Bernoulli's Tongue
Grade 3 Academic Lesson #2

Topic: air (science)

Lesson Reference: The paper bag mask activity is from NASA's *Aeronautics: An Educator's Guide.*

Length of Lesson: 45 minutes

Objectives:

- Students will construct a device that demonstrates Bernoulli's principle.
- Students will understand the effect of air flowing over a curved surface.
- Students will compare Bernoulli's principle to working as hard as they can in school to be able to "fly high in life!"

Next Generation Science Standards:

- 3-PS2-1-Plan and conduct an investigation to provide evidence of the effects of balance and unbalanced forces on the motion of an object

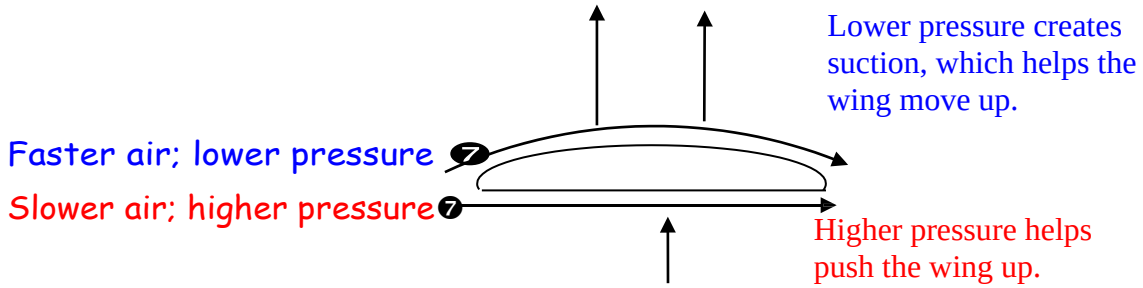
CCSS ELA:

- RI.3.1-Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- RI.3.2-Determine the main idea of a text; recount the key details and explain how they support the main idea.
- RI.3.10-By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2-3 text complexity band independently and proficiently.

Credit: Beth Elwood

Background Information:
A change in the speed at which air is flowing will cause a change in air pressure. Daniel Bernoulli, a Swiss scientist in the 18th century, discovered what is now called Bernoulli's principle: "the pressure in a fluid (gas and liquids), decreases as the speed of the fluid increases."

The wing of an airplane is a device that creates changes in the speed of airflow, thus creating a change in air pressure. Air moving over the curved top portion of a wing will travel at higher speed and produce lower pressure than the air moving past the smooth bottom portion of a wing, thus, creating lift. Lift is a force caused by the equalization of pressures. Equalization always occurs from areas of high pressure to low pressure. An inflated balloon has higher air pressure inside than outside. The balloon will pop when the pressure difference becomes too great for the material.
Another example of Bernoulli's principle can be seen using the paper bag mask. When the student blows through the hole in the paper bag mask and over the curved surface of the "tongue," unequal air pressure will lift the tongue, just like an airplane is lifted off the ground. This experiment will be designed by the class, with direction from the teacher, to determine the effect of unequal forces on an object.

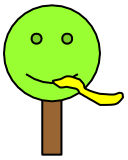


"Lift"

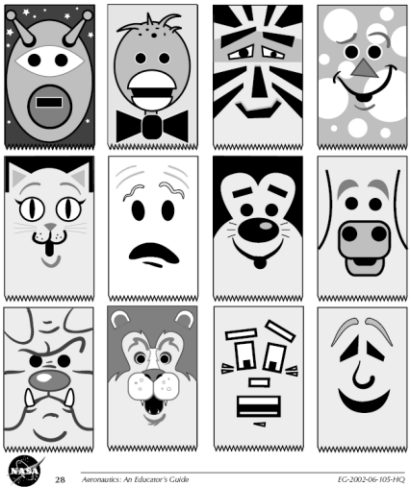
"Introduction to Flight"

Materials:

- *large paper grocery bags
- scissors
- crayons or markers
- gift bag tissue paper or copier paper
- tape or glue
- metric ruler
- fan (optional)
- Teachers will need a free account with Newsela.com in order to meet the ELA standards attached to this lesson.
- Teachers will need to print the article from Newsela called "Four Forces on an Airplane."



* If grocery bags are not available, use posterboard to cut out a face shape (or rectangle shape). Attach a wooden craft stick to the bottom to create a mask. Students can make the face mask look like one that belongs to a human, animal, or even an alien! See examples.



NOTE: A timesaving tip is to have "tongues" already cut for the students. To make the tongue, cut a strip of gift bag tissue paper or copier paper approximately 3 cm wide and 20 cm long.

Lesson Presentation:

1. (optional) Put students in "teams" and ask them if they'd like a challenge or a competition. Once students are set up in teams, give each "team" a piece of copy paper. Tell the students that the team that can successfully complete the three challenges below will win the challenge.

Your challenge is to hold a rectangular piece of paper close to your mouth, blow across the top of it and get the paper to move down. Sounds simple enough but give it a go and see if you change your mind.

Next, try and make a piece of paper into a simple bridge and get the bridge to rise up by blowing under it.

