Aeronautics Research Mission Directorate

Build Your Own Mars Helicopter

Suggested Grades: 3-8

Activity Overview

NASA sent a helicopter to Mars! This helicopter is called Ingenuity and is designed to test whether or not flight is a good way to study distant bodies in space.

We have sent spacecraft to other planets, but this is the first aircraft that actually flew on another world. In this activity, you will learn about this amazing feat of engineering as you build your own Mars helicopter model.

Time: 30 minutes

Materials

- 1 Large marshmallow
- 4 Small marshmallows
- 5 Toothpicks
- Cardstock (to print out the last page of this document)
- Scissors

Steps

1. The large marshmallow will represent Ingenuity's fuselage. Ingenuity is fairly small, about 19 inches tall and weighing about 4 pounds, and the fuselage is about the size of a softball. The fuselage contains batteries, sensors, and cameras to power and control Ingenuity's flight. It is insulated and has heaters to protect the equipment in the cold Martian environment where it can reach -130 ºC at night.

2. Insert the four toothpicks into the marshmallow so they come out at angles as shown in *Figure 1*. The toothpicks represent the four hollow carbon-fiber legs on Ingenuity.

   Ingenuity's legs are designed to be lightweight while still supporting the helicopter when on the Martian surface. To take up less space, Ingenuity's legs were folded while it was being carried to Mars.

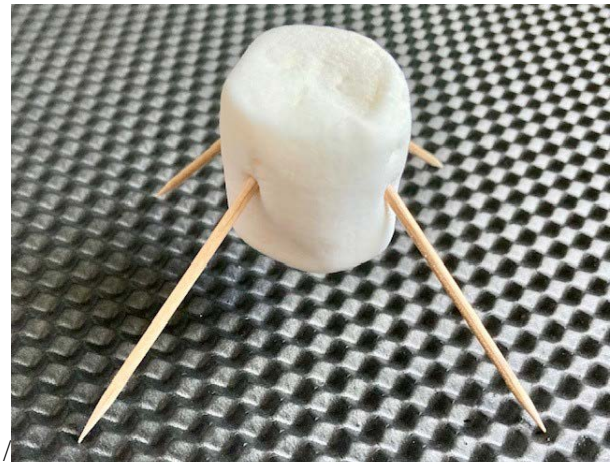


Figure 1. Insert the four toothpicks into the marshmallow to represent Ingenuity's legs.

3. Place a small marshmallow at the end of each of the four toothpicks as shown in *Figure 2*. These make the ends of the legs rounded, just like on Ingenuity.

   The rounded ends of the legs help the helicopter sit firmly, even on mildly uneven ground.

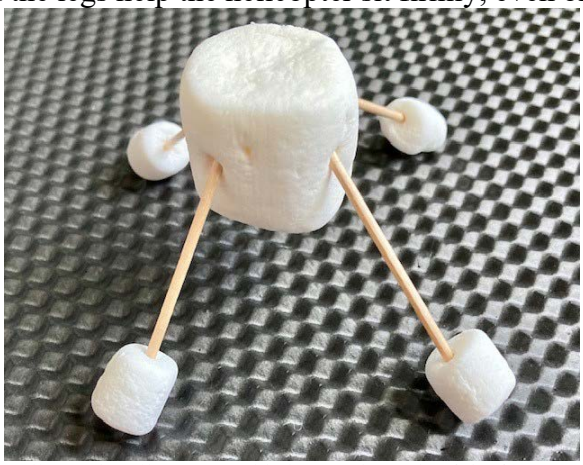


Figure 2. Small marshmallows are added on to the ends of the four toothpicks.

4. Print out the final page of this document on cardstock or other stiff paper. As shown in *Figure* 3, you will need to cut out one set of parts (a solar panel and two rotor blades) for each helicopter you are making. NOTE: The final page contains two sets in case you are making multiple models – you only need **one** set per model.

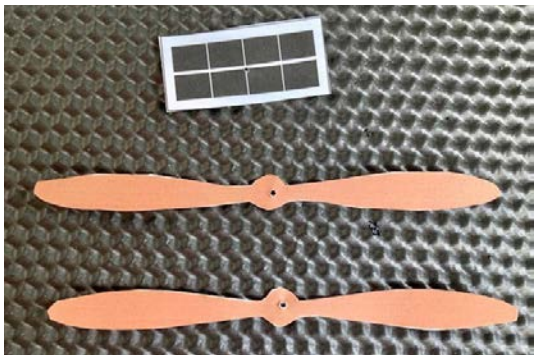


Figure 3. Cut out one set of parts for your helicopter.

