THE FRANKLIN INSTITUTE

Post-Show

FLIGHT

After the Show

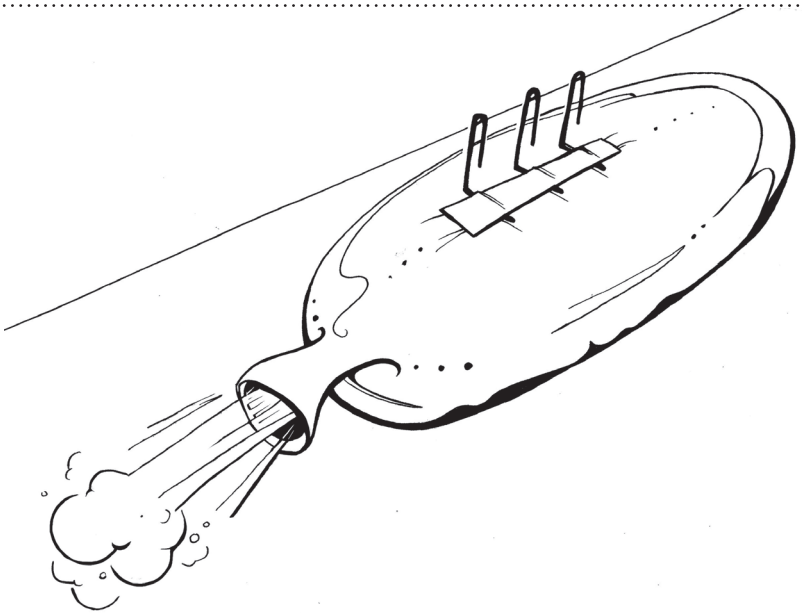
We recently presented a flight show at your school, and thought you and your students might like to continue investigating this topic. The following activities are designed to review and extend the ideas covered in the show.

Please remember to use appropriate safety measures for all activities. An adult instructor should always supervise students during experiments.

Visit us online at www.fi.edu/TSS or contact us at tss@fi.edu.

3, 2, 1...LIFT-OFF!

FOR GRADES 1-4



During the show, we sent a soda-bottle rocket soaring! A rocket launch is an example of propulsion, or a force that pushes an object forward. In this experiment, students will launch a jet-propelled balloon.

EQUIPMENT

String
Tape
Balloon (oblong balloons work better than circular ones)
Paper clamp
Three paper clips

PROCEDURE

1. Run string across the room. Pull taut and attach securely to opposite walls.
2. Inflate the balloon. Instead of tying a knot, secure the open end of the balloon with the paper clamp. Sometimes it helps to fold the end once or twice before clamping it.
3. Next, bend paper clips into "L" shapes and tape them in a straight line on top of the balloon. Use these clips as hooks to hang the balloon on the string.
4. Have a countdown, then release the clamp from the balloon. What makes the balloon move? Why does it go in that direction?

WHY?

The escaping air pushing against the inside of the balloon provides propulsion. As the air escapes in one direction, the balloon is pushed in the opposite direction. This is an example of Newton's Third Law of Motion, which states that "For every action, there is an equal and opposite reaction." For an extra challenge, try building a model rocket!

HELICOPTERS

FOR GRADES 3-6

How slowly can you make a piece of paper fall? During the show, we learned about four forces that affect how objects, from planes to paper, move through the air. In this activity, students use paper to construct a device that falls through the air very slowly.

EQUIPMENT

Paper
Scissors
Paper clip

PROCEDURE

1. Photocopy the pattern provided on the next page. Trim pattern along the lines labeled 1, all the way down to the bottom.

2. Cut along line 2 to divide the top into two "wings." Fold along line 6 so that one wing faces towards you, and the other away.

