Problem 1
Cumulative Canon

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Problem

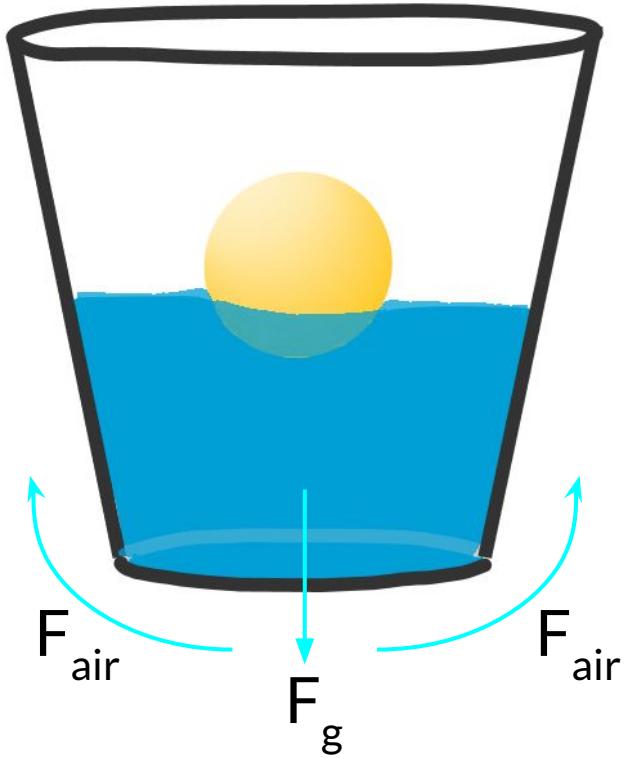
How high may a ping-pong ball jump using the setup on the video?

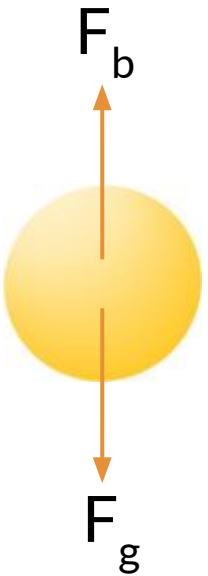
What is the maximal fraction of the total kinetic energy that can be transferred to the ball?

To determine the maximum height of the ball

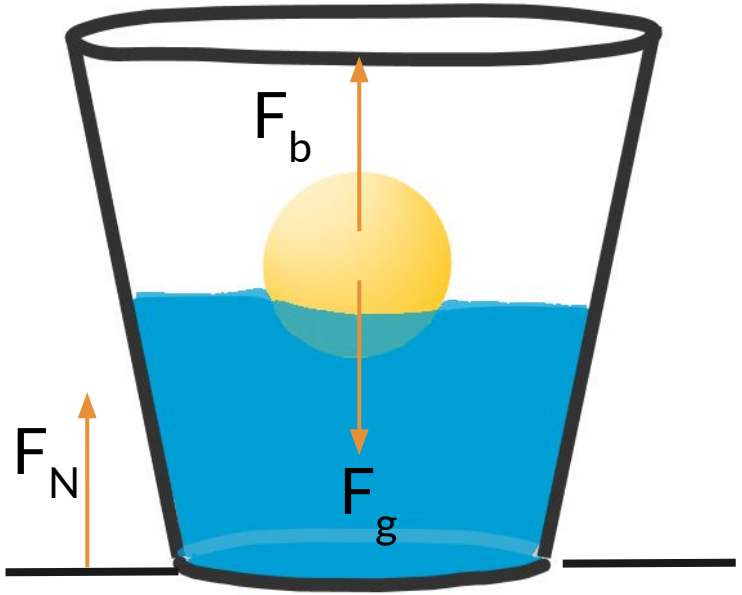
1. We explore theory
2. Compare with Experiment
3. Extend Considerations

