Includes Teacher's Notes and Typical Experiment Results

Instruction Manual and Experiment Guide for the PASCO scientific Model ME-6814

012-06293A
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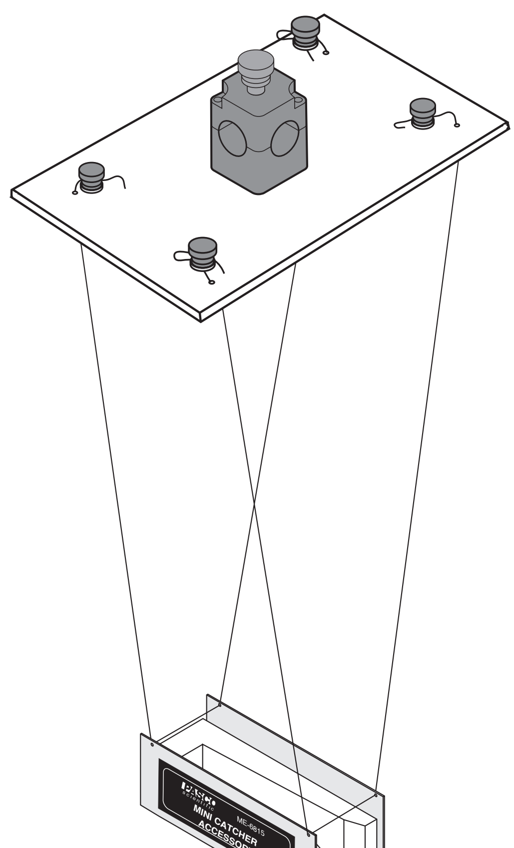
MINI CATCHER ACCESSORY



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Introduction

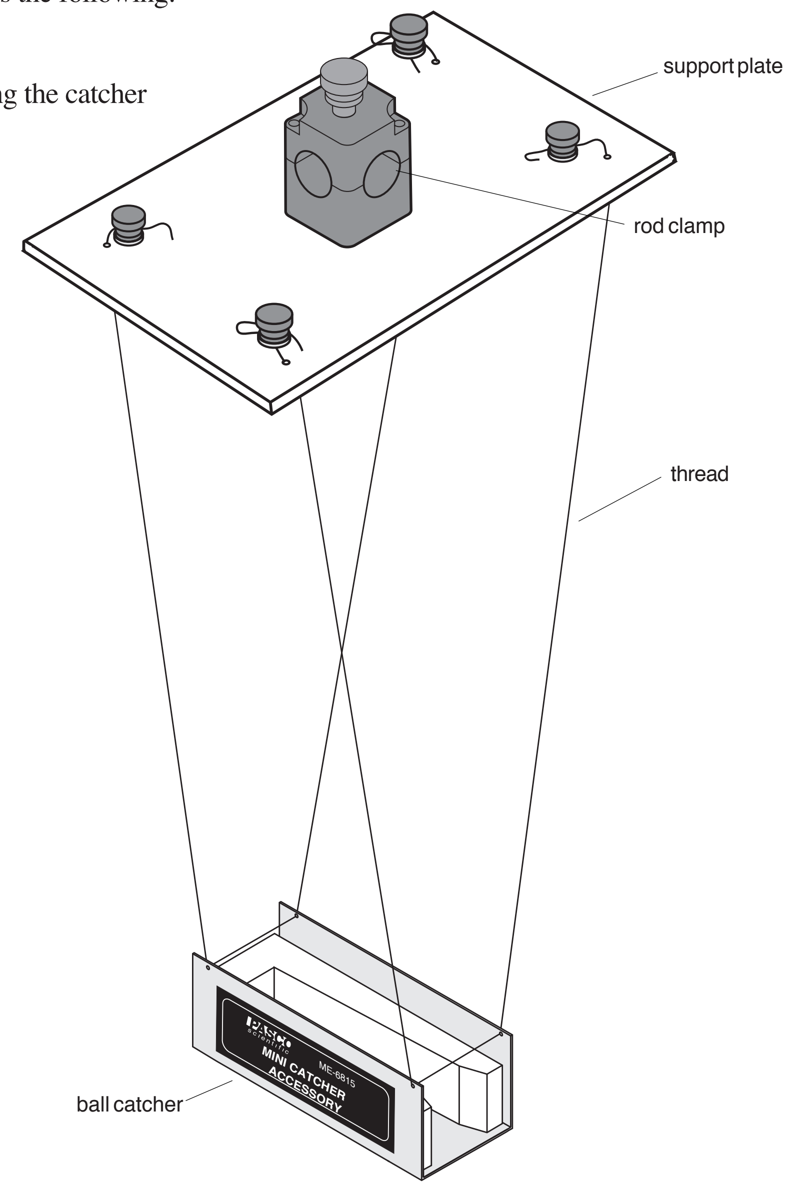
The PASCO ME-6814 Mini Catcher Accessory is used with the PASCO ME-6825 Mini Launcher to perform ballistic pendulum experiments. The Mini Catcher functions as a ball catcher-pendulum. Students can determine the initial velocity of the projectile, the height achieved by the pendulum after ballistic collision with the steel ball fired from the Mini Launcher, and the percent loss of kinetic energy as a result of the elastic collision.

