Sparking Discovery in the Classroom

TRAVELING SCIENCE WORKSHOPS

DISCOVERY MUSEUM

Flight

Teacher Resource Guide

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MathWorks®

Flight

Flying objects fall into two categories: those lighter than air, like hot air balloons and weather balloons, and those heavier than air, like birds and airplanes. Objects lighter than air go up but don't come down. When objects that are heavier than air are still, they stay on the ground; when they are airborne and stop moving, they will fall back to the ground.

The following activities introduce several forces that affect flight: **thrust, drag, gravity** and **lift**. After these introductory activities, students will make three types of paper airplanes, each illustrating a different combination of effects from the four forces. In addition, students can “trim” their paper airplanes in order to experiment with and test assumptions about design. Such experiments can lead to better understanding about how to keep a plane airborne as long as possible or what design element can create a stellar loop-the-loop. Paper airplanes can become a fun way to think scientifically and to learn about the phenomenon of flight, instead of a traditional classroom scourge.

Drag Activity

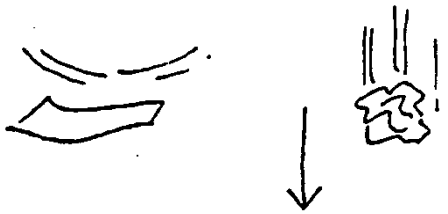
Drag, or air resistance, is a frictional force that objects encounter as they move through air and push it aside. Anyone who has flown a kite knows that air, although not solid, offers a lot of resistance. Objects like kites offer a large surface for air to push against, so you encounter a lot of drag when you run with a kite. When you stop running, or the wind stops blowing, the kite falls slowly to the ground.

Materials

two sheets of paper
chair
student volunteer

Procedure

1. Have the student stand on a chair and crumple one piece of paper into a ball.
2. Holding the crumpled paper in one hand and the flat paper in the other, have the student raise his or her arms high.
3. Ask the class to predict which paper will reach the ground first, if the student drops both simultaneously.
4. Have the student drop both sheets at the same time.
5. Was the class prediction correct?
6. Why did the crumpled sheet fall more quickly?
7. Which forces acted on the paper?



Thrust gets things into the air in the first place. When the student raises his or her arms, this action provides a force (thrust) that moves the paper upward. Thrust can be in any direction, but an upward thrust launches objects. Next, each paper encounters drag as it falls. The flat paper encounters more drag because its surface area is greater than that of the crumpled paper. Finally, gravity pulls both sheets down toward the ground once the student releases them.

Gravity is a force that pulls all objects heavier than air down towards the earth. Gravity causes a falling object to accelerate. The longer an object falls, the faster it will go. However, the faster an object falls, the more drag it encounters because it sweeps more air aside. Objects speed up as they fall, until drag balances the acceleration due to gravity, at which point the object falls at a steady speed until it hits the ground. The fastest an average person can fall is about 120 miles per hour.

All objects would fall at the same rate if there were no air to cause drag. Lighter objects, like feathers, tend to fall more slowly than heavier objects, like hammers, because the strength of the force from drag affects the lighter objects more. Consider this later, when you experiment with paper airplanes. Lighter planes have more drag than heavier planes of the same size. You can use different weights of paper or different size airplanes to test this. Add paper clips to one of two same-sized planes to add weight and notice if one flies farther and faster than the other.

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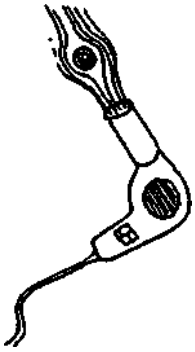
Lift Activities

Lift is the most complicated of the forces involved in flight. Lift causes objects to move into low-air-pressure areas. Low-air-pressure areas exist when air moves more quickly in one place than in other areas nearby. Weather forecasters commonly use the term "low pressure" when forecasting a storm. If there is a low-pressure area over your town, there will probably be a storm, because clouds are pulled into these low-pressure areas.

In these activities, students move air with hairdryers, their breath, and the spinning action of a propeller, creating low-pressure areas. Students can then witness the force of lift on light objects like a ping-pong ball or a propeller.



