Physics 2010
Lab 2: Motion and Gravity

THERE IS A PRELAB THIS WEEK! IT IS A SEPARATE DOCUMENT, DOWNLOAD AND PRINT IT FROM THE WEBSITE, AND DO IT BEFORE YOU COME TO LAB! Bring it with you, thanks.

In this lab, you will be working with air tracks and exploring to discover some properties of motion, acceleration, and the effects of gravity.

Important!

The air tracks and measurement devices are sensitive and easily broken. The air tracks and gliders can be destroyed if their surfaces are gouged or bent. Do not elevate the air tracks past approximately 10 degrees.

Section 1: Setting Up (15 min.)

In this lab we work with gliders moving along the air track. The speed of a glider on the track will be determined with photogate timers. A card, placed on top of the glider, interrupts a light beam in the photogate and triggers a timer (See the figure below). The photogate timer can be used to measure either the time for the glider to travel between two gates (when the timer control is set to PULSE mode), or the time for the card to pass through one gate (when set to GATE mode). The timer can be set to read either milliseconds (ms) or 0.1 ms. With 0.1 ms resolution, the timer will count up to a maximum of 2 s before overflow.

Air track, glider with card attached, and two photogates

1. Turn on the air supply to the track (get instructions from the TA).
2. Level your track carefully: Come up with a sensible procedure yourself! (Hint: if it is level, with the air on, what should happen?)
3. Place one glider on the track, and play around in order to get a feel for how the cart moves, and determine how the timers work. Ask the TA for help if you are stuck.
4. Measure the size of your card, record it here:
A. How are the air track and glider different from objects you normally encounter?

B. Make a couple of measurements of how long it takes for a glider to pass through a gate when you gently push it. Please record the times below:

C. Are the measurements always the same? Why or why not?

Section 2: Instantaneous vs. Average Velocity (10 min.)

Play with the timers in the PULSE mode and the GATE mode, and make sure you understand the difference. Answer the following questions in the space provided.

D. How can you measure average velocity of the cart as it travels between two gates?

E. How can you measure approximately the instantaneous velocity of the cart as it passes through one gate?

F. Suppose you could always start the glider with the same initial speed. What would be the best way to get the most accurate measure of the time it takes for a glider to pass through a gate: Take one measurement? Average several measurements? Take the “middle-most” measurement? (Why?)
Section 3: Measuring Gravity on an Incline (45 min)

Galileo understood that you could reduce the effects of gravity by placing an object on a slope -- that is, by only having a component of the earth's gravity pulling in the direction of motion along an inclined plane. You will basically be doing his experiments with inclined planes with much more precise equipment.

Play around with the air tracks by raising one end and placing a block under it. NEVER INCLINE THE TRACK MORE THAN 10 DEGREES.

Fix your angle of incline for the track. Make it somewhere between 5 and 10 degrees.

G. Determine the angle $\theta$ of your track by measuring distances and using trigonometry. Record your measurements and calculations, draw a sketch, how are you doing this?

In this section you will measures how long the glider takes to travel a given distance, starting from rest. It's very important that the glider always starts at rest. Do not give it a shove -- even a slight nudge will throw off the measurement. Think creatively of ways to let the glider go with a minimal velocity. Describe your technique below:

H. Describe how you should use the photogates to measure how long it takes for the glider to travel from rest to a point 0.25 m from the starting point. (Should you use GATE mode or PULSE mode? One or both photogates? Where should the gate or gates be placed?)
A good test of how well you've succeeded is whether your measurements are repeatable. Below, you will record several measurements for each distance.

I. Measure how long it takes the glider to travel from rest to 0.25 m away. Try taking 4 or 5 measurements and calculate the average time.

J. Pick three other distances. We recommend 50 cm, and 75 cm, and 1 m (or even further if you have room), and measure the time it takes to travel from rest to each of these distances. Again do several trials and take the average.

K. Make a table of the distance traveled (x) versus time (t) for each of your four distances. Do you see a pattern? ("No" is an acceptable answer provided that you justify it.)

L. Add another column to your table for \( t^2 \) (time squared), and record the square of each value of time t. Do you see a relation between (x) and (t^2)? Make a plot of (x) versus (t^2) (graph paper is available in the lab). Make sure to label your axes and use units. Look back at the prelab to help you with this! (The vertical axis is x, the horizontal axis is t^2, don’t flip those)
M. Solve for the acceleration of the glider on the air track using your data and/or graph. Is the value of acceleration along the track greater than or less than the acceleration due to gravity? From your value of acceleration \( a \), compute the acceleration due to gravity \( g \) using

\[ a = g \sin \theta \]

N. Compare your computed value of \( g \) with the known value. How did you do? What are the possible sources of this discrepancy? Please be specific.

O. If you have some time left, play some more with the gliders and air track. Some ideas:
Given your measurements above, predict what the timer will measure in the lower gate when it is switched to GATE mode. Make a quantitative prediction, then try it out!! How’d you do?

There are some masses that you can “stack” on the little pins to the side of the gliders. (Stack symmetrically so it is not tipped) Make a prediction: would this (much heavier!) cart take LONGER, SHORTER, or the SAME amount of time to travel the same distance you used earlier. Think about your reasoning, and then try it out! (What do you conclude?)

Now that it is more massive, go back to part B (gentle push on a level track, measuring time to go through gates), now what do you predict - for the same push, does the cart take LONGER, SHORTER, or the SAME amount of time to travel between gates? Think about your reasoning, and then try it out! What do you conclude?

What other basic experiments can you come up with with this setup?