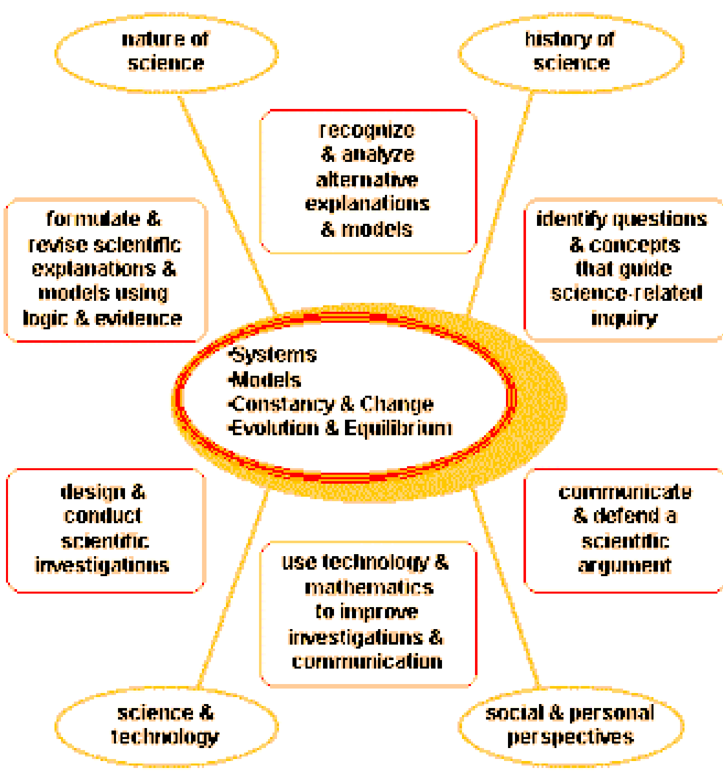
Basic Aerodynamic Principals of Lift

LEARNING AREA: Scientific Concepts and Applications
EDUCATION LEVEL: Middle School
CONTENT STANDARD: Physical Systems

STANDARD:

1. Designing and conducting investigations and field studies.
2. Analyzing data to support or refute hypotheses by identifying patterns in data; and comparing results to known scientific theories, current models, or personal experience; and considering multiple interpretations of data.
3. Describing how scientific concepts, principles, theories, or laws support a premise.
4. Creating a model to illustrate a contemporary or historical concept, principle, theory, or law.

LARGE PROCESSES/CONCEPTS:



NEXT STEP: ASSESSMENT TASK

ASSESSMENT TASK---

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Description:
This project is to demonstrate the aerodynamic principals associated with the varying configurations of a model wing.

Phase 1 will be to design a lift surface. The lift surface will consist of a piece of corrugated cardboard acting as the bottom portion of the airfoil. The top of the airfoil will be made of construction paper or light single thickness poster paper. Masking tape will be used to fasten the leading edge materials together and 3-4 stickpins will be used to vary the **cord** of the wing.

Phase 2 of the project will be to increase the aerodynamic cord and record data related to that change. As the cord is increased, students will note the reduced amount of airflow required to make the airfoil "fly".

Phase 3 the student should witness improved lift performance by varying the **camber** using a flap concept.

Phase 4 the student will be able to observe disrupted airflow over the wing with the incorporation of turbulent indicators.

Products/Evidence of Learning:

1. Construct a model
2. Generate a test cell
3. Collect data based on varying configurations
4. Analyze data

Overview:
As a demonstration of Bernoulli's principal, the airfoil exercise demonstrates the use of low-pressure areas produced on airfoils with varying cords and cambers. The **cord** of the wing is the distance between the lower and upper surface of the wing area. The **camber** of the wing is the curve that is made along the lengthwise axis by the mean cord. In this experiment we will continue to increase the cord by moving the upper panel tailing edge forward by .25-inch increments. The result will be an increase in the mean cord or average cord width. Increased cord width means the upper airflow molecule must go a greater distance to get to the same place behind the wing at the same time as the lower airflow molecule.

We will call these little Bernoulli's. As the distance of the upper surface increases by increasing the cord, the distance between the individual Bernoulli's on the topside of the airfoil increases (they get further apart).

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Because they get further apart, the Bernoulli's underneath the wing which are closer push up on the wing creating what we call lift. This principal is used in kites, sail boats, airplanes and almost every form of subspace air travel.
We can increase the camber in other ways as well. By bending the last inch of the airfoil down by increase angles, we simulate a flap, which is used to enable the aircraft to fly at slower speeds and is usually used when landing the airplane. If we put too much flap down, we increase what is called induced drag, which puts increased load on our engine and can actually cause us to stop flying.
If we slow down too much or try to climb to quickly, we will stop or **stall** the lift on the wing and loose lift altogether. By watching the strings on the wing, you will be able to see when the airfoil is stalling. This means the Bernoulli's are no longer able to hang onto the airfoil and the strings will move around wildly indicating a stalled condition.

In the first portion of the exercise the student will use a 5"X11" piece of cardboard and the 5"X11" piece of poster paper to construct the foil. The simple airfoil is the two pieces of material positioned on top of one another.

1. Put masking tape all along the leading edge of the airfoil, and it will act as a hinge point as the cord is increased.

Note: The airfoil <u>leading edge</u> will be along one of the 11" sides of the rectangle and will be taped as a hinge point. The trailing edge will be along the opposite 11" side. The poster paper will be moved forward at .25-inch increments to increase the cord width.

2. Fasten 3 rows of stall indicator strings at one-inch intervals (space 1.5 inches apart) on top of the wing, starting 1 inch back from the leading edge. These strings should be about 1 inch long and made of a light thread. Use a small amount of tape or glue to fasten the string to the poster paper so at least .75 inches of string is free.

3. Place stickpins in at a shallow angle to hold the top poster paper in place approximately .25 inches forward from the trailing edge of the airfoil.

4. Holes for string should be made in the front corners of the airfoil and 4-5 inches of string attached to the airfoil and then to a fixed object such as a desk or chair leg.

5. Place a fan in front of the airfoil to act as the air source.

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6. When attaching the airfoil to the stationary objects (the legs of a desk or chair) fasten the attaching stings so that the airfoil leading edge hangs horizontally, approximately in the middle of the air source path.

7. Position the air source (fan) 12 to 18 inches in front of the airfoil and mark the distance with a piece of tape. Turn the fan on and record the results by measuring the trailing edge of the airfoil distance off the floor.

8. Move the fan closer about half way to the airfoil and take another measurement.

9. Move the fan to 3-4 inches from the airfoil and take another measurement of the trailing edge distance from the floor.

Note: You will repeat this process for each time you move the trailing edge of the top surface forward by .25 inches and when bending the trailing edge of the lower surface down to simulate flaps.

10. Remove the stickpins and move the trailing edge of the poster paper forward .25 inches and reinsert the stickpins. Repeat steps 3, 7, 8, and 9 in the process with the now increased cord width. Record the results. Repeat this process 2 more times, each time increasing the cord by moving the trailing edge poster board forward by .25 inches.

11. After the third increase in the cord, bend the cardboard along a ruler edge were the poster paper ends on the lower cardboard piece. Bend the cardboard down or away from the poster paper. Start with a small deflection, repeat steps 3, 7, 8, and 9 and then increase it 2 more times up to about a 45-degree angle. (Tape may be required to hold the angle)

12. The next portion we will visibly note the loss of lift on the airfoil. Start the air source positioned 3-5 inches from the airfoil. Slowly begin moving the air source further from the airfoil. Notice as the distance increases, airflow becomes less and trailing edge of the airfoil begins to drop. As the trailing edge drops, the strings will begin to move about wildly. As you continue to move the air source further away, the next set of strings will do the same until the airfoil starts “flopping” or what we call stalling. When this happens the air source is no longer providing sufficient airflow to lift the airfoil.

CHECKLIST:

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Y = Yes
N = No Evidence Shown

Student	*Type of Evidence*	Teacher
______	Cardboard airfoil is constructed according to specifications	______
______	Stall string indicators were attached appropriately and used to note airflow path on the airfoil model	______
______	Stickpins were used to vary the cord of the wing	______
______	Flaps are used to increase the camber of the wing	______
______	Data was documented and interpreted systematically	______
______	Measurements were accurate and consistent with tasking	______

Special Notes: *Includes any tips or special instructions.*

The strings securing the airfoil to the desk or chair leg should be relatively taught to eliminate a twisting motion that will be imparted by circular airflow of a fan air source.

After collecting the data, graph the data points on a chart. The chart axis should depict the trailing edge distance above the floor on one axis and the airflow over the airfoil on the other axis. Airflow should be interpreted as low, medium and high corresponding to the furthest position, middle position and the closest position respectively. The graphs should show increased lift by an increase in measurement from the floor to the trailing edge of the airfoil at the 3 different air source positions. As the cord and camber are increased, the graph should show increase lift as the air source is in the corresponding 3 designated positions.