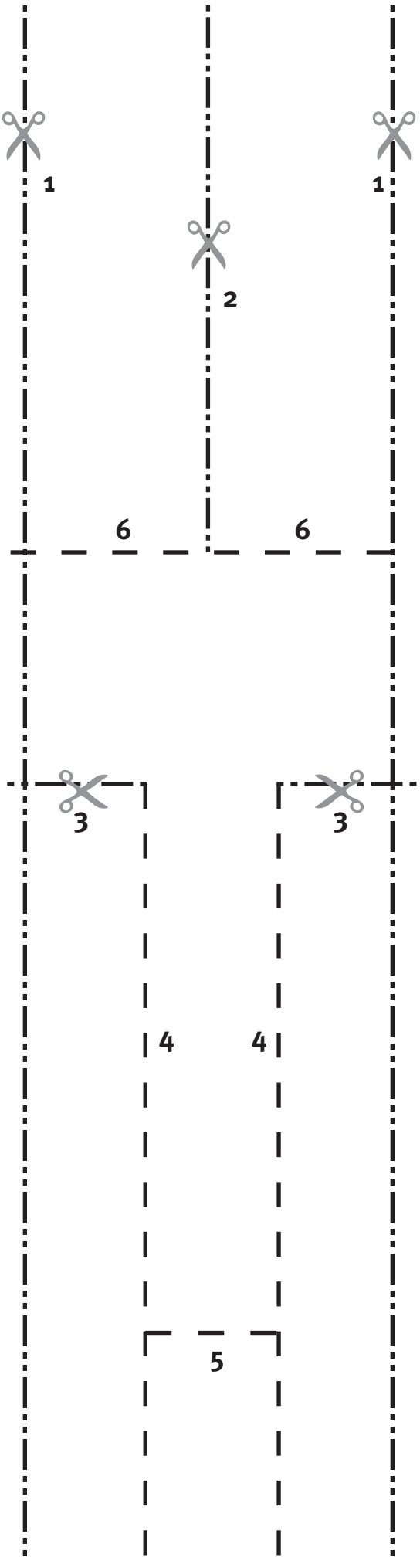
3. Cut along line 3. Fold flaps towards each other along line 4. At the bottom, fold along line 5 and attach the bottom tab with a paperclip.

4. Hold your helicopter high above the ground. Pinch at the paperclip, and then release. How long does it take to reach the ground? How would you describe the helicopter's motion?

5. For an extra challenge, make a target on the floor. Can you release your helicopter in such a way that you consistently get a bulls-eye?

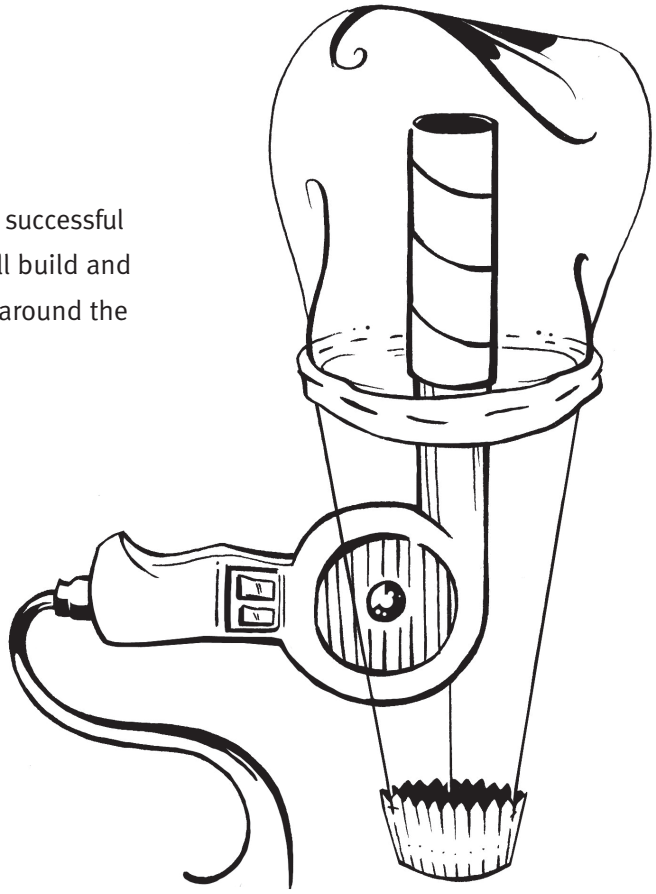
WHY?

