The Magic of Flight

A film produced by MacGillivray Freeman Films

for the

National Museum of Naval Aviation,

Pensacola, Florida.

Made possible through the sponsorship of

McDonnell Douglas

and

F/A-18 Industry Partners:

Northrop Grumman Corp.,

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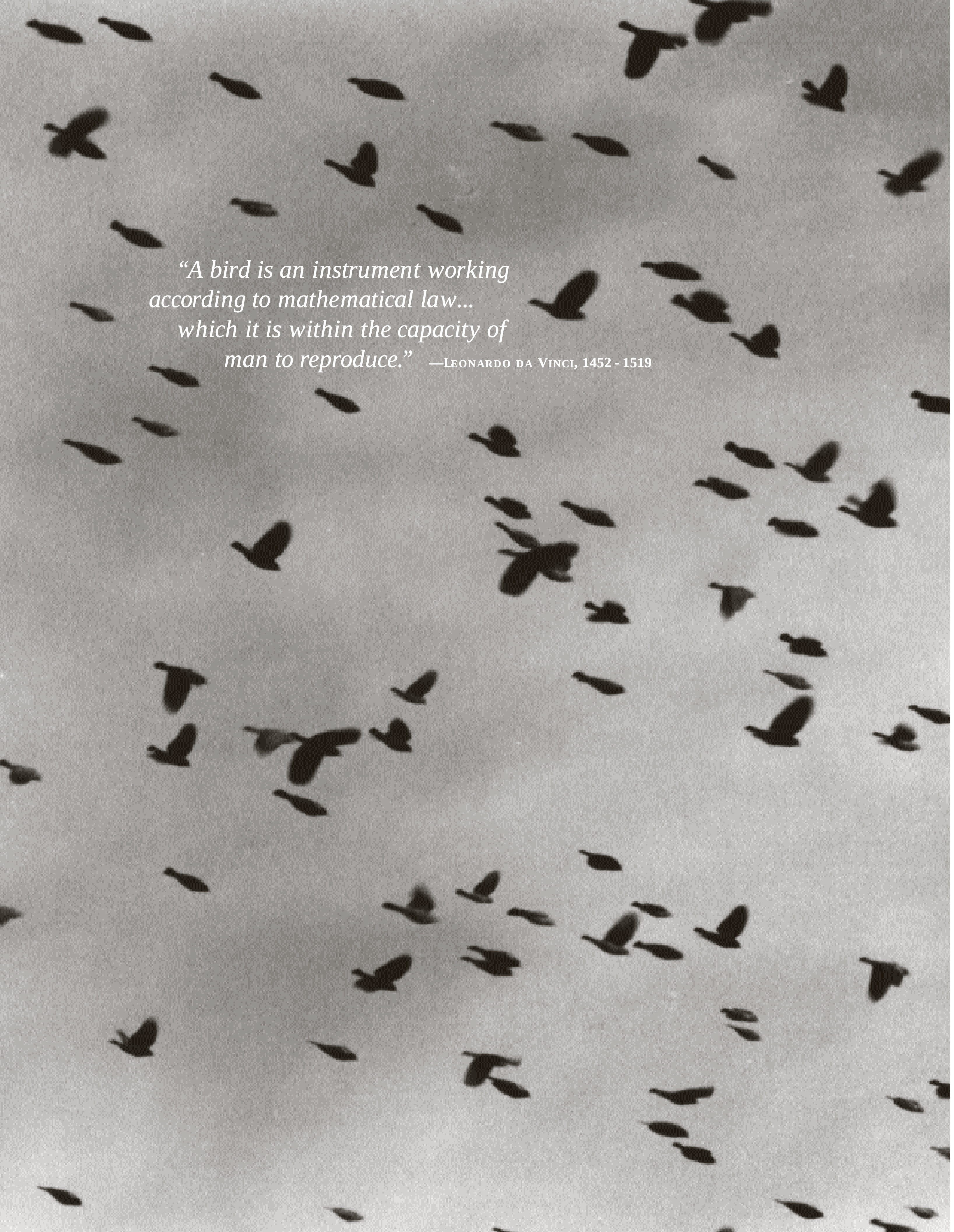

An Educational Resource for Teachers

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The Magic of Flight

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The Magic of Flight

ACTIVITY Introduction

For millions of years, no one has had a better feel for flight than birds. Grasping air by the wingful, they pull themselves up and, almost magically, they soar through the sky.

Only 100 years ago, we discovered the means to soar with the birds. Flying meant freedom: freedom from the bonds of earth and its obligations. And once we were set free, there was no stopping us.

LANGLEY'S AERODROME

EARLY ATTEMPTS AT FLIGHT

In the early part of the nineteenth century, George Cayley, England's "father of aeronautics," was credited with the first major breakthrough in heavier-than-air flight: understanding wing shape and lift. By 1809, Cayley had created a variety of fixed-wing model gliders, and not long after that, full-scale gliders. Legend has it that in 1853, Cayley's coachman became the first human to glide in the air successfully. However, it was such a harrowing experience for the man that he abruptly gave notice saying that he was hired to drive and not fly!

Otto Lilienthal, a German civil engineer, studied bird flight and aerodynamic theory for two decades before coming up with eighteen successful glider designs between 1891 and 1896. His gliders were constructed of common materials such as willow rods and waxed cotton and helaunched them into the wind from atop a hill. When Lilienthal took off, "the spectacle of a man supported on huge white wings, moving high above you at racehorse speeds," was indeed, an unforgettable sight.

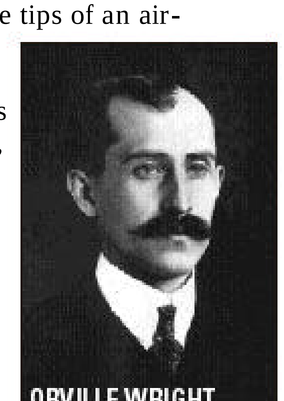
LILIENTHAL'S GLIDER

In May, 1896, Samuel P. Langley, secretary of the Smithsonian, launched the first scale prototype, heavier-than-air, powered model of his original "Aerodrome," which flew a distance of 4,200 feet. However, later full-scale models proved successful only in dumping the pilot, Charles Manly, into the Potomac.

Late inthe nineteenthcentury, two brothers challenged their ingenuity and creativeness with a variety of diverse projects; these ranged from initiating a school newspaper to manufacturing chewing gum from sugar and tar, to building and repairing bicycles. Orville and Wilbur Wright both possessed natural mechanical abilities and restless minds.The pursuit of flight was a new and challenging project for them.

