PHYSICS 332
MECHANICS LABORATORY

GUIDELINES FOR LAB REPORTS

These guidelines should be followed for all lab reports associated with this course. However, they reflect the particular points that your instructor wishes to emphasize and hence the guidelines will not necessarily be appropriate for other physics laboratory courses. Note that the first few reports you submit will not include all of these sections.

Preliminaries:

Assume the report will be read by someone who has never set foot in the lab. The reader is interested in understanding what *you* did and why you did it so that the believability of your data can be judged. *You are not trying to teach the reader how to do the experiment.* Reports should be neat, legible, and free of grammatical and spelling errors.

Cover Page:

The first page should indicate the title of the report, the author, the name of the lab partner (if none, indicate) and the date the report was *turned in* (not the due date). It should also include a one paragraph abstract that provides a summary of the purpose of the experiment and the key results.

Introduction:

An introductory section should clearly state the objective of the experiment and should discuss the theory, introducing any relevant concepts and equations. While it is not usually necessary to re-derive equations appearing in the lab manual or in a text, you should make sure that you introduce all of the relevant physics and discuss any approximations or conditions that apply to the equations you have introduced. In many of the labs in this manual, there are questions incorporated into the theory discussion or the description of the procedure. These questions should be addressed either in the introduction or in one of the subsequent sections, wherever the material fits in most conveniently. *All key theoretical predictions should be discussed at this point*. It is better not to refer to the specific apparatus at this point unless you are prepared to describe it in detail, because you are to assume the reader has not seen the apparatus before.

Procedure:

This section should describe the apparatus and methods in a manner complete enough so that a reader who has never seen the apparatus can understand what you did and why you did it. In each step it should be clear how that step helped you measure a quantity necessary to achieve your objectives or minimize and/or assess error in measurements. In most reports, a diagram of the set-up will be required. Under no circumstances should you copy word for word major sections of the lab hand out. In this section, you should describe what you actually did, not what the lab manual said you should do. Thus sentences will typically begin with "We measured the..." rather than "You measure...." If you repeated a measurement several times, which is usually a good thing to do, indicate that. Finally, **explain *why* you did what you did**. Put another way, the purpose of this section is to tell the reader how you accumulated your data (it is *not* the purpose to teach the reader how to perform the experiment).

Results and Discussion:

The results section should include all of your raw data as well as any useful quantities you have derived from it. Show sample calculations to make clear how you obtained the derived quantities. Large collections of data should be displayed in tabular or graphical form. Make sure that all units are included. Finally, this section is designed to be read—it is not just a collection of numbers, equations and graphs. Include sufficient text so that the reader understands the significance and the context for all that you show. *This section should also include a discussion of your results and a numerical error analysis.*

Conclusion:

In the final section you should draw conclusions from your results. Refer back to your introduction and discuss whether or not your objective was met. Include here a discussion of the discrepancy between theory and experiment. If necessary, conclude with a discussion of how the experiment might be better performed. In deciding whether or not a given theory has been verified, it is important to take into account the numerical uncertainties you have calculated. It does not matter so much if theory and experiment agree to within 10%, 1% or 0.1%. What matters is if they agree to within the anticipated uncertainty you have calculated.

PHY 332 LAB
GRADE/COMMENT SHEET
(Sample)

/2 MECHANICS
- Title Page/Abstract
- Grammar, Legibility

/4 INTRODUCTION
- Objective
- Theory

/4 PROCEDURE
- Clarity of Explanation
- Correctness

/8 RESULTS
- Presentation
- Accuracy of Measurements
- Accuracy of Calculations
- Completeness of Calculations
- Discussion of Results

/2 CONCLUSIONS
- Connection to Objectives

/1 ERROR ANALYSIS MULTIPLIER

/20 TOTAL= Mechanics+Introduction+Procedure+
(Error Analysis Multiplier)X(Results+Conclusions)

***NOTE THAT FOR THE LARGE AMPLITUDE OSCILLATION LAB, THE SECTIONS ARE WEIGHTED DIFFERENTLY: INTRODUCTION 3, PROCEDURE 6, RESULTS 7.

Sample Lab Report

Comments will appear in this font

Determination of the Moment of Inertia of a Hollow Sphere

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Lab Partner: John Thomsen

Date Submitted: January 1, 2003

Abstract

The moment of inertia of a hollow sphere was determined by timing a ping pong ball rolling down a ramp. The general form for the moment of inertia of round objects is $I=\beta MR^2$. In this experiment, the calculated value of β was 1.1 +/- 0.4, which is not consistent with the theoretical prediction of 2/3 . Possible sources for the discrepancy are discussed.

Don't forget to state key results in your abstract

Introduction

The moment of inertia associated with round objects can often be expressed in the form

$$I = \beta M R^2 \qquad (1)$$

where M is the mass of the object and R is its radius. β is a dimensionless quantity that varies according to the geometric nature of the object. For a hollow sphere, the predicted value of β is 2/3. The purpose of this experiment is to determine the value of β for a ping pong ball. We expect this value to be very close to that of a hollow sphere.

