

# The Secrets of Flight

## Description

Students explore the forces of flight and use the design process to improve the flight times of paper airplanes.

**Suggested Grade Levels:** 3–6

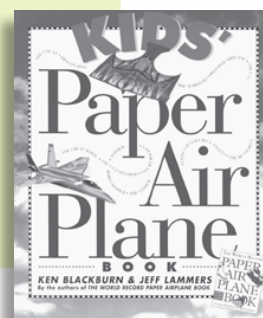
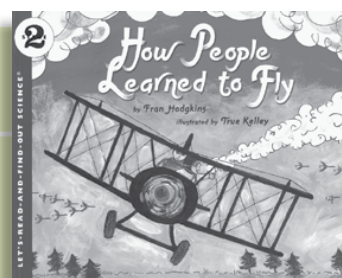
## Lesson Objectives Connecting to the Standards

### Content Standard B: Physical Science

**K–4:** The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

### Content Standard E: Science and Technology

**K–4:** Make proposals to build something or get something to work better.  
**K–4:** Evaluate designs and modify designs based on the results of evaluations.  
**K–4:** Create oral, written, and pictorial communications of the design process and products.  
**5–8:** Implement a proposed design, evaluate completed technological designs or products, and communicate the design process.



## Featured Picture Books

Title	<i>How People Learned to Fly</i>
Author	Fran Hodgkins
Illustrator	True Kelley
Publisher	HarperCollins
Year	2007
Genre	Nonnarrative Information
Summary	Reveals the many obstacles that have been overcome in the history of human flight and explains the four forces of flight with simple text and illustrations

Title	<i>Kids' Paper Airplane Book</i>
Authors	Ken Blackburn and Jeff Lammers
Publisher	Workman
Year	1996
Genre	Nonnarrative Information
Summary	This activity book provides information on the principles of aerodynamics, suggestions for designing airplanes, and instructions for folding paper planes and doing stunts.

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### Time Needed

This lesson will take several class periods. Suggested scheduling is as follows:

Day 1: **Engage** with Flight Semantic Map and **Explore** with Flight Data Sheet

Day 2: **Explain** with *How People Learned to Fly* and Forces of Flight diagram

Day 3: **Elaborate** with *Kids' Paper Airplane Book* and introduction of the Paper Airplane Contest and rules

Day 4: Test flights and modifications

Day 5: **Evaluate** with Paper Airplane Contest and Our Best Airplane

### Materials

(per pair)

- Scotch tape
- Glue stick
- Scissors
- Paper clips
- Several sheets of 8 ½ in. × 11 in. copier paper
- MyChron silent student timer or a stopwatch
- Safety glasses or goggles
- Paper Airplane Contest Announcement (for teacher use)

MyChron timers are  
available from

[www.onlinesciencemall.com](http://www.onlinesciencemall.com)

[www.teachersource.com](http://www.teachersource.com)

**SAFETY**

Use glue sticks with low or no volatile  
organic compounds (VOCs).

### Student Pages

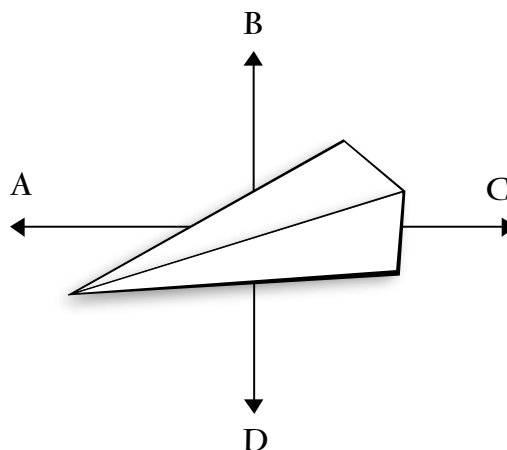
- Flight Data Sheet
- Simple Paper Airplane Instructions
- Forces of Flight
- Test Flight Log
- Our Best Airplane

