Experiment No. : 07

Title of Experiment : Determination of Coefficient of restitution for Collision of Elastic Bodies (Law of Conservation of Momentum)

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Semester : 1

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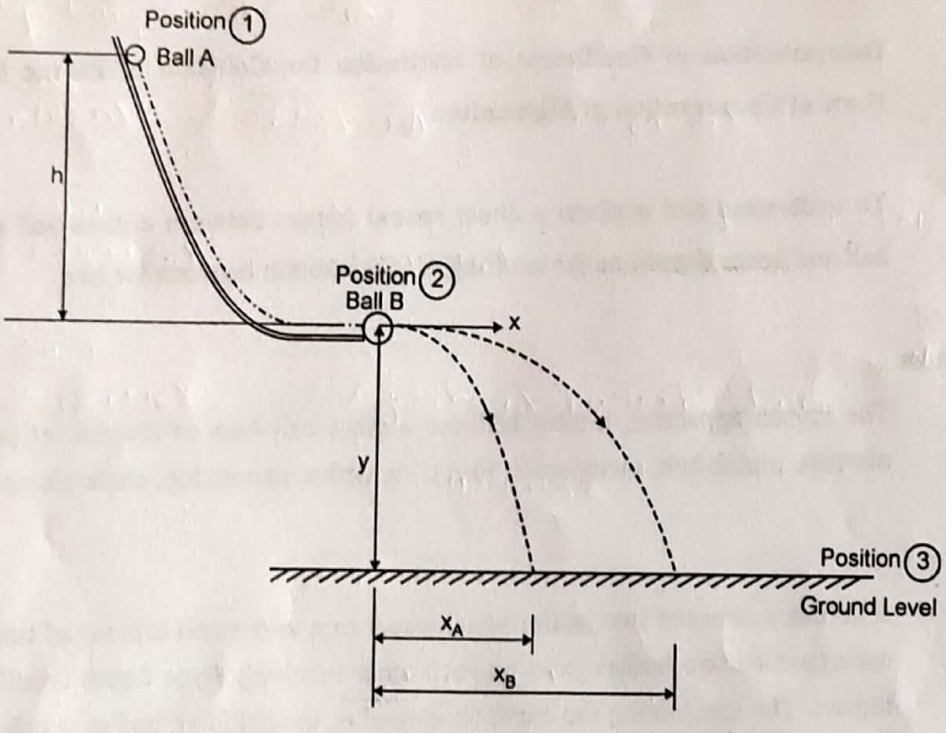
Punctuality	Reading & Understanding	Application	Total	Signature & Date
02	04	04	10	

DJ19FEC104.01	Illustrate the effect of force and moment and apply the same along with the concept of equilibrium systems with the help of FBD.
DJ19FEC104.02	Demonstrate the understanding of Centroid and its significance and locate the same.
DJ19FEC104.03	Correlate real life application to specific type of friction and estimate required force to overcome friction.
DJ19FEC104.04	Establish relation between velocity and acceleration of a particle and analyze the motion by plotting the relation.
DJ19FEC104.05	Analyze general plane motion of rigid bodies using Instantaneous centre.
DJ19FEC104.06	Analyze particles in motion using force and acceleration, work-energy and impulse-momentum principles.

Set-up Diagram



LAW OF CONSERVATION OF MOMENTUM APPARATUS

Experiment No: 07 **Date:** 08/04/2021

Title : **Determination of Coefficient of restitution for Collision of Elastic Bodies (Law of Conservation of Momentum)**

Aim: To understand and perform a direct central impact between a glass and a steel ball and hence determine the coefficient of restitution between the two.

Apparatus :

The impact apparatus, a steel ball and a glass ball both of the size of playing marbles, plumb bob, meter scale, firm table with a smooth top, chalk pieces.

Theory :

A collision between two bodies which occur in a very small interval of time and during which two bodies exert on each other relatively large forces is called an Impact. The line joining the common normal of the colliding bodies is called the line of impact. When the mass centers of the colliding bodies lie on the line of impact, the impact is known as Central Impact. When the velocities of both the colliding bodies are along the line of impact, the impact is referred to as a Direct Central Impact.

