Experiment # 4b

Acceleration
Picket Fence II

Principles

Refer to the experiment "Kinematics in x-mode" for necessary discussion of "principles". We shall reproduce the time dependent kinematic equation here, for ready reference:

$$d = v_o t + (1/2)at^2 \qquad \text{..........(1)}$$

For v_o or v to be zero, Eqn. (1) will reduce to:

$$d = (1/2)at^2 \qquad \text{..........(2)}$$

Objective of the Experiment

To determine the acceleration of the given system produced by the given force.

Setting Up

The setting up of the experiment is the same as for the experiment "*Picket Fence I*". We shall, therefore, recall the two equations that were developed there and use them in this experiment.

$$(\Delta t)^2 = \left(\frac{2}{a}\right)[\sqrt{(d+l)} - \sqrt{d}]^2 \qquad \text{..........(3)}$$

$$a = \left(\frac{m}{m+M}\right)g \qquad \text{..........(4)}$$

This experiment *Picket Fence II,* essentially uses the same technique for determining the acceleration of the given system, as is used in the experiment *Picket Fence I.* However, in this experiment, we use an advanced electronic timer that has multiple memories that can all be switched on synchronously but switched off differently. The facility allows us to set up all ten flags, all at once, by using 11 pins. All 11 pins become part of the glider permanently.

The leading edge of the pin in hole # 0, serves as the leading edge for all 10 flags and activates all 10 memories. The leading edge of the pin in hole # 1, shuts off (closes) the first memory only. The other 9 memories ignore the signal and keep running. The leading edge of the pin in hole # 2, closes memory # 2 but the other 8 memories ignore the signal and keep running. This process goes on until the last pin (hole # 10), which closes the last memory (the 10th memory). After the "march past" of the flags, past the infrared beam of the photogate, the timer presents us with 10 values of time t_i for the 10 flags of flag lengths l_i. The *march past* itself takes a few seconds!

With all 11 pins installed in the glider, we get 10 flags as follows. Pins in hole #s 0 & 1 make up the 1st flag, pins in hole #s 0 & 2 make up the second flag, and so on. Finally the pins in hole #s 0 & 10 make up the 10th flag.,

