

**Physics 2BL**  
**A LABORATORY COURSE ON EXPERIMENTAL METHODS OF PHYSICS**

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web: <http://www-physics.ucsd.edu/students/courses/winter2006/managed/physics2bl/>

**Text:** J. R. Taylor, An Introduction to Error Analysis. Second Edition

**Introduction to the Course**

The objective of this course is to provide you with instruction and experience in the use of experimental methods of physical science as a means to solve problems. For each laboratory exercise, a problem is presented that is to be solved by one or more physical measurements.

The stages in the performance of an experiment include:

- Identification and description of the problem.
- Design and construction of equipment to make measurements.
- Testing and calibration of the instrumentation, data-taking.
- Analysis of the data for the solution of the problem.
- Preparation of a written report.

Our intention is that you gain a little experience in all of the above steps, so that you will emerge from the course with some first hand experience with the “scientific method.”

The equipment that you will use ranges from consumer items available in hardware stores to a few technical instruments such as the “photogate” timing device. For each experiment, you will receive a statement of the problem to be solved, but you will not receive a cookbook type description of how to solve it. The lectures will present one or more examples of how to do each experiment and a discussion of the experimental problems that are likely to arise in each. You must decide which methods to use in the laboratory.

**Procedure**

**Proposal.** Prepare a written plan or “proposal” that describes how you intend to perform the experiment. Be succinct. It must be no more than two pages long (12 point type, 1 inch margins) including diagrams and calculations. Lab partners may discuss the proposed experiment together, then prepare and submit separate proposals.

Accurate and concise description of an experiment is an essential part of what we hope you will learn in this course. We suggest you write a first draft of the proposal without attempting to meet the length requirement exactly and then to edit it to make it more

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accurate and concise. You should seek advice and help, in the laboratory, from the TA's and the instructor in preparing the plan.

A copy of the proposal must be submitted to the TA at the time that you are scheduled for the lab and before you begin the experiment. It should describe:

- The question to be answered by the experiment: For example, "Determine which of several fluids provides the greatest reduction of friction between two pieces of steel".
- The variables that will be measured and the equipment for measuring them. For the question posed above, the variables might be the force used to drag a steel block across a steel plate at constant velocity and the magnitude of that velocity. The equipment might include a weight and pulley to provide the constant force, a meter stick to measure distances and a pair of photo-gate timers to measure the velocity.
- A discussion of the anticipated accuracy of the measurement: For example, time can be measured with the photo-gate timers to about  $\pm 1$  millisecond (ms) over an interval as long as a few seconds. Distance can be measured to about  $\pm 0.5$  mm with a ruler (for lengths up to about 1 m), or to about  $\pm 0.05$  mm with micrometer calipers (for lengths up to about 10 cm). The overall error in the velocity measurement would then be a result of the "propagation" of the errors of both of these measurements through the computation of velocity. The reading assigned in Taylor is to teach you how to do this. If the estimated errors in the experiment exceed the anticipated differences between the various samples, then the experimental design is not adequate to answer the question posed.
- A description of possible systematic errors and experimental tests to eliminate them. A systematic error would arise, for example, if the "photogate" timer was incorrectly calibrated.

**Methodology.** Assemble the experimental apparatus using items that are available in the lab or that you obtain on your own, learn how to use them, and obtain the desired data. Any equipment, simple or complicated, will yield better results as the experimenter gains experience with it. Extensive notes in a laboratory notebook are also an essential part of any experiment. They provide an accurate record of your measurements and procedures. You will need these notes when you write a description of the results of your experiment.

**Report.** Write a report in your laboratory notebook and turn it in to the TA before leaving the laboratory. The report should include:

- A brief paragraph that summarizes the experiment as actually performed.
- A statement of the results of the experiment including tables of data, graphs, sources of error, and error estimates.

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If data in your notebook is already entered in readable form, then your report can refer to a page number rather than rewriting the data. In some cases, such as when your results are inconclusive, you may wish to discuss what was wrong with the technique and alternative techniques which you think would yield better results.

Data should never be fudged to get the expected result.

Clarity and brevity are the most important requirements for this report. Busy scientists or managers do not have time to wade through unnecessary verbiage or a badly written report. Because of the heavy emphasis on preparation in this course, the report is intended to require no more than 30 minutes at the end of the laboratory period.

### **Laboratory Notebooks**

I ask that you purchase two notebooks. You will use one book while the other is being graded by the TA.

### **Lectures**

Lectures will be on Monday. Details are in the schedule.

The lectures will contain material that is essential for satisfactory performance of the experiments. Both the experiments and general error analysis will be covered in the lectures. Your understanding of the lectures will be greatly enhanced if you have read the instruction sheet and any background reading for each experiment and have some preliminary ideas how to proceed.

### **Homework: Reading & Problems**

Homework assignments in Taylor are intended to prepare you for the experiments that you will perform. If you have not learned this material, your laboratory work will not be satisfactory. The assigned problems are given in the schedule, they are to be turned in to your lab TA. The homework problems are excellent preparation for the final. You may find it helpful and perhaps necessary to solve problems in addition to those listed.

### **Grades**

Class grades will be based on:

Each Laboratory Exercise (4)	15%	60%
Each Homework problem (10)	2%	20%
Final Exam		20%