GSK Science in the Summer™
In partnership with UNC Morehead Planetarium and Science Center

Science in the Summer at Home Level III Activity Materials
(for rising 6th – 8th graders)

Urban Planning	**Quantity**
Pencil	1
Neighborhood Checklist	1
Planning a Town	
Paper (white, 11” X 17”)	1
Pencil	1
Tape Measure	1
Alka-Seltzer Rockets	
Film Canister	1
Construction Paper	2
Scissors	1
Tape (scotch)	1
Tape Measure	1
Alka-Seltzer	2
Whirligig	
Construction Paper	1
Scissors	1
Pencil	1
Tape Measure	1
Ping Pong Challenge	
Ping Pong Ball	1
Cups (plastic, 5 oz)	2
Bernoulli Paper	
Straw	1
Paper (white, 8.5” X 11”)	1
Scissors	1
Tape	1
Casts and Splints	
Plastic fork	1
Sponge	1

Cardboard Tube	1
Popsicle Sticks	5
Foam Sheet	1
Cotton Balls	10
Mesh	2
Rubber Bands	3
Tape	1
Pencil	1

Materials from home
Water
Markers/Colored Pencils/Crayons

URBAN PLANNING

BIG IDEA

Step into the role of an urban planner as you complete a checklist about the design of your neighborhood.

READY ...

Gather materials:

- neighborhood checklist
- pencil

SET ...

For this activity, you will be thinking about your neighborhood. Determine if you will go outside, look out of a window, or simply use your imagination to picture your environment.

GO!

1. Look around your neighborhood. What do you see?
2. Use the neighborhood checklist to record your observations. Think about the structures—but also think about the overall impressions you have. Is there a lot of green space? Are most of the buildings tall? How do your surroundings make you feel?
3. As you look at your checklist, what do you notice about the buildings you listed? Do the buildings have anything in common? What types of buildings did you notice?
4. Why do you think these buildings are in the neighborhood you observed? Is your neighborhood next to a big factory? Why or why not?
5. Think of at least two ways you can tell that the neighborhood was designed. Some examples could include:
   - There is a school nearby, so young people in the neighborhood can easily get to and from school.
   - There is a soccer field, playground, or other open area nearby so young people can play outside.
   - There is a grocery store right down the street, so that the people living nearby can get food.
   - There are roads that allow people in the neighborhood to travel from their homes to other parts of the town or city.
   - There are one or more fire hydrants in the neighborhood.
   - There is a bus stop nearby, so people in the neighborhood can use public transportation.
   - There are sign posts with the names of streets, speed limits, or other messages.

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WHY IS THIS ENGINEERING?

Civil engineers are involved in the design, construction, and maintenance of the built environment. Typically, their work serves the general public. Civil engineers work with scientists and other engineers to make sure their creations are safe and effective for people to work, play, and live in. Civil engineering is one of the oldest forms of engineering.

Civil engineers can be involved in projects ranging from designing airports and amusement parks to creating bridges and bioswales (green spaces designed to deal with rainwater runoff). They may even be involved in town and city planning. Civil engineers and urban planners work together to figure out how land in specific areas will be used.

Neighborhood Checklist

Buildings where people work	
Buildings where people live	
Areas where people play	
Places where people eat	
Other places	

MAKE & TEST AN AIRPLANE

BIG IDEA

Use quantitative measures (distance and time) to evaluate the design of a paper airplane.

READY ...

Gather materials:

- calculator
- pace calculation sheet
- paper
- pencils
- tape measure
- timer

SET ...

Ask an adult helper to help you find an area where you can test your plane. If an outdoor space is unavailable, clear a space inside.

Remember, we must never throw our paper airplanes toward or near someone's face.

GO!

1. Your challenge is to build a paper airplane then measure how far and long it can fly. You can use an airplane design you have tried before, or you can design something entirely new!

FOLDING

2. Effective folding has several steps:

a. Gently bend the paper to align the fold.

b. Firmly press with fingertips to make the fold.

c. Firmly press with a fingernail to finish and crease the fold.

NAMING

3. Manufacturers often use unique names and numbers to keep track of particular models, and you can do the same with your airplane designs:

- Write your label on the upper surface of a wing of the plane (or somewhere equally visible if your plane does not have typical wing structure).
- An example of a name and model number is "The Laser, NH004." The model number should be your first and last initials, and end in the number of planes that you have built so far. For example, Nick Hoffmann has made four planes: NH001, NH002, NH003, and NH004.

