Name______________________

LAB 10
Pressure and Fluids

What to learn and explore

Physicists have found that if they visualize (or *model*) a gas as a collection of small, hard molecules in constant random motion, it can help explain the pressure that gases exert on their surroundings. As you do the experiments below, try to see if this model can help you make predictions that correspond to the observed pressure behavior of air and water vapor. Do some of the behaviors you observe <u>not</u> correspond to the model predictions?

What to use

Suction cups, Magdeburg hemispheres, liquid nitrogen, balloon, metal cans, vacuum pumps, balls, blowers, balloon bottle, light bulbs, funnel, ping-pong ball. Fun things to use with the liquid nitrogen: flowers, banana, grapes…..etc. Here's your chance.

What to do

The following fun and simple experiments will help you discover some surprising principles about the air (a fluid) that surrounds us. You may do the various experiments in any order. Answer the questions posed, and other questions of your own—*such as* where else do you see these principles in action?

As usual, (a) make predictions in writing before making observations and (b) discuss your predictions and observations with your lab partners.

Mandatory Comments

When you finish the lab, please write your comments here. Which experiments were the most helpful in showing you the underlying principles we were trying to demonstrate? Were some of them not so helpful? Did any of the experiments surprise you?

1) Suction Cups

Look at the different sizes of suction cups and predict which of the cups will be hardest to remove after pushing them onto a smooth surface to make them stick.

a) Write down your prediction in the space below along with your reasoning — i.e., why should one be harder than another? Discuss and compare your prediction and reasoning with those of your partners before doing the experiment.

b) Try the experiment. Can you tell which is hardest? Do your partners agree? How do the results compare with your predictions? If they differ, can you think of an explanation?

c) Remember that atmospheric pressure provides a force of about 15 pounds on every square inch of surface that contacts the open air. To get a feel for how much this is, hold the metal bar vertically on your hand.

Calculate the total force on the rubber square by estimating how many square inches it is.

2) Magdeburg Hemispheres

Look at the Magdeburg hemispheres and note that they don't screw together but simply fit loosely against one another with a soft gasket to make a seal. Use a pump to remove some of the air from inside the sphere.

a) After you have pumped out some air, in what way have you changed the number of collisions that air molecules are having with the inside of the sphere?

b) How will this affect the ease of pulling the hemispheres apart? Write down your prediction and reasoning below and discuss it with your partners, then try to pull the hemispheres apart.

c) Describe the results—were you able to pull the hemispheres apart? Try again after pumping more or less air out. How do the results compare with your predictions? If they differ, can you and your partners explain why?

d) Would it be easier or harder to pull the hemispheres apart if they were very large? (Assume you pumped out almost all the air in both cases) Why?

3) Inside-out Balloon

Blow up a balloon inside a plastic box, and then put a stopper in the hole in the side. (DO NOT try to blow up the balloon with the stopper in place!)

a) Why doesn't the balloon deflate - what keeps it “blown up?”

4) Marshmallows or Balloon in a Vacuum

a)Predict what will happen to the marshmallows (or balloon) when you remove the air from the vacuum jar. Do the experiment and report your results. What happens when you let the air back in?

5) Steam in an Aluminum Can

In this experiment, you will fill an aluminum can with steam (water vapor), then quickly immerse the end of the can in cold water. (Hold the can over the steam generator for a full 30 seconds.)

a) What do you and your partners predict will happen? Why?

b) Describe the results of the experiment and compare them with your prediction in the space below.

6) Balloon in Liquid Nitrogen

Nitrogen is a gas at room temperature; it makes up nearly 80% of our air, mixed with about 20% oxygen. The air molecules are bouncing around and banging on every surface they can touch, as we observed in the previous experiment. But when air is cooled, its molecules move more and more slowly. And when it becomes really cold, the molecules condense into a liquid and stop bouncing around entirely.

If you put an inflated balloon into contact with liquid nitrogen, you gradually cool the air inside all the way down to liquid nitrogen temperature. What will happen? **Do not touch the liquid nitrogen; it can freeze water and human tissue very quickly!** You may use a pencil or a stick to push the balloon deeper into the nitrogen.

a) Discuss your ideas with your partners and write down your prediction and reasoning.

b) What do you observe? Can you explain it? How do your observations compare with your predictions?

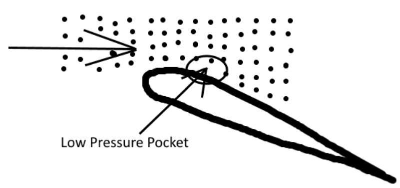
c) With your partners, discuss and try to answer this question: How is this balloon experiment similar to the experiment with the steam in an aluminum can (part 5)?

Section 2- Lift! – Fluids flowing past curved surfaces.

When a fluid flows past a curved surface, it can drag away some of the air that was hanging out behind the curve. This leaves a little pocket of reduced pressure behind the curve. The flowing air is pushed toward this pocket, which causes it to hug the surface. The object is also pushed toward the low pressure pocket, which is what we call **lift.** In these stations, look for this principle in action.

7) Airplane wing in wind tunnel.

Watch the film on the computer. Notice how the air over the top of the wing changes its direction.



What pushes the flowing air toward the low pressure pocket?

What pushes the wing toward the low pressure pocket?

Which force do you think is bigger? (Hint – remember Newton's third Law)

8) Wing shapes in air stream.

The air hose can be moved so that it blows air over or under the different wing shapes. For each situation, predict what will happen and then test your prediction:

1) Air blows under flat side of wing.
   Prediction:

   What happened?

   Draw a sketch of the how you think the air flows in this situation.

2) Air blows over flat card.
   Prediction:

   What happened?

   Draw a sketch of the how you think the air flows in this situation.

3) Air blows over the top of curved wing.
   Prediction:

   What happened?

   Draw a sketch of the how you think the air flows in this situation.

9) Design your own wing.

On the tablet we have a wind tunnel simulator. You can draw your own wing shape and see how air flows around it. To draw, go to "Interact" and click "Draw Wall". To reset, click "File" and "Reset".

First draw a flat wing (a straight line). What happens to the air that goes over the top?

About how much lift does it create?

Add a curved top to your wing. Now what happens to the air that goes over the top?

About how much lift does it create?

A good wing will generate a lot of **lift**. What we hope to avoid is **drag** - a backwards force which slows down a plane. Play with different shapes to see how much lift you can get while minimizing drag. You can rotate your wing with two fingers inside the wing.

10) Ball in an Air Stream

Carefully observe a beach ball in an air stream from a blower.

a) Using the streamer and your eyes, see if you can map out the fluid flow around the ball. Does the air stream mostly go above the ball, below the ball, or neither? Does the ball change the direction of the air from its original course? In which way? Draw a sketch below showing how you think the ball changes the direction of the air flow, if any.

b) Based on how the ball redirects the air, in which direction is the force on the flowing air. Where do you think the low pressure pocket is located?

c) In which direction is the force on the ball? Which is bigger, the force on the air or the force on the ball?

11) Hanging Light Bulbs

a) Predict what will happen when you blow between two hanging light bulbs. Draw a sketch of how you think the bulbs will redirect the air. Based on that, which way will the bulbs move? Do the experiment and report on the results.

12) Ping Pong Ball in Funnel

a) Predict what will happen when you turn on the air blower with the ping-pong ball inside the funnel with the face up. Do the experiment and report on the results.

b) Now, repeat the experiment, except with the funnel facing down. As usual, first discuss your prediction with your partners, then do the experiment, describe the results and compare with prediction in the space below.