Scientific Explorer

Star Rocket

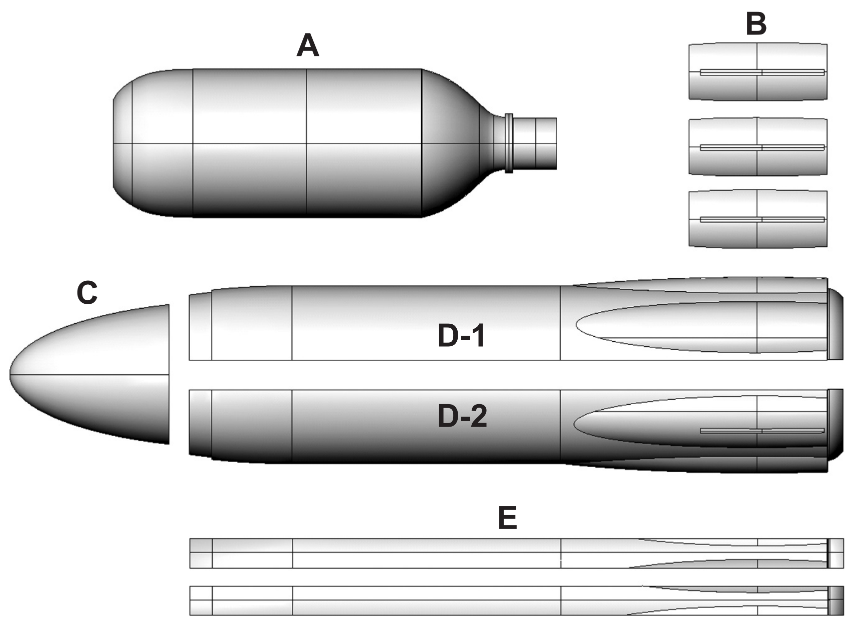
Blast into the future!

Get ready for an incredible, high-flying science experience! Your Star Rocket is easy to put together, and you won't believe how high baking soda and vinegar will make it fly!

> **IMPORTANT SAFETY NOTE**
> Adult supervision is required for flying the Star Rocket. Before launching the rocket you must carefully read the safety rules beginning on page 5 of this booklet.

What's included in your kit

- 1-liter bottle (A)
- 3 fin mounts (B)
- nose cone (C)
- 2 fuselage halves (D-1, D-2)
- 2 strip mounts (E)
- Clear tube
- Stopper assembly
- 3 balsa wood sheets
- Silver foil
- Orange foil



What you'll need to get

- Vinegar
- Baking soda
- Hobby knife or sharp scissors
- Ruler
- Kitchen funnel
- Measuring cup

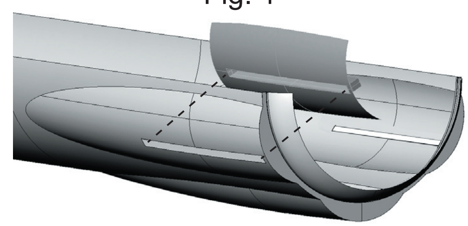
Building the Star Rocket

Install Fin Mounts

1. The two halves of the fuselage have slits cut in them. D-1 has one slit and D-2 has two slits. These slits are where the fins will attach to the rocket body.

2. Practice attaching a fin mount by placing it on the inside of one of the fuselage halves, so that the slot on the fin mount lines up with the slit in the fuselage. See Fig. 1.

Fig. 1



3. Once you've seen how these parts fit together, peel off the white tape on one of the fin mounts to expose the sticky adhesive. Press the fin mount onto the inside of the fuselage, making sure the slot in the fin mount lines up with the slit in the fuselage. Do the same with the other two fin mounts.

Attach Strip Mounts

The strip mounts fit inside the fuselage and hold the two parts together.

The tail end of each strip is flared to fit the raised flutes at the tail of the rocket. See Fig. 3. When you attach the strip mounts, be sure to align them so that the flared ends are at the rocket tail.

