TEACHER'S GUIDE

KIDS' Paper Air Plane

BOOK

KEN BLACKBURN & JEFF LAMMERS

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A NOTE TO TEACHERS

Dear Teacher,

Many years ago, I was that kid in the back of the classroom making paper airplanes. For me, paper airplanes brought science and aerodynamics to life and became the foundation for my current career as an aeronautical engineer at Boeing.

This teacher's guide to the *Kids' Paper Airplane Book* helps to explain the basic concepts of flight and shows how to incorporate hands-on flight-related activities into subjects across the curriculum. I hope this guide helps your students discover the fun and fascination in science that I experienced as a kid folding up sheets of paper.

Happy Landings,

Ken Blackburn

Introduction: How Do Airplanes Fly?

THE POWER OF AIR

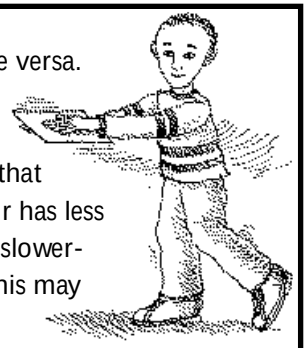
Flying is about harnessing the power of air. Air may be invisible and seem like "nothing." But in fact, air is all around us, takes up space, and weighs quite a bit. The air that fills a bedroom weighs about 100 pounds.

The weight of air bearing down on Earth creates the air pressure around us. We don't feel the pressure of the air because the pressure is the same inside and outside our bodies. When we fly in an airplane (there is reduced air pressure as it climbs higher) or dive underwater (there is increased water pressure as you go deeper), we can feel the pressure change. Air pressure helps to drive the weather, and lets birds and airplanes fly.

BERNOULLI'S PRINCIPLE

Humans have marveled at the flight of soaring birds throughout history. However, the journey to flight wasn't truly started until a Dutch-born Swiss scientist made an important discovery about air.

In 1738 Daniel Bernoulli discovered that when air (or any other gas or liquid) speeds up, its pressure drops and vice versa. Bernoulli's principle basically says that fast-moving air has less pressure than slower-moving air. This may not sound like much. However, it explains how wings in nature work and is the central principle behind the design of aircraft wings, hang gliders, Frisbees, and most other fliers.



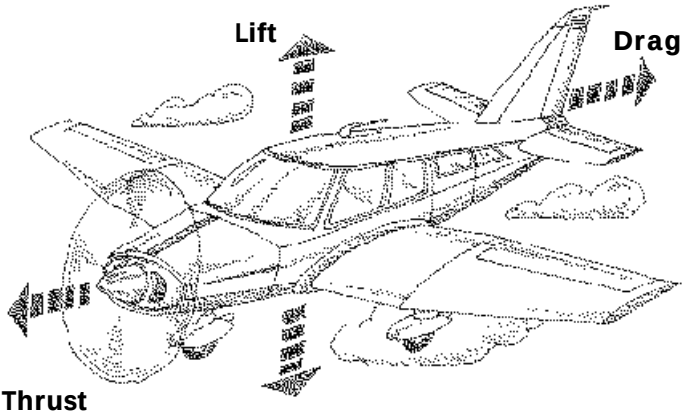
Think of the shape of a bird or airplane's wing. The leading (front) edge of the wing is a little higher than the back edge. Because of this, as the wing travels through the air, the air rushing over the top of the wing speeds up and the air going below the wing slows down.

Bernoulli's principle says that faster air has less pressure, so the air zooming over the top of the wing drops in pressure and creates a suction, pulling the wing upward. Meanwhile, the air below the wing is moving slower, so it has more pressure, which means that it pushes up on the wing. The result is an upward force, called lift.

Lift is the force that pulls an airplane off the ground. Unfortunately, gravity pulls it back down. And while the engines thrust the plane forward,

drag (air resistance) pulls it back. Gravity, lift,thrust, and drag are the four competing forces of flight. Flying is a balancing act between these forces.

THE FOUR FORCES OF AERODYNAMICS



UP OR DOWN?