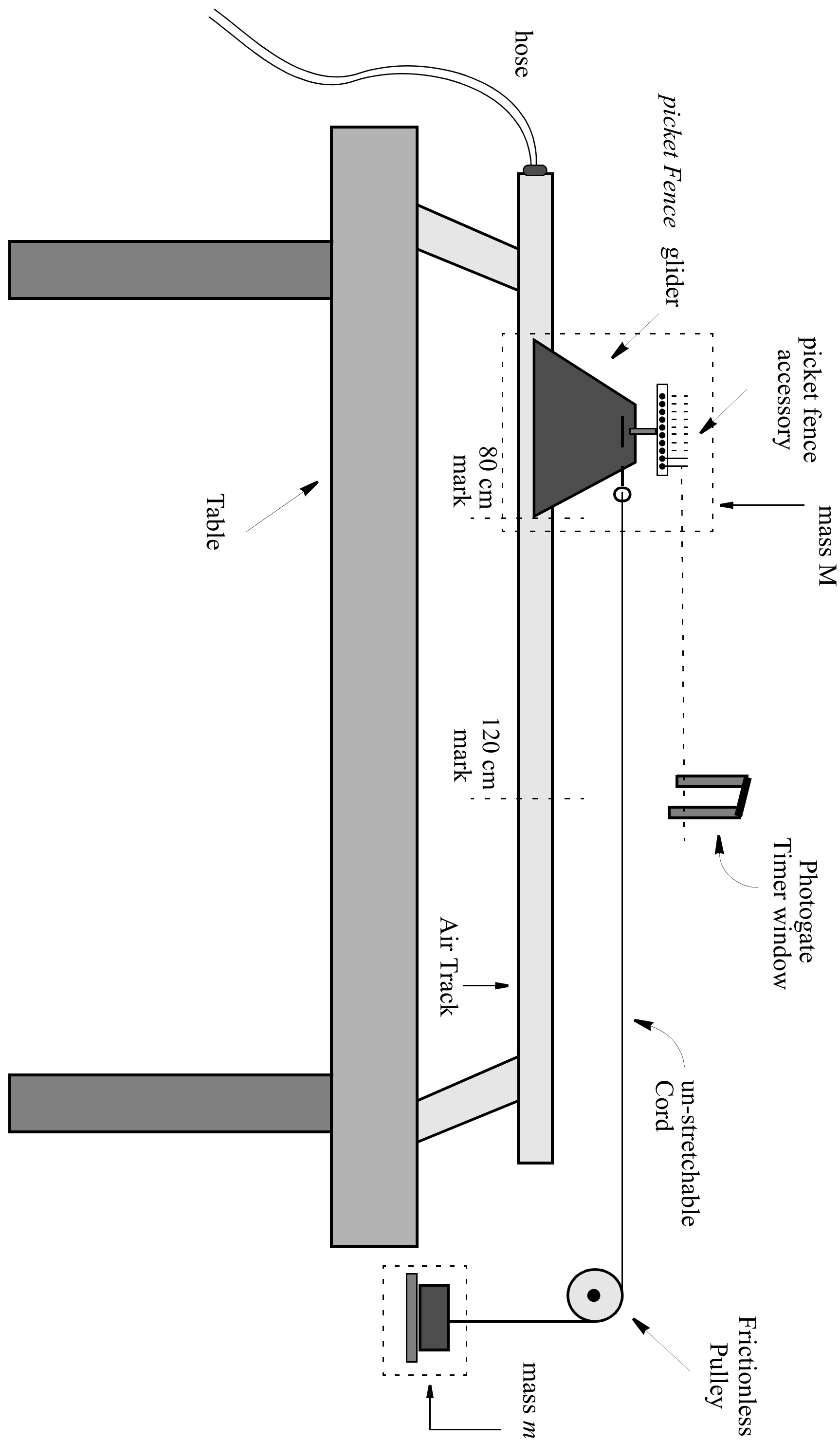


Fig (1) Horizontally Accelerated System

Apparatus Required

(1) Linear air track, with air source

(2) Electronic timer with multiple memories, and the Photogate.

(3) The Picket Fence glider, with 11 pins,

(6) Accessories: masses, mass holder, unstretchable cord, vernier calipers, etc.

Procedure

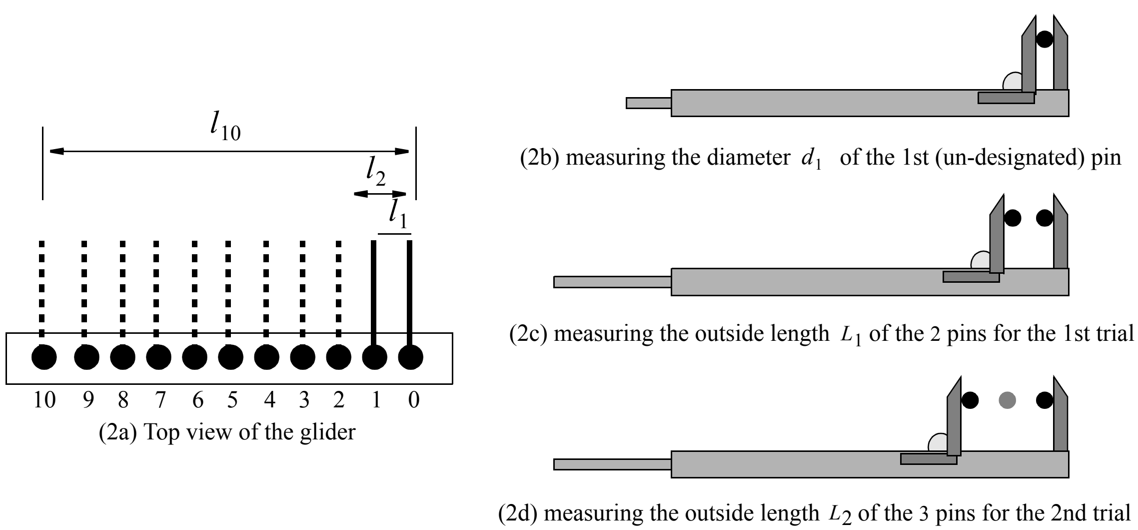
(1) Fig (2a) shows an enlarged view of the picket fence accessory of the picket fence glider. It shows the 11 holes that are numbered from right to left. The right-most hole is numbered zero. All 11 pins are installed. The timer functions as described above.