Immediately As it Begins To Fall



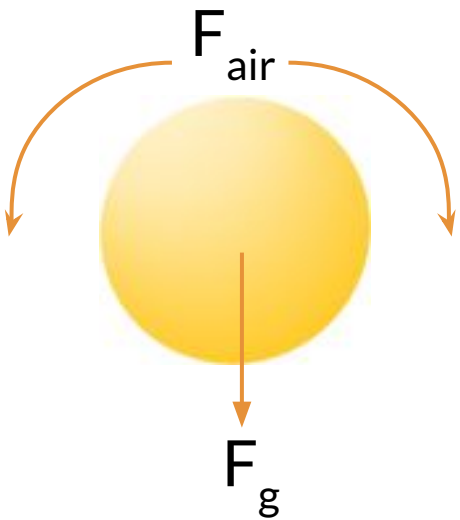


At the Floor

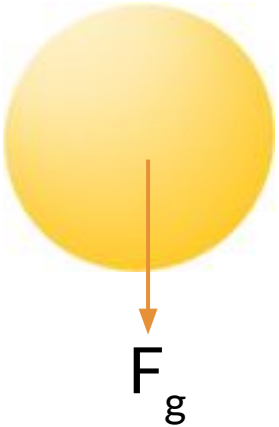


Then just the ball flies up and up and up!

During:



At max height:



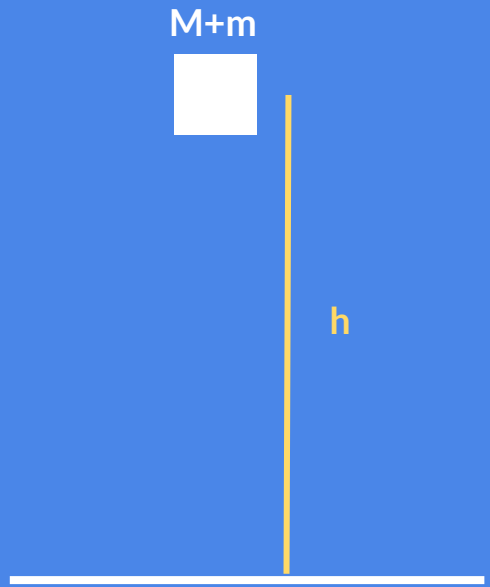
Analysis

Energy:

$(M+m)gh$

Forces:

$F_g=(M+m)a=(M+m)g$



At collision

Assuming a closed system energy is conserved!

Before:

Energy

$\frac{1}{2}(M+m)(2gh)$

After:

Energy:

$\frac{1}{2} m v_a^2$ where $v_a=(2gh(M+m)/m)^{\wedge}\frac{1}{2}$

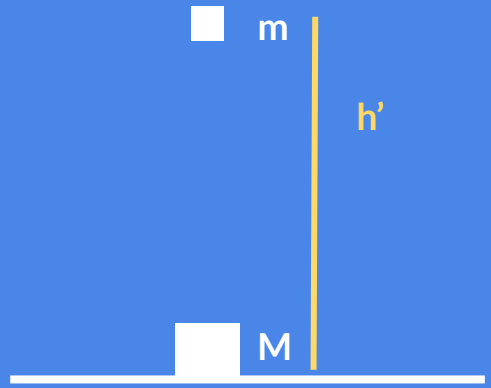
At the max!

Energy:

Mgh’ where h’= h(M+m/m)