MEASURING DISTANCE AND TIME

4. Go to the designated throwing area to test your airplane design.

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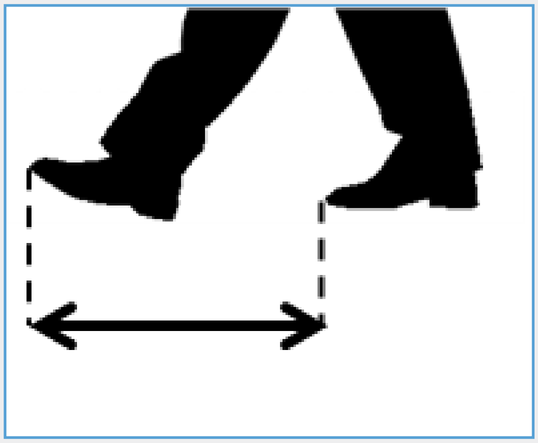
5. Use your timer to determine the duration of the airplane's flight. You can throw the plane with one hand and hold the timer in the other hand, or a helper can time the flight while you throw.

6. The easiest way to measure flight distance quickly is by using your own pace:



- A pace is the distance you cover in a single step, from the front of one foot to the front of the other. If you keep your paces equal at all times, you can count the number of paces to pick up your airplane and calculate the true distance.
- Calculate the length of your pace by using your tape measure. It's a good idea to measure three times and calculate the average.

7. Each flight may be affected by variables (things that can vary or change), such as wind, angle of throw, strength of throw, etc. What are the variables that may have affected the flight of your plane today?

8. Aerospace engineers conduct tests in order to ensure their designs are safe and effective. Their tests provide information that can lead to improvements in the designs. Based on your tests, how would you improve your paper airplane design?

PLANNING A TOWN

BIG IDEA

Plan a town—on one sheet of paper!

READY ...

Gather materials:

- piece of paper
- pencil
- ruler
- markers (optional)

SET ...

No setup needed!

GO!

1. Your challenge is to design a town—and to draw the whole plan on one piece of paper. Instead of drawing specific details of buildings, you can draw outlines. For example, you can draw a rectangle for a school and label the shape with the building's name.
2. As you plan, consider the five "land use" categories that urban planners use:
   - Residential—Places where people live
   - Commercial—Places where people buy things
   - Industrial—Places where people work
   - Community—Places for the community
   - Vacant—Places with nothing on them
3. If you did the "Urban Planning" activity, compare the land-use categories to the neighborhood you observed. Which land-use categories are used there? Do you plan to include some features of that neighborhood in the town you are planning?
4. Remember other places you know about. Can you think of buildings and other features of those places? How do those buildings and features fit into the land-use categories? These are some examples:
   - Residential—houses, apartments, townhouses
   - Commercial—stores, restaurants, movie theaters, gas stations
   - Industrial—factories, offices, warehouses
   - Community—schools, libraries, parks, places for worship, hospitals, fire stations, airports, landfills
   - Vacant—natural places, forests

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5. As you draw the plan for your town, ask the kind of questions urban planners ask.

- Should an airport be placed right next to the school?
- Should our town only have houses? Should it only have stores?
- Do we want all of our residential areas on one side of the town, but our grocery store on the other side an hour drive away?
- Are the buildings conveniently located?

6. Here are some ideas for things to include in your town:

- Somewhere to buy food
- Somewhere to buy medicine
- Park or playground
- School
- Doctor's office or hospital
- Town hall
- Library
- Fire station

7. Once you have drawn the basic outline of your town, add other features. For example, a transportation plan for the town can include roads, crosswalks, sidewalks, bike paths, bus stops, traffic lights, etc.

WHY IS THIS ENGINEERING?

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Civil engineers can be involved in projects ranging from designing airports and amusement parks to creating bridges and bioswales (green spaces designed to deal with rainwater runoff). They may even be involved in town and city planning.

Urban planners try to keep a good combination of the land-use categories when planning a town or city. Urban planners and civil engineers work together to figure out how land in specific areas will be used.

WITH THANKS AND FOR MORE INFORMATION, VISIT:

This activity has been adapted from *A Kid's Guide to Building Great Communities: A Manual for Planners and Educators* by the Canadian Institute of Planners.

CASTS & SPLINTS

BIG IDEA

Bioengineer a cast or splint to help mend a broken bone.

READY ...

