



Lesson Plan
Revised 6/04

Lesson #42 Wright Flight Grade Level: 3-4

Teachers, this is a basic lesson plan that you may modify at your discretion.

Modifications to video: There have been several changes to the lesson plan since the video was made. This lesson plan reflects the latest changes made as a result of suggestions from teachers who have presented the lesson during the daytime program. Please continue to send us your ideas!

Overall educational objective: Students will understand and be able to explain the interactive relationships between the forces of lift and gravity, thrust and drag, as they apply to airplanes in motion. They will know that Orville and Wilbur Wright produced and flew the first airplane based on these principles.

Associated Standard and CORE objective:

Standard III: Understand the relationship between the force applied to an object and resulting motion of the object; Objective 1: Demonstrate how forces cause changes in speed or direction of objects.

Standard IV: Understand that objects near Earth are pulled toward Earth by gravity; Objective 1-a: Demonstrate that a force is required to overcome gravity.

Materials list:

- | | |
|--|--|
| 1 - Model of modern small airplane | 1 - Electric fan mounted on skateboard |
| 1 - Model of Wright Brothers 1903 flyer | 1 - Hair dryer and ping pong ball(s) |
| 1 - Wind tunnel (electric fan, fabric sock, plexiglass tunnel box, Styrofoam block and airfoil on a stick) | |
| - Sample helicopter and instruction sheet | 1 - Extension cord . |
| - Supply of paper helicopters ready to cut and fold | |

Six graphics:

- | | |
|------------------------------------|--|
| Photo of Orville and Wilbur Wright | Sketch of air flow over airfoil |
| Photo of first flight | Sketch of ping pong ball in air flow |
| Airplane with directional arrows | Sketch of Wright Bros. airplane for coloring / copying |

Teacher Provides:

- strips of paper (approx. 2"x 8") and paper clips for student use
- copies of airplane sketch for coloring (optional)
- scissors for cutting helicopter patterns
- paperclips for helicopters

Suggested Setup:

Place long work table front and center as teacher work station, with space for students to access all sides. If discipline is sufficient to preclude student tampering, have table arrayed with the following as attention-getters:

- Graphics as listed above
- Fan mounted on skateboard
- Modern model airplane
- Hair dryer and ping pong ball

Have power cord plugged in and readily available behind table. Some items may need to be set aside during thrust demonstration with fan/skateboard. Have 2"x 8" strips of paper cut and ready for quick distribution, also paper clips. Set up wind tunnel assembly on a second, small table nearby, arranged for student access on both sides. Adjust tilt of fan for level air stream and draw plexiglass tunnel and fan apart so fabric is taught and straight as possible. This is for use at end of lesson.

Introduction:

Who invented the first flyable airplane? (Wright Brothers: Orville and Wilbur) Display graphic no. 1.

When did they first fly? (On Dec. 17, 1903 they first flew 120 feet at Kill Devil Hill near Kitty Hawk, North Carolina) Display graphic no. 2, the actual photo of their first flight.

The year 2003 is the 100th anniversary (centennial) of powered flight. We are helping celebrate by learning what the Wright Brothers had to discover to make the first airplane fly.

Four Forces:

Write the word **FORCES** boldly on board. (do this in advance)

Exemplify the four opposing forces of gravity, lift, drag and thrust as follows:

1. Hold a book about 12 inches above a table surface. Pretend the book is an airplane that we want to fly. Ask: will the book rise up like a plane when released? (no)
2. Demonstrate by dropping book. Ask: what force pulled the book down when we wanted it to fly? (gravity)
3. Write *gravity* below **FORCES** on the board and draw a downward pointing arrow between the two words.
4. Ask: what kind of force did the Wright Brothers need to make their airplane rise? (lift)
5. Write "lift" above **FORCES** on the board and draw upward pointing arrow between the two words.
6. Identify problem no. 1: How to create "lift" force powerful enough to overcome force of "gravity." (write "how to create 'lift' force" on board)
7. Airplane must also move forward. What kind of force is needed? Exemplify forward movement by making the book slide along table top with a thrusting push and release.
8. Ask: What kind of force made it move forward? ("thrust" force from muscle power)
9. Write "thrust" to the left of **FORCES** and draw leftward pointing arrow between the two words.
10. Ask: What kind of force stopped book from sliding along table? ("drag" from friction against table surface and against air molecules)
11. Write "drag" to the right of **FORCES** ; draw rightward pointing arrow between the two words.