Begin by peeling the long pieces of tape off the strip mounts to expose the adhesive (don't peel off the short pieces). See Fig. 2. Fit the strip mounts along the inside edges of fuselage part D-2, pressing them firmly against the inner edges of the fuselage. See Fig. 3. Leave half of the strips sticking up over the edge to join them to the other part of the fuselage tube. See Fig. 4.

Fig. 2

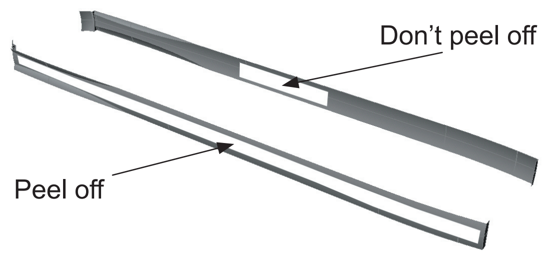


Fig. 3

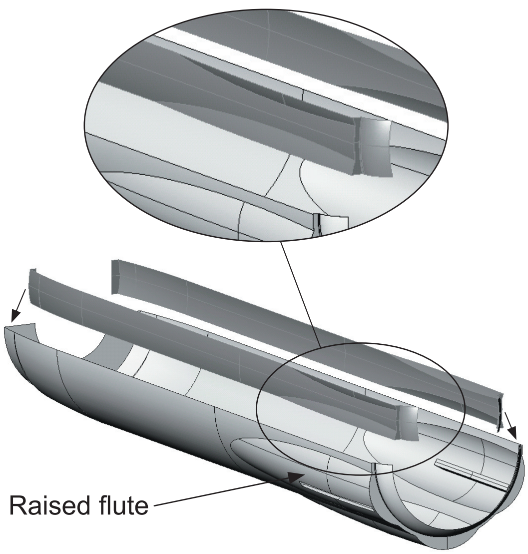
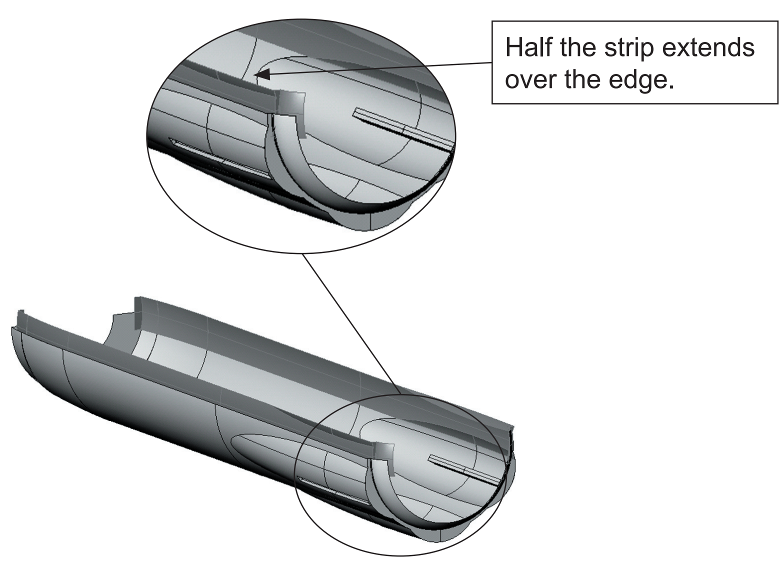


Fig. 4



Place Fuel Chamber Bottle in Fuselage

1. The bottle has a seam running down the side. Place the bottle in the fuselage so that the seam is aligned with the edge. See Fig. 5. Place the bottle so that there is a 1 1/16 inch space between the top of the bottle and the tail end of the fuselage. See Fig. 6
2. Holding the bottle in place, reach between the bottle and strip mounts and peel off the white tape to expose the adhesive. Stick the bottle to the adhesive.