As the helicopter falls, air pushes up against the two flaps, bending them up slightly. When air pushes on the slanted flap, it creates some horizontal thrust. Both flaps receive some thrust; however, since they are slanted in opposite directions, the thrust acts in both directions, causing the toy to spin. How could you make it spin faster, or in the opposite direction?


1
1
2
6
6
3
3
4
4
5

FULL OF HOT AIR

FOR GRADES 5-8



As we discussed in the Flight show, hot air balloons were the first successful "lighter-than-air" flying machines. In this activity, students will build and launch a simple hot air balloon. Note: gloves should be worn around the heat source.

EQUIPMENT

Lightweight plastic bag (dry cleaner bags are ideal)
Floral or florist's wire
Paper cupcake liner
3 pieces of string (each 10 inches long)
Hair dryer or heat paint stripper
(paint stripper works best, hair dryer is safer)
Cardboard tube
(wide enough to fit around the top of the heat source)
Tape, clamps, or ring stand

PROCEDURE

1. Fold the open edge of the bag up about one-half inch and sew it in place with the wire, using stitches 2-3 inches long. The bag opening will gather to form a collar 5 or 6 inches in diameter. When completed, twist the ends of the wire together.

2. Poke three evenly spaced holes in the top edge of the cupcake liner. Tie one end of each string to the liner. Tie the free ends to the wire in the bag collar, spacing as evenly as possible.

3. Insert the end of the heat source into the cardboard tube to make a chimney. Clamp or tape the chimney so that it points straight up.

4. Insert the free end of the chimney into the neck of the bag. Do not allow the bag to touch the tube or the heat source, as the bag may melt.

5. While holding the collar of the balloon, ask a teacher to turn on the heat source. Allow hot air to fill the balloon, until the exhaust coming out the bottom feels hot.

6. Release the bag and turn off the heat source. What happens to the balloon? Why?

WHY?

The density of a gas, like air, depends on its temperature. At higher temperatures, air molecules are spread further apart, and therefore less dense. Air that is less dense than the surrounding air rises up. In this experiment, a lightweight balloon contains the hot air and is pushed upward as the air rises. Once the air inside the balloon is away from the heat source, it cools down; when it is denser than the surrounding air, the balloon sinks back down. Try putting coins in the cupcake liner. How much weight will the hot air balloon lift up?

MORE INFORMATION...

We've provided the following information to help refresh your memory about the topics we covered during the show, and to deepen your understanding about flight.

Gravity: A fundamental force which pulls all objects on or near the Earth toward the center of the planet.

Air Pressure: Air pressure is caused by the weight of air in the atmosphere. Since air is everywhere, this pressure pushes on everything, including you, with a force of 1 kilogram per square centimeter (14.7 lbs. per square inch). Sometimes, we notice changes in air pressure. For example, when you travel in an airplane or drive in the mountains, your ears may "pop" as they adjust to the change in pressure. Air pressure makes our lungs work, makes suction cups stick, makes balloons stay the same size, and makes heavier-than-air flight possible. Unfortunately, it can also cause problems like "the bends" in deep-sea divers.

Bernoulli's Principle: "Fast-moving air has less pressure than slow-moving air." -Daniel Bernoulli, 1738. Gliders, birds, and planes have wings shaped to make use of this property. The wing is convex on the top, and flat or concave underneath. As air flows over the top of the curve, it gets squeezed between the wing and the layers of air above, and therefore speeds up. (When you force a gas or liquid through a smaller space, you force it to speed up. You've seen this if you've ever put your thumb over half the top of a garden hose to make the water go faster and farther.) As the air over the top of the wing speeds up, its pressure decreases relative to the air beneath the wing. The higher pressure underneath the wing pushes up towards the area of lower pressure, lifting the aircraft up.

