

Reliving the  
Invention  
of Flight



# The Society

The year is 1900, and you are employed by the Cincinnati Scientific Society, a group of about 100 progress-minded people who are interested in learning about the latest advances in science and technology. Some of the members are very wealthy and regularly sponsor lectures, studies, and expeditions. At the Society meeting last month, Mr. Pierpont reported that his cousin from Dayton had written him about her neighbors, two bicycle salesmen named Wilbur and Orville Wright. People were saying that they were making a large glider in the back of their bicycle shop. In talking with the Wrights, Mr. Pierpont's cousin had learned that they were attempting to invent a flying machine.

This is just the kind of thing the Society is interested in. Society members had avidly read reports about the gliding experiments of the German Otto Lilienthal, who was killed when his glider went out of control and crashed in Germany in 1896; about the Englishman Percy Pilcher, who died the same way in 1899; and about the Americans Octave Chanute and Samuel Langley. Mr. Sidney Krause makes a motion that the Society send an investigator to report on the efforts of the Wright Brothers. The motion passes unanimously; you are selected to be the investigator. The Society gives you strict instructions to report only the facts and not to mention the name of the Society in your investigations. (Society members want to avoid the appearance of being out to steal anyone's ideas. They are just interested in science.) Mr. Pierpont gives you the address of the Wrights and their shop, and you set off for Dayton the next morning.



*Chanute showing off the multiplane soaring machine "Katydid."*

Courtesy of the National Air and Space Museum,  
Smithsonian Institute. Negative 1A-20406 A494771  
(<http://www.smithsonian.org/>).



*Langley's "Great Aerodrome" perched aboard a houseboat on the Potomac, just before a disastrous launch that tumbled the aircraft down into the river.*

*Lilienthal's flight station near his home in Steglitz  
(today part of Berlin).*

Courtesy of Archive Otto-Lilienthal-Museum  
([www.lilienthal-museum.de](http://www.lilienthal-museum.de). Inquiries are directed to  
[LilienthalMusuem@t-online.de](mailto:LilienthalMusuem@t-online.de)).



## Activity 1—Early Aviation

Before you go to Dayton to investigate the Wright Brothers, it is important to do some research and get some background information. You need to go to the library and/or the Internet and find out about the progress of attempts to build a flying machine up to the year 1900 (try searching under terms like “early aviators” on the Internet). Write a short paragraph about each of the following and their accomplishments up to 1900:

1. Otto Lilienthal



2. Octave Chanute



3. Samuel Langley



See whether you can answer the following questions:

1. Why do you think some of these early pioneers were using gliders instead of powered aircraft? Why didn't their craft have engines?
2. What was the record for distance and time aloft by a manned glider in 1900?
  - a) 20 feet and 2 to 3 seconds
  - b) 100 feet and 5 to 6 seconds
  - c) 500 feet and 8 to 10 seconds
  - d) Over 1300 feet and 12 to 15 seconds
3. Why was gliding so dangerous at the time?
4. Why do you think Chanute chose to test his gliders at the Indiana Dunes on the southern shore of Lake Michigan?
5. How far is it from Cincinnati to Dayton? How do you think you might have travelled from Cincinnati to Dayton in 1900?



## Activity 2—Your First Interview



Now that you know something about the state of flying machines in 1900, pretend that you are a reporter for the Dayton Daily News. You are being sent to interview the Wright Brothers. What questions do you think you would want to ask them about what they are attempting to do?

A. 1.

2.

3.

4.

5.

6.

B. If you are working in a class, team up with a classmate and see how your questions compare.

C. Discuss how you think the Wright Brothers might answer your questions.



*News reporters waiting for the Wright Brothers to fly.*





## Meet the Wrights

Having been appointed by the Society to learn about the flying experiments of Wilbur and Orville Wright, you travel by train to Dayton. The trip takes about 2 hours, and when you arrive in Dayton, you ask for directions to the Wright Cycle Shop located on West Third Street. You catch the streetcar as directed.

Instead of going directly to the cycle shop, you decide to talk first with the neighbors. You run into a bunch of kids playing in the street and ask them what they know of the Wright Brothers. "They can fix anything," says one youngster. "They're good with bicycles," says another. "I like their kites!" pipes in another.

This is what you came to hear. "Last year, Wilbur made the biggest, best kite!" a boy declares. "It had two wings, was 5 feet across, and had four strings to it, one to each corner. When he pulled on the strings, the kite twisted and dove through the air. He could make it go any direction and he just about dove it into us kids. It really scared us!"

You thank the kids. Near the bicycle shop, you introduce yourself to a lady sitting on her porch. Does she know the Wrights? "Indeed I do, ever since they was little," she says. "Oh, they was always up to somethin', they was. They used to publish their own newspaper. Now they fix and sell bicycles. They really don't talk too much," she continued. "I hear tell they're buildin' some big flyin' contraption in their shop, but I ain't seen nothin'. I'd ask, but they pretty much like to keep to theirselves." You thank her, and go over to the cycle shop.

As you enter the shop, a tall man with sharp features comes out of the back room and introduces himself as Wilbur Wright. He asks you if he can help you, and you pretend to be interested in a bicycle. He shows you several makes, including some that he and his brother Orville designed themselves.

As you look at bicycles, you talk about a number of things. A shorter man in a derby hat comes in and Wilbur introduces him as his brother, Orville. As you talk about bicycles and transportation in general, you mention something about Octave Chanute and glider flights on the Indiana dunes. The eyes of both brothers light up at this, and they mention that they too have done a bit of research on the subject of flight. Wilbur says the key to success is being able to control a craft in the air. "The lack of control," says Orville, "cost Lilienthal and others their lives." The brothers say that they plan to carry out some experiments in North Carolina in the fall, but don't offer any more details. You shake hands and leave the shop.

Before you return to Cincinnati, you decide you are just too curious; you can't resist trying to get a look at whatever's in the back of the cycle shop. You wait until evening and slip around to the back of the shop. Looking in through a dirty window, you see the biggest kite or glider you ever saw. Although it's difficult to make out in the dim light, you see that it has two wings, one above the other. The wings must be 15 or 20 feet in length! At last, afraid of being discovered, you head for the train station and manage to catch the last train of the night back to Cincinnati.



*Wilbur Wright working in the Wright Cycle Shop.*







## 1900: Kitty Hawk

Having visited the Wrights in Dayton, you make your report to the members of the Society. Everyone is extremely interested in the craft being built in the back of the shop; the members excitedly discuss the possibilities of human flight. Mr. Pierpont's cousin says that the Wrights' sister Katharine told her that they are going to a place called "Kitty Hawk" in September. This sparsely populated North Carolina spot has high sandy hills, few trees, and almost continuous winds from the ocean: ideal conditions to test a glider.

The Society is anxious to send you there to learn of the experiments, but not in an obvious way. It is decided that you will apply for a temporary position with the U.S. Lifesaving Service, which has a station near Kitty Hawk. Several Society members help you to secure a job as a lookout while you also maintain your position and salary with the Society. The adventure and the money are too good to pass up.

You arrive in Elizabeth City, North Carolina, in August and catch a ride on the mail boat out to the Lifesaving Station near Kitty Hawk. If a shipwreck occurs, your crew's job is to brave the surf and rescue stranded sailors.



*Crew of the U.S. Lifesaving Service at Kitty Hawk, 1900.*

On September 13, Wilbur Wright arrives in Kitty Hawk and stays with William Tate, the local postmaster. Soon, Orville arrives and they set up a tent camp about a one-half mile from the Tates. You receive word that the brothers' kite has arrived, so you decide to visit their camp.



You introduce yourself to the Wrights as a lookout from the Lifesaving Station. Wilbur recognizes you from your visit to their shop in Dayton, and you tell him you are a college student from Cincinnati and were in Dayton visiting friends.