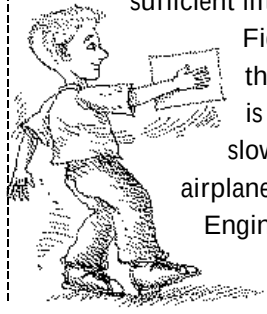
Read the GRAVITY AND LIFT section on pages 6 and 7 of Kids' Paper Airplane Book. Remember that weight is a measure of the amount of gravity pulling down on something. (Weight = Gravity x Mass)

The amount of lift needed to get a plane or bird off the ground depends on its weight. A big plane needs more lift than a small plane does. Ostriches may have wings, but they can't fly. Their wings would have to be much bigger to produce the needed lift.

FORWARD OR BACKWARD?

Read the DRAG AND THRUST section on pages 7 and 8 of Kids' Paper Airplane Book. The forward-pushing force of thrust also plays a part in getting a plane or bird flying. A large, heavy plane uses the thrust from powerful engines to accelerate to a high speed.

Air flows faster and faster over the wings of the airplane as it speeds up until enough lift is created for take-off. The engines also keep the jet moving forward once in the air so the wings can continue to generate sufficient lift.



Fighting against thrust is drag. Drag is the air resistance slowing down the airplane or bird. Engineers try to reduce the

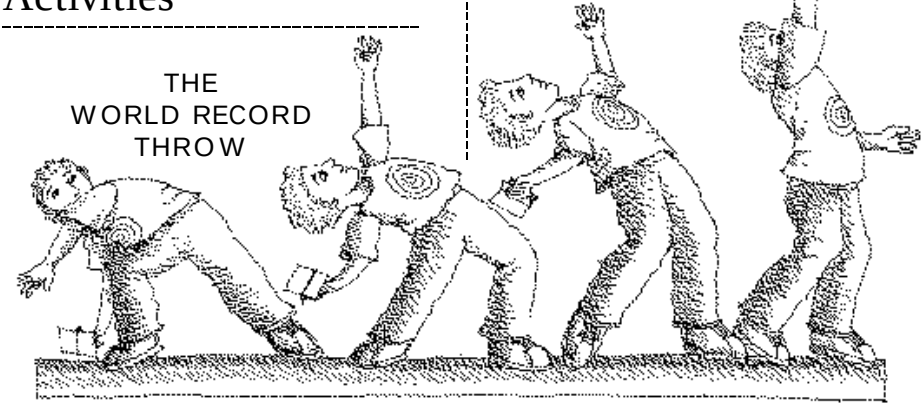
amount of drag on an airplane through aerodynamic design. The shape of airplanes are streamlined and smooth to

minimize air resistance, or drag. Engineers also try to keep aircraft as light as possible. Less weight means less lift is needed to reach and maintain flight. That's why many birds have hollow bones—to lighten their load.

Taming the four forces of flight may get a plane off the ground—but it won't keep it there. A flier needs stability to keep the nose end going forward and the wings level. The Wright Brothers were the first to fly because they successfully created a stable aircraft. Read the WHY PAPER PLANES CRASH section on page 8 of Kids' Paper Airplane Book for more about stability.

Curriculum-Based Activities

THE WORLD RECORD THROW



HANDS-ON PHYSICAL SCIENCE/MATH

These experiments allow students to experience the four forces of flight using planes from Kids' Paper Airplane Book. Also ask your students to do the activities demonstrating lift and drag on pages 7 and 8 of the book. Encourage students to make predictions, and careful observations, then draw conclusions. The extensions allow students to quantify their observations using math skills.

■ Gravity Copters Have students take two Robo-Choppers each. Have them assemble one following the instructions on page 41 of Kids' Paper Airplane Book and have them crumple the other into a ball of paper. Have the students drop both from an equal height. What happens? [The ball of paper falls faster and hits the ground first.] Why?