5. Make a small hole (see *Figure* 4) in the middle of each of the parts you cut out in the previous step. This can be done using a pushpin or other sharp object. This is to allow the toothpick to be pushed through the paper. Be careful poking the hole – you may need the assistance of an adult.

Figure 4. Poke a small hole in the center of each of the parts you cut out in the previous step.

6. Push a toothpick through the hole in the center of one of the rotor blades. The rotor blade should be about 3/4 of an inch from the end of the toothpick as shown in *Figure 5*.

   On Ingenuity, each rotor blade is about 4 feet long and rotates very fast (about 2800 revolutions per minute). The rotor blades need to be this large and rotate so quickly in order to create enough lift, the upward force on the helicopter, in the extremely thin Martian air.

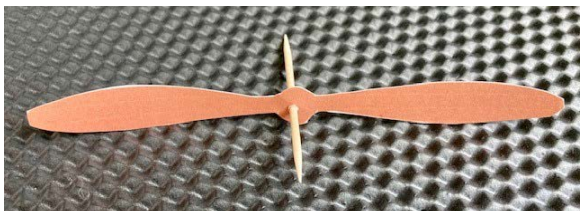


Figure 5. Push the toothpick through the hole in the center of one of the rotor blades.

7. Push the toothpick through the hole in the second rotor blade and adjust the blades so that they are aligned in different directions as shown in *Figure 6*. There should be a space of about 1/8 inch between the two rotors.

   Ingenuity has two rotor blades in order to create enough lift. Additionally, the two rotor blades rotate, or spin, in opposite directions. Normally when a rotor blade spins, it creates a force on the fuselage. By rotating in opposite directions, the forces created by the two rotor blades cancel each other out.

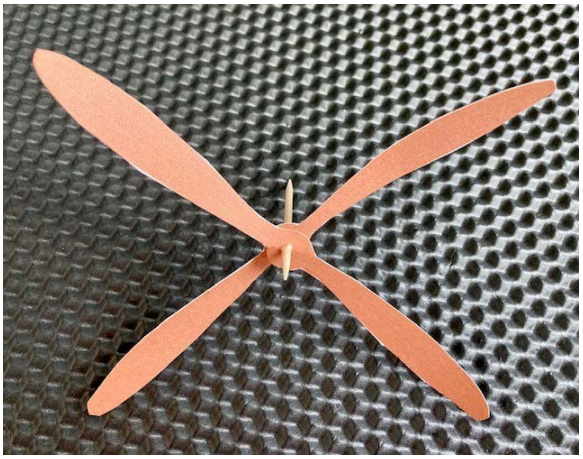


Figure 6. Push the toothpick through the second rotor blade and adjust the blades so they are aligned in opposite directions.

8. Push the end of the toothpick with the rotor blades on it through the hole in the center of the solar panel as shown in *Figure 7*. There should be about ¼ inch of the toothpick sticking out from the top of the solar panel. This piece of the toothpick represents the antenna located atop Ingenuity.

   On Ingenuity, the solar panel converts the Sun's energy into electricity to charge the batteries. The antenna allows Ingenuity to communicate with the Mars rover, Perseverance, which can then communicate with NASA personnel back on Earth.

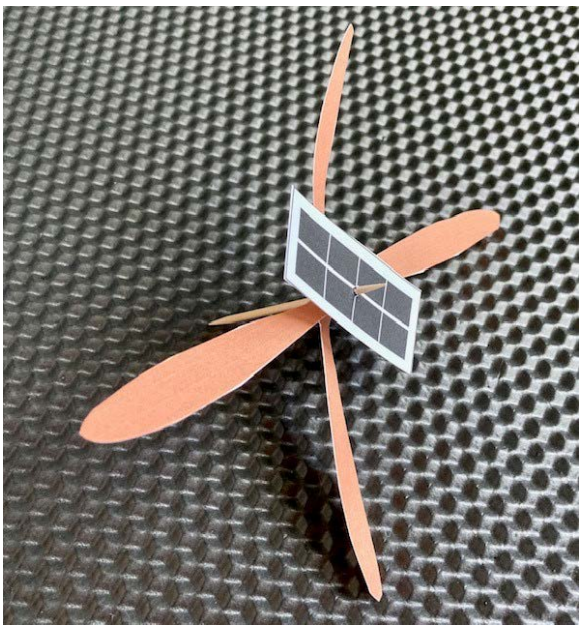


Figure 7. The toothpick is pushed through both rotor blades and the solar panel.

9. Push the end of the toothpick which is furthest from the solar panel down through the center of the top of the large marshmallow as shown in *Figure 8*.

