Manned Aircraft Components

Session Time: Three, 50-minute sessions

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

The intended purpose and use of an aircraft drives aircraft design considerations and construction techniques, materials, and components. (EU1)

A deep understanding of how an aircraft operates enables a pilot to fly the aircraft to its maximum capabilities in both normal and abnormal situations. (EU6)

ESSENTIAL QUESTIONS

- What is the most important part of an aircraft?
- Are there any parts of an aircraft we can do without?

LEARNING GOALS

Students Will Know

1. Names of major components of aircraft
2. Where major components of aircraft are located
3. How major components of aircraft influence flight

Students Will Be Able To

1. *Identify* the location of the major components of fixed-wing airplanes, rotorcraft, and lighter-than-air aircraft. (DOK-L1)
2. *Explain* the function of major components of fixed-wing airplanes, rotorcraft, and lighter-than-air aircraft. (DOK-L2)
3. *Make observations* about the functionality of various aircraft components using simulated flight. (DOK-L2)

ASSESSMENT EVIDENCE

Warm-up
Students will observe photographs of three different types of aircraft and discuss what components they see and how those components might influence flight.

Formative Assessment
Students will build a simple model airplane, label the components, and describe the functions of each in a provided activity sheet.

Summative Assessment
Students will synthesize what they have learned about the components of various aircraft types and the function(s) of each component.

LESSON PREPARATION

MATERIALS/RESOURCES

- Manned Aircraft Components Presentation
- Manned Aircraft Components Student Activity 1
- Manned Aircraft Components Student Activity 2
- Manned Aircraft Components Teacher Notes 1
- Manned Aircraft Components Teacher Notes 2
- Manned Aircraft Components Teaching Aid

Modeling an Airplane's Components (per student)

- Cardboard
- Paper towel or toilet paper rolls
- Scissors
- Tape or Glue
- Markers

Recommended Student Reading

- **Pilot's Handbook of Aeronautical Knowledge**
  Chapter Three, Aircraft Construction
  https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/05_phak_ch3.pdf
- **Helicopter Flying Handbook**
  Chapter Four, Helicopter Components, Systems and Sections
  https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/helicopter_flying_handbook/media/hfh_ch04.pdf

LESSON SUMMARY

Lesson 1: Manned Aircraft Components
Lesson 2: Unmanned Aircraft Components

In this lesson, students will learn about the primary components of three main types of manned aircraft: fixed-wing airplanes, rotorcraft, and lighter-than-air. They will be able to identify the names and locations of these components and explain how they influence flight.

Students will begin this lesson by examining photographs of aircraft to see if they can identify different components and predict how they contribute to flight. In the first session, students will learn about the main components of airplanes. This session concludes with a formative assessment in which students build a simple model airplane, label the components, and describe the functions of each in a provided activity sheet.

The second session of this lesson will focus on the components of rotorcraft and lighter-than-air aircraft.

In the third session of this lesson, students will participate in a simulation activity to make observations about the functionality of various components they just learned about in the lesson. The lesson concludes with a summative assessment that requires students to identify the components of the three aircraft types and the function(s) of each component.

BACKGROUND

Most aircraft are heavier-than-air, meaning the aircraft must create enough lift to overcome the aircraft's weight. The two main types of heavier-than-air aircraft are fixed-wing airplanes, which are supported in flight by the dynamic reaction of the air against the wings, and rotorcraft, which are supported in flight by lift created by one or more rotors.

Some aircraft are lighter-than-air, meaning the aircraft's structure is filled with gas that is lighter than air (heated air, hydrogen, or helium). The lighter-than-air gas displaces the surrounding ambient air and allows the aircraft to float.

Although airplanes are designed for a variety of purposes, most of them have the same major components. The overall characteristics are largely determined by the original design objectives. Most fixed-wing airplane structures include a powerplant (or engine), wings, fuselage, empennage, and landing gear.

A rotorcraft contains thousands of components and is actually pretty complicated. This lesson will cover the major components of a rotorcraft, including the fuselage, powerplant, main rotor, tail rotor, and landing gear.