Materials

paper cups
hairdryer
ping-pong ball
hand-powered propeller toy (helicopter)

Procedure

1. Turn on the hairdryer, hold it aimed straight up, and place a ping-pong ball in the stream of moving air.
2. While keeping the hairdryer pointed straight up, move it in horizontal circles, and observe what the ping-pong ball does.
3. Now, slowly tilt the hairdryer to the left and right, so the ball is suspended in the stream of air at an angle from the hairdryer.

The ball does not fall, because the stream of air from the hairdryer has lower air pressure than the still air around it. The ball stays within the lower pressure air. Thrust from the stream of air pushes the ball away from the hairdryer initially, and then the effect of lift overcomes the pull of gravity. If the airstream is tipped too far to the left or right, gravity overcomes lift and pulls the ball to the ground.

Procedure

1. Put the ping-pong ball into a paper cup.
2. Blow across the top of the cup with your breath or with the hairdryer.
3. Try to position another cup to catch the ball.

By blowing across the top of the cup, an area of low pressure is created. The ping-pong ball is lifted up into this low-pressure area.

Procedure

1. Spin the helicopter toy counterclockwise and observe what happens.
2. Now, spin the helicopter clockwise and observe again.
3. Have students discuss the reasons for the results.

Look carefully at the helicopter toy. The blades are tilted so that, as it spins counterclockwise, air rushes over the tops of the blades faster than it rushes under them, creating an area of low pressure above the blades. If you spin it quickly enough, the helicopter will lift up into the low-pressure area formed. This is similar to what happens when you stick your hand out of a car window and angle your palm up. If the car is going fast enough, your arm will lift.

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Making Airplanes

The Dart

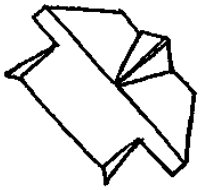
Dart airplanes are traditional paper airplanes. Their shape minimizes drag.

The Glider

Gliders maximize drag. They stay up longer than darts, but can't be thrown with as much thrust.

The Split-Nosed Bat

This plane is a glider that incorporates lift.



Trimming Your Airplane

You can trim your airplane to increase or decrease drag and lift in several ways. Add paper clips near the front of the plane to balance it, keeping the plane from stalling or nose-diving. Cut flaps on the backs of the wings and fold them up or down to achieve similar effects. Try folding one flap up and the other down to make the plane spin! Or, you can cut and bend a rudder from the back of the plane (under the wings) to make it fly straight or in a curved formation.

Trimming the planes turns paper airplane fun into a true science project. Each modification is an experiment intended to solve a problem or test a prediction. When students fly their planes, they can see the results of these experiments.

Once students master folding and flying each design, encourage them to experiment with paper of different sizes and weights, such as printer paper or heavy card stock. Have fun!

Resources:

<u>Lower Elementary (K-3) Print Resources</u>

- *Kids' Paper Airplane Book,* Ken Blackburn and Jeff Lammers, Workman Publishing Co., 1996
- *Big Book of Airplanes,* DK Publishing, 2001
- *Planes,* Amy Shields, National Geographic Kids, 2017
- *Paper Airplanes,* Jenny Fretland VanVoorst, Jump!, 2016
- *How Does it Work?: Airplanes,* Jenny Fretland VanVoorst, Jump!, 2018
- *How it Works: Airplanes,* Kelli Hicks, Rourke Educational Media, 2014
- *Let's Fly a Plane!,* Chris Ferrie, Sourcebooks Explore, 2020

<u>Upper Elementary (4-6) Print Resources</u>

- *The Science of Flight,* Ian Graham, Franklin Watts, 2019
- *Amazing Paper Airplanes: The Craft and Science of Flight,* Kyong Hwa Lee, University of New Mexico Press, 2016
- *Folding Paper Airplanes with STEM,* Marie Buckingham, Capstone Press, 2020

<u>Online Resources</u>

- http://www.cln.org/themes/paper_airplanes.html
  - A whole collection of paper-airplane related links, including templates and videos.
- http://www.exploratorium.edu/science_explorer/roto-copter.html
  - A pattern and instructions for making your own roto-copter from the Exploratorium.