To measure the lengths of flags, proceed as follows. Select one pin for the zeroth hole and place it in the zeroth hole.

Measure the diameter d_1 of the next (first) pin (using the digital vernier callipers), as shown in Fig (2b) and place it in the next hole (hole #1). Now measure the outside length of the two pins, using the vernier calipers, as shown in Fig (2c). This will be the outside length for the first trial. Call it L_1. Next measure the diameter d_2 of the next (second) pin and place it in the next hole (hole #2). Now measure the outside length of the three pins, as shown in Fig (2d). Call it L_2. Next measure the diameter d_3 of the next (third) pin and place it in the next hole (hole #3). Now measure the outside length of the four pins. Call it L_3.

Continue until you have measured the diameter of the 10th pin, d_{10} and placed it in the tenth hole, *and* measured the outside length of all 11 pins (called L_{10}).

The lengths l_i shown in Fig (2a) are found as $l_i = L_i - d_i$.



(2a) Top view of the glider

(2b) measuring the diameter d_1 of the 1st (un-designated) pin

(2c) measuring the outside length L_1 of the 2 pins for the 1st trial

(2d) measuring the outside length L_2 of the 3 pins for the 2nd trial

Fig (2) Measuring $l_1, l_2, ...l_{10}$

(2) Find the mass of the picket fence glider (with all 11 pins installed), using a digital balance and call it M.

(3) A suggested value of the suspended mass is 25-g. The instructor may prefer to assign a different value. Find the total mass of the suspended mass and the mass holder, using a balance and call it m. Use a digital balance.

(4) Set up the linear air track. Switch on the air flow and, with the glider floating on a cushion of air, level the track. Let the glider be at the 120-cm (or 80-cm) mark and adjust the levelling screws such that the glider stays in a state of rest. Switch off the air flow.

(5) Attach the cord (with the suspended mass at the other end) to the glider and make sure that the cord is parallel to the air track.

(6) With the pin # 0, in the zeroth hole, position the glider such that its right-most (or the left-most) edge is exactly at the 120-cm (or the 80-cm) mark. Now move the photogate (on its stand) to the left (or the right) slowly and carefully. Find the position where the timer *just about* begins to count. Leave the photogate here and do not disturb its position for the rest of the experiment.

(7) Set the electronic timer in the ***Pulse*** mode. Select 4 decimal places for the measurement of time and select ten memories.

(8) With the photogate in place, the timer set, and the glider holding all eleven pins, we are ready for the experiment. The glider now really looks like a picket fence! The starting position for the glider will be the 80-cm (or the 120-cm) mark. The right-most (or the left-most) edge of the glider must coincide with the 80-cm (or the 120-cm) mark. This sets d to be 40-cm exactly

(9) Switch on the air flow and let it stay on all the time.

(10) Hold the suggested edge of the glider gently at the suggested starting position. Clear the timer (or press the start key) and release the glider. Stop it manually soon after it has cleared the photogate. As the glider moves past the photogate window, the timer records all ten values of the time: $(\Delta t)_1$ through $(\Delta t)_{10}$.

(11) Record all ten values of Δt in the data table. If you are using a computer, you may transfer all ten values of time directly to the computer.