The brothers remember your interest in flight and proudly show you their creation. This is the same large craft that you saw in their shop. It has two wings about 17 feet long and 5 feet deep, one set about 4 feet above the other. Both wings are made of a tightly woven white material stretched over a light wooden frame. Wire bracing keeps the structure tight. A square structure that looks like a small wing made of the same white material is sticking out a few feet in the front. You note that the wings are arched. When you ask about the

open space you see in the lower wing, Orville informs you that the pilot rides there, lying on his stomach, so it is indeed a glider. Due to light winds, they are testing the glider with chains to simulate the weight of a pilot. You ask permission to stay and watch, and they ask whether you'd be willing to help!



As strong breezes blow, the glider, which must weigh nearly 100 pounds with the chains, just floats in the air. You and Orville struggle to hold onto cables that act as kite strings; Wilbur is behind the glider pulling on another set of wires. As he pulls on one wire, the wings twist and the glider tilts and drifts to the side. When he pulls the other wire, the glider turns in the opposite direction. This is just like the kite the kids in Dayton had described to you. The control was truly wonderful! You want to stay all day, but your shift as a lookout is coming up. The brothers thank you for your help and invite you back.



*Wilbur Wright at first camp at Kitty Hawk, 1900.*

You visit the camp a few more times, and you notice that the curvature of the small front wing is sometimes different, and this seems to cause the glider to fly at a different angle. You always see the brothers flying the glider as a kite, but the other men at the station tell you that one day they had seen Wilbur actually piloting the glider. On that particularly windy day, they say, he had glided for 10 to 20 seconds and covered 300 to 400 feet before suffering a minor crash landing.

Soon after, the Wrights pack up and return to Dayton, leaving their crashed glider in the sand; Postmaster Tate's wife washes the fine sateen fabric of the wings and makes dresses for her daughters. You take leave of the Lifesaving Station and return to Cincinnati to report to the Scientific Society.



*The Wrights' 1900 Glider.*



*October 1900: 10-year-old Tommy Tate, son of Kitty Hawk postmaster William Tate, standing in front of the 1900 Glider with his drum fish. Tommy flew as a lightweight pilot on some of the Wright Brothers' glider flights.*

## Activity 4—Build a Model of the 1900 Glider

The Society asks you to make a model of the Wright's 1900 aircraft as a part of your report. Turn to page 41 and follow the instructions to make your model.





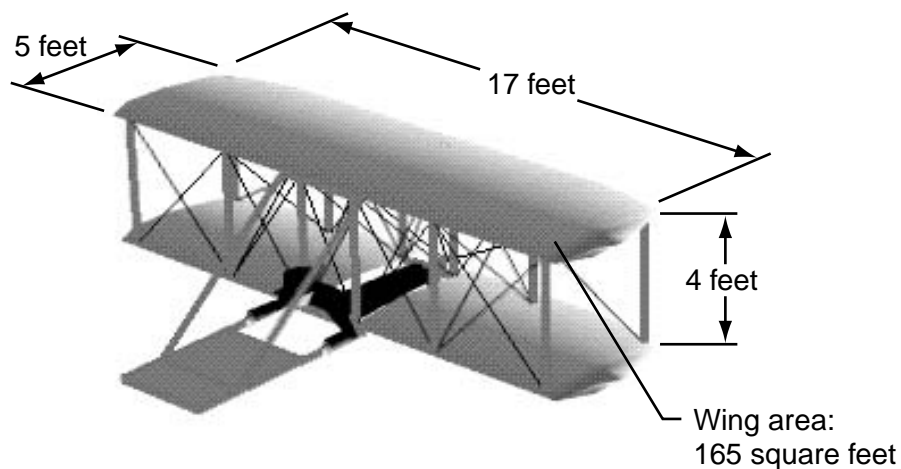
## Activity 6—What Would You Design?

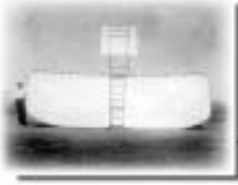
Orville told you that he and Wilbur are determined to create a flyable machine, and that to do this they are going to have to get more lift out of their craft so it can support a pilot. When you report this to the Cincinnati Scientific Society, the members start to debate about what they think is the best way to accomplish this. It is decided to have a contest to see who can produce the best design to improve upon the Wright Glider.

1. If you were to enter this contest, what specific changes would you make to give the 1900 Glider more lift?

2. How do you think each change would improve the original design?

3. This is a drawing of the 1900 Glider. It had a wingspan of 17 feet and a wing area of 165 square feet. On another sheet of paper, draw a sketch of your proposed glider, showing a top view and a front view. Be sure to put dimensions on your sketch. How long, wide, and high will your glider be?

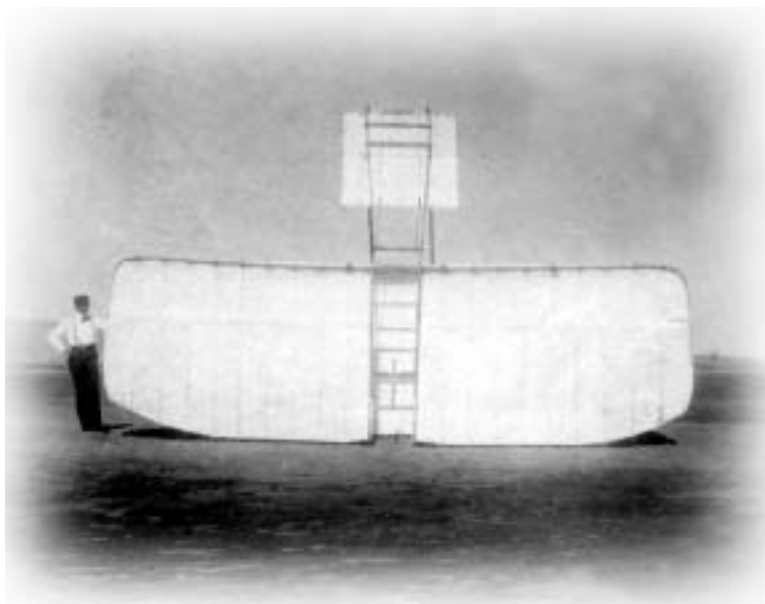




## 1901: The First Improvement

You are involved with various activities as secretary for the Cincinnati Scientific Society when a letter arrives in March from the cousin of Mr. Pierpont, the neighbor of the Wright Brothers. She has spoken with Katharine Wright, who told her that her brothers have constructed a new glider and intend to go to Kitty Hawk for testing much earlier than last year, leaving sometime in July. With anticipation, you arrange to return to the Lifesaving Station at Kill Devil Hills in late June to resume duties as a temporary lookout so you can observe the new trials.

The Wright Brothers arrive on July 10, 1901. This year, in order to be closer to their launch site at Kill Devil Hills, they move their camp about 4 miles south to the base of Big Hill. This puts them much closer to your station, and it's easier to observe their experiments.



*The 1901 Glider.*

The new glider is much bigger than the first. It still has two wings, but they are larger, each 7 by 22 feet. The total wing area is now 290 square feet, and the aircraft weight has doubled to 100 pounds. This would be the biggest glider ever flown! You have the opportunity to visit the brothers' camp a number of times to observe and assist with flights. Wilbur is the pilot on each trial. There are other visitors to the camp, and you are introduced to Mr. Octave Chanute and two assistants, who are there to observe as well as test a glider of their own.

The flights of the 1901 Glider are disappointing. Orville tells you that they had used the data from tables published by Otto Lilienthal to design the new wings, but the glider only produces about one-third of the expected lift. Could Lilienthal's data be wrong? Although

there are frequent glides of around 300 feet, you notice other problems as well. The front rudder doesn't seem to do much to control the up-and-down pitch of the glider, and when the wings are warped to turn, the craft sometimes settles backward and spins out of control. In one of these crashes, Wilbur suffers minor injuries. After that, they only fly the aircraft as a kite.