Fig. 5

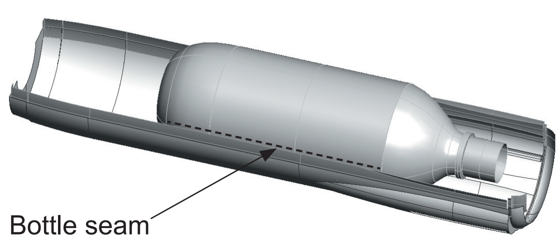
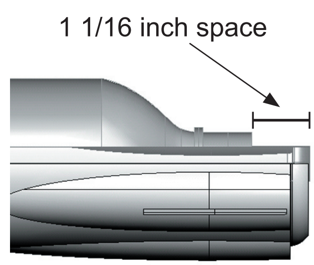


Fig. 6



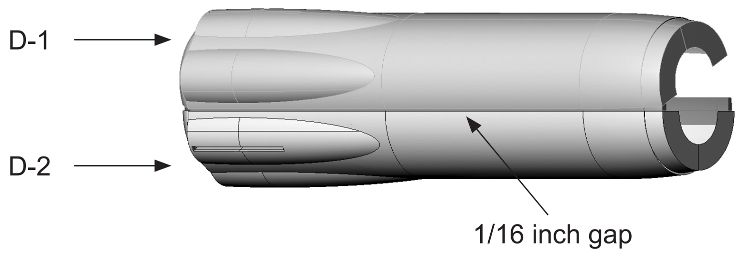
Close Fuselage

Fuselage part D-1 fits over the bottle and the strip mounts on part D-2 to complete the fuselage tube.

It is important to leave about a 1/16 inch gap between the fuselage parts on both sides of the rocket. See Fig. 9.

1. Press one edge of fuselage part D-1 against the strip mount on part D-2. Put the fuselage halves together so that there is about a 1/16 inch gap along the entire edge. See Fig. 7.
2. Complete the fuselage tube by closing part D-1 over the bottle and over the strip mount on the other side of the fuselage. See Fig. 8. Be sure to leave a 1/16 inch gap between the fuselage parts when you close the two halves together. See Fig. 9.

Fig. 7



The thickness of this line is 1/16 inch.

Fig. 8

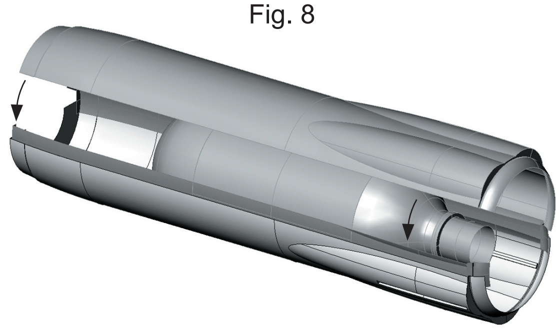
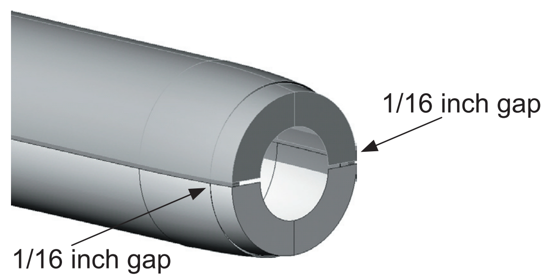


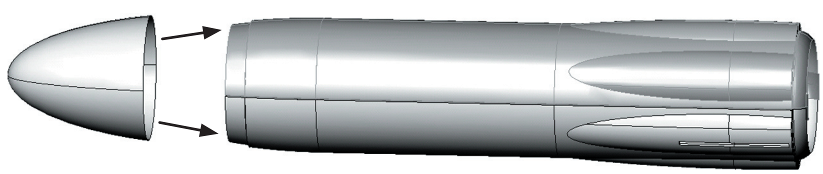
Fig. 9



Push Nose Cone onto Fuselage

Push the nose cone onto the top of the rocket, as shown in Fig. 10. The bumps inside the nose cone will snap into the grooves on the fuselage. For extra high flying fun, load the secret payload chamber by putting your payload in the nose cone before pushing it onto the top of the rocket. Be sure to use a very light object, or its weight will hinder the rocket's flight.