One way of determining the moment of inertia of a round object is to study its motion as it rolls without slipping down an inclined plane. The rotational speed, ω, of an object that rolls without slipping is related to its center of mass speed, v, through

$$v = \omega R \qquad (2)$$

The kinetic energy of such an object can be expressed as

$$\begin{aligned} KE &= \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 \\ &= \frac{1}{2}Mv^2 + \frac{1}{2}\left(\beta M R^2\right)\left(\frac{v}{R}\right)^2 \qquad (3) \\ &= \frac{1}{2}(1+\beta)Mv^2 \end{aligned}$$

When this object is released from rest, its gravitational potential energy is converted to kinetic energy (assuming no work done by nonconservative forces):

$$Mgh = \frac{1}{2}(1+\beta)Mv^2 \qquad (4)$$

where h is the height loss of the rolling object and v is its speed at the end of the height drop. Solving for β, we find

$$\beta = \frac{2gh}{v^2} - 1 \qquad (5)$$

Often it is easier to measure the average speed, $\overline{v}$, of an object rolling down a ramp, rather than its final speed. Noting that $v=2\overline{v}$ when the object is released from rest, we have

$$\beta = \frac{gh}{2\bar{v}^2} - 1 \qquad (6)$$

The average speed of an object moving through a distance Δx in a time Δt is given by

$$\bar{v} = \frac{\Delta x}{\Delta t} \qquad (7)$$

Notice that the introduction states clearly what the objective of the experiment is. This is usually most conveniently done in the first or the last paragraph of this section. Any equations that will be used to analyze the data must be introduced in this section. Equations 6 and 7 are the important ones here. This discussion does not refer to details of the apparatus (the meter stick, the nature of the ramp, etc.) since they will not be introduced until the Procedure section.

Procedure

A ping pong ball was timed as it rolled down a ramp in order to determine its average speed. The ramp was made from a plastic meter stick laid on its side and raised slightly at one end. A groove cut in the edge of the meter stick served as a guide to keep the ping pong ball rolling down the edge.

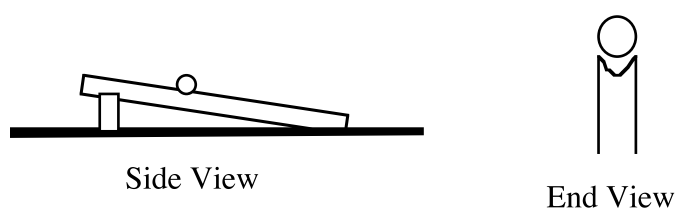

Figure 1: Side and end on views of the ping pong ball rolling down the meter stick. The end view is enlarged to show detail.

The ball was released from rest at the 90 cm mark on the meter stick.

Simultaneously with its release, a hand held stopwatch was started. When the ball reached the end of the incline, the watch was stopped. Data was discarded if the ball did not stay on the ramp all the way down, which happened in roughly half of the trials. A total of five time measurements were made.

The corner of the support block lay just underneath the 90 cm mark on the meter stick, so the effective height of the incline could be determined by measuring the height of the block.

Notice the focus on how the data is acquired. However, numerical results are not reported here. A figure is often useful in clarifying the set up of the experiment (hand drawn is fine). Remember that you are writing this report as if it will be read by someone who has not been in the lab and does not intend to do the experiment. Explain how the apparatus works or what it is capable of, and focus on how you actually acquired data (not on what you were instructed to do or what you think the reader should do). Do not refer to a piece of the apparatus by a definite article ("the") until you have introduced it. That is, do not open your procedure with "the ping pong ball was timed…" because the reader has not yet heard about the ping pong ball. Beginning with "A ping pong ball" alerts the reader that this is the first time this object is being discussed.

Results

Results from the five time trials are listed below, as is their average. The uncertainty is based on the spread in experimental results.

Trial	Time
1	3.50s
2	3.80s
3	3.62s
4	3.49s
5	3.37s
Average	(3.6 +/-0.2)s

The length of the ramp along which the ball traveled was (0.90+/-0.002)m, while the height was (0.027+/-0.001)m. The average speed is

$$\overline{v} = \frac{\Delta x}{\Delta t} = \frac{(0.90 \pm 0.002)m}{(3.6 \pm 0.2)s} = 0.250 \pm 0.015\frac{m}{s}.$$

Using equation 6, we find β to be

$$\beta = \frac{gh}{2\bar{v}^2} - 1 = \frac{9.8\frac{m}{s^2}(0.027 \pm 0.001)m}{2\left(0.25 \pm 0.015\frac{m}{s}\right)^2} - 1 = 1.1 \pm 0.4$$

The expected value of 2/3 lies outside the range determined experimentally.

Uncertainty values have been incorporated at each step of the calculation. Large sets of data are presented in tables. Some discussion is included so that this section reads well (it is not just a set of numbers and calculations). Graphical representations should be computer-generated, using a program such as Excel.

Conclusions

In this lab we were able to determine the coefficient β that appears in the moment of inertia equation for the ping pong ball. Our value was not consistent with the theoretically expected result of 2/3 even with experimental uncertainties accounted for. Hence, there must be other problems in the way we have interpreted our data. Since our value for β was higher than anticipated, the value for v may have been unexpectedly small. That is, the ball took longer than expected to roll down the ramp. It was noted during the course of the experiment that the ping pong ball was not uniform--it had a ridge around its circumference. Furthermore, we observed that the ball did not always stay on the ramp. It is possible, then, that rather than rolling smoothly down the ramp, the ball had a somewhat bumpy ride. It would be difficult to quantify the effect of this consideration without repeating the experiment using a higher quality ball.

Make sure your conclusion connects back to your stated objective. Don't be afraid to say that your results are not consistent with theoretical predictions. If that should be the case, then it is useful to consider other possible sources for the discrepancy, which may or may not be quantifiable.