

Airplane Design

OBJECTIVES

This activity introduces students to paper airplanes and some basic elements of airplane design.

The students

- ▶ build and fly two different types of paper airplanes
- ▶ observe how the shape of the paper airplane affects its flight performance
- ▶ identify the parts of a real airplane
- ▶ discover that streamlining reduces drag in flight

SCHEDULE

Session I About 45 minutes

Session II About 30 minutes

VOCABULARY

drag
fuselage
streamlined

tail assembly
wings

MATERIALS

For each student

- 1 Activity Sheet 5, Parts A and B

For each team of two

- 2 sheets paper, plain*
- 1 paper clip, large

For the class

- 1 Dart Design
- 1 kite (from Activity 4)

- 1 penny*
- pictures of airplanes*
- 1 Slider Design
- 1 roll tape, transparent

*provided by the teacher

PREPARATION

Session I

- 1 Make a copy of Activity Sheet 5, Part A, for each student. Make a copy of the Dart Design and the Slider Design for each team of two.
- 2 Clear some space where students can launch their paper airplanes. You may want to conduct the activity in a large room, like the gymnasium or cafeteria, or go outdoors if it is not too windy.
- 3 You will need to borrow a team's kite (in good condition) from Activity 4. You will also need a penny and a piece of transparent tape.
- 4 Each team of two will need two sheets of paper, a copy of the Dart and Slider Designs, one large paper clip, and a small piece of transparent tape.

Session II

- 1 Make a copy of Activity Sheet 5, Part B, for each student.
- 2 Several days before the activity, ask students to begin collecting pictures of different kinds of airplanes. Tell them to bring their pictures to class to share with others.
- 3 The teams will need their Sliders and Darts from Session I.

BACKGROUND INFORMATION

When we think of flying machines, we usually think of airplanes. An airplane is a heavier-than-air craft supported in flight by the movement of air around its **wings**. As students will learn in Activity 7, the curved upper surface of the wing allows the plane to achieve lift and overcome gravity.

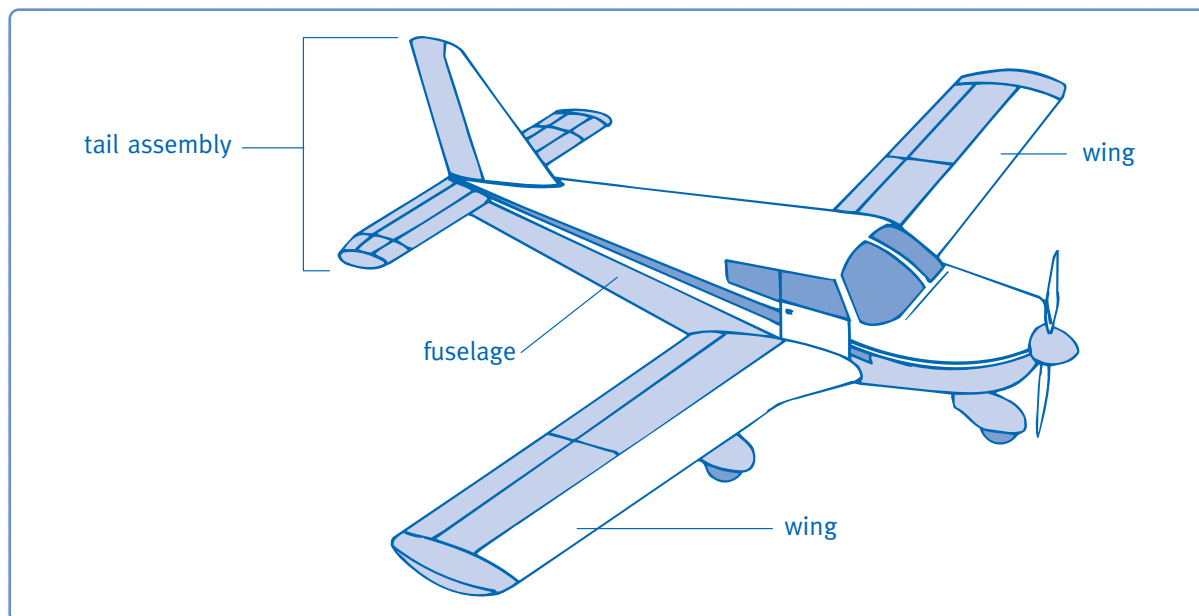
The wings are attached to the midsection of the **fuselage**. The fuselage is the tube-shaped body of the aircraft that houses the passengers and cargo. The cockpit is located at the front end, or nose, of the fuselage. At the rear of the fuselage is the **tail assembly**. The tail assembly consists of horizontal and vertical stabilizers, which keep the plane balanced in flight.