The Mini Catcher Accessory is intended for use in a supervised classroom setting.

Equipment

The Mini Catcher Accessory includes the following:

- a ball catcher
- support plate from which to hang the catcher
- spool of thread
- Velcro® assembly
- (2) chromed steel balls



Ball Catcher Setup

Suspending the Mini Catcher as a Pendulum

Secure the rod clamp on top of the support plate to a support rod that is clamped to the table. Cut two pieces of string, each about one and a half meters long. Thread one string through the front two holes in the ball catcher. Thread the other through the back two holes in the ball catcher. Thread the ends of the strings through the holes in the support plate and secure them, making sure the catcher hangs level. (See Figure 2.)

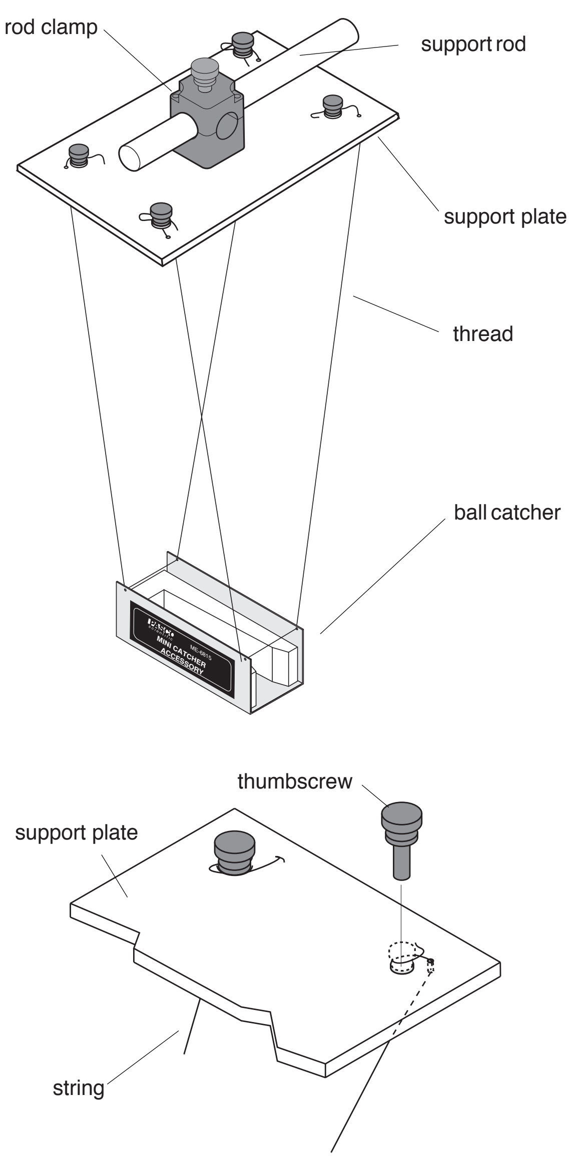


Figure 2. Suspending the Ball Catcher

Velcro Assembly

To enable the user to measure the height to which the pendulum swings, a thread must be connected between the ball catcher and the launcher. The amount of extension of the string shows how far the pendulum swung. One end of the string slips through a Velcro assembly on the Mini Launcher base, and the other end threads through a hole in the ball catcher. (See Figure 3.)