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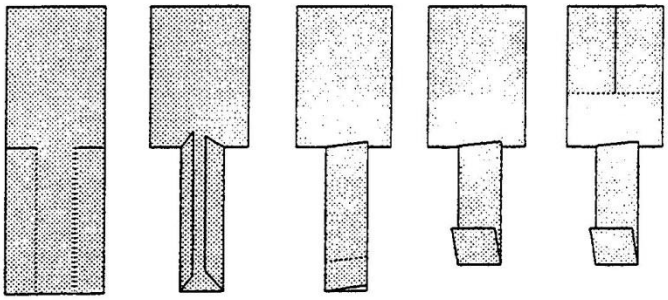
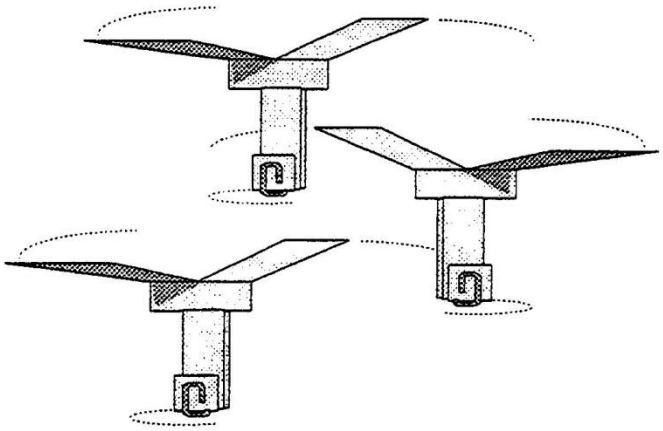
- http://www.paperairplanes.co.uk/planes.php
    - Videos for making many kinds of paper airplanes

Instructions for The Helicopter





THE PLANE
- Cut on the two middle horizontal lines, and fold in.
- Fold the bottom flap up.
- Cut the vertical line at top to create two flaps.
- For best results, attach a paper clip to the bottom
- Drop and watch it spin!

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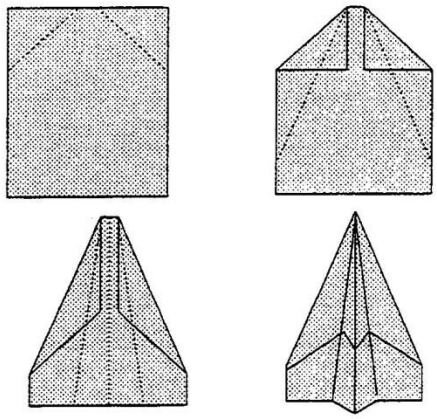
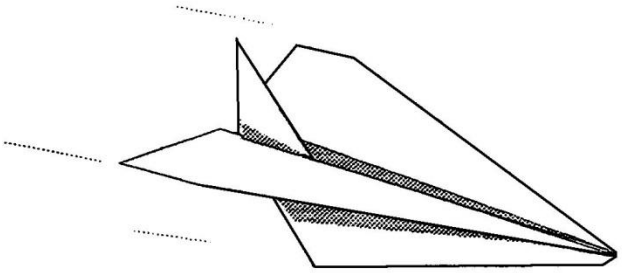
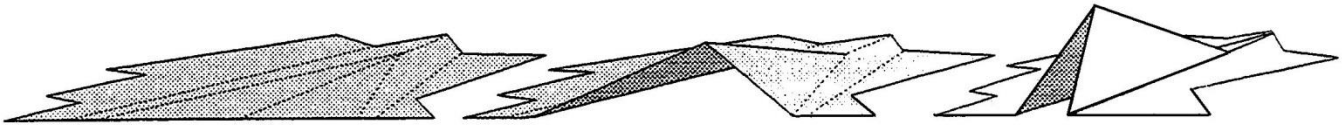