An airplane's engines provide the power, or thrust, that pushes the craft forward through the air. As the airplane moves forward, it runs into molecules of air. This air resistance, called **drag**, hinders flight by reducing the speed of the aircraft and therefore the lifting capacity of the aircraft's wings. The faster the plane moves through the air, the greater the drag.

To reduce drag, airplanes are designed to be **streamlined**. The fuselage, for example, is shaped like a missile. Its streamlined shape allows air to flow freely and smoothly over the surfaces of the airplane body. The more streamlined the aircraft, the less drag it produces.

The shape of the wings is as important as the shape of the fuselage. For example, high-speed jets have narrow, swept-back wings. The narrow wings are used because these planes have tremendous thrust and so do not need large wing areas to produce lift. The sleek wing design allows fast jet planes to travel through the air with minimal resistance. Single-engine planes have broad, rectangular wings. Broader wings are used to enhance lift on smaller planes with less powerful thrust. In short, the shape of an aircraft depends largely on the speed at which it will fly.

In Session I of this activity, students build their own paper airplanes and observe how the shape of an aircraft—in particular, the wings—affects its flight performance. In Session II, students learn the parts of a real airplane (see Figure 5-1) and the importance of a streamlined design.



▲ Figure 5-1. The parts of an airplane.

▼ Activity Sheet 5, Part A

Airplane Design

1. Draw pictures of your team's Slider and Dart.

Slider	Dart

2. Predict:

Which plane do you think can fly faster? Why?

Answers will vary.

Which plane do you think can stay in the air longer? Why?

Answers will vary.

3. Describe the flight path of the Slider.

The Slider meanders and may fly in lazy circles.

Does the slider fly better at high speeds or low speeds? low speeds

4. Describe the flight path of the Dart.

The Dart flies very straight.

Does the dart fly better at high speeds or low speeds? high speeds

5. Which plane flew faster? the Dart

Which plane stayed in the air longer? the Slider

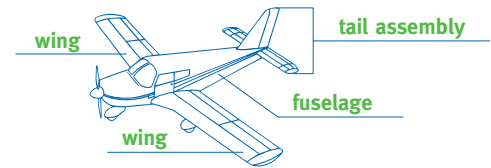
6. How does the shape of each plane affect its flight performance?

The Dart is more pointed and therefore flies quickly and in a straight path. The Slider is broad, which slows it down but also keeps it in the air longer.

▼ Activity Sheet 5, Part B

Airplane Design

7. Add the following labels to the diagram of the airplane: wings, fuselage, tail assembly.

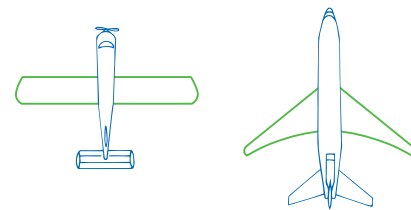


8. What force slows a plane down as it moves through the air? drag

Why are airplanes designed to be streamlined?

to reduce the amount of drag they produce in flight

9. Add wings to the airplane bodies below.



10. Think about your experiments with paper airplanes in Session I. Which of the planes above do you think flies better at high speeds? Which flies better at low speeds?