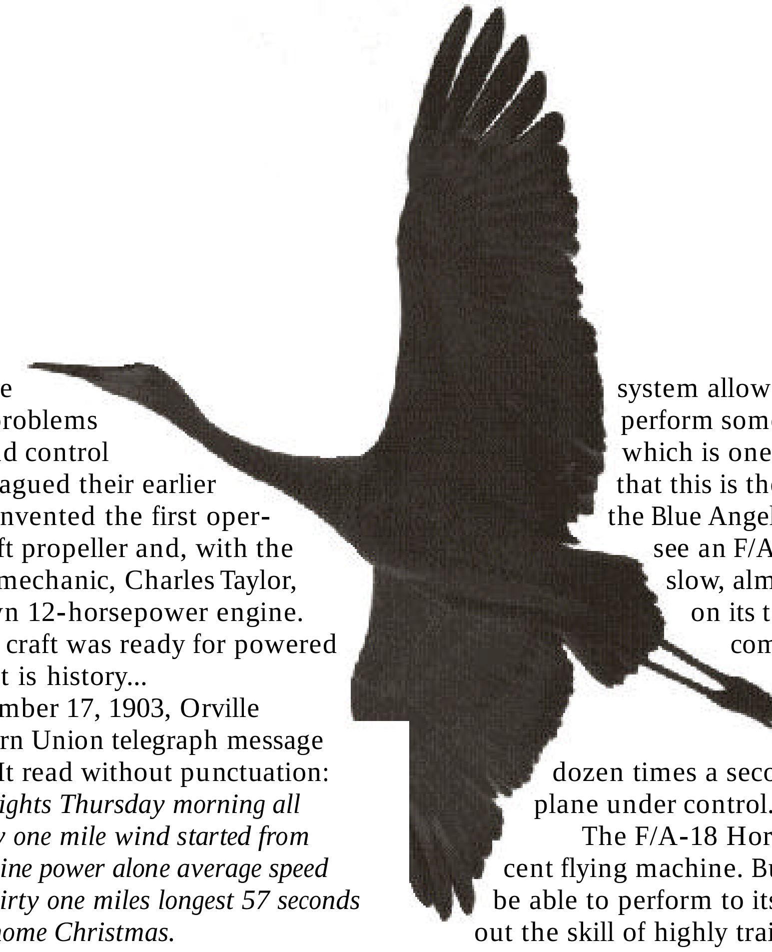
After studying the previous four decades of flying experiments and corresponding with the leading experts in the field, the Wrights began applying their knowledge to the construction of a series of gliders.They realized quickly that they had to create a system for controlling and stabilizing flight, since Lilienthal's "weight shifting" was clearly inadequate. Eventually they designed an answer to the problem: "wing warping," a mechanism for twisting the tips of an aircraft's wings in a similar manner as a bird.

Initial tests of theWright's gliders in 1900 at Kitty Hawk, North Carolina, proved disappointing.Through painstaking research and experimentation over the next two years, however,



ORVILLE WRIGHT

WILBUR WRIGHT



they were able to solve the problems of stability and control which had plagued their earlier efforts.They invented the first operational aircraft propeller and, with the help of their mechanic, Charles Taylor, built their own 12-horsepower engine. By 1903 their craft was ready for powered flight.The rest is history...

On December 17, 1903, Orville wired a Western Union telegraph message to his father. It read without punctuation: *Success four flights Thursday morning all against twenty one mile wind started from Level with engine power alone average speed through air thirty one miles longest 57 seconds inform Press home Christmas.*

Unfortunately, the airplane was wrecked by a sudden gust of wind shortly after the fourth trial; there would be no more flights that year, and in fact the Wright 1903 Flyer never flew again.

FLYING MACHINES TODAY

In the film, *The Magic of Flight*, a Harrier "Jumpjet" rises off a runway, lifting straight up. These remarkable flying machines control the power of their jet engine with what's called "vectored thrust." The Harrier can lift off by vectoring this thrust downward; then as the jet moves forward, the wings begin to create lift of their own.Their short vertical takeoff and landing make these aircraft ideal for operation from ships or small landing sites.

While the Harrier is built for special landings and takeoffs, other jet aircraft, equally sophisticated, are built for speed and maneuverability. Many aviation enthusiasts agree that these aircraft are also a beautiful sight to behold.

The F/A-18 Hornet is truly a state-of-the-art aircraft equipped with a computer system that actually reconfigures the Hornet's wings in flight, much as birds do by instinct.This system allows the Hornet to perform some incredible feats which is one of the reasons that this is the aircraft used by the Blue Angels. In the film, we see an F/A-18 very low and slow, almost standing on its tail, with the computer-controlled horizontal stabilators fluttering a dozen times a second to keep the plane under control.

The F/A-18 Hornet is a magnificent flying machine. But it would not be able to perform to its capacity without the skill of highly trained and qualified pilots... like the Blue Angels.

Just mentioning the name Blue Angels conjures up in people's minds, aviators of great skill. Their precision flying shows attract millions of visitors around the country each year and inspire awe in young and old alike.

Since their first demonstration in June 1946 at Naval Air Station Jacksonville, Florida, in Grumman F6F Hellcats, the Blue Angels have indeed become a living legend. In July 1965, the Blues left the U.S. for their first European tour, and in 1971 they toured the Far East.The Blue Angels have changed flying machines and pilots throughout the years, but they have always represented, both in equipment and people, the capabilities of high-performance aviation.

HARRIER VTOL JET

ACTIVITY 1

Build Them and They Will Fly

OBJECTIVE: Students will create paper airplanes of two designs to demonstrate the principles of flight.

IN THE FILM: Viewers travel back in time to the early attempts at flight. From the 1804 Cayley's Model Glider which had a tail and a rudder to the Lilienthal Glider flown in Germany from a man-made mountain launch pad, from the successful Wright Brothers flight at Kitty Hawk to the Blue Angels and VTOL (vertical take off and landing) military aircraft, viewers get a glimpse into the past as well as the present. The future can only be imagined.

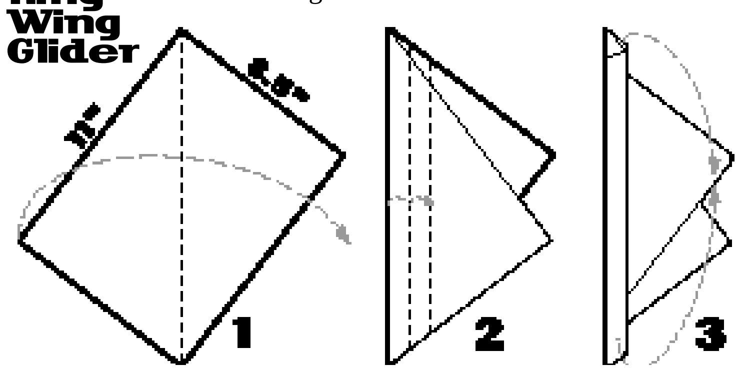
MATERIALS:

- ☐ Several sheets paper 8½“ x 11”
- ☐ Copies of the paper airplanes in this activity
- ☐ A large open space
- ☐ Scissors

BACKGROUND: The Barnaby Glider in this activity was Captain Barnaby's original design and won first in the First International Paper Airplane Competition. Captain Ralph S. Barnaby was a retired United States Navy pilot who knew Orville Wright and was a well-known aviation pioneer.

The Ring Wing Glider demonstrates the possibilities for innovation in the aeronautic field. An airplane or glider does not need a conventional shape: the sky is the limit in the design of new aircraft!

Ring Wing Glider



TO DO: To create the Barnaby Glider: Place a sheet of 8½“ x 11”paper on a flat surface in front of you. Fold crosswise along "X". Unfold the paper and make a series of nine quarter-inch folds, lengthwise, using half the sheet of paper.