At the end of August, the brothers return to Dayton in disappointment. You stay on an additional week to compile your notes and then return to Cincinnati to report to the Scientific Society. You report that Wilbur has said that he believes that people will fly, but not in their lifetimes. After two summers of trials, the Wright Brothers are very discouraged.

### Activity 7—Build a Model of the 1901 Glider

To make a model of the 1901 Glider for your report, follow the instructions beginning on page 48.



## Activity 8—Forces on the 1901 Glider

The picture below shows the Wright Brothers at Kitty Hawk, NC, with their 1901 Glider being flown as a kite. It weighed 98 pounds and had a wingspan of 22 feet. The kite appears to be floating in the air, but it is actually being held motionless because the forces that are acting on it are “balanced.”



1. You know that wind is needed to fly a kite, so draw an arrow on the picture to show which way the wind would be pushing on the glider.
2. There are three other forces that are acting on the kite. One of these is the lift caused by the wind acting on the wings of the glider. Draw an arrow to show the direction that this force acts on the glider.
3. The third force acts on you and all other objects on Earth all the time. It is called \_\_\_\_\_. Draw an arrow to show the direction that this force acts on the glider.
4. Look at the men in the picture and see if you can determine the direction of the fourth force. Keep in mind that the glider is motionless, so the fourth force must act to balance out the other three forces. Draw an arrow to show the direction of the fourth force.
5. Do you see anything in the picture that shows that all the forces are canceling each other out? If yes, what is it?
6. If the speed of the wind increased, what would happen to the glider?



## Activity 9—Questions on the 1901 Glider

The report of the summer of 1901's activities caused quite a stir in the Cincinnati Scientific Society. When you mailed sketches of the new craft back in July, many members had thought that the additional surface added to the wings would provide the lift needed. Clearly something was wrong.

1. Why do you think that the new glider with its larger wings failed to perform as expected?
2. If you were Wilbur or Orville Wright, what would you do at this point? Why would you do this?
3. To solve a problem, the Wright Brothers would only make a single change at a time. Why is this a scientific way to do an experiment?

## Activity 10—Wrong Ideas

Advances in science are often hindered by making wrong assumptions, making assumptions based on incorrect information, or by not understanding information or data in the right context. The Wright Brothers thought the reason their 1901 Glider did not perform up to expectations was that Lilienthal's data, on which they had based their calculations, were wrong.

Choose one or more of the following ideas that were once accepted as correct in science. Find out who may have challenged these ideas and how our thinking changed as a result. Write down your answers.

1. The Earth is flat.
2. The Sun revolves around the Earth.
3. There are only four elements: earth, air, fire, and water.





## New Data

After your second season at Kitty Hawk, you resume your duties at the Scientific Society. Several members attend the meeting of the Western Society of Engineers in Chicago, where Wilbur Wright is a featured speaker. Upon their return they're eager to talk to you about his speech and your observations at Kitty Hawk. The members are impressed with the Wrights' scientific knowledge and their logical problem-solving approach. The positive reaction from the audience encouraged Wilbur in spite of the past year's disappointments. You will make another visit to Dayton soon to see how the investigations are going.

In December you correspond with Mr. Pierpont's cousin to find out what the brothers are up to. She responds that they have constructed some sort of device to measure the effectiveness of different wing shapes. She says that she even saw Orville riding on a bicycle with a wheel attached to the handlebars, with what looked like little wings on the wheel. She guessed he was testing the wings somehow.

You arrange to travel to Dayton in January. When you enter the shop, Orville greets you with pleasure. You tell him you are visiting friends on break from school and thought you would stop in and say hello. Orville invites you into the back room, where you see a bicycle with a wheel mounted flat on the handlebars. Upstairs, the brothers have set up a 6-foot-long box with a fan on one end, and a table with a number of small wing models.



*Reproduction of the 1901 Wright wind tunnel, the first wind tunnel to produce reliable aerodynamic data.*



*Orville Wright and Edward Sines at work in the Wright Cycle Shop, 1897.*

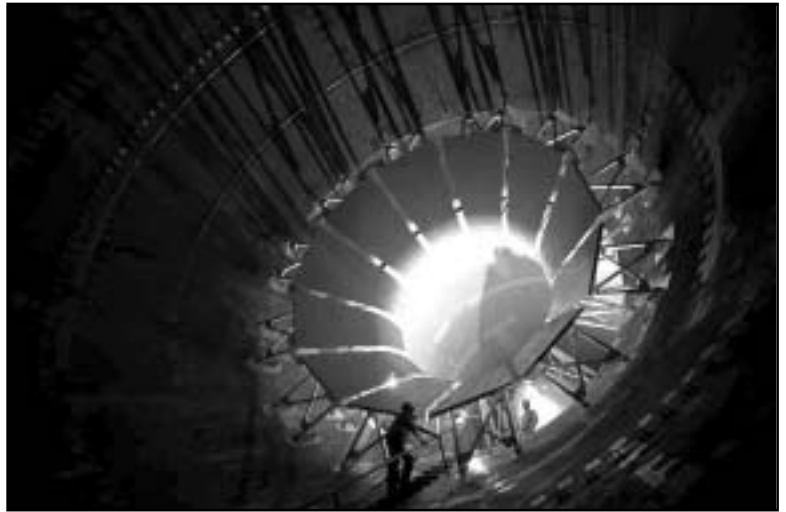
Orville explains that Wilbur's talk in Chicago had recharged their enthusiasm. They suspected that the second glider's poor performance might be due to errors in Lilienthal's data tables. To test this, Orville placed the wing shapes on a bike wheel mounted on a bike's handlebars, and rode off to provide wind. The angles of attack predicted by Lilienthal did prove to be in error. In fact, the Wrights discovered that the shape of the wing, viewed from above, is very important in the generation of lift. Lilienthal's data only applied to small, oval-shaped wings, while the brothers' wings were rectangular shaped. Orville and Wilbur decided that they needed to collect their own data.

Orville shows you the box they built for testing. A belt turns a large fan, which pushes air through the box, and a grid straightens out the flow of air as it enters the box. The brothers observe the testing through a glass window above the test area, where the wing shapes are mounted on a balance made of hacksaw blades and bicycle spokes (this box has come to be known as a "wind tunnel"). Orville says that they've tested a large number of shapes in several combinations, and with their new data they are designing a glider to try in late summer. You wish him luck, tell him that you hope to see him in the summer, and leave to catch your train back to Cincinnati.

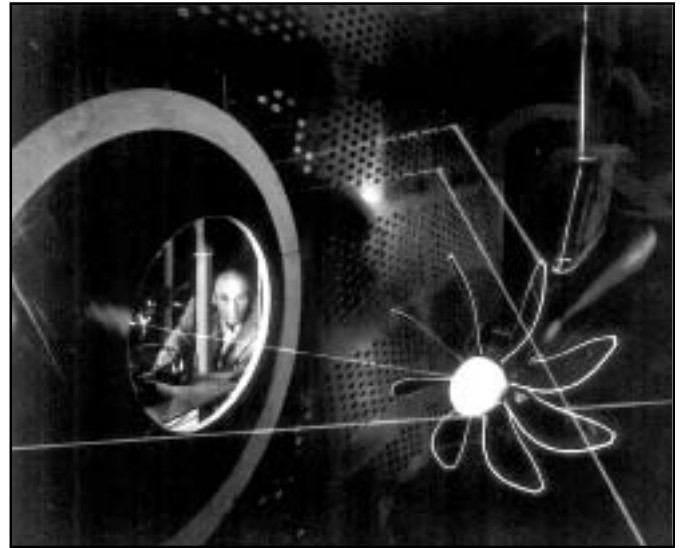


## Modern Wind Tunnels

*Inlet diffuser of a wind tunnel at NASA Ames Research Center. The inlet diffuser works like the grid that was used for “straightening” the wind in the Wright tunnel. Ames has the world’s largest wind tunnel at its site in California.*



*Propulsor fan (like the fan to create airflow in the Wright tunnel) of the Transonic Wind Tunnel at NASA Langley Research Center (the fan blades of this older tunnel are made of wood). The first major U.S. wind tunnel was built at Langley in 1920.*



*Test section of a supersonic (high flight speed) wind tunnel at NASA Glenn Research Center. The white “lines” are laser beams that engineers use to measure the performance of the model. The Wrights used a bicycle-spoke balance to do the same job in their tunnel. A researcher is peering in at a window just as the Wrights did.*

### Activity 11—The Wrights’ Wind Tunnel

The Wright Brothers are credited with a number of “firsts” in the science of aeronautics. One of these firsts was using a wind tunnel of their own design (a 6-foot-long rectangular box) to gather data and to design wing shapes (called airfoils). Wind tunnels are still used for many kinds of research. Some of them are very large; some are supersonic; some are very cold; and some simulate very high altitudes.