The airplane with swept-back wings probably flies better at high speeds. The plane with broad, straight wings probably flies better at low speeds.

Guiding the Activity

Session I

1

Borrow a student's kite from Activity 4. Remove the tail, paper clip, and string. Insert a penny into the ridge at the front end of the craft, and tape the penny in place.

Stand where all students can see you. Hold the kite at about eye level, supporting it from underneath with both hands. Ask students, **What do you think will happen if I let go of this kite?**

Release the kite by simply moving your hands out from under it. Then ask students, **Did the kite fall straight to the floor?**

Ask, **In what direction did the kite travel?**

Additional Information

You may want to make a new kite if students' kites are crumpled or torn.

Students will probably say that the kite will fall to the floor.

Students should have observed the tailless, stringless kite "glide" to the floor.

Elicit that the kite traveled forward as well as down.

Guiding the Activity

Ask, **What kind of flying machine does this remind you of?**

Tell students that this activity will introduce them to paper airplanes and some basic principles of real airplane design.

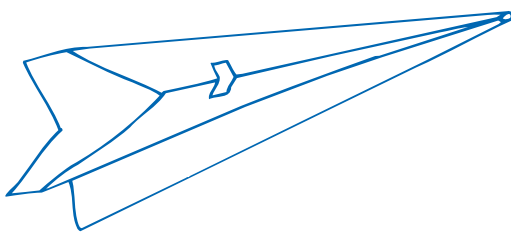
Additional Information

a glider or airplane

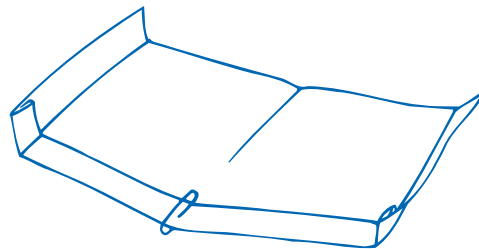
- 2** Distribute a copy of **Activity Sheet 5, Part A**, to each student. Divide the class into teams of two, and distribute two pieces of plain paper, one copy of the Dart Design, one copy of the Slider Design, a large paper clip, and a piece of transparent tape to each team.

Review the folding instructions with students. Then have one student in each team make the Dart while the other student makes the Slider. Tell students that their Slider will fly better if they attach the paper clip to the nose of the craft (see Figure 5-2). Have students write their names on their gliders.

Remind students that paper airplanes fly best when they are folded carefully, with sharp creases at every fold.



Dart



Slider

▲ *Figure 5-2. The completed Dart and Slider.*

- 3** After the teams have finished making their paper airplanes, have students compare the designs. Ask, **How would you describe the Slider?**

Ask, **How would you describe the Dart?**

Have students draw pictures of their Sliders and Darts at the top of their activity sheets. Then ask, **Which design do you think can fly faster? Why?** Have students record their predictions on their activity sheets.

The Slider is broad, with wide, straight wings.

The Dart is very pointed, with narrow, swept-back wings.

Again, answers may vary. Students may suspect that the pointed plane (the Dart) can fly faster.

Guiding the Activity

Ask, **Which plane do you think can stay in the air longer? Why?** Have students record their predictions on their activity sheets.

Tell students that each team is going to conduct a series of test flights to see how their planes perform.

4 Upon arriving, have the teams spread out to give themselves plenty of “airspace.”

Starting with the Slider, have students launch the plane by giving it a very gentle push.

Have students repeat the launch several times. Then ask, **How would you describe the flight path of the Slider?** Have students record their observations in step 3 of their activity sheets.

Now have students launch the Slider with a harder push and observe what happens. Ask, **What happened when you launched the Slider with a lot of force?**

Ask, **Do you think the Slider flies better at high speeds or low speeds?** Have students write their ideas on their activity sheets.

5 Next, have students repeat the test flights, this time with the Dart. Begin by having students launch the Dart with some force.