① Separate the Velcro hook and loop strips.

② Cut two square pieces of Velcro hook and one square piece of Velcro loop.

③ Determine the approximate height at which the Velcro assembly will be applied. This is determined by the approximate height of which the ball catcher hangs.

④ Remove the protective covering from the back of each Velcro square.

⑤ Arrange the two square pieces of Velcro hook and one square piece of Velcro loop onto the vertical plate of the Mini Launcher base as shown (Figure 3).

⑥ Cut one piece of Velcro loop 5 – 6 cm long. Do not remove the protective backing.

⑦ Tie a thread to one of the front holes in the ball catcher as shown (Figure 3).

⑧ The other end of this thread will pass between the square piece of Velcro loop (attached to the Mini Launcher base) and the long piece of Velcro loop which should be applied to the three Velcro squares attached to the Mini Launcher base.

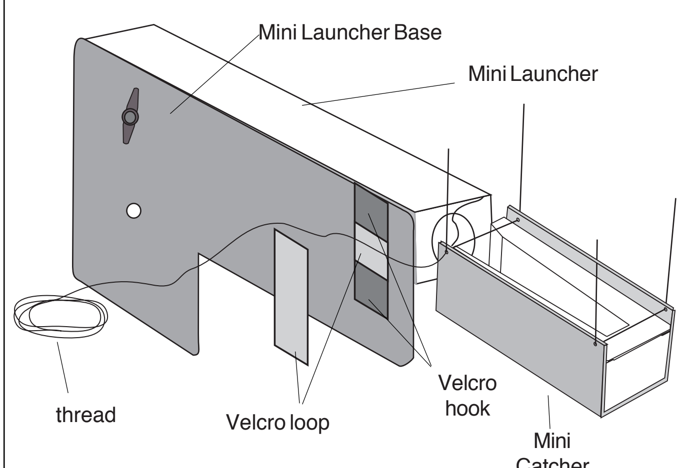


Figure 3. Velcro Assembly

Experiment 1: Ballistic Pendulum

EQUIPMENT NEEDED	
– Mini Launcher and steel balls (ME-6825)	– table clamp
– Mini Catcher Accessory (ME-6814)	– meter stick
– Universal Table Clamp (ME-9376B)	– white paper, carbon paper
– Support Rod (90 cm) (ME-8738)	– plumb bob
– Right Angle Clamp (SE-9444)	– mass balance

optional: Photogates and Photogate Bracket

Purpose

Students will determine the percent loss of kinetic energy as a result of an elastic collision by determining the initial and final velocities of the projectile from the Mini Launcher and by using the laws of Conservation of Energy and Conservation of Momentum.

Theory

A ball is launched horizontally and embeds in the bob of a pendulum. The pendulum then swings up to a particular height, h. (See Figure 1.1.)

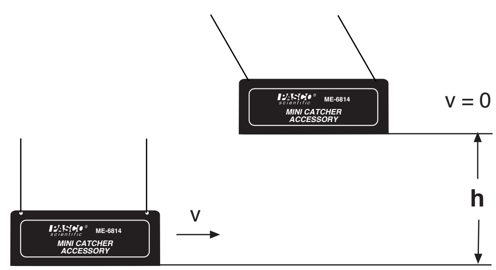


Figure 1.1. Conservation of Energy

Momentum is conserved during the collision, but kinetic energy is not. The momentum after the collision is equal to the momentum before the collision:

$$m_b v_o = (m_b + m_c)v \quad (1)$$

where m_b is the mass of the ball, v_o is the muzzle velocity of the ball, m_c is the mass of the catcher, and v is the velocity of the catcher (and ball) after the collision. (See Figure 1.2.)

