Abstract

The experiment described below investigated the motion of an aluminum glider on a nearly-horizontal air-track. The goal of the experiment was (1) to determine the average speed of the glider over the course of a complete one-direction journey along the track and (2) to study how the speed of the glider varied from one part of the journey to another. Several timed trials were conducted on the complete journey and on various sub-sections of the journey, using non-standard units for space (*'BICs'*, where one *BIC* is defined to be the cross-sectional diameter of the cap of a BIC pen) and time ('*Clicks*', where one *Click* is defined to be the interval between two collision sounds on a *Newton's Cradle*). The average speed of the journey was found to be 23 BICs/Click +/- 4 BICS/Click. Variation was found between the average speeds of different portions of the journey, with the fastest speeds being found near the beginning of the journey. However, this variation was <u>not</u> significant compared to uncertainty intervals, so nothing conclusive can be said about the variation in average speed over the course of the journey.

Introduction

Average speed, defined as total distance divided by total time (see *Analysis* section), is a fundamental concept in physics and an essential building block for the study of motion. Average speed provides information about the overall motion of an object over a period of time, but it gives no information about how that speed varied within the designated time interval. By sub-dividing a journey into shorter time segments, researchers can obtain more precise information about the changes in speed over the course of the journey. In this experiment, an aluminum glider and air-track were used to explore the relationship between average speed for a whole journey and average speeds for various segments of the journey. These materials provided an effective experimental environment, because the nearly frictionless air track makes it possible to produce slow, continuous, but not perfectly uniform, motion, without the use of propulsion, which makes it easier to collect reliable time measurements.

Research Questions

What is the average speed of an aluminum glider as it travels along an approximately horizontal air track?

Does this average speed vary significantly as the glider moves from section to section of the air track? If so, how does it vary?

Data Collection

Traditional measuring implements (stop-watches and meter-sticks) were unavailable at the time of experimentation, so it was necessary to construct units and measuring devices from available materials, prior to collecting data. In this task, three main factors were considered: consistency, efficiency, and precision. A unit that varies from moment to moment or from measurement to measurement will be inconsistent and will produce inaccurate measurements. A unit which is too small as compared to the thing being measured will be inefficient: tedious to use and (in the case of time) difficult to keep count of. A unit which is too large, on the other hand, will create high uncertainty and low precision. The cap of a standard ballpoint BIC pen was used to measure distance. The cross-sectional diameter of the cap served as the unit, called a '*BIC*'. A *Newton's Cradle*, which produces click sounds at consistent short time intervals, was used to measure time. The unit was the interval between these clicks, named (ironically, perhaps) a '*Click*'.

In order to prepare for data collection, the track was leveled. Leveling the track—i.e. making it as nearly horizontal as possible—made it possible to produce long, slow trips down the track. This was important, because the slower the trip the easier it is to collect reliable data. The *Click* is a consistent unit, but it is only slightly shorter than the intervals between beats in a healthy human resting pulse. This makes it difficult to take high precision timings, which would be necessary if the glider were moving quickly along the track.

It was observed that, with the track nearly horizontal, the glider did not make complete trips along the track. Placed at one end of the track and released from rest, it would glide for some two thirds the length of the track, then stop naturally (due presumably to slight resistance from contact with the track). This trip, from one end of the track to the point where the glider naturally came to rest, was considered a complete journey for the purposes of the experiment.

Three trials were performed, measuring the time and distance for a complete journey of the glider. The experiment continued with three trials measuring the time and distance for the first of half the journey, three trials measuring time and distance for the second half of the journey, and three trials measuring time and distance for the first third of the journey. The data from all twelve total trials can be found in Table 1, in Appendix A.

Diagram

[not shown]

Analysis

Each trial involved two measurements: time and distance. The definition of average speed was used to calculate average speeds from these data:

$$Average\ Speed = \frac{total\ distance}{total\ time}$$

By applying this equation to the distance and time from each trial, average speeds were generated for each of the twelve trials. The speeds for the three trials that examined the complete journey were then averaged, thus producing an *average* average speed for the complete journey. The same thing was done for the trials from each of the three sub-sections of the journey, producing an *average* average speed for each sub-section. The results of these calculations can be found in Table 1, in Appendix B.

Uncertainty

[not shown]

Conclusion

The average speed for one complete trip of a glider along a nearly horizontal air track was found to be 23 BICs/Click +/- 4 BICs/Click. The average speeds for the various sub-sections seemed to show a trend of decreasing speed from the early sections to the later sections: 24 BICs/Click +/- 3 BICs/Click for the first third down to 19 BICS/Click +/- 4 BICs/Click for the second half. As can be seen, however, the uncertainty intervals for these average speeds are actually overlapping. In interval form, the average speed for the first third is between 21 and 27 BICs/Click, while the average speed for the second half is between 15 and 23 BICs/Click. Thus, it is entirely possible, based on the data obtained, that the average speeds for the first third and for the second half are identical at, say, 22 BICs/Click. Since the uncertainty intervals overlap, we cannot say for certain that the average speeds actually vary from the beginning to the end of the journey.