Forces on a Wing: The Coanda Effect

Students will learn about one of the three explanations of lift by observing and testing two activities designed to demonstrate the Coanda Effect.

LESSON PLAN

Learning Objectives:

The students will:

- Predict the effect of moving water or air on air pressure
- Explore the power of wind
- Analyze the results of two activities and infer that moving air causes an area of lower pressure
- Identify common characteristics in the flow of a fluid, as stated in Coanda Effect
- Explore the effects of blowing air through the tube and the movement of a ball in reaction to the fast moving air.

Purpose:

This class is designed to give students the opportunity to practice, observe, and analyze the effects of lift and the applications that apply to this scientific phenomenon. Students will understand one of explanations of lift: the Coanda Effect. The Coanda Effect explains how air is able to follow the curvature of an airplane wings allowing for the effects from the Bernoulli principle and Newton's Laws. From these explanations and activities, students will learn how the Coanda effect has shaped our aircraft engineering from its origins to our modern times.

Introduction:

Students will perform two activities that each define one of the components of lift that are used for aircraft and flying objects. In each activity, they will learn about the Coanda Effect. Let us discuss this application individually and how it effects the theory of lift. The Coanda Effect explains that a wing's trailing edge must be sharp, and be aimed diagonally downward if it is to create lift. Both the upper and lower surfaces of a wing act to deflect the air. This effect determines the operation for which an airplane's wings are designed. There are two different types of airfoils that stem from this development, laminar and conventional flow. This airfoil helps to determine the overall shape, size, and design of the airplane wing. The Coanda Effect is just one of the three applications that helps to explain the theory of lift and why we are able to develop various types of airframes. (Pg. 4 for pictures)

Grade Level: **6 – 8**

Ohio Learning Standards/Science (2018)

Expectations for Learning

Nature of Science

Physical Science:

6.PS.2: Changes of state are explained by a model of matter

6.PS.3: Energy: kinetic & potential

6.PS.4: Object's motion: speed & direction

8.PS.2: Forces can change motion of object

Materials Required:

- One Ping-pong ball per student plus the instructor
- Piece of string (8 cm)
- Transparent tape
- Sink with a faucet
- Drinking straw for each student
- Data recording sheet or individual student journals
- Index cards or 3" squares of heavy paper per student

Procedure:

A. Warm-up

1. Share with the class the previous information included in Introduction.

2. Tell students step-by-step (starting in Activity #1 in part B below) how all the activities will proceed.

3. Have students write predictions of what will happen in individual student journals or on data recording sheets.

4. Remind students to share predictions with the class.

B. Activity I

1. The instructor will conduct this experiment in front of whole class. Begin by explaining that air and water are both fluids and, therefore, water can be used to demonstrate the same Coanda Effect that takes place as air moves over an airplane wing.

2. Tape the string to the ball.

3. Turn on a faucet, and let the water run fast.

4. The instructor will hold the string and ball as close as possible to the stream of running water without letting the ball touch the water. You may want to repeat this step several times allowing students to take turns.

5. Have the students record observations in student journals or on data recording sheets.

6. Discuss observations. Lead students to realize the ball moved toward the stream of water because, as the water followed the curvature of the ball, an area of lower pressure was formed near the rapidly moving water, causing the ball to be "drawn or pulled" in.

C. Activity II

1. Students, individually, will hold a ping-pong ball over the short end of a straw bent into L shape and blow through to observe the reaction.

2. Students experiment to find a speed that will cause the ball to stall and spin above the straw in midair.

3. Next, cut a 3" circle from the index card.

4. Cut a 1-1/2" slit into the center of the circle.

5. Overlap the cut edges to form a funnel shape and glue or tape in place.

6. Cut off tip of funnel just enough for the straw to fit through.

7. Fit the straw into the bottom of the funnel and repeat activity one. (Note: You may need to secure the straw to the funnel with tape.) Now invert the funnel while blowing through the straw. (Make sure you take a very deep breath so as to sustain your blowing through this maneuver.) The ball should stay in the funnel. Several attempts may be needed to accomplish this feat. Students may record number of tries or seconds the ball stayed in the funnel.

8. From these observations, students should make a sketch of air molecules and movement for the two activities above. Use arrows as needed.

Assessment/Evaluation:

Listen to student remarks during discussions to see if their predictions and observations demonstrate an understanding of the Coanda Effect. Ask questions to check for understanding. Check summary paragraphs and illustrations.

