Fluids Part 4: Pressure

In last week's e-mail we looked at how changing the temperature of a sample of a **fluid** changes the **fluid's** density. We asked:

1. How can we use the ideas of temperature and density to explain how wind occurs?
2. Where does pressure fit into this?

Air pressure

To begin, let's take a look at **air pressure.** Here's an image that may help:

Imagine a rigid, lightweight plywood or plastic sheet suspended from the ceiling. Tennis balls are thrown at one surface of the sheet. The tennis balls exert forces on the surface of the sheet as they hit it. The sum of *all* the forces being exerted at the same time on the surface of the sheet is the **pressure** on the surface.

Like the tennis balls, tiny particles (molecules of oxygen, nitrogen, carbon dioxide, and water vapor) of air are also pushing against <u>all</u> surfaces of the sheet, exerting pressure on the sheet. Because the **air pressure** is equal on all the surfaces, the sheet does not move. But when the combined pressure the tennis balls and the air exert on one side is greater than the **pressure** of the air on the other side, the sheet will move away from the barrage of tennis balls. Similarly, if the **pressure** from the air is great enough, it can make objects and substances move. For instance, when you blow air into a balloon, the **pressure** on the rubber on the inside of the balloon increases and the rubber expands. If you blow too much air into the balloon, the **pressure** gets so great that the rubber breaks, and the balloon pops.

Air pressure is the push exerted on objects or substances by the tiny molecules that are bumping against and bouncing off the surface of the object or substance.

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How can we gauge the intensity of air pressure? (How hard are those tennis balls being thrown?) Here's a "thought experiment":

Air pressure experiment

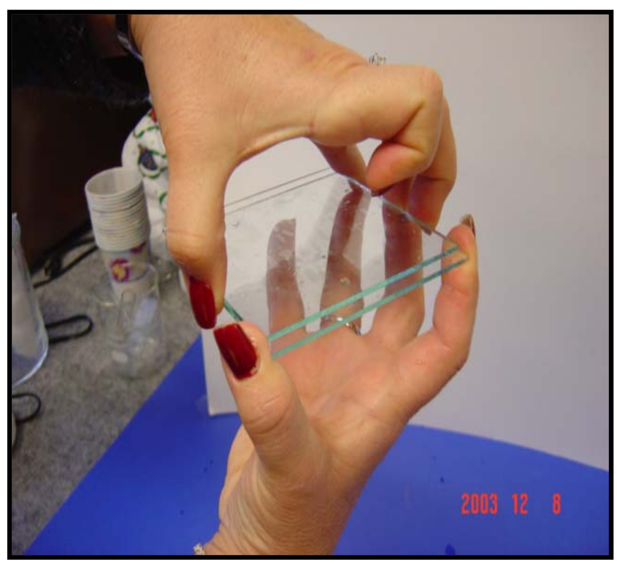
You'll need:
- 2 large glass sides
- water

Procedure:
1. Wet both glass slides to ensure that all surfaces are flat (most glass has tiny flaws)
2. Place slides together, one on top of each other, on a tabletop.
3. *Predict what will happen when you attempt to lift the top slide straight up off the bottom one.*

So what happens?

No matter how hard you pull straight up, you will not be able to lift the top slide. That's because the **air pressure**, pushing in all directions, is 14.7 pounds per square inch at sea level. "The force on 1,000 square centimeters (a little larger than a square foot) is about a ton!"[1]

This sounds like an incredible force! How do we deal with it? We're so used to it, we don't even notice it unless we go far above or far below sea level. Remember, there is plenty of air inside our bodies as well, exerting pressure in all directions.



Here's an **air pressure** "thought experiment" that provides evidence of **air pressure** in multiple directions. You've likely already done this as a child, messing around with your food.

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The straw experiment

You'll need:
- A clear straw or tube
- A small glass half-filled with water

Procedure:

1. Place the straw into the glass.
2. Suck the water about three-quarters of the way up the straw
3. Before removing your mouth from the straw, place your finger over the top of the straw. *What do you predict will happen to the level of the liquid inside the straw?*
4. *What will happen when you remove your finger?*

So what happens?

When you have your finger over the straw, there is a lot of **air pressure** on the bowl of water, but only a tiny amount of air pressing down on the water inside the straw. Therefore, the water level of the liquid inside the straw does not move. When you remove your finger, however, you allow much more air to push down on the water inside, which makes the water move out of the straw and into the glass, causing the water level in the glass to rise. Depending upon the size of the glass and straw, it may be a small change, but it is perceptible.

(Remember messing around with this as a kid? Your students have most likely done this as well.)

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Temperature, density, pressure, and wind

Now let's connect last week's concepts of **fluid** temperature and density to **pressure**. How can we combine these ideas to help us teach about wind?

Remember last week when we mixed hot and cold water? We showed that when a **fluid** is cold it is denser than when that **fluid** is hot, and this leads to the movement of fluids. In this case, cold and hot air react the same as cold and hot water; this contributes to the air movement known as wind:

> "The atmosphere is composed of air which, in turn, is made up of tiny particles of different gases, nitrogen, carbon dioxide, water vapor and oxygen. The Sun shines on our atmosphere all of the time. But, it heats the surface of the Earth unevenly, so that in some places it is warm while in other places it is cold. As air gets warmer, its particles speed up and the distance between the particles is greater. The density of the air decreases as it warms and colder, less dense air around it slides under and pushes the warmer air up. Differential heating results in the motion of air masses called convection currents. The differential heating of the Earth's surface and the resulting convection is what causes wind on this planet."[2]

For students, the swaying tree branches, the feel of a breeze on their faces, the spinning motion of a stationary pinwheel are all examples of *evidence* of the existence of wind, but not an explanation of it. To fully understand wind, they need to realize the connection between temperature, density, and pressure of **fluids**.

Upcoming

Next week we'll tie the **Fluids** series together by looking at liquids, gases **and** solids.

In the meantime, consider this; it's a fill-in-the blank item:

> The two reoccurring themes for the **Fluids** series are:
>
> 1. Matter is made up of ________.
> 2. They are in _____________.

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What do the standards say?

In the Elementary Core Curriculum, Standard 4, The Physical Setting,

Major Understandings state:

- 2.1a Weather is the condition of the outside air at a particular moment
- 2.1b Weather can be descried and measure by:
  - temperature
  - wind speed and direction
  - form and amount of precipitation
  - general sky conditions (cloudy, sunny, partly cloudy)

In the Intermediate Core Curriculum, Standard 4, The Physical Setting,

Major Understandings state:

- 2.1b As altitude increases, air pressure decreases.
- 2.2k The uneven hearing of Earth's surface is the cause of weather.
- 2.2l Air masses form when air remains nearly stationary over a large section of Earth's surface and takes on the conditions of temperature and humidity from that location. Weather conditions at a location are determined primarily by temperature, humidity, and pressure of air masses over that location.

[1]http://kids.earth.nasa.gov/archive/air_pressure/index.htm
[2]http://sln.fi.edu/tfi/units/energy/whatwind.html

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