Coefficient of Restitution 'e' is the ratio of relative velocities after impact to the relative velocities before impact. If V_A and V_B are velocities of colliding bodies A and B before impact and V_A' and V_B' are velocities after impact then,

$$e = \frac{V_B' - V_A'}{V_A - V_B}$$

The value of coefficient of restitution 'e' is always between 0 and 1 and depends to a large extent on the two materials involved. The velocities of impact, shape and size of the colliding bodies also effect 'e'

Observation Table:

Sr. No	Height	Velocity before impact		After Impact				Velocity after impact		Coeff. of restitution
				Ball A		Ball B				
	h (m)	V_A (m/s)	V_B (m/s)	X (m)	Y (m)	X (m)	Y (m)	V_A' (m/s)	V_B' (m/s)	e
1	0.17	1.826	0	0.115	0.88	0.72	0.88	0.271	1.698	0.782
2	0.145	1.687	0	0.13	0.88	0.62	0.88	0.307	1.462	0.685
3	0.12	1.534	0	0.10	0.88	0.56	0.88	0.236	1.321	0.707
									Mean e =	0.725

Procedure:

1. Fix the impact apparatus on the edge of a firm table.
2. Place a glass ball B on the holder. Adjust the height of the holder such that the collision of the steel ball with the glass ball is direct central.
3. Note the height 'y' of the holder from the ground using a meter scale.
4. Using a plumb bob mark a point 'o' (origin) on the ground just below the holder.
5. Place a steel ball on the slide at a certain vertical height 'h' from the holder. Note the height 'h' with the meter scale.
6. Let the initial location of steel ball be position (1), location of glass ball on the holder be position (2), ground be position (3).
7. Release the steel ball from position (1) and let it slide down and strike the stationary ball B at position (2). Both the steel and glass balls after impact undergo projectile motion, falling through a height 'y' land at different spots on the ground i.e. position (3). Mark these spots by a chalk and measure the horizontal range 'x' from the origin 'o' to the spot. Thus the steel and glass balls travel same vertical distance but different horizontal distances.
8. Repeat the above steps by changing the height 'h' of the ball for two more sets of observations.

Calculations :

1. Using Work Energy Principle to ball A from position (1) to (2)

$$T_1 + \Sigma U_{1-2} = T_2$$

$$0 + mgh = \frac{1}{2}mV^2$$

$$\therefore \quad V_A = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.81 \times 0.17}$$

$$\therefore \quad V_A = 1.826 \text{ m/s}$$

2. Apply projectile motion to ball A and B from position (2) to (3)

Ball A	
Horizontal Motion	Vertical Motion
Using $V = \frac{s}{t}$ $\therefore \quad V_A' = \frac{x_A}{t}$ $= \frac{0.115}{0.424}$ $\therefore \quad V_A' = 0.271$ m/s	Using $s = ut + \frac{1}{2}at^2$ $\therefore \quad y = 0 + \frac{1}{2} \times 9.81 \times t^2$ $t^2 = \frac{y}{1/2 \times 9.81} = \frac{0.88}{1/2 \times 9.81}$ $\therefore \quad t = 0.424$ sec

Ball B	
Horizontal Motion	Vertical Motion
Using $V = \frac{s}{t}$ $\therefore \quad V_A' = \frac{x_A}{t}$ $= \frac{0.72}{0.424}$ $\therefore \quad V_A' = 1.698$ m/s	Using $s = ut + \frac{1}{2}at^2$ $\therefore \quad y = 0 + \frac{1}{2} \times 9.81 \times t^2$ $= \sqrt{\frac{2y}{9.81}} = \sqrt{\frac{2 \times 0.88}{9.81}}$ $\therefore \quad t = 0.424$ sec

3. Use $e = \frac{V_B' - V_A'}{V_A - V_B} \Rightarrow \frac{1.698 - 0.271}{1.826 - 0}$

$\therefore \quad e = 0.782$

Result:

The mean coefficient of restitution between steel ball and glass ball is $e = 0.725$

Precautions:

1. The impact of the steel ball with the glass one should be perfectly along the line of impact.
2. When the balls land on the ground their exact location on the ground should be marked with a chalk. In fact one person should concentrate on steel and the other on the glass ball.