

Aerodynamics and Bottle Rockets!

Lesson Type: Project/Demo

Target Grade: Elementary/High School

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Brief Overview/Challenge

The goal of this lesson is to teach students about gravity, air drag, thrust, and the principles behind rockets. Students will also work through the engineering design process, especially the prototyping and improvement steps, to build two rockets.

Teaching Goals

- Learn about gravity, air resistance, and thrust
- Learn about force balances
- Work through the engineering design process

Agenda

- **Introductions** (10-15 min)
 - Introduce yourselves to your mentees!
 - Play a quick icebreaker like “What’s your favorite _____?” or anything else that is relatively quick
 - Try to learn all of the mentees’ names and have them learn yours!
 - Do the “What is an engineer?” activity on a large sheet of butcher paper.
- **Introduction of rockets** (5-10 min)
 - Introduce forces
 - Gravity, air drag, and thrust should all come up in the discussion
 - Introduce the design challenge: build a basic paper rocket that will be launched from a stomp rocket base.
 - Show the students a basic example design.
- **Build paper rockets** (10-15 min)
 - Distribute materials after introduction.
 - Every group of 2-3 students gets two sheets of paper and tape.
- **Test paper rockets** (5-10 min)
 - Test the students’ designs

- Review what went well and what could be improved. Be constructive!
- **Water Rocket Launch** (10 min)
 - Launch a water rocket to make all the students go “Wooooah!”
 - If time permits, launch the bottle more than once.
- **Recap** (5 min)
 - Go over what went well and what could be improved on.
 - It might be a good idea to test each design once, recap, and then test the designs again just for fun if you have time.

Materials

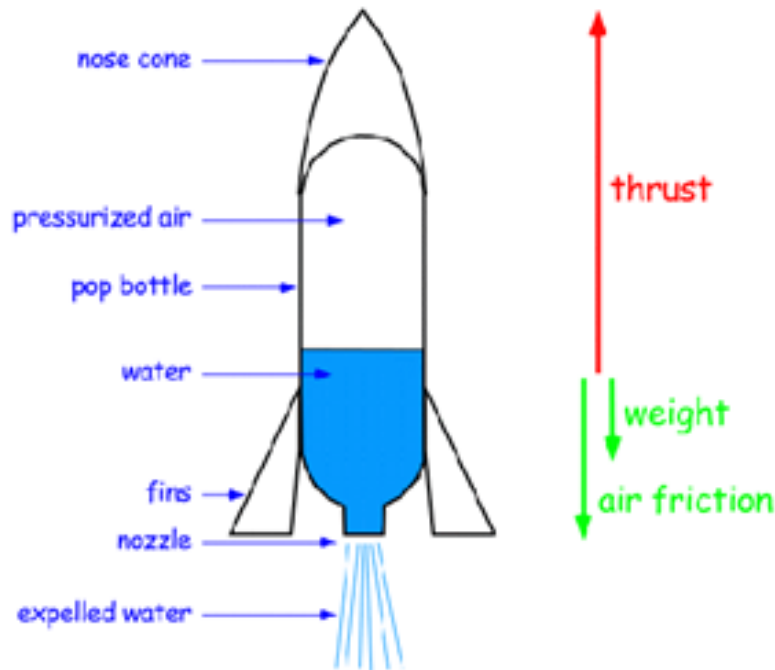
- Half a pack of Index Cards
- 10-15 sheets of paper (may be supplied by schools, but bring in case)
- 1 empty large soda bottle and 1 large cork
- 1 bottle rocket stand
- duct tape, scotch tape, scissors, markers
- 1 Stomp rocket base
- 1 Bike pump and needle

Procedure/Tips for building

- Build the fuselage of the paper rockets by wrapping paper around the launch tube.
 - Make a nose cone as pointy as possible to reduce air drag, but not too long to destabilize the rocket.
 - Let the students build whatever they want, but when discussing the results bring up the fact that a pointier nose cone is more aerodynamic.
- Make sure the nose cone is really securely taped to the top of the fuselage so that air doesn't leak out when you launch the rockets.
- You should add fins (cut index cards for paper rockets) to the sides of the paper rockets, but they must be securely attached with tape or else they will likely fall off.
- General Bottle Rocket Construction Procedure:
 - Fill the bottle $\frac{1}{3}$ of the way full with water
 - Put the bike pump needle into the pre-made hole in the cork. You'll probably have to push the needle in harder than you'd think.
 - Put the cork in the bottle mouth **very tightly**. Twist the cork in for the best seal.
 - Thread the bike pump hose through the hole in the side of the base and out the top of the base.
 - Attach the hose to the needle in the cork.
 - Place the rocket cork side down onto the launch stand while slowly pulling the bike pump hose back out the side of the base.
 - Pump the bike pump until the rocket launches!
 - Pressure reading will be around 30-40 psig when the rocket launches

Material to Teach

- Force of gravity = mass x acceleration
 - Acceleration in this case = g (gravitational acceleration constant) = 9.81 m/s^2
- Drag Force (aka Air Resistance)
 - The air in front of and alongside the rocket rubs against the rocket and needs to be pushed out of the way
 - This is an example of friction which causes the rocket to slow down.
- Thrust
 - The force that propels the rockets is caused by expelling fluid (in this case water) out of the bottom of the rocket.
- Force balance on the rocket
 - Thrust must outbalance air resistance and weight for the rocket to fly.



Background for Mentors

- Acceleration of the rocket will be determined by force balance
 - Thrust - Mass of device x gravity – drag = Mass of device x acceleration
 - Only bring up the equations if there are students curious about the force balance or if you are mentoring advanced students.
 - For advanced students mention that thrust through fluid propulsion is an example of the law of conservation of momentum.

Reference

- <http://www.instructables.com/id/DIY-Stomp-Rockets/?ALLSTEPS>

Summary Materials Table

Material	Amount per Class	Expected \$\$	Vendor (or online link)
Tape	2	-	Inventory
Index Cards	Half pack	-	Inventory
Bike Pump and needle	1	-	Inventory and requests
2L Soda Bottle	1	-	Collect Recyclables!
Soda Bottle Base	1	-	Recycling
Paper	10-15 sheets	\$8 per 500 sheets	Staples
Stomp Base	1	-	Inventory
Scissors	2	-	Inventory
Cork	1	\$8.89	Amazon