instructions give the necessary theory?

This is to emphasize that the laboratory is an integral part of the entire course. The theory is available in the textbook, and the preparation section for each laboratory states which sections should be read. Reading the text and doing the predictions and questions preceding each problem gives an adequate preparation for the lab. A computer check-out assures both you and your students that they have a basic understanding of the necessary text material before coming to class. Doing the lab problems should help students, with your guidance, clarify and solidify the ideas in the text and in the lecture.

What is the reason for giving minimal laboratory instructions?

One of the primary goals of the laboratory is to help students learn to solve physics problems *better*. Good problem solving requires informed decision making. Most of our students need a great deal of practice in making analytical decisions. The labs are designed to leave most of the decisions up to the students. As with any problem, there are usually several correct paths. Discussing the possible choices within the group gives each student the opportunity to solidify correct concepts and dispel alternative conceptions. This freedom also allows groups to make incorrect choices. It is another true cliché that "we learn from our mistakes." Observing students' incorrect decisions allows the instructor (you) to teach to the needs of the particular students or groups.

Why should the students write up lab problems?

No matter how conscientious the lab instructor, many students will leave the lab with some of the same misconceptions as when they entered. The presentation of the course material may also generate new misconceptions. Reading a student's words gives you valuable knowledge about that student's knowledge of the physics. This can help you direct your teaching more effectively. In addition, our students should begin the process of clear, concise, meaningful written technical communication that they will need in their future careers.

Why have team meetings?

To teach large classes as efficiently as possible, we divide the teaching responsibilities among members of a team. A lecturer in front of a large class best does some functions, and some are best done with a small group. Because different people perform these functions, extensive communication is necessary. The presentation of a coherent picture of introductory physics to our students requires that the lectures, labs, and discussion sections be highly coordinated. There are usually several ways to present a topic in physics each with different notation, terminology, and emphasis. These different approaches, while interesting to the expert, are confusing for an introductory student. The team meetings serve to make sure that everyone knows and abides by the approach chosen for the class. At your team meetings, discuss a rationale for the class "party line" until everyone feels that they know the reason for it and can enthusiastically support it to their students. Nothing is more demoralizing for the students than decisions which are not supported by *all* of their instructors. Ideally, coherence would be maintained by having every instructor visit every other instructor's class. Since this is not always possible, the team meetings serve this purpose.

Team meetings also allow the lecturer to discuss with the lab / discussion section instructors the pace and organization of the lectures and what the lecturer assumes that the students understand and can do. The lab / discussion section instructors discuss with the lecturer and among themselves the extent to which the students understand the material and which approach to teaching may help. Fast feedback is essential if this information is to influence the pacing and approach of the course. Of particular importance is detailed feedback from the grading of tests and lab reports. All instructors are encouraged to visit the lectures, discussion sections, and labs of other instructors as much as possible. The lecturer will visit your sections as much as possible and you should attend lecture whenever you can.

Outline: General Plan for Teaching a Laboratory

Preparation Checklist:

- ❑ assign new roles
- ❑ assign new groups and roles (when appropriate)
- ❑ review/complete Prediction and Methods Questions
- ❑ decide what to have students put on board
- ❑ pre-lab checkscores (when appropriate)
- ❑ Group Functioning sheets (when appropriate)

	What the Students Do	What the TA Does
Opening Moves: 15 min	• Do their individual predictions before they get to class. • Arrive at group consensus about their prediction(s). • Recorder/checker puts *group* prediction on board. • Participate in discussion about prediction(s).	0. Get to the laboratory classroom early. 1. Check individual predictions in grade book. 2. Diagnose major conceptual problems. 3. Lead class discussion about *reasons* for group predictions. 4. Assign groups problems to complete. 5. Tell class time they need to stop and remind managers to keep track of time.
Middle Game	• Do the assigned laboratory problems: - explore apparatus - decide on measurement plan - execute measurement plan - analyze data as they go along - discuss conclusions . . .	6. Diagnose difficulties. 7. Intervene when necessary. 8. When appropriate, grade journals. 9. Ten minutes before you want them to stop, tell students to find a good stopping place and clean up their area. Make sure you are done grading journals. Also pass out group functioning forms at this time.

End Game: 10-20 min	• Finish problem, clean up lab area • Participate in class discussion	10. Select one person from each group to put their results or data on the board. 11. Lead a class discussion of these results. 12. If necessary, lead a class discussion of group functioning. 13. Tell students what problem to do predictions for next week. 14. Assign students problems to write up (if last week of lab).

