611-0380 (40-416) Happy/Sad Balls

Warranty and Parts:

We replace all missing or defective parts free of charge. For additional parts, use part numbers above. We accept American Express, Mastercard, Visa, checks, school P.O.'s. All products guaranteed free from defect for 90 days. Does not include accident, misuse, or normal wear and tear.

Description:

This pair of balls, 1" in diameter, can be used in a variety of experiments to demonstrate the difference between elastic and inelastic collisions. While they look identical, the "Happy" ball bounces and the "Sad" ball does not.

The "Happy" ball is made of natural rubber; the "Sad" ball of polynorbornene rubber. Polynorbor- nene has strong impact absorption and little resonance occurs by external vibrations. It absorbs inputted energy and dampens the impact from a colliding object without causing the object to react. It is characterized by low restitution elasticity (around 3%); especially good energy absorption under normal temperature ranges of 10 to 30°; and the ability to absorb high frequency vibrations extremely well.

Lab Activity I

Objective:

1. Explore properties of bouncing balls
2. Measure and understand the elasticity coefficient for a bouncing ball
3. To understand the role of energy conservation involving bouncing balls

Comparison of Mechanical Properties

Feature	Natural Rubber (Happy)	Polynorbornene (Sad)
Tensile Strength (kg f/cm^2)	162	105
Stretch (%)	650	800
Hardness (JIS A)	45	60
Specific Gravity	1.10	1.27

Materials Needed:

- Happy balls and meter sticks
- Variety of other balls

i.e. ping pong balls, tennis ball, foam ball, racket ball, rubber ball, wooden ball, steel ball etc.

Procedure:

1. Drop a ball from a measured height $\mathbf{h_0}$ of about 1 meter. The ball will recoil to a height $\mathbf{h_1}$ where $\mathbf{h_1}$ is less than $\mathbf{h_0}$. The ratio $\mathbf{r = h_1/h_0}$ is the *elasticity coefficient* of the ball. Drop the ball from several different heights and measure the bounce heights. Record your data.
2. When the ball is dropped from a different initial height $\mathbf{H_0}$, it will bounce to a corresponding height $\mathbf{H_1}$ where $\mathbf{r = H_1/H_0}$ is the same for each bounce. This means that the coefficient of restitution **r** determines the ration of the "drop height" to the "bounce height" for the ball from the surface. The elasticity coefficient represents the fraction of the mechanical energy of the ball that remains after the bounce, the remaining fraction being converted into heat and acoustic energy. In principle, both ball and surface become warmer due to the bouncing process.
3. If the ball bounces several times in succession, heights $\mathbf{h_0, h_1, h_2, h_3, h_4, h_5}$ ... become smaller by the same ratio: $r = h_1/h_0 = h_2/h_1 = h_3/h_2 = h_4/h_3 = h_5/h_4$...
After 10 - 20 bounces, the ball stops bouncing.
4. Take the box of balls and drop each ball from a height of 1.00 meters. Despite the wide variety of bounce heights, the balls that have the same constitution bounce to a similar height, independent of their size.

Variations:

- Bounce the Happy ball back and forth about a central location. Release from a given height with both a spin and a horizontal speed.
- Throw the happy ball off a smooth horizontal surface and then under a table. Note the ball usually comes back to you, like a boomerang. Why?

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Lab Activity II

Objective:

1. To observe a ball bouncing off a hard surface one time, or sequentially
2. To study how the ball bounces
3. To describe and explain the motion of the ball

Method:

The first part of this lab involves making careful, qualitative observations of a single bounce. Next, students in teams take a ball and measure quantitatively how high it bounces when dropped from a given height. Categorize various types of balls as to how much they bounce. Analyze a single ball as it bounces several times. Study the progressive decrease in heights to which it goes.

Qualitative Study Procedure:

1. Bounce a ball a number of times off a table or bench, catching it on first bounce. Ask for descriptions. Make a list of qualitative observations. For example:

- Ball is released from rest and picks up speed until it hits the surface and bounces off
- After bouncing off the surface, the ball comes back up to a height which is less than the height at which it started
- The higher the distance from which the ball is dropped, the higher it will bounce.
- The ball makes very brief contact with the table and leaves nearly instantaneously
- The ball makes a sound as it hits, which changes with the height from which it is dropped
- The ball may bounce differently when it hits different points on the table.

Quantitative Study Procedure:

1. Give each student a ball to drop from height **h** of one meter and measure distance **d** to which it bounces upward. Arrange results according to the types of balls. Discuss which balls bounce well and why.
2. Have each student release the ball from several heights [**h** = 50 cm, 75 cm, 100 cm, 125 cm, 150 cm etc.] and measure the distance **d** to which it bounces. The ratio **d/h** - termed the elasticity coefficient - should be roughly the same for each height.
3. Allow a given ball to bounce several times after being released from an initial height **h**. Measure the sequence of bounce heights, $\mathbf{d_1}$, $\mathbf{d_2}$ $\mathbf{d_3}$ **....** The bounce height reduces by roughly the same factor, the coefficient of restitution:

$$\mathbf{d_1/h = d_2/d_1 = d_3/d_2 = ...}$$

Discussion:

The ball begins at rest from height **h** with potential energy **mgh**, where **m** is its mass and **g** the acceleration due to gravity. On first bounce is reaches height **d**, corresponding to potential energy **mgd.** The coefficient of restitution, **d/h**, is the fraction of mechanical energy remaining after first bounce.

Energy is dissipated in the form of heat and acoustical energy. This demonstrates the principle of conservation of energy as a consequence of the symmetry of the basic interaction under translations in the time coordinate.

Variation:

- Bounce a ball across the room to a helper so it strikes the floor several times. Draw the ball's trajectory, describing its motion as completely as possible.

History of Rubber Processing:

Although the rubber-making process is considered to have been invented in England in the mid-19th century, new evidence suggests that that date may be off by as many as 3,800 years. Rubber apparently was used to make balls in an ancient Indian culture in the New World - the Mayan society which flourished in the Yucatan peninsula in Mexico from 2000 B.C. to the 16th century AD.

Proof of the Mayan mastery of rubber is found in the records of the Spanish Conquistadores. They were so intrigued by solid rubber balls made by the Mayans that they brought back a few samples to show King Carlos V. At that time, the only balls known in Europe were made of leather and feathers and bounced poorly.

The Mayans made their rubber by collecting sap or latex from the rubber tree and adding sulfur and heat. They mixed the latex with juice from a morning glory vine and stirred for 15 minutes. The hot climate approximated the heat which is added to the modern recipe for rubber.

It is unknown exactly how the Mayans' ball games were played or when they developed. Illustrations on pottery and reports from the Spanish explorers give us some hints, however. In one game, a small ball was struck by a stick. In another, a larger ball was thrown through an overhead hoop.

Related Products:

Science First manufactures a variety of low-cost labs that are available from most science distributors.

40-120 Collision in One Dimension: Propel a steel ball down an aluminum channel track, hit balls further down. Observe how far and how many balls move as a result of this collision. Includes track and molded plastic supports, 5 balls, instructions.

40-330 Variable Inertia: Load two plastic discs with balls, roll together down an incline. Instantly change distribution of mass with 8 balls that can be inserted into your choice of compartments. Which is faster - the one with the mass toward the center or toward the rim? Why?

30-205 Leaning Tower of Pisa : A fast, intriguing lab in stability. Contains 4 cylinders, 2 metal, 2 plastic. Place cylinders on support rod, stand "tower" on a book, tilt the book and measure at what angle the "tower" falls. Does it make a difference if the metal cylinders are on the bottom? Instructions.