## Background

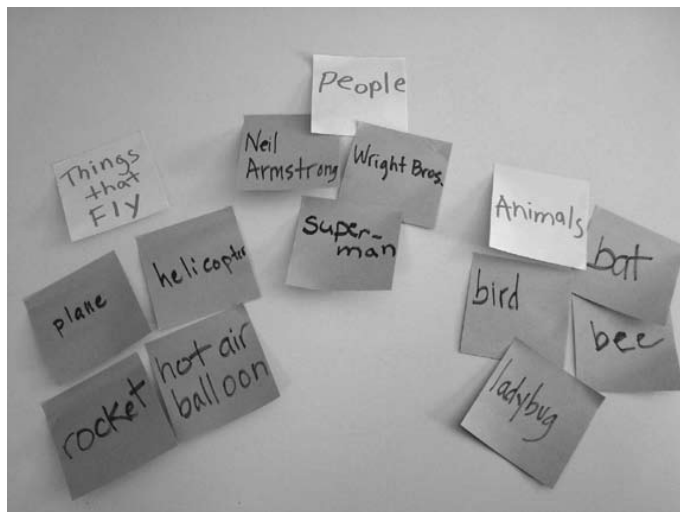
The date was December 17, 1903. The place was a windswept beach near Kitty Hawk, North Carolina. With Orville Wright at the controls and his brother, Wilbur, running alongside, the small airplane took off. This event lasted for only 12 sec., but it made history as the first successful, sustained flight by a human-piloted aircraft. The Wright brothers had uncovered the secrets of flight. This lesson addresses Physical Science concepts from the National Science Education Standards (NSES) such as motion and forces, but the true focus of the lessons lies in the areas of Science and Technology and History and Nature of Science. The NSES indicate that students in grades K–8 should develop the abilities of technological design—namely, to identify a problem or need, design a solution, implement a solution, evaluate a product or design, and communicate the design process. They advise that students should be involved in activities that are meant to meet a human need, solve a problem, or develop a product. In this lesson, students use the technological design process to build simple gliders, test them, and make changes to improve them.

The flight of a paper airplane, bird, jet, or any other flying object involves four forces: gravity, lift, drag, and thrust. *Gravity* pulls objects to the Earth. *Lift* is the force pushing up on the weight of a flying object and is created primarily by air molecules hitting the underside of the plane. For flight, the force of lift must be equal to or greater than the force of gravity. When anything flies through the air, it collides with air molecules that slow it down. This force is called *drag*. *Thrust* is the push that keeps the object from slowing down. In a real airplane, this force is created by an engine. When an airplane is flying level and thrust is greater than drag, the plane speeds up. If there is less thrust than drag, the airplane slows down. The initial thrust for a paper airplane is created by throwing it.

The Guinness World Record for paper airplane time aloft, 27.6 sec., is held by Ken Blackburn. He has an engaging and informative website at [www.paperplane.org](http://www.paperplane.org), where you can see a video of this record-making flight and download free paper airplane templates and a teachers guide for the *Kids' Paper Airplane Book*.



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CREATING CATEGORIES

## Engage

### Flight Semantic Map

A semantic map is a tool that helps activate prior knowledge, determine misconceptions, and show relationships among concepts. Discussion of a semantic map helps students become aware of new words, create new meanings for terms, and recognize the relationships among numerous words related to the science content. Before making the semantic map, throw a paper airplane and ask students

- ? What are some terms you think of when you hear the word *flight*?

Give groups of 2 to 3 students some sticky notes and ask them to write one word about flight on each sticky note. Give them time to generate a dozen or so sticky note words per group. Then ask them to sort the sticky notes into categories. They can label each category with another sticky note. For example, the category “Things That Fly” might include the words *airplane*, *helicopter*, *hot air balloon*, etc.