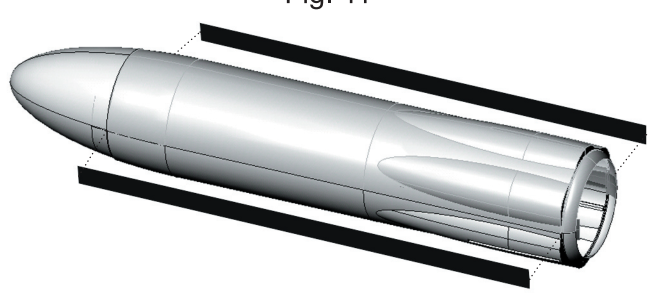
Fig. 10



Apply Seam Tape

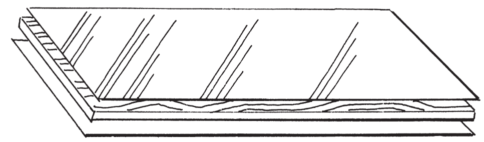
Cut two strips of silver foil 5/8 inch wide and 14 ¼ inch long. Remove the paper backing to expose the sticky adhesive, and cover the seams on both sides of the rocket. See Fig. 11.

Fig. 11

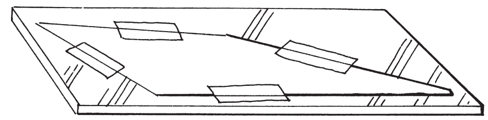


Cut out Fins and Attach to Rocket

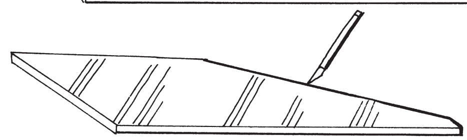
1. Cut six 2-inch wide strips of silver foil. Remove the paper backing to expose the sticky adhesive, and apply the foil to both sides of the balsa wood pieces. Try to apply it smoothly so there are no wrinkles or bubbles in the foil.



2. Cut out the fin templates and tape them to one side of each piece of balsa wood.

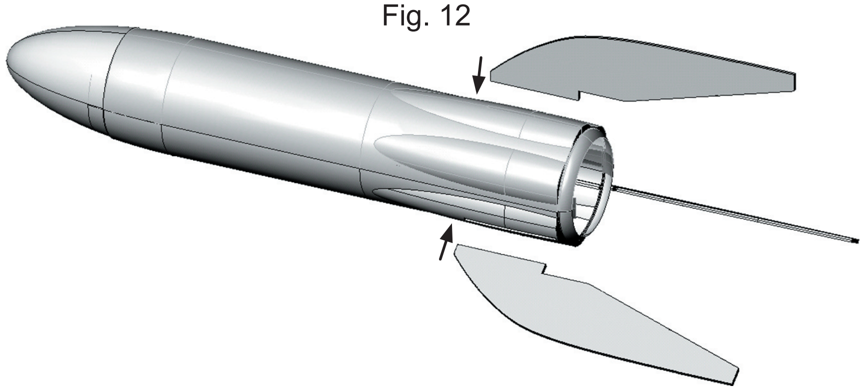


3. Ask an adult to carefully cut out the fins along the template lines with a hobby knife. If you don't have a hobby knife, the fins can be cut out with sharp scissors.



4. Mount the fins by pushing them into the slots in the fuselage, as shown in Fig. 12. Friction should hold them firmly in place. But if they don't stay, you can tape them in place with the siver foil.