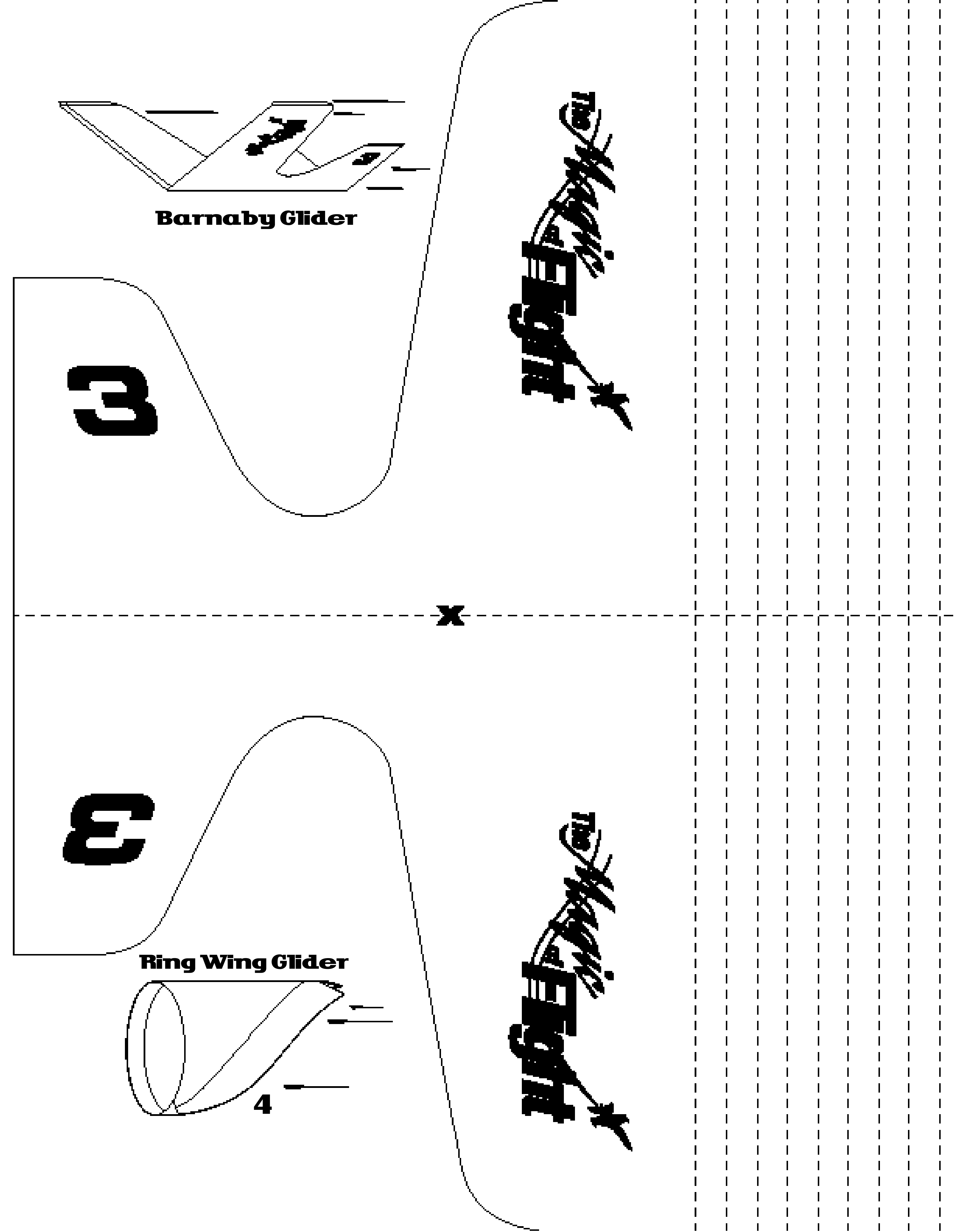
Once the smaller folds are completed, fold the entire sheet along the previous fold. While holding the paper folded, cut out the shape indicated in the diagram at right. This cut will distinguish the body of the glider from its tail. Once you have cut out the glider, open the wings and crease each tip up by a quarter inch. Fold the outside edges of the tail down a quarter inch to finish the glider. Grasp the tail of the glider and launch with a gentle upward thrust. *NOTE:* You can change the Barnaby's flight characteristics by experimenting with narrower or wider folds for the wing tips or tail fins.

To create the Ring Wing Glider: Place an 8½“ x 11”sheet of paper on the table in front of you. Fold the paper in half to make a large, uneven triangle. Make a fold that is one half-inch deep along the long edge of the triangle. Make a second half-inch fold along the original folds. Curl the ends of the paper together to make a ring with the folds inside the curl. To secure the round shape, tuck one end of the triangle into the folds of the other side. Gently grasp the "V" between the two "crown points" with your thumb and index fingers and toss the glider lightly forward.

WHAT'S GOING ON? The numerous folds of the Barnaby Glider along the front edge of the wings add weight to the front of the glider. Minute changes in the folds made on the wing tips and the tail fins can also make a difference in this glider's flight.

The folds in the Ring Wing make an airplane wing that is heavier in the front than in the back. Changing the shape of the wing into a ring provides the stability necessary for controlled flight.

TAKING IT FURTHER: Construct several different types of paper gliders and have a "Fly Off." Choose the most creative plane, the fastest flyer, the most aerobatic flight, and the easiest to make from the entries. Try experimenting with paper clips, placing them in different positions on gliders to see how the flight characteristics are affected by changes in the center of gravity.



Lift Yourself Up!

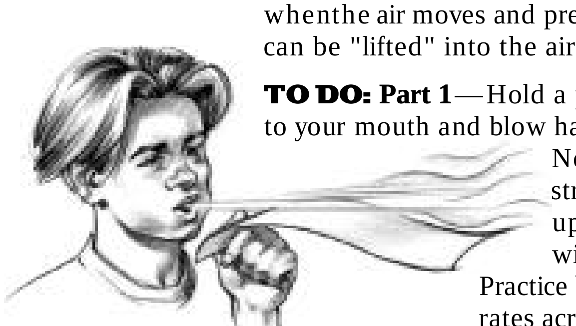
ACTIVITY 2

OBJECTIVE: Students will experiment with lift as a basic force of flight through the Bernoulli effect.

IN THE FILM: Before powered flight, lifting off the earth was a novel concept for humans. Without birds and flying insects as models, we might never have thought about flying. In the film, the viewer watches the artistry and symmetry of the Blue Angels formations; it is easy to visualize a migrating flock of birds in a similar formation.

MATERIALS:
- □ Paper strips three to four inches long
- □ Two ping pong balls
- □ Strong thread
- □ Fast drying glue
- □ Tape
- □ A ruler
- □ A drinking straw

BACKGROUND: In 1738 a Swiss mathematician named Daniel Bernoulli observed that whenever air moves, its pressure drops. In fact, the faster air moves the more the pressure drops.This effect is important in considering flight.The Bernoulli effect demonstrates that whenthe air moves and pressure drops, objects can be "lifted" into the air and made to fly!



TO DO: **Part 1**—Hold a paper strip close to your mouth and blow hard across the edge. Notice that the paper strip will curve gently up rather than down with your breath. Practice blowing at different rates across the edge of the paper and notice what happens to the paper strip each time.

Part 2—Glue six inches of thread to each of the ping pong balls. Allow the glue to set and then tie the thread, secured to each ball, to a ruler. Keep the balls ¾“ apart while making sure the balls are suspended at equal heights. Have a friend hold the ruler so the balls are hanging in front of your face. Stop the balls from moving. Once they are still, hold the drinking straw between the two balls and blow hard. Notice that the harder you blow the closer the two balls come together.

WHAT'S GOING ON? **Part 1**—When air is blown over the top of the paper strip, the pressure of the air on the top of the paper drops (Bernoulli effect).The lower pressure on the top of the paper gives in to the higher pressure under the paper, causing it to rise.

Part 2—The harder you blow between the two balls the closer the balls come together. This is because the harder you blow, the faster the air streams or moves between the balls. The pressure between the balls drops. The drop in pressure allows the balls to move, pushed together by the higher air pressure on the outside of each ball.

SO WHAT? Wings can lift almost anything from a paper glider to a jumbo jet into the air because of the difference in air pressure between the top and bottom of the wing. Airplane wings provide lift because they have a curved top and a flat bottom. As the wing flies through the air, it separates the air at its leading edge flowing over the top curved surface and bottom flat surface and then joining again at the trailing edge.The curved path of air is longer than the straight path, so the air streaming over the top of the wing is forced to flow faster than the air beneath the wing. Consequently the air above the wing is at a lower pressure than the air beneath, and the pressure difference provides the lift.

For an airplane to fly in level flight at a constant speed, four forces must be in balance: The thrust of the engines must be sufficient to overcome the drag (resistance) of the surrounding air while moving the airplane forward so the wing can generate lift. See *Diagram C* on page 7.Also, the lift generated must be enough to overcome the weight of the plane.