The two main types of engines are piston engines and turbine engines. Piston engines, also called reciprocating engines, are generally used in smaller airplanes and rotorcraft. Turbine engines produce much more power for their size, and are also used on both airplanes and rotorcraft.

A helicopter's engine is attached to a transmission, which turns the main rotor. The main rotor provides lift, and by varying the angle of the blades, controls the direction of motion of the helicopter. Since Newton's Third Law says that for every action there is an equal and opposite reaction, the turning rotor would cause the fuselage of the helicopter to rotate in the opposite direction without a compensating force. In most helicopters, that compensating force is provided by a tail rotor.

The lesson also discusses the main components of lighter-than-air aircraft (hot air balloons and airships). Airships are engine-driven, lighter-than-air aircraft that can be steered. Airships may be non-rigid, where the shape is kept constant as a result of the internal gas pressure. Non-rigid airships are often called blimps. A semi-rigid airship uses a combination of internal gas pressure plus a stiff keel or truss that helps maintain the shape. A rigid airship has an internal structure to help it keep its shape. Rigid airships are often called zeppelins.

It is important for pilots to be able to distinguish various components of an aircraft. Aircraft characteristics provide the common vocabulary for how pilots communicate about aircraft. Knowing aircraft components and how they influence flight also helps pilots understand an aircraft's performance, such as speed and climb rate.

DIFFERENTIATION

To support students who struggle with the component terms in this lesson, consider creating a set of flashcards for each component for the different types of aircraft (airplane, rotorcraft, and balloon/airship). The front of the flashcard should feature the component's name and possibly an image of the component. The back should include the component's location and function.

To support student retention of knowledge, consider distributing blank diagrams of an aircraft from each category. As students learn about the location of each component, they should add this label to the diagram. This strategy will be especially effective to prepare students for **Manned Aircraft Components Student Activity 1**, which requires them to label the components on a model of a fixed wing airplane.

LEARNING PLAN

ENGAGE

Teacher Material: Manned Aircraft Components Presentation

Slides 1-3: Introduce the topic and learning objectives of the lesson.

Slide 4: Conduct the **Warm-Up.**

In this lesson, students will learn about the components of three types of aircraft--fixed-wing airplanes, rotorcraft, and lighter-than-air aircraft. They will be able to identify the names and locations of the primary components and explain how they influence flight. A component is a part of an aircraft that is part of its primary construction or is critical to the control or stabilization of the aircraft.

Warm-Up

Show students the three photographs on the slide. Working individually, ask students to list what components (parts of the aircraft) they observe and write down how those components might influence flight. Allow for a brief discussion and help students understand that, while aircraft are designed for a variety of purposes, most of them have the same major components. The overall characteristics are largely determined by the aircraft's original design objectives. [DOK 2; categorize]

EXPLORE

Teacher Materials: Manned Aircraft Components Presentation, Manned Aircraft Components Teacher Notes 1
Student Material: Manned Aircraft Components Student Activity 1

Slide 5: Explain each type of aircraft the students will learn about in this lesson. Explain that heavier-than-air means the aircraft must create enough lift to overcome its weight. Lighter-than-air aircraft are filled with a gas that is lighter than the surrounding air to provide lift.

Define each type of manned aircraft:

- Fixed wing - This heavier-than-air aircraft is supported in flight by the dynamic reaction of the air against its wings, which creates enough lift to overcome the aircraft's weight.
- Rotorcraft - This heavier-than-air aircraft is primarily supported in flight by one or more rotors. The rotor system creates lift and controls movement of the aircraft.
- Light-than-air - This aircraft can rise and remain suspended by filling the structure with a gas that is lighter-than-air (heated air, hydrogen, or helium). The lighter-than-air gas displaces the surrounding ambient air and allows it to float.

Using the photographs, point out the the main component that provides lift in each aircraft: the wings on the jet, the rotor on the helicopter, and the balloon (or envelope) containing heated air in the hot air balloon.

Slide 6: Point out the main components of a fixed-wing airplane that will be covered in the lesson. The following slides will describe each of these components in more detail.

