



STRAIGHT UP HELICOPTERS IN ACTION

A FILM FOR THE SMITHSONIAN INSTITUTION'S NATIONAL AIR AND SPACE MUSEUM

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STRAIGHT UP HELICOPTERS IN ACTION

Teaching Poster

GRADE LEVEL: 4-8

TIME REQUIRED: 3 CLASS PERIODS

OVERVIEW

Before viewing the IMAX® film, *Straight Up! Helicopters in Action*, students learn basic information about how helicopters fly and what helicopters can do. They look at photographs of some of the helicopters depicted in the film and try to identify the special task each is designed to do. After viewing the film, students design a new helicopter suited to a specific task.

NATIONAL SCIENCE EDUCATION STANDARDS ADDRESSED IN THIS ACTIVITY

Students should develop

- Abilities of technological design
- Understanding about science and technology

The activities in this teaching poster will help students:

- Identify appropriate problems for technological design
- Design a solution or product
- Implement a proposed design
- Evaluate completed technological designs or products

OBJECTIVES

With the activities in this teaching poster students will:

- Learn the basics about how helicopters fly
- Identify different types of helicopters
- Identify features that enable helicopters to do different jobs
- Design a helicopter that can do something new

TEACHER BACKGROUND INFORMATION ON HELICOPTERS

The background information for this lesson is also the answer key to the quiz “How Much Do You Know About Helicopters?” on page 7. You’ll use this information twice. First, for your own review before beginning this lesson and, later, for class discussion after students have completed the quiz.

1. **TRUE: A helicopter has wings.** The rotor blades are actually thin wings. The pilot twists the blades for climbing and descending or tilts the blades for flying forward, backward, or sideways.
2. **TRUE: A helicopter rises into the air because the spinning of the rotor creates lower pressure above the blades and higher pressure below the blades.** To lift the helicopter, the pilot adjusts the angle of the rotor blades. This change in angle causes a change in air pressure. As the rotor speeds up, the low-pressure air above the blades pushes on the wing less than the high-pressure air below the blades. The higher-pressure air below the blades lifts the helicopter into the air.
3. **TRUE: If a helicopter did not have a tail rotor, the body of the helicopter (*fuselage*) would spin in the opposite direction of the main rotor.** The engine spins the main rotor, which causes the fuselage to spin in the opposite direction. The push of the tail rotor keeps the fuselage from spinning. Helicopters that have two main rotors do not need a tail rotor. With two main rotors, the rotors spin in opposite directions.
4. **FALSE: If all its engines fail, a helicopter will crash to the ground.** If a helicopter’s engine quits, it can still glide to the ground without crashing. Without the engine, the rotor blades spin around freely, slowing the descent and allowing the helicopter to land. This kind of landing is called *autorotation*. When the helicopter is about 50 ft (15 m) from the ground, the pilot will raise the nose to slow the helicopter and then increase the angle of the rotor blades to increase lift and soften the landing. This is the trickiest maneuver to perform in a helicopter and is one that pilots practice extensively.