Additional Information

Answers will vary. Some students may suspect that the plane with the larger wings (the Slider) can fly longer.

Tell students to collect their paper airplanes, activity sheets, and a pencil, and to follow you to the launching area (if other than the classroom).

Encourage partners to stand some meters apart and launch their planes at one another. This way students can take turns launching and observing. They will also spend less time retrieving planes.

The Slider should be grasped from behind and launched by pushing it into the air. If the plane climbs steeply and then dives to the ground, tell students to angle the plane down a bit at launching. If the plane just dives to the ground, students should adjust the angle up a bit.

The Slider has a meandering flight path. Some of the Sliders may fly in lazy circles.

The Slider may have fallen straight to the floor, or it may have climbed or dived sharply before crashing. In any event, the Slider probably did not fly well when launched with a lot of force.

Students should conclude that a Slider flies best at low speeds.

Tell students to hold the Dart by the crease beneath the wings, a few inches back from the nose, and to launch it in the usual way. If their plane climbs steeply or dives, tell them to adjust their launching angle.

Guiding the Activity

After several test flights, ask, **How would you describe the flight path of the Dart?** Have students record their observations in step 4 of their activity sheets.

Now have students launch the Dart with a very gentle push and observe what happens. Ask, **What happened when you launched the Dart with very little force?**

Ask, **Do you think the Dart flies better at high speeds or low speeds?** Have students write their ideas on their activity sheets.

6 Next, have students see which plane they can get to fly the fastest and which they can get to fly the longest.

For the first contest, they should compare the flight speeds of each Glider. For the second contest, they should count aloud the number of seconds each plane is aloft.

When students have finished, ask, **Which plane flew the fastest? Which plane stayed in the air the longest?** Have students record their answers on their activity sheets.

7 After students have completed their test flights, return to the classroom to discuss their results.

Ask, **Which plane flew best at high speeds?**

Ask, **Which plane flew best at lower speeds?**

Ask, **Which plane flew fastest?**

Ask, **Which plane remained in the air for the longest time?**

Borrow a team's Dart and a Slider. Hold them up and encourage students to speculate about the differences in design that led to the difference in flight performance of these two paper planes. Tell students to write their conclusions at the bottom of their activity sheets.

Additional Information

Unlike the Slider, the Dart has a very straight flight path.

Without much speed behind it, the Dart probably crashed to the floor.

Students should conclude that a Dart flies best at high speeds.

Students should have found that a Dart flew the fastest while a Slider remained airborne the longest.

the Dart

the Slider

the Dart

the Slider

The Dart, with its narrow, swept-back wings, cuts through the air more cleanly and so travels fast and in a straight path. The Slider is a wider, bulkier glider, resulting in a slower, lazier flight. However, the broad wings keep it in the air longer.

Guiding the Activity

Tell students that in Session II, they are going to learn the parts of a real airplane and the importance of streamlining in airplane design.

8

Tell students to save their paper airplanes for use in Session II. Tell them to store their activity sheets and copies of the Dart and Slider Designs in their folders.

Session II

9

Pass around the pictures of airplanes that students have collected. Give students an opportunity to study and compare the size and shape of the different aircraft.

Then distribute a copy of **Activity Sheet 5, Part B**, to each student, and review the parts of an airplane as a class. Write the words *fuselage*, *wings*, and *tail assembly* on the board. Tell students to label the diagram on their activity sheet.

10

Ask students, **What do you notice about the shape of the fuselage?**

Ask, **Why do you think the fuselage is shaped that way?**

Remind students of what happens as objects move through the air. Ask, **What did your parachutes run into as they fell in Activity 2?**

Remind students that as an object moves through the air, it bumps into molecules of air and pushes them out of the way and that each molecule offers some resistance to being pushed aside.

Write the word *drag* on the board. Explain that the air resistance that a airplane encounters as it is pushed through the air is called **drag**. Drag hinders flight by slowing down the speed of the aircraft.

