Exp-2: Bouncing Ball experiment

OBJECTIVE:

1. Observe the potential and kinetic energy conversion and dissipation of total energy due to friction, etc.
2. Observe the coefficient of bouncing for different balls.

APPARATUS:

Meter scale, Tape, Assorted types of balls, for example tennis ball, golf ball and table tennis ball

THEORY:

The Law of Conservation of Energy states that energy cannot be created or destroyed, but can be transformed**.**

In the Bouncing Ball Drop experiment, we would see energy transformation.

Before dropping a ball, you must lift it up from its' resting surface. When you do this, you are transferring energy from your muscles to the ball. You are giving the ball **potential energy**, specifically **gravitational potential energy**.
Gravitational potential energy (PE) is the energy gained by an object as its height above ground level increases. An object's GPE is determined using this formula:

PE = *height* × *mass* × *acceleration due to gravity, g*

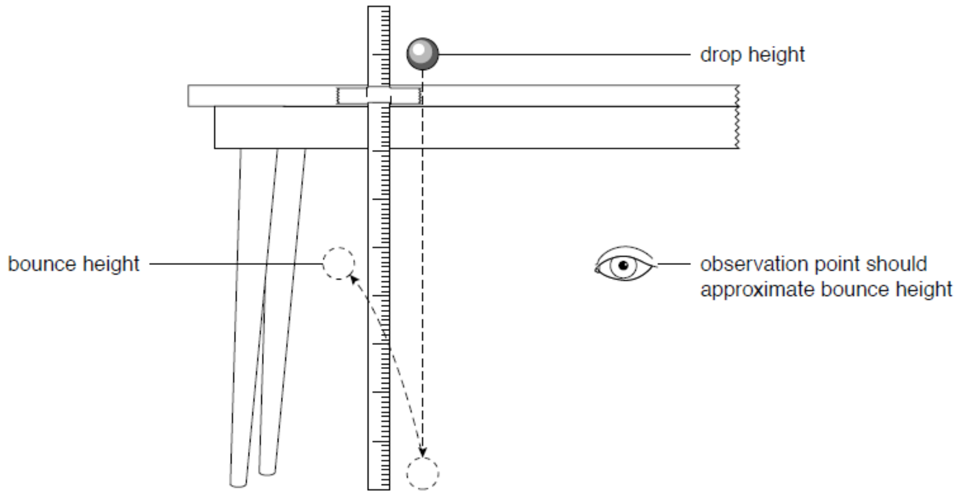
Objects that are the same weight will gain more GPE the higher they are positioned. If one object is heavier than the other at the same height, the heavier object will have more GPE.

As the ball falls towards the ground, its gravitational potential energy is transformed into **kinetic energy (KE)**.
Kinetic energy is the energy of mass in motion. An object that has motion (velocity *v*) no matter the direction has kinetic energy.
KE = $\frac{1}{2}mv^2$
The kinetic energy of the ball will continue increasing as the ball gains momentum, until it finally collides with a surface (floor).

At the floor, PE must equal the kinetic energy on impact, PE = KE, thus velocity of the falling ball, $v = \sqrt{2gh}$
Newton's third law says that the floor will then push back on the ball, sending it rising. Thus KE will transform to PE again to send the ball at bounce height.

For an ideal case of **elastic collision** the ball would reach the drop height after the bounce.

However, a ball dropping (not thrown) is an example of an **inelastic collision** where part of the kinetic energy is changed to some other form when colliding with a surface. Thus a ball that is dropped **never** bounces back up to the original height, and will rise less with each bounce.



When a ball hits a surface, some energy is transformed into *sound energy*, some is transformed into *thermal energy* from the friction created, and some becomes *elastic potential energy* resulting from the instantaneous deformation of the ball when it collides.

Now due to the elastic PE the ball is able to bounce, or rebound. When the ball bounces back up from the ground its elastic PE is converted back into KE. At the bounce height KE again converted to gravitational PE as the ball resumes its original shape. In this experiment you would see how the velocity of the ball changes before and after the impact with the floor.

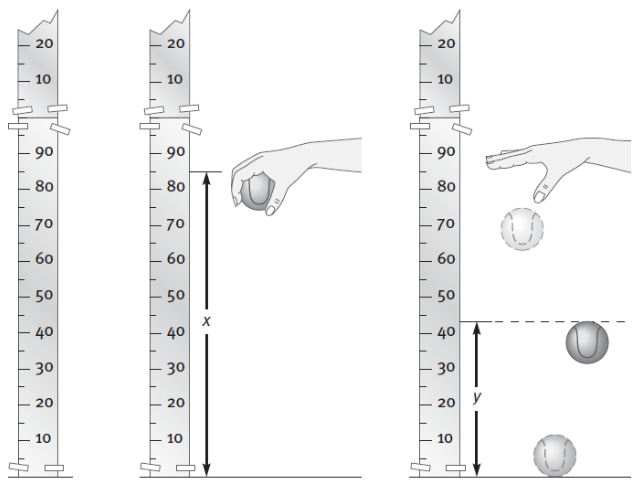
Some balls, however, are more efficient in how they store and release their elastic PE than others. The more efficiently a ball stores and converts elastic PE back into KE, the higher the ball bounces.