What a Drag!

ACTIVITY 3

OBJECTIVE: Students will develop an understanding of drag as one of the basic forces of flight.

IN THE FILM: As we follow the bird sequence, we learn how birds can successfully take flight using lightweight body construction, and carefully designed (by nature) wings, tail, and body which can react to the changing air currents. Later we learn that drag on an airplane is created in part by the air resistance against the structure including wing struts and other non-lifting shapes. For instance, if the drag increases, as in a biplane with many struts, thrust must increase to overcome it.

MATERIALS:
- □ A piece of card stock paper, 6”x 8”
- □ A candle and matches
- □ Paper clips
- □ A glass dish
- □ Modeling clay

BACKGROUND: To keep the drag (friction with the air) to a minimum, cars, airplanes, and birds are specially-shaped, or "stream-lined." This special shape allows the air to flow around them as smoothly as possible.

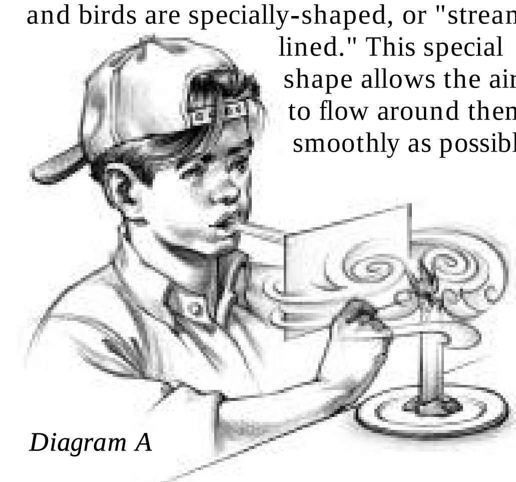


Diagram A

TO DO: Attach the candle securely to the glassplate with a lump of clay. Light the candle and from a distance of three inches, hold a piece of card stock parallel to the burning candle. Blow hard at the flat card stock. See *Diagram A.* Observe that the flame from the candle gutters, or moves, toward the card.

Now bend the card stock into a teardrop shape and secure it with paper clips. Hold the card stock shape in front of the burning candle, lining up the edge of the paper with the center of the candle. See *Diagram B.* Blow hard at the rounded outer-edge of the card stock. Notice that the flame will bend smoothly away from the card stock.

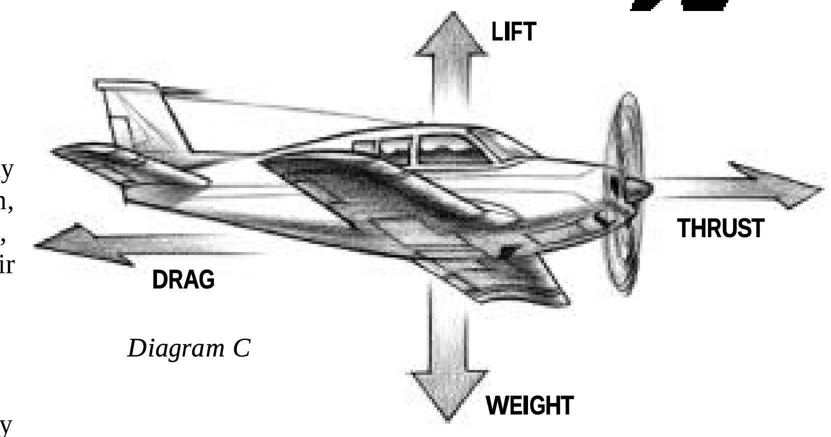


Diagram C

WHAT'S GOING ON? In this experiment, the flame moved toward the flat card because of the air stream curls and eddies that formed around the card.The drag on this shape is considerable and for this reason this shape would not be thought of as aerodynamic. Once it has been clipped together, the shape separates the incoming air cleanly in front, allowing the air in back to come together with little disturbance.The airflow barely upsets the flame of the candle. The slim, aerodynamic, teardrop-shape (called an airfoil) is much like that of an airplane wing.This steamline shape can be seen in anything that is designed to reduce drag and travel at great speeds.

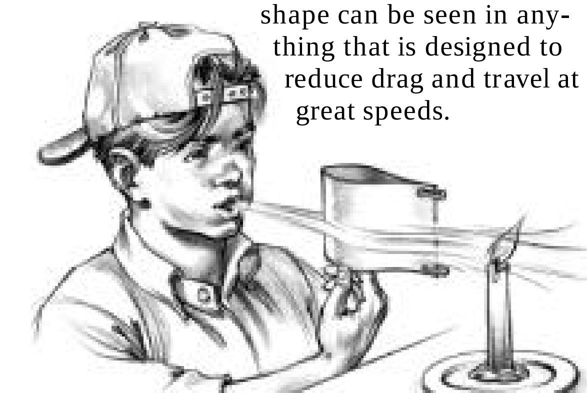


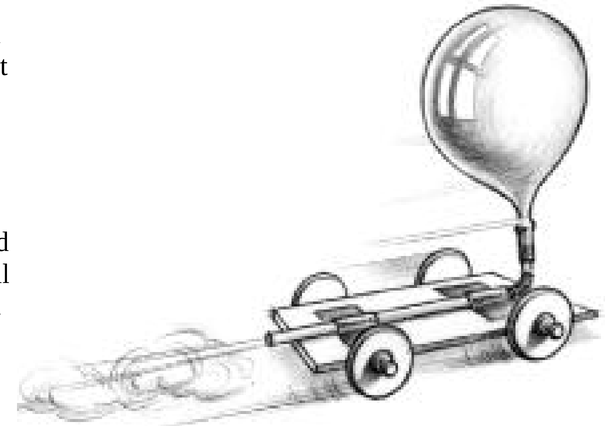
Diagram B

ACTIVITY 4

It Takes Thrust In The Right Direction!

OBJECTIVE: Students will experiment with simple household items to learn about thrust as a basic force of flight.

IN THE FILM: We see the Blue Angels descend toward the horizon of the desert and the Santa Rosa Mountains of southern California near El Centro. Then the jets turn and come backtoward us. With a roar, all planespull straight up into the vertical, flashing sun-hot afterburners. What a demonstration of thrust!



MATERIALS: Part 1—

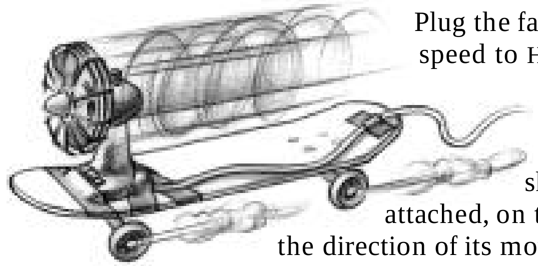
- □ An oscillating electric fan
- □ An extension cord
- □ Duct tape
- □ A skateboard

Part 2—

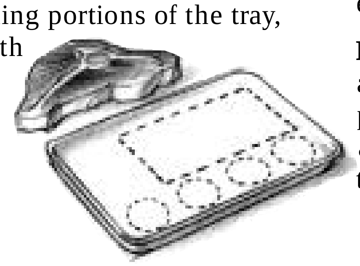
- □ One Styrofoam meat tray
- □ A flexible straw
- □ A small round balloon
- □ Ruler and compass
- □ Four pins
- □ Tape
- □ Marker
- □ Scissors

BACKGROUND: In 1687 Isaac Newton described the physical principles that govern motion. Newton's third law of motion explains how jet aircraft and rockets move. This law states that for every action there is an equal and opposite reaction.