Additional Information

*The body of the plane is the **fuselage**. The fuselage houses the passengers and cargo. The **wings** are attached to the middle of the fuselage. The **tail assembly** consists of vertical and horizontal stabilizers that balance the plane in flight.*

Students should comment on its narrow, tubular shape.

Students will probably answer that the shape of the fuselage helps it move through the air more easily. Accept all answers for now.

Students should recall that the parachutes ran into the molecules that make up air, which slowed their descent.

Guiding the Activity

Ask, **Now do you have an idea of why the fuselage is shaped the way it is?**

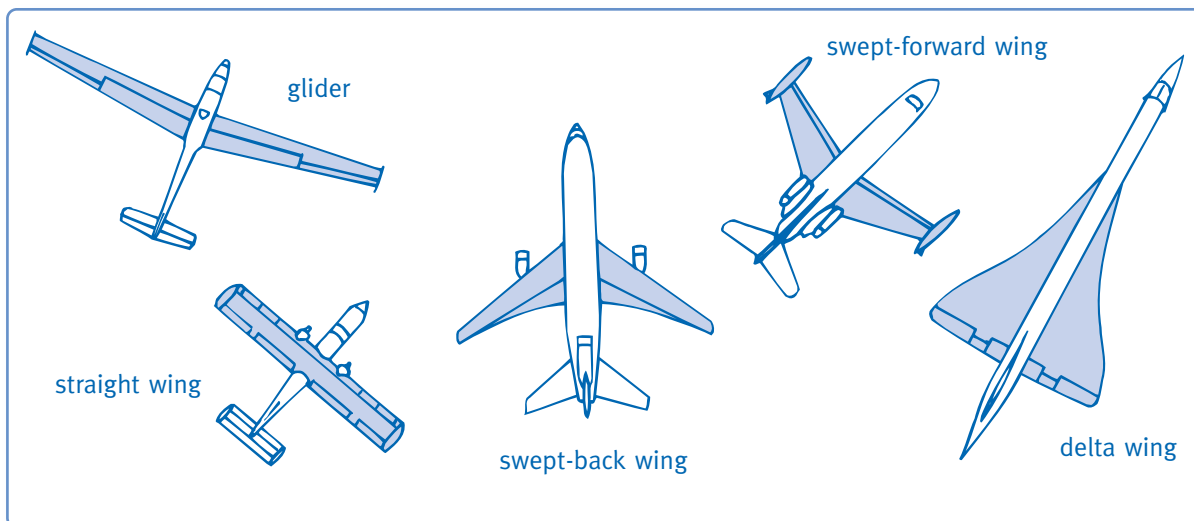
Explain that airplanes are designed to be **streamlined**, or sleek and smooth. Write the word *streamlined* on the board. Then have students answer the question in step 8 on their activity sheets.

Ask, **What are some other things that are streamlined?**

Additional Information

Students should be able to explain that the fuselage is designed to run into as few molecules as possible as it travels through the air.

Answers will vary. Some possible answers include cars, boats, trains, fish, birds—anything that is meant to move through air or water.



▲ *Figure 5-3. Airplane wings come in many shapes and sizes.*

11

Next, have students compare the shape of the wings in the pictures of airplanes (several are shown in Figure 5-3). Ask, **Are all wings the same size and shape?**

Have students add wings to the diagrams of the airplanes in step 9 of their activity sheets.

Ask, **Why do you think wings come in so many different shapes and sizes?**

No. Some wings are narrow while others are broad; some stick straight out from the side of the airplane while others are swept back or forward.

Students should realize from Session 1 that the shape of the wing affects flight performance.

Guiding the Activity

12 Have students retrieve their Darts and Sliders from Session I. Tell them to compare the shape of the paper airplanes with the shape of the planes in the diagram they just completed at the bottom of their activity sheet. Ask, **Which plane does the Slider resemble? Which plane does the Dart resemble?**

Ask, **Based on the flight performance of your paper airplanes, which plane in the diagram do you think flies best at high speeds? Which flies best at slower speeds?** Have students record their answers at the bottom of their activity sheets.

