WELCOME TO THE PHYSICS LABORATORY!

Physics is our human attempt to explain the workings of the world. The success of that attempt is evident in the technology of our society. The products that result from the application of that understanding surround us: technological inventions including clocks, automobiles, televisions, and computers.

You have already developed your own physical theories to understand the world around you. Some of these ideas are consistent with the accepted theories of physics. Others are not. This laboratory is designed to focus your attention on your interactions with the world so that you can recognize where your ideas agree with those accepted by physics and where they do not.

You are presented with contemporary physical theories in lecture and in your textbook. The laboratory is where you can apply those theories to problems in the real world by comparing your application of those theories with reality. The laboratory setting is a good one to clarify your ideas through *discussions* with your classmates. You will also get to clarify these ideas through writing in a report to be read by your instructor. Each laboratory consists of a set of problems that ask you to make decisions about the real world. As you work through the problems in this laboratory manual, remember that the goal is *not* to make a lot of measurements. The goal is for you to examine your ideas about the real world.

The three components of the course - lecture, discussion section, and laboratory - each serve a different purpose. The laboratory is where physics ideas, often expressed in mathematics, come to grips with the real world. Because different lab sections meet on different days of the week, sometimes you will deal with concepts in the lab before meeting them in lecture. In that case, the lab will serve as a good introduction to the lecture. In other cases, when the lecture about a topic precedes the lab, the lecture will be a good introduction to the lab.

The amount you learn in lab will depend on the time you spend in preparation before coming to lab!

Before coming to lab each week you must read the appropriate sections of your text, the read assigned experiment to develop a fairly clear idea of what will be happening, and complete the prediction and methods questions for the assigned problems.

Often, your lab group will be asked to present its predictions and data to other groups so that everyone can participate in understanding how specific measurements illustrate general concepts of physics. You should always be prepared to explain your ideas or actions to others in the class. To show your instructor that you have made the appropriate connections between your measurements and the basic physical concepts, you will be asked to write a laboratory report. Guidelines for preparing lab reports can be found in the lab manual appendices and in this introduction. An example of a good lab report is shown in Appendix F. Please do not hesitate to discuss any difficulties with your fellow students or the lab instructor.

Relax! Don't be afraid to explore or make mistakes. **Ask lots of questions**, and have fun.

WHAT TO DO TO BE SUCCESSFUL IN THIS LAB:

Safety always comes first in any laboratory.

If in doubt about any procedure, or if it seems unsafe to you, do not continue. Ask your lab instructor for help.

A. What to bring to each laboratory session:

1. Bring an 8" by 10" graph-ruled lab journal, such as University of Minnesota 2077-S to all lab sessions. Your journal is your "extended memory" and should contain everything you do in the lab and all of your thoughts as you are going along.

2. Bring a scientific calculator.

3. Bring this lab manual.

B. Prepare for each laboratory session:

Each laboratory consists of a series of related problems that can be solved using the same basic concepts and principles. Sometimes all lab groups will work on the same problem, other times groups will work on different problems and share results.

1. Before beginning a new lab, you should carefully read the Introduction, Objectives and Preparation sections. Read the sections of the text specified in the *Preparation* section. **Before you come to the lab, you must pass a short test covering some basic material in the textbook.**

   These lab prep-tests are on computer and are designed to take about 15 minutes to complete.

2. Each lab contains several different experimental problems. Before you come to a lab, be sure you have completed the assigned *Prediction* and *Warm-Ups.* The Warm-Ups will help you build a prediction for the given problem. It is usually helpful to answer the Warm-Ups before making the prediction. **These individual predictions will be handed in and checked (graded) by your lab instructor previous to the beginning of each lab session (your lab instructor will provide you with the exact details).**

   This preparation is crucial if you are going to get anything out of this laboratory work. There are at least two other reasons for preparing:

   a) There is nothing more dull or exasperating than plugging mindlessly into a procedure you do not understand.

   b) The laboratory work is a **group** activity where every individual contributes to the thinking process and activities of the group. Other members of your group will not be happy if they must consistently carry the burden of someone who isn't doing their share.

