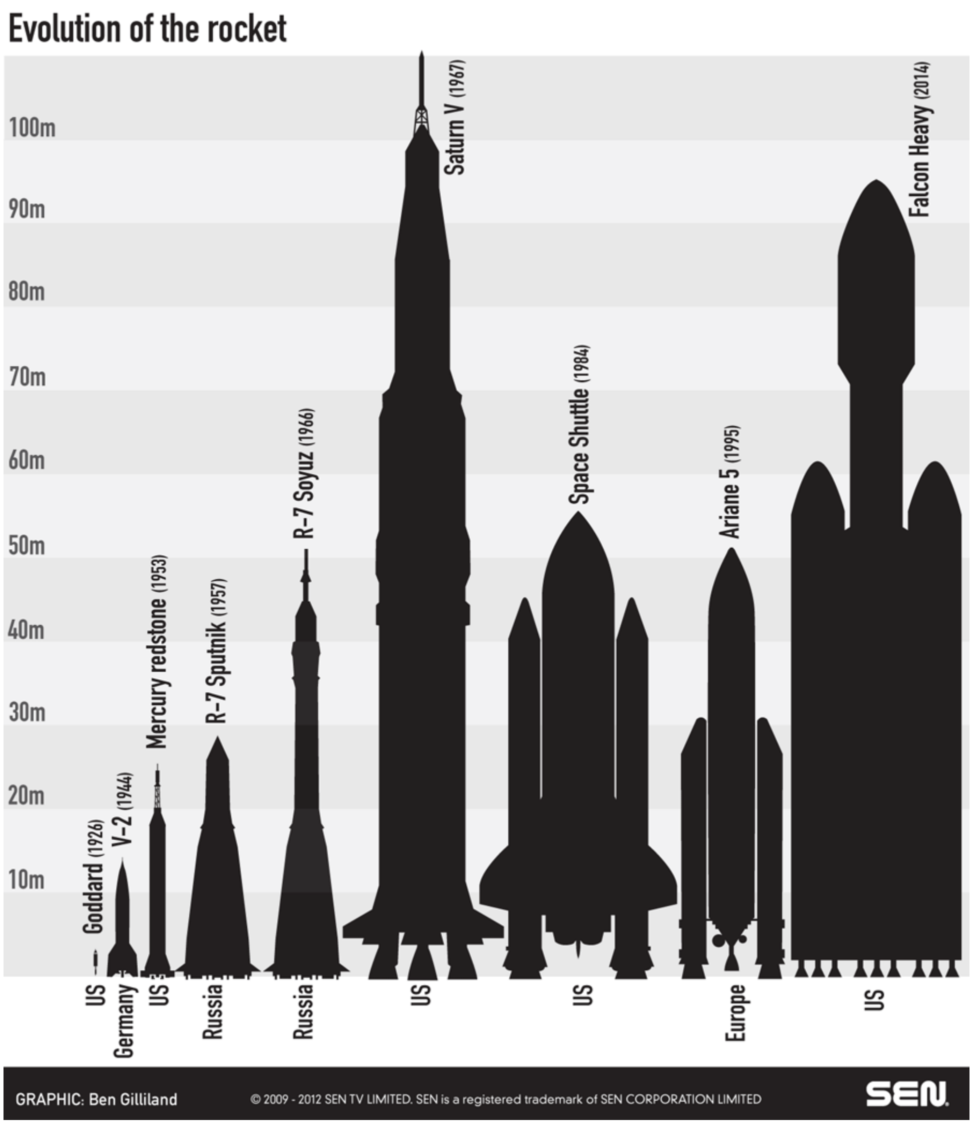
ROCKETS

Rocket Launching Experiment

What do you know about engineering rockets?

What do you want to know about engineering rockets?



Introduction

Launching rockets is currently the only way to get into space. What is the best kind of rocket to get you where you want to go? Modern rocket design has been going on since the early 20th century, but engineers are still changing the designs of rockets and their launching systems to make better rockets.

Check out the above diagram of various rocket designs. What are some similarities between the rockets? What are some of the differences?

The table below shows how heavy each of these rockets were and the ***payload***, which is the amount of weight the rocket can carry. Usually the payload is determined by how much weight the rocket can carry to ***low-Earth orbit***, which is defined as an orbit that is less than 1000 km from the Earth's surface.