Write the word *flight* in the center of a sheet of chart paper or on the board, and circle it. Have students share their words and how

they categorized them. Discuss the categories and terms, choose several main categories to write on the map, and have students place their sticky notes on the board or chart paper under the corresponding categories. Display the map throughout the lesson, adding new categories and terms as students learn more about flight.

## Explore

(The following activity is adapted from the last page of *How People Learned to Fly*.) Tell students the Wright brothers, who invented the first successful airplanes, began by building gliders. Explain that a paper airplane is actually a glider because it doesn’t have an engine. Ask

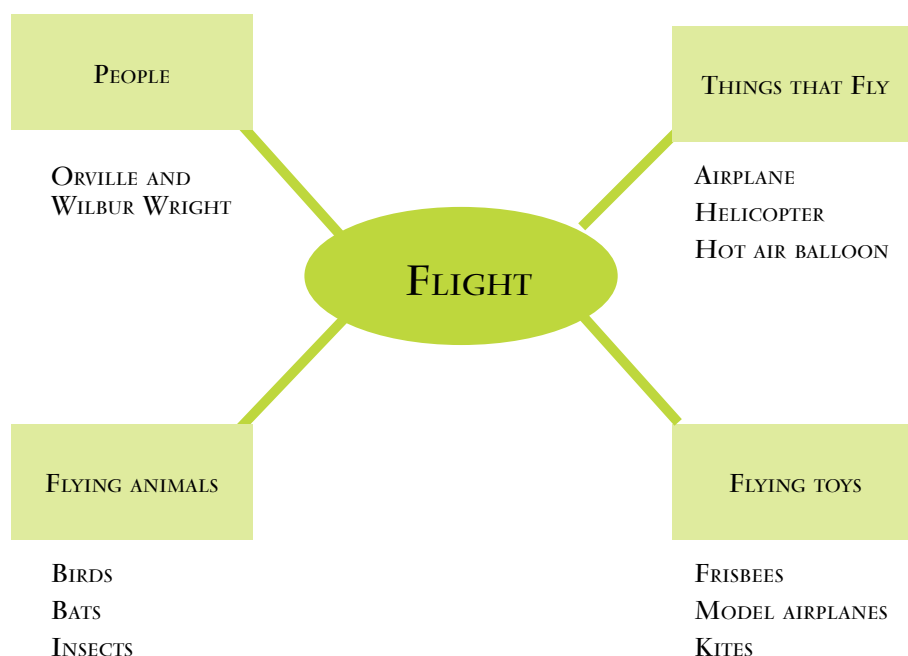
- How does a paper airplane get the push it needs to fly? (from your hand)

Give each pair of students the Flight Data Sheet, a MyChron timer or stopwatch, a sheet of copier paper, and the Simple Paper Airplane Instructions. Allow time for each pair to create a paper airplane. Next find a large open space inside your school (e.g., cafeteria, gym, hallway, etc.) to be used as a designated flying area. After reviewing safety procedures (do not throw paper airplanes toward people!), have students go to the designated flying area and test their models a few times. Then students should take turns throwing their airplanes while their partners use a stopwatch to determine how long the planes are in the air. They can use the Flight Data Sheet to record their times. Students should wear safety goggles or glasses during this activity.

Next tell students they will be comparing how their airplane flies outside compared to how it flew inside. Ask

- ? What do we need to do to make a fair comparison between inside flight and outside flight? (Use the same plane design with no adjustments; throw it with the same amount of force; use the same stopwatch; etc.)

## Sample Semantic Map for Flight



Now have students go outdoors, record the weather conditions, repeat the timing procedure, and answer the remaining questions on the Flight Data Sheet.

## Explain

Discuss the answers to the questions on the Flight Data Sheet:

- ? Were all of your plane's flight times indoors the same? Why or why not? (Times will vary. Students should understand that this is due to the person throwing it, how hard they threw it, the person timing it, etc.)
- ? Describe the weather conditions. (Students should describe the wind conditions, precipitation, temperature, etc.)
- ? Were all of your planes' flight times outdoors the same? Why or why not?