Tell students that in the next two activities, they are going to learn how the wings on a real airplane help lift it into the air.

Additional Information

The Slider resembles the plane with the broad, straight wings. The Dart resembles the plane with the swept-back wings.

The plane with the swept-back wings flies best at high speeds. The plane with the broad, straight wings flies best at slow speeds.

REINFORCEMENT

Have students design their own paper airplanes and then enter them in a flying contest. Which flies the farthest? the fastest? Which does the most tricks in the air? After the contest, display the winning gliders in each category. Challenge students to select one design feature and to explain how it helped the airplane perform so well.

Assessment Opportunity

This Reinforcement also may be used as an ongoing assessment of students' understanding of science concepts and skills.

SCIENCE JOURNALS

Have students place their completed activity sheets and their Dart and Slider designs in their science journals.

CLEANUP

Students can store their airplanes in their folders. Save the pictures of the airplanes for use in Activity 7.

SCIENCE AT HOME

Have students ask their family members to each make a paper airplane. Tell students to examine the shape of the plane and observe how it flies. Tell them to explain to their family the relationship between airplane shape and flight performance. Invite students to bring in the best examples to share with the class.

Connections

Science Challenge

- ▶ Have students study drawings and photographs of birds of different sizes and shapes, for example, barn swallows, hummingbirds, eagles, seagulls, and herons. Ask students to predict how each bird flies, based on body type (wing spread, body shape, and so forth). Researching each bird's feeding habits and natural habitat may also offer clues as to how it flies (for example, whether it soars high in the air, dives into the water, or hovers). Encourage students to watch birds outdoors. Or, locate a video of birds in flight. Encourage students to observe the flying styles and flight patterns of various birds. They may be able to make a connection between each bird's body type and how it flies. (A similar study can be made of flying insects.)
- ▶ As an extra challenge, ask students to study pictures of a flightless bird, such as the emu or the penguin. Encourage them to analyze, based on the bird's body, why it cannot fly.

Science and Math

Hold a competition for paper airplane designs. Encourage students to research different patterns for paper airplanes and, if they wish, make their own modifications to the designs. Then, set up three graphs—one for speed, one for distance, and one for time-in-the-air—to record each plane's performance during the competition. Label the vertical axes *Speed (m/s)*, *Distance (m)*, and *Time-in-the-Air (s)*, respectively. Along the horizontal axes, list each student's or team's name.

Science and the Arts

Suggest that students find poems and/or songs about flying, which might include

descriptions of birds in flight. Have them rehearse the poem or song in advance, then read it to the class. Discuss how the poet evokes flight and what words and poetic devices contribute to that evocation.

Science and Careers

Many people's efforts and inventions contributed to the development of powered flight. Have students research the lives and contributions of one such person, then role-play that person as another student does a "live interview." Some names students might consider include the following:

- Sir George Cayley (1773–1857), often called the inventor of the airplane because he was the first to propose the use of a fixed wing.
- Octave Chanute (1832–1910), an engineer who, upon retirement, spent most of his time trying to invent the airplane. He was also the author of *Progress in Flying Machines*, a comprehensive book on heavier-than-air flight.
- Otto Lilienthal (1848–1896), a German engineer whose work on fixed-wing gliders paved the way for other developments.

Science, Technology, and Society

Fighter planes, bombers, space shuttles, seaplanes, airbuses, gliders, light aircraft, pedal-powered planes, airliners, supersonic transports (the Concorde), helicopters, and hang gliders fill the skies. They are all able to fly because their designers understood and applied similar principles of aerodynamics. Suggest that students team up to research different types of aircraft, then use drawings and fact cards to create a bulletin board display. The fact cards should include information about how each machine is used and how it flies (for example, how fast, at what altitudes, and with how much maneuverability).