TO DO: Part 1—Place the electric fan over the front wheels of the skateboard. Securely fasten the fan to a skateboard with duct tape. Plug the fan in and adjust the speed to HIGH. Adjust the fan so the air stream is flowing parallel to the floor. Place the skateboard, with fan attached, on the floor and observe the direction of its movement. *NOTE:* You may need to use an extension cord for the skateboard to travel further.



Part 2—Using a ruler and marker, draw a rectangle three by seven inches onto the meat tray. On the remaining portions of the tray, draw four circles with the compass, that are three-inches in diameter. Cut out each piece.



Push one pin through the center of each circle and into the edge of the rectangle to make wheels for a vehicle. The pins become the axles for the wheels. Do not push the pins in snugly but allow the wheels to rotate freely—they will wobble slightly.

Inflate the balloon several times to stretch it out. Attach the balloon to the end of the straw closest to the bend. Secure the balloon with tape to make sure the seal is tight. Attach the straw and balloon to the Styrofoam vehicle, leaving part of the straw protruding off the edge of the vehicle.

Blow up the balloon. Place your finger over the opening of the straw to prevent the air from escaping. Set your vehicle on a smooth surface and let go of the straw. Notice what happens to your vehicle.

WHAT'S GOING ON? Part 1—The turning blades of the fan are actually acting as an airfoil creating "lift." As the blades turn the relative motion of the blade and the air creates a low pressure on the side of the blade moving it in the direction of the low pressure.The skateboard moves backward.This backward motion of the skateboard is a dramatization of Newton's third law of motion.This law states that for every action there is an opposite and equal reaction.

Part 2—Here the third law is demonstrated again.Thrust is created by the differential pressure within the balloon and the escaping air. The escaping air causes the vehicle to travel in the opposite direction.

ACTIVITY 5

Music To Fly By

OBJECTIVE: Students will listen to, select, and write music to represent the experience of flight .

IN THE FILM: Music is an important backdrop for any film, but in a large format film the music must be as large and expansive as the image on the screen. Notice the high-energy music during the Blue Angels scenes; don't you feel pumped up and raring to go? In contrast, the music is more subdued and mellow in other scenes, suggesting a gentler mood. And, during the magnificent images of birds in flight, the music enhances the visuals, lifting you into the sky and making you soar.

MATERIALS:

- □ Written accounts of historical flights or excerpts from novels dealing with flight. Suggestions: works by Anne Morrow Lindbergh and Antoine de Saint-Exupéry. Also the poem "High Flight" by John Gillespie Magee.
- □ Photographs or video footage of birds and insects taking flight.
- □ Inspiring pieces of music, both modern and classical, from the local library or personal music collection. Suggestions: *Flight of the Bumblebee* by Nikolai Rimsky-Korsakoff, *Aviation Suite* by Ferde Grofé, or the fourth movement of *The New World Symphony* by Antonin Dvorak, or some modern music by Kenny Loggins (from the *Top Gun* soundtrack), or Sting.
- □ Musical instruments such as the violin, guitar, harp, drums, maracas, clarinet, trumpet, etc.

BACKGROUND: When the Wright brothers created the first gas-powered airplane they brought us to a new dimension of transportation. The Wright brothers also gave us the ability to enter a world which had previously been open only to winged-members of the animal kingdom. Once humans took flight they began to share their exhilarating experiences with others. Since then, numerous works of literature, art and music have been written and readers and listeners can "soar" with these works into the magical world of flight.

TO DO: Break the class into groups of three or four students each. Allow each group of students to view the videos of natural flight and read the literary selections dealing with flight. Have each group of students listen to several musical pieces, both classical and contemporary, and select one piece that best fits what they feel is the experience of flight. Now have students match their musical selection with one literary piece and one video excerpt. Students must be able to justify their selections by characterizing their mood i.e. energetic, contemplative, sad, happy, etc.

Once students have chosen music from the pre-recorded selections, have them make an arrangement of original music to express how they feel about flying. Have students perform their arrangements for the class. Discuss the differences between the two musical selections. *NOTE:* Some students may feel the excitement of flying and reflect this in their musical selections.There may be students who do not like the experience of flight, because of motion sickness or fear. The musical selections chosen by these students will show the variety of emotions felt when humans "defy nature" to fly.

Radio Age!

ACTIVITY 6

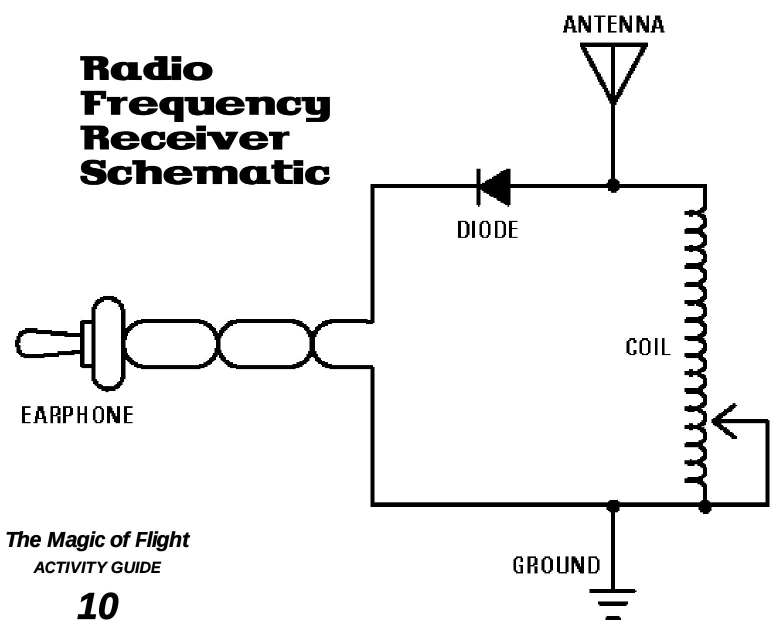
OBJECTIVE: Students will make a small Radio Frequency (RF) receiver.

IN THE FILM: In a Blue Angels sequence we hear the team leader call "Smoke On," over the radio. Immediately the planes in formation send out smoke trails.Then we continue to hear the complex radio chatter accompanying their toughest maneuvers. Radio communications between airplanes and ground controllers is a critical part of modern aviation.

MATERIALS:

- ☐ A plastic film canister
- ☐ 116 feet of 30 gauge magnet wire cut into three lengths: 100 feet for coil
  6 feet for ground
  10 feet for antenna
  (the longer the antenna the better the radio reception)
- ☐ Wood Screws and screwdriver
- ☐ A piece of stiff wire *(an unfolded paper clip)*
- ☐ Germanium Diode *(D1 OA79 or equivalent)*
- ☐ Balsa wood
- ☐ Sandpaper
- ☐ Crystal earphone
- ☐ Rubber Cement
- ☐ Double-sided tape

Radio Frequency Receiver Schematic



BACKGROUND: Radios are such a part of our daily lives that you probably don't give a thought to how they work.All aviators rely heavily on the use of radios to communicate —it could mean the difference between life and death.

TO DO: Apply the double-sided tape to the film canister to cover an area 1½ inches wide. Wrap the film canister with the wire placing each wrap right next to the preceding one. Leave six inches of wire unwrapped at the beginning and the end of the film canister. These wires will be connected to ground and/or antenna wires later in the activity.

Scrape the insulation from a uniform band along the coil of wire on the film canister, with the sandpaper. Attach the film canister to a piece of balsa wood using rubber cement. Turn the canister so the band of exposed wire is on the side. See *Diagram A*. Attach the stiff wire (paper clip) to the wood with a screw. Make sure this wire is firmly touching the exposed portion of the coils on the canister. This is the tuner for your radio.

Attach a Germanium Diode to the balsa wood near the film canister, with rubber cement.