TESTING PAPER AIRPLANES OUTDOORS

- ? Did your paper airplane glide longer inside or outside? Why do you think that happened? (Depending on weather conditions, the paper airplanes may fly shorter or longer times outside than inside. The

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important thing is that students identify conditions that affect the flight time.)

- ? How do you think weather conditions affect a real airplane's flight? (It is harder for planes to fly against the wind and easier to fly in the direction of the wind; aircraft icing can make flying dangerous; etc.)
- ? Why doesn't your paper airplane keep flying like a real airplane? (The paper airplane does not have an engine to keep it moving through the air, so gravity pulls it down; it is not really flying but gliding; etc.)

Next give each student a copy of the Forces of Flight student page. Explain that a force is a "push" or a "pull" on an object. Read the names of the four forces in the word bank.

Tell students that as you read *How People Learned to Fly*, you would like them to listen for each of the four forces. Read the book aloud, stopping to discuss how each force affects flight.

After reading, have students place the words in the correct places on the student page. Answers are A—thrust, B—lift, C—drag, and D—gravity.

Ask

- ? What force pulls your paper airplane to the ground? (gravity, page 12)
- ? What creates drag on your paper airplane? (air resistance, page 16)
- ? What creates lift on your paper airplane? (the wings, page 22)
- ? What creates thrust with your paper airplane? (the force we throw it with, page 27)

Next brainstorm ways to solve the following problem:

- ? How could you make your paper airplane fly longer? (add or remove paper clips, add tape or glue, bend the wings up, etc.)

Point out that the scientists and inventors who have contributed to human flight

over the years have had to continually design, test, evaluate, modify, and communicate with others. The Wright brothers' first flight was the culmination of years of research, design, experimentation, and even frustration. Orville and Wilbur Wright were never completely satisfied with their airplane designs. They were always trying to improve their safety, flight time, distance traveled, and so on.

## Elaborate

Tell students that the Guinness World Record for the longest hand-launched paper airplane flight is held by Ken Blackburn. His plane flew for 27.4 sec! Show them the cover of *Kids' Paper Airplane Book* and tell them that one of the authors is Ken Blackburn. Read aloud from pages 9–10 about how he set the Guinness World Record. He set a new world record on October 8, 1998, of 27.6 sec. For more information about Ken Blackburn and to view a video of his record flight, go to [www.paperplane.org/record.html](http://www.paperplane.org/record.html).

Next announce that you are going to have a paper airplane flight contest to see whose paper airplane can stay aloft (in the air) the longest. Post the paper airplane contest announcement and explain the rules. These rules have been modified from official Guinness rules (the official Guinness guidelines can be found on page 10 of *Kids' Paper Airplane Book*):

- 1 The plane must be made of a single sheet of 8 ½ in. × 11 in. copy paper. It may be cut smaller, but it cannot be larger.
- 2 You may use tape, glue, or paper clips.
- 3 The plane must be thrown from level ground.
- 4 The timer must start when you release the plane and end when the plane touches ANYTHING (the floor, a wall, a chair, etc.).



## Determining Importance

Tell students that you are going to read a section of the book called “World Record Throw.” Have them listen for the description of the world record throw as you read pages 14–15 of the *Kids’ Paper Airplane Book*. After reading, ask a student volunteer to act out the throw described and pictured on page 14. Next set a date for the contest and allow students time to create and test various airplane designs.

Provide each pair of students with several sheets of paper, paper clips, a glue stick, scissors, a MyChron timer or stopwatch, and a copy of the Test Flight Log. Explain that a test flight log is a convenient way for students to keep track of their designs, modifications (changes to their designs), and flight times. Ken Blackburn used a log similar to this when testing planes for his world record attempt. Set up both a design area and a testing area in your school. A gymnasium works well because of the high ceilings. Indoors is best, but if you are unable to find a space indoors, students can test their planes outside. Be sure to explain that to see if a certain change helps a paper airplane stay in the air longer, students should change only one thing at a time. Have students repeat this problem-solving process until they are satisfied with their paper airplane designs or until you run out of time. Explain that the Wright brothers were successful because they didn’t give up; they kept trying different designs until they solved the problems they were working on.

