PHY/ENS 119 EXPERIMENT NO. 2
ACCELERATION

Introduction
In this experiment, we will first learn how to use the computerized lab equipment. Then we will measure the gravitational acceleration constant g, using two related methods.

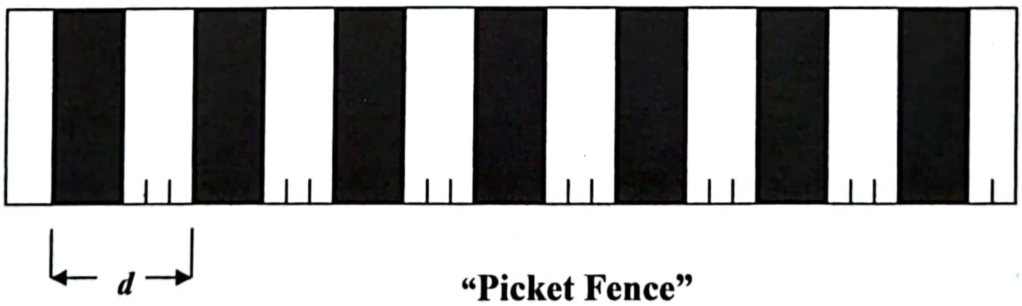
Equipment
One computer, one photogate, one "LabQuest" interface box, one plastic "picket fence" and masking tape, one air track, one glider, one vernier caliper, wooden blocks, one meter stick.

Part I: Free Fall of a "Picket Fence"

Method

By dropping a transparent plastic object with regularly-spaced markings (a "picket fence") through a photogate, we can determine the rate at which the object will accelerate due to the earth's gravitational force. A clear plastic rectangle is marked with black stripes at regular intervals. The marks will block the (infra-red) light beam in the photogate and turn on and off a precision timer in the computer. The times will be recorded in the computer and displayed on the monitor. Using the distance between successive marks and these times, the computer will perform the calculation of the average velocity of the "picket fence" in each of these intervals during the fence's fall. The results can be displayed graphically in various instructive ways.

Procedure



"Picket Fence"

1. Measure the interval d between the two successive leading edges of the tape pieces; i.e., the width of one black strip plus one clear interval. To do this more accurately, measure the distance from the leading edge of the first black strip to the leading edge

of the last black strip and divide it by the number of intervals between them. Why is this more accurate? **Be sure to calculate and record your best determina-tion of *d*.**

2. Check that the computer is turned on, and click on the "Acceleration" file on the desktop. If a "Sensor Confirmation" window comes up, make sure the photogate is plugged into the "LabQuest" interface and click "OK" or "CONNECT" (whichever appears).

3. A series of menus should appear at the top of the screen. Click on the "Data" menu to open it, then click on "User Parameters", and enter your value of d **(in meters!)** from step 2. Enter "4" in the "Places" box (if it is not already there), then click "OK".

4. Now we are almost ready to take data. Click on the "Experiment" menu and then click on "Clear Latest Run" to clear any old data that might be left in the program.

5. Now click the green "COLLECT" button on the toolbar. Hold the "picket fence" just above the photogate and drop it between the arms of the photogate, so that the black strips on the fence will interrupt the infra-red light path. Click the red "STOP" button on the toolbar after the fence has fallen. **Before dropping the picket fence, set up a lab stool to catch the fence after being dropped, so it does not fall all the way to the floor.**

7. A table of elapsed time and corresponding distances and computer-calculated velocities will appear on the screen. (The "Gate State" column indicates whether the photogate was blocked (1) or unblocked (0) as the ruler fell.

8. **Copy down a table of values of velocities and corresponding times** from the computer monitor into your lab book, and make a plot of velocity vs. time. The velocities are put on the "y" or vertical axis, and the times on the "x" or horizontal axis. By eye, fit a straight line through these points. **(Note: this line will not pass through the origin. Why?)** Calculate the slope of your line to determine the gravitational acceleration constant g which is the average rate of change of the velocity of the picket fence as it falls. Next, fit a line that would have a larger slope and one with a smaller slope than the first one (The lines should still fit the data reasonably). These two additional lines should give an indication of the uncertainty in the slope of the first line. Calculate the slopes of the lines and determine the uncertainty as you did in last week's lab. Are error bars appropriate in this plot? How would you determine them?

9. The computer program has the facility to determine the slope of the graphed velocity *vs* time data and should display it. **(If it does not, open the "Analyze" menu and click "Linear Fit".** Record its result in your lab book for this run. Compare the values with the ones you have determined in your lab book from step 8 above. Repeat the experiment four more times to determine four more g values in this way. **You do not need to record the individual velocities in these additional runs.** For each run just write down the g value as calculated by the computer. From these values,

calculate the average gravitational acceleration constant g and its associated uncertainty. How does this value compare with the value given in the textbook? If there is a discrepancy, what could be the possible sources for it?

10. You might try dropping the picket fence from above the photogate to give it a higher initial velocity before breaking the beam. What effect does this have on the acceleration, or the straightness of the line?

Part II: Acceleration of a Glider on an Air Track

Procedure:

1. Turn on the blower and level the air track by carefully adjusting the single leveling screw at one end of the track. When the track is level, the glider should remain nearly stationary in the middle of the track. Be sure to tighten the wing nut on the leveling screw when the track is level. **Please turn off the blower when not actually leveling or doing a run on the air track to minimize noise in the lab! Also be sure the glider is positioned at one end of the track when the blower is off, to insure that the glider LED does not remain on when not doing a run.**

2. Carefully measure and record the width of a wooden block, using the vernier calipers. Put the block under the leveling screw, so that the air track has a slight tilt. Using the meter stick, measure and record the distance between the leveling screw and the support screws on the other end of the glider. You will use this measurement and the block width to determine the tilt of the air track.

3. Remove the ¼" photogate plug from the "LabQuest" interface box and replace it with the ¼" plug from the air track.

4. As in Part I of this lab, the distance from the leading edge of one "picket" to the leading edge of the next must be measured and entered into the computer. **(This distance will *NOT* be the same as it was for the ruler.)** Follow the procedure described in steps 2-9 of Part I, except do not record the velocity data, just record the acceleration a, as determined by the computer fitting program.

5. According to theory, the glider will accelerate at a rate $a = g\sin\theta$, where θ is the tilt angle of the air track. It is not hard to show that $\sin\theta = w/L$, where w is the width of the block used to tilt the glider and L is the distance between the support screws on the air track, so $a = gw/L$. You can use this equation to determine g. **Be sure to determine your uncertainty in your reported value of g.**

Appendix: How to use the Air Track

CAUTION: DO NOT DROP THE GLIDERS OR ANYTHING ELSE FROM A HEIGHT OF EVEN A FEW INCHES ABOVE THE TRACK. DO NOT SLIDE THE GLIDERS ON THE TRACK WHEN THE AIR SUPPLY IS OFF. Always treat this delicate, expensive equipment CAREFULLY.

You will not get good results from the air track unless you plan carefully what you will do.

It is easy to level the air track. Simply place a glider on it and raise or lower the end which has only a single screw by turning that screw until the glider will sit at rest for a few seconds at the center of the track.

Keep all the surfaces of the air tracks and gliders clean. If they get gummed up, ask your TA to have them cleaned with alcohol. The data can be excellent if you perform the measurements with enough care.