COEFFICIENT OF RESTITUTION

LAB 7-2

CONCEPT

The “coefficient of restitution” (C_R) is a measure of how elastic a collision is. The coefficient of restitution is defined as the ratio of the speed of separation after a collision to the speed of approach before the collision:

\[ C_R = \frac{v_{after}}{v_{before}} \]

For a collision with perfect conservation of mechanical energy (an “elastic collision”), C_R = 1. The coefficient of restitution is a convenient way of specifying how much kinetic energy in a collision is transferred to internal energy.

There is a lot of physics when trying to explain why a ball bounces. A ball bouncing off the ground is considered to be an elastic collision. An elastic collision is an encounter between two bodies in which the total kinetic energy of the two bodies after the encounter is equal to their total kinetic energy before the encounter. Since the ground does not move, all the kinetic energy is restricted to the velocity of the rebounding ball.

During the collision of small objects, kinetic energy is first converted to potential energy associated with a repulsive force between the particles that make it up. This potential energy is then converted back to kinetic energy and the ball bounces.

The coefficient of restitution is the ratio of heights of a falling object, from when it hits a given surface to how high it rebounds. In laymen’s terms, the coefficient of restitution is a measure of bounciness.

\[ C_R = \frac{h_2}{h_1} \]

OBJECTIVE

The purpose of this experiment is to determine the coefficient of restitution for various balls.

MATERIALS

Meterstick, Several balls, floor.
PROCEDURE

1) On a hard surface take a ball and hold it at a set height above the surface. (one meter)
2) Drop the ball and record how high it bounces. Repeat several times to get an average.
3) Determine the coefficient of restitution for each ball.
4) Repeat with 6 balls. One ball must be wood and another must be aluminum.

DATA

<table>
<thead>
<tr>
<th>Object</th>
<th>Drop Height ($h_1$)</th>
<th>Rebound height ($h_2$)</th>
<th>Coefficient ($C_R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
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<tr>
<td>1-Tennis</td>
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<tr>
<td>2-golf</td>
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<td>3</td>
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<td>4</td>
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DATA ANALYSIS

1. For each bounce:
   a) Determine the impact velocity and the upward bounce velocity.
   b) Plot a graph of $v_{\text{return}}$ vs $v_{\text{impact}}$ (x-axis) then determine the COR.
   c) Calculate the amount of kinetic energy lost ($mg\Delta h$) upon each bounce and the percent.
2. Where is the lost kinetic energy? Is bouncing elastic or inelastic for this lab?
3. Suggest a formula for COR using the heights of drop and return, then verify it for one of your trials.
4. Estimate the COR for a golf ball, tennis ball, and one other ball using your equation for heights of drop and return.
5. For a perfectly elastic collision what is the COR?
6. On your graph, sketch a line for a perfectly elastic collision and one that is totally inelastic.
7. Most rubber products have a specific heat of 1600 J/kg°C. Assuming the ball absorbs all of the lost kinetic energy as heat, calculate the temperature change for one of your rubber ball trials.