Extension:

Allow students to experiment with larger balls of varying weights on a number of different sources of air movement. An industrial sized fan, available in many schools, works well with beach balls – even allowing for several beach balls to be balanced in the air stream at the same time!

Resources/References:

Lift:
https://www.grc.nasa.gov/WWW/K-12/airplane/lift1.html

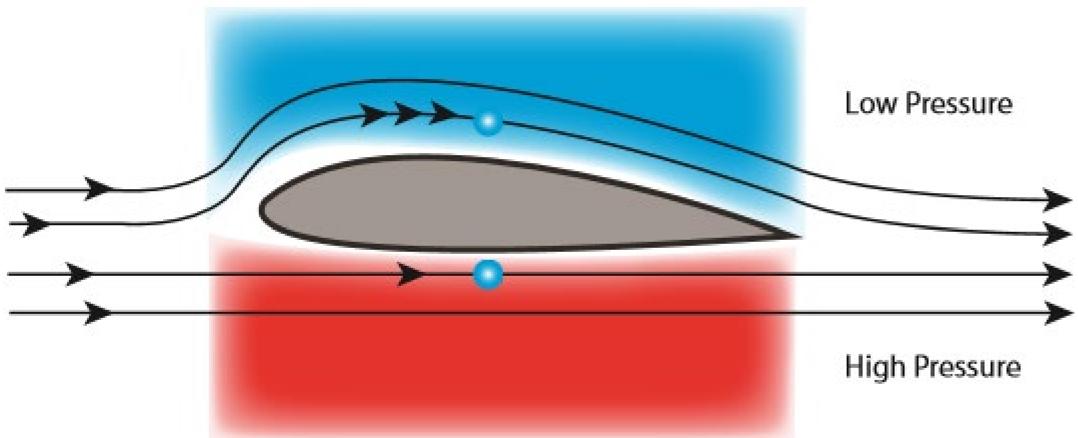
Coanda Effect:

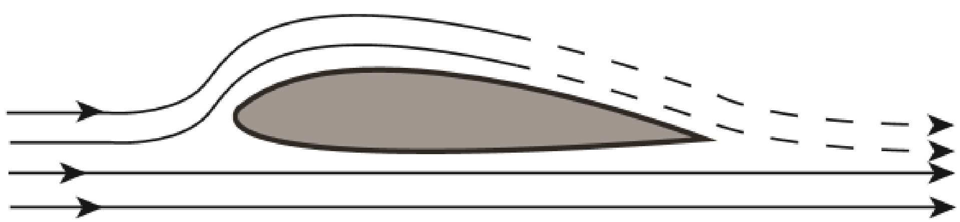
https://flight.nasa.gov/pdf/foam_wing_k-12.pdf
https://www.discoverhover.org/infoinstructors/guide8.htm
https://youtu.be/AvLwqRCbGKY

Lift from Pressure-Area:
https://www.grc.nasa.gov/WWW/K-12/VirtualAero/BottleRocket/airplane/right1.html

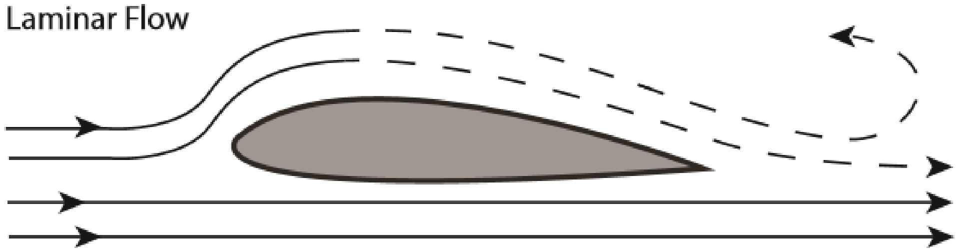
Lift from Flow Turning:
https://www.grc.nasa.gov/WWW/K-12/VirtualAero/BottleRocket/airplane/right2.html

Bernoulli Principle & Newton's third law:
https://www.engineering.com/Blogs/tabid/3207/ArticleID/190/Bernoulli-Ball.aspx
https://demos.smu.ca/index.php/demos/fluid-mechanics/94-bernoulli-floating-ball
https://www.grc.nasa.gov/WWW/K-12/airplane/bernnew.html





Laminar Flow



Conventional Flow