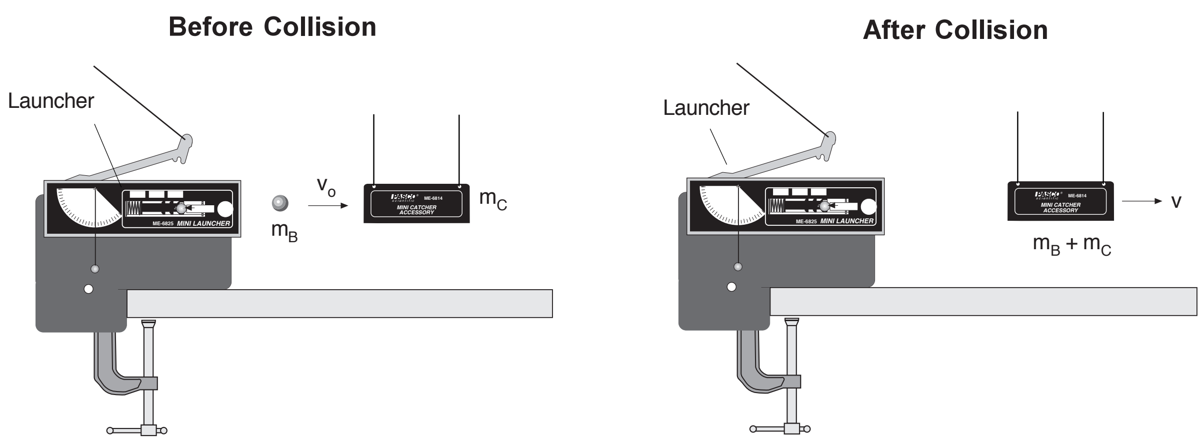


Figure 1.2. Conservation of Momentum

The kinetic energy of the catcher (and ball) after the collision is converted completely to potential energy at the top of the swing:

$$(2) \quad \frac{1}{2}(m_b + m_c)v^2 = (m_b + m_c)gh$$

So to find the muzzle velocity of the ball, we begin with the potential energy of the pendulum at the top of its swing and work backwards from there. From our equation for energy conservation (2):

$$(3) \quad v = \sqrt{2gh}$$

Substitute (3) into the equation for momentum conservation (1):

$$m_b v_0 = \left(m_b + m_c\right)\sqrt{2gh}$$

$$v_0 = \left(\frac{m_b + m_c}{m_b}\right)\sqrt{2gh}$$

For comparison, the initial speed (muzzle velocity) of the ball is determined by shooting the ball horizontally off the table onto the floor and measuring the vertical and horizontal distances through which the ball travels.

For a ball shot horizontally off a table with an initial speed, v_0, the horizontal distance (x) travelled by the ball is given by $x = v_0 t$, where t is the time the ball is in the air. Air friction is assumed to be negligible.

The vertical distance (y) the ball drops in time t is given by $y = \frac{1}{2}gt^2$.

The initial velocity of the ball can be determined by measuring *x* and *y*. The time of flight of the ball can be found using

$$t = \sqrt{\frac{2y}{g}}$$

and then the muzzle velocity can be found using $v_o = \frac{x}{t}$.

Part I: Determining the Initial Velocity of the Ball

Setup

① Clamp the Mini Launcher to a sturdy table near one end of the table. (See Figure 1.3).

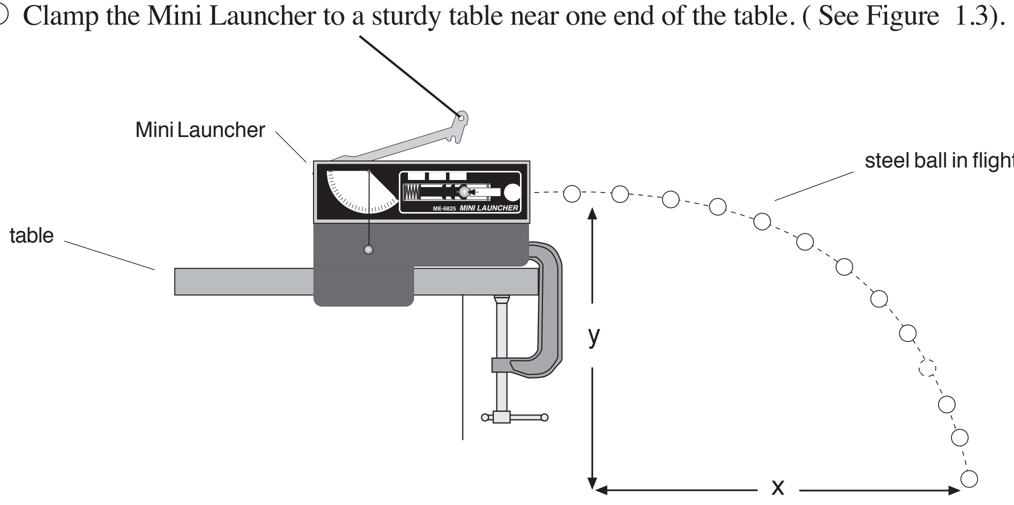


Figure 1.3. Setup for Part I: Determining V_0, method 1

② Adjust the angle of the Mini Launcher to zero degrees so the ball will be shot off horizontally, away from the table onto the floor.

