Aerodynamics

Before Demo, make sure you communicate to the teacher that their students will be racing balloon rockets (activity #2). Ask if they can hang a string if they can in the classroom prior to the presentation. With activity #3 make sure that the teacher is comfortable with flying planes in the classroom ahead of the demo. If not, skip that activity.

How this relates to the curriculum:

In the Grade 6 Air and Aerodynamics unit, students recognize that air is a compressible fluid that takes up space and exerts pressure, and describe when air movement generates lift (Bernoulli's Principle). The Grade 6 Flight unit focuses on airplane design. The terms wing, fuselage, vertical and horizontal stabilizer, elevators, ailerons, and rudder are discussed. Atoms and molecules are referred to simply as particles until junior high.

Part 1: Creating Lift

Pressure

Air is always pushing on us, this is called **air pressure**! Air pressure is when molecules of air collide with all the surfaces it touches. With a greater number of molecules, the number of air molecules colliding with objects increases. Thus, greater air pressure occurs. This is why air pressure decreases with higher altitudes, and why your ears may pop when you're on an airplane!

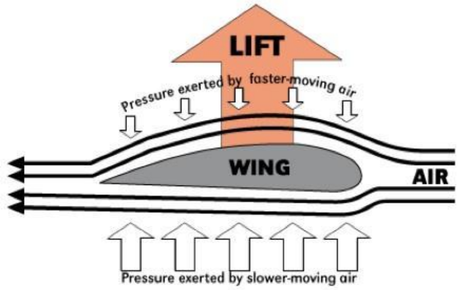
Air diffuses from an area of higher concentration to an area of lower concentration to maintain **equalized pressure**.

What is equalized pressure? Equalized pressure occurs when air molecules are evenly displaced in an area. It is important to maintain equilibrium as unequal pressure may cause pain in your ears, for example, for mountain climbers (who are at a **HIGHER** altitude and **LOWER** air pressure) or for scuba divers (who are at **LOWER** altitudes and **HIGHER** pressure)!

Bernoulli's Principle

How does the speed of moving air affect air pressure? First, fast-moving air exerts less pressure than slow-moving air. This is known as **Bernoulli's Principle**. Airplanes use Bernoulli's Principle to fly. When a plane starts moving along the runway, the wings are curved so that air passing over the top of the wings moves faster than air passing underneath the wings. Bernoulli's principle states that velocity of the air is greater above the airplane wing than underneath it, the pressure above the wing is lower than the pressure below. This pressure difference generates an upward force called **lift.** When the plane gathers enough speed, the wings generate a large enough pressure difference for flight to occur.

This concept may be difficult for students to grasp. Try using a diagram on the board to help illustrate your explanation. Remember the basics of Bernoulli's Principle, fast moving air=low pressure. Air pressure always tries to balance itself, from high pressure to low pressure. Since there is high pressure underneath the wing, and low pressure above the wing, lift is created.



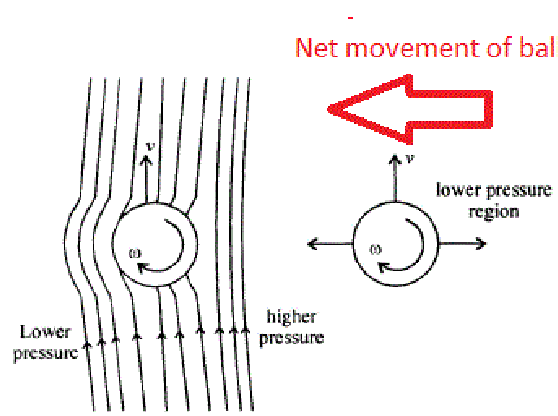
Activity l:

Materials:

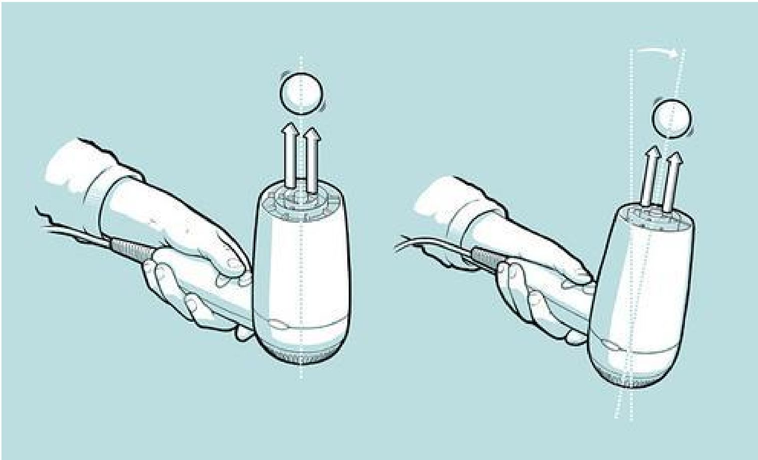
- Hair Dryer
- Ping-Pong ball(s)
- Balloon with Coin inside (optional)

Procedure:

1. Set the hair dryer to cool, switch it on (high setting), and point it at the ceiling.
2. Carefully put the Ping-Pong ball in the stream of air. Hold the hair dryer very steady and watch as the Ping-Pong ball floats in the stream of air.
3. Carefully move the hairdryer from left to right and watch how the ball moves as well, staying in the stream of air. You can even try rotating the hair dryer to see how long the ping pong ball can stay in the air stream before gravity causes it to fall.



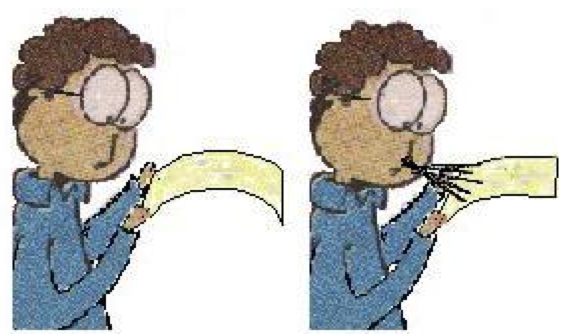
4. Try floating other lightweight objects in the air stream at the same time! With the hair dryer on, place an inflated balloon over your levitating Ping-Pong ball. You might want to place a penny in the balloon before you blow it up to give it some added weight (supply your own if you do this part).
5. Try to float two or more balls in the same air stream. How many can you float at once? How do they behave when there is more than one?



What happened?

According to Bernoulli's Principle, the fast-moving air around the sides of the ball is at a lower pressure than the surrounding stationary air. This is why you can make the ball follow the stream of air as you move the hair dryer. If the ball tries to leave the stream of air, the stationary, higher pressure air will push it back in – thus, the ball will float in the air flow no matter how you move.

A final demonstration to show how planes fly can be done with a piece of paper. Hold the paper by the edge and blow across the top. The paper should float up. By increasing the speed of the air molecules, you have decreased the pressure. The pressure under the paper is now greater than above, forcing the paper upwards. The wings of an airplane are specially shaped to create this pressure difference.



Interesting fact: Groundhogs exploit Bernoulli's principle to ventilate their homes. Groundhog burrows always have one entrance that is at a higher altitude than the other entrance. Since the air at the more elevated entrance moves faster than the air at the less elevated entrance, the pressure at the elevated entrance is lower than the pressure at the less elevated entrance. This pressure differential between the two entrances causes air to be continually pulled through the burrow, resulting in the groundhog's very own ventilation system!

Part 2: Rocket Science

Question time: *What makes a rocket move fast?*

When a rocket flies into space, a rocket shoots up in a straight line to overcome the gravitational pull of the earth. In this simplified scenario, a rocket only uses thrust generated by the combustion of chemicals. When the mass is expelled backwards at a high velocity, there is enough upward force to overcome the enormous weight of the rocket.

Question time: *What other factors make a rocket move fast?*

To make a rocket move faster, you can either increase the thrust it experiences or decrease the resistive forces that act on the rocket. One problem is the **drag force**. When you move, you are constantly colliding with millions or billions of molecules in the air. When you travel at high speeds the force experienced is exponentially greater.

If you are not bored and or disgusted by formula analysis, you can look at the drag force formula before. If you are, please disregard. (do not try to explain the formula to the kids, this is for your understanding)

$$F_D = C_D A \frac{\rho V^2}{2}$$

where
F_D is the drag force
C_D is the drag coefficient
A is the reference area
ρ is the density of the fluid
V is the flow velocity relative to the object

To minimize drag, the rocket must have an aerodynamic shape that minimizes air resistance. This shape minimizes the contact area of the object (rocket) when it is the fluid (air).

EXAMPLE: Next time you are driven by someone, try sticking your hand out the window. First put your palm facing forwards, then place your palm facing down. You should be able to feel your hand being pushed back when you place your palm forwards.

Activity 2: BALLOON ROCKETS

Materials:

- Balloons (one per group or students can build their own)
- Masking tape (40 cm per group)
- 8 ½ x 11 Paper (2 sheets per group)
- Fishing Wire (2)
- Scissors (one pair for releasing the rockets, students need their own)

- Straws

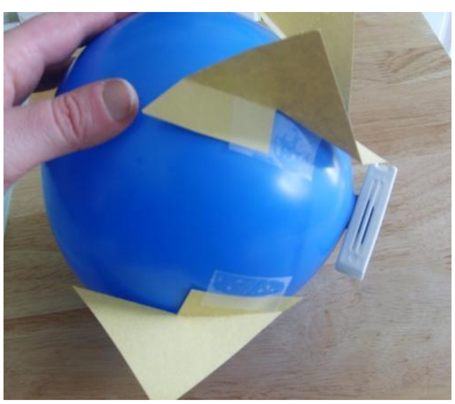
Note: try to ensure all the balloons have the same volume of air. You may want to blow them up next to a template size.

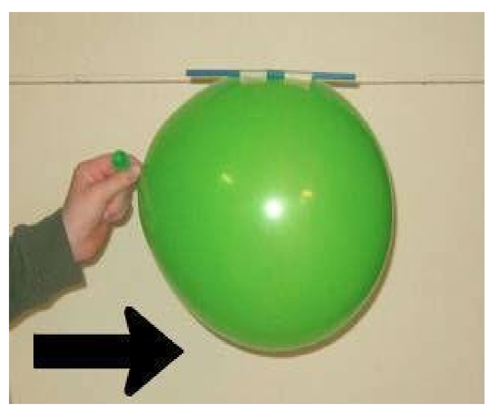
Procedure:

Have the students form groups of three. Each group will be making a paper rocket to attach to a balloon. Each rocket must contain a loop of paper or a straw through which the rocket can be hung on a string that will run the length of the classroom. Have one volunteer stand on a chair and hold the string and tape the other end to the wall on the opposite side of the room. Students can try one of three challenges: (or more if you can think of them)

1. Making their rocket go the farthest
2. Move the straightest along the string
3. Rotate around the string in a spiral

Students can incorporate any ideas they want. They may have learned previously about the stabilizing effects of wings (see picture for example). Before students begin building, discuss the implications of the balloon shrinking in size during flight. Test the rockets one at a time by looping one end of the string through the rocket (have someone hold this end instead of anchoring it each time), and pinch the balloon behind the knot. Cut the knot off the balloon and release your fingers when ready to launch! Alternatively, have two strings going at once and do balloon rocket races.





Note that in this activity we were not concerned about lift, only with air pushing backwards or side to side on the vehicle. Discuss the following:

How does the structure of the fast rockets relate to the streamlined shapes seen in moving vehicles? What makes these shapes "fast"? (not in slides but you can talk about it)

- Rockets are aerodynamically engineered to reduce drag – that is, they are shaped in such a way that limits air resistance. If it were not for their streamlined structure, it would be very difficult for rockets to reach the speeds that they do.)

How does air flowing backwards out of the balloon push the rocket forward? How is this related to jet engines? (not in slides but you can talk about it)

- The air released from the balloon, like jet engines, generates a force known as thrust that propels the balloon forward. When the air is expelled outwards at great speeds, an equal and opposite force should push the plane forwards.

Example: Think about how you move when you swim. When you push the water back, you move forwards.

Question time: *What could be changed about the balloons to make the rockets go even faster? Why?*

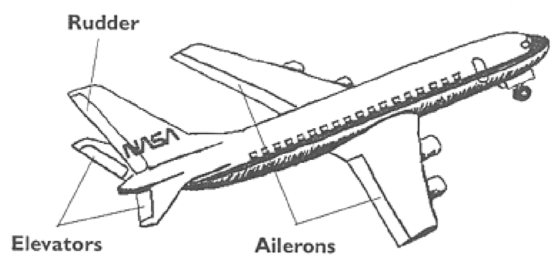
- **Increase the amount of thrust** – blow more air into the balloon or use more elastic material. The air capacity of the balloon will greatly affect how much air is blown out.

- **The rocket's shape could be modified so that it is more aerodynamic.** This will reduce drag experienced by the rocket. One example would be to use a more slender shape rather than a bigger rounder balloon. On a larger balloon, more air molecules will collide with a larger surface area on the larger balloon and thus air resistance(drag) increases. Additionally, the flatter the balloon shape the more drag it will produce. Therefore, a more pointed surface is better.

Part 3: FLYING AIRPLANES

Question time: *What makes airplanes turn?*

- Airplanes are able to point up and down and roll left and right because they have flaps (ailerons, rudders, and elevators) that alter the movement of air along the surface of the plane. By altering the position of these flaps, the airplane can control its direction of movement.



Activity 3: Folding the Most Aerodynamic Paper Airplane (ONLY IF TIME ALLOWS)

Note: Make sure to ask the classroom teacher for permission to do this experiment as some teachers do NOT enjoy having their students focused on making paper airplanes as the general volunteers are leaving the classroom.

Materials:

8.5 x 11 inch paper (preferably one per student otherwise one per group) (ask your teacher for scrap paper)

Hand out the paper to the students (no more than one per person) and make sure they know that they each get one chance to throw their airplane. Explain to them that the most aerodynamic and most balanced airplanes will be the ones that fly the furthest because it creates lift on the wings of the airplane. When all the students are done folding their paper, set a designated "throwing spot" next to a wall in the classroom. Get students to throw their creation one by one (measurements will not be taken). After the students have all thrown, the volunteer will throw their paper airplane (diagram for what should be the most aerodynamic and balanced airplane below). Make sure to take your time folding the paper to make it as even as possible. This will hopefully allow your airplane to fly further than the students' airplanes.

Question time:

How far did your paper airplane fly?

How long did the airplane stay in the air for?

How fast did the airplane go?

The Best Paper Airplane! - Changing the Design

Some characteristics that affect flight are:

1) The size of the paper airplane
2) The size of the wings
3) Materials the paper airplane is made of

If we maximize these three characteristics correctly, we can possibly make our paper airplanes go greater distances!

Reflection questions:

How does the size of the plane affect the flight distance of the plane? Do bigger planes fly a farther distance?

How does the wing size affect the plane? Do planes with larger wings fly farther? What does lift do to larger wings?

How does changing the paper affect the flight distance of the plane? What's the difference between using printer paper, newspaper, or cardboard?