Attach one of the leads of the Diode to the middle of one of the ends of wire not wrapped, by twisting the flexible wire around the Diode lead. Twist the end of the same wire together with the ten feet of additional wire. This will act as your radio antenna. Hang the antenna, fully extended out the window or up a nearby tree.The longer the antenna you have on your radio, the louder and clearer the radio signals will be.The antenna must be outdoors in order to pick-up radio waves. *NOTE:* Do not string antenna to grounded metal objects such as fences.

Bend the ground wire toward the screw holding the tuner wire. Attach the six-foot sectionof wire to a grounded metal object such as a plumbing fixture.Attach this wire under the screw, and finger-tighten the screw.

Separate the wires from the crystal ear-piece.Attach one of the earphone wires (it does not matter which one) to the second

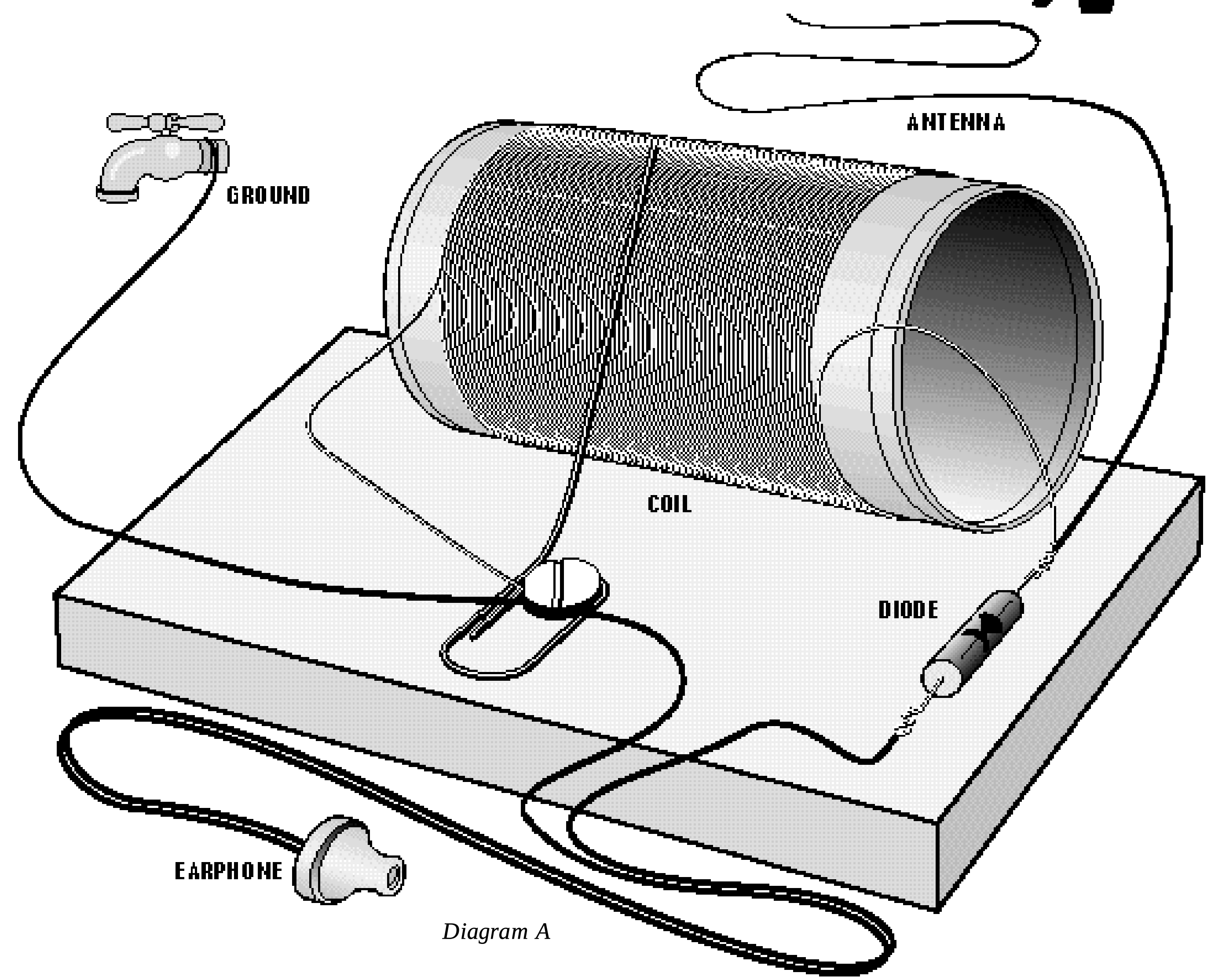


Diagram A

lead of the Diode. Attach the other ear phone wire to the screw connecting the ground, and the paper clip tuner. Finger-tighten the screw.

Place the earpiece in your ear and tune your radio by moving the tuner (stiff wire) along the exposed portion of the coiled wire. You will hear sounds and static as you get close to areas where the signals are being transmitted. Use the screwdriver to secure the wire in the position you desire. Depending on the length of the antenna and the strength of the radio signals, you can tune in to a local station.

WHAT'S GOING ON? Radio signals are part of the electromagnetic spectrum. Waves of the electromagnetic spectrum (called radiation) are changed into an electrical signal when pulled into the Germanium Diode and travel through to the ear piece. Radio stations transmit signals at a variety of frequencies. When tuned to different frequencies, radios can pull in the signals sent out by the stations. *NOTE:* Radio parts may be purchased at local electronic stores such as Radio Shack. See resource list in the back of this guide for information on purchasing a radio kit.

Helicopter Rising

ACTIVITY 7

OBJECTIVE: Students will construct a paper rotor, or helicopter, and investigate its behavior.

IN THE FILM: One of the most spectacular flying machines featured in *THE MAGIC OF FLIGHT* is the Harrier JumpJet. This airplane can lift off vertically like a helicopter, then move forward, as the wings begin to create lift of their own. The Harrier is built for short landings and takeoffs while other jet aircraft are built for higher speed and maneuverability.

MATERIALS:

- □ White bond paper 8½" x 11"
- □ Rulers
- □ Pencils
- □ Scissors

BACKGROUND: The spinning blades of a helicopter both lift it into the air and provide its thrust—similar to a combined wing and propeller. Each of the long, thin blades—the number can vary from two to six—has the airfoil shape of an aircraft wing with the leading (front) edge angled upwards. To lift the aircraft off the ground the blades are rotated and their pitch (the angle at which they meet the air stream) is gradually increased. As a result, air pressure decreases above each blade and increases underneath, providing an upward force (the Bernoulli effect). When the lift beneath the blades is greater than the weight of the helicopter, it rises into the air.

TO DO: Using a ruler and pencil, measure and mark a sheet of white paper with the configuration in *Diagram A*. Notice that the dotted lines on *Diagram A* are intended to be folds and the solid lines to be cuts.

Cut out the shape and fold where indicated in *Diagram A*. Hold your helicopter with the wings at the top and the body down, similar to the way a real helicopter would fly. Hold your hand above your head and let go of the paper rotor. Observe its motion as it travels to the floor. You may need to experiment with the height at which you release the helicopter in order to get the device to rotate as it spins to the ground.

WHAT'S GOING ON? As the paper model falls to the ground it spins because the air moves the blades, imitating the rotor blades of a real helicopter. The paper models will not rise, however, since there is no thrust to move the blades faster.

TAKING IT FURTHER: Create another helicopter. This time alter the type of paper, the location of the folds, or the shape and position of the rotors (the pitch, or angle in relation to the shaft) to test its performance.

Use the paper twister as a "cargo vessel" by attaching paper clips. Students can figure out how many clips can be carried successfully by the helicopter without providing too much weight.

Draw a target on a piece of paper and place it on the ground. From a predetermined height release the "cargo helicopters" with the intent of getting the precious cargo to the target drop point. Students may make adjustments to their helicopters to ensure a safe landing.