12. Identify problem no. 2: How to create “thrust” force powerful enough to overcome “drag” force. (write “how to create ‘thrust’ force” on board)
13. Exhibit graphic no. 3 and explain that an airplane in flight is in a continuous tug-of-war between these opposing forces.
14. Holding model of modern small airplane aloft with demonstrating motions, help students deduce that “lift” force must exceed “gravity” force, and “thrust” force must exceed “drag” force before a plane can take off and fly. When in level flight, the forces of “lift” and “gravity” are equal, as are the “thrust” and “drag” forces. When the pilot shuts down the engine, “thrust” and “lift” are reduced; “drag” and “gravity” win the tug-of-war and make the plane fall.

Creating Lift Force

Stimulate curiosity with the following activity:

1. Have each student pick up by one end a previously provided slip of common paper approximately 2" x 8" in size. Press the end against the upper chin just below the lower lip so that the paper extends forward like an extended tongue. Have them predict how the paper will move when they blow outward along the paper's top surface. Then have them blow. Most will be surprised to see that it moves upward towards the stream of air, rather than being blown farther downward.
2. Challenge students to explain why the paper rose upward. (**NOTE:** this is a demonstration of Bernoulli's principle, which states that an increase in the velocity of any fluid is always accompanied by a decrease in pressure. Air is a fluid (it can flow). By causing the air to move rapidly across the upper surface, the pressure on that upper surface is made less than the ambient pressure affecting the lower surface. Therefore, the higher pressure underneath “lifts” the paper into the zone of lower pressure above.)
3. Display graphic no. 4 to illustrate how this happens. The velocity of air molecules flowing over the top wing surface is automatically greater than along the bottom surface because the top side curvature forces them to travel a greater distance than their companion molecules on the bottom side. Because they all must reach the wing's trailing edge together, those on top must flow faster! Note that this same effect is created either by a moving air flow across a non-moving wing (airfoil), or by the wing moving through still air. When airplanes take off and fly into the wind, a combination of the two effects occurs. That is why pilots always try to take off into the wind. It requires less power, less ground speed and shorter runway distance to achieve take-off. (Exemplify this by holding the model airplane in and out of the electric fan's air flow.)
4. Help students see that this is how the Wright Brothers solved the first problem (producing “lift” force to overcome the “gravity” force)
5. “Magical Suspension” demonstration activity
 - Connect hair dryer and turn on high speed with nozzle directed straight up.
 - Gently place ping pong ball into invisible air stream a few inches above dryer nozzle. It will float suspended in that position.
 - Allow ball to settle as motionless as it will, then gently tilt hair dryer laterally so that the air stream is directed at a sideways angle. To a certain point, the ball will remain suspended in the invisible air stream, defying the expectation that gravity will cause it to fall. Hold it high for all to see. Suggestion: select a student to hold and tilt the dryer under teacher direction. (Teacher should practice this once in advance to get a feel for how the ball hangs and the point at which it ultimately falls.)

- Challenge students to explain how the ball remains suspended, in light of what we just learned about creating “lift” force (Bernoulli’s Principle).
- Clarify by exhibiting graphic no. 5. Note that ball does drop just a little, until it’s lower surface encounters the invisible plane where moving air meets still air. At that point, the ball encounters the pressure difference explained above.