For a ball the ratio of drop height and bounce height (= H_1 / H_2), which we call the coefficient of bouncing, should be roughly the same for each height. In this lab you would see the efficiency of ball bouncing for different balls.

In the ball dropping experiment the total mechanical energy, E = KE + PE decreases with each bounce of the ball. In this lab you would see that with each successive bounce, it dissipates more energy to friction, air resistance and heat.

PROCEDURE:

1. Measure the mass of each ball by using the top pan balance.
2. Divide the activities so that one student drops the ball, one student watches the bounce and estimates the height to which it bounces, and one student records the data. Tape/hold the scale to the edge of a table (you need to do this on a hard surface).
3. The height to which the ball bounces is to be estimated as carefully as possible. Both the height of drop (H_1) and the height of bounce (H_2) should be recorded in data Table A.

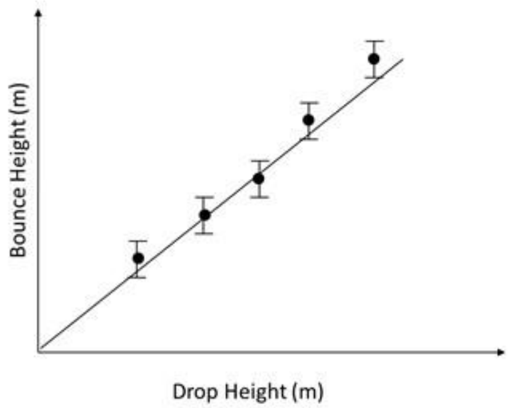


4. Select one ball, for example table tennis ball and drop the ball and record how high it rebounds.
5. Drop the ball at least five times and average of the bounce heights.
6. Find the potential energy of before it dropped, $PE_1 = m\ g\ H_1$ (J) and potential energy of ball after one bounce, $PE_2 = m\ g\ H_2$ (J)
7. Find the velocity of falling, $v_1 = \sqrt{2gH_1}$ and velocity of bouncing, $v_2 = \sqrt{2gH_2}$
8. Calculate the KE during falling and bouncing, and record in Table B.
9. Now repeat this whole process for each of the other balls, and record in Table B.

<u>Study of bouncing coefficient</u>

10. Take the table tennis/golf ball and drop the ball from different dropping heights (mentioned in the table C).
11. Both the height of drop (H_1) and the height of bounce (H_2) should be recorded in data Table C.

12. Draw a graph of bounce height (H_2) vs drop height (H_1), use the standard deviation values as error bars.
13. Draw a best fit line for the data points. Note: This is NOT a line drawn to connect each point. It is a line which best shows the relationship involved - in this case a straight line.



14. Use the graph to predict the height of the bounce for a ball dropped half way between two drop heights, for example 0.85 m. This method is called **interpolation**, when the value to be calculated lies within your data.
15. Use your graph to predict the height of the bounce for a ball dropped from more than 1 m height, for example 1.10 m. This method is similar to interpolation, but is called **extrapolation**, when the value to be calculated lies outside the data.
16. Find the slope of fitted line and calculate the bouncing efficiency of the ball.

Lab Report

Name of the Experiment :

Your Name :

Your ID # :

Name of the Lab Partner :

Date :

Instructor's comments:

Table A

Drop Height, H_1 (m)		First Bounce height (m) Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Mean bounce height, H_2 (m)	Ratio of heights, H_1/H_2
Tennis	1.0							
Golf								
Table Tennis								

Mass of the Tennis ball = kg

Mass of the Golf ball = kg

Mass of the Table Tennis ball = kg

Table B

Ball	PE_1 (J)	v_1 (m/s)	KE_1 (J)	$E_1 = PE_1 + KE_1$ (J)	PE_2 (J)	v_2 (m/s)	KE_2 (J)	$E_2 = PE_2 + KE_2$ (J)	Lost energy (J)	% Energy loss
Tennis										
Golf										
Table Tennis										

Table C

Drop Height, H_1 (m)		First Bounce height (m) Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Mean bounce height, H_2 (m)	Standard deviation, σ_{H2} (m)
Golf ball	1.0							
	0.9							
	0.8							
	0.7							
	0.6							

You have already learned how to calculate standard deviation, σ (see Expt 1). The standard deviation of a distribution of measurements is defined as follows:

$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(H_i - \overline{H})^2}$ Where $\overline{H} = \frac{\sum_{i=1}^{N} H_i}{N}$

You can easily do it by using your scientific calculator in STAT mode.

Slope 1 coefficient of bouncing for table tennis/golf ball =

Interpolated bounce height for example at 0.85 m =

Extrapolated bounce height for example at 1.10m =

Questions

1. Which ball was the most efficient? What characteristics does that ball have that you think helped it be efficient?

2. Why is it impossible for a ball to be 100% efficient?

3. How did the GPE change with height?

4. What percentage of the initial potential energy was ‘wasted’ as the ball was hitting the ground?

<u>Pre lab-2</u>

Student ID & Name:

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1. Consider a ball of mass 0.050 kg release from 0.85 m height, what velocity does the ball will attain when it hits the floor?

2. In a bouncing ball lab experiment what do you expect about the bounce height of the ball?

3. Without air resistance, the ball is still not be able to bounce to its original drop height, why?

4. Name some factors that would affect the bounce height.