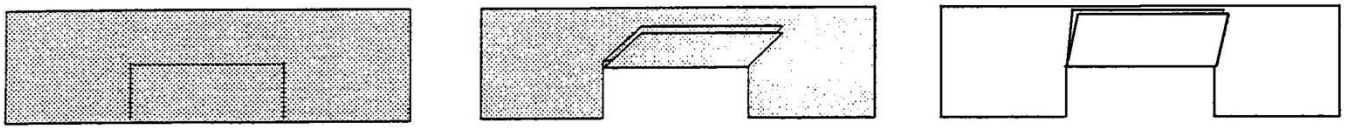
THE PLANE

-- Flip the paper over so that the printed fold lines are facing down.
-- Turn the corners back to the outside fold lines and crease. Repeat for the next set of folds.
-- Fold up along the center line so text is inside and graphics are on the outside.
-- Finally fold down each wing.
-- Throw briskly and slightly angled up.



THE STICK-UP TAIL

-- Bring the two angled fold lines together.
-- Crease along the top.



THE FASTENING CLIP

-- Cut on the sides.
-- Fold to one side to hold the plane together.

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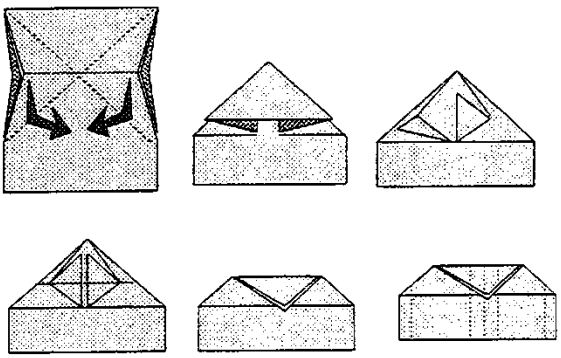
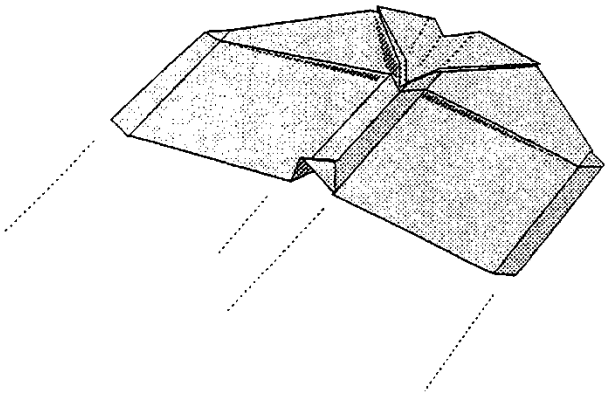
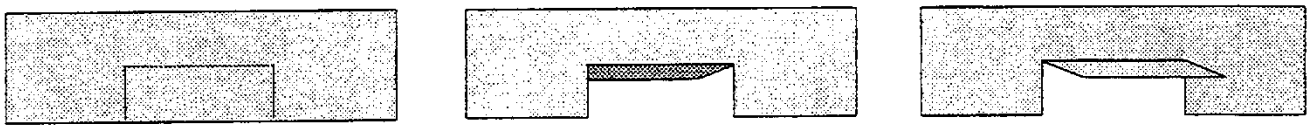


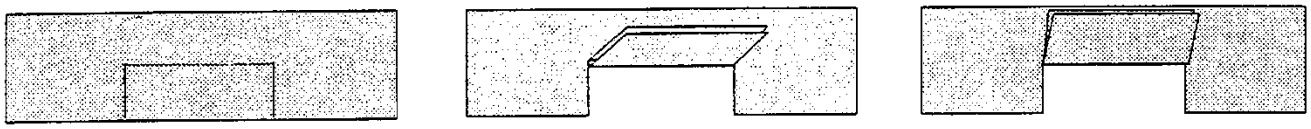


THE PLANE
- Flip the paper over so that the printed fold lines are facing down.
- First fold forward, crease and open back up along both diagonal lines. Also fold back on the horizontal line and re-open.
- Then pull and tuck the folds together as shown in the first two drawings.
- Now fold the corners of the each triangle up, almost to the center line.
- Fold the nose of the plane back.
- Fold up along the center line and then fold down each wing.
- Throw gently for distance...throw hard and up for overhead loops!



