Lab Information

There is nothing that happens in physics that should not happen. Nature never messes up and does the wrong thing. We, as students of Nature, try to determine the workings of Nature through experiments. In Physics, we use experimental results as evidence for physical laws. In this class, we will use lab reports as evidence and a record of our experiments. For labs, we are required to include all the parts of the lab write-up written in ink in your notebook. All lab write-ups are individual assignments.

Lab Format
All labs for physics must be completed digitally and printed. All graphs, data tables and sample calculations must be done using the computer.

Components of a Lab Write-Up
All labs will need to be written in an organized fashion that includes all needed components. Label each section of your lab; making sure it is complete, well written and organized.

Design
Title & Purpose– Name your experiment. It can be the one given, or one you create. Make sure that it is relevant and appropriate for your topic. Clearly state the reason for doing this experiment. “I have to” is not a good purpose for anything.

Variables – List the variables in your experiment. Note which variable is the independent variable and which is the dependent variable. Also include a list of parameters, quantities that could be variables, but will be held constant for your experiment.

Procedure – List the materials used in your lab and make a brief sketch on how they are arranged. Record the steps of the experiment. This should be written step by step, not in paragraph form. Give as much detail so that someone unfamiliar with your exact experiment could follow what you did. If this is given to you with the lab instructions, you may rewrite it in your own words to shorten it, as long as all the steps are still included.

Data Collection
Data: Raw –Record **all** your raw data from your experiment, even if you later omit it as an outlier. Organize all the data in an orderly table. This table should not only include your data. If your data is recorded from a graph, submit a sample graph to show how you collected your data.
Data Processing – When you process your data, include a sample calculation to show how you arrived at your processed data. This process must also be clear. Many times you will graph your results. Include all graphs and derived equations in this section. All equations should be written using appropriate symbols and needed units. As far as the grading rubric is concerned, raw data is what you physically measure and record from your experiment, while processed data are graphs and equations you create from your raw data. Significant figures should be used with all data all the time.

Results
Error Analysis & Improvements – Discuss possible sources of errors. Limit your analysis to the 2 or 3 most important errors in your lab. Discuss possible ways for minimizing or eliminating the errors in your lab. Each error should be written in its own paragraph.

1. ***State the Error and Type*** - For example, “*We did not take into account the friction acting on the cart which is an unmet theoretical assumption.*”
2. ***State the Effect*** - “*As a result, the final velocity of the cart was smaller than we anticipated causing the actual value for Kinetic to be smaller than the theoretical value.*”
3. ***State the Fix*** - “*For better results in the future, we could use a cart with smoother bearings that will minimize the effects of friction.*”

Conclusion – Record your conclusion to the lab. Your conclusion must be supported by a logical argument based upon your data. Restate results from the lab. In this section show how your results agree with what you know of physics. Your conclusion should be straightforward and to the point. It should be based on your data and be closely related to the purpose of the lab. Your conclusion should have 3 parts.

1. ***State your Conclusion*** - For example, “*We determined the conversation of mechanical energy to be obeyed during our lab.*”
2. ***Support your Conclusion with Data*** - “*Our data shows that the final energy is, on average, equal to 90% of the original energy.*”
3. ***Explain the meaning of your Data*** - “*This means that 90% of our energy is conserved within our system, which makes it reasonable to predict that energy is conserved, given the errors that were present.*”

Physics Lab Rubric

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Design	Title and Purpose	Inappropriate title or purpose		Clear and correct title and purpose
	Variables	Does not identify any relevant variables.	Only one correct variable identified or independent and depend variables reversed	Correctly identified variable
	Procedure	Incorrect or does not allow for the collection of relevant data	The procedure allows for the collection of insufficient relevant data	The procedure allows for the collection of sufficient relevant data
Data Collection	Data: Raw	Does not record any appropriate quantitative raw data or raw data is incomprehensible.	Records appropriate quantitative and associated qualitative raw data, but with some mistakes or omissions.	Records appropriate quantitative and associated qualitative raw data, including units where relevant.
	Data: Processing	No processing of quantitative raw data is carried out or major mistakes are made in processing.	Processes quantitative raw data, but with some mistakes and/or omissions.	Complete and correctly processed
	Data: Presentation	Presents processed data inappropriately or incomprehensibly.	Presents processed data appropriately, but with some mistakes and/or omissions.	Presents processed data appropriately and, where relevant.
Results	Error Analysis	Identifies irrelevant weaknesses and limitations.	Identifies some weaknesses and limitations, but the evaluation is weak or missing.	Evaluates weaknesses and limitations.
	Improvements	Suggests unrealistic improvements.	Suggests only superficial improvements	Suggests realistic improvements in respect of identified weaknesses and limitations.
	Conclusion	States no conclusion or the conclusion is based on an unreasonable interpretation of the data.	States a conclusion based on a reasonable interpretation of the data.	States a conclusion, with justification, based on a reasonable interpretation of the data.
Overall	Overall Organization	Out of order and difficult to follow	Everything in order but somewhat cluttered or messy	Everything in order and clearly laid out

Possible Causes of Errors/Discrepancies

- **Human Error (experimental or theoretical blunders):** Examples include failing to connect a wire or making mistakes in calculations. Human error is NOT acceptable – these errors must be fixed!

- **Systematic Equipment Error:** This type of error will give results that are consistently too high or too low, in other words inaccurate. Often these types of errors are due to faulty apparatus, such as a meter that reads consistently low or an electrical connection that has extra resistance. For systematic errors, your graphs will generally have the expected shape with a difficult-to-explain vertical intercept.

- **Unmet Theoretical Assumptions**: For example, a theory may assume negligible friction or air resistance but the experiment may be unable to meet these idealized conditions. In this case, reasonable steps must be taken by the experimenter to minimize the discrepancy. If the overlooked factor (friction, air resistance, etc.) is consistent, you will have a systematic error – the graphs will have the expected shape but will be shifted vertically. If the overlooked factor does not have a consistent effect, your graph will have unexplained wiggles or even appear completely random.

- **Measurement Scale Limitations:** The experimenter can only be as precise as his/her measuring equipment. For example, if your ruler is only marked to the nearest centimeter then you will only be able to record significant figures to the nearest 10th of a centimeter (when measuring you estimate one digit past the instrument markings). This means that if you plot a data point to be at 3.4 cm, it actually could be anywhere from 3.0 cm to 4.0 cm. This type of error will cause your graph to “wiggle” a bit from its expected shape.

- **Approximations in Measurement:** At times the experimenter may have to make approximations. For example, when measuring a pendulum’s length it may be difficult to determine the location of the center of the bob, giving perhaps a 2 mm (0.2 cm) uncertainty. In this case, a meter stick marked to 0.01 m is not any more useful than one marked to 0.1cm. The resulting uncertainty is essentially the same as a measurement scale limitation.

- **Random Errors:** Random errors are experimental uncertainties due to unpredictable changes in conditions. Repeated trials (doing the exact same thing more than once) help to minimize the effect of random errors. Random errors will cause your graph to “wiggle”, sometimes wildly. Random errors are most severe when experimental constants have not been identified or are allowed to vary.

- **Systematic Drift:** This may be caused by conditions such as a battery dying, or a string stretching with use. In the case of systematic drift the graph will not be the correct shape.