(12) Select the 2nd, 3rd,.... 10th value of the suspended mass m, as suggested by the instructor and repeat steps 10 and 11. Transfer data to the computer for processing.

(13) The experiment ends; switch off the timer and unplug it. Switch off the air source and arrange everything neatly on the table.

Note: Air track positions given in parentheses apply if your table position is such that the air inlet hose is on your left hand side.

Calculations & Graphs

(1) Calculate the 10 value of a using the 10 values of the suspended mass m, (or for as many values as you were instructed to carry out) using Eqn (4). This are the "expected" value of a.

(2) For each of the 10 l values, calculate (i) $(d+l)$, and (ii) $[\sqrt{(d+l)}-\sqrt{d}]^2$ You will need to do this calculation only once, irrespective of the number of trials you carried out. This calculation can be done easily on the computer using the Cricketgraph program.

(3) For each trial calculate $(\Delta t)^2$, for each of the 10 flags of one trial. This should also be done on the computer.

(4) Plot the values of $[\sqrt{(d+l)}-\sqrt{d}]^2$ on the x-axis and the values of $(\Delta t)^2$ on the y-axis. Instruct the computer to fit a straight line and print its equation together with the value or r^2, (the coefficient of determination). The equation should have 5 decimal digits.

(5) The slope equals $(2/a)$. Solve it for a. This is the "experimental" value of a.

(6) Repeat steps (3), (4) & (5) for the remaining 9 trials with the remaining 9 values of m, (or for as many trials as you were asked to carry out).

(7) For each trial compare the two values of a and find percent error.

Conclusions and Discussions

Write your conclusions from the experiment and discuss them.

What Did You Learn in this Experiment?.

A hearty and thoughtful account of what you learned in this experiment by way of the principle and the techniques of experimentation, should be given

Data & Data Tables

Name....................................   **Date**..............................

Instructor..............................   **Lab Section**...................

Partner..........................   **Table #**..........................

Total mass of the picket fence glider, M: kg

Total mass of the suspended mass and the mass holder, m_{tot}: kg

The initial distance of the glider from the photogate beam, d: 0.40 m

Table 1: Recording the 10 l values

hole #	d_i (mm)	L_i (mm)	$l_i = L_i - d_i$ (mm)	$l_i = L_i - d_i$ (m)	hole #	d_i (mm)	L_i, (mm)	$l_i = L_i - d_i$ (mm)	$l_i = L_i - d_i$ (m)
1					6				
2					7				
3					8				
4					9				
5					10				

Table 2 Recording the Δt values.

Trial #	m_{tot} kg	$(\Delta t)_1$ (sec)	$(\Delta t)_2$ (sec)	$(\Delta t)_3$ (sec)	$(\Delta t)_4$ (sec)	$(\Delta t)_5$ (sec)	$(\Delta t)_6$ (sec)	$(\Delta t)_7$ (sec)	$(\Delta t)_8$ (sec)	$(\Delta t)_9$ (sec)	$(\Delta t)_{10}$ (sec)
1											
2											
3											
4											
5											
6											
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8											
9											
10											

Additional set of data tables:

Table 1: Recording the 10 l values

hole #	d_i (mm)	L_i (mm)	$l_i = L_i - d_i$ (mm)	(m)	hole #	d_i (mm)	L_i, (mm)	$l_i = L_i - d_i$ (mm)	(m)
1					6				
2					7				
3					8				
4					9				
5					10				

Table 2 Recording the Δt values.

Trial #	m_{tot} kg	$(\Delta t)_1$ (sec)	$(\Delta t)_2$ (sec)	$(\Delta t)_3$ (sec)	$(\Delta t)_4$ (sec)	$(\Delta t)_5$ (sec)	$(\Delta t)_6$ (sec)	$(\Delta t)_7$ (sec)	$(\Delta t)_8$ (sec)	$(\Delta t)_9$ (sec)	$(\Delta t)_{10}$ (sec)
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