Figure 8. The toothpick containing the rotor blades and the solar panel is pushed through the top of the large marshmallow.

Optional: Put your helicopter on Mars! NASA has sent several rovers to Mars and has made many images of the Martian surface available. You can find some of them at:

https://www.nasa.gov/gallery/ingenuity-mars-helicopter/

You can print out a picture of the Martian surface and display your completed model on that picture.

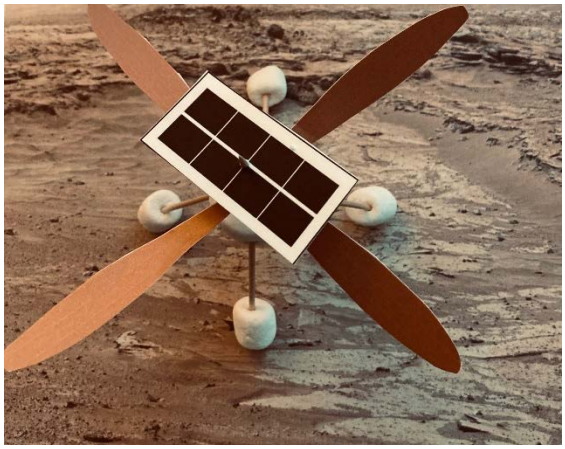


Figure 9. The completed model on the Martian surface

Further Information

The purpose of Ingenuity was to demonstrate that flight is possible on distant worlds such as Mars. It was deployed from the Mars rover Perseverance and conducted over 70 flights above the Martian surface. Since there isn't a consistent magnetic field on Mars, compasses could not be used for navigation. Instead, Ingenuity determined its position partially by looking at the position of the Sun and of the Martian surface. Ingenuity has paved the way for future flight missions on other planets and moons. By flying above the surface, we can study areas of the Martian surface that cannot be reached by ground-based rovers.

