Air and Pressure

FRAMEWORK

I. Scientific and Engineering Practices
II. Cross-Cutting Concepts
III. Physical Sciences

SKILLS/OBJECTIVES

- To have kids practice making observations and predictions as well as interact with counterintuitive phenomena relating to "levitating" objects, the relationship between airspeed and pressure, vacuums, and how suction cups work.

MATERIALS

- 2 bathroom scales
- Plastic Magdeburg hemispheres
- Suction cup
- Large plates & O-ring
- Isopropanol wipes
- 40 half sheets of paper
- Ping pong balls (~80-100)
- Soda bottle funnels (~80-100)
- Straws
- Small clear plastic cups
- Levitation pipes / "floating ball game" (25)
- Hair dryers (4)
- Objects for levitation (beach ball, golf ball, crumbled piece of paper, rubber bouncy ball)

NOTES

Activities 1 and 2 should be done as a large group. Activities 3, 4, 5, 6, 7 and 8 should be done in small groups or pairs.

BACKGROUND

- A force is any influence that causes an object to undergo change in movement, direction, or form. For example, when you crush a soda can, you are applying a force to the can, which makes it change its shape or form into the crumpled can. When you push on a ball, you apply a force to it, which makes it move.
- Pressure is a force distributed/spread over an area.
- The larger the area a force is pressing against, the smaller the pressure is. We will take a look at how this works in real life with bathroom scales.

Activity #1	**Bathroom Scales**
Materials	Bathroom Scale
Worksheet	No

- Pressure is a force distributed/spread over an area**.** When you stand on a scale, you exert a certain force, if you take into account the area of the soles of your shoes, then you get a measure of pressure.
- **Have a volunteer stand on one scale, and read out the value.** Ask what will happen to the value on that scale if the person stands with each foot on a different scale. **Have the same volunteer try it out, and read off value.**
- It should be half as big as the first value because we have distributed the force exerted by the student standing over twice the area (the platform of the scale).
- Another example of larger area, lower pressure: Stepping on a single nail (ouch!) vs. lying on a bed of nails. The bed of nails has a much larger area, so the same force (a person's weight) results in a lesser pressure at the tip of each nail.
- Smaller area, higher pressure examples: Which exerts more pressure on the ground: wearing high-heels or sneakers? (High-heels).

Activity #2	**Unbreakable Magdeburg Spheres**
Materials	• Plastic Magdeburg hemispheres • Suction cup • Large plates & O-ringIsopropanol wipes (for cleaning plastic tubing)
Worksheet	No

- Have a volunteer show that the two Magdeburg hemispheres can be easily put together and pulled apart.

- **Put the hemispheres together and ask them to inhale as deeply as possible, sucking out air from the chamber, close the stop-valve right before they stop.** Let them try to pull the two hemispheres apart.
- We have created a vacuum! Since there is now very little air inside the sphere the pressure is lower than it was, but the air pressure on the outside hasn't changed. It is like a Push-of-War: before both teams were equally strong so we could move the hemispheres around, now the team on the outside is stronger, so the sphere won't come apart. (If we let more air back into the sphere is comes apart again.)
- **Show them the suction cup and explain how it seals and releases.**
- **Show them the Magdeburg plates. Make sure o-ring is in place. Have one volunteer suck out the air, and close the valve.** Let the students try to pull it apart.

Activity #3	**Fast Moving Air Between Two Light Objects**
Materials	• Half sheets of paper (2 per student) • or: Small clear plastic cups
Worksheet	No

- **Take a deep breath and blow a jet of air between half-sheets of paper (**also works with two empty plastic cups on the table). **Notice what happens.**
- They will fall in toward each other, because the pressure will be lower between the sheets were the air is moving faster compared to the still air on the outer sides of the paper.
- Air that moves faster is at lower pressure than air that moves more slowly.