Students should wear safety glasses or goggles during this activity. Also remind them to work carefully when using scissors.

## Evaluate

On the day of the contest, have each pair choose its best airplane, name it, write the name on the plane with marker, and decorate it if they wish. Choose one student in the class to be the timer



KEEPING A TEST FLIGHT LOG

and another to be the judge (you may want to ask another staff member to be the judge to add excitement).

The timer’s role is to use the stopwatch to time each flight and call out the time. The judge’s role is to write down each team’s name and the flight time of its airplane. The timer should start the stopwatch as soon as the thrower lets go of the plane and stop it as soon as the plane lands or hits something. The judge tells each person when he or she can make a throw. Have each pair make one official throw. The duo with the longest-lasting flight wins the contest. You may want to give pairs several opportunities to throw and enter their best flight time in the contest. (Note: Guinness allows six attempts.) After the contest, have students create a poster featuring their pair’s best airplane. Give each pair a copy of the Our Best Airplane student page. Here they will draw a picture of their team’s most successful design, including the plane’s name and any

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PAPER AIRPLANE MOBILE

special features. They will label the four forces of flight, using arrows to show the direction of each force. They also will list their best flight time and explain why they think that design worked better than the others they tried.

You may want to have students display the paper airplanes in your classroom by making paper airplane mobiles as described on page 25 of *Kids' Paper Airplane Book*. Teams can write the longest time aloft on their planes with a marker before hanging them on the mobiles.

## Inquiry Place

Have students brainstorm questions about airplane design, such as

- ? Which type of paper makes a better paper airplane: notebook paper, construction paper, or card stock? Test it!
- ? Do paper airplanes with longer wings fly longer or farther than paper airplanes with shorter wings? Test it!
- ? What is "aircraft icing" and how can it be prevented? Research it!
- ? What is the world's fastest aircraft? Research it!
- ? What is the world's largest aircraft? Research it!

Then have students select a question to investigate, or have groups of students vote on the question they want to investigate as a team. Students can present their findings at a poster session or gallery walk.



## Websites

Ken Blackburn's Paper Airplanes  
[www.paperplane.org](http://www.paperplane.org)

National Paper Airplane Contest  
<http://teacher.scholastic.com/paperairplane/index.htm>

What Makes Paper Airplanes Fly?  
<http://teacher.scholastic.com/paperairplane/airplane.htm>

NASA's Ultra Efficient Engine Technology (UEET)  
Kid's Site  
[www.ueet.nasa.gov/StudentSite](http://www.ueet.nasa.gov/StudentSite)

## More Books to Read

Adler, D. 1999. *A picture book of Amelia Earhart*. New York: Holiday House.

Summary: This book recounts the life of the famous pilot, from her days as a tomboyish school-girl to her career as a courageous and determined pilot to the mystery surrounding her doomed flight around the world. Realistic, double-page watercolor illustrations complement the text.

Burleigh, R. 1997. *Flight*. New York: Putnam Juvenile.  
Summary: Relive the historic and dramatic story of Charles Lindbergh and his flight across the ocean, the first solo Atlantic crossing ever, which brought him from the United States to Paris with only two compasses and the stars as his guides. Lush, impressionist paintings accompany the brief text.

Crowther, R. 2007. *Flight: A pop-up book of aircraft*. Somerville, MA: Candlewick Press.

Summary: From an acclaimed 3-D master comes a jam-packed, interactive book on flying machines that will send readers soaring. Loaded with flaps, pull tabs, and pop-ups to manipulate, this fact-filled exploration of flying machines from balloons to Boeings builds up to two big finales—an intricate pop-up cockpit that puts readers at the controls and a bustling airport runway that zooms into the future of flight.