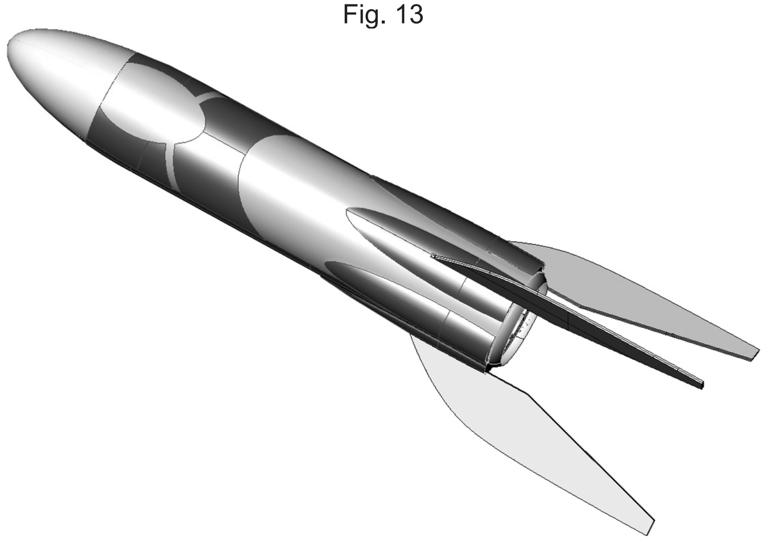
Fig. 12



Decorate Rocket

The silver and orange foil is for decorating the rocket. We have included a pattern for one design or you can exercise your creativity to create your own decorative designs.

Fig. 13



Flying the Star Rocket

The Star Rocket is a powerful, high performance rocket. You must follow these safety rules when launching the Star Rocket:

1. **ADULT SUPERVISION IS REQUIRED.**
2. **Never stand over the front of the rocket or point it at anyone.**
3. **Never point the back of the rocket toward yourself or anyone else.**
4. **Never try to catch the rocket in flight.**
5. **Don't fly the rocket where it could land on someone.**

Where to fly the Star Rocket

If the Star Rocket is launched straight up, it will normally come down within 100 yards of the launch site. Only fly the rocket where it can land on grass or other soft surfaces. Do not launch the rocket where it can land on concrete or other hard surfaces. Smooth dirt, grass, or a piece of cardboard make good, level launch pads.

Fueling the Star Rocket

1. Locate the stopper assembly. Loosen the red rubber stopper. See Fig. 14.
2. Push the clear tube firmly onto the end of the stopper assembly See Fig. 15. Fill the tube with baking soda up to about 1⁄2 inch from the top.

Fig. 14

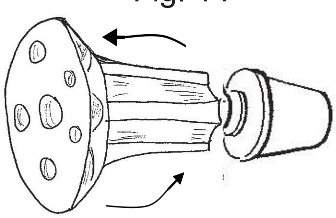
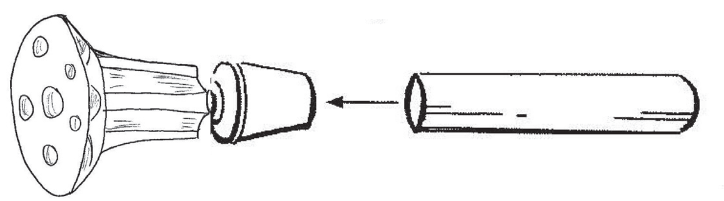
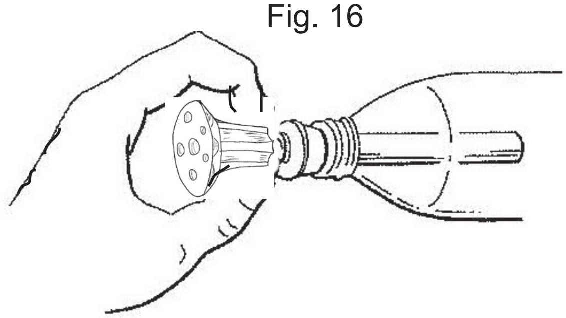


Fig. 15



3. Turn the rocket upside down (with the nose facing downward). Use a funnel to pour 3⁄4 to 1 cup of vinegar into the mouth of the bottle. Be sure not to spill any vinegar outside the bottle. It will weaken the adhesive holding the fuselage together.
4. Hold the rocket horizontally (to keep the vinegar and baking soda from mixing) and insert the stopper and tube into the mouth of the bottle. Push it in as tightly as you can, twisting the stopper as you insert it.

Fig. 16



5. Be sure to hold the rocket steady so the baking soda and vinegar don't mix yet. Then turn the red, rubber stopper to tighten. This makes the black rubber stopper expand, strengthening its grip on the bottle, and increasing the gas pressure needed to blow it out.
6. Do not overtighten the red stopper. If it is too tight, the pressure inside the bottle may not be able to blow out the stopper. This will prevent the Star Rocket from launching.