Detailed Advice for TAs about General Laboratory Lesson Plan

0. Get to the laboratory classroom early.

When you get to the classroom, go in and lock the door, leaving your early students outside. The best time for informal talks with students is after the lab!

Prepare the classroom by checking to see that there is no garbage around the room and that the proper equipment is on student tables and on the front table. On the blackboards, provide space for each group to present its predictions. If you have changed groups, list the new groups and roles on the board at this time also. (Remember to follow the guidelines for forming groups, pages 7-9.)

Let your students into the classroom when you are prepared to teach the lab. To keep the students from starting the problem before they discuss their predictions, set aside a small but necessary piece of equipment. Pass this out only after the predictions and discussion are finished.

Be sure to rotate roles each week (see page 11). For computer labs, it is particularly important that the Recorder/Checker is different each week so ***every*** student spends the same time using the keyboard.

1. Check students' individual predictions in your grade book.

This should be done within the *first five to ten minutes* of the starting time for the laboratory session, **and not after**. That is one of the best ways that has been found to encourage students to be on time to class.

2. Diagnose major conceptual difficulties.

This is easier to do for some lab problems than others. When possible, the mentor TAs will pass out research papers on common alternative conceptions that relate to current laboratories, and alternative conceptions will be discussed in the weekly all-TA meetings.

No matter how severe students' conceptual difficulties seem to be, or how unprepared students seem to be, **DO NOT LECTURE** to students at the start of lab. They have an opportunity to see the theory of physics in their lectures and textbooks, but lab gives them an opportunity to find out for themselves whether they are right about the way the world works. Even if the lecturer has not yet covered the material (which happens occasionally), **DO NOT LECTURE** the students about the concepts or lab procedures. Many lab problems serve as good introductions to a topic, and need only minimal reading from the text for students to be able to complete the Predictions and Methods Questions before the lab.

3. Lead class discussion about reasons for group predictions.

This is important! Many students can come up with correct answers or reasonable looking graphs for strange reasons that do not follow the accepted laws of physics. If you do not discuss these reasons, your students will never realize later that their reasoning is incorrect. **DO NOT TELL THE STUDENTS IF THEIR PREDICTIONS ARE CORRECT!** This would spoil the whole purpose of the labs.

4. Assign groups problems to complete (if necessary).

If you have a group that is working very quickly, assign them longer or harder problems. If you have a group that is experiencing great difficulties, remember that it is better that they spend two or even three hours on the first problem, and learn it, than that they work quickly and do not learn.

5. Tell class when (at what time) they need to stop and remind Managers to keep track of time.

If you see that there are prevalent or varied alternative conceptions shown in students' group predictions and reasons, you will want to stop students earlier so that you can have a longer discussion of their results. If, on the other hand, students seem to understand the relevant physics before they begin their laboratory problem, you will not need as much time for discussion. The students should then be able to complete the problem very quickly to check their prediction.

6. Diagnose initial difficulties with the lab problem or with group functioning.

Once the groups have settled into their task, spend about five minutes circulating and ***observing*** all groups. Try not to explain anything (except trivial clarification) until you have observed all groups at least once. This will allow you to determine if a whole-class intervention is necessary to clarify the task (e.g., Be sure to . . .).

7. Monitor groups and intervene when necessary.

Establish a circulation pattern around the room. Stop and observe each group to see how easily they are solving the experimental problem and how well they are working together. Don't spend a long time with any one group. Keep well back from students' line of sight so they don't focus on you. Make a mental note about which group needs the most help.

Intervene with the group that needs the most help. If you spend a long time with this group, then circulate around the room again, noting which group needs the most help. Keep repeating the cycle of (a) circulate and diagnose, (b) intervene with the group that needs the most help.

Computer labs bring out the tendency to dominate in some students. Check to see the assigned Recorder/Checker still has the keyboard. Is the Recorder/Checker sitting in the middle, with the other students looking at the screen and contributing to the conversation, or is one person sitting away from the monitor? If so, intervene. Another way to keep groups functioning well is to assign certain tasks to each role. For instance, the manager could take the movie, the recorder could fit the data, and the skeptic could take all necessary measurements and check that all the data is being recorded.

8. When appropriate, grade journals.

This should be easy and quick to do. Check to see that students are keeping track of their data and that they are doing analysis in their lab journals ***as they go along.*** If they are not, tell the students they have lost their journal point(s). Losing a point once will prompt almost any student to improve his or her journal keeping.

In computer labs, not all analysis is completed on the computer. Students should be taking data and writing down coefficients and equations as they analyze their data.

