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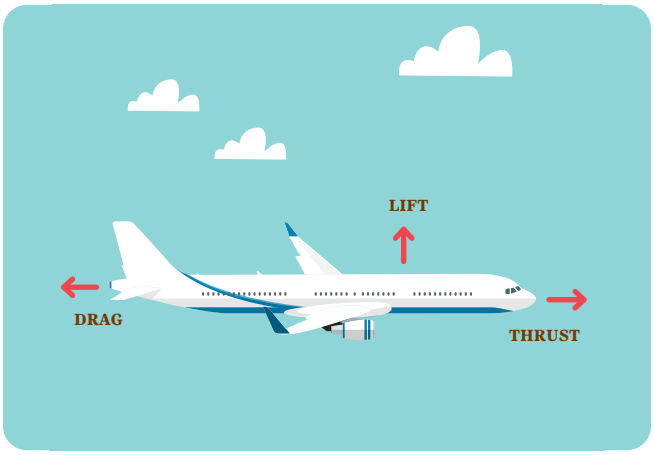
Explore Rocketry

Rocketry is the design and creation of rockets. They're often built by aerospace engineers. **Aerospace** is the earth's atmosphere and the space beyond it. An **engineer** is someone who uses science and technology to build machines and solve problems. An **aerospace engineer** is someone who develops aircraft and spacecraft. They also build rockets for all kinds of uses, like space exploration, deploying satellites, and national defense. They're rocket scientists! However, you don't have to be an aerospace engineer to build rockets—**sport rocketry** is when nonprofessionals use model or sport rockets to experiment with different designs and rocket motors.

Sport rocketry is:

- A fun way to learn about aerospace engineering and careers through hands-on experience with rocket design, construction, and STEM
- A popular hobby, with over 12 million flights per year around the globe and practiced in 25,000 schools across the U.S.
- A chance to work with peers and experts as you develop important skills like teamwork, problem-solving, and leadership

Flight Forces: How They Work



For something to fly, lift must be greater than weight, and there must be thrust that can overcome drag.

- **Balanced forces:** When forces are equal on an object, the object does not move
- **Drag:** The force (air molecules) that acts against something in flight
- **Force:** The strength or energy that creates movement (push and pull are examples)
- **Friction:** The force that slows moving objects
- **Gravity:** The force that pulls objects toward each other and toward the earth
- **Lift:** The force that pushes back up on the wings during flight
- **Thrust:** The force that moves an object forward
- **Unbalanced forces:** When forces are unequal on an object, the object moves in the direction of the greater force

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Activities

Check out these hands-on activities to explore aerospace engineering, flight, and rocketry.

Learn About Flight with Paper Airplanes

Purpose: Design paper airplanes to explore the different forces involved in flight.

Materials:
- Paper of different sizes and weights
- **Optional:** marker, stickers, and other materials to decorate

Activity:
To get started, choose a sheet of paper and fold a paper airplane. Try it out—how well does it fly? What worked? What didn't work? How can you improve the paper airplane?

Then, use what you learn to make a few more paper airplanes. Try different designs and papers of different weights and sizes.

When you're ready, choose a starting point and fly all your airplanes. Which went the farthest? Which went the highest? Why do you think this happened?

When you're done, consider how your paper airplanes were able to fly. Match each question with its answer, then check your answers at the bottom of this page!

Questions

1. What makes the airplanes move? _____
2. What is the force that makes the airplanes move forward? _____
3. What is the force that lets the airplanes stay in the air? _____
4. What is the force that pulls the airplanes down? _____
5. Why did the airplanes slow down? _____

Answers

A. Drag

B. Lift

C. Thrust

D. Force

E. Gravity

Bonus Question: Were forces balanced or unbalanced when the plane flew?
Circle your answer.