Rocket Name	Date	Weight	Payload to low-Earth orbit
Goddard	1926	26 kg	
V-2	1944	12,700 kg	
Mercury Redstone	1953	30,000 kg	
R-7 Sputnik	1957	280,000 kg	1,322 kg
R-7 Soyuz	1966	304,000 kg	7,100 kg
Saturn V	1967	2,800,000 kg	127,000 kg
Space Shuttle	1984	2,000,000 kg	24,400 kg
Ariane 5	1995	777,000 kg	21,000 kg
Falcon Heavy	2014	1,420,000 kg	63,800 kg

One way to determine the efficiency of a rocket is by comparing its payload with its weight. For example, the R-7 Sputnik rocket can carry 1,322 kg to low-Earth orbit and weighs 280,000 kg:

$$\frac{1{,}322\ kg}{280{,}000\ kg} = 0.005.$$

A higher number means that the rocket can carry a higher payload, given its weight, to low-Earth orbit. Looking at the table above, what rocket was the most "efficient?"

Now let's make our own mini rocket and engineer the best way to build and launch a rocket!

Materials you will need:

- ☐ Stomp rocket launcher
- ☐ Printer paper
- ☐ Cardstock
- ☐ Index card
- ☐ Tape

Instructions

1. Roll a piece of paper around the launch tube. The rolled paper should be snug, but it should be able to slide easily along the launch tube.
2. Tape the paper to itself, using enough tape to completely seal the seam and make it airtight. This is the body, or ***fuselage,*** of your rocket.
3. Slide the fuselage off of the launch tube.
4. Make a ***nose cone*** for your rocket. You can do this by taping paper over your fuselage, making sure that it is airtight, or you can pinch one end of the fuselage and fold it over and tape it to the rocket's body.

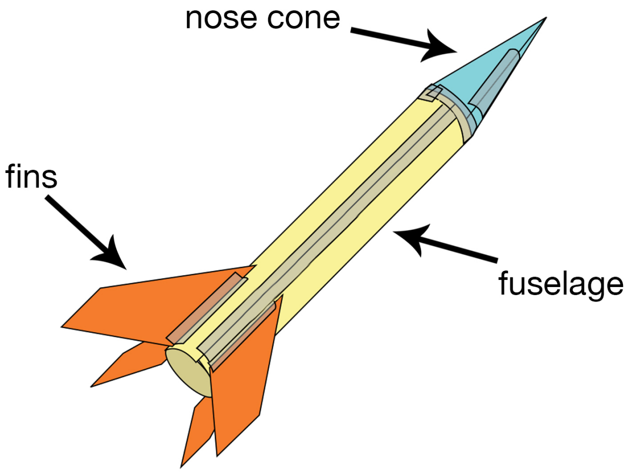


Image credit: jpl.nasa.gov

5. Cut out ***fins*** and attach them symmetrically to the lower part of the fuselage. You can choose whatever shape for the fins that you think will help the rocket go the straightest and highest.
6. Name your rocket!

Experiment

Your mission is to engineer the rocket that goes the highest.

1. Make sure you're outside in a safe spot before launching your rocket.
2. Pick a tree or a building that you can use to serve as a "ruler." Ask a friend to help judge how high your rocket goes.
3. Place your rocket on the launch tube.
4. Stomp on the bottle to launch your rocket! Have a friend record the launch on a cell phone so you can better analyze the rockets' flight. It can be especially useful to record in slow-motion mode!
5. Repeat the launch process at least 3 more times to get a consistent measurement of the altitude your rocket reaches.

Analysis

1. Examine your rocket design and analyze its flight performance, then compare the designs and flight performance with your classmates.
2. Discuss what constitutes good flight performance. *Height? Stability? Smooth trajectory?*
3. Think about the specific aspects of rocket design: *number of fins, placement and design of fins, nose cone design, fuselage length, materials used*, etc.
4. Identify the best characteristics of high performing rockets. Based on your observations, hypothesize what aspects of rocket design are linked to better flight performance.
5. As a group, optimize your rocket design and build a better rocket.
6. Launch the optimized rocket and see how high it goes!

Alka-Seltzer Rockets

What do you know about gas and pressure?
What do you want to know about gas and pressure?

Gas and Pressure

Gas is composed of particles (molecules or atoms) that are randomly moving in all directions. These particles travel in a straight line until they hit another particle or the surface of the container they are in. When they hit the side of the container, they exert a force on that surface, this is what scientists call ***pressure***. Formally, ***pressure*** is defined as a *force per unit area.*

Anything that increases either the number of collisions on the surface of a container or the force of the collisions will increase the pressure. The velocity of the particles increases with temperature, and when the particles are moving faster they exert more force when they collide with the surface, which increases the pressure. Decreasing the size of the container means the same number of particles have a smaller area to move in and are more likely to collide. In this way, changing the volume of the container can increase or decrease the pressure.

Can you think of examples of things that have high pressure?