Creating Thrust Force

1. Ask: How do airplanes create the airflow needed to cause the lift force just discussed? (Answer: Engines turn propellers which thrust the planes forward through the air fast enough to cause airflow over the wings. This thrust force also overcomes the drag force which tries to hold the plane back. It works the same as a boat propeller creating thrust against the water and moving the boat forward.)
2. The propeller drives the plane forward by pushing the air backward. The air, reacting to the action of the propeller, pushes it forward. (For every action, there is an equal and opposite reaction - Newton’s Third Law of Motion.) Because the propeller is attached to the plane, it pulls the plane through the fluid air very much like a boat propeller pushes the boat forward through the fluid water.
3. Demonstrate propeller thrust effect by operating fan-driven skate board on long table. Like a taxiing airplane, the propeller in the fan will drive the skate board forward. Involve students as much as possible. One can place and direct the skate board at the “take-off” end of table; another at opposite end can catch it to avoid running off the *-edge. Teacher should manage power switch and slack in electrical cord.
4. Help students conclude that this is how the Wright Brothers solved the second problem (producing “thrust” force to overcome the “drag” force.
5. Hands-on student experiment: make a helicopter. (see attached pattern and instructions.) Students can do this individually or in teams of two. Explain that the helicopter rotor is like an airplane propeller in that its rotating blades push against the air as they are driven by a force. On an airplane, the driving force is the engine. With our paper helicopter rotors, the driving force is gravity. Help students observe a major difference, however: with the plane, the force of the engine is much greater than the resistance of the standing air. Hence, the “opposite reaction” involves air being pushed away dramatically by the powerful propeller. With the paper rotor, the resistance force of standing air is greater than the rather weak force of gravity pulling the rotor down. Hence, the “opposite reaction” here is the rotor spinning around as gravity pulls it downward against the resistant air.

Feel the THRUST and the LIFT

Explain that Orville and Wilbur built a wind tunnel to experiment with different shapes of wings and determine what shape best created lift. A stationary propeller, like a fan, was used to create thrust in the tunnel. Inform students that they can actually feel what lift on an airplane wing is like by gently maneuvering the red airfoil piece inside our wind tunnel. Turn on tunnel fan and briefly demonstrate how. (Place one finger lightly beneath each end of the red wooden dowel where they protrude from the sides of the tunnel box. Without grasping, simply raise the two ends upward together through the wind stream. The “floating on air” phenomenon is both felt and seen. Note that it is most pronounced as the foil approaches the top of the box. Restrain students from this experience until after the following lesson conclusion.

Putting it All Together

How did Orville and Wilbur Wright, in their Dayton, Ohio, bicycle shop one hundred years ago, ever manage to invent a machine that could create both thrust and lift enough to overcome the drag and gravity and make over 900 pounds raise off the ground and fly! (refer again to graphic 3) What do you think it looked like? Something like our model airplane, perhaps? (no) Well let's take a look! (Teacher present the Wright Flyer model).

At this point, invite students to rotate for hands-on experience among the wind tunnel, the thrusting skateboard, the "magic suspension" activity, flying their helicopters, and examining the Wright Flyer model.

Optional Activities

Copy drawing of the original plane from copy master in kit; distribute to students for coloring activity.

Vocabulary exercise: Define and clarify usage of the following key words as they occur during the lesson. They are italicized throughout. Write them on the board.

- Centennial
- Velocity
- Thrust
- Gravity

Caution

Though students are encouraged to closely examine and even touch the Wright Flyer model, it must not be handled or carried about by students. It is for fixed display only and should be placed safely on a secure table or elevated platform. It is expensive and rather delicate, so please safeguard it well.

At end of day, please be sure all materials are returned in transport container. Refer to materials list on first page.

Copyright © 1997, Utah State University
Junior Engineering. All rights reserved.

Junior Engineering, UMC 3735, Utah State University, Logan, UT 84322-3735 **E-mail:** jreweb@ext.usu.edu
Phone: (435) 797-8000 **Fax:** (435) 797-8005 **URL:** juniorengineering.usu.edu