Lauching the Star Rocket

> **IMPORTANT SAFETY NOTE**
> When the vinegar and baking soda mix, a chemical reaction will start, which will immediately begin to pressurize the bottle. Be ready to set it down on the launch pad and quickly get away. Do not stand over either end of the rocket. Do not point the rocket at anyone.

1. When you're ready to launch the rocket, turn it upside down (with the nose facing downward) and give it one good shake. Without delay, turn it over and place it upright on the launch pad. Make sure the rocket is pointed straight up.
2. Stand back at least 15 feet to watch the Star Rocket blast off. In a matter of seconds, the reaction chamber will pressurize and blow out the stopper, sending the rocket sky high. The time this takes depends on the amount of fuel and the tightness of the stopper. Normally, the rocket will launch in 8 to 30 seconds.

> **IMPORTANT SAFETY NOTE**
> If the rocket doesn't launch within two minutes, the stopper is too tight. If this happens, an adult should pick up the rocket, hold it firmly, and pull the stopper out (like removing a champagne cork). Do not stand over the rocket at any time or allow the nose or tail end to point at anyone. The pressurized gas can send the stopper flying over 20 feet.

Tips and Troubleshooting

1. If the stopper blows out before you can set the rocket down on the launch pad, the stopper may not be in tight enough. Before you insert the stopper, make sure the wing nut is loose. Push the stopper in as far as you can. Then tighten the wing nut 6 to 9 half turns. If it is still unsuccessful, try tightening the wing nut a few more half turns.
2. If the climate is hot, the vinegar and baking soda may react too fast and blow out the stopper too soon. Try cooling the vinegar in the refrigerator before using it. This will slow down the chemical reaction.
3. If the stopper blows out but the rocket only flies a short distance, the stopper may not be tight enough. See tip number 1.
4. The tighter the stopper, the greater the pressure will be inside the bottle when the stopper blows out. And the greater the pressure, the higher the rocket flies. But if the stopper is too tight, it may never blow out on its own. Then you must ask an adult to carefully pull out the stopper to release the pressure.

Repairs

A hard landing can bang up your rocket. Usually the damage is easily repaired with household tape (Scotch Tape or another brand) or with some of the excess silver, black, or orange foil. If necessary, you can also make patches from soda bottles or other lightweight plastic.

Rocket History

Rockets have been around a long time. The first rockets were invented by the Chinese almost a thousand years ago. Early rockets were made of bamboo tubes full of gunpowder. When the powder burned, fire shot out a small hole and propelled the rocket through the air. For hundreds of years, these simple rockets were used mostly as weapons in war. But beginning in the 1800s, scientists and inventors began to see more possible uses for rockets, and some began to dream of rockets that would carry people into space. Rocket scientists and engineers built bigger and better rockets that flew faster and higher. As they did this, they also learned more about the science behind these amazing flying machines. By the early 20th century, scientists began to have a clear understanding of rocket science. Only then did the technology of space rockets really take off! Thanks to scientists like Konstantin Tsiolkovsky in Russia, Hermann Oberth in Germany, and Robert Goddard in the USA, we now have the giant sophisticated rockets of the space age. They provide us with satellite TV, help us predict weather, and explore the vast cosmos that lies beyond the thin shell of earth's atmosphere.

Rocket Science

If you've ever watched a rocket blast high into the sky, you've probably wondered what makes it fly. Let's look at the three forces that are present in all rocket flights – gravity, thrust, and drag.

What is gravity? It's the invisible force that pulls every object, large or small, down toward the earth. Gravity is a wonderful thing. Without it, we would all drift into outer space. Even worse, stars like the Sun wouldn't form to provide us with warmth and light. Planets wouldn't even form to make a place for us to live. The entire universe would be a formless blob of gas. As you might expect, the force of gravity acts downward on the rocket.

What is thrust? This is the force that pushes the rocket upward when the engine fires up. The secret of thrust is in Sir Isaac Newton's third law of motion, which tells us that for every action, there's an equal and opposite reaction.

In Newton's language, action is just another word for force. Every force is met with an equal force in the opposite direction. This means that when you push against a wall, not only are you putting a force on the wall – but the wall is putting an equal force back on you!