Gather materials:

- cardboard tubes
- cotton balls
- foam sheets
- mesh
- paper
- pencil
- plastic fork
- Popsicle sticks
- rubber bands
- scissors
- sponges
- tape

SET ...

No setup needed!

GO!

1. Break the handle of your fork. The fork will represent a broken bone in this activity.
2. You are a biomedical engineer who has been tasked with designing a new type of cast or splint for your broken fork!
   - Casts are made of a hard material, like fiberglass or plaster, and wrap all the way around an injury to keep the bone still while it heals. A cast should only be removed by a medical professional, because it must be carefully cut off with a saw or blade.
   - Splints are sometimes called “half-casts” because the hard part of a splint does not wrap all the way around the injured area. Splints are held in place by elastic bandages or Velcro and are much more adjustable and easier to remove. They are also designed to hold the bones in place while they heal.
3. Most engineers have rules or constraints they must consider, such as a budget or availability of materials. For this project, you will have a budget of $500. Here is the cost of each type of material you can use:
   - Cardboard tube—$200
   - Sponge—$100
   - Foam sheet—$100
   - Popsicle stick—$70
   - Rubber band—$70
   - Mesh—$50
   - Cotton balls—$50 for set of 4
   - String—$25
4. Spend some time thinking about design possibilities and ideas. Draw some sketches to envision how these designs might look and work.

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5. Select one of your ideas (or combine elements from several ideas) to work on.

6. Consider what materials are available and how much they cost. Some of the materials are soft, like the foam, and some are hard, like the Popsicle sticks. Which will work best? How many items can you afford? Write a supply list with all the materials you will need for your prototype. Check your budget.

7. Build a working model of your design.

8. Test the working model on the broken fork. Experimenting in this way is an important step in the engineering design process. Trying out a design helps engineers discover the strengths and weaknesses of their solution.

9. Based on your test, can you improve your design? Will different materials or building methods improve the design's comfort, cost, weight, or strength?

10. Build and experiment with your improved design.

WHY IS THIS ENGINEERING?

Casts and splints are designed by biomedical engineers. Comfort, cost, weight, and strength are some of the criteria that biomedical engineers must consider when designing these devices to support and protect broken bones.

Biomedical engineering combines biology and engineering—applying engineering principles to medicine and healthcare. Biomedical engineers create machines, devices, and equipment that can be used in hospitals and other healthcare settings. Some examples of biomedical engineering are prosthetics, hearing aids, surgical robots, insulin pumps, heart-rate monitors, and masks.

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BERNOULLI PAPER

BIG IDEA

Build a simple device that shows how wings help airplanes fly.

READY ...

Gather materials:

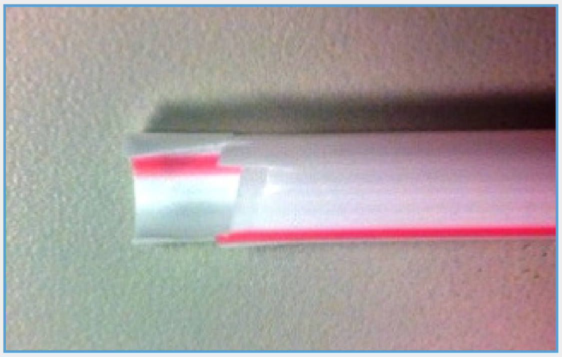
- thin strip of paper
- straw
- scissors
- tape

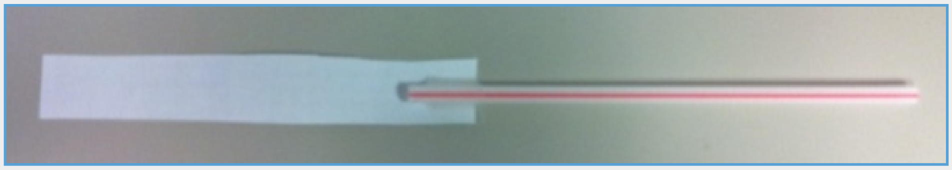
SET ...

No setup needed!

GO!

1. Use your scissors to bevel one end of the straw.
2. Tape an inch of the beveled end of the straw (bevel face down) to the paper.
3. Blow through the straw, and the paper should lift. The easiest method is usually to blow through the straw quickly at the start and then continue by blowing more gently. This will lift the paper quickly and keep it steady.





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WHY IS THIS ENGINEERING?