Slide 7: A powerplant is another name for an aircraft's engine. The powerplant provides the energy, or thrust, needed to propel the airplane forward. The two main types of powerplants are piston engines and turbine engines. Piston engines, also called reciprocating engines, are generally used in smaller airplanes and rotorcraft. Turbine engines produce much more power for their size, and are also used on both airplanes and rotorcraft.

While there are many types of reciprocating engines, four-stroke engines are most commonly used in small, fixed-wing aircraft today. The engine is called a four-stroke because the piston (the moving part contained in cylinder) completes four movements: (1) intake - pulling in an air/fuel mixture, (2) compression - the piston compresses the mixture, (3) combustion - the mixture is ignited, typically by a spark plug, pushing the piston back down, and (4) exhaust - the spent mixture is expelled.

The four-stroke engine uses the combustion of an air/fuel mixture to generate power to drive the propeller and provide the force necessary to move the aircraft forward and overcome drag. This force is known as thrust and, in conjunction with the lift created by the wings, causes the aircraft to fly. Students will learn more about lift, weight, thrust and drag in Unit 4.

Teachers may want to point out to students that a powerplant is not a requirement of all fixed-wing, heavier-than-air aircraft. For example, gliders have fixed wings, but they do not have an engine. Students learned about gliders in the first unit.

Slide 8: The other primary type of powerplant is a turbine engine, sometimes referred to as a jet engine.

Turbine engines may come in many different shapes and sizes. Students learned about the main components of a turbine engine in the grade nine curriculum. Remind students that a turbine engine has five main components: intake, compressor, combustor, turbine and exhaust.

Air enters the engine at the intake through suction created by the engine itself. This air then passes through a compressor. The compressor section is made up of several stages, each with a set of blades rotating at very high speed. Each stage of the compressor increases the pressure of the air. Compressing, or increasing the pressure of the air, increases the density and therefore energy contained in the air passed to the combustor. Inside the combustor, the air is injected with fuel and ignited, creating a contained explosion. Due to the energy released at ignition, the air is pushed through a turbine component and then through the exhaust. The turbine component is a series of stages with rotating blades, not dissimilar to the compressor section. The high-energy air forces the turbine blades to rotate. A shaft connects the turbine and compressor sections, allowing the turbine to drive the compressor section. Next, the high-energy air leaves the engine through the exhaust at high speed.

The air moving rearward at high speed propels the engine (and attached aircraft) forward due to Newton's Third Law (for each action, there is an equal and opposite reaction).

Turbine engines can also use their rotational energy to turn a propeller to generate thrust, and this type of engine is known as a turboprop.

Slide 9: The fixed wing of an airplane is the primary source of lift. Wings come in all different shapes and sizes, each with its own flight characteristics. The wings are attached to either side of the fuselage.

The wing incorporates several control surfaces that help maneuver the aircraft in flight. The rear part of the wing (the trailing edge), contains the ailerons and flaps. These two surfaces change the shape of the wing to create more or less lift for different phases of flight. Students will learn more about primary and secondary control surfaces later in the course.

- Ailerons are found near the tip of the wing on the trailing edge. The rectangular ailerons move up or down to disturb the airflow over the wing. Ailerons create more lift on one wing than the other, which rolls the aircraft and causes it to turn.
- Flaps are found on the rear part of the wing, nearest the fuselage. Flaps can be extended to create more wing surface area, thereby creating more lift for takeoff and landing.

For some aircraft, the wings also serve to support the propulsion systems. This is especially true for multi-engine aircraft.

Slide 10: The fuselage is the main portion of the aircraft body, to which all the other components are affixed. This large portion of the aircraft accommodates a mounting for the powerplant(s), a fixture for the wings, attachment points for the empennage (tail assembly), the cockpit, cabin, and cargo spaces. While some aircraft may have all of these components, others may only have a few. For example, a small Cessna 172 has one space that is the cockpit, cabin, and cargo space, while a commercial airliner has separate defined spaces for each of the compartments. A small fighter jet, like the F-16, only has a cockpit, very limited to no cargo space, and no passenger accommodations.