Procedure

① Using the pushrod that came with the Mini Launcher, put the steel ball into the Mini Launcher and cock it in the long range position (three clicks).

> ➤ Important! Never look down the barrel of the Mini Launcher. You can tell whether the Mini Launcher is loaded by looking at the viewing window located on the top front of the barrel. If the window is clear, the Mini Launcher is loaded. If in doubt, place your hand over the muzzle and pull the trigger.

② Fire one shot to locate where the ball hits the floor. At this position, tape a piece of white paper to the floor. Place a piece of carbon paper (carbon-side down) on top of this paper and tape it down. When the ball hits the floor, it will leave a mark on the white paper.

③ Fire about ten more shots.

④ Using a plumb bob as an aid, measure the vertical distance from the bottom of the ball as it leaves the barrel (this position is marked on the side of the barrel) to the floor. Record this distance in Table 1.1.

Find the point on the floor that is directly beneath the release point on the barrel. Measure the horizontal distance along the floor from the release point to the leading edge of the paper. Record in Table 1.1.

Measure from the leading edge of the paper to each of the ten dots and record these distances in Table 1.1.

⑤ Find the average of the ten distances and record in Table 1.1.

⑥ Using the vertical distance and the average horizontal distance, calculate the time of flight and the initial velocity of the ball.

⑦ Record your data in Table 1.1 and Table 1.4.

Table 1.1 Determining the Initial Velocity

Vertical distance (y) = _______________.

Horizontal distance to paper edge = _____________.

Initial velocity (v_0)= ________________.

Trial Number	Distance
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Average	
Total Distance	

Alternate Method: Determining the Muzzle Velocity with Photogates

① Attach the Photogate Bracket to the launcher and attach two Photogates to the bracket. Plug the Photogates into a computer or other timer.

② Put the ball into the Mini Launcher and cock it to the long range position.

③ Run the timing program and set it to measure the time between the ball blocking the two Photogates.

Shoot the ball three times and take the average of these times.

Record in Table 1.2.

Use a distance between the Photogates of 10 cm, to calculate the initial speed and record it in Table 1.2 and Table 1.4.

Table 1.2 Initial Speed Using Photogates

Trial Number	Time
1	
2	
3	
Average Time	
Initial Speed	

Part II: Ballistic Pendulum

Setup

① Find the masses of the ball and the catcher and record in Table 1.3.

② Suspend the ball catcher as a pendulum as explained in the general instructions.

③ With the Mini Launcher mounted as in Figure 1.4, clamp the suspended ball catcher directly in front of the muzzle.

④ Attach a thread to the ball catcher and string it through the Velcro assembly (see the general instructions) on the base of the Mini Launcher.

Procedure

① Load the Mini Launcher with the steel ball on the long range setting. Fire a test shot to see how far out the thread is pulled. Pull a few centimeters of the thread back through the Velcro, leaving the rest of the thread slack between the Mini Launcher and the catcher. When the ball is shot into the pendulum again the thread will