When you blow above the paper, the air pressure is reduced. The air pressure below the paper remains the same and is now greater than the air pressure above the paper. This difference in pressure causes the paper to rise. This concept, called Bernoulli's principle, is named for its discoverer—Daniel Bernoulli, a Dutch scientist who lived in the 1700s.

Bernoulli's principle also affects airplanes. An airplane's wing slices through the air, causing some air to go over the top and some to go underneath. The air on top of the wing travels faster, producing low pressure, while the air underneath the wing moves slower, producing high pressure. The high pressure under the wing is pushing more than the low pressure on top of the wing, causing the wing to be lifted.

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ALKA-SELTZER ROCKET

BIG IDEA

Use the engineering design process as you design, build, and test a rocket.

READY ...

Gather materials:

- 1 Alka-Seltzer tablet
- 1 film canister
- construction paper
- charts for Trial 1 and Trial 2
- pencil
- ruler
- scissors
- tape
- tape measure
- water (in a small container)

SET ...

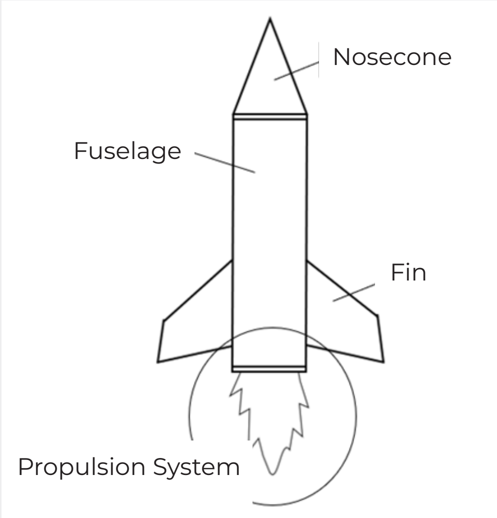
1. An adult helper should decide on an outdoor area where you can launch your rocket. You will need to launch in an area away from people.
2. Put water in a cup or other container. You will be taking the water with you when you go outside to test your rocket.

GO!

ENGINEERING DESIGN PROCESS: This is a process that engineers follow in their work. They are presented with a problem and work with a team to brainstorm or explore solutions. After deciding on the best idea, they design a plan and create a prototype or example of the solution. After experimenting with their prototype, they make improvements and most likely test the prototype again.

1. PROBLEM: Identify the problem, requirements, and constraints that must be considered.

Your goal is to make a rocket that flies as high as possible. Your rocket will have a basic propulsion system made of Alka-Seltzer and a film canister. And you will design the other parts of the rocket to optimize the rocket's flight.



2. EXPLORE: Brainstorm solutions and research ideas.

Most rockets have the same basic parts:

- The fuselage is the main body of the rocket that holds the control systems.
- The fins provide stability so that the rocket flies straight.
- The nosecone makes the rocket more aerodynamic and reduces drag.

You are going to design and build these parts out of construction paper and add them onto the film canister.

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All rockets have some kind of propulsion system, or engine, to provide thrust and get it off the ground. Your rocket will be propelled by a chemical reaction between water and an Alka-Seltzer tablet.

3. DESIGN: Sketch and plan possible designs; choose a design to prototype.

Take a few minutes to sketch or write down the plan for your rocket design in the chart for Trial 1. As you design your rocket, keep in mind:

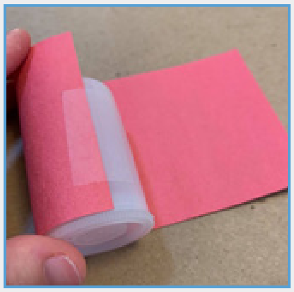
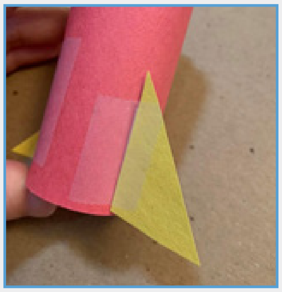
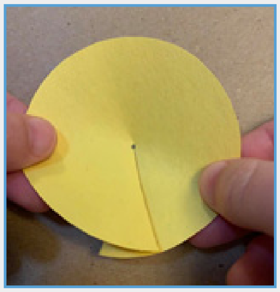
- You will need to build your rocket with the film canister upside-down, with the lid on the bottom.
- The lid of the film canister should not be covered with paper or tape. The lid must be able to be opened so that water and the Alka-Seltzer tablet can be added.