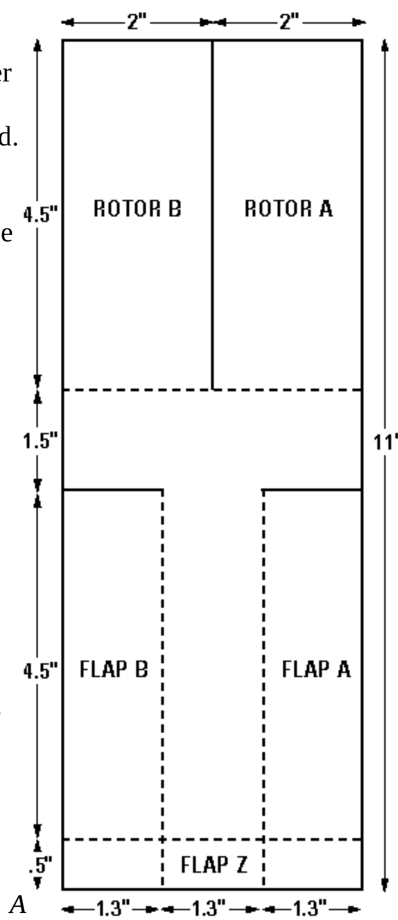


Diagram A

Flying Back In Time

ACTIVITY 8

OBJECTIVE: Students will research and share major events in the history of aviation.

IN THE FILM: *THE MAGIC OF FLIGHT* unfolds with reminiscences of early flight ventures and misadventures. From Cayley's 1804 Model Glider to Orville and Wilbur Wright's first airplane, the film takes you on a journey back in time to human's early attempts at flying. One scene in the film recreates the huge flying contraption, the Aerodrome, built by Pilot Charles Manly and designer Samuel Langley in 1903. The Aerodrome's wings collapsed abruptly, falling, as a reporter commented " like a handful of mortar," and dumped Manly into the river unhurt.

MATERIALS: Reference materials including documentary videos, books, and newspapers from your local library.

BACKGROUND: By doing research into the development of flying machines, we can appreciate the progress made over the years. For example, in early planes, passengers and pilots had to deal with loud engine sounds; today passengers and pilots benefit from sound-proofing materials. Also, the speed of flight has increased over the years. New carbon materials designed to make an aircraft lighter allow them to travel at greater speed, with the same amount of thrust, than the heavier planes of the past.

TO DO: Have students do two of the following activities using library and/or museum resources, and share them with the class.

Make a timeline of the developments in aviation. Begin with early inventions of the airplane and glider and end with the progression into space travel.

Make a model or draw a picture of a historical aircraft such as the Otto Lilienthal glider or the Wright Brother's flyer. Write a description of the building process and relate it to the process that the original builders employed. Today aircraft are created with steel and new carbon materials whereas early aircraft were constructed from wood. Show how the constraints of building materials on the construction of an aircraft affects how the aircraft will fly.

Write a biography for a famous person in aviation history. Research the life of this person so you can authentically "be" that person for one day. Dress in the clothing style of that person and visit other classrooms, sharing information about your life as an aviator.

Contact a person who was a participant of a historical military campaign involving airplanes (i.e: Pearl Harbor or the Battle of Britain.) Invite them to share their experiences with the class.

Conduct a video interview with docents of an aviation or aerospace museum. Get as much history on the construction of each particular aircraft as you can. Use this video as a reference guide for some of the other activities named above (i.e: timeline.)

TAKING IT FURTHER: As a culmination to the activities above, sponsor a special "Aviation Day" at your school at which members of the class can present their projects to the rest of the students at school. Include parents in the event and have students deliver the presentations at a Parent/Teacher Open House as well.

Have students collect stories of "first flights" from family members and share them with the class.

ACTIVITY 9

Do You Have the “Right Stuff?”

OBJECTIVE: Students will discuss the special qualities needed to fly high performance aircraft as is required of members of the Blue Angels precision flying team.

IN THE FILM: A great deal of work goes into preparing a flying team like the Blue Angels. Not only do the planes have to be in top shape, but the pilots must be as well—both physically and emotionally. G-forces

cause the blood to drain from the pilot's head causing him/her to black out. At high G-loads, the eyeballs also lose blood and oxygen and vision becomes blurred and tunneled. Many pilots test these physical limits in aeronautical centrifuges. In addition, engineers tell us that they can design planes now that no human can fly, no matter how well trained.These planes would be too complex and require reaction time beyond human control.

MATERIALS:
- ☐ Library resources
- ☐ United States Navy pilots
- ☐ US military flight crew members

BACKGROUND: The Blue Angels are a team of highly trained professional pilots. Not only do team members have exemplary mental ability, they are also in top physical condition. Blue Angel pilots need to be able to perform calculated maneuvers at breakneck speeds. Slow reactions due to mental or physical stress could be hazardous to the pilot and the rest of the team.

TO DO: Invite a military pilot to visit your classroom. Discuss the requirements to enter various naval aviation programs, including the Blue Angels. What are the educational and physical requirements for these programs?

Research phenomena such as G-forces on the human body. Find out how these forces affect visual perception and reaction time.

Invite a jet pilot to come to the class and describe what flying "feels like." Ask him or her to describe the experiences of: flying upside down, flying straight up on the vertical, encountering G-forces. Have students relate these experiences among themselves. Do they have the "right stuff" to follow this career path?

Organize a "Right Stuff" day at your school. Set up a physical fitness course where participants do challenging exercises. Participants could: run through tires; climb ropes; scramble over walls; or jump through hoops. Time each participant and graph the results.

Set up a mental "fitness" course for the "Right Stuff" day. These participants could: add a list of numbers in their head; repeat a list of numbers and letters from memory; draw an object with only verbal cues; read a selection of literature and answer related questions. Time each of these events and graph the results.

Ask students to analyze the results of the graphs. Would a person with a slow physical time and a fast mental time be a better candidate for the Blue Angels than a person who is quick in both areas? Discuss the importance of both physical fitness, and mental acuity for the Blue Angels. Discuss the need for physical and mental "fitness" in the event of an emergency that occurs while in flight.

TAKING IT FURTHER: Find a flight simulation video game for students to test their "Right Stuff" skills. Have students keep track of their flight records and decide whether or not they will make good pilots.

Let's Sit Together!

ACTIVITY 10

OBJECTIVE: Students will use teamwork to do a simple task.

IN THE FILM: Teamwork is a vital part of what makes the Blue Angels performances a success. Maintenance teams and support teams are ready well in advance, with engines and spare aircraft ready to go. "Fat Albert," the legendary support plane of the Angels practices its takeoff with a rocket assisted ascent so it is prepared for the first show of the year. And, of course, the Angels themselves have been tirelessly practicing their routines and are mentally and physically ready for the challenge of precision flying.

When the Blue Angels begin their training they start out flying far apart, then move closer and closer as the team members develop confidence in themselves and each other. Solo planes practice with the whole squadron and their high alpha maneuvers and tight turns illustrate the technical sophistication that can be achieved by these skilled professionals.

MATERIALS:
- ☐ A large open area and more than fifteen people.

BACKGROUND: Teamwork plays a role in many tasks we perform. Often we find ourselves in a situation where we must work together as a team to "get the job done." When working in a group, no one person can do all of the work. Instead each team member must do his or her part to complete the task. (It is said that an Austrian Empress used the type of teamwork found in this activity to allow her soldiers to keep dry while they rested in a wet field.)

TO DO: Create a circle by having all students stand next to each other, shoulder-to-shoulder. Now have all students pivot to the right so they are facing the backside of the person standing in front of them. Do not change the distance between each person.