5. **FALSE: Large helicopters land on skids, but small helicopters land on wheels.** Skids are the runners or metal tubes that helicopters land on. Usually, small helicopters land on skids and large ones land on wheels. Small helicopters can be put on trailers or have wheels attached to their skids, but larger helicopters are too heavy to move this way so they have to carry their wheels with them.
6. **TRUE: Helicopters can land on water.** Helicopters that land in water have floats instead skids or wheels. Some floats are fixed and inflated at all times; other floats can be inflated if the pilot needs to land the helicopter in water during an emergency.
7. **TRUE: Helicopter pilots must use both hands and both feet to fly the helicopter.** Flying a helicopter requires great skill. The pilot's right hand controls the cyclic pitch, making the helicopter move forward, backward, left or right. The pilot's left hand controls the collective pitch lever, making the helicopter go up or down and twists the throttle grip on the collective lever to control engine speed. The pilot uses foot pedals to swing the helicopter around.
8. **FALSE: Helicopters have lots of windows because helicopter pilots enjoy beautiful scenery.** Helicopters have lots of windows because pilots need to be able to see in all directions to land, take off, and complete the job they intend to do. Windows above, below, and beside the pilot's head enable him or her to see in all directions. Airplane pilots land on what they see in front of them, while helicopter pilots land on what they see below them.
9. **FALSE: A helicopter is a kind of fixed-wing aircraft.** (*Fixed* means attached in place.) A helicopter is a vertical flight, rotary wing aircraft. A helicopter's wings, or rotor blades, rotate; they are not fixed.
10. **TRUE: Helicopters cruise at about 125 miles per hour. Jet airliners cruise at about 500 miles per hour.** (*Cruising speed* is the likely speed for most trips.)
11. **FALSE: Helicopters can hover (stay in the air without moving in any direction) for up to 15 minutes.** Helicopters can hover for a long time, as long as they have fuel! In fact, the ability to hover is one reason a helicopter is often the only aircraft to do a job. (The ability to take off and land in small spaces is another reason helicopters are so valuable.)
12. **TRUE: A tilt rotor changes from helicopter to airplane in midair by tilting its rotors from a straight up position for takeoff to a propeller position for forward flight.** A tilt rotor can fly vertically as a helicopter and fly at high speeds as an airplane.
13. **TRUE: Though the artist Leonardo da Vinci sketched an "airscrew" helicopter in the late 1400s, we didn't have safe, useful helicopters until the 1940s.** Many inventors and engineers tried to build vertical flight, rotary wing aircraft, but faced design problems: They hadn't developed an engine that could provide enough power to lift the helicopter; they hadn't invented controls that could move the helicopter forward, backward, right or left; and they hadn't figured out how to keep the main rotor from making the fuselage spin too. Although these problems were solved in the 1920s with gyroplane experiments, it was not until the late 1930s that inventors such as Louis Breguet, Heinrich Focke, and Anton Flettner were able to combine these complex solutions into a functioning aircraft. After the World War II era, more versatile and powerful helicopters were developed, and they are still being developed today!
14. **TRUE: For about \$10,000 you could purchase your own brand-new, rotary wing aircraft and park it in your own garage.** Here are two main differences between a helicopter and a gyroplane:
 1. The gyroplane uses an engine-powered propeller to generate thrust and move forward like an airplane.
 2. The gyroplane's rotor blades turn freely like a windmill to create lift. A gyroplane cannot hover the way a helicopter can, but it can take off and land in short distances. Because a gyroplane is always in autorotation, it can land without its engine running more easily than a helicopter can. In the 1920s and 30s, experiments on the much simpler gyroplane helped engineers develop the helicopter. (Note to aircraft shoppers: a used helicopter will cost you at least \$50,000!)

PREPARATION

1. Review all the information on this teaching poster.
2. Photocopy the handouts “How Much Do You Know About Helicopters?” (page 7) and “Helicopters on the Job” (pages 8-9) for each student.
3. If needed, review the “RESOURCES” section (page 6) for extra information.

PROCEDURE

1. Ask students to think of three situations in which a helicopter is the best kind of vehicle (aircraft or otherwise) for a particular purpose. Ask them to list things a helicopter can do that no other vehicle can do.
2. Tell students that they are going to watch a film called *Straight Up! Helicopters in Action*, which is about helicopters designed to do various jobs. Ask whether anyone in the class has ever ridden in a helicopter. What was the experience like? Then, write this question on the board: “What features can you find on this helicopter that help you guess what job it is designed to do?” Have students, individually or in small groups, examine the front of this poster. As a class, discuss their answers to the question, above. Then explain that the picture shows an EADS HH-65 Dolphin, a U.S. Coast Guard helicopter, that is shown completing an air-sea rescue in the *Straight Up!* film. Some special features of the HH-65 Dolphin include:
 - It carries a crew of four – pilot, copilot, crewchief, and rescue swimmer.
 - Its automatic flight-control system will keep the helicopter hovering 50ft (15m) above a selected object, an important safety feature for rescues in darkness or bad weather.

Some easily observed features of this helicopter include the winch for raising or lowering rescue crew or injured people, the many cockpit windows to help the pilot see injured people below, the windshield wipers for flying through poor weather or sea spray, and the searchlight for night flying.