Materials

- ☐ An open outdoor area
- ☐ A film canister
- ☐ An Alka-Seltzer tablet
- ☐ Water

Instructions

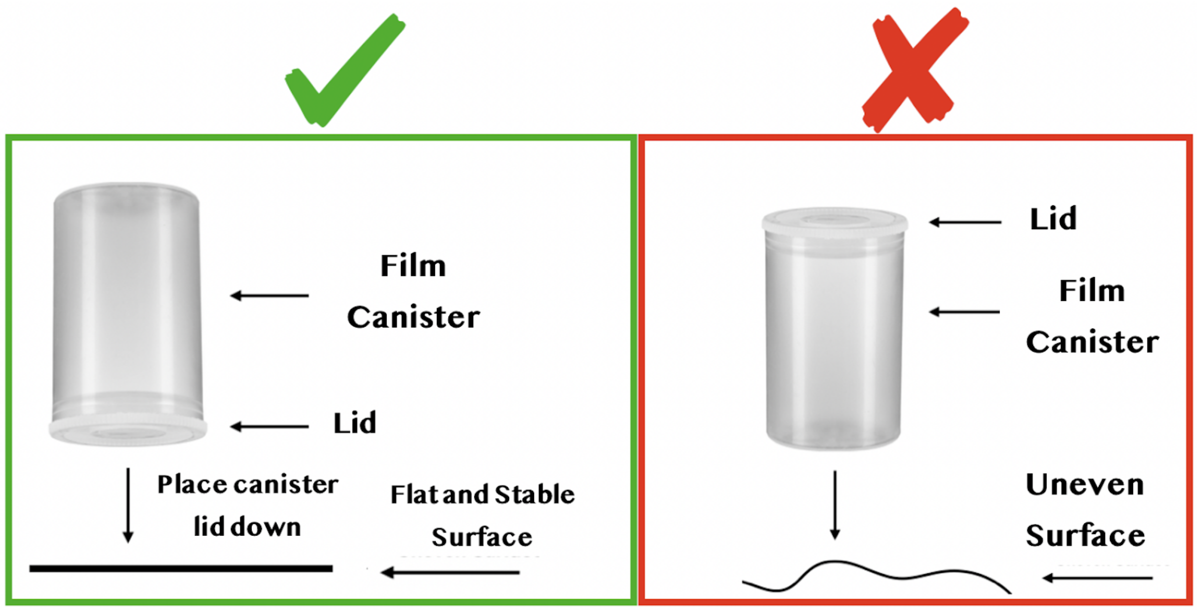
1. Break an Alka-Seltzer tablet in half.
2. Get a glass bowl or cup and fill it up with water.
3. Drop the Alka-Seltzer tablet in the cup or bowl of water. Note: A clear cup/bowl will work best.
4. Observe: what happened when you added the tablet? Either describe it in words or draw a picture below.

What's happening?

A ***chemical reaction*** happens when Alka-Seltzer is put into water. The tablet contains sodium bicarbonate (baking soda) and citric acid. In the presence of water, the sodium bicarbonate and citric acid react to form **carbon dioxide gas** (along with a molecule called trisodium citrate and water molecules). That is why bubbles form when you put an Alka-Seltzer tablet in water!

Experiment

1. Take the other half of the tablet from earlier and place it in the film canister.
2. Add a small amount of water (about 2 tablespoons) into the canister and **very quickly** secure the canister lid. Quickly shake the canister and place it **lid down** on the launch pad. Step back at least 5 feet.



Analysis

1. Describe *or* draw a picture of what you observed.

2. How long did it take the canister to launch?

3. How high did the canister go into the air?

4. Was anything left behind on the launch pad?

5. What makes this film canister a rocket?

Now that you've made a rocket, what do you think we can do to make the rocket launch higher in the air? Our film canister rocket launches because of pressure build up from the carbon dioxide produced from the chemical reaction. Are there ways we can change the experiment that would build up more pressure?

Scientists think about each step of an experiment, and change one part of a step first to see how it changes the final outcome. If you change too many things at the same time, it will be hard to know which change you made was more impactful than the other changes.

6. What steps would you change to make the rocket launch higher in the air? (*Could you use more of the Alka-Seltzer tablet? Could you shake it more or less? What temperature of water works best?)*

Can you think of anything else that builds up gas or pressure? For example, have you ever mixed baking soda and vinegar? Could you use baking soda and vinegar to make a rocket? Experiment and find out!

Use the table on the next page to design your own rocket experiment. We've included a few ideas to get you started, but consider what else you can change to make the best rocket possible.

	Prediction	How long did it take the rocket to launch?	How high did the rocket launch?	Anything left on the launch pad?	Any other notes?
Half tablet, not crushed with water					
Half tablet, crushed with water					
Whole tablet, not crushed with water					
Whole tablet, crushed with water					
Baking soda and vinegar					