[The Robo-Chopper generates lift, which balances gravity to allow it to descend slowly; the ball of paper does not produce lift, and gravity quickly pulls it to the ground.] Extension: Ask what would happen if this experiment were performed on the moon? [Both would fall at the same rate, as there is no air for the Robo-Chopper to generate lift. Remind students that all objects fall at the same rate, no matter how heavy. Also, gravity on the Moon is one-sixth that of Earth, so they would fall more slowly than on Earth.]

FLYING FACT

Leonardo da Vinci drew plans for a glider and a helicopter in the 16th century.

■ LIFT STRIP Have students cut out—but not assemble—a Dragon Ring as shown in step 1 on page 51 in Kids' Paper Airplane Book. Ask students to hold the narrow end of their strips to their lips and blow over the top of the paper. Ask what happens [The strip lifts up to flutter horizontally from the mouth.] Why? [Bernoulli's Principle—the air flowing over the downwardly curved paper speeds up and reduces pressure, creating lift. (Note: Younger students may need to cut along fold line 4 to make a lighter-weight strip.) Extension: Invite students to further experiment with lift by similarly blowing on the front of wings of assembled fliers from the book. Pirate's Secret and The World Record Paper Airplane work especially well.

■ THUNDERBIRD THRUST Have students assemble two of the Thunderbird or Blue Angel planes according to the instructions on page 53 of Kids' Paper Airplane Book. Make sure both are flying equally well. The WHAT TO DO IF... box on page 52 will help solve flying problems. Invite students to launch both of their planes at the same time and in the same direction, one from each hand. Ask them to do this a number of times, noting which hand's plane goes farther. Ask: Which plane gets more thrust or power? [The one flown from the dominant hand.] What's the result of more thrust? [Longer flight and/or more lift.] Extension: Challenge students to measure the actual distances flown and calculate an average for their dominant and non-dominant hand.

■ DRAGGING THUNDERBOLT Have students assemble the two Thunderbolt planes according to

the instructions on page 49 of Kids' Paper Airplane Book. Making sure both are flying equally well, use the WHAT TO DO IF... box on page 48 to solve flying problems. Next have students modify one of their planes, following these steps:

a) Open up one of the planes flat so that fold line 1 is facing up.
b) Draw a dashed line perpendicular to fold line 1 so it bisects the yellow 1.
c) Cut along the pink-dotted fold lines 2 and 3 from the inside of the tail wings to the drawn dashed line.
d) Fold these flaps up. Replace the paperclip on the nose.

Now invite students to launch each airplane several times, noting how far each travels. Ask: Which plane flies farther? [The unmodified one.] Why? [It's streamlined, or aerodynamic, shape cuts down on drag. The popped-up flaps on the modified plane work like brakes, slowing the plane down with air resistance or drag.] Extension: Challenge students to measure the actual distances flown and graph the results.

LIFE SCIENCE

■ ANIMAL FLIERS Students investigate animal flight using the animal theme planes in Kids' Paper Airplane Book. Have students choose and assemble either the Glider (p. 38), Aerobat (p. 42), or the Butterfly (p. 46). Then invite them to find out fun facts about their animal flier. (Those who made the Glider can choose between an eagle, dragonfly, or pterosaur.) Challenge students to find out what their animal flier's wings are made of, how far it can fly, and how flying helps it survive. Invite students to divide themselves into groups according to their chosen animal flier and put together a presentation to make to the rest of the class. Extension: Explore the world of other flying and gliding animals, such as flying squirrels, flying fish, mosquitoes, swallows, or hummingbirds.

FLYING FACT

Hummingbirds beat their wings 22 to 78 times a second and can fly sideways, and backward, or hover like tiny helicopters.