3. Distribute the quiz, “How Much Do You Know About Helicopters?” on page 7. Have students complete the quiz individually or in groups. Try to keep the quiz fun, because most students will not have any real knowledge of helicopters to draw on. After they complete the quiz, discuss the answers with them.

(See “Teacher Background Information on Helicopters” on page 1.)

4. On the board, write the following quotation from the film: “The helicopter is meant to be endlessly useful. It will always be asked ‘What can you do for me next?’” Ask the class to list all the uses for helicopters they can think of, have experienced, or have seen in movies. They might mention some of the following uses for helicopters:
 - Flying ambulance for people injured in accidents
 - Traffic and news reporting
 - Law enforcement
 - Rescue for people stranded on a mountain or in the ocean
 - Transportation in places where there is no airport
 - Tourism, to view places like volcanoes or canyons
 - Transportation and rescue for soldiers in battle
 - Firefighting
 - Tracking wildlife
5. Explain that helicopters have special sizes, shapes, and equipment for the jobs they are designed to do. Ask the class to consider what special equipment or features a helicopter would need if it were used to rescue people at sea. The class might mention that the helicopter would need some of the following features:
 - Floats, instead of skids, so it could land at sea
 - A “basket” or cage to lift people from the sea
 - A winch, or a hoist, to lift a person into the helicopter
 - Medical/ambulance equipment inside so its crew could treat the injured
6. Distribute copies of the handout, “Helicopters on the Job” on pages 8 and 9. Have students work in groups or individually to study the six helicopter photographs and try to understand the job each helicopter is designed to do. Explain that they will learn more about each of these helicopters when they watch the *Straight Up!* film and that you will also give them some information about the helicopters after they have completed the handout.

7. When students have completed the handout, “Helicopters on the Job,” share with them this information about each helicopter.

Mi-26

Able to carry up to 20 tons of cargo, or 70 passengers, the Mi-26 helicopter is the heaviest and most powerful helicopter in the world. It is about the same size as an airliner. The Mi-26, which debuted in 1977, is the first helicopter with an eight-blade main rotor. The Mi-26 has been used to deliver humanitarian supplies, to fight fires in high-rise buildings, and to carry engineering supplies such as huge pipeline and support beams for highway bridges. In the film, the Mi-26 delivers food to hungry people in Sierra Leone.

Bell 47G

Built in the late 1940s, the Bell 47G’s Plexiglas bubble makes it easy to recognize. The first helicopter approved for civilian use, the Bell 47G has been used for agricultural spraying, aerial survey, police patrol, and rescue work. In the film, the demonstration pilot is flying a Bell 47G.

Piasecki H-21B Workhorse

Nicknamed “Flying Banana,” the Piasecki H-21B Workhorse was developed in the early 1950s for the military. The H-21B’s odd shape keeps the rotors from interfering with each other. Some H-21Bs had inflatable pontoons on the wheels to land on water. A modified H-21 made the first nonstop transcontinental helicopter flight in 1956.

Boeing-Sikorsky RAH-66 Comanche

The RAH-66 Comanche is the U.S. Army’s new reconnaissance and attack helicopter. Its first flight was in 1996. The Comanche can search for enemies and targets for other helicopters to attack because the Comanche is a “stealth” helicopter; it is very difficult for people to see on radar. The Comanche can transmit data over the Internet in real time.

Agusta A109 K2

Agusta A109 K2 helicopters are used for medical emergency rescue missions. Special equipment aboard the Agusta 109 K2 includes a cargo hook, a rescue hoist, and a searchlight. In the film, the Agusta 109 K2 is the helicopter that rescues the boy buried in the avalanche.

Boeing 234

The Boeing 234 is often used to fly workers or equipment to oil rigs far out in the ocean. In some cases this helicopter is used to carry up to 44 passengers; other versions use the cargo hook to lift up to 28,000 lb. In the film, the Boeing 234 is shown lifting logs using a huge claw. Its powerful engines allow it to operate at higher altitudes than most other helicopters.