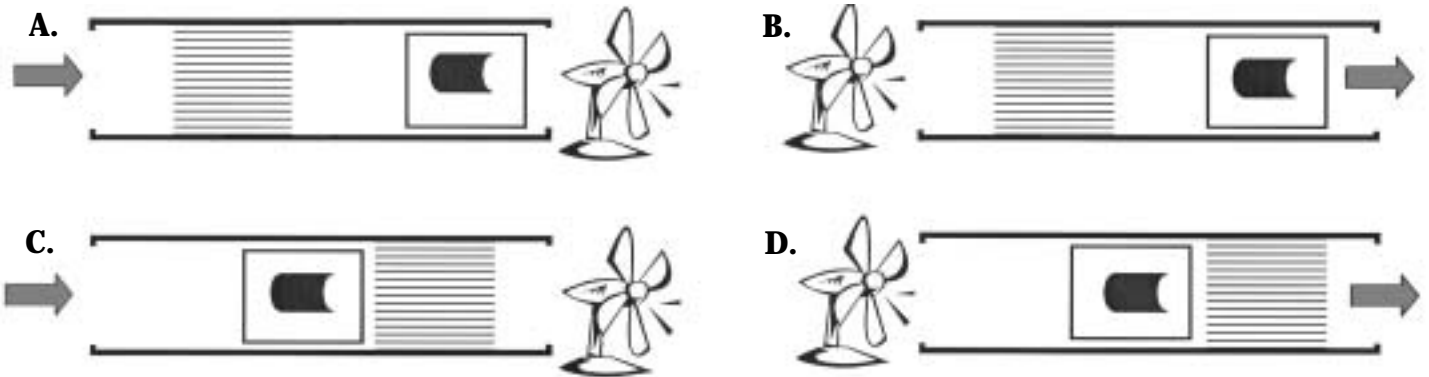
1. Why did the Wrights construct their own wind tunnel?
2. When they ran their tests, the Wrights only allowed one person in the room and that person always had to stand in exactly the same place. Why do you think they had to take this precaution?



3. A grid was placed in the end of the box where the air entered. What function would you guess this served?

4. What advantages are there to testing airfoils in a small box? (Try to list at least three.)

5. If you were to try to get good data on how well a wing design worked, which of the following wind tunnel arrangements do you think would be best?



What factors made you decide on this as the best design?



## Activity 12—Operate the Wrights' Tunnel

Wilbur and Orville didn't understand why their larger 1901 wing didn't provide the lift they expected. To find out why, they built their own wind tunnel and conducted almost 200 tests of wing shapes and combinations. The wind tunnel tests showed how air flowed over the airplane wing, and what effect the wing's shape had on the amount of lift that the airplane could generate. You can conduct these very same tests yourself in the very same kind of wind tunnel (only you will be using an online computer program). The wind tunnel test can be found at the following Web site:

<http://wright.grc.nasa.gov/airplane/tunnlint.html>



### Interactive Wright 1901 Wind Tunnel

Glenn  
Research  
Center

We present here a Java applet derived from [FoilSim](#) which simulates the operation of the Wright 1901 Wind Tunnel.

**1901 Wind Tunnel Test Section (Overhead View) Model #1**

Lift Balance  
Drag Balance

Direction of Air Flow

Dial

Select Model

Select Step 2.

**Detailed Dial**

0 10 20 30 40 50 60 70 80 90

Model Group  1  2  3

**Procedure**

Step 1: Select Model

Step 2: Set Angle of Attack

Angle of Attack

Step 3: Start Tunnel

Step 4: Adjust for Drag

Step 5: Record Data

Step 6: Reduce Data

#	Shape	Area-sq in	Cam	AR
1		<input type="text" value="6"/>		1
2		<input type="text" value="6"/>		4
3		<input type="text" value="6"/>		6
4		<input type="text" value="6"/>	1/12	1
5		<input type="text" value="6"/>	1/16	1
6		<input type="text" value="6"/>	1/20	1

#	Shape	Area-sq in	Cam	AR
7		<input type="text" value="6"/>	1/12	6
8		<input type="text" value="6"/>	1/16	6
9		<input type="text" value="6"/>	1/20	6
10		<input type="text" value="6"/>	1/12	6
11		<input type="text" value="6"/>	1/16	6
12		<input type="text" value="6"/>	1/20	6

*Airfoil images courtesy of The Franklin Institute Online - <http://www.fi.edu/wright/index.html>. Tunnel and balance images courtesy of Wright State University via OhioLINK Digital Media Center.*

You can download your own copy of this applet by pushing the following button:



To operate the balance, follow these steps:

1. Choose a wing model to be placed in the tunnel from the menus at the bottom left and right.
2. Set the angle of attack by clicking on the Set Angle of Attack button and enter numbers in the box.  
Or use the mouse to move the arm in the diagram.
3. Start the tunnel with the Start Tunnel button.
4. Adjust for the drag caused by the balance with the Adjust for Drag button.
5. Record the reading on the Lift Dial. The greater the deflection on the Lift Dial, the more lift is being provided by the wing.

A. Which wing shape is better, short and wide (model 1) or long and thin (model 3)?

1. Choose model 1, set the angle of attack to 3 degrees, start the tunnel, adjust for drag, and record the reading on the Lift Dial.
2. Repeat this at angles of 6, 9, 12, 15, and 18 degrees.
3. Now choose model 3 (which has the same area as model 1) and record the data for the same angles.  
You can get a copy of a form to record your data by pushing the "Data Form" button.
4. Make a graph of your results. There should be two lines on your graph. Which wing shape is providing more lift? Which shape is better, short and wide or long and thin?

B. Which wing surface provides more lift, a flat surface or a curved surface?

1. Choose model 3, set the angle of attack to 3 degrees, start the tunnel, adjust for drag, and record the reading on the Lift Dial.
2. Repeat this at angles of 6, 9, 12, 15, and 18 degrees.
3. Now choose model 9 (which has the same area as model 3, but is curved) and record the data for the same angles.
4. Make a graph of your results. There should be two lines on your graph. Which wing is providing more lift? Which wing surface is better, flat or curved?

C. Which provides more lift, a more strongly curved surface (model 4) or a less strongly curved surface (model 6)?

1. Choose model 4, set the angle of attack to 3 degrees, start the tunnel, adjust for drag, and record the reading on the Lift Dial.
2. Repeat this at angles of 6, 9, 12, 15, and 18 degrees.
3. Now choose model 6 (which has the same area as model 4) and record the data for the same angles.
4. Make a graph of your results. There should be two lines on your graph. Which wing is providing more lift? Which wing surface is better, more curved or less curved?





## 1902: Success at Last

When the Society hears of the Wright Brothers' logical approach to overcoming the 1901 disappointments and their successful wind tunnel trials, excitement builds about human flight. Arrangements are again made for you to resume your position as a lookout with the Kill Devil Lifesaving Station. Your friends at the station are glad to see you again.