Hunter, R. A. 2003. *Into the air: An illustrated timeline of flight*. Des Moines, IA: National Geographic Children's Books.

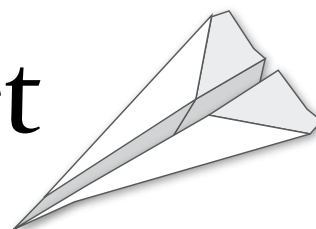
Summary: From flying prehistoric creatures through hot air balloons and the first manned flights to today's space travel and envisioned future wonders, this lavishly illustrated picture book traces the entire history of flight in a colorful and innovative way that will strongly appeal to young children. An accompanying fact-filled time line running throughout the pages features whimsical spot illustrations that complement the text and provide another layer of information for young flight enthusiasts.

Old, W. C., and R. A. Parker. 2002. *To fly: The story of the Wright brothers*. New York: Clarion Books.

Summary: This detailed picture book traces the work of the two Wright brothers to develop the first machine-powered aircraft. The story begins with two young brothers who dreamed of flying; describes their printing business, bicycle shop, glider tests, and modifications; and ends with that first flight on December 17, 1903.

Name: \_\_\_\_\_

# Flight Data Sheet



## Indoor Flight

- 1** Find an open space in your classroom or hallway. Safety warning: **DO NOT THROW PAPER AIRPLANES TOWARD OTHERS.** One person should throw the paper airplane while the other measures the amount of time the paper airplane stays in the air. Record the time in the table below. Discuss and record any flight observations. Then switch jobs.

### FLIGHT DATA: Indoors

Trial	Flight Time (sec.)	Flight Observations
<b>1</b>		
<b>2</b>		
<b>3</b>		
<b>4</b>		

- 2** Were all of your plane's flight times the same? Why or why not?

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## Outdoor Flight

- 3** With your teacher, go outdoors. Describe the weather conditions.

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- 4** Repeat the procedure above with your airplane outdoors, and record your data on the following page.

Name: \_\_\_\_\_

# Flight Data Sheet cont.

## FLIGHT DATA: Outdoors

Trial	Flight Time (sec.)	Flight Observations
1		
2		
3		
4		

**5** Were all of your plane's flight times outdoors the same? Why or why not?

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**6** Did your paper airplane glide longer inside or outside? Why do you think that happened?

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**7** How do you think weather conditions affect a real airplane's flight?

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**8** Why doesn't your paper airplane keep flying like a real airplane?

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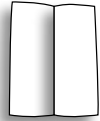
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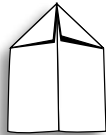
Name: \_\_\_\_\_

# Simple Paper Airplane Instructions

(Adapted from “Build a Simple Paper Airplane” at [www.paperplane.org](http://www.paperplane.org))



**1** Fold a piece of copy paper in half lengthwise.



**2** Fold both top corners into the center crease.



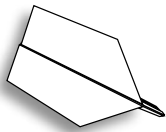
**3** Fold the paper in half with the flaps on the outside.



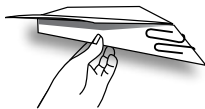
**4** Fold one wing down.



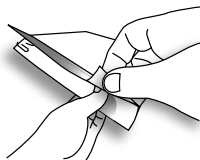
**5** Fold the other wing down.



**6** Fold the wings out.



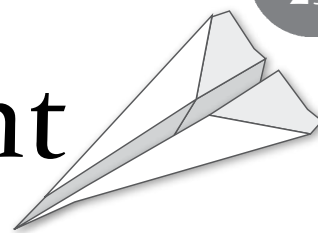
**7** Add paper clips to the nose (3 small or 2 large).



