SC12:PHYSICS
Instructor: Gregory

LABORATORY WORK

Laboratory experiences are an important part of this courses so it is important to learn how to correctly keep a lab notebook. The laboratory notebook will be used to record experimental data throughout the school year. Each lab report will be kept in a three-ring binder, which will serve as a laboratory notebook. The notebook will contain a record of what was done, how it was done, and what the results were. The records need to be formal, neat, and complete enough so that any reasonably knowledgeable person familiar with the subject of the experiment can read the entries, understand exactly what was done,and, if necessary, repeat the experiment.

Labs must be typed or written in black or blue ink. Pencil is unacceptable in a lab notebook; the marks are easily smeared, and may accidentally be erased. Never remove pages from your notebook, and never erase anything. If a mistake is made, draw a single line through the mistake and add a small note indicating why the information is incorrect.

OUTLINE OF A LABORATORY REPORT

1. **Title of Experiment**
   Make the title, and all of the headings for each section in your report, descriptive enough that the reader can find information quickly and easily.

2. **Date and Time of Record**

3. **The Name(s) of Lab Partners**

4. **Objective**
   This should simply be an elaboration of the title, possible giving the method used to conduct the experiment, and no more than one to two sentences in length.

5. **Theory**
   Briefly explain the concepts used in the experiment, and a mathematical statement of these concepts and their derivation, if possible. It should be no more than one to three sentences.

6. **Equipment List**
   Be as descriptive as possible. List the name of each piece of equipment used, the manufacturer, the model, the serial number, and any other information that may be pertinent to performing the lab.

7. **Experiment Set-Up**
   Include a labeled sketch of the equipment set-up, details of component assembly, etc.

8. **Statement of Procedure**_
   Briefly state the procedure that will be followed in conducting the experiment, either in a paragraph or two or as a numbered list stating the procedure step-by-step. Don't be excessively specific, but don't leave out any important information either. If the procedure is to be developed during the lab, be sure to leave enough space.

9. **Table of Observed Data**
   These tables, like everything else in the report, should be constructed before the lab is performed. Tables for recording observed data should be clearly labeled with descriptive terms and units, logically organized, with plenty of room in the margins for corrections or notes.

   The day of the lab, data will be entered directly into the table, in blue or black ink, as the experiment is performed. Incorrect data should be neatly lined out, with an explanation of why the data has been lined out written somewhere nearby. The correct data should be written in the table, if possible. If a large number of mistakes have been made, or an entire data table even is found to be incorrect, neatly draw a large X over the table, then write a note in the margin explaining the error. Create a new data table for entering the correct information.

10. **Table of Calculated Results and Sample Calculations**
    Any calculations necessary to yield final results should be neatly summarized in a Calculations Table. Clearly label all results, and be sure to include units. It isn't necessary to show work for every single calculation performed, but all formulae and samples of each different type of calculation must be included.

11. **Graph(s) of Results**
    Where appropriate (which is nearly always), plot the data from your Calculations Tables on a graph.

    A brief review of graphs: All graphs must have a descriptive title, and X and Y axes labeled with quantity and units. Adjust the scale of the graph so that the information being presented fills an entire page of the lab report. Data points, if plotted by hand, should be plotted with very small "pinprick" of ink, surrounded by a small, more visible, circle. When appropriate (nearly always), draw a smooth “best fit” line through the points. If graphing several sets of data on the same graph, clearly identify the different sets of data by using different shapes around the data points (circles, squares, triangles, etc.), and include a key to these symbols.

    Instead of plotting by hand, some form of graphing software or spreadsheet program may be used to create the graph. These printed graphs should conform to all the requirements listed above, and be neatly trimmed and taped or stapled into the lab report.

12. **Discussion**
    The Discussion section of each entry is used to summarize the findings in paragraph form. Typically, the Discussion section will include the following:

    Comparison with Known Values and Error Analysis
    Compare the lab results with known values. Any time that results have been obtained by more than a single method, or a standard value is available for comparison, then percent difference (in the case of results obtained by two different methods) or percent error (in the case of a result compared to a known quantity) must be calculated.