Teaching Tips

Thinking back to the previous unit, discuss with students how the inside of a fuselage can be configured differently to fit different roles. For example, the Boeing 747 can serve different needs by changing the configuration of the compartments in the fuselage, such as the following roles:

- Passenger - fuselage is mostly seats
- Cargo - fuselage is large open space to hold materials
- Firefighting tanker - fuselage holds water to extinguish fires

Slide 11: The empennage is the tail section of an aircraft. In traditional designs, this is where the vertical and horizontal stabilizers are affixed, contributing greatly to the stability of the aircraft. The trailing, articulating portion of the vertical stabilizer is the rudder, and the trailing, articulating portion of the horizontal stabilizer is the elevator.

The rudder and elevator are primary flight controls and help maneuver the aircraft through the sky. The rudder controls the left-right direction of the aircraft (known as yaw). The rudder is connected to the foot pedals in the cockpit.

The elevator moves up and down in order to make the airplane's nose move up or down. The elevator is connected to the yoke. If you were to pull back on the yoke in the cockpit, the elevator would be moved upward, forcing the horizontal stabilizer to go down and the aircraft's nose to go up.

Slide 12: Students learned the three main types of landing gear in the last unit: tailwheel (conventional), tricycle, and tandem. Ask students to recall and describe each type.

Some aircraft have skis or floats in order to land on snow or water, respectively. A typical single-engine land airplane will have either tricycle landing gear or tailwheel landing gear. Tricycle gear means that there are two main wheels with a nose wheel in front. On aircraft with tailwheel gear, there are two main wheels with a single wheel in back, under the tail. Tailwheel gear is also referred to as conventional gear.

In some airplanes, the landing gear will be fixed, meaning it stays in place at all times. Larger, more complex airplanes, will likely have retractable gear, where the gear retracts into the wings and/or fuselage with wheels flush against the surface or concealed behind doors. Retractable gear increases aircraft performance because it reduces air resistance, known as drag.

The landing gear on most aircraft consists of wheels and struts. Struts attach the wheels to the fuselage and are designed to help absorb the energy of the landing.

Slide 13: Conduct the **Formative Assessment**. This activity will take the remainder of the first session of the lesson and part of the second session.

Formative Assessment

Provide students with copies of **Manned Aircraft Components Student Activity 1.** In this activity, students will use easily accessible materials (cardboard, paper, scissors, tape/glue, markers) to build a simple model airplane and label its parts. The model airplane does not need to fly. The activity sheet provides a table with the components discussed so far in this lesson. For each component, students will write a sentence or two that describes the component's function and how it influences flight. Refer to **Manned Aircraft Components Teacher Notes 1** for correct answers to the student activity.

Provide students with examples of simple model airplane designs to aid in the creative process. Remind students that they are not being judged on their artistic abilities. They are being assessed on whether they include all the components and how accurately they explain the function of each one.

[DOK-L1; define; DOK-L2; construct]

EXPLAIN

Teacher Material: Manned Aircraft Components Presentation

The second section of the lesson covers the components of rotorcraft and lighter-than-air aircraft.

Slide 14: Point out the main components of a rotorcraft that will be covered in the lesson. Advise students that a rotorcraft has thousands of components and is actually pretty complicated. This lesson will just cover the major components of a rotorcraft, including the fuselage, powerplant, main rotor, tail rotor, and landing gear.

Slide 15: Like an airplane, the fuselage is the main structure of the rotorcraft. The fuselage contains the cabin which houses the flight crew, passenger compartment and cargo compartment(s). The fuselage also contains the powerplant and is an attachment point for the landing gear, main rotor and tail boom.

Slide 16: Rotorcraft powerplants provide power to drive the main rotor and tail rotor. Helicopters can use either piston or turbine engines. The powerplants of smaller training helicopters are often piston internal combustion engines, as they are simple to operate and more cost effective than their more powerful and expensive turbine counterparts.

For weight, balance, and simplicity of construction, helicopter engines are located near the rotor mast, either on top or inside the fuselage.