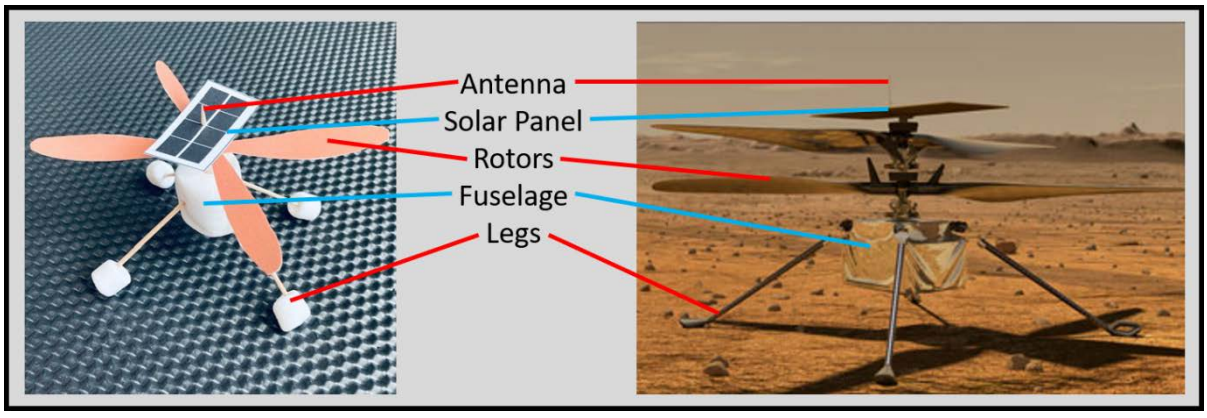
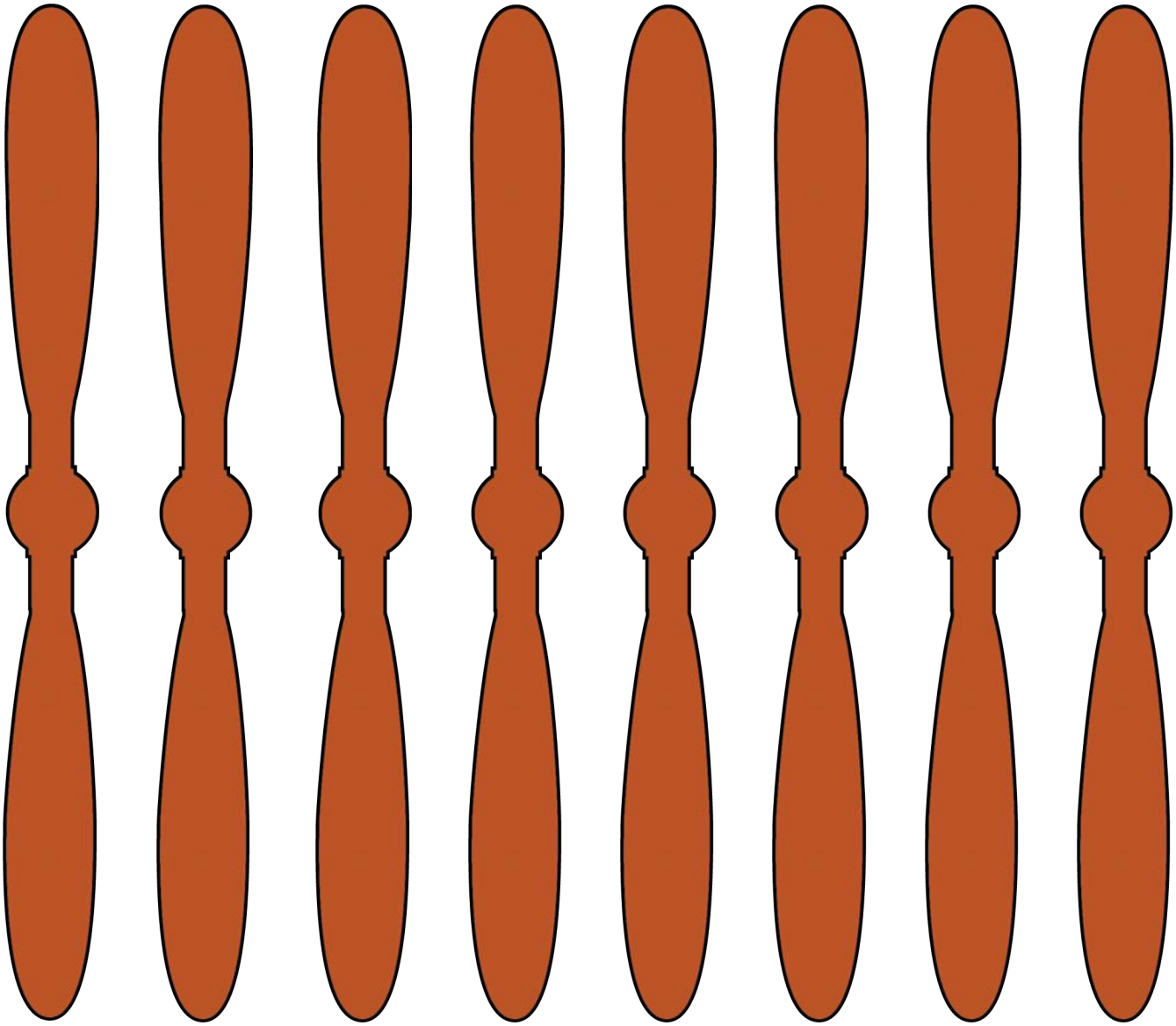


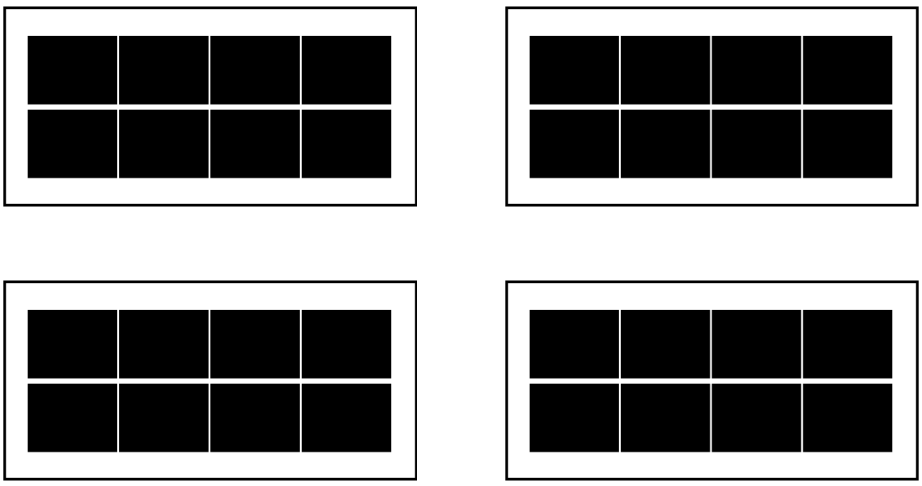
Figure 10. Comparison of your model to the actual Mars helicopter.

Mars Helicopter Parts

Print on cardstock or other stiff paper.



Rotor Blades



Solar Panels