**8** Bend the back of each wing up a little bit.

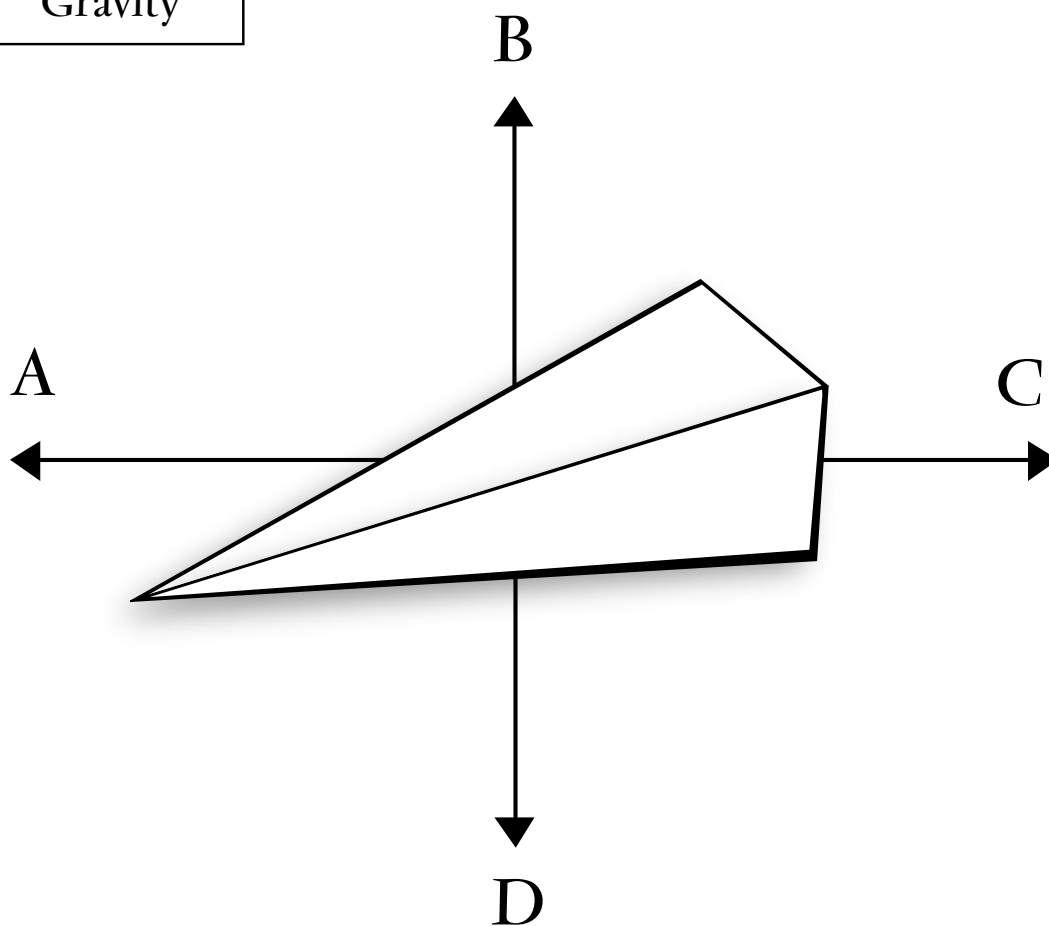
Name: \_\_\_\_\_

# Forces of Flight



## WORD BANK

Lift  
Thrust  
Drag  
Gravity



Name: \_\_\_\_\_

# ANNOUNCING!

Our class will be holding a



## PAPER AIRPLANE CONTEST

on \_\_\_\_\_  
(date)

### RULES

- 1** The plane must be made of a single sheet of 8 1/2 in. × 11 in. copy paper. It may be cut smaller, but it cannot be larger.
- 2** You may use tape, glue, or paper clips.
- 3** The plane must be thrown from level ground.
- 4** Timing will begin when you release the plane and end when the plane touches ANYTHING (the floor, a wall, a chair, etc.).