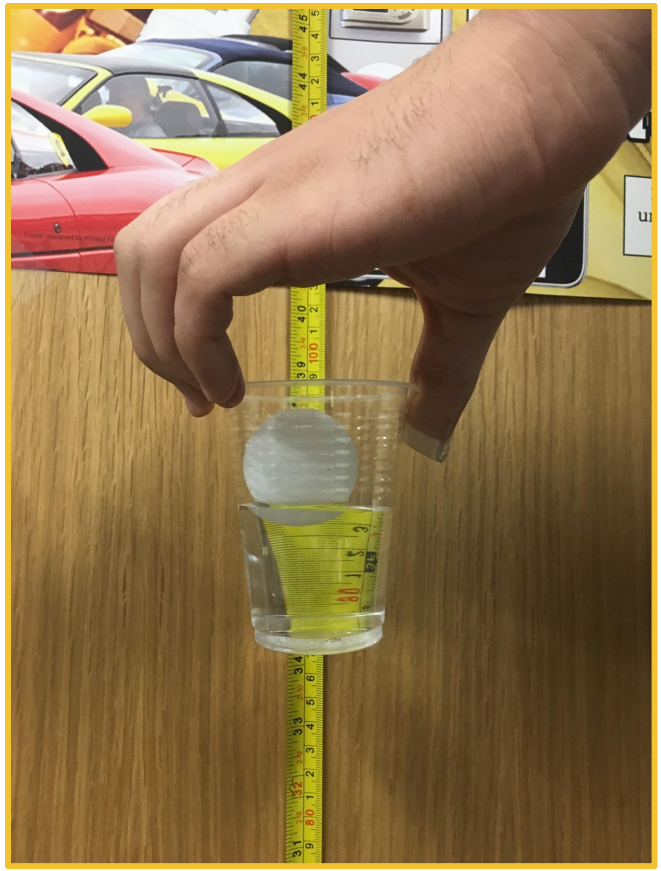
Forces:

F_g=ma=mg



Compare with Data

Experimental Setups!



Experiments:

2 Oz : 2ft

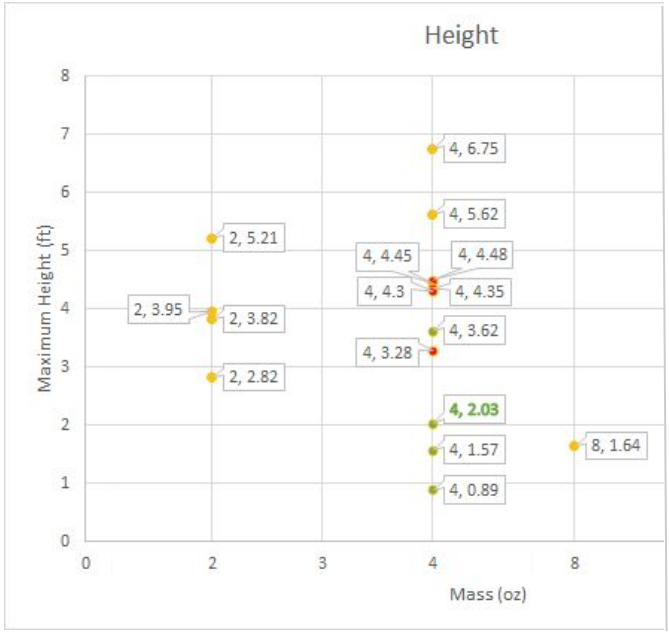
Mean: 3.95 ft
STD: 0.69 (error: 0.49)
Precision Error: 0.11
Total Error: 0.50

4 Oz : 1ft, 1.5ft, 2ft

Mean: 2.03 | 4.03 | 5.62 ft
STD: 0.82 (0.58) | 0.54 (0.38) | 1.61 (1.61)
Precision Error: 0.09 | 0.11 | 0.10
Total Error: 0.59 | 0.39 | 1.61

8 Oz : 2ft

Mean: 1.64 ft
Precision Error: 0.09



Comparison: m=2.7 g to get Maximum Heights!

Theoretically: h'=h(M+m/m)

2 Oz : Start 2ft : End 3.95ft M=59.14
Theoretically: 13.96 ft
Fraction: 28.29%

4 Oz : Start 1ft, 1.5ft, 2ft : End 2.03, 4.03, 5.62 ft
Theoretically: 13.65, 20.48, 27.31 ft
Fraction: 14.87%, 19.67%, 20.57%

8 Oz : Start 2ft : End 1.64 ft
Theoretically: 54.02
Fraction: 3.03%

Additional Considerations

Why do we swirl the water?

So the ping pong ball stays in the center!

What can we do next?

- Different cup surfaces (surface tension)
- Cup shape
- Different Liquid Medium
- Different ping pong ball (weighted)

Experimental Methods:

- Accurate height measuring (tube)
- Perfect dropping method (tube)

Ping Pong Ball in a Cup