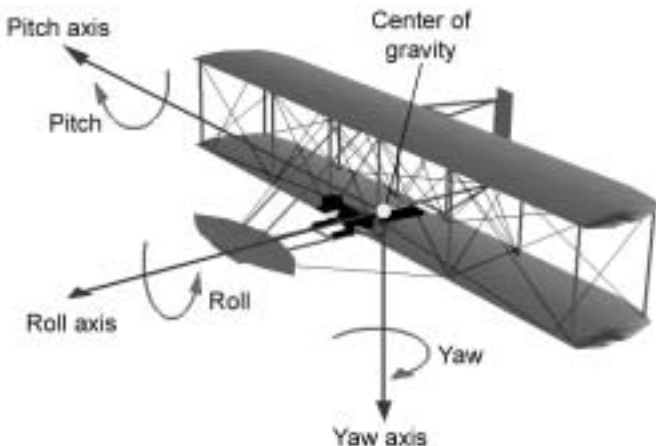
At the end of August the Wrights arrive and rebuild their camp. When they uncrate and assemble their glider, it is indeed a changed machine. The wingspan has grown to 32 feet and the width has been decreased to 5 feet. A control device called a "hip cradle," which the pilot operates by moving his hips, controls the wing-warping. The front rudder has been modified to look more like a wing. In addition, a tail with two 6-foot-high vertical tails has been added. On your first visit, Orville explains that they are hoping the tails will give the pilot more control in turning. You help to carry the craft up the hill—it weighs a good 120 pounds.



*Testing the 1902 Glider.*

The glider flies wonderfully, much better than the one last summer. A new problem, however, soon arises. In about one flight in fifty, the glider spins out of control and crashes after making a turn. The brothers make several adjustments, but nothing seems to help.

When you return in a few days, the brothers have removed the two vertical tails and replaced them with just a single tail. Wilbur has also rigged the tail to the hip cradle control that warps the wings. Now when the pilot shifts his hips to bank, the tail also turns. "Orville reasoned that in low-speed turns, the tail was acting like a vertical wing, providing a sideways force that caused the glider to spin," said Wilbur. "I thought up how to rig the wing-warping to the tail-turning." That's just one example of how the two brothers thought and worked so well together.



When Wilbur takes off, your jaw drops. The glider banks left and then right, rises up and down on command, and then glides to a smooth landing. They've done it! The brothers have achieved complete control in the air. You're watching the first machine in history that can be controlled in three dimensions: pitch, yaw, and roll.

Over the next few weeks, the brothers make several hundred glides, becoming better and better at controlling their craft. You are sending glowing letters back to the Society and helping Orville develop some of the pictures he has taken. The brothers feel that they only need to add an engine and propellers and they will become the first in the world to fly a powered aircraft.

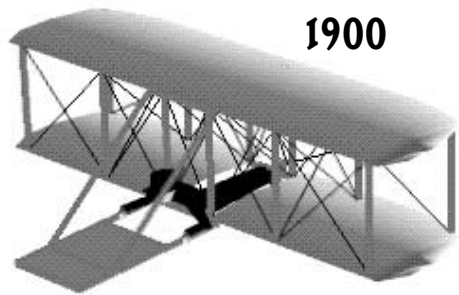
### Activity 13—Build a Model of the 1902 Glider

To make a model of the 1902 Glider, follow the instructions beginning on page 55.

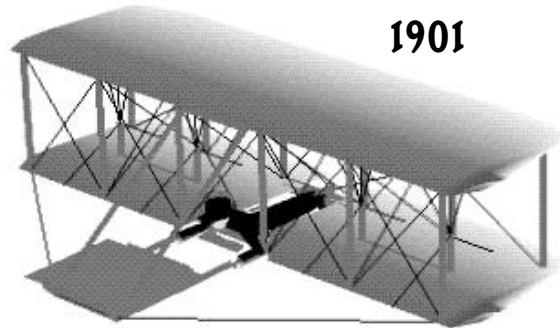


## Activity 14—Compare the 1900, 1901, and 1902 Gliders

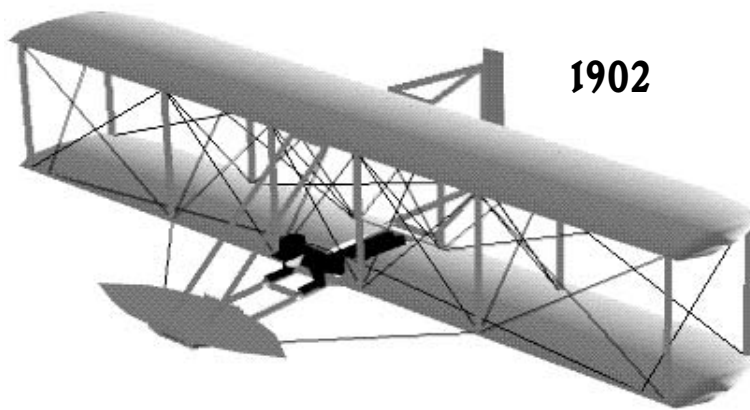
Below are drawings of the gliders the Wright Brothers tested in 1900, 1901, and 1902. Notice that Wilbur Wright is the same size in all three, which means all three are drawn to the same scale.



**1900**



**1901**



**1902**

1. Try to list five ways in which all the gliders are alike.
2. What are some of the ways that they are different?
3. The 1901 and the 1902 gliders both have about the same wing area and they weigh nearly the same. Why do you think the 1902 is a better glider?
4. Notice that in all three gliders, Wilbur is lying down. What do you think the effect would be if he sat up while flying them?



## Activity 15—Prices Then and Now

The pictures at the Wrights' camp were captured by something called a "box camera." The Wright Brothers also took pictures on 5- by 7-inch glass plates, which they developed and printed themselves. Over 300 of these images are on display at the Carillon Historical Park in Dayton, OH.

The year that the Wright Brothers decided to build their first kite, 1900, was the year that a very popular box camera was offered for sale, the Eastman Kodak Brownie. Brownies were the first cameras most amateur photographers ever owned. Many of the first owners of Brownies were kids. Brownie cameras were sold, modeled, and remodeled (about 100 times!) for six decades. Your family probably owned one too!

The 1900 Brownie camera cost \$1. In 1900, a laborer might have worked a month to earn \$50. A professional might have earned \$100 or \$200 a month. Do you think the Brownie camera cost about the same amount (the same percentage of a monthly salary) for a buyer in 1900 as a \$100 camera would cost us today?

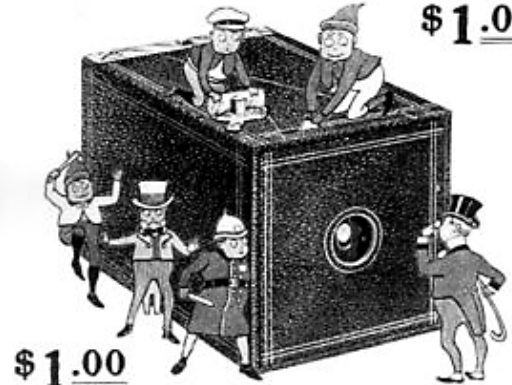
1. If you made \$100 a month in 1900, and a camera cost \$1, what percentage of your monthly salary would it take to buy a camera in 1900?
2. If your yearly salary today is \$36,000 and you want to buy a camera that costs \$100, what percentage of your monthly salary would you have to spend? How does this compare to 1900?
3. The Wright Brothers had to buy all the food to stock their camp and ship it by boat and horse-drawn wagon. In 1900, a loaf of bread cost 5 cents. Today it costs about \$1, or 100 cents. The price of bread has increased by 100 cents divided by 5 cents, or 20 times. Find out how many times these items have increased in price since 1900 by completing the table. You will need to find out today's prices.

Food	1900 price	Price today	Increase
5 pounds flour	13 cents		
1 pound butter	26 cents		
1 dozen eggs	21 cents		
1 gallon milk	27 cents		

Which item showed the biggest change in price?

## Any school-boy or girl can make good pictures with one of the Eastman Kodak Co.'s Brownie Cameras

**\$1.00**



Brownies load in daylight with film cartridges for 6 exposures, have fine meniscus lenses, the Eastman Rotary Shutters for snap shots or time exposures and make pictures 2 1/4 x 2 1/4 inches.