ART

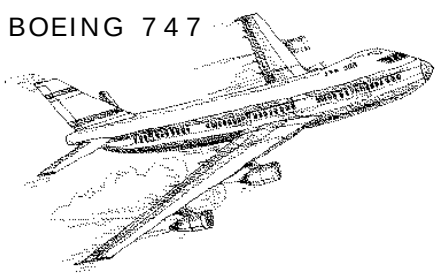
■ PLANE ART Students use the airplane patterns in the Kids' Paper Airplane Book as templates for creating their own fliers. Invite students to choose a flier whose shape and design inspires them. Then have students trace the out-

line of the pattern—along with the numbered fold and cut lines—on the front side of the paper. Then have them flip the paper over and trace the reverse side of the pattern onto the back of their tracing paper. Next challenge students to assemble their fliers according to the particular instructions for each. Then invite students to use crayons, paint, glue, glitter, markers, and whatever else they can think of to turn their flier into a work of art! (If your students are very young, you might consider making a double-sided photocopiable tracing of one of the simpler designs yourself.) Extension: Invite student groups to fashion a mobile out of their fliers. See page 25 of Kids' Paper Airplane Book.

FLYING FACT

A 747 jumbo jet is longer than the distance flown during the Wright Brother's first flight.

BOEING 747



SOCIAL STUDIES

■ FLIER FACTS Students investigate real airplanes and rockets, using the planes in Kids' Paper Airplane Book. Have students choose and assemble either the Thunderbolt (p. 48), Blue Angel (p. 52), Thunderbird (p. 52), Saturn Rocket (p. 54), or F-15 (p. 62). Have them read the information on their flier's opposite page in Kids' Paper Airplane Book and then invite them to find out more about their plane or rocket (see Resources, page 9 in this guide). Consider creating a report page handout with such questions as: What is the length and weight? When was the flier first built? What was it used for? Is it still used today? Who flies it? How much did/does it cost? What was innovative about it? Extension: Challenge the class to create a timeline of aircraft showing how aircraft design has evolved through the years.

WRITING

■ FIRST FLIGHT MINI-BOOKS Students write mini-books about the first powered flight. Have students find out about the Wright Brothers' first flight at Kitty Hawk, North Carolina, on December 17, 1903, using books, encyclopedias, and multimedia (see Resources, page 9). Once the students are familiar with the story and the facts, invite them to

write and illustrate mini-books about the event. Younger students can draw simple picture books with a few words, while older students can use the mini-books as a format for reports, pasting in photocopied photographs.

FLYING FACT

A fear of heights is called acrophobia.

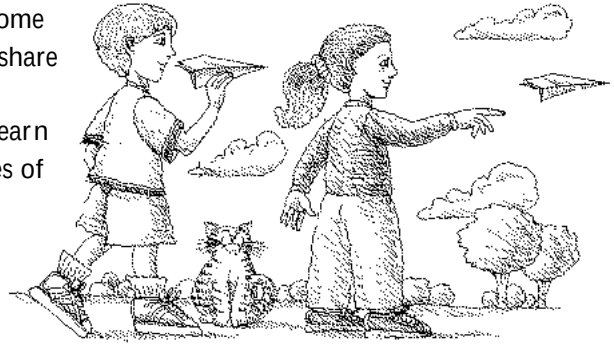
LITERATURE

■ FEAR OF FLYING Read The Sky of Now by Chaim Potok as a class. It's about a 10-year-old boy who overcomes his fear of heights by taking a flight lesson aboard his uncle's glider. Assure students that everyone has fears, and invite students to name their own similar fears or phobias, like fear of dogs, closed spaces, heights, flying, or water, listing them on the board as they talk. Divide students into groups and assign each group one or two fears. Challenge each group to come up with ways to overcome the fears and then let students share their findings with the class. Extension: Invite students to learn and use the fun scientific names of fears or phobias, such as "acrophobia," "hydrophobia," "claustrophobia," and the like.

HEALTH

■ Pilots in Training

Students design a "pilots' training" exercise program and chart their own progress. Training to be a fighter pilot or astronaut includes being physically fit. Challenge students to think of a countable exercise they can do in the classroom—sit-ups, push-ups, jumping jacks, for example. Have each student do his or her exercise for two minutes, counting the number of repetitions completed. Ask students to write down their exercise, how many were completed in two minutes, and the date. Repeat the activity three times a week for several weeks, while encouraging students to "train" at home, too. After several weeks, invite students to share how they've progressed. Extension: Challenge students to make a line graph of their progress, plotting the number of repetitions against time.