4. CREATE: Build a working model, or prototype, of your design.

Use construction paper to create your rocket's fuselage, fins, and nosecone—then add them to the film canister.

Some techniques for constructing your rocket:

- For the fuselage: Cut construction paper to desired height. Tape the paper to the side of the film canister and roll into a tube around the canister. Tape to secure the tube.
- For the fins: Cut out the desired shape and number of fins from construction paper and tape onto the fuselage. Simple triangles work well.
- For the nosecone: Start by cutting out a circle of construction paper. Then, cut a slit from the edge of the circle to the center point. Take the edges of the slit and overlap them to create a cone shape. Tape to secure. The more you overlap the edges, the taller and narrower the nosecone will be. Tape onto the fuselage.

- As you build your rocket, be careful not to cover the lid with paper or tape, since it will need to be opened and filled with the water and Alka-Seltzer.

Record the number of fins, length of fuselage, and shape of nosecone that you have chosen for Trial 1 on the chart. You can use a ruler to determine fuselage length.

5. EXPERIMENT: Evaluate your solution by testing your design.

Follow these steps to test your rocket design:

a. Go to the launch zone to test. Make sure you launch in an outdoor area away from people. Never direct the rocket at another person. Back away quickly once you set the rocket down for launch.

b. Look around the launch zone. You will approximate how high the rocket flies by comparing it to a nearby landmark, like a shrub, tree, or side of a building.

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c. Fill the film canister 1/3 of the way up with water.

d. Break an Alka-Seltzer tablet into thirds—and drop one third into the film canister.

e. Quickly put the cap on the film canister (making sure it snaps into place), give it a shake, and put it cap-side down on the ground in the launch zone.

f. QUICKLY BACK AWAY.

g. Watch what happens! It may take 20–30 seconds, so be patient. (If the rocket engine fails to launch, the lid is likely loose and leaking. Try the experiment again, making sure you hear a snap when putting the lid on.)

h. Compare the approximate height of the rocket's flight to the landmark you chose. You can use your tape measure to figure out how high the rocket flew.

i. Record the height of the flight path in the Trial 1 chart.

6. IMPROVE: Based on the results of your test, make improvements to your design.

a. Now that you have tested your design, think about adjustments you can make to improve your rocket.

b. Design and build another rocket. Record fin number, fuselage length, and nosecone shape in the Trial 2 chart.

c. Return to the launch site and follow the steps above to test your new design.

d. Record your testing data in the Trial 2 chart.

e. Compare your observations from Trial 1 and Trial 2.

- Did you notice if the rocket with the longer or shorter fuselage flew higher?
- Was there an optimal number of fins?
- Because the paper weighs the rocket down and these engines provide relatively little thrust, you may have found that the design with the least amount of paper flew highest.

f. Based on your tests, what would the ideal rocket look like?

WHY IS THIS ENGINEERING?

Employing the same principles of flight that are used to design airplanes, engineers can help us travel and explore even farther with rockets. Airplanes can soar through the skies, but they can't leave Earth's atmosphere. Rockets can take us up through Earth's atmosphere and into space!

In your experiment with a rocket propulsion system, Alka-Seltzer dissolved in water, causing a chemical reaction that released carbon dioxide gas. Gases like to expand to fill their containers, but the film canister containing the gas was too small. The gas kept pushing and pushing until the pressure was finally released and launched the canister into the air! This release of pressure provided thrust to make your rocket soar upward. Gravity quickly pulled your rocket back down to Earth, but real rockets have enough thrust to keep travelling upward until they leave Earth's gravitational pull.

AIRPLANE DESIGN PRINCIPLES

BIG IDEA

Learn design principles that engineers use to stabilize and control an airplane's flight.

READY ...

Gather materials:

- paper
- paperclip (optional)
- penny (optional)
- tape (optional)

SET ...

Ask an adult helper to help you find an area where you can test your planes. If an outdoor space is unavailable, clear a space inside.

Remember, we must never throw our paper airplanes toward or near someone's face.

GO!

ELEVATORS AND RUDDERS

1. Most airplanes fly best when they have a steady, even flight. Here are two of the ways you can modify a plane to stabilize its flight:

- Elevators—or horizontal stabilizers—are small flaps on the rear end of the wing.
- Rudders—or vertical stabilizers—are small flaps on the rear end of the plane's body.

