

Lab Manual
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INTRODUCTION

If a ball is dropped onto a surface, the speed that it rebounds with will be less than the speed it had when striking the surface. The coefficient of elasticity (also called the coefficient of restitution) is a measure of the ratio of the speed just after striking the surface to the speed just before striking the surface.

Read:

- **University Physics Volume 1 Chapter #6: LINEAR MOMENTUM AND COLLISIONS**
- [Theory of collisions](#)

If a ball is dropped onto a surface, the speed that it rebounds with will be less than the speed it had when striking the surface. The coefficient of elasticity (also, called the coefficient of restitution) is a measure of the ratio of the speed just after striking the surface to the speed just before striking the surface. As speeds are not as easy to measure as displacements, it is convenient to express the coefficient of elasticity in terms of lengths. The initial energy of the ball is all potential energy and is given by mgh . The final energy of the dropped ball is all kinetic and is given by $\frac{1}{2}mV^2$. Setting these energies equal and solving for V gives:

$$V = \sqrt{2gh}$$

A similar analysis applies to the ball as it rebounds from the surface.

Immediately after striking the surface, the energy of the ball is all kinetic and is given by $\frac{1}{2}mV'^2$ where the symbol ' denotes a final, rather than an initial, value. At the end of the rebound, this kinetic energy has converted into potential energy given by mgh' . The setting these energies equal and solving for v gives:

$$V = \sqrt{2gh}.$$

We can now express the coefficient of elasticity in terms of heights rather than velocities. The coefficient of elasticity is defined as $e = \frac{V'}{V}$.

In a case where frictional forces can be neglected and the object is dropped from rest onto a horizontal surface, this is equivalent to:

Substituting the expressions, we found for V' and V into this definition gives:

$$e = \sqrt{\frac{h'}{h}}.$$

So, to find the coefficient of elasticity of a ball we need only drop the ball from an initial height h , and measure the height to which it rebounds, h' .

MATERIALS

- Five balls made of different materials

- A meter stick

PART ONE: COEFFICIENT OF ELASTICITY

PROCEDURE

1. Select a hard surface that will not be damaged by dropping each ball from a height of about 1 meter.
2. Drop each ball and record the height to which it rebounds.
3. Repeat seven times for each ball and record the measurement on your data table.

DATA ANALYSIS

1. Using your measurement data, calculate the arithmetic mean for the height for each ball and record this value on your data table.
2. Calculate the relative error of your measurement for the height
3. Calculate the coefficient of elasticity, e , for each type of ball.
4. Determine the best estimate of the error the coefficient of elasticity
5. Calculate $1 - e^2$ for each ball. This represents the fraction of kinetic energy lost in the collision. (If you multiply this fraction by 100% you have the percentage of kinetic energy lost in the collision). As a challenge, using the equations for kinetic and potential energies, attempt to prove that $1 - e^2$ is the fraction of kinetic energy lost in the collision.
6. Do an internet search to find estimated values for the coefficient of elasticity (or restitution) for the types of balls used in this experiment or for other common types of balls (e.g., basketball, tennis ball, golf ball, etc.).
7. Calculate the percent error of your experimental result.

PART TWO: COLLISIONS IN TWO DIMENSION

We going to use the [online simulation](#) which represents two dimension collisions. The simulation allows changing mass of each of the bolls, add more than two bolls for the impacts, analyze the elastic and inelastic collisions. Try various values for masses and the option for the elastic and inelastic, see what happens.

PROCEDURE DATA ANALYSIS

1. Use “Advanced” simulation. Change the mass of each balls three times for the total elastic collisions.
2. Create the Data Table and record all data on it.
3. Derive the equation of Force of impact during collisions.
4. Calculate the impact Force, and define the direction of this Force.
5. Calculate the Coefficient of Restitution for only one impact during the elastic collisions.

6. Change the mass of each balls three times for the inelastic collisions.
7. Record your data on the Data Table.
8. Calculate the impact Force, and define the direction of this Force.
9. Calculate the Coefficient of Restitution for each impact in the inelastic collisions.
10. For the inelastic collision, plot the kinetic energy fractional change, $D_k(\%)$ vs.

$$x = \frac{m_1}{m_1 + m_2}$$

Since the collision is inelastic, the initial KE is not equal to the final KE .
the kinetic energy fractional change:

$$D_k(\%) = \frac{KE_f - KE_i}{KE_i}$$

11. What are the slope and intercept of a straight line fit to these data? Does a straight line fit these data reasonably? What was the average loss of the kinetic energy in this part of the experiment?
12. Discuss the Coefficient of Restitution in the elastic collisions compare of the Coefficient of Restitution in the inelastic collisions.