Activity #4	**Airplane Wing**
Materials	• Half sheets of paper – one for each student
Worksheet	No

- **Using a half sheet of paper, hold one of the short sides below your lips, and blow straight across, perpendicular to the floor.** The paper will rise! This is part of how planes stay in the air.
- When we blow out, that air moves faster and has lower pressure than the slower air below the paper, so the sheet is "pushed" up by the difference in pressure.
    - Airplane wings are curved on top, the air above the wing must travel farther than the air below in the same amount of time, so it has to be traveling faster than the air below → Difference in pressure → lift!

Activity #5	**Straws and Spray**
Materials	• Straws • Half-sheet of paper
Worksheet	No

- Give everyone 2 straws and cup, they will reuse the half-sheet of paper from earlier. **Fill the cup almost to the top with colored water.**
- Ask them about how we usually use straws, tell them that today we will get the liquid to climb up the straw without suction!
- **One student should hold one straw so that it is centered in the cup, not touching the bottom, but mostly submerged and hold the half sheet of paper behind the cup with their other hand.**
- **Have the other student blow air as hard as they can through a second straw pointed (perpendicular) across the top of the other straw at the sheet of paper.** (Tell them to aim at the top half-inch/bit of the straw, if you aim at the air just above the straw, it doesn't work.)
- Explanation: normally when we use straws we use *suction* to create a space of *lower pressure* in our mouths, because the pressure of the atmospheric air pushing down on the liquid in the cup has not changed the liquid rises up the straw and into our mouths. Today we blew across the straws, *making air at the opening move faster* to generate *lower pressure*.

Activity #6	**Ping Pong Ball Challenge**
Materials	• Ping pong balls (~80-100) • Soda bottle funnels (~80-100) •
Worksheet	No

- Demonstrate how light the ping pong ball is, how easy it is to blow it away when it is in your hand.
- Now give them their challenge: **Blow the ping pong ball up and out of the funnel when it is vertical.**
- Ask **them to make some observations about what is different in the two situations** (in your hand vs. in the funnel).
- Notice: there is a little room between the ball and bottle, so air can pass through.
- Then explain that the air below the ball is moving much faster than the air above it, which means *the air below is at lower pressure than the air above*, and therefore you cannot blow it out; in fact the harder you blow, the larger the pressure differential, and the less likely it is that you will dislodge the ball.
- <u>Alternate Challenge:</u> Find a way to make the ball levitate using your lungs.

- This can be achieved by covering most of the funnel with one hand and blowing across the top of the ball—it will jump up and spin toward your hand!

Activity #7	**Levitate a Ping Pong Boll**
Materials	• Hair dryers • Ping pong balls • Levitation pipes / "floating ball game" (25)
Worksheet	No

- Have them make a hypothesis about what will happen when you place the ping pong ball in the stream of air exiting the hair dryer.
- Demonstrate this (again the air moves faster on both sides of the ball, and above it keeping it centered over the air stream and at approximately the same height.
- **Pass out the "floating ball game" devices, and have the clubbers levitate the balls.**
- Show them that you can raise and lower the hair dryer, as well as tilt it to a certain angle (then gravity takes over). What happens if you interrupt the air flow?
    - Have them try this with the floating ball game setups!

Activity #8	**What will levitate?**
Materials	• Objects for levitation (beach ball, golf ball, crumbled piece of paper, rubber bouncy ball)
Worksheet	No

- Have students make predictions about what objects will levitate above the hair dryer and which won't.
- Ping pong ball, golf ball, beach ball, flat paper, crumpled paper, rubber bouncy ball, and other objects from around the room.

CONCLUSIONS

- Force over smaller areas result in more pressure! This is why stepping on a single nail hurts so much, but people can lie on a bed of nails.
- High pressure likes to go to low pressure. This is why we can not break apart the two hemispheres.
- Fast moving air is at a lower pressure than air that moves more slowly.
    - this is how airplanes work to have "lift"