Bouncing with Momentum

Introduction

The collision of objects is a great way to demonstrate the conservation of momentum. Engage students by having them drop and collide toy balls of different mass and size. The results may be surprising! This inquiry-based activity will really get your students thinking about momentum.

Concepts

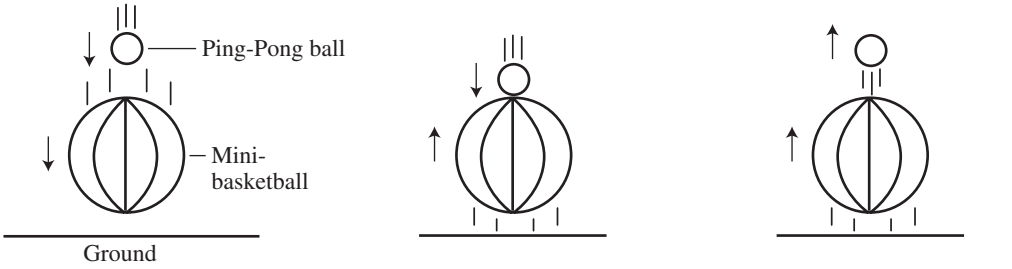
- Collisions
- Conservation of momentum
- Elasticity

Background

When an object is in motion, it has a property known as *momentum*. Momentum (p) is calculated by multiplying the mass (m) of the object by its velocity (v); $p = mv$. A fundamental principle of physics is that the momentum of an isolated system of objects always remains constant. This is known as the *conservation of momentum*. If objects within a system collide, the momentum of each individual object before and after a collision may change, but the total momentum of the system will remain constant.

There are two types of collisions—elastic and inelastic. An elastic collision occurs when objects collide and then separate after the collision. An example of an elastic collision is the collision between a baseball and a bat. An inelastic collision is when objects collide, stick together, and move as one object after the collision. An example of an inelastic collision is when a baseball hits a catcher's mitt and stops. In every collision, elastic or inelastic, momentum is always conserved.

In this activity, a Ping-Pong ball and a mini-basketball will be dropped simultaneously, creating an elastic collision. The collision is created by holding the Ping-Pong ball over the top of a mini-basketball and releasing both at the same time. This is shown in Figure 1. The mini-basketball will hit the surface below and rebound, colliding with the Ping-Pong ball. When the balls collide, the momentum of the more massive mini-basketball is imparted to the Ping-Pong ball. Although the momentum of the system is conserved, the Ping-Pong ball will have a larger velocity due to its small mass.



a. Drop

b. Collision and rebound of mini-basketball

c. Collision of Ping-Pong ball and mini-basketball

Figure 1.

Materials

Basketball, mini, 3¾" diameter
Buret clamp
Meter stick
Ping-Pong ball
Support stand

Safety Precautions

Wear safety glasses. The goal is to launch the various balls vertically, but the launch direction will be random and may occasionally be at an angle or horizontal. Be sure all students are wearing eye protection before performing the double-ball drop.

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Procedure

1. Set up the support stand, buret clamp, and meter stick as shown in Figure 2.
2. Line up the bottom of the mini-basketball with the 20 cm mark on the meter stick. *Note:* For each ball drop, the release height will be 20 cm from the tabletop to the bottom of the lowest ball.
3. Drop the mini-basketball from 20 cm. Observe and record the maximum rebound height. Perform three more trials.
4. Repeat steps 2–3 using the Ping-Pong ball.
5. Line up the Ping-Pong ball on top of the basketball as shown in Figure 3. The Ping-Pong ball should be nearly touching the basketball. Make sure the center of the Ping-Pong ball is vertically aligned with the center of the mini-basketball.
6. Line up the bottom of the mini-basketball 20 cm above the tabletop and then release both balls at the same time. Observe the flight of the rebounding Ping-Pong ball. *Note:* The balls may launch at random angles. Make sure to wear safety goggles.
7. Practice steps 5 and 6 until the Ping-Pong ball launches nearly straight up along the path of the meter stick. It may take several attempts to obtain vertical rebounds that are repeatable.
8. Once two or three vertical rebounds are successfully completed, repeat steps 5 and 6 to obtain quantitative data for a total of four trials. Measure and record the maximum rebound height of the Ping-Pong ball for each "successful" trial. (A "successful" trial is one in which the Ping-Pong ball launches nearly straight up along the meter stick.) *Note:* Even after becoming proficient in generating successful vertical rebounds, not every trial will respond as expected. Be patient and work slowly to obtain quality results. Overall, it may take multiple ball drops to obtain four measurable heights.
9. Create new ball combinations using other balls such as tennis balls or golf balls. Repeat steps 2–8 for the new ball combinations and record four quality data trials for each ball combination.
10. Analyze the data to figure out what combination launched the top ball the highest.