9. **Ten minutes before you want them to stop, tell students to find a good stopping place and clean up their area.**

Make sure you are done grading journals. Also pass out group-functioning forms at this time (if necessary, about every 2 - 3 weeks). (Note: Another common teaching error is to provide too little time for students to process the quality of their cooperation. Students do not learn from experiences that they do not reflect on. If the groups are to function better next time, members must receive feedback, reflect on how their actions could be more effective, and plan how to be even more skillful during the next lab or discussion session.)

When you were an undergraduate, your laboratory instructor probably did not stop you to have a class discussion at the end of the laboratory period. Doing this is one of the hardest things you will have to do as a TA. You may be tempted to let students keep working so that they can get as much done as possible, or to let them go home early so that they like you better. However, research has shown that students do not learn from their laboratory experiences unless they have the chance to process their information. One good way to do this is by comparing their results to their predictions with the whole class.

Most students do not want to stop, and may try to keep working. If it is necessary, you can make your students stop working by removing a small but essential piece of equipment (i.e., a battery or a connecting cable) so that they are forced to stop taking data. You are in charge of the class, and if you make it clear that you want the students to stop, they will.

10. **Select one person from each group to put their results and conclusion on the board *next to their prediction(s)*.**

In the beginning of the course, select students who are obviously interested, enthusiastic, and articulate. Later in the course, it is sometimes effective to occasionally select a student who has not participated in the labs as much as you would like. This reinforces the fact that *all* group members need to know and be able to explain what their group did. Typically, the Recorder/Checker in each group is NOT selected.

11. **Lead a class discussion of these results and conclusions.**

A whole-class discussion is commonly used to help students consolidate their ideas and make sense out of what has been going on in the lab. Discussions serve several purposes:

- to summarize what students have learned;
- to help students find out what other students learned from the same problem;
- to produce discrepancies which stimulate further discussion, thinking, or investigations; and
- to provide a transition to the next problem.

These discussions should always be based on the groups, with individuals only acting as representatives of a group. This avoids putting one student "on the spot." The trick is to conduct a discussion about the results without (a) **telling** the students the "right" answer or becoming the final "authority" for the right answers, and (b) without focusing on the "wrong" results of one group and making them feel stupid or resentful. To avoid these pitfalls, you could try starting with general, open-ended questions such as:

- How are these results the same?
- How are these results different?

Then you can become more specific:

- What could be some reasons for them to be different?
- Are the differences important?
- Do these differences indicate a real difference in the physics, or are they a matter of judgment (e.g., decisions about starting times and positions for a graph).

Always encourage an individual to get help from other group members if he or she is "stuck."

Encourage groups to talk to each other by redirecting the discussion back to the groups. For example, if a group reports a certain result or conclusion, ask the rest of the class to comment: "What do the rest of you think about that?" This helps avoid the problem of you becoming the final "authority" for the right answer.

Students should be able to explain to their classmates how they collected and analyzed their data in order to come up with the answer to the experimental problem. If their predictions were very different, ask students to think about and discuss why they might have thought differently before and after the lab.

In <u>computer labs</u>, there is a tendency for students to rely too much on the printout of their analysis. The printout, however, does not give the solution to the problem – it is only a step toward the solution. The remainder of the information they need to solve the problem should be in their journals. Make sure you focus the discussion on the analysis and conclusion, not just the printed report.

12. Lead a class discussion about the group functioning (when appropriate).

Discussing group functioning occasionally is essential. Students need to hear difficulties other groups are having, discuss different ways to solve these difficulties, and receive feedback from you.

- Randomly call on one member from each group to report either
    - one way they interacted well together, or
    - one difficulty they encountered working together, or
    - one way they could interact better next time.
- Add your own feedback from observing your groups (e.g., "I noticed that many groups are coming to an agreement too quickly, without considering all the possibilities. What might you do in your groups to avoid this?")

13. Tell students what lab problem to do predictions for next week.

You will decide what lab problems all students should do in your team meetings. If there is extra time, you can decide what problem all students will do based on your knowledge of the conceptual difficulties your students have experienced up to this point.

14. Assign students problems to write up (if last session of lab).

Each student will write up one problem from each lab individually. If there was one person in a group that was not participating as well as you would like in a particular problem, you might want to assign that problem to the student. This way either the group will help the student catch up with the important information, or the student will be taught (by the bad grade you will give) to participate in the future.

15. Leaving the Lab

Leave a neat lab room for the next class. Do NOT let the next group of students into the classroom.

Be sure you have signed the lab-room sheet.