Brownie Camera, for 2 1/4 x 2 1/4 pictures, . . . . .	\$1.00
Transparent Film Cartridge, 6 exposures, 2 1/4 x 2 1/4, . . . . .	.15
Faded Film Cartridge, 6 exposures, 2 1/4 x 2 1/4, . . . . .	.15
Brownie Developing and Fixing outfit, . . . . .	.75
Brownie Removable Finder, . . . . .	.25

Take a Brownie Home for Christmas.

Brownie circulars and Kodak catalogues free

EASTMAN KODAK CO.

Courtesy© Eastman Kodak Company.





## 1903: Powered Flight

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The Society thanks you for the report on the success of the 1902 Glider. They are also following the progress of Samuel Langley's flying research. Langley had successfully flown a steam-powered aircraft three-quarters of a mile and won a \$50,000 government grant to develop a passenger-carrying powered aircraft. Society members wondered whether the Wrights could beat him on their small budget, having spent less than \$1,000 so far.

You have been on this project for almost 3 years, and the Society president asks you if you want to continue. You say yes. By now you have come to admire the Wrights and their genius and want to see them succeed. You know that powered flight is moving closer to becoming reality.

The reports from Dayton are that the brothers had been trying to find an engine with at least 8 horsepower and weighing less than 200 pounds. They couldn't find an engine like that, or a company willing to make one, so with the aid of their bicycle mechanic Charlie Taylor, they have been building their own engine. You travel to Dayton to check on progress, and when you arrive, they are already testing it. In just 6 weeks, having never made an engine before, they have produced one weighing 179 pounds that develops 12 horsepower! They never cease to amaze you.

Orville tells you that they are having difficulty with the design of the propellers. There are no reliable data on air propellers, only on water propellers, which would not apply to an aircraft. "Our only solution," he says, "is to design our own!" You wish them luck and they say they hope to see you at Kitty Hawk in the fall. You return to Cincinnati wondering whether they will get it right.

Further reports from Mr. Pierpont's cousin in Dayton indicate that the brothers intend to return to Kitty Hawk at the end of September, so once again, you head back to the Lifesaving Station. The Wrights arrive on September 25, 1903, and are glad to enlist your help in rebuilding their camp buildings and unpacking the crates holding the new craft. "This is the very first time we've seen it all together," comments Wilbur. "There just wasn't room in our shop." The aircraft looks like the 1902 model, but measures 40 feet from wing tip to wing tip and has twin rear rudders. On the lower wing opposite the pilot position is the motor, connected by chains to two long, thin propellers at the rear of the wing.



*Wilbur in the damaged flyer after his unsuccessful trial on December 14, 1903. His hand still grips the wooden control lever.*

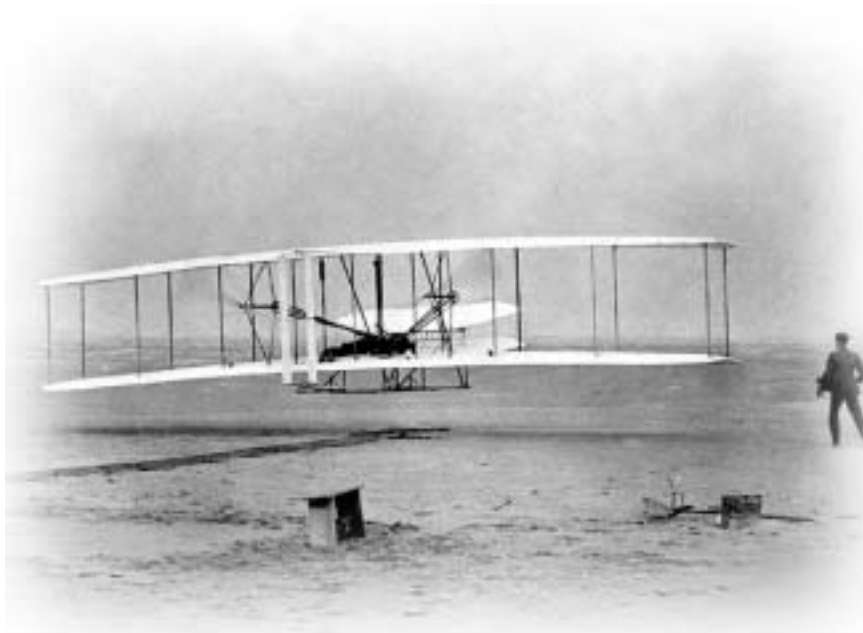
"We spent 5 months working on those propellers," said Wilbur. "Orville finally figured out that they needed to be shaped like rotating wings." Once the aircraft is together and testing begins, there are problems with the propeller shafts. Quick fixes don't work, so Orville travels back to Dayton to get new, stronger shafts.



He returns on December 11 and everything is ready to test on December 14. The brothers hoist their red flag, a signal for you and the Lifesaving crew to come help. The wind is not strong enough to launch from level ground, so the 60-foot launching track is set up on the side of Big Hill (the launching track consists of 15-foot sections of wooden rail, on which runs a launch cradle with bicycle hubs for wheels). The aircraft is pushed to the top of the track on its launch cradle. With the restraining rope in place, the motor is started and the propellers start to turn. Orville and Wilbur toss a coin to see who will be the first pilot. Wilbur wins and takes his position. He pulls the release rope, and the aircraft rolls on the cradle about 40 feet down the track, and starts to become airborne. Wilbur pulls up the nose a bit too sharply, and it stalls and settles back in the sand, breaking a few parts. It had been airborne just 3 seconds.

It takes some time to repair the damage, and on December 17, the red flag is hoisted again. It is very cold today, and the puddles on the way to the brother's camp are frozen over. The wind is blowing much harder than before. When the aircraft is set on the cradle, it is now Orville's turn to pilot. Orville has set up his box camera facing the end of the track and hands the squeeze camera bulb to John Daniels of your Lifesaving crew. Orville then gets into the craft and the rope is released. The wind is so strong that Wilbur runs alongside the craft to steady the wing as it takes off. Just as he lets go and the craft becomes airborne, Big John squeezes the camera bulb and snaps one of the most famous pictures ever taken. Orville flies for 12 seconds and lands a little over 120 feet from the end of the track. All of the people watching are cheering as you run to retrieve the airplane. You all shake hands and then go warm up by the stove before you carry the plane back up the track.

Three more flights are made, the longest being Wilbur's, which lasts 59 seconds and covers 852 feet. At long last, a man had flown a powered flying machine. As the brothers are getting ready for a fifth flight, a powerful gust of wind picks up the airplane and rolls it over and over. It is so badly damaged that more flights are out of the question. The Wrights thank everyone for their help, walk 4 miles up the beach to telegraph their father of their success, and pack up and return to Dayton to perfect their airplane.



*The Wright Flyer takes off on the world's first successful airplane flight on December 17, 1903. Orville is at the controls, while Wilbur runs alongside.*

## **Activity 16—Build a Model of the 1903 Flyer**

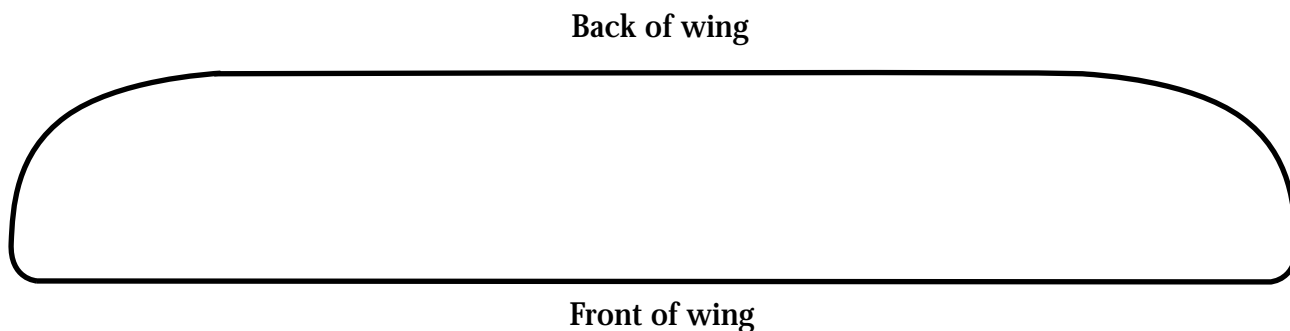
To make a model of the 1903 Flyer, follow the instructions beginning on page 63.