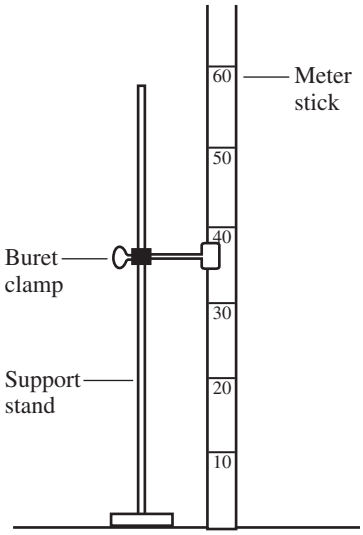

Figure 2.

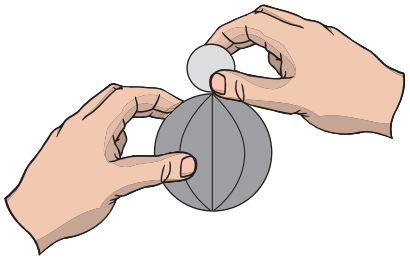

Figure 3.

Disposal

The materials may be saved for future use.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
MS-PS2 Motion and Stability: Forces and Interactions
PS2.A: Forces and Motion
PS2.B: Types of Interactions

Disciplinary Core Ideas: High School
HS-PS2 Motion and Stability: Forces and Interactions
PS2.A: Forces and Motion
PS2.B: Types of Interactions

Science and Engineering Practices
Developing and using models
Constructing explanations and designing solutions

Crosscutting Concepts
Cause and effect
Structure and function

Tips

- For further concept development try the Flinn Scientific "Basketball Blasters" Student Laboratory Kit (Catalog No. AP6915). This kit comes with mini-basketballs, marbles, Ping-Pong balls, rubber balls, student worksheets, background information, and complete instructions. It contains enough materials for thirty students working in pairs.
- To obtain the best height, the two dropped balls must be close to, but not touching, each other as the bottom ball collides with the ground.
- Demonstrate a triple-ball drop using different types of balls, such as a regular-sized basketball as the bottom ball and a tennis or racquet ball as the middle ball with the Ping-Pong ball on top. Use extreme caution when performing this demonstration—the top ball can fly anywhere. All students should wear safety glasses during this demonstration.
- Have the students develop an equation for the speed of the top ball using the conservation of momentum and conservation of kinetic energy expressions.

Sample Data Table 1. Individual Ball Drop

Ball	Release Height	Maximum Rebound Height				
		Trial 1	Trial 2	Trial 3	Trial 4	Average
Basketball	20 cm	5 cm	7 cm	10 cm	11 cm	8 cm
Ping-Pong Ball	20 cm	16 cm	16 cm	17 cm	16 cm	16 cm

Sample Data Table 2. Double Ball Drop

Bottom Ball	Top Ball	Release Height	Maximum Rebound Height				
			Trial 1	Trial 2	Trial 3	Trial 4	Average
Basketball	Ping-Pong ball	20 cm	90 cm	80 cm	80 cm	77 cm	82 cm

Materials for *Bouncing with Momentum* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP6915	Basketball Blaster—Student Laboratory Kit
AP8294	Meter Stick, Hardwood, English/Metric
AP8354	Single Buret Clamp, Plain Jaw
AP4550	Support Stand, Economy Choice

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.