Balanced Unbalanced

Answer Key: 1. D, 2. C, 3. B, 4. E, 5. A, Bonus: Unbalanced

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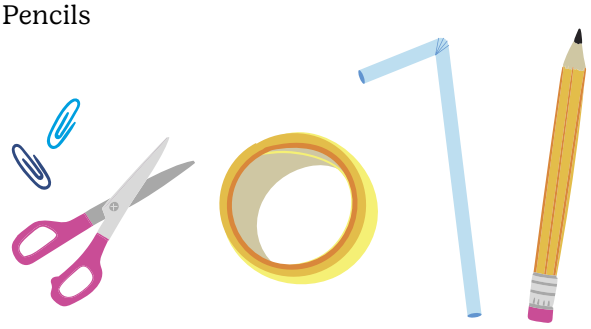
Build a Rubber Band-Powered Plane

Purpose: Make a paper airplane with a rubber band to increase its thrust.

Materials:

- Dowels, BBQ skewers, straws, craft sticks, etc.
- Paper clips
- Large rubber bands
- Paper of different sizes and weights
- Tape (masking or duct) or glue
- Scissors
- Scrap paper for drawing designs
- Pencils



Activity:

First, decide on a goal for your paper airplane. Do you want it to fly far? Stay in the air a long time? Do tricks like a flip?

Then, draw your design. How can you add a rubber band to increase the thrust? When stretched, the rubber band can work similarly to a slingshot, thrusting the plane through the air. Use your imagination and materials to sketch and build your design.

Next, test your paper airplane. How well does it fly? Is there anything you want to improve? If needed, make changes. Then continue to test your plane, flying it at least 3 times and recording your results.

	Flight 1	Flight 2	Flight 3
Flight Length *(How far it goes)*			
Flight Duration *(Amount of time airborne)*			
Skills and Tricks *(Number of flips, loops, etc.)*			

After, analyze your data. If you want, redesign or make more planes to test your ideas.

- Which flight would you consider most successful? Which was the least? Why?
- What forces impacted your test flights?
- What force pushes the plane forward through the air?
- Why does the plane slow down?
- What force pulls the plane back down to the ground?
- How can you improve your paper airplane? For example, how could you create more thrust?

Did You Know? The rubber band creates "thrust," moving the paper airplane through the air. It also pushes air molecules out of the way, slowing the plane down and creating "drag." Gravity pulls it back down to ground. However, air is in the way—the wings deflect the air, which pushes back up on the wings and creates "lift."

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Make a Stomp Rocket

Purpose: Build a model rocket powered by compressed air.

Materials:

- 1-inch-wide bicycle inner tube (cut to create a hose 3+ ft. long) and 1-inch-wide PVC pipe (1+ ft. long) OR 2 ft. piece of garden hose
- 2-liter soda bottle(s) (empty)
- 2 pieces of construction paper or card stock
- Tape
- Scissors
- Pencil

Activity: First, decide on a goal for your stomp rocket. Do you want it to fly high, stay in the air a long time, or do something else?

Then, follow these steps to build and launch a stomp rocket:

1. **Build your rocket body.** Roll a piece of paper lengthwise around the outside of the PVC pipe or garden hose, creating a tube that fits around it but can slide off. Use tape to secure the tube.
2. **Make a nose cone.** Cut one end of the rocket body to a point and seal it with tape (it must be fairly airtight to fly well) OR roll a triangular piece of paper into a cone and tape it securely to the rocket body, trimming extra paper from the edges as needed.
3. **Add fins to the base of your rocket body.** Fins will help your rocket fly straight. Tape triangles of paper or cardstock to the rocket base. Try different triangle sizes and shapes to see which ones work best.
4. **Build your launcher.** Place one end of your bicycle tube or garden hose over the opening of the empty 2-liter bottle and secure it with tape. If using the bicycle tube, tape the other end of the tube to one end of the PVC pipe. Make sure these connections are airtight so all the air from your bottle will go into your rocket when you stomp.
5. **Launch your rocket.** Place the paper rocket just over the open end of the garden hose or PVC pipe, pointing the hose or PVC pipe in the direction you want the rocket to go. Then stomp on the bottle and watch how the air pushed out creates thrust, moving the rocket into the air.

