Granular Physics: Making Particles and Measuring the Angle of Repose

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Overview

• What is Granular Physics?
  – Study of behavior of many small particles
  – Different from solid or liquid behavior

• Where is it used?
  – Applications in industry
  – Natural phenomena
Project Outline

• Long term project
  – Flow and Angle of Repose
  – Shape, Size, Material, Effective Gravity

• This Summer
  – Method Improvement
  – Manufacturing Particles
  – Preliminary measurements
Accomplishments

• Adjustment of method of production
  – Bed of Nails
  – Electrostatics
  – Simple platform

• Manufactured tens of thousands of identical particles

• Particle analysis
- Particles rough around the edges
- N particles = \( \frac{M}{D/V} \)
- Cutting method is still not optimal

\[
L_1 = 0.0318", \quad L_2 = 0.019", \quad L_3 = 0.016" \\
\text{(reference: } 1/32 = 0.03125)\]

<table>
<thead>
<tr>
<th>Mass Measurements used to calculate total number of collected particles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Large Square</td>
</tr>
<tr>
<td>Large Triangle</td>
</tr>
<tr>
<td>Small Square</td>
</tr>
<tr>
<td>Small Hexagon</td>
</tr>
<tr>
<td>Large Hexagon</td>
</tr>
</tbody>
</table>
Angle of Repose Data

- Angle of Repose = $\tan^{-1}(h/r)$
- Carbon Paper Squares
  - Side width = 0.054 in
- Carbon Paper Triangles
  - Side width = 0.073 in

<table>
<thead>
<tr>
<th>Particle Type</th>
<th>Carbon Paper Squares</th>
<th>Carbon Paper Squares</th>
<th>Carbon Paper Triangles</th>
<th>Carbon Paper Triangles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Radius (cm)</td>
<td>1.237</td>
<td>2.497</td>
<td>1.237</td>
<td>2.497</td>
</tr>
<tr>
<td>Avg. Height (cm), Ten trials</td>
<td>1.26</td>
<td>2.25</td>
<td>1.33</td>
<td>2.22</td>
</tr>
<tr>
<td>Angle of Repose (deg)</td>
<td>45.5</td>
<td>42.0</td>
<td>47.2</td>
<td>41.7</td>
</tr>
</tbody>
</table>
Future Direction

• Suggestions
  – Make intermediate sizes
  – Cut circles and ovals
  – Reconsider the bed of nails

• A lot remains to be done
  – Different materials
  – Tens of microns down to nanometers
  – Increased gravity
  – poly-disperse collection of particles
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References