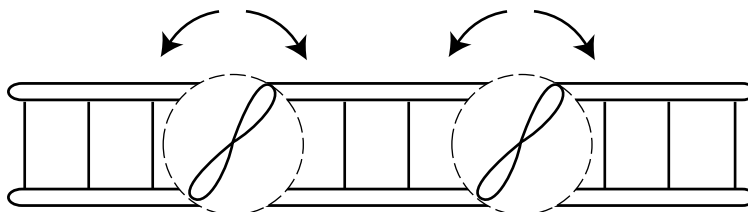
## Activity 17—Balancing Forces

If you were either Orville or Wilbur Wright, and it came time to design a flying machine with an engine, where would you place the engine and where would you place the pilot? Do you think that the pilot should sit up or lie down on the wing? Don't forget that there had been numerous crashes in the brothers' gliders over the past 3 years. Give some serious thought to the reason or reasons for your decision.

The drawing below is a top view of the lower wing of the 1903 flying machine. Draw where you would put the pilot and the engine.



1. What are the advantages in the way you placed the engine and pilot?
2. What problems do you think might be created with your placement?
3. Does your pilot sit up or lie down? Why?
4. Circle the direction that each propeller needs to turn to create the least amount of torque (twisting) of the aircraft.



## Activity 18—Center of Gravity

In constructing their 1903 Flyer, the Wright Brothers chose to place the engine on the wing next to the pilot. They felt that this would be safer for the pilot because the engine would not land on him if the flyer crashed. The problem that this created for them was one of balance. Neither Wilbur nor Orville weighed as much as the engine, and the wings needed to be level in order to have control of the plane. Try the following activity to see how to solve the problem:

Take a string and tie it around a 12-inch ruler in the exact middle. Now hook two paper clips together to represent the pilot and four paper clips together to represent the engine. Open up one of the end paper clips on each group as shown so that they can hang on the ruler (you can also cut the paper clip to size with a wire cutter). Hook the groups on either side of the center and then slide the paper clips along the ruler until the ruler hangs level.

When the ruler is level, the total weight of one set of paper clips times the distance from the center is equal to the total weight of the other set of paper clips times their distance from the center. Write down the inch readings for each group of clips.

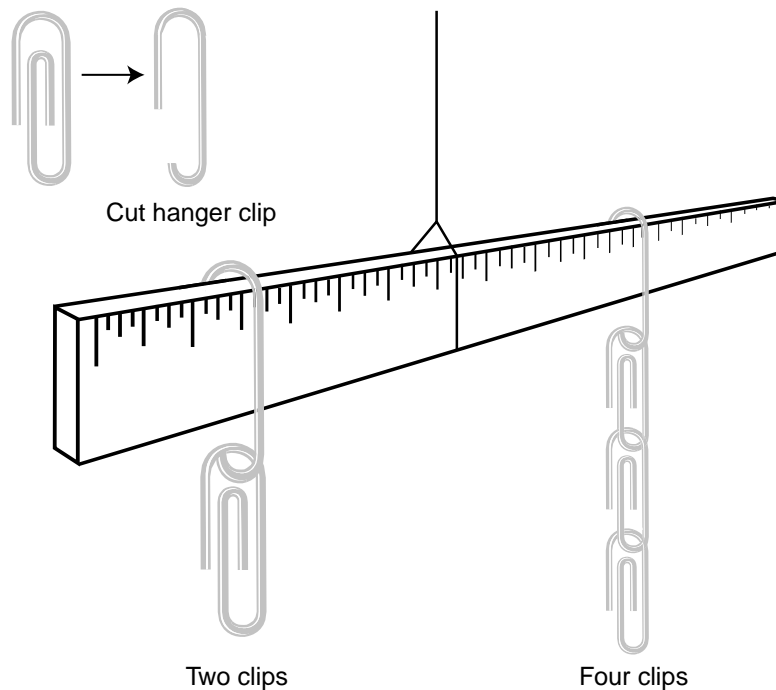
Two paper clips set at \_\_\_\_\_ inches from the center

Four paper clips set at \_\_\_\_\_ inches from the center

Since one group weighs twice as much as the other group, it should only be half as far from the center. Check the inch marks and see if this is true.

The Wright Brothers needed to stay near the center of the plane in order to control it, so rather than move farther out on the wing to balance the engine, they made the wings on the engine's side of the plane 4 inches longer than on the pilot's side. This caused extra lift force on that side to counteract the extra weight of the engine and keep the wings level!

You can simulate this by moving the four-paper-clip weight 1/4 inch farther away from the center so things are no longer balanced. Now, instead of moving the two-clip weight to rebalance, move the location of the string holding the ruler until everything is back in balance. Did you move the string toward the two-clip weight or the four-clip weight?



## Activity 19—How Far Did They Fly?

### Materials

Wooden ice cream sticks or craft sticks  
Tape measure  
Stopwatch or watch with a second hand

1. Have each person put his or her name on a wooden stick to use as a marker.
2. Go outside to the playground, a large field, or a baseball diamond and choose a starting point. This could also be done indoors in a gym or long hallway.
3. Each person takes a turn at placing their marker where they think 120 feet from the starting point would be, the distance of the Wright Brother's first flight. (These should all be placed along the same line from the starting point. You may want to lay a very long string down first to use as a guide, or you could use the foul line of a baseball field. Or each person could walk toward the same distant object.) Once placed, each person should stay by his or her marker so no one else steps on it.
4. When all the markers are in place, use the tape to measure off exactly 120 feet from the starting point and determine whose marker was the closest. Also, measure the distance each person was from the 120-foot mark and record these results in the table below. Once measured, be sure to remove all the sticks.
5. It took Orville 12 seconds to fly 120 feet, with Wilbur running alongside the airplane as it launched. See if you can run this fast. Time how many seconds it takes each person to run 120 feet and record the results.

<b>Name</b>	<b>Distance from 120-foot mark</b>	<b>Time to run 120 feet</b>
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		



## Questions

1. Whose stick was the closest to the actual 120-foot mark? Do you think this is a very far distance to fly?
2. Could the Wright Brothers have flown ...
  - A. From home plate to first base on a baseball field?
  - B. From home plate to the outfield wall of the nearest professional baseball stadium?
  - C. From one wing tip of a Boeing 747 jumbo jet to the other?
  - D. From one goal line to the other goal line on a football field?
3. Make a graph showing the distance from each person's marker to the actual 120-foot mark of the first flight. Did the group make good estimations of the distance? Find the average distance from the 120-foot mark.
4. Make a graph showing how long it took each person to run 120 feet. Did the group run faster than the Wright Flyer flew? Find the average time for the group.

## Math challenge

1. Your car can easily go 60 miles per hour and a jet airliner can cruise at 600 miles per hour. If the Wright Brothers flew 120 feet in 12 seconds on their first flight, calculate their speed in miles per hour.

Hint: To do this you need to change feet to miles by dividing 120 feet by 5280, the number of feet in 1 mile. Then you need to change 12 seconds to minutes by dividing by 60, the number of seconds in 1 minute, and then change minutes to hours by dividing your last answer by 60, the number of minutes in 1 hour. Now divide the number of miles by the number of hours to find speed in miles per hour.





