Air Track

APPARATUS

1. Air Track with air blower
2. Glider with spring bumpers
3. Stop clock
4. Set of four 1.27 cm thick spacers
5. Meter stick (and vernier caliper)

INTRODUCTION

The air track is a long hollow aluminum casting with many tiny holes in the surface. Air blown out of these holes provides an almost frictionless cushion of air on which the glider can move. The air track and gliders operate best if they are clean and smooth. If their surfaces are dirty or show bumps or nicks, inform your instructor before proceeding. Dirt, bumps, and nicks can result in scratching the surfaces of the track and glider. To avoid scratching, use care in handling the apparatus. The most important rule is this: *at no time should the glider be placed on the air track if the blower is not in operation.*

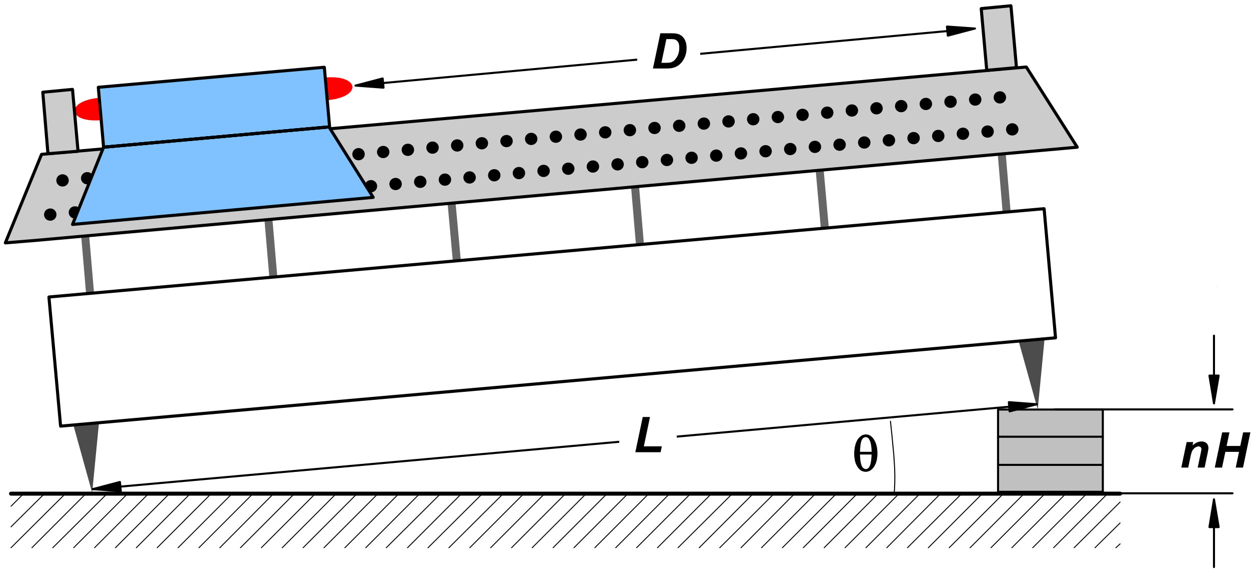

Figure 1: Air Track with dimensions.

The air track, with air blowing, serves as an almost frictionless surface. When one end is raised, it becomes a frictionless inclined plane (see Fig. 1). According to theory, the acceleration a of an object due to gravity down a frictionless incline of angle θ is $a = g\ sin\,\theta$. The main idea of this experiment is two-fold: first, to check that the acceleration is proportional to $sin\,\theta$, and second, to find the value of g, the acceleration of free fall.

The acceleration down the track is to be found for each of four incline angles by measuring the time t required for the glider to slide the measured distance D down the length of the track, and, using the formula $D = \frac{1}{2}\,a\,t^2$, to get $a = 2\,D/t^2$ (see Fig. 1).

The collision between the glider and the spring bumper at the bottom of the track is not perfectly elastic, that is, the glider rebounds at lower speed and less kinetic energy than it had just before the collision. This is demonstrated by the fact that the glider rebounds a distance $D' < D$. The potential energy of the glider with respect to the bottom of the track just before release is $m\ g\ D\ sin\,\theta$, while the potential energy at standstill after rebound is $m\ g\ D'\ sin\,\theta$. These are also the kinetic energies just immediately before (K) and immediately after (K') the collision, respectively. The fractional loss of energy is then: $(K - K')/K = 1 - (K'/K) = 1 - (D'/D)$.

PROCEDURE

Part A: Determining the acceleration

1. Check that the air track is level (horizontal). It should take the glider at least 10 seconds to move across the track, no matter at which end it is placed. If it is not sufficiently level check with your instructor.

2. Measure:

   a) The distance D the glider moves in going from one end of the track to the other.
   b) The distance L between the base supports of the air track.

3. Place one spacer under the single track support. With the air on, place the glider at the upper end with about one millimeter gap between the glider and the stationary spring. Take a few practice timings to get used to starting the clock at the time the glider is released, and stopping the clock when it hits the spring at the lower end.
   Be careful when reading the clock. The two dials have different divisions.
   When you are used to the process of release and timing, then proceed.

4. Set up a table with the headings shown below:

n (# of blocks)	t_1 (s)	t_2 (s)	$t_{average}(s)$	a (m/s^2)
1				
2				

   Be sure to indicate the units used. For each value of n, from 1 to 4, measure the time twice. If they differ by more than 5%, then take another pair of times. Continue until two successive times are within 5%.

5. With four blocks in place, $n = 4$, take a total of six times. We will use this information to determine the variability in our time measurements.

Part B: Determining the dissipated energy

1. With two spacers, measure the rebound distance D'. Use the average of two successive measurements that are within 5% of each other.
2. Evaluate the fraction of the original kinetic energy that is lost in the collision.
3. Explain the equations relating K and K' to D and D' and then derive $K'/K = D'/D$.

ANALYSIS

1. If friction has been eliminated, what are the forces exerted on the glider?
   Draw the Free Body Diagram of the glider.
   Find the net force and apply Newton's Second Law to determine the algebraic relation between the acceleration a, g and the angle θ of the track.
   Use the fact that $sin\,\theta = n\ H/L$ to express a in terms of n algebraically.
   What kind of a graph would you expect for a vs. n?
2. Review the material in the introduction to the lab manual on graphing, and using graphs. Select scales so that the graph of a vs. n takes up most of the page. Do include the origin. Plot your data points. Draw the single straight line that best fits your data points. Determine the slope of that line by using two widely separated points on the line that are not data points. What are the units of the slope?
3. Use the analysis of step 2 to relate your value of the slope to g. Determine g from your slope.
4. In order to compare your value of g with the standard value, a value for the experimental uncertainty is needed. Review the material in the introduction on "Measurements and Uncertainty" and on using graphs. Determine the range of the six times measured for $n = 4$. Take this value as the uncertainty in time measurements, Δt. Determine the uncertainty in the value of acceleration Δa due to Δt. The uncertainly in the slope measurement is just Δa divided by the range of n. Finally, determine Δg from the relation between g and the slope.
5. Compare your value with the standard value by calculating the Uncertainty Ratio:

$$\frac{|g - g_{standard}|}{\Delta g}$$

   Values less than 1 indicate excellent agreement, greater than 4, disagreement and possible mistakes. Values between 1 and 4 are ambiguous, indicating fair or poor agreement. How well does your result agree with the standard value?