So how do you get thrust from this? All rockets contain a propellant. In most rockets, the propellant is a gas, but it can also be a liquid. When a rocket blasts off the launch pad, the force of the propellant flowing out the back of the rocket creates an equal and opposite force, pushing the rocket into the sky. This upward force is the thrust. It's that simple – the propellant flying downward makes the rocket fly upward!

What is drag? Once the rocket is accelerating up into the sky, the air puts a downward force on it called drag – which is just a fancy word for air resistance. If you've ever watched a feather fall slowly to the ground you've seen air resistance in action. Without air resistance, a feather would drop like a rock!

With the rocket flying upward there are three forces acting on it – thrust, gravity, and drag. Two of these are downward forces and only one is an upward force. What do you think will happen? As long as the thrust force is greater than gravity and drag combined, the rocket will continue to accelerate upward. But sooner or later the rocket will run out of propellant and the thrust will die. At this point, unless the rocket has escaped earth's gravity, both gravity and drag will take over to slow the rocket and it will eventually fall back to earth.

Rocket Chemistry

How does vinegar and baking soda make the Star Rocket fly so high? When these two materials mix inside the fuel chamber bottle, a chemical reaction occurs and produces lots of carbon dioxide gas – the same gas you breathe out when you exhale. As the gas fills the bottle, the pressure inside rises and pushes against the rubber stopper. When the pressure is strong enough, it blows the stopper out. What do you think happens then? That's right. It's Newton's third law of motion. The propellant – carbon dioxide gas, baking soda, and vinegar – shoots out the back with great force and the rocket flies sky high!

What's so special about vinegar and baking soda? Scientists group chemicals into three categories: acids, bases and neutrals. When an acid and a base mix, they react and neutralize each other, creating new chemicals. Household vinegar is acidic, since it is made of 95% water and 5% acetic (uh-SEE-tick) acid. Baking soda is made of a chemical called sodium bicarbonate (SO-dee-um by-CAR-buh-nit), which is a base. So when acetic acid and sodium bicarbonate mix, they react and produce new chemicals, including carbon dioxide gas.

Activities and Experiments

Thrust In Action

What you need
- A flat, level surface outdoors. It should be smooth enough that you can easily roll on skates or on a skateboard.
- A skateboard, rollerblades, or rollerskates.
- A basketball, soccer ball, football or other similar size ball. The heavier the ball, the better this activity works.

What you do
Stand motionless on the skateboard or skates on the flat surface. Now pick up the ball and throw it horizontally (level with the ground) as hard as you can. (Be careful not to hit anything!)

What happened? You probably noticed you moved in the opposite direction that you threw the ball. By throwing the ball, you put a forward force on it so that the ball flew through the air in front of you. And according to Newton's third law of motion, the ball also put an equal force on you in the opposite direction. This force is what pushed you backwards. Yes, that's right. The ball pushed back on you and actually made you move!

If two opposite forces are equal, why did the ball move a lot farther than I did? The effect a force has on an object depends on how much the object weighs. The same amount of force made the ball go a lot farther because it weighs much less than you do.

What's this have to do with rockets? Rockets create thrust by throwing stuff out the back of the rocket. It's just like when you threw the ball. The stuff flies in one direction, and the rocket flies in the opposite direction.

What a Drag!

What you need
- Two sheets of paper of the same size

What you do
1. Crumple up one sheet of paper into a ball. Hold the paper ball at arms length and drop the ball. See how *quickly* it falls to the ground.
2. Now hold the flat sheet horizontally (level with the ground) at arms length and drop it. See how *slowly* it falls to the ground.
3. Using both hands, drop the flat paper sheet and paper ball at the same time. Which one fell faster?

What's going on? As light as air is, it really is a powerful thing! Drag, or air resistance, tends to slow objects down when they move through the air. The amount of air resistance an object has depends on its surface area. The more surface area, the more air can push on it to slow it down. In this experiment, the flat sheet has more surface area than the ball. So the force of the air against the sheet is greater, causing it to fall more slowly.