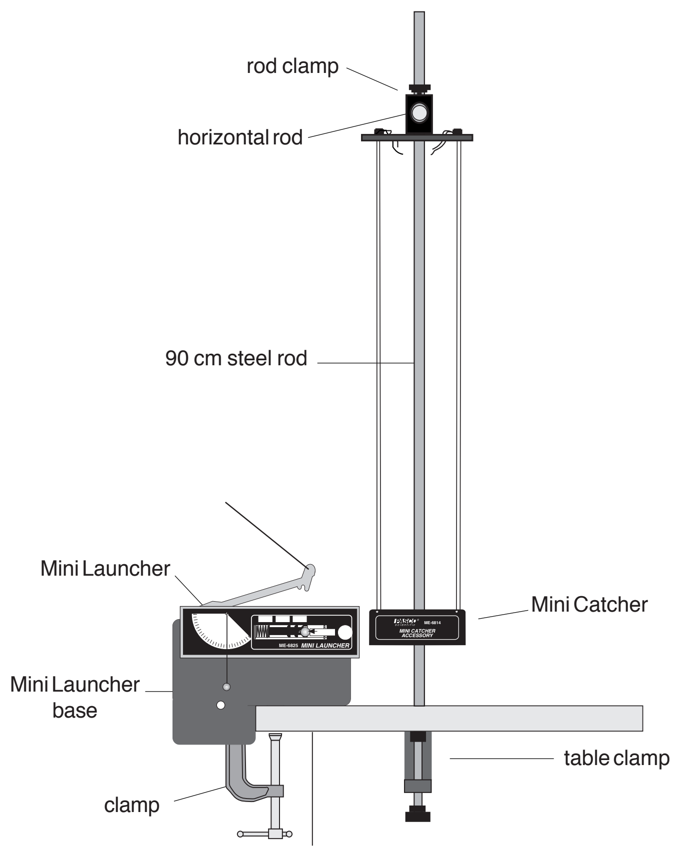


Figure 1.4. Setup for Part II

become taut just before the catcher reaches its maximum height. This reduces the effect of friction on the thread.

② Anchor the string on the Mini Catcher base with a piece of tape and measure the perpendicular distance from the bottom of the Mini Catcher to the table.

③ Fire the ball into the pendulum five times. After each trial, pull the pendulum back until the thread is taut and measure the height above the level of the muzzle to which the pendulum swung. Record in Table 1.3.

Analysis

① Calculate the average of the heights in Table 1.3 and record the result in Table 1.4. Using the average height, calculate the velocity immediately after the collision and record it in Table 1.4.

② Using the velocity calculated in the previous step and the masses, calculate the muzzle velocity of the ball and record in Table 1.4.

③ Calculate the percent difference between the muzzle velocities found in Parts I and II. Record in Table 1.4.

Table 1.3 Ballistic Pendulum Data

Mass of Ball = _____________.

Mass of Catcher = __________.

Height

Table 1.4 Results

Average Height	
v_0, Method 1 (Part I)	
v_0, Method 2 (Part II)	
v (ball + catcher)	
KE before collision	
KE after collision	
% difference in KE	

Questions:

① What percentage of the kinetic energy is lost in the collision? Use the masses and velocities to calculate this percentage:

$$\%\ Lost = \frac{KE_{before} - KE_{after}}{KE_{before}}\ x\ 100\%$$

② Where did the kinetic energy go?

Notes

Teacher's Guide

Experiment 1

Hints for successful data collection (Part II):

- Be sure that the Mini Catcher is level and hanging close to, but not touching, the Mini Launcher.
- Check to be sure the muzzle is aligned with the foam pad.
- Be sure the string moves freely in the Velcro assembly.
- Check to be sure the support plate is perpendicular to the table.
- To be sure any force exerted by the string attached to the Mini Catcher is minimized, leave enough slack in the string to necessitate its being pulled only a few centimeters at the top of the swing of the Mini Catcher.
- Be sure to tape the string to the Mini Launcher base after firing the Mini Launcher and before measuring h.
- Be sure students are using for their velocity calculations in Part II the Δh of the bottom of the Mini Catcher, not the absolute height above the table top of the bottom of the Mini Catcher.

A Sample Data Set:

mass of steel ball = .016 kg

mass of Mini Catcher = .024 kg

ave. Δh = 0.16 m

y = 0.77 m

x = 1.8 m

v_0 (Part I) = 4.5 m/s

v_0 (Part II) = 4.4 m/s

K.E. before collision = 0.15 Joule

K.E. after collision = 0.063 Joule

Loss of K.E. = 58 %

Question 2:

The remainder of the K.E. was converted primarily to heat energy that was dissipated in the foam pad. Other potential contributors to kinetic energy loss include torque in the swing path of the Mini Catcher and potential energy in the elastic deformation of the foam pad by the steel ball.

Notes

Technical Support

Feedback

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