C. Laboratory Problem Reports

At the end of every lab (about once every two weeks) you will be assigned to write up one of the experimental problems. Your report must present a clear and accurate account of what you and your group members did, the results you obtained, and what the results mean. A report is not to be copied or fabricated. Copying someone else's work constitutes scientific **fraud!** To make sure no one gets in that habit, such behavior will be treated in the same manner as cheating on a test: a **failing grade for the course and possible expulsion from the University**. It should describe your predictions, your experiences, your observations, your measurements, and your conclusions. A description of the lab report format is discussed at the end of this introduction. **Each lab report is due, without fail, within two days of the end of that lab.**

D. Attendance

Attendance is required at **all** labs without exception. If something disastrous keeps you from your scheduled lab, contact your lab instructor immediately. The instructor will arrange for you to attend another lab section that same week. **There are no make-up labs in this course.**

E. Grades

Satisfactory completion of the lab is required as part of your course grade. Those not completing **all** lab assignments by the end of the semester at a 60% level or better will receive a grade of F for the **entire course**. Once again, we emphasize that **each lab report is due, without fail, within two days of the end of that lab.**

There are two parts of your grade for each laboratory: (a) your laboratory journal, and (b) your formal problem report. The lab instructor grades your laboratory journal during the laboratory sessions. Your problem report will be graded and returned to you in your next lab session.

If you have made a good-faith attempts but your lab report is unacceptable, your instructor may allow you to rewrite parts or all of the report. You must hand in a rewrite within two days of its return to you by the instructor, in order to obtain an acceptable grade.

F. The laboratory class forms a local scientific community. There are certain basic rules for conducting business in this laboratory.

1. **In all discussions and group work, full respect for all people is required.** All disagreements about work must stand and fall on reasoned arguments about physics principles, the data, or acceptable procedures, never on the basis of power, loudness, or intimidation.

2. It is OK to make a reasoned mistake. It is in fact, one of the more efficient ways to learn.

   This is an academic laboratory where you learn things, and test your ideas and predictions. You learn by collecting data and determining which conclusions from the data are acceptable and reasonable to other people and which are not.

What do we mean by a "reasoned mistake"? We mean that after careful consideration and a substantial amount of thinking has gone into your ideas you simply give your best prediction or explanation as you see it. Of course, there is always the possibility that your idea does not accord with the accepted ideas. Then someone says, "No, that's not the way I see it and here's why." Eventually persuasive evidence will be offered for one viewpoint or the other.

"Speaking out" your explanations, in writing or vocally, is one of the best ways to learn.

3. It is perfectly OK to share information and ideas with colleagues. Many kinds of help are OK. Since members of this class have highly diverse backgrounds, you are encouraged to help each other and learn from each other.

   But it is never OK to copy the work of others.

   Helping others is encouraged because it is, in fact, one of the best ways for you to learn. But copying is completely inappropriate and unacceptable. Write out your own calculations and answer questions in your own words. It is OK to make a reasoned mistake; it is wrong to copy.

   No credit will be given for copied work. It is also subject to University rules about plagiarism and cheating, and may result in dismissal from the course and the University. See the University course catalog for further information.

4. Hundreds of other students use this laboratory each week. Another class probably follows directly after you are done. Respect for the environment and the equipment in the lab is an important part of making this experience a pleasant one.

   The lab tables and floors should be clean of any paper or "garbage." Please clean up your area before you leave the lab.

   The equipment needs to be either returned to the lab instructor, or left neatly at your station, depending on the circumstances.

   If any lab equipment is missing or broken, submit a problem report form to the lab coordinator by clicking the *Labhelp* icon on any lab computer desktop. Be sure to include a complete description of the problem and include the lab room number. You can also file a report containing comments about this lab manual (for example, when you discover errors or inconsistencies in statements).

In summary, the key to making any community successful is **RESPECT**.

Respect yourself and your ideas by behaving in a professional manner at all times.

Respect your colleagues (fellow students) and their ideas.

Respect your lab instructor and his/her effort to provide you with an environment in which you can learn.

