Physics of Flight

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Subject: Physics

Grade Level: 3-8

Standards: Next Generation Science Standards (www.nextgenscience.org)

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Schedule: 4-45 minute lessons

CCMR Lending Library Connected Activities:

Objectives:	**Vocabulary:**
Learn about Bernoulli's principle, the aerodynamics of an airplane, and the forces acting on it.	Aerodynamics Force Lift Drag Thrust Distance Time Velocity
Students Will: - Understand that lift is the force that hold an aircraft in the air. - Know that there are two types of lift: Newton lift and Bernoulli lift - Perform demos to look at the affects of Newton lift and Bernoulli lift - Construct a straw hoop plane	**Materials:** **For Group Demos (6 Stations)** ***Bernoulli's Water Gun*** Cup Straws ***Crashing Cans*** 2 Soda cans or bottles ***Magic Moving Ball*** 2 Cups Ping Pong Ball ***Flip a coin*** Dimes and Pennies Paper Plate ***Heavy Ball*** Funnel Straws Ping Pong Ball ***Mighty Card*** Index Cards **For Each Group (2 students)** **Straw Hoop Plane** Straw Stiff Paper **For Class** Tape Directions for Hoop Plane **Teacher Will Need to Provide** Scissors
Safety	This activity does not contain any safety concerns.

Science Content for the Teacher:

Air flowing over a curved surface (like the top of an airplane wing) moves faster than air flowing over a flat surface (like the bottom of an airplane wing). As the air goes past the wing, the shape of the wing also turns the air downwards.

The difference in the speed of the air, combined with the turning of the air downward mean that there is a pressure difference between the top and bottom surface of the wing: there is low pressure on the top of the wing and high pressure underneath the wing. Since objects naturally move toward areas of low pressure, this causes the wing to be 'sucked up' into the air, in an effect called **lift**.
Lift is also what helps your hoop glider stay up in the air. The curved surface of the hoop glider's loops create a difference in pressure above and below the loops.

Other forces acting on a glider are:

Gravity: downward pull toward the Earth

Drag: also called **air resistance**- the more "stuff" there is, the harder it is to move that stuff through the air

Thrust: the force you exert when you throw it

We cannot change gravity, but by maximizing lift, minimizing drag and with just the right amount and direction of thrust, hoop gliders can fly quite far!
Questions to think about while you experiment:

How far does your hoop glider fly?

Can you design a hoop glider that flies farther?

What happens when you change:

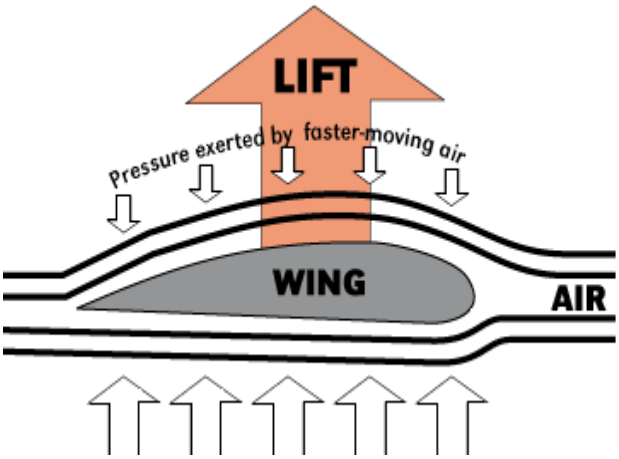
- Loop Shape?
- Straw Length?
- Glider Weight?
- Loop Size?
- Number of Loops?[1]

How does the Bernoulli Principle relate to airplane flight?

[1] "February 2013: Hoop Glider Engineering | Discovery Center." 2013. 20 Jan. 2016 <http://legacy.mos.org/discoverycenter/aotm/2013/02>

The concept that an increase in a liquid's speed creates a pressure decrease and a decrease in a liquid's speed creates a pressure increase.

An example of Bernoulli's principle is the wing of an airplane; the shape of the wing causes air to travel for a longer period on top of the wing, causing air to travel faster, reducing the air pressure and creating lift, as compared to the distance traveled, the air speed and the air pressure experienced beneath the wing.