Launch your rocket multiple times, and write down your results and observations. For example, how far did the rocket go each time? Did it fly straight? Did it "fly" or "glide" like a plane once it stopped climbing? If needed, you can replace your bottle and repair or reinforce your rocket between test flights.

After, analyze your data. If you want, redesign your rocket to test your ideas.

- **Which flight would you consider most successful?** Which was the least? Why?
- **What forces impacted your test flights?**
  - What force pushes the rocket up and forward through the air?
  - Why does the rocket slow down?
  - What force pulls the rocket back down to the ground?
- **How can you improve your stomp rocket?** For example, how could the shape of the nose cone or wings change how the plane flies?

Lastly, brainstorm ways to improve the rockets. Ask questions like, "How could you change the design to create more thrust? How could the shape of the nose or fins change how the plane flies?" Check out these ways you can continue the fun and learn more about aerospace engineering, space science, and rocketry.

Did You Know? The compressed air creates "thrust" which moves the rocket. The rocket also has to push air molecules out of the way, which slows it down and creates "drag." The shape of the nose cone helps push the air away, making it easier for the rocket to fly. Gravity also pulls the rocket back down, but the fins also deflect the air, which pushes back up and creates "lift."

Keep the Fun Going

Build Your Own Model Rockets
Once you're ready to build your own full-sized, motor-powered model rockets, begin with a starter kit or build your own from scratch. You can do an internet search using keywords like "DIY or homemade model rocket" or find resources from organizations such as the National Association of Rocketry (NAR) and the American Rocketry Challenge. As you build your model rocket, try a variety of materials, designs, and motors. Use flight-simulation software to save you time, materials, and money. Keep detailed notes about your design process and flight data to help make improvements.

Attend a Sport Rocketry Launch
The National Association of Rocketry (NAR) was founded in 1957 to provide a safe and inexpensive way for young people to learn the principles of rocket science and flight. NAR has local and regional clubs (called Sections) that may host competitions or noncompetitive sport launches, where teams and individuals can fly rockets. Check out the launch calendar or use the NAR Club Locator to contact your nearest NAR Section. Then, bring your rockets, motors, and flight supplies to join in on the fun! There may also be other rocketry clubs, teams, or groups in your area.

Start a Rocketry Team
As you explore rocketry, you'll likely be connected with peers and experts who have similar interests. Coming together to form a team can provide you all with a stable network to explore aerospace engineering and rocketry. Together you can develop your base of knowledge, build rockets, and solve problems. For ideas to get started, check out the Rocketry Toolkit from Girl Scouts of the USA.

And while building and launching model rockets is fun, some groups like to add the challenge of competition to the process. Competitions can provide teams with a common goal, guidelines, structure, and deadlines to work toward. For example, Girl Scouts in grades 6-12 can compete in the biggest rocketry competition in the world, the American Rocketry Challenge. It provides 6th- through 12th-graders with real-life experience in designing a r ocket that meets a specified set of requirements, working together in the same way aerospace engineers do. Check out rocketcontest.org for more details, including contest rules, key competition dates and deadlines, and frequently asked questions.

Learn More with Girl Scouts
To support Girl Scout councils and troops who want to pursue sport rocketry (both competitively and non-competitively), Girl Scouts of the USA has created the Rocketry Toolkit (link). This toolkit includes information and resources for organizing team rocketry experiences and finding volunteers, materials, mentors, meeting locations, and funding to help explore the world of rocketry.

If you're a Girl Scout who wants to earn related badges, check out the Space Science badges (K-12), Think Like an Engineer Journey (K-12), and Mechanical Engineering badges (K-5). Find out more on the Award and Badge Explorer.

Not a Girl Scout yet? Join Girl Scouts today at girlscouts.org/join