Resources

Books for Young Readers

Baylor, Byrd. Hawk, I'm Your Brother. Scribner, 1976. (fiction)

Evans, David and Claudette Williams. Air & Flying. Dorling Kindersley, 1993.

Gibbons, Gail. Flying. Holiday House, 1986.

Pearl, Lizzy. The Story of Flight. Troll Associates, 1994.

Potok, Chaim. The Sky of Now. Knopf, 1995. (fiction)

Taylor, Barbara. Up, Up & Away!: The Science Of Flight. Random House, 1992.

Walter, Mildred Pitts. Brother to the Wind. Lothrop, Lee & Shepard Books, 1985. (fiction)

Williams, John. Projects With Flight. Gareth Stevens, 1992.

Books for Experienced Readers

Berliner, Don. Before the Wright Brothers. Lerner, 1990.

Darling, David. Up, Up, and Away: The Science of Flight. Dillon Press, 1991.

Gormley, Beatrice. Mail-Order Wings. Dutton, 1981. (fiction)

Lantier-Sampon, Patricia. Airplanes. Gareth Stevens, 1994.

Lopez, Donald. Flight. Time-Life Books, 1995.

Moser, Barry. Fly!: A Brief History of Flight Illustrated. Willa Perlman Books, 1993.

Parker, Steve. Airplanes. Copper Beech Books, 1995.

Weiss, Harvey. Strange and Wonderful Aircraft. Houghton Mifflin, 1995.

Multimedia

Daring to Fly!: From Icarus to the Red Baron. Arnowitz Studios; Maxis, 1994. (CD ROM)

Dreams of Flight. SunWest Media Group, 1993. (5-volume video set)

Let Me Tell You All About Planes. Traditional Images, 1994. (video)

World of Flight. Microsoft Corp., 1995. (CD ROM)

Internet

The Aviation History On-Line Museum. www.aviation-history.com/

Author Ken Blackburn's Homepage. www.geocities.com/CapeCanaveral/1817/

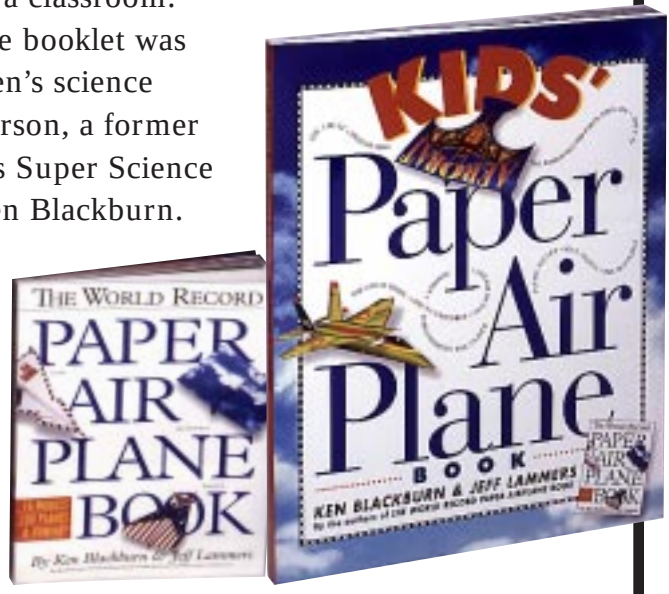
NASA's Space Link Page. spacelink.nasa.gov/.index.html

The National Aerospace Museum. www.nasm.edu/NASMhome.html

Lift, Gravity, Aerodynamics, and Even Bernoulli's Principle

This guaranteed smooth lesson plan on the physics of flight brings together science, math, history and even important health lessons. Packed with curriculum-based activities, it's a teacher's guide that shows how paper airplanes can be a valuable addition to a classroom.

This informative booklet was developed by children's science writer Mary Kay Carson, a former editor of Scholastic's Super Science Blue, and author Ken Blackburn.



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