Explanation of Intro Activities:

Bernoulli's Water Gun
The water should rise up in the first straw and blow across their table. This happens because the air blowing across the straw in the cup reduces the air pressure at that point. The normal pressure underneath pulls the water up the straw and the moving air blows the water out and across the room. Have students experiment with different straw lengths as the "blower."
Crashing Cans
By blowing between the cans, you are making the air between the cans move faster than the air on the other side of the cans. The difference in pressure causes the cans to be pushed together.
Magic Moving Ball
The ball should jump from one cup to the next. This is because the air pressure moving across the top of the cup is less than the pressure inside the cup. The higher pressure inside the cup forces the ping pong ball to jump out of the cup. Have the students experiment with how far apart they can place the cups and still get the ping pong ball to jump from one to the other.
Flip a Coin

The coin will "fly" onto the plate when you blow across the top of the coin. The air pressure is now less on top of the coin than on the bottom, so it gets pushed up onto the plate.
Heavy Ball
The air below and on the sides of the ball is moving faster than the air on top of the ball. The greater pressure on top pushes the ball and keeps it in the funnel.
Mighty Card
The card will not move and will even bend down towards the table. This is because the fast air moving under the card creates lower air pressure. The higher air pressure above the card pushes it down and holds the card in place.

Preparation:

Set up Stations before class. Include the directions at each station.

Classroom Procedure:

Explore (30 minutes):
Have students visit each station and perform the demos.
Review demos with the class. Ask the students what they observed at each demo. Was it what they expected? Why or why not? How did each demo work?

Experiment (60 minutes):
Give each pair of students the instructions and materials to build a hoop plane. Have them record information on their activity sheet.
Have students perform an experiment, changing a variable on their plane to see its affect on the flight. A basic experimental outline is included.
Review with class some of the variables and how they affected the flight of the planes.

Challenge (30 minutes):
Have students use experimental data to build a hoop plane. Each group will compete to see whose can fly the farthest or stay in the air the longest.

Extras:
Students can make and fly paper airplanes (see resources)

Assessment:

The following rubric can be used to assess students during each part of the activity. The term "expectations" here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

1= exceeds expectations
2= meets expectations consistently
3= meets expectations occasionally
4= not meeting expectations

	Engage	Explore	Explain
1	Shows leadership in the discussion and offers creative ideas reflecting a good understanding of the physics of flight	Completes work accurately while providing an explanation for what is observed. Works very well independently.	Provides an in-depth explanation of findings, making good use of vocabulary terms. Fills out activity sheet clearly.
2	Participates in the brainstorm and shows an understanding of the physics related to flight.	Completes work accurately and works productively.	Provides clear explanation of findings. Fills out worksheet clearly.
3	Contributes to the brainstorm, but shows little understanding of flight physics.	Works independently, but makes some mistakes with the procedure.	Provides a limited explanation of findings. Fills out some of the worksheet.
4	Does not participate in brainstorm. Shows no understanding of flight physics.	Has trouble staying on task. Does little to complete the procedure.	Is not clear in explanation of findings. Does not fill out worksheet.

Resources:

"The Physics of Flight (Newton and Bernoulli) - Portage, Inc." 2011. 25 Jan. 2016 <http://www.portageinc.com/community/pp/flight.aspx>

"PAPER AIRPLANE AERODYNAMICS - Paper Airplanes." 2005. 28 Jan. 2016 <http://www.paperplane.org/Aerodynamics/paero.htm>

"Idea 129: Paper airplane glider (no tape needed) | Big Blog ..." 2015. 28 Jan. 2016 <https://michaelplews.wordpress.com/2014/04/22/idea-129-circular-paper-plane-no-tape-needed/>

"Lift - Aviation For Kids." 2008. 18 Feb. 2016 <http://www.aviation-for-kids.com/Lift.html>

“Paper Airplane Made Of Hoops - Exploratorium." 2014. 18 Feb. 2016 <https://www.exploratorium.edu/science_explorer/hoopster.html>