Waves, Light & Heat Laboratory Manual for Physics 341 Fall 2005

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Physics 341
Waves, Light and Heat Laboratory

Introduction

Physics 341 is a laboratory course designed to accompany the material presented in the lecture course, Physics 340. The subject matter is pretty well described by the title. The goal is to provide "hands-on" experience with the fundamental ideas of these important areas of physics. We also hope to provide an opportunity to use and understand the kinds of equipment that might be found in a modern research environment, such as digital voltmeters, oscilloscopes, and of course, lasers and computers. Finally and most important, physics is an empirical science – not a branch of applied mathematics. No matter how elegant, every serious physical theory must be validated by observations. Even those of us who have practiced this game for many years find it exciting to witness the congruence of theoretical prediction with experimental reality. We would also like to avoid a "cookbook" approach to these experiments. If you have ideas you would like to explore that go beyond what is described, please ask the instructor for help.

Course organization

Physics 341 is taught in several sections that meet one day a week in the afternoon from 1 pm to 4 pm in room 4265 of New Randall Laboratory. The class will be divided into pairs of people to work on experiments. Read the notes for each experiment carefully. You will be graded on how well you complete the assigned material. You will also find helpful hints for using the apparatus. Please arrive on time. – Usually explanatory comments are provided by the instructor at the beginning of the lab period.

You should bring three items to class:

1. Two laboratory notebooks are required. One is for experiments 1,3, and 5, and the other one is for experiments 2,4, and 6. These are blank bound notebooks with graph paper pages. All of your laboratory data and other observations must be written in these books. If you have data or analyses on Excel spreadsheets, these should be printed out and taped into your lab book. Each notebook will be graded in class three times during the semester. Using ink or pen is okay. "Summaries" should be comprehensive and clear. Entries in the notebooks should refer to the appropriate section of this manual.

2. A digital calculator. This is for your convenience only. The PC's also have calculators on them.

3. A floppy disk or USB memory stick for your data is required, so that you can work on analysis away from class. You can also e-mail files to yourself from the lab computers.

No textbook is required for this course. You may refer to relevant parts of the Physics 240 textbook, *Fundamentals of Physics*, by Halliday, Resnick and Walker (abbreviated HR&W elsewhere in this workbook) at appropriate points in the course. Another popular textbook is *University Physics* by Young and Freedman.

Eight Windows PC's are available in the classroom. Microsoft Excel is loaded on the computers, and you will be expected to use it for analyzing data and calculating theoretical predictions. There are Excel spreadsheets available to help with the analysis for many of the experiments. It is a good idea to copy these for use "at home". Computer simulation of geometric optics with a dedicated application program is part of the assigned material to be performed for Experiment 3.

Safety

No science laboratory is completely devoid of hazards and Physics 341 is hardly an exception. The best way to prevent accidents is to use common sense. If you have any doubts about the procedures you are using, ASK AN INSTRUCTOR! In this class, the most obvious hazards are:

- High pressure gas cylinders
- Cryogenic and boiling liquids
- Lasers
- High current power supplies

Gas cylinders can be lethal if dropped and the valves on top become damaged. In this case, the tank can behave like an unguided rocket. Tanks should be kept strapped to the wall or lab benches and moved only with gas carts. The thermometry and ideal gas law experiment uses both liquid nitrogen and boiling water. Handle both with caution. There are safety glasses and gloves available for use when pouring liquid nitrogen. Lasers are potential sources of eye damage if viewed directly. The power ratings for the devices used in this class do not require protective eyeglasses. However, these are also not toys. Do not stare directly at the beam - EVER. In physics labs, high voltages are frequently present, providing the possibility of electric shock. In this lab, most of the equipment is powered by the standard 115 volts that you find in your home or dorm. Even though familiar, it should be treated with respect. Much of the actual equipment operates at much lower voltages, reducing shock hazards considerably. This does raise a danger associated with high currents. If you wear metallic rings and they accidentally short a high current power supply, the electrical heating can produce nasty burns. In case of any accident, notify your instructor and dial 911 for emergency help. A telephone is located at the southwest corner of the lab classroom.