Action and Reaction: Newton's Third Law of Motion says that for every action, there is a reaction that is equal in size but opposite in direction. This is what makes "flapping" flight possible: when the wing pushes down, the air pushes back with an equal amount of force. The light weight of flying creatures, along with special wing adaptations, makes this force sufficient to push the creature up. This effect also helps lift airplanes. As the angle of the wing pushes air downward, air reacts by pushing upward against the wing. This force lifts up the wing, and with it, the whole aircraft.

Lift: The force that overcomes the pull of gravity. Buoyant lift occurs when lower density gases (such as heated air, helium, or hydrogen) are used within a balloon or dirigible. Aerodynamic lift, which lifts airplanes and gliders, is generated by a curved airfoil or wing. When higher pressure air underneath the wing pushes up (as determined by Bernoulli's Principle), lift is produced. Lift is also generated by the upward reaction of air described by Newton's Third Law (Action and Reaction). While neither Bernoulli's Principle nor the Law of Action and Reaction can entirely account for lift on their own, the combination of the two effects seems to explain lift. Scientists still debate the exact reasons for lift.

Drag: The force created by the friction between a moving aircraft and the air it flies through. It is a mechanical force that opposes the efficient motion of an aircraft through the atmosphere. Drag can be altered by the smoothness of an aircraft's outer skin, qualities of the air itself, and the amount of thrust force generated by the aircraft.

Thrust: The force that pushes an aircraft through the air. To achieve the forward acceleration necessary for takeoff, the force of thrust must be greater than that of drag. Without thrust an aircraft's wings cannot create sufficient aerodynamic lift to raise the aircraft off of the ground. Newton's third law states that every action has an equal and opposite reaction; hence, rearward thrust pushes an aircraft forward.

Birds, Bats, and Bugs: These are the only living things that can truly fly under their own power. (Flying squirrels and flying fish do not fly, they glide.) Although they have their own specific adaptations, all three share a few characteristics. Besides having wings, all three types of animals are also streamlined, lightweight, and have muscles concentrated in the chest and wing area. Even the largest flying birds weigh no more than thirty pounds.

Airplanes: An airplane is simply a glider with a motor. A glider depends on its own speed to keep air flowing over its wings. Adding a motor keeps the aircraft moving forward, and therefore in the air, for longer periods of time. Orville and Wilbur Wright were the first ones to develop the right combination of wing shape, motor power, and total weight to get an airplane to fly. Their historic first flight took place near Kitty Hawk, North Carolina, in 1903.

Propellers: The first airplane motor used a propeller to push the plane forward. Each propeller blade is shaped like a wing. It is curved on one side and flat on the other. As the propeller spins around, it makes an area of lower pressure in the front. The higher pressure behind the propeller then pushes the propeller, and anything attached to it, forward. Propellers can also be used to create lift, as in helicopters.

Jets and Rockets: Jets and rockets both use the principle of action and reaction. Jets consist of an air intake, a combustion chamber, and an exhaust outlet. Air is pulled in, fuel is injected into the combustion chamber, and the air and fuel are burned. This creates a mixture of gasses, which take up more room than the air and fuel did, so they are pushed out of the engine. When the engine pushes the exhaust, the exhaust pushes back, so the engine goes forward. A rocket is almost identical in function, but carries its own oxygen as well as its own fuel. This makes it heavier, but enables a rocket to work in space. Rockets use higher power fuel than jets, which enables them to achieve orbit.

MORE RESOURCES...

The Franklin Institute: On your next field trip, check out Franklin Air Show, an interactive exhibit about flight. You can even grab a pair of wings and feel the four forces of flight! Go to http://www.fi.edu/teacherresources/ for a guide to the exhibit.

Plane Sense: Visit http://www.fi.edu/msp/variables/basics3.html for a collection of resources on flight and airplanes. You'll find lesson plans, games, videos, and more!