MAPLE SEEDS and PARACHUTES

Which is more effective at slowing descent?

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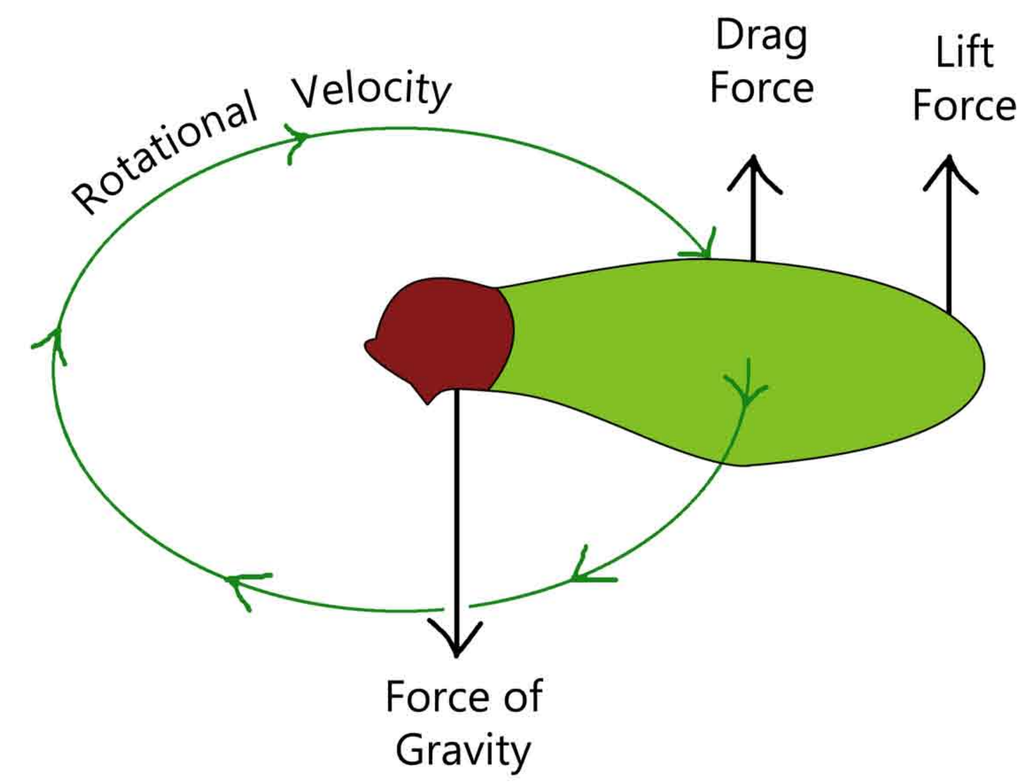
ABSTRACT

There has been interest recently in developing maple seed-like parachutes[2]. This provokes the question: **which parachute design is more effective at slowing descent: that of a maple seed or traditional dome parachute?**

The model we developed and validated predicts that under ideal conditions, the maple seed design is most effective at slowing descent.



(left) **Maple seeds utilize both drag and lift to counteract the force of gravity.** As they spin, they deflect air particles downward, generating an upward reactionary force.

Parachutes, on the other hand, only use drag.

MODEL DESCRIPTION

Our model uses the following equations to simulate the trajectory of a maple seed[1][3]:

downward velocity, surface area

$$F_{drag} = \frac{1}{2}\,\rho\, v_d^{\,2}\, A\, C_d$$

coefficient of drag

density of air

rotational velocity

$$F_{lift} = \frac{1}{2}\,\rho\, v_r^{\,2}\, A\, C_l$$

coefficient of lift

Using F=ma, these forces are converted into accelerations, which are then added to gravitational acceleration to calculate net acceleration.
To simulate the parachute, we used only the equation for drag.

MODEL ASSUMPTIONS and LIMITATIONS

Lift and drag coefficients were approximated. Calculating these is extremely mathematically rigorous. Instead, we used reasonable figures from scientific studies of similarly shaped seeds[5].

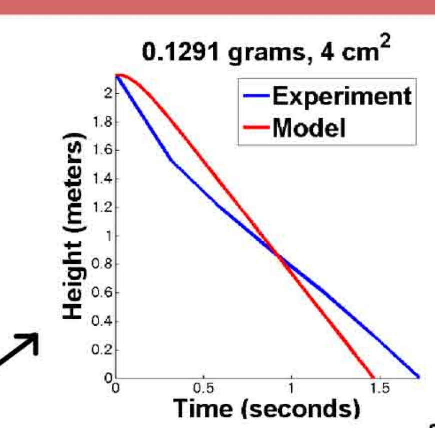
Wind was ignored. This allows the model to focus on the problem of hang time in an ideal setting.

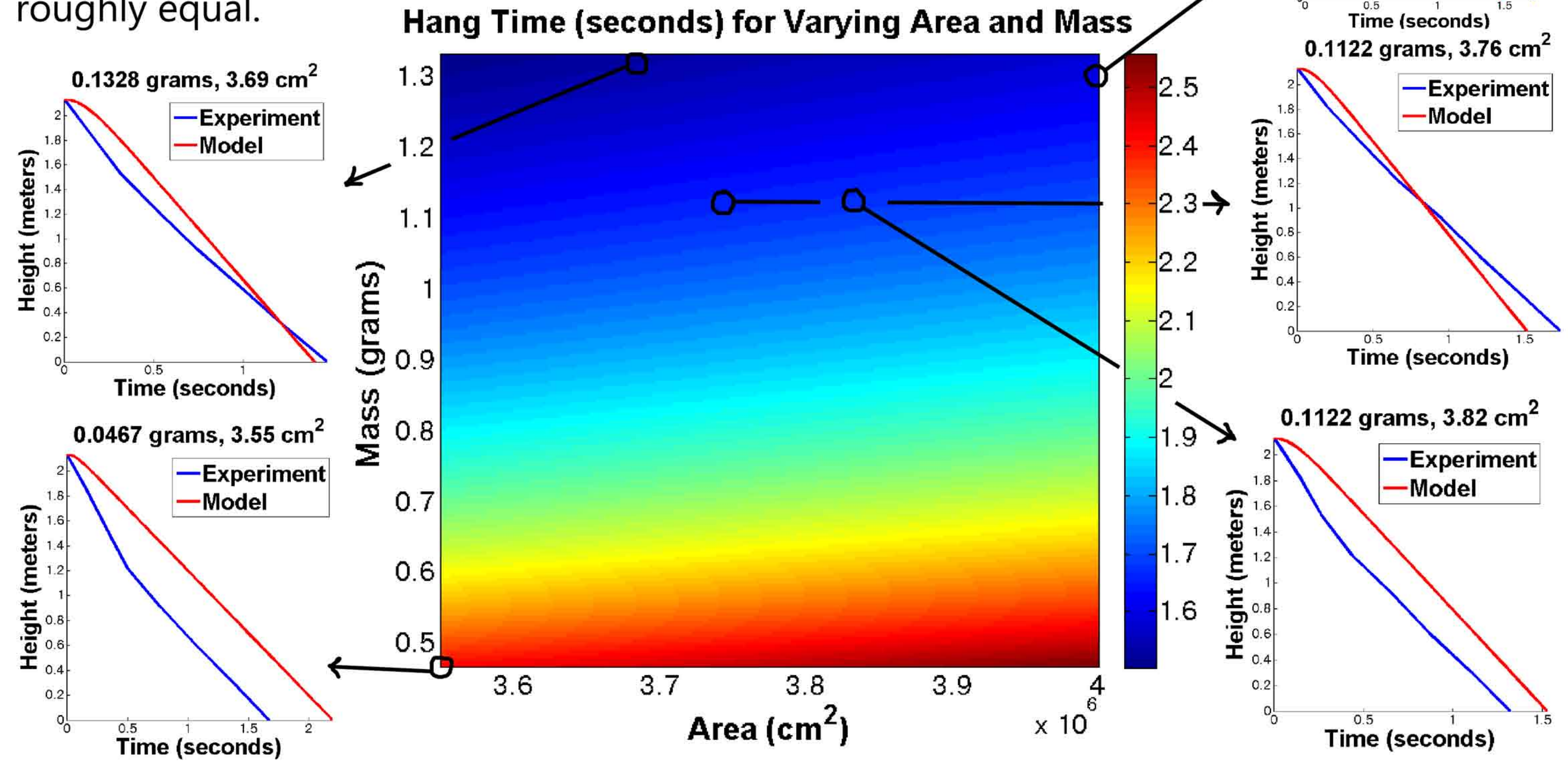
The seed begins spinning immediately after falling. Maple seeds usually fall about one foot before beginning their rotation. The model assumes that the seed begins rotating immediately.

Rotational velocity is proportional to downward velocity. The model assumes that the faster the seed falls, the faster it spins.

EXPERIMENTAL VALIDATION

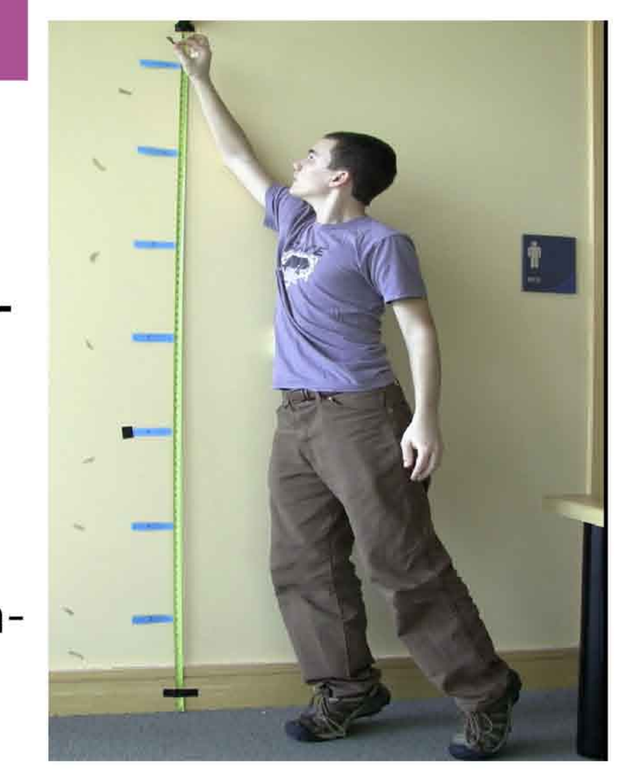
Below is a graph showing **hang time for varying mass and surface area**. Surrounding it are height/time graphs comparing our model to actual seeds experiments. Note that terminal velocities are roughly equal.



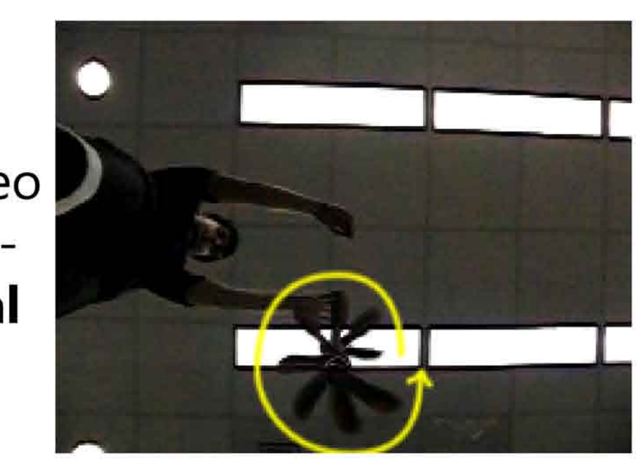


EXPERIMENTS

We performed two experiments with actual maple seeds of varying mass and surface area to find **the proportionality constant between downard and rotational velocity**.



First, we measured the surface area and mass of five different maple seeds and then dropped each one at 2 meters and measured its position over time and **terminal downward velocity.**



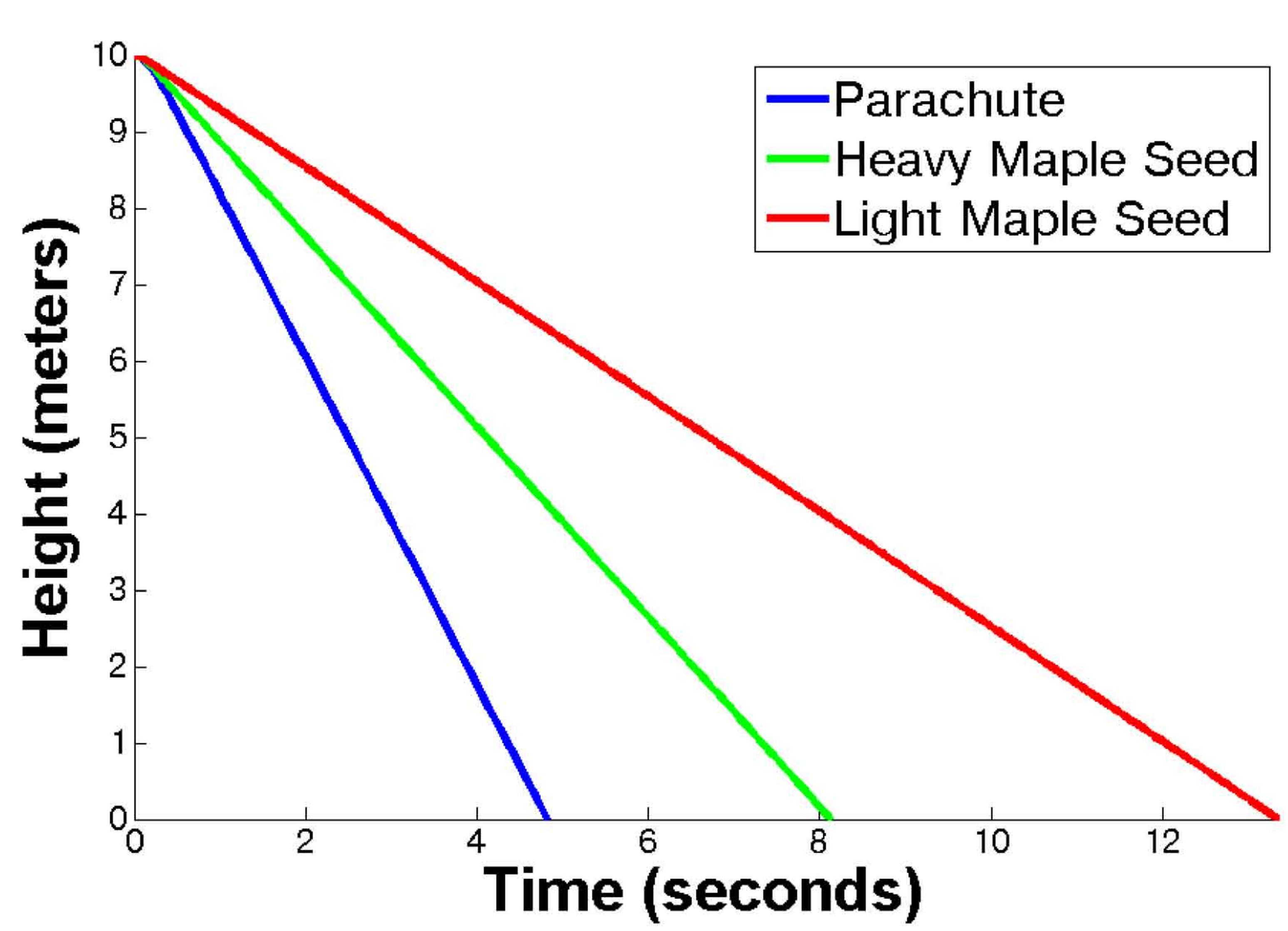
Second, we took high-speed video of seeds rotating in freefall to determine their **terminal rotational velocity.**

THE VERDICT

To compare the effectiveness of maple seeds and parachutes at slowing descent, **we scaled the maple seed to the size of the parachute by increasing its mass to 80 kg, the weight of an average person, while keeping its ratio of mass to surface area constant**.

We then simulated the trajectories of this giant maple seed against a traditional parachute, both carrying the same mass.

The results of this simulation are pictured to the right.



CONCLUSIONS

Our simulations clearly showed that the maple seed design is more effective at slowing descent. This can perhaps be attributed to the fact that the maple seed design uses both lift and drag, whereas the parachute uses only drag.

We thus conclude that the maple seed parachute is a feasible concept and should be developed further.

Citations

1. “Drag (Physics)”. <http://en.wikipedia.org/wiki/Drag_(physics)>.

2. “The Guided Samara: Design and Development of a Controllable Single-Bladed Autorotating Vehicle.” <http://dspace.mit.edu/bitstream/handle/1721.1/42047/229893867.pdf?sequence=1>.

3. “Lift (Force)”. <http://en.wikipedia.org/wiki/Lift_(force)>.

4. “Shape Effects on Drag”. <http://www.grc.nasa.gov/WWW/k-12/airplane/shaped.html>.

5. “Various Flying modes of wind-dispersal seeds”. <http://www.sciencedirect.com/science?_ob=MiamiImageURL&_cid=272314&_user=1238599&_pii=S0022519303002169&_check=y&_origin=&_coverDate=07-Nov-2003&view=c&wchp=dGLzVlV-zSkWA&_valck=1&md5=2793163c9f5173a86c23e697fa268386&ie=/sdarticle.pdf>.