8. Give students blank sheets of paper and tell them that now that they know a little bit about how helicopters are designed to do different jobs, they get to draw/design their own helicopter. Tell them that their helicopter must have the following elements:

- Fuselage
- Fins
- Landing gear
- Tail
- Main rotor and tail rotor or two main rotors
- Windows and door(s)
- Cockpit

Students may add special equipment to enable the helicopter to do the job they want it to do. They should label their helicopter’s special features. On the back of their drawing, students should explain the special job their helicopter is designed to do, why a helicopter is the right aircraft for that particular job, and the special features they designed for their helicopter. You may want to make a bulletin board display of the helicopters that students designed.

REFLECTION AND DISCUSSION

1. Before students see the film, ask them which of the six helicopters they have studied interests them the most and why. Ask them to write down at least one question they have about that particular helicopter, or about helicopters in general, and to listen for the answer to their question while they watch the film. You may want to collect the students’ questions before seeing the film and use them afterward as the basis of a class discussion.
2. After watching the film, ask students these questions: What have you learned about helicopters that you didn’t know before? What are some interesting facts about helicopters that you think most people do not realize?
3. Now that students know more about helicopters, invite them to try to predict how helicopter use will have changed in 15 to 20 years, when they are adults. Will more people be traveling by helicopter? Will more helipads be built? And, if so, where? Could increased helicopter traffic cause any problems?

EXTENSION

1. As students learned in item 7 on the quiz “How Much Do You Know About Helicopters?,” helicopter pilots use both hands and both feet to fly the helicopter: the pilot’s right hand controls the cyclic pitch stick, making the helicopter move forward, backward, left or right. The pilot’s left hand controls the collective pitch lever, making the helicopter go up or down and twists the throttle grip on the collective lever to control engine speed. The pilot uses foot pedals to swing the helicopter around. Flying a helicopter requires lots of skill and coordination.

In groups of three, have students try this activity to see how accurately they can move each hand and foot. One student should sit in a chair. This student will be the “pilot” and will try to follow the commands and mimic the way a helicopter pilot moves his hands and feet during takeoff. The second student should read aloud the seven commands, below, giving instructions to the pilot. The third student should record any errors the pilot makes. Students might want to score each other or set a minimum score to “qualify” as a helicopter pilot. Each student in the group should get a chance to try being the pilot.

Helicopter Takeoff Commands:

1. Sit in a chair with both feet on the floor.
2. Make a loose fist with your left hand while it is hanging by your left side.
3. Slowly raise your left hand (in a fist) to waist height while twisting your hand away from your body.
4. Make a loose fist with your right hand and rest it in your lap.
5. Move your right hand slightly to the left, but keep it in your lap.
6. Press your left foot down.
7. Lift your right foot up slightly.

Note: A helicopter pilot completes all of these actions simultaneously; we’ve separated these actions for this activity.

2. What’s in a helicopter’s name? The U.S. Army has a tradition of naming its helicopters after American Indian tribes such as Apache and Comanche. (Some Native Americans are offended by this tradition.) Other names for helicopters include Sea King, Jetranger, Skycrane, “Huey,” Defender, and Lynx. Have students name the helicopter they drew and explain why they gave it this name.
3. In this activity, students designed a new helicopter to meet a new purpose. As an extension, have students discover whether the helicopter they designed, or one that can do the same things, actually exists. Have students use the library or the Internet to discover whether “their” helicopters have already been invented.
4. One distinguishing feature of the helicopter is its sound. (That’s why it’s nicknamed a “chopper.”) Have students try to make a helicopter’s distinctive sound using voice, hands, instruments, or other means. Have students record themselves making this sound and play their recordings for the class. *Note:* the more blades a helicopter has the less “whomp-whomp” noise it makes and the more it sounds like a purr. Really loud helicopters are ones that have only two blades.

RESOURCES

Books for Adults

Beard, B. T.: *Wonderful Flying Machines: A History of U.S. Coast Guard Helicopters* (Annapolis, Md., Naval Institute Press, 1996).

Holley, C. and M. Sloniker: *Primer of the Helicopter War* (Grapevine, Tx., Nissi Publishing, 1997).

Spenser, J. P.: *Whirlybirds: A History of the U.S. Helicopter Pioneers* (Seattle, University of Washington Press, 1998).