    Sources of Experimental Error
    "Experimental error" refers to variability in results due to limitations in the experimental design; it's the reason scientists perform multiple trials of any given experiment, and report their results as a statistical average with a deviation included. In this section of the report, do list any observed reasons that may have contributed to errors in the experiment, including specific problems with the equipment, difficulties in reading the equipment, or limitations in the design of the experiment. Only mention specific sources of error for which there is a legitimate reason to believe affected the results, and explain how those sources of error affected your results.

    Please do not refer to "human error." Examples of so-called human error include misreading a ruler, mis-timing a reaction, miscalculations, or any kind of mistake. Do not report these. Instead, repeat the experiment more carefully. Points will be deducted from the lab report for any discussion of "human error".

    Restate any questions posed in the lab handout that haven't already answered in the course of the entry, and provide answers in complete sentences.

13. **Summary of Results**
    This is a brief, one-paragraph, summary of the results of this experiment, with a discussion of whether or not the experiment supports the hypothesis, or the subject material covered in class

LABORATORY SAFETY GUIDELINES

1. Follow directions. Come to lab prepared to perform the experiment. Follow all written and verbal instructions. When in doubt, ask.

2. Absolutely no horseplay. Be alert and attentive at all times. Act like an adult.

3. Report all accidents, injuries or breakage to the instructor immediately. Also, report any equipment that you suspect is malfunctioning.

4. Dress appropriately. Avoid wearing overly-bulky or loose-fitting clothing, or dangling jewelry that may become entangled in your experimental apparatus. Pin or tie back long hair and roll up loose sleeves.

5. Use goggles:
   - when heating anything.
   - when using any type of projectile.
   - when instructed to do so.

6. Use equipment with care for the purpose for which it is intended.

7. **Do not perform unauthorized experiments.** Get the instructor's permission before you try something original.

8. Be careful when working with apparatus that may be hot. If you must pick it up, use tongs, a wet paper towel, or other appropriate holder.

9. If a thermometer breaks, inform the instructor immediately. Do not touch either the broken glass or the mercury with your bare skin.

10. Ask the instructor to check all electrical circuits before you turn on the power.

11. When working with electrical circuits, be sure that the current is turned off before making adjustments in the circuit.

12. Do not connect the terminals of a battery or power supply to each other with a wire. Such a wire will become dangerously hot.

13. Return all equipment, clean and in good condition, to the designated location at the end of the lab period.

14. Leave your lab area cleaner than you found it.

USE OF THE LAB TIME

Before the Lab Period
Complete the lab entry up to the Table of Observed Data. Make sure that you've looked over the lab and have a good idea of what you're going to be doing during the 80 minutes of lab.

During the Lab Period
The labs are designed for most people to complete within the 80-minute time period. Students who haven't prepared adequately, or who perform the experiment poorly the first time, may find that they'll need an additional 10-15 minutes to complete the work. Students that finish the data collection and clean-up before the end of the lab period are expected to stay in the classroom to begin working on the remaining sections of their lab entry. All students need to get the instructor's dated signature on the lab to receive credit for their work.

After the Lab Period
Students will need to complete the remaining sections of the lab entry before turning in the completed lab report at the beginning of the class following the lab. It is expected that students will collaborate with lab partners and other students in the class. Students are encouraged to discuss the lab, and even to consult with others as during completion of the lab entry. However, each student is expected to complete his or her own lab entry, with all calculations and written entries completed in his or her own words.

SCORING RUBRIC FOR PHYSICS LABORATORY REPORTS

The experiments in each unit are designed to give you the opportunity to gain hands-on experience of the physics concepts presented in class. For these experiences to be meaningful, you must exhibit skillful and careful technique in the lab and must take a logical approach to each exercise.

The following scoring rubric outline seven levels of performance in the laboratory. Each level describes the scientific skills required in the physics lab and the quality of analysis expected in the written report.