## 1904: Improvements in Dayton

---

The Society now has you working on other projects, but you are still interested in the progress the Wright Brothers are making, so on your own, you travel up to Dayton in the fall of 1904. When you inquire at the shop, you are told that Wilbur and Orville are experimenting at a farm just outside Dayton owned by a man named Torrence Huffman. Before you go, you call on a friend who is a reporter for a Dayton newspaper. He tells you that the Wrights had twice invited the press out to see their invention, and both times, it didn't even fly! Nobody he knew was bothering to go back.

Puzzled by this, you catch the electric trolley and head for the Huffman farm. What you see amazes you. There, in a 100-acre cow pasture called "Huffman Prairie," you see Orville flying in a circle around the field! Wilbur is standing by a small building in the corner of the field, and you hurry over to greet him. He tells you that they had some bad luck with the engine both times they invited the press out, and now they don't come at all.

Astonished, you mumble something about how far the brothers have come since Kitty Hawk. Wilbur says that they've made a stronger frame with a larger engine, and moved the center of gravity to the rear, but have still not



*Orville and Wilbur standing by the Wright 1904 Flyer.*



*Launching derrick.*

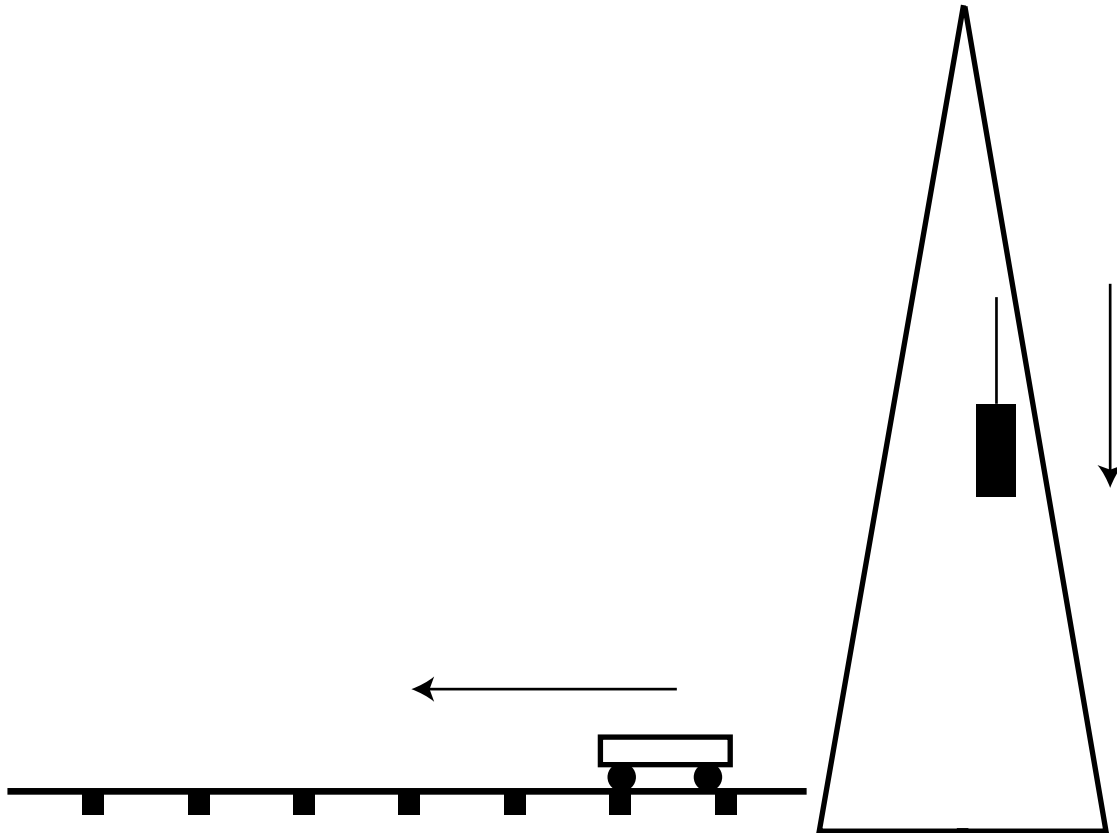
perfected the up-and-down control. It's hard to keep the craft from bobbing up and down. You ask how they get up into the air without the wind and hills at Kitty Hawk, and he shows you a launching derrick they built. A 1600-pound weight is hoisted to the top. When the weight drops, the plane is catapulted down 60 feet of track and becomes airborne. Their longest flight has been about 5 minutes.

You stay and watch a few more flights, help the brothers put the flyer away, and ride back to Dayton with them on the trolley.



## Activity 20—How To Launch the Flyer

This diagram represents the derrick (shown on page 34) used to launch the 1904 Flyer, which would rest on the small wheeled trolley (or launch cradle) shown on the launch track. The problem is how to get the launch cradle to move forward when the weight drops. Can you draw ropes (lines) and pulleys (circles) in a way that would make this happen? Draw arrows to show the direction each section of rope would move when the weight is dropped.



1. If the wind generally comes from the west, which way should the launch cradle travel?
2. What are the difficulties in using this launch system?
3. Why didn't they just use the force from the flyer's propellers to take off like planes do today?







## 1905: Complete Flight at Last

---

You hear from your Dayton friends that Orville and Wilbur have still not given up on perfecting flight. It is now 7 years since their kite experiments of 1899. After all the crashes, how easy it would have been for the brothers to quit long ago. You see a few items in the Cincinnati papers about their flights, but none of the New York or Chicago papers pick up these stories. The world still doesn't know much about their great achievements. You decide to visit again, and when you reach Huffman Prairie in October, you see that some major changes have occurred.

Flyer III sits on the rail ready to launch. The wings look the same, but the craft is a full 10 feet longer than the earlier model. The front elevator has been moved forward, and the rear rudders have been moved further to the rear. You watch as the weight drops in the launch derrick, the launch cradle carrying the flyer shoots down the track, and the flyer climbs into the air. Then, stunned, you watch as Orville circles the field again and again, does figure eights, and finally lands after 20 full minutes in the air! In addition, the flight looks smooth and totally controlled—no more jerky up-and-down motions as in 1903 and 1904.

“Wait until the Society hears about this!” you think excitedly. “It's just incredible. How can it be that the world still doesn't know about this? Is it that people don't understand it, or don't believe it?”

Wilbur explains calmly that they have achieved more precise control in flight by separating the controls for the rudder and wing-warping. Moving the front elevator and rear rudders away from the center of the plane also improves up-and-down control.

This 1905 airplane can be flown until the fuel tank is empty, staying in the air for more than half an hour at a time. It can fly for nearly 25 miles around Huffman's farm, executing turns and figure eights 50 feet above the ground. After 7 years of work, the brothers finally have a practical working airplane.

As you leave, you thank Orville and Wilbur for letting you be a small part of their experiments, and you congratulate them, they've made the dream of powered flight come true. You feel privileged. After all that you've seen, you know that the world is on the verge of a big change.



*1905 Wright aircraft in flight.*



## Activity 22—Design a Mission Patch

A “mission patch,” like the ones shown here, is designed for every NASA spaceflight. Choose one of the years from 1900 through 1905 and design a patch for the Wright Brothers’ mission that year (you can find more mission patches under the “History” link at the top of the page at <http://spaceflight.nasa.gov>).



## Activity 23—Be an Inventor

If you have read all the sections in this book about the Wright Brothers’ quest for flight, you know that they followed a very logical process to solve a number of problems. Not everything they tried worked the first time, and they had to go back and redesign things several times to get them to work. In the end, their ideas were excellent; they are still used today to control a plane in three dimensions. They discovered how propellers work in the air and they constructed and used a wind tunnel to give accurate results. They were remarkable inventors.

Suppose you were an inventor and were also interested in transportation like Orville and Wilbur Wright. Write a short paragraph or two about what you would like to invent. How would your invention improve transportation? What problems do you think you would have to solve to be successful? How would you get people to learn about your invention? On another piece of paper, draw a diagram or sketch of your idea.