Books for Children

Jefferis, D.: *Read About Helicopters* (New York City, Warwick Press, 1990)

Petty, K.: *Helicopters* (New York City, Franklin Watts, 1987)

White, D.: *Helicopters* (Vero Beach, Fl., Rourke Enterprises, Inc., 1989)

Web Sites

National Air and Space Museum (NASM)

Aircraft of the Smithsonian

<http://www.nasm.si.edu/nasm/aero/aircraft/>

Descriptions and photographs of the 356 aircraft in the NASM collection.

Straight Up! Helicopters in Action

<http://www.skfilms.com>

The official web site for the film with helicopter facts, more links and an electronic version of the teaching poster.

American Helicopter Museum and Education Center

<http://www.helicoptermuseum.org>

In addition to information about the museum, the web site offers a valuable list of helicopter links.

A Rotocraft Catalog

http://avia.russian.ee/vertigo/full_list.html

A Russian helicopter enthusiast's full catalog of rotorcraft, both historic and modern.

American Helicopter Society (AHS)

http://www.vtol.org/History.htm#_Toc486998800

"U.S. and Russian Helicopter Development in the 20th Century," a comprehensive paper originally presented at an AHS meeting in 2000.

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www.nasm.si.edu

www.skfilms.com

Photo Credits: All photos are from the film
"Straight Up! Helicopters in Action."

HANDOUT: HOW MUCH DO YOU KNOW ABOUT HELICOPTERS?

Give this quiz a try. Don't worry if you have to guess to answer some of these questions. Your teacher will explain the answers when you're done, and you'll learn lots more about helicopters when you watch *Straight Up! Helicopters in Action*.

- True False 1. A helicopter has wings.
- True False 2. A helicopter rises into the air because the spinning of the rotor creates lower pressure above the blades and higher pressure below the blades.
- True False 3. If a helicopter didn't have a tail rotor, the body of the helicopter (*fuselage*) would spin in the opposite direction of the main rotor.
- True False 4. If all its engines fail, a helicopter will crash to the ground.
- True False 5. Large helicopters land on skids, but small helicopters land on wheels.
- True False 6. Helicopters can land on water.
- True False 7. Helicopter pilots must use both hands and both feet to fly the helicopter.
- True False 8. Helicopters have lots of windows because helicopter pilots enjoy beautiful scenery.
- True False 9. A helicopter is a kind of fixed-wing aircraft. (*Fixed* means attached in place)
- True False 10. Helicopters cruise at about 150 miles per hour. Airliners cruise at about 500 miles per hour. (*Cruising speed* is the likely speed for most trips.)
- True False 11. Helicopters can hover (stay in the air without moving in any direction) for up to 15 minutes.
- True False 12. A tilt rotor changes from helicopter to airplane in midair by tilting its rotors from a straight-up position for takeoff to a propeller position for forward flight.
- True False 13. Though the artist Leonardo da Vinci envisioned an "airscrew" helicopter in the late 1400s, we didn't have safe, useful helicopters until the 1940s.
- True False 14. For about \$10,000 you could purchase your own brand-new, rotary wing aircraft and park it in your own garage.

HANDOUT: HELICOPTERS ON THE JOB *page 1*

Study the picture of each helicopter closely. Can you tell what job this helicopter is designed to do?

For each picture, answer the three questions listed on the right.

1. *How many people do you think this helicopter can hold?*

2. *What kinds of special equipment can you identify on this helicopter to help you predict the job it is designed to do?*

3. *Compare this helicopter to one of the others in this handout. How is this helicopter different from the other one?*

Mi-26



1. _____
2. _____
3. _____

Bell 47G



1. _____
2. _____
3. _____

Piasecki H-21B Workhorse



1. _____
2. _____
3. _____

HANDOUT: HELICOPTERS ON THE JOB *page 2*

Study the picture of each helicopter closely. Can you tell what job this helicopter is designed to do?

For each picture, answer the three questions listed on the right.

1. *How many people do you think this helicopter can hold?*

2. *What kinds of special equipment can you identify on this helicopter to help you predict the job it is designed to do?*

3. *Compare this helicopter to one of the others in this handout. How is this helicopter different from the other one?*

Boeing-Sikorsky RAH-66 Comanche



1. _____
2. _____
3. _____

Agusta A109 K2



1. _____
2. _____
3. _____

Boeing 234



1. _____
2. _____
3. _____