Physics of Bouncing (Coefficient of Restitution) Lab #20

Pre-Lab Discussion

In a perfectly elastic collision of a bouncing ball, all the KE will be stored as PE of deformation of the ball. When the ball restores itself to its original shape, the PE will be reconverted to KE and the ball will rise to its original height where the KE is now stored as ΔPE or mgΔh. In practice, bouncing balls are mostly elastic deformation but some energy is converted to sound and heat and ‘lost’ to the height of return. One way to measure the amount of elasticity is the coefficient of restitution (COR) which is equal to the velocity of the return divided by the impact velocity \( \frac{v_{\text{return}}}{v_{\text{impact}}} \). In this investigation, we will measure the height of a dropped ball and the height of its return and calculate the values of \( v_{\text{return}} \) and \( v_{\text{impact}} \).

Research Question

How can the COR be measured and calculated?

Materials

- meter stick
- golf ball
- rubber ball
- high bounce ball

Method

1. Record the mass of a ball and record it on the data table.
2. Rest a vertical meter stick on a lab bench and drop the ball exactly one meter (measure from the bottom of the ball). Carefully determine the return height of the bounce and record this value on your data table.
3. Repeat Step 2 four times, each time dropping the ball from the previous return height (you should have a total of five return heights).
4. Repeat Steps 1 through 3 for the other two balls.

Data Collection and Processing

Data Table

<table>
<thead>
<tr>
<th>Ball Type</th>
<th>Mass</th>
<th>Drop 1</th>
<th>Drop 2</th>
<th>Drop 3</th>
<th>Drop 4</th>
<th>Drop 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Data Collection and Processing (continued)

Calculations

1. For each drop, calculate the of $v_{\text{impact}}$ and $v_{\text{return}}$ and record the results in the table below.

<table>
<thead>
<tr>
<th>Results Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Ball</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>rubber ball</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

2. For the golf ball, calculate the amount of KE lost on the first drop based on the change in height ($mg\Delta h$). [Show the equation, substitutions, and units.]

3. For the first drop with the golf ball, calculate the coefficient of restitution. [Show the equation, substitutions, and units.]

4. Report the coefficient of restitution for the first drop for both the other balls.
   rubber ball ______________________  high energy ball ______________________

Conclusions

1. Plot a graph of $v_{\text{return}}$ vs. $v_{\text{impact}}$ (x-axis).
2. On your graph, sketch a line for a perfectly elastic collision and a totally inelastic collision.
3. Determine the COR (golf ball) from the graph. ________________________________
4. Suggest a formula for the COR based on the heights of drop and return.

\[ \text{COR} = \]

5. What is the COR for a **perfectly elastic** bounce?

6. Are the bouncing balls in this lab **elastic** or **inelastic**? Where is the energy going?

7. Most rubber has a specific heat of 1600 J/kg\(^\circ\)C. If the loss of KE for the rubber ball in this lab was all converted to heat, calculate the temperature change for the first drop of the rubber ball. [Show the equation, substitutions, and units.]