Pressure lab

Station 1: Vacuum

Explore how pressure affects the following (by evacuating air out of the container and then releasing the valve):
Balloon filled with air
Balloon filled with water
Marshmallow
Tangerine
Cherry tomato
Don’t forget to reflect in your journal.

Based on your observations what do you think will happen to the marshmallow when you evacuate the container?
Draw a face on a marshmallow and test your prediction. Now, release the valve and observe the marshmallow
In your journal, explain your observations
What will happen to the marshmallow?

Gordon evacuates air out of the container

**Station 1: Vacuum (Explanation)**

When you pump air out of the container, the pressure in the container drops. Items that contain air cavities (e.g., balloon with air) are now able to expand compared to their size at atmospheric pressure. Since water is, to a large extent, an incompressible fluid, the size of the balloon containing water will be the same under low pressure and under atmospheric pressure. A marshmallow contains air pockets and therefore it will expand when you create vacuum in the container. When you release the valve, air rushes back into the container, increasing the pressure (until it reaches atmospheric pressure) and the marshmallow will return to its original size. If you would to increase the pressure in the container the marshmallow will shrink.
Station 2: Bernoulli

Below are three challenges. Experiment with them and explain your approach.
(1) Can you fill the bag in one blow? Have a friend holding the bag at the knotted end so the bag is horizontal.
(2) Can you tilt the flame of a candle to the left side/right side, using a straw?
(3) Hold the piece of paper just under your bottom lip. Can you lift it up without touching it with your other hand?

Materials for Station 2

What is the common to all these experiments? Discuss it with your group and reflect in your journal.
Hint: draw the pressure distribution in each of these experiments.
Station 2: Bernoulli (Explanation)

All these experiments can be explained using Bernoulli’s principle. When you blow into the bag, holding the bag close to your mouth, the air rushes into the bag and reduces the pressure in. Since you are blocking the ability of air from outside to get into the bag, no additional air can get it. When you hold the bag few inches away from your mouth and blow toward the bag you create a stream of air with a higher velocity and hence lower pressure. The air around the opening of the bag is under higher pressure compared to the air that is blown and therefore rushes into the bag with the blown air.
Similarly, you can move the flame sideways by blowing air with a straw sideways from the candle. By blowing air you create a region of low pressure (according to Bernoulli’s principle: higher velocity, lower pressure). Air will flow from the surrounding higher pressure to the region of low pressure causing the flame to tilt towards the location of lower pressure.

Last, when you place the piece of paper below your lower lip and blow you create a region of higher velocity and low pressure above the paper. Below the paper the pressure is higher causing it to lift.
LOW

Paper (with blowing)

Paper (no blowing)
Station 3: Perception of weight

You have two steel balls (a big and a small one).
1. Hold each ball in one palm. Which one is heavier?
2. Choose a volunteer and cover his/her eyes. Place each ball in a funnel (note, a small beaker was inserted to each funnel to hold the ball still. Experiment does not work well if the ball is rolling) and ask the volunteer to hold each funnel at its collar. Ask the volunteer which ball is heavier and record his/her answer. Repeat this experiment with another volunteer/s.

Materials for Station Three

Was the perception of weight in the “blind” test different from the original one (1)? Why? Explain in your journal.
Weight the balls to determine which one is heavier and reflect in your journal.
Pressure is fun for everyone!

**Station 3: Perception of weight (Explanation)**

The mass of the large ball is 144g and that of the small ball is 128.7g. When you hold the balls in your hands the smaller ball exert higher pressure on your hand (smaller surface area; \( P = \frac{F}{A} \), where \( P \) is pressure, \( F \) is force and \( A \) is surface area) making you feel it is heavier. When you hold the balls in the funnels, the surface area to which the force applies is similar for both balls and they appear to be of equal mass (or the more sensitive of you may say the larger ball is slightly heavier).
Station 4: Hydrostatic pressure

You have a pipe with 1 small exit hole near the bottom and several large holes plugged with rubber stoppers. By removing a stopper and letting water overflow through the hole, you can fix the height of water column above the exit hole.

1. What do you expect to happen when you fill the tube with water and open the exit hole? Explain your observations in terms of the forces acting on the fluid.

2. What do you expect will happen when the water height is increased? Why?

Begin by removing the lowest rubber stopper. Hold your finger over the small exit hole, and fill the pipe with water until it runs out the hole the stopper was in. Measure the height of the water column above the exit hole. Then let the water run out the small exit hole while you keep filling the pipe with water. Note how far the water travels (when it first strikes the ruler). Repeat the steps for the four lower holes.

Materials for Station Four
Station 4: Hydrostatic pressure (Explanation)

1. What do you expect to happen when you fill the tube with water and open the exit hole? 
   The weight of the water columns exert pressure on the water at the level of the hole (imagine a cross-sectional area of the tube at the level of the hole), causing it to shoot out.

2. What do you expect will happen when the water height is increased? Why? 
   The pressure will increase causing the water to shoot to a larger distance. 
   Recall: hydrostatic pressure is given by \( P = \rho gh \), where \( P \) is pressure, \( \rho \) is the density of water, \( g \) is the gravitational acceleration and \( h \) is the height of the water. If \( h \) increases \( P \) must increase, too.
The pressure (ρgh) is the potential energy per unit volume. As a parcel of water squirts out of the column most of this energy is transformed to kinetic energy (ρv²/2, where v is the velocity perpendicular to the hole). Some energy is lost to friction on the side of the hole, and thus when the hole is very small the velocity is reduced compared to larger holes.
Extra Pressure Demos:

Glass ball and balloon
Hair dryer and ping pong ball

Pascal Press