Bernoulli and Human Lungs

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

SKILLS/OBJECTIVES
o Have kids practice making predictions and observations. o Demonstrate counterintuitive phenomena. o Help make connections about how pressure is critical to everyday life.
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MATERIALS
• Half sheets of paper • Ping pong balls • Soda/water bottles cut into funnels • Hair dryer • Wind tunnel setup • Rulers • Straws • Tape • Thin box (to act as a fulcrum) • Balloons • Lung Demonstration Kit o

BACKGROUND

- **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.
- More tangible examples of differences in pressure:
    - Stepping on a nail vs. lying on a bed of nails. One can do this because their weight is spread out across a larger area, which means that they exert a smaller pressure on each nail than when they step with their foot.
    - What happens to the water if you cover part of the mouth of a hose? It goes farther, because it is coming out at high pressure.

Activity #1	**Airplane Wing Demonstration**
Materials	Half Sheet of Paper
Worksheet	N

- 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! We have just demonstrated the concept of lift; this is part of how planes stay up in the air.
    - When we blow across the paper, that air moves at higher speeds which results in lower pressure above the page than below, so the paper rises.
    - 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. This results in a difference in pressure, and, lift!

Activity #2	**Ping Pong Ball Challenge**
Materials	Ping Pong Ball, Soda/Water Bottle
Worksheet	N

- 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!
- Ask them to describe what is different about the two situations (in your hand, in the bottle).
- Notice that there is room between the ball and the 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.

Activity #3	**Levitate a Ping Pong**

	Ball with a Hair Dryer
Materials	Ping Pong Ball, Hair Dryer
Worksheet	N

- 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.
- Show them that you can raise and lower, as well as tilt the hair dryer to a certain angle (then gravity takes over).

Activity #4	**Air Moving Between Two Light Objects**
Materials	Two Sheets of paper, Hair Dryer
Worksheet	N

- Blow the hair dryer between two sheets of paper or two small plastic cups.
- They will fall in toward each other, because the pressure will be lowered by the higher velocity air, resulting in a push from the air on the other side of the object toward the high velocity air.

Activity #5	**Upside-down Vacuum Demonstration**
Materials	Funnel, Vacuum, Ping pong ball
Worksheet	N

- Place a funnel on the end of a vacuum.
- Turn vacuum on in the "blow" setting; let them feel that the air is being blown out, not sucked in.
- Place the ball in the funnel.
- You can turn this setup upside-down and the ball will stay inside the funnel – counterintuitive the our ideas about gravity and air blowing out of the vacuum

- Again this is due to the lower pressure on the ball on the side farther from the vacuum.

Activity #6	**Blowing Up a Balloon**
Materials	Balloon
Worksheet	N

- Have one student blow up a balloon
- Talk to them about what the inside and outside pressures are (which one is greater) while you are blowing up the balloon, when it is still expanding.
    - I think of this as a kind of Push-of-War (instead of Tug-of-War)
- Ask them why the balloon stops expanding at a certain point (the inside and outside pressures are equal).

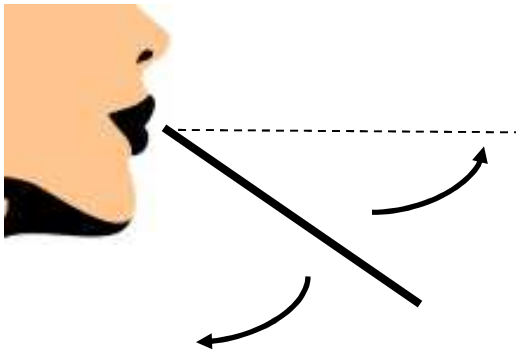
Activity #7	**Human Lungs**
Materials	None
Worksheet	N

- Pressure is important to how we breathe.
- The space inside of your chest cavity (inside of your ribs) but outside of your lungs has its pressure altered by a muscle that sits at the bottom of your rib cage, called the **diaphragm**.
- When you inhale the diaphragm muscle contracts/squeezes and moves farther away from your lungs, this increases the space inside of your chest cavity, which decreases the pressure in the cavity, and allows your lungs to expand.
- When you exhale the diaphragm muscle relaxes and moves back closer to your lungs, this decreases the space inside of your chest cavity, which increases the pressure in the cavity, and allows your lungs to expand.

Worksheet attached:

WORKSHEET:

1. **Airplane Wing.** Circle the direction the paper moved in when you blew air across it:



2. **Ping Pong Ball Challenge.** Where did the ping-pong ball go when you blew air into the soda bottle funnel?

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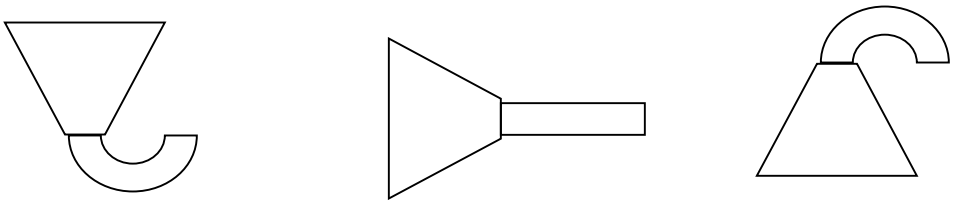
3. **Straw Seesaw.** Fill in the line that shows what your seesaw looked like when you blew air under one side. Circle the side you blew air under.

4. **Vacuum Funnel.** Draw where the ball was when the vacuum was on.



TABLE/FLOOR