Your final challenge is to hold 2 paper strips near your mouth, blow between them and get them to fly apart.

2. Once the challenges are completed and the students are back in a whole group, ask the students what observations they had of each of the 3 challenges. Which ones worked like you thought they would? Which ones didn't work like you thought they would? Why did some "work" and some not?

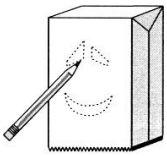
3. Tell students that they will do a fun experiment to understand how and why a streamer seems to float in the air when air flows over it. Tell them that they are going to make paper bag masks, and they must make a tongue for the mouth on the mask. Distribute "tongues" to students or have them make one at this time. To make the tongue, cut a strip of gift bag tissue paper or copier paper approximately 3 cm wide and 20 cm long.

4. Have students crumple the tongue a bit to make it a bit softer and more flexible.

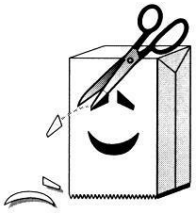
5. Tell students to hold one end of the tongue just a bit below their bottom lip and create a stream of air by blowing straight over the end of the tongue that is near their mouth. Ask students to observe what happens. (The tongue rises and seems to float in the air just like the streamer.)

6. Ask students to try to explain why that happens. Tell them that blowing over the top of the tongue causes the air to move quicker over the top of the tongue than under the tongue. When air moves fast enough over the top of some curved surfaces, the object gets lifted up. The person who realized this was a man named Daniel Bernoulli. The idea of something getting lifted up because air is moving fast enough over the top of it was named for him. It is called "Bernoulli's principle." Have students say that with you, "Bernoulli's principle." Tell them that they can remember his name by breaking it up into three small words: burr (like being cold), new (as in a new bike), and lee (as in someone's name). Put them together and you have the pronunciation for Bernoulli. Have students practice saying the three small words to remember Bernoulli's name. Tell them that when air moves fast over the top of the tongue, there is high pressure underneath the tongue that helps push the tongue up. There is low pressure on the top, which helps the tongue get "sucked" up, like drinking with a straw. There is a push on the bottom, and a pull on the top. To explain pressure, have students press on their leg with their hand. That's an example of more pressure on one's leg.

7. Tell them that they are now ready to make their paper bag masks. Show students a finished example and how the tongue lifts when you blow through the mouth hole of the mask.



1. Place a bag over the head of one student and have a second student carefully draw small dots where the eyes, nose, and mouth are located (or the teacher can do each one).
2. Remove the bag from the head and draw a face around the marks made in step 7.



3. Cut out two holes (approximately 2 cm diameter) for the eyes.
4. Cut a hole (approximately 4 cm diameter) for the mouth.

5. Tape or glue one end of the tongue inside the bag at the bottom of the mask's mouth. Allow the tongue to droop through the mouth on the outside of the bag.

6. Place the bag over the head and blow through the mouth hole. Observe the movement of the tongue.

8. Ask students to relate the tongue on their masks to how airplanes fly. Remind them that the unequal pressure around the wings of the plane affects or causes the lift. Show students the videos below to explain how Bernoulli's Principle is related to flight.

   "The Aerodynamics of Flight"
   The above video relates Bernoulli's Principle to flight.

   "Steve Spangler Toilet-Papers Ellen's Studio"
   The above video is a Steve Spangler (on Ellen's talk show), as he does an experiment to explain Bernoulli's principle.

9. Work through the Newsela.com article whole group or individually (there are question sets and the Lexile level can be adjusted on the website to accommodate different learners). Once the passage has been read, discuss the questions. Always try to relate the lift force that is working on a plane to Bernoulli's principle.

Summarization:
Ask students what they learned today. (You may encourage the correct ideas by asking these two questions: *What caused the tongue to lift? What special name is given to the idea that faster moving air over the top of a surface like a wing can cause it to lift up? How do we know the lift in an airplane works to keep such a big object in the air?*)

Character Connection: Tell students that what people say using their tongues can help to "lift" people's spirits. When we say nice things to people, we help people feel good. The opposite is also true. If we do not think about what we say and just let ugly things fly out of our mouths, we can cause someone's feelings to crash and be splattered on the ground. Tell students that you want their paper bag mask to remind them of two things: Bernoulli's principle and that everything they say can be used to lift people up just like the tongue in their masks.

Assessment:

- teacher observation
- student answers to class discussion questions
- construction of paper bag masks
- Newsela article questions

Additional activity ideas to enrich and extend the primary lesson (optional):

- Have students experiment with different tongue lengths.

- Have students experiment blowing over the tongue quickly and slowly. Observe the effects and discuss.

- Inflate two balloons. Attach a piece of string to each balloon. Hold the end of each piece of string so that the balloons are about 5 inches apart from one another. Ask students what they think will happen if someone blows a steady stream of air between the two balloons. Invite a volunteer to blow a steady stream of air between the two balloons. Students should observe that the balloons move closer to one another. This is another example of Bernoulli's principle.

- Allow students time to experiment with Bernoulli's Principle with paper airplane design and how the wings affect the path of the plane.