Slide 17: Unlike a fixed-wing airplane, a helicopter has wings that move. The main rotor is a helicopter's wing. By whirling its wing (rotor) in a circle, a helicopter can create lift over the rotor without any corresponding forward movement of the fuselage. Therotor blades are like thin wings, "running" on the spot, generating a massive downdraft of air. In addition to lift, the main rotor provides thrust which propels the helicopter forward. The amount of lift and thrust provided by the main rotor is dependent upon the angle or pitch of the blade. The pilot controls the pitch at which the main rotor blades are spinning by moving the cyclic and collective controls.

Teaching Tips

Have students mimic a helicopter's main rotor with their body and arms.

- Stand up with arms outstretched horizontally
- Rotate whole body slowly on the spot
- As the body is turning around, swivel arms at the shoulders.

That's roughly what a helicopter does with its blades, except that the rotor turns about 3–4 times each second.

Slide 18: The spinning main rotor creates a twisting (torque) effect on the airframe of the helicopter, resulting in the tendency for it to rotate counter to the rotation of the rotor. This is explained by Newton's Third Law, which says for every action there is an equal and opposite reaction. This torque effect can be countered in several ways, the most common being a tail rotor mounted on the end of the tail boom. The tail rotor has controllable pitch, allowing for the pilot to vary the force it creates as the speed and torque from the main rotor changes.

The tail rotor is controlled using the anti-torque pedals located in the same place as the rudder pedals in an airplane. The anti-torque pedals control the direction that the nose of the aircraft points. Applying the pedal in a given direction changes the tail rotor blade angle, increasing or reducing tail rotor thrust and making the nose yaw in the direction of the applied pedal.

Show students a video that describes how a helicopter is controlled and provides a basic understanding of several of the components described so far.

- "How Helicopters Work for Beginners" (Length 2:21)
  http://video.link/w/6yYd

Slide 19: The landing gear systems of helicopters differ from airplanes because most helicopters do not need a rolling start. Some helicopters have skids whereas some have wheels. Wheels are used for a rolling takeoff or taxiing. Other helicopters have floats for water-based takeoffs and landings.

Slide 20: Review the main components of a hot air balloon with the students. This will be followed by a discussion of the main components of an airship.

The envelope of a hot air balloon is the balloon itself. The envelope is the colorful fabric bag that holds the hot air. When the air inside the envelope is heated, the balloon rises.The envelope is comprised of vertical panels of fabric, commonly made of nylon or Dacron, called gores. The gores may be further broken down into smaller sections called panels. This construction allows for smaller portions of the envelope to be replaced in the case of damage, instead of the entire envelope.

When the balloon is filled, if the pilot should need to initiate a decent or stop a rapid ascent, the parachute vent (an opening, covered with a large piece of fabric) on the top of the balloon can be opened by use of the actuation, or control line. When the parachute vent is not being opened by the pilot, it is kept closed by the air pressure inside the balloon. In addition to controlling ascent or descent, the vent is used during deflation.

Slide 21: The heater system increases the temperature of the air inside of the envelope, making the air less dense than the surrounding air. A hot air balloon works in this manner:

- A burner generates a flame that heats the air inside the balloon.
- As air inside the balloon gets warmer, the density of the air in the balloon decreases.
- The less dense air causes the hot air balloon to be lifted off the ground due to the buoyant force created by the surrounding air.

Large balloons may require several burners to create sufficient warmth to heat the internal air to a temperature that allows for lift. Tanks located in the basket provide the fuel for the burner(s). Propane is the most commonly used fuel.

Slide 22: The basket of the hot air balloon carries all of the passengers, cargo, and fuel (for the burners). It is like the fuselage of an airplane or rotorcraft. The basket is traditionally made of wicker, or woven plant materials. It may also be made of aluminum with a lightweight cloth over the frame. The few instruments that a hot air balloon may have will also be affixed here.

Slide 23: Airships are engine-driven, lighter-than-air aircraft that can be steered.