Respect the laboratory equipment so that others coming after you in the laboratory will have an appropriate environment in which to learn.

WHAT IS EXPECTED IN A LAB REPORT? HOW IS IT HANDLED?

1. Before you leave the laboratory, have the instructor assign the problem you will write up and initial your cover sheet.

2. A cover sheet for each problem must be placed on top of any work handed to the instructor. It can be found at the end of every lab. **It tells you the qualities we wish to find in a report.**

3. A problem report is always due **within two days of the end of the lab.**

4. A problem report should be an organized, coherent display of your thoughts, work, and accomplishments. It should be written neatly (word processor recommended) in English that is **clear, concise, and correct.** It may help you to imagine that hundreds of people will read your report and judge you by it. **Communication is the goal of the report.** In many cases tables and graphs can aid communication.

5. A sample report is included in *Appendix F*. Listed below are the major headings which most lab reports use.

MAJOR PARTS OF A LAB REPORT:

COVER SHEET

See the end of this introduction for a sample cover sheet.

STATEMENT OF THE PROBLEM

State the problem you were trying to solve, and how you went about it. Describe the general type of physical behavior explored, and provide a short summary of the experiment.

PREDICTION

This is a part of the lab where you try to predict the outcome of the experiment based on the general knowledge of Physics. Generally, you start from fundamental laws or principles and derive the theoretical expression for the measured quantity. Later you are going to use your prediction to compare with experimental results.

EXPERIMENT AND RESULTS

Following the Prediction is an Experiment and Results section that contains a detailed description of how you made your measurements and what results you obtained. "Experiment and Results" involves an organized, coherent display of labeled diagrams, tables of measurements, and tables of calculated quantities and graphs. Explanations of all results must occur in correct grammatical English that would allow a reader to repeat your procedure.

Mathematical calculations connecting fundamental physics relationships to the quantities measured should be given. Any unforeseen behavior should be explained. Difficulties performing the experiment should be described as well as any subtleties in the analysis.

All data presented must be clearly identified and labeled. Calculated results should be clearly identified. Anybody should be able to distinguish between quantities you measured, those you calculated, and those you included from other sources. Clearly assign uncertainties to all measured values -- without uncertainty, the data is nearly meaningless.

CONCLUSIONS

The Conclusions section should include your answers to the following questions: What generalized behavior did you observe? Was it different from what you expected? Why? (e.g. What were the possible sources of uncertainties? Did you have any major experimental difficulties?) How do your results compare with the theory presented in your textbook or during lectures? Can you think of any other ways to check your theory with your data?

SAMPLE COVER SHEET

PHYSICS 1102 LABORATORY REPORT

Laboratory I

Name and ID#: _____

Date performed: _____ Day/Time section meets: _____

Lab Partners' Names: _____

_____

_____

Problem # and Title: _____

Lab Instructor's Initials: _____

Grading Checklist	Points
LABORATORY JOURNAL:	
PREDICTIONS (individual predictions and warm-up completed in journal before each lab session)	
LAB PROCEDURE (measurement plan recorded in journal, tables and graphs made in journal as data is collected, observations written in journal)	
PROBLEM REPORT:*	
ORGANIZATION (clear and readable; logical progression from problem statement through conclusions; pictures provided where necessary; correct grammar and spelling; section headings provided; physics stated correctly)	
DATA AND DATA TABLES (clear and readable; units and assigned uncertainties clearly stated)	
RESULTS (results clearly indicated; correct, logical, and well-organized calculations with uncertainties indicated; scales, labels and uncertainties on graphs; physics stated correctly)	
CONCLUSIONS (comparison to prediction & theory discussed with physics stated correctly ; possible sources of uncertainties identified; attention called to experimental problems)	
TOTAL(incorrect or missing statement of physics will result in a maximum of 60% of the total points achieved; incorrect grammar or spelling will result in a maximum of 70% of the total points achieved)	
BONUS POINTS FOR TEAMWORK (as specified by course policy)	

* An "R" in the points column means to rewrite that section only and return it to your lab instructor within two days of the return of the report to you.