# GOOD LUCK!



Name: \_\_\_\_\_

# Test Flight Log

Use the test flight log below to record information about each paper airplane you test. Two sample flight entries are below.

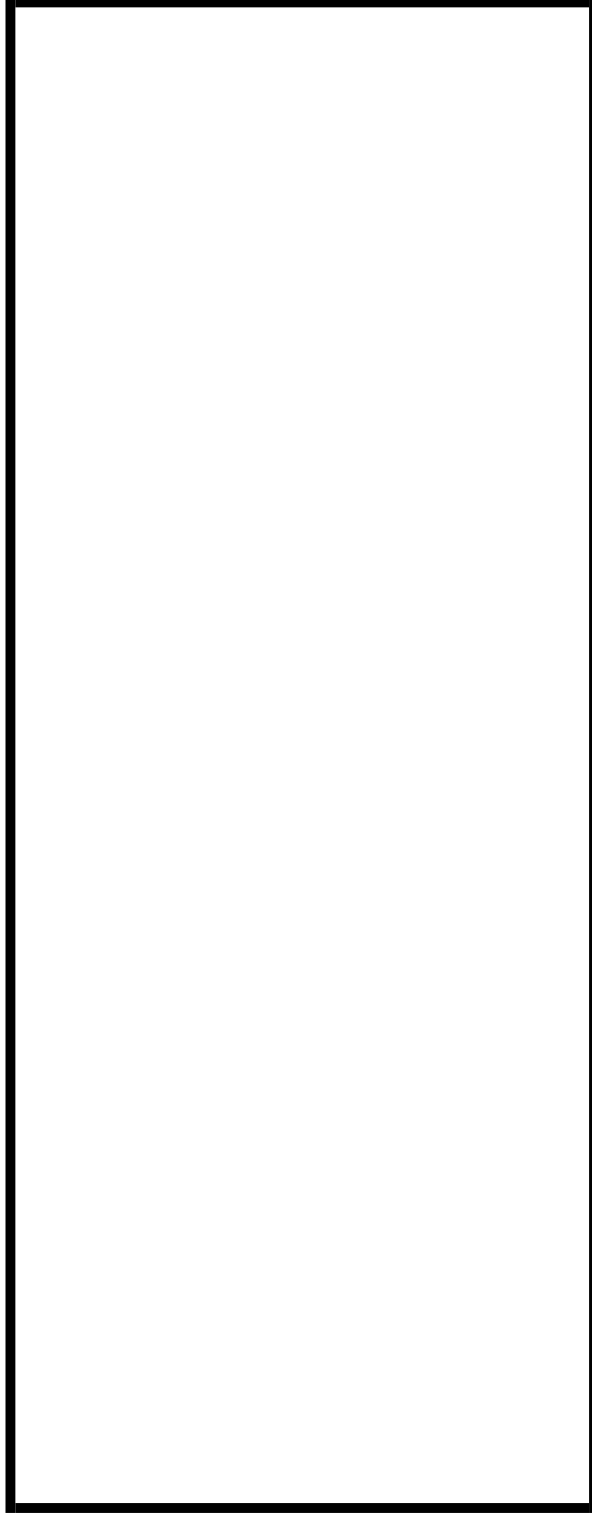
Date	Airplane Name	Modification	Time	Notes
9/12	<i>The Dominator</i>	<i>None</i>	<i>2.5 s</i>	<i>Turned to the left and crashed</i>
9/12	<i>The Dominator</i>	<i>Bent rudder to the right</i>	<i>3 s</i>	<i>Flew straighter</i>

CHAPTER  
23

# Our Best Airplane

Name: \_\_\_\_\_

- 1 Draw a picture of your team's most successful design, and be sure to
  - include the plane's name,
  - label any special features, and
  - label the four forces of flight, using arrows to show the direction of each force.



- 2 What was your plane's best flight time? \_\_\_\_\_
- 3 Why do you think this design worked better than the others you tried?

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