Experienced Level (Raw Score 6)

- Excellent technique is used throughout the lab procedure. Procedures are well-planned and well-executed.
- Data and observations are recorded correctly, descriptively, and completely, with no serious errors.
- Calculations and data analysis are performed clearly, concisely, and correctly, with correct units and properly performed calculations.
- Graphs are drawn accurately and neatly and are clearly labeled.
- Students recognize the connections between their observations and the related physics concepts; this understanding is expressed clearly and completely.
- Good reasoning and logic are evident throughout the report.
- Answers to questions are complete.

Competent Level (Raw Score 5)

- No errors in technique are observed during the lab procedure. Procedures are well planned and carried out in an organized fashion.
- Data and observations are recorded correctly, descriptively, and completely, with only minor errors.
- Calculations and data analysis are preformed correctly, with correct units and properly performed calculations, but the work may be slightly unclear or disorganized.
- Graphs are drawn accurately and neatly.
- Students effectively express recognition of the connections between their observations and the related physics concepts
- Good reasoning and logic are evident throughout the report.
- Answers to questions are correct, but may reveal minor misunderstandings.

Intermediate Level (Raw Score 4)

- Only minor errors in technique are observed during the lab procedure. Procedures are carried out well but may be slightly disorganized.
- Data and observations are recorded correctly, with only minor errors or omissions.
- Calculations and data analysis are performed correctly, but some minor errors are made either in calculations or in applying correct units.
- Graphs are drawn accurately and neatly.
- Students adequately express their recognition of the connections between their observations and the related physics concepts.
- Reasoning is occasionally weak in the report.
- Answers to most questions are correct, but there are some minor misunderstandings or minor errors.

Transitional Level (Raw Score 3)

- Only a few errors in technique are observed during the lab procedure, but they are significant. Procedures are not well planned or they are carried out in a disorganized fashion.
- Data and observations are recorded adequately, with only minor errors or omissions.
- Calculations and data analysis are performed correctly, but minor errors are made both in calculations and in applying correct units.
- Graphs are drawn adequately.
- Students recognize connections between their observations and the related physics concepts, but this understanding is very weakly expressed.
- Reasoning is weak throughout much of the report.
- Some answers to questions are incorrect because of misunderstandings, minor errors, or poor data.

Beginning Level (Raw Score 2)

- Several serious errors in technique are observed during the lab procedure. Procedures are not well planned and are carried out in a disorganized fashion.
- Most data and observations are recorded adequately but with several significant errors or omissions.
- Calculations and data analysis are preformed inaccurately, but correct units are used most of the time.
- Graphs are drawn adequately.
- Students may or may not recognize connections between their observations and the related physics concepts; no expression of understanding is evident in the report.
- Errors in logic are made in the report. Parts of the report are disorganized and unclear.
- Some answers to questions are incorrect or poorly written.

Inexperienced Level (Raw Score 1)

- Many serious errors in technique are observed during the lab procedure. Procedures are very poorly planned and disorganized, and they show a lack of understanding of the lab.
- Data and observations are incorrect or incomplete.
- Calculations and data analysis are performed incorrectly, with no units or with incorrect units.
- Graphs are drawn incorrectly.
- Students obviously do not recognize connections between their observations and the related physics concepts.
- Errors in logic are made throughout the report.
- Some answers to questions are so incorrect that it is obvious that the students do not understand the lab or did not collect any meaningful data.

Unacceptable level (Raw Score 0)

- All work is unacceptable.
- No responses are relevant to the lab.
- Major components of the lab report are missing.

Raw Score	Points (40 max)	Percent Grade	Letter Grade
6	40	100%	A+
5	38	95%	A
4	34	85%	B
3	30	75%	C
2	26	65%	D
1	22	55%	F
0	0	0%	F

Lab reports may not be re-written for a higher grade. If you earn a low score on your report, learn from your mistakes and incorporate the suggestions into your next report.

You are responsible for your own work. Plagiarism will result in a score of zero for all parties involved, as well as a disciplinary hearing before the Student Faculty Judicial Committee.