PHY152H1S – Practical 1: Fluids

Practices in keeping a good notebook :
Everything you do in the lab should be recorded in your lab notebook while you are doing the practicals activities. There is no point in copying information that is already in this guide sheet. Nor is there any point in writing a detailed essay on your procedure; note form is quite sufficient, as long as it is complete and comprehensible to your Practicals Instructor.

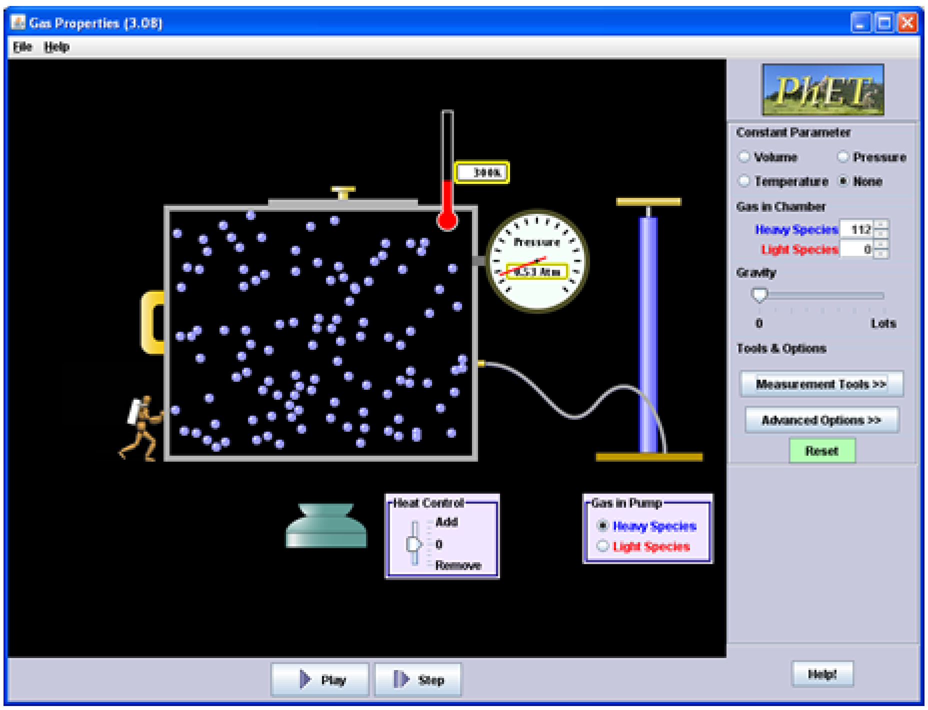
- List the NAMES of all participants on the first page of each day's write-up. Note if any participants arrived late or left early.
- Put the DATE (including year!) at the top of every page in your notebook.
- NUMBER the pages in your notebook, in case you need to refer back to previous work.
- DO NOT use loose paper for data taking or calculations. All your work should be entered and appear in your lab notebook.
- Diary format means that the record is written in the order in which a procedure, calculation or inspiration actually occurred. You should NOT leave blank pages to be filled in later.
- If you use graph paper (obtainable from the Resource Centre) or have computer drawn graphs, or screenshots, stick or staple them in neatly beside the description of your experiment. There is a color printer in the Practicals room.
- You should also NOT spend much time "tidying up" your notebook, or "rewriting history"; your time is too valuable, and it vitiates the function of the notebook.
- Do not us liquid paper, or big blotchy marks, or torn-out pages to obscure parts of your work. If you have written down something that you later realize is wrong, simply put a line through it and label it as "wrong". Many times you might figure out later that what you thought was wrong was not wrong and you'll be glad you didn't blotch it out!

Note that the activities below have numbers which refer to numbers in the Fluids Module at http://faraday.physics.utoronto.ca/Practicals/ . We are skipping some of the activities there, so some activity numbers are missing (for example, there is no "Activity 2").

Activity 1 (20 minutes)

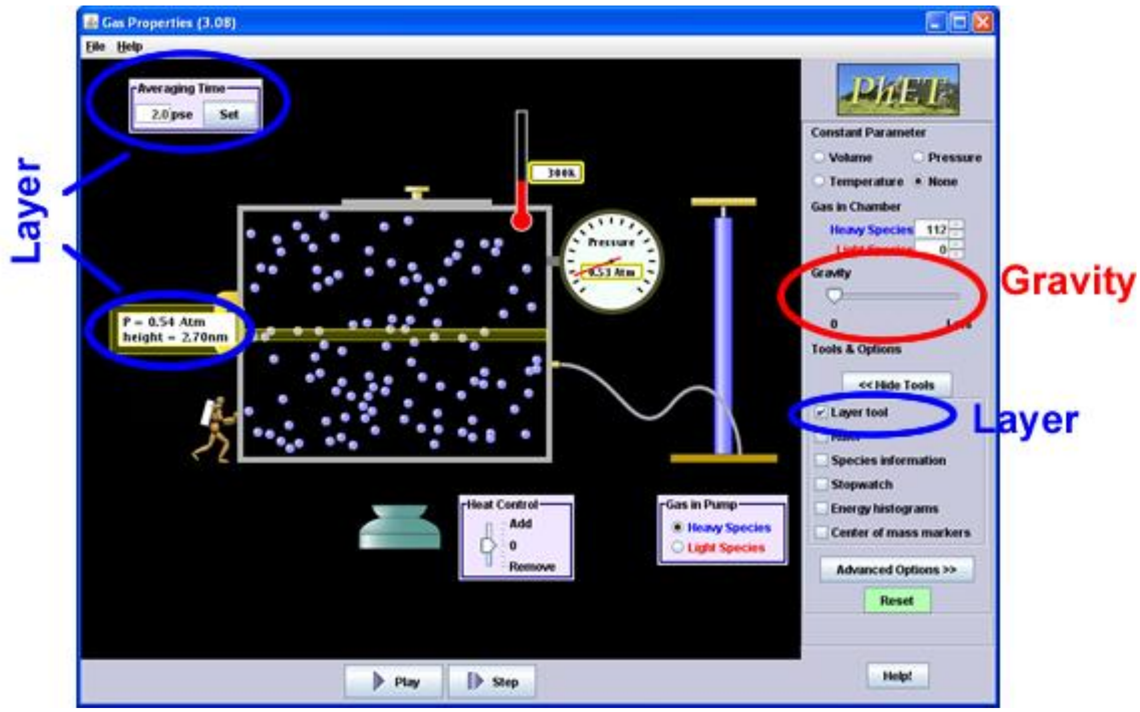
Open the `gas-properties.jar` animation which is located at `feynman:public/Modules/Fluids`.
Or: http://faraday.physics.utoronto.ca/Practicals/Modules/Fluids/PHET/gas-properties.jar
There are many useful ways to use this animation, and we will only draw you attention to a couple of things that you may wish to do; you are encouraged to explore further.

Here is a screen shