Dear Fellow Stomp Rocketeer,

I've loved to launch rockets since I was a kid. I hope you enjoy it as much as I have! By now I hope you've watched the instructional video, built your own version of a stomp rocket and launcher, and blasted a rocket into the air for fun.

Now comes the really fun stuff – maximizing your rocket and launch system performance for the highest flights possible!

Safety

A big stomp puts a huge amount of energy into a rocket. Even when made of paper, these rockets can move at high velocity. NEVER aim at people, animals or fragile objects you don't want to risk damaging. Safe launches are fun launches. Keep it fun by staying safe!

Fantastic, fun flights

Job #1 with stomp rockets is having a great time building and launching them. To have the most fun and avoid typical troubles encountered with systems like these, I recommend checking out these pointers:

- Before each flight, check to make sure the rocket slides smoothly on the launch tube. Friction due to a crinkled paper rocket fuselage robs the rocket of launch energy. Also check to make sure the launch tube is as smooth as possible – especially if it's the handmade cardboard version.
- Also before each flight, make sure the bottle is re-inflated as fully as possible. This can be hard, especially after a lot of launches. Each stomp usually puts another few permanent dents in the bottle. The larger lungs of a grown-up can help with re-inflation, and as you furiously blow air back into the bottle through the launch tube, you'll also quickly discover air leaks in the system that make re-inflation more difficult and rob your rocket of launch energy during a stomp.
- Make sure you use duct tape to seal up all those air leaks in your system!
- Don't hesitate to replace your bottle when necessary. They often wear out and develop cracks after 15-20 solid stomps.
- Rebuild your rockets as often as necessary – they usually crumple near the nose cone after a few nose-down landings!

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Maximizing Performance

So you want to make your rocket fly higher? Me too! Here are some pointers to keep in mind during all optimization testing.

- Change only <u>one</u> thing at a time. This lets you more accurately determine the effect of each change.
- It can be tricky to keep the stomp the same every time in a way that lets you isolate the effects of other changes! The most consistent way I've found is to drop a heavy weight onto the bottle from the same height each time.
- Putting a camera on a tripod to record launches with short videos is a great way to get a qualitative comparison of launch heights – especially if you have a reference point in the background like a tall tree. Make sure to put the camera far enough back that the rocket doesn't launch out of frame!

Junior Rocketeers

There's a lot you can learn about how a stomp rocket launch works just by making careful observations and doing mini-experiments! Here are some suggestions to get you started asking cool questions and thinking up some tests.

- How important is that stomp bottle anyway? How much air power is needed to launch a stomp rocket? Try out some other methods of adding air power to the launch tube, like your lungs or a balloon. How well do other methods work?
- What <u>kind</u> of air power is needed for a great launch? Is it more important to have a large amount of air (volume), or a sharp blast of air (pressure)? Which makes the biggest difference? Try a launch where you slowly step onto the bottle and squish it all the way (max volume but low pressure). Then try a launch where you put a brick or block on each side of the bottle to stop your foot part way down (ideally less than half), and give it a huge stomp for only the amount of squish allowed by your stoppers. Which works better? How does the high pressure/low volume launch compare to the full power launch?
- What's important in the rocket's design to make it fly high? How do different nose cone designs affect the flight? Come up with a hypothesis and test out several designs to see which ones work best!
- For a literal twist, bend the trailing tips of your fins all a little bit in the same direction so the back edge of the fins are trying to make a slight spiral. Launch again and see what happens!

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Launch Commanders

These rocket systems provide everything you need for engineering experimentation and physics fun in as much detail as you want. Here are some of my favorite explorations:

- In these rocket launches, we're trying to accelerate the rocket to as high a velocity as possible from a stomp. We **accelerate** the rocket to a high **speed** by **pushing** it upward with the **force** produced by the **air pressure** from our stomp. A big push makes the rocket go fast!

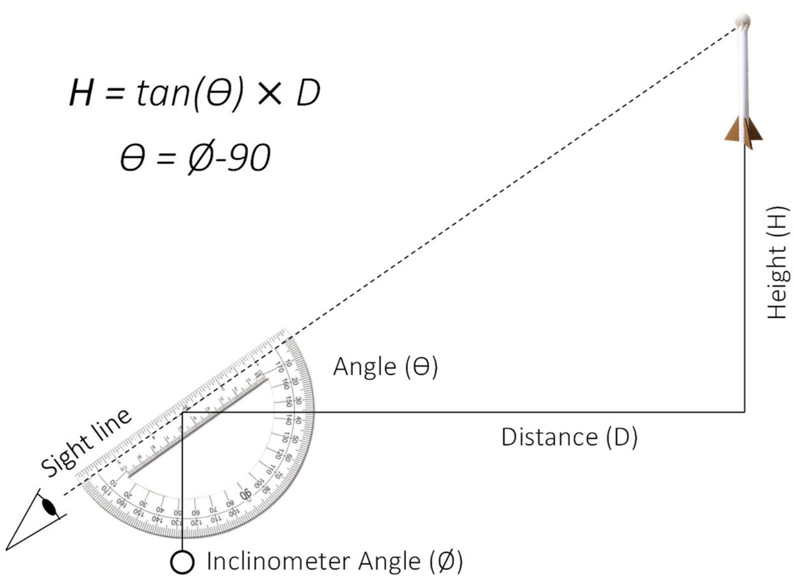
  Experiment with different launch tube diameters. Before testing, form your hypothesis: what kind of a launch will a larger diameter launch tube create? A small one? If you're already ahead of me, before testing: calculate the expected launch velocity you can achieve with a certain launch pressure and tube diameter.

  For both qualitative and quantitative tests, set up a camera on a tripod to record the launch that takes video in slow motion (many phones can now do 240 fps). Then behind the launch setup, place a visual reference like a piece of lumber marked in half-meter increments. Then launch and compare the velocity for different rocket tube diameters. What's the biggest diameter launch tube you can use for a regular 2-liter bottle? At what diameter do you run out of air volume before the rocket leaves the tube?

- For height measurements using trigonometry, set up an *inclinometer* that can measure angles easily. The fun and easy way is to suspend a small weight (like a washer) on a string from the center of a protractor. Then stand at a known distance *D* from the launch site and sight along the edge of the protractor during flight, keeping the top edge aligned with the rocket. Stop at the rocket's peak altitude (the *apogee* of its arc), and have a friend record the inclinometer angle *Ø* the string is hanging at. Subtract 90 degrees from *Ø* to get the flight angle *Θ* , then calculate the height *H* of your rocket's flight using the angle *Θ* and distance *D*!

$$H = \tan(\Theta) \times D$$

$$\Theta = Ø - 90$$



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- Experiment with rocket length as well. What's the longest rocket you can launch using a single 2-liter bottle? What is it that maxes out the length of a rocket that can be launched for a given air volume? How long is the longest paper rocket you think can be launched, and how many bottles would it take? Now try it out! And send me the video, I've wondered this for a long time!

Thanks for joining in the fun of this awesome project I've enjoyed since I was a kid and am now having a blast doing with my own kids too. Happy launching!

Make cool stuff,

Nate

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