Give the signal for every member of the group to slowly sit back onto the knees of the person behind them. Surprise! Students will see themselves as a part of a large circle with everyone relaxing on the laps of those who are sitting behind them. With practice, you may even be able to get the entire group to take a few steps together.

WHAT'S GOING ON? You are relying on the person behind you to support the weight of your body while you are supporting the weight of the person in front of you. If all members of the group sit at exactly the same time the weight of the entire group is dispersed evenly to every member. This illustrates that if every member of a team takes an equal responsibility, the task is easier to accomplish.

GLOSSARY

lift The force created by the difference in air pressure above and below the wings.

drag The resistance a moving object meets as it moves through a gas or liquid, such as the resisting force exerted on an aircraft parallel to its air stream and opposite in direction to its motion.

gravity The invisible force exerted by all matter related to its mass and the distance between surrounding bodies. In the case of the earth, it is the force on all solids, liquids, and gases, that tends to draw all bodies toward the center of the earth, its center of gravity.

thrust A force which causes movement, ie: the thrust of a propeller or jet engine on an aircraft.

spin The angular momentum of an object, produced by rotation about one or more of its own axes.

yaw To swing to the left or right on the vertical axis so that the longitudinal axis forms an angle with the line of flight of an aircraft.

airfoil The curved part of an aircraft, such as a wing, rudder, propeller, or rotor blade that is specifically designed to exert force on an aircraft to control its movements by reacting to the air through which it moves.

aerodynamics The branch of aeromechanics that deals with the forces (resistance, pressure, etc.) exerted by air or other gases in motion.

BIBLIOGRAPHY

Blue Angels: A Portrait of Gold,
Brian Shul,Mach 1, Inc.,California, 1995.

Engineer's Mini-Notebook,
Forest M.Mims III, Siliconcepts,1991.

Elementary School Aerospace Activities: A Resource for Teachers,
National Aeronautics and Space Administration, Washington D. C.,1977.

Exploring Matter and Energy,
Milo K. Blecha,Franklin G.Fisk, and Joyce C. Holly, Laidlaw Brothers, Illinois, 1980.

How In the World? A Fascinating Journey Through the World of Human Ingenuity,
Reader's Digest, New York, 1990.

How Science Works: 100 Ways Parents and Kids Can Share the Secrets of Science,
Judith.Hann, Reader's Digest,New York, 1991.

How Things Are Made,
National Geographic Society, Washington D. C., 1981.

How Things Work,
National Geographic Society, Washington D. C.,1983.

Small Inventions That Make a Big Difference,
National Geographic Society, Washington D. C.,1984.

Smithsonian Guides: Aviation,
Donald S. Lopez, Macmillan,New York, 1995.

The Family Creative Workshop,
Plenary Publications International,1974.

The New Games Book,
New Games Foundation,
Headlands Press,New York,1976.

RESOURCES FOR TEACHERS:

Booklets

Discovery Tour,
NationalAirand Space Museum,
Smithsonian Institution,1982.

History of Flight Tour,
National Air and Space Museum,
Smithsonian Institution, 1982.

Rockets: Physical Science Teacher's Guide With Activities,
GregoryL.Vogt, Ed.D.,National Aeronautics and Space Administration, Washington D. C. 1993.

The Sky's the Limit! With Math and Science,
Project AIMS, California.

Kits

Crystal Radio Kit, SmithsonianEasy Science,
Natural Science Industries Ltd.
West Hempstead, NY 11552-3942.

Rockets

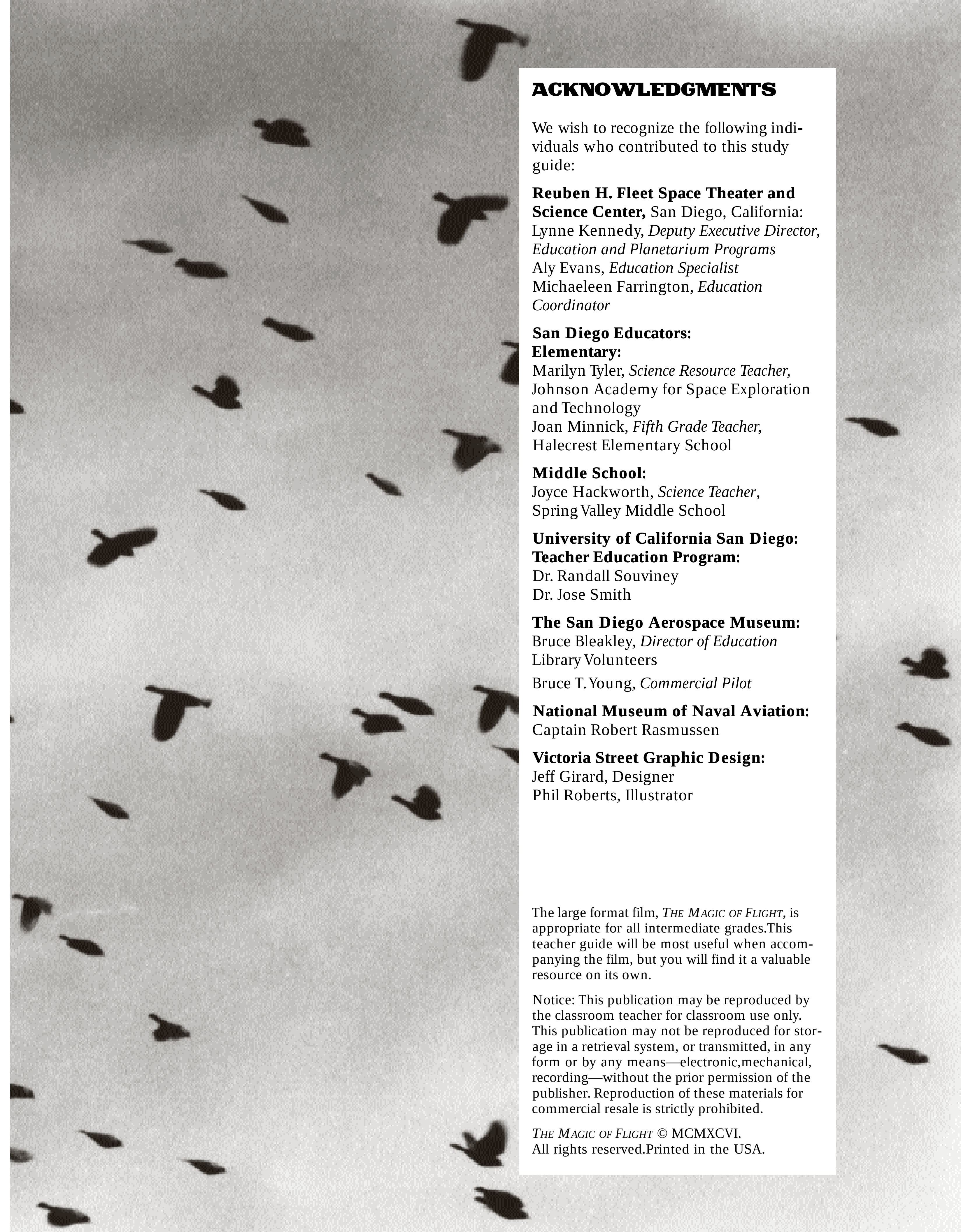
Estes Industries, P. O. Box 227, Penrose,CO 81240.

Organizations

AIMS Education Foundation,
5629 East Westover Street,Fresno, CA 93727.

National Air and Space Museum,
Smithsonian Institution, Education Division,
MCR 305, Washington, D.C. 20560.

U.S. Space Camp, Space Academy and Aviation Challenge,
U.S. Space & Rocket Center, One Tranquility Base,
Huntsville,AL 35807.



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The large format film, *The Magic of Flight*, is appropriate for all intermediate grades.This teacher guide will be most useful when accompanying the film, but you will find it a valuable resource on its own.