INTRODUCTION

Laboratory measurements make an essential part of the scientific method. We observe and measure physical quantities associated with natural phenomena, propose relationships between those quantities, and test the validity of those relationships through further measurements. Of course, relationships (the laws) of classical physics have been repeatedly confirmed. In this laboratory, you will be making measurements and calculations that verify these established laws. The objectives of this laboratory are:

- To introduce the significance of the experimental approach through actual experimentation;
- To develop a better understanding of the fundamentals of classical and modern physics through hands-on experience and apply the theory presented in class and in the textbook to real-life problems;
- To introduce you to the methods of data analysis commonly used in science and engineering. To familiarize you with a large number of basic instruments and their applications; facilitate you to realize that such tools as graphing, difference analysis, calculus, are of fundamental importance;
- To improve your ability of self-expression through report presentation. You are expected to prepare in advance for each experiment so that you will be able, before beginning the experiment, to answer questions based on the general content of the experiment and conclude your findings at the end of the experiment.

This year, a variety of experimental setups will give you experience with the basic concepts in measurement, kinematics and dynamics in the first semester, and in electricity and magnetism, along with familiarization with electrical equipment in the second semester. The set of experiments arranged here are aimed to provide you gain some experience in the operation of basic instruments. Equally important is the need to understand the interactions between an instrument and the system it is observing.

A mathematical analysis of a physical system almost always involves the use of idealized models which provide an approximate description of the properties of the system. It is important to bear this in mind when comparing your analytical predictions with actual observations of the behaviour of the system; the two will seldom agree exactly. The disagreement can be due either to experimental errors (that is, errors in the measurements) or to the lack of precision of the model, or both, and it is important to understand the distinction.

Although much of your experimental work is concerned with making quantitative measurements, the importance of *qualitative* observations should not be overlooked. Often qualitative observations, including the effects of changing the variable quantities in the experimental setup, will help you gain additional insight and physical intuition related with the physics of the situation. It is always useful to record these qualitative observations, as well as the numbers resulting from your quantitative measurements, for later reference.

GENERAL INFORMATION AND GRADING

Please visit the laboratory web page at **http://www.fen.bilkent.edu.tr/~physlab/** for general information and grading procedure of laboratory work.

RULES FOR FRESHMAN PHYSICS LABORATORY

The laboratory significantly affects the overall grade that you receive for the course. The following rules are going to apply in relation to the laboratory of the course:

- All students must participate in all of the scheduled lab sessions. There will be no make-up sessions without an official excuse (e.g., a proper report from the Bilkent Health Center). Grades from all lab sessions will be considered to determine the final lab grade. If a student misses two or more lab sessions without an official excuse, her/his lab grade will automatically be "F" and fail not only the laboratory but the entire physics course. To be satisfactory final lab grade must be at least 60/100.

- There will be no make-up sessions without an official excuse (e.g., a proper report from the Bilkent Health Center) for any kind of personal problems. The health reports must fulfil the requirements stated by the Health Center and the articles 5.1 & 5.2 of the University Regulations for Teaching Examinations and Assessments. Note that, a student can have a make-up for one experiment only in a semester! More is not allowed even if a valid health report is submitted.
- Students must be present in the lab on time. Nobody will be allowed to participate in a lab session if he or she arrives late. If students need to visit the Health Center during lab hours, he/she must come to lab in time and inform the assistant first. Otherwise, any papers (other than health reports) showing that the student visited the Health Center during the lab hours will not be accepted.
- Students must come to the laboratory sessions prepared. There will be quizzes at the beginning of each session, which will contribute to 30% weight of the overall lab grade. The quiz may be about the theoretical background of the experiment and/or the experimental procedure.
- Students are responsible for the proper use of the equipment in the lab. If you are not sure about the proper use of any piece of equipment, please ask your assistants before using it. This is for your safety as well. Anyone who damages equipment in the lab is expected to pay for it.
- The lab staff is responsible to supply the experimental setup only. Any other equipment (pencil, eraser, ruler, protractor, set square, calculator, etc.) will not be provided by the lab staff, and is solely under the responsibility of the student.
- Lab reports should be completed during the experiments and handed to the assistants at the end of the session. The reports should contain sufficient information to show the work done in the lab, and the results of the experiment.
- Everyone must do the experiments with the group that they are originally assigned to.
- Consumption of food and beverages (including bottled water) is strictly forbidden in the lab.

HINTS TO PERFORM THE EXPERIMENTS & FILL OUT THE REPORTS

Experimental setup and procedure:

- While performing the experiment, please double-check the apparatus provided, and make sure at once that there is no shortage of equipment or malfunctioning equipment.
- Set up the equipment in accordance with the instructions. Proceed carefully and develop scientific methodical work habits.
- Remember that scientific equipment is extremely expensive and frequently quite susceptible to damage. If the setup is at all complicated, ask the lab assistant to inspect your layout before you proceed with the actual performance of the experiment.
- Fill in each part systematically in the form supplied by the lab staff. Clarify each step and write legibly.

Data & Measurement

- All measurements must be recorded directly into the lab report.
- You must also know the limits of your measurements. For example, if you are using a ruler with a millimeter resolution on it, recording a measurement more accurate than mm is nonsense (i.e., you cannot measure 3.75 cm; it must be either 3.7 or 3.8 cm).
- Place the units of the quantities being measured at the top of the data columns (these units will mostly be provided by us at the lab report. If not, you should decide and write the appropriate units). All the measured data should have appropriate units.

- Data may be secured by a group (or a person), but under no circumstances may students use data that belongs to another group.

Computation Outline:

- State all formulae.
- Identify all symbols.
- Watch your number of significant figures. Do not retain a greater number of significant figures in a result computed from multiplication and/or division than the least number of significant figures in the data from which the result computed.

Graphs and Results:

- Give the graph a concise title.
- The dependent variable should be plotted along the vertical (y) axis and the independent variable should be plotted along the horizontal (x) axis. Label axes and include units.
- Scale the axes carefully. First look at your data. The label of the major ticks of each axis must cover the maximum value of your data. The scale must be arranged such that you can easily find value of data points. Then label the major ticks only. You can show the minor ticks if you want.
- Indicate your data on the graph with a dot. Do not draw lines connecting the data points and the axis. Also do not show the data points' values on the axis.
- Draw the best line through the data points. This line does not have to coincide with all the data points.
- When reporting graphical results, show carefully slope calculations and the values obtained from the axes of the graphs. The slope must be calculated by taking two points on the best line, not the data points. You must not use protractor to find slope.
- List the numerical results as found in the computation outline. If the results are qualitative, describe them briefly.
- Pay attention to proper units.

Discussion or Conclusion:

- Think about why the experiment was performed.
- Discuss the meaning of your graphical results. Please do not explain how you have performed the experiment steps.
- If several methods are used, describe the benefits of a particular analytical approach as compared to others. If only one approach is used, discuss its significance.
- Make sure to compare what you expect to observe in the experiment and what you indeed observed during the experiment.
- Compare the expected value and the observed value by means of a percentage calculation. Just stating that “It is less/more than the expected value.” is not instructive.
- Make a brief error analysis. It does not matter how much error you obtained. The important thing is how you explain the error. This does not mean that you can make mistake as you want. You must minimize the personal errors.

Questions

- Answer all the questions listed at the end of the report.
- Explain briefly your solutions.