THE ADJUSTABLE FLAPS
- Cut on sides.
- Fold up to make the plane rise...fold down to make the plane drop.

Note: When printing on printers that require a large bottom margin, the adjustable flaps may not print.



THE FASTENING CLIP
- Cut on the sides.
- Fold to one side to hold the plane together.

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A

B

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HANDS-ON • MINDS AT PLAY

The Helicopter

C

D

A

B

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The Helicopter

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The Helicopter

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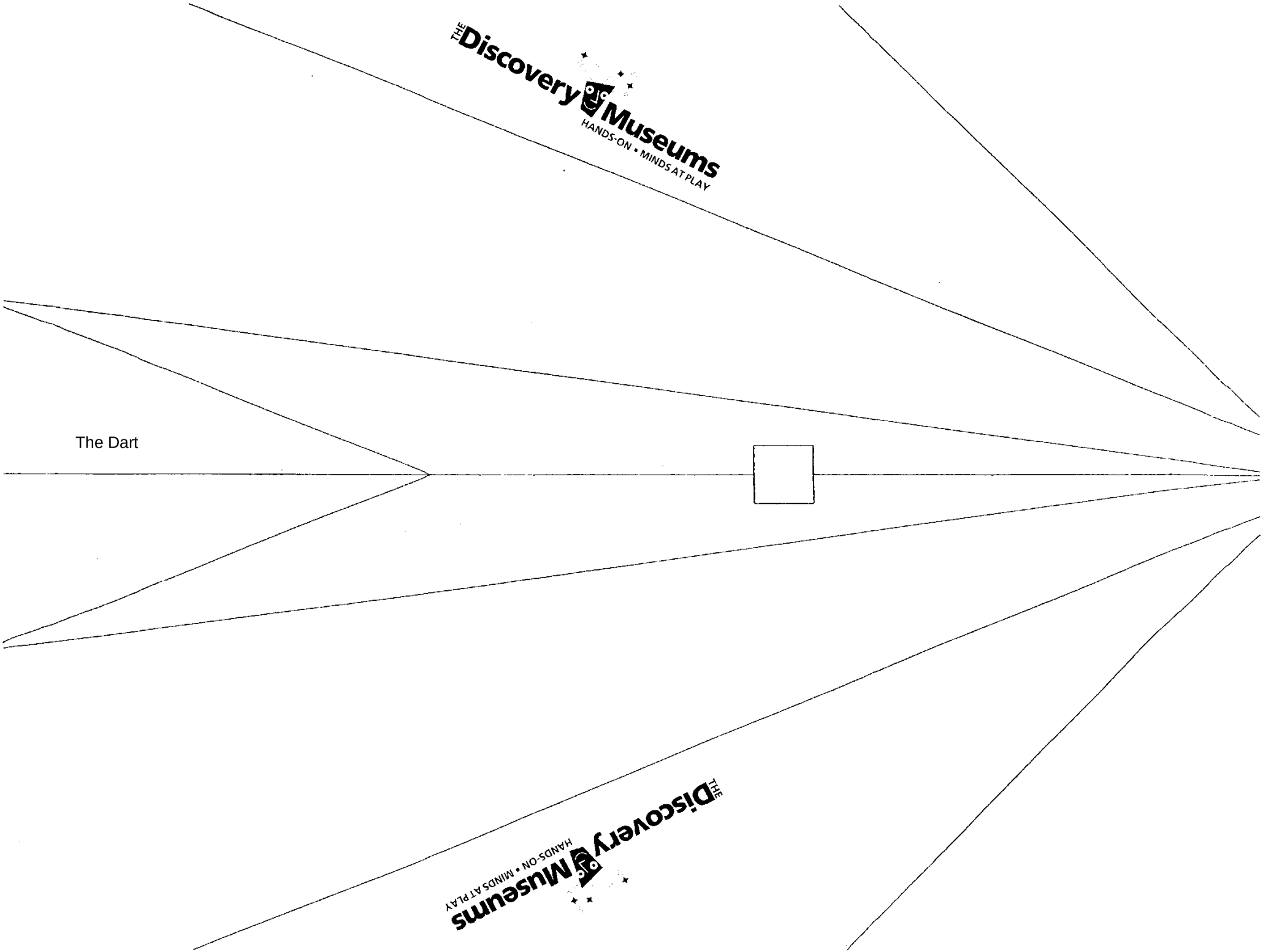
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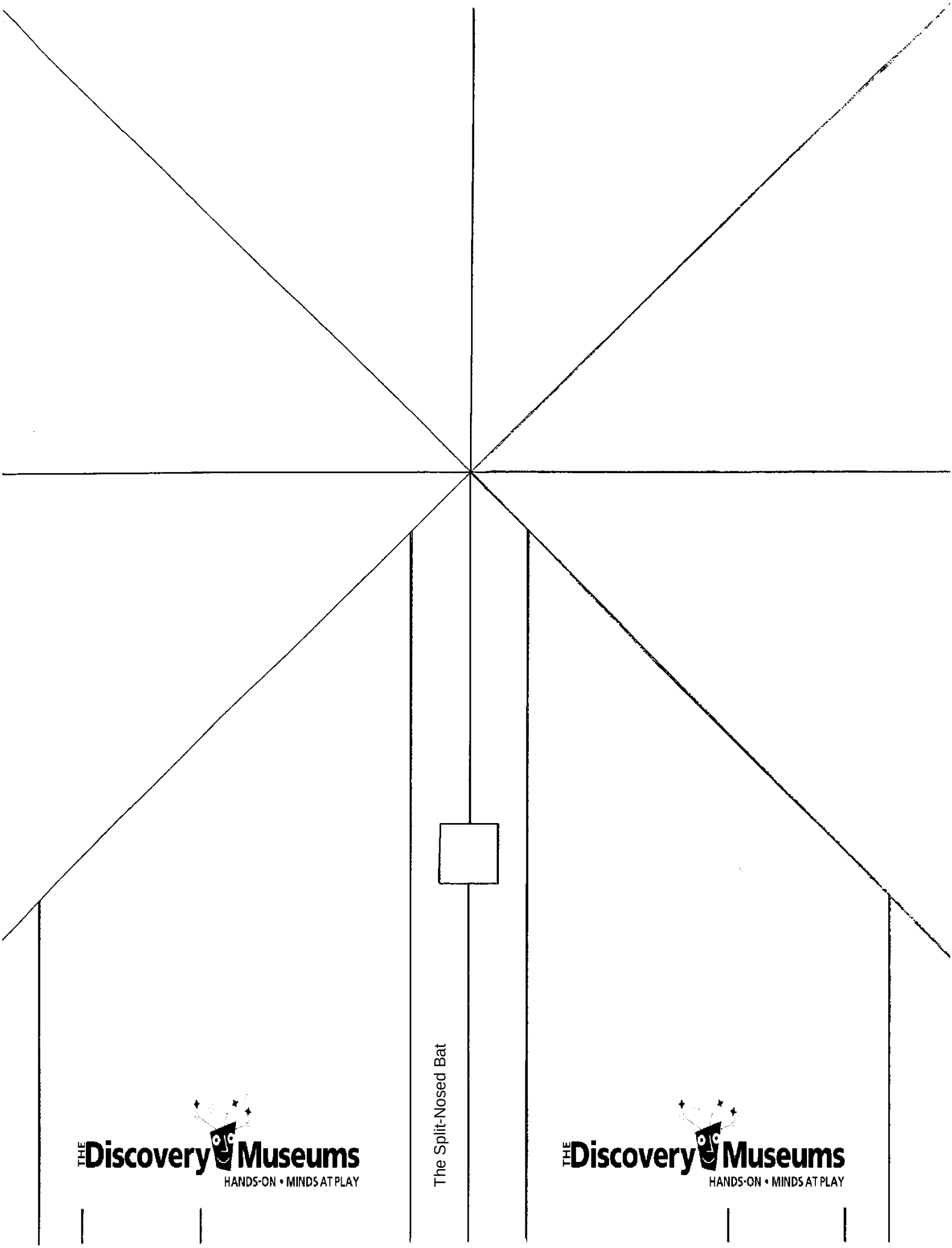

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The Split-Nosed Bat

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