The shapes and designs of hot air balloons and airships differ greatly, as their applications are different. Airships retain commercial applications such as platforms for filming and broadcasting, whereas hot air balloons are predominantly recreational, partly due to the lack of controllability.

Slide 24: The most visible part of an airship is the envelope, which contains the lifting gas, typically helium. All other components of the airship are attached to the envelope or gondola.

Airships may be non-rigid, often called blimps, where the shape is kept constant as a result of the internal gas pressure. They may also have a rigid internal structure that maintains the shape of the envelope. A rigid airship is often called a zeppelin.

Slide 25: The tail section of an airship is similar to the tail section of an airplane. Both airplanes and airships have rudders and elevators to control yaw and pitch. However, unlike an airplane which changes direction using ailerons to induce roll, an airship changes direction by yawing, using the rudder.

Slide 26: The gondola of an airship is similar to the fuselage of an airplane or helicopter. It is the structure that holds the flight crew, passengers, and cargo below the envelope.

Slide 27: Airships can have various types and sizes of engines, depending on their use. The main functions of the engines are to provide propulsion, as well as directional control. On some airships, the engines fully articulate, meaning that they be directed, allowing the pilot to use the engines to steer the airship.

EXTEND

Teacher Material: Manned Aircraft Components Teaching Aid

The third session of this lesson includes an airplane simulator activity/discussion and concludes with the lesson's summative assessment.

Slide 28: Students will use a simulation activity to make observations about the functionality of various components they just learned about in the lesson. Teacher involvement in this first simulator activity will help students learn how to operate the simulator, as well as achieve the objectives of this lesson. Students will also learn that an airplane simulator is a learning tool, not just a "video game" or "toy." This is a guided activity, requiring the teacher to lead students through the exercise, pausing at appropriate places to identify learning points. Refer to **Manned Aircraft Components Teaching Aid** for guidance.

If limited simulators are available, have students not flying the simulator(s) work on the summative assessment.

EVALUATE

Teacher Materials: Manned Aircraft Components Presentation, Manned Aircraft Components Teacher Notes 2
Student Material: Manned Aircraft Components Student Activity 2

Slide 29: Conduct the **Summative Assessment.**

Summative Assessment

Provide students with **Manned Aircraft Components Student Activity 2**. The activity provides a list of aircraft types and component functions. For each component, students should identify the correct aircraft type that has this component and the function(s) of the component. Some components will have multiple categories and functions. The correct answers are provided in the **Manned Aircraft Components Teacher Notes 2**. [DOK-L2; categorize; classify]

Summative Assessment Scoring Rubric

- **The student follows directions.**
- **Student work demonstrates:**
  - an ability to connect each component to the correct type of aircraft
  - knowledge of each component's function(s)

Points	Performance Levels
9-10	Consistently demonstrates criteria
7-8	Usually demonstrates criteria
5-6	Sometimes demonstrates criteria
0-4	Rarely to never demonstrates criteria

GOING FURTHER

If time allows, return to the **ESSENTIAL QUESTIONS** for this lesson and ask students to discuss each with a partner:

- What's the most important part of an aircraft?
- Are there any parts of an aircraft we can do without?

STANDARDS ALIGNMENT

NGSS STANDARDS

- **HS-ETS1-3** - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
  - Science and Engineering Practices
    - Constructing Explanations and Designing Solutions
  - Disciplinary Core Ideas
    - ETS1.B: Developing Possible Solutions
  - Crosscutting Concepts
    - None

COMMON CORE STATE STANDARDS

- **MP.2**: Reason abstractly and quantitatively.
- **MP.5**: Use appropriate tools strategically.
- **MP.7**: Look for and make use of structure.
- **RI.9-10.4**: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
- **W.9-10.2**: Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and **analysis of content.**

- **W.9-10.4**: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

REFERENCES

https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/05_phak_ch3.pdf https://www.faa.gov/regulations_policies/handbooks_manuals/aircraft/media/faa-h-8083-21.pdf https://www.grc.nasa.gov/www/k-12/airplane/airplane.html https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/helicopter_flying_handbook/media/hfh_ch04.pdf