2. Conduct an experiment to see how elevators and rudders stabilize an airplane's flight:

a. Make two similar paper airplanes. The first plane should have elevators cut into the back of the wings, and the second plane should have a rudder cut into the rear of the body.

b. Take the planes to the testing area and throw each plane, adjusting the stabilizers to figure out what each one does.

c. Observe the flight of each plane.

3. What are your observations about the elevators and rudders? Were you able to control your airplanes better with elevators and rudders?

4. Fly your planes again and see if you notice any of the following effects as a result of your modifications:

- Elevators stabilize the pitch—the upward/downward direction in which the nose points.

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- When an elevator is pitched upward, the tail of the plane will move downward. This increases the amount of lift the plane receives.
- If elevators are pitched in different directions, they will tilt the plane from left to right. This usually results in a quick crash.
- Rudders stabilize the yaw, the left/right direction in which the nose points.
- When a rudder is angled to the right, it will deflect air to the right. The tail will then move to the left, which turns the plane to the right. Similarly, if the rudder is angled to the left, the plane will turn to the left.

5. Will you use these modifications in your future paper plane designs?

DIHEDRAL AND ANHEDRAL ANGLES

6. Roll is the rotation of the plane around its axis. Wings with different sizes and shapes can create different amounts of lift, tilting an airplane to the side until it crashes. To help account for the roll caused by slightly different wing size, you can adjust the angle between the wing and the plane's body.

- When the wings are folded to point upward from the plane's body, they create a dihedral angle. Dihedral-angled wings compensate for each other's roll. For instance, if an airplane rolls to the right, a dihedral-angled left wing will create additional lift and roll back to the left.

- When the wings are folded to point downward from the plane's body, they create an anhedral angle. Anhedral angles reduce the stability of a plane's body. This is not ideal for a paper airplane, but it is useful in some other aircraft. For instance, fighter planes must be able to roll and maneuver very quickly.

7. Experiment with your paper airplanes by setting their wings at different angles to control the direction and amount of the planes' roll.

CENTER OF GRAVITY

8. Distribution of weight is another important factor affecting flight. An airplane's center of gravity is the point at which it balances, and it usually lies about halfway along the body of the plane.

- You can find the center of gravity by holding the airplane's body very gently between two fingers, using the fingers as a fulcrum to balance the plane's weight. If the airplane's weight causes it to tilt, move your fingers until it no longer tilts.
- In most airplanes, the center of gravity is near the midpoint of the airplane's body. However, most airplanes are more stable when the center of gravity is closer to the airplane's nose than to the tail.
- The center of gravity can be moved forward by adding weight to the front of the plane. For paper airplanes, this can be done in many ways, such as sliding paper clips onto or taping pennies to the nose of the plane.

FORCE OF FLIGHT—DRAG

BIG IDEA

Make a whirligig to observe drag, one of the forces of flight.

READY ...

Gather materials:

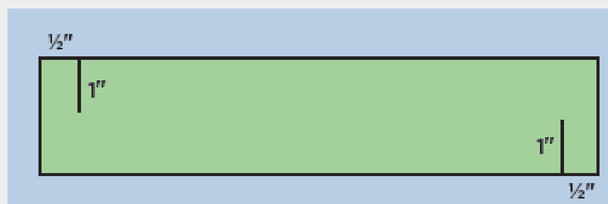
- card stock
- pencil
- ruler
- scissors

SET ...

No setup needed!

GO!

1. Cut a strip of card stock longer than it is wide.



2. About half an inch from each end of the paper, cut a 1-inch slit. One slit will be at the top and one at the bottom of opposite sides of the paper.

3. Fold the strip into a loop and connect the loop by sliding the bottom slit into the slit at the top of the paper.

4. Toss your whirligig high in the air in front of you and watch it twirl as it floats down.

5. Think about the force that is making the whirligig whirl. Why doesn't the whirligig just drop straight down? Drag causes the whirligig to twirl and float!

WHY IS THIS ENGINEERING?

Drag is one of the four forces of flight. Drag pushes back on an airplane as it moves through the air. Similarly, drag pushes back on the whirligig as it falls. (The other three forces of flight are lift, weight, and thrust.)

Drag is caused by the molecules that make up a fluid. You can feel these molecules if you wave your arms fast enough. The molecules of the air push back on your hand, just as your hand pushes on them.

Air, a very thin fluid, is relatively easy to push through; and denser fluids, like water, are harder to push through. For example, moving your hand through water is harder than moving your hand through air—because water molecules are packed more closely together.