Supplemental Information
Projectile Motion

1. Required Data
   (a) $h$ - height from the floor. $\Delta h = 1$ mm.
   (b) $D_{\text{eff}}$ - Effective diameter. Measure using the screw-actuated linear translator (SALT). 1 turn = 1/28 inch.
   (c) Table 1.A to 1.E using Different Heights (FIVE TABLES)

<table>
<thead>
<tr>
<th>Trial</th>
<th>Time $t$</th>
<th>Distance $x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 trials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average $x$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta x$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average $t$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta t$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   Height From Table $y$

   (d) Table 2 - Summary of Table 1.A to 1.E

<table>
<thead>
<tr>
<th>Height ($y$) From Table</th>
<th>Average $x$</th>
<th>$\Delta x$</th>
<th>Average $t$</th>
<th>$\Delta t$</th>
<th>$v_x$</th>
<th>$\Delta v_x$</th>
</tr>
</thead>
</table>

   Five Heights

2. Required Graphs
   (a) (Do at home) Graph 1 - $x$ versus $v_x$. Draw error bars. Find slope and slope uncertainty ($K$ and $\Delta K$). Compare slope with $\sqrt{2h/g}$. Plot also the theoretical formula on the same graph
   
   $$x = v_x \sqrt{\frac{2h}{g}}$$

   (b) (Do NOW) Graph 2 - $x$ versus $y$ based on Table 2. Use this graph to predict the distance $x$ from a height $y$ which you have not previously measured. Show the TA that the ball indeed drops within the vicinity of your predicted distance.

3. Error Analysis
   (a) For each Table 1.x,
   $$\Delta x = (x_{\text{max}} - x_{\text{min}})/2$$

   Use similar formula for $\Delta t$.
   (b) $\Delta v = (v_{\text{max}} - v_{\text{min}})/2$ where
   $$v_{\text{max}} = \frac{(D + \Delta D)(t - \Delta t)}{t}$$
   $$v_{\text{min}} = \frac{(D - \Delta D)(t + \Delta t)}{t}$$

4. Guide Questions
   (a) Based on the SALT instrument you used to measure the ball’s effective thickness, to what precision can you measure $D_{\text{eff}}$? In other words, what is $\Delta D_{\text{eff}}$?
   (b) Derive
   $$x = v_x \sqrt{\frac{2h}{g}}$$

   starting from the equations of motion in the horizontal and vertical directions.
   (c) Do your experimental data points agree with the theoretical line? Discuss.