Experiments

The following experiments have been selected for this course:

Experiment 1: Temperature and the ideal gas law.
Experiment 2: Light intensity, blackbody radiation and the Stefan-Boltzmann law.
Experiment 3: Geometric optics.

Experiment 4: Polarization.
Experiment 5: Interference, diffraction, and spectroscopy.
Experiment 6: Speed of light:

Each experiment will take two consecutive lab sessions. The schedule for the course is shown in the table below. All sessions are 1 to 4 PM in Room 4265.

Fall 2005 Schedule	Monday session	Tuesday session	Wednesday session	Thursday session
Exp. 1	–	September 6	September 7	September 8
Exp. 1	September 12	September 13	September 14	September 15
Exp. 1	September 19	September 20	September 21	September 22
Exp. 2	September 26	September 27	September 28	September 29
Exp. 2	October 3	October 4	October 5	October 6
Exp. 3	October 10	October 11	October 12	October 13
(Study Break/ No Lab)	October 17	October 18	October 19	October 20
Exp. 3	October 24	October 25	October 26	October 27
Exp. 4	October 31	November 1	November 2	November 3
Exp. 4	November 7	November 8	November 9	November 10
Exp. 5	November 14	November 15	November 16	November 17
Exp. 5	November 21	November 22	November 23	November 24
Exp. 6	November 28	November 29	November 30	December 1
Exp. 6	December 5	December 6	December 7	December 8

Evaluation

There will be a quiz at the beginning of each experiment except the first one. This quiz will cover the results of the previous experiment. In order to encourage you to read the material in the manual beforehand, there will also be general questions on the new experiment. The quizzes will usually be "open notebook", closed lab manual.

Laboratory notebooks will be due the week following the completion of the experimental work. The notebooks will be judged on both content and clarity. Late lab reports will be penalized by 10% per day. Note that the setups are put away on Friday of the second week when the next experiment is set up, so you can't count on apparatus being available afterwards.

Final grades will be assigned based on lab notebooks (50%), quiz scores (40%), and laboratory performance (10%). We do not use a "curve". Everyone could get an A. Alas, somehow that never happens.

Instructor

The instructors for this course are Professor Michael Longo and Mr. Ramón Torres-Isea. Professor Longo can be contacted at 764-4445, mlongo@umich.edu, or in his office – 354 West Hall. Mr. Torres-Isea can be contacted at 764-3443, rtorres@umich.edu, or in his office, 4263 Randall Laboratory. Mr. Torres-Isea is also the laboratory supervisor.

Some additional comments

Experimental science is a creative endeavor. It requires preparation, ingenuity, thought, persistence, a bit of skill, a great deal of discussion, and finally, some courage. We can prepare you and protect you from physical risk; but intellectual risk is the name of the game. You won't just observe nature – that's too passive. You will investigate it.

This manual is not a cookbook. We give some directions, and raise some questions, but the design and execution of the experiments is up to you. Your notebook is the one and only permanent record of your observations. In the write-ups we often have bulleted lists to point out measurements and observations you are expected to make, but you must use some initiative and look beyond these. Label each section in the write-up with the corresponding section number from the manual. Your conclusions, which will be in the notebook, must be supported by recorded observations there.

Not everyone enters this course with the same proficiency in laboratory techniques, so there will be times when you must ask for help, or give help to others. An instructor will be available most of the time for one-on-one consultations to make sure everything is going smoothly. We encourage you to try to figure out things for yourself, but there is a lot to cover in each experiment, so if you can't figure it out in a few minutes, ask! This is not so different from what happens in the research labs in the basement of this building, or at Fermilab or CERN. However, your laboratory notebook is yours alone, and will be the basis for your grade.

Make sure before you leave the lab that you have all the measurements that you need. Most of the graphing can be done at home. If you have data or spreadsheets on the lab computers, copy them and finish the analysis on any computer with Excel. Make sure that the notebook is available to the instructor the week following the lab, so that we can read your work and evaluate your performance.

Lab partners are expected to have pretty much the same data in their lab reports, but the analysis and summary should be done independently. Often we find that one partner seems to do most of the work while the other sits passively. Try to share the responsibilities in the lab so each partner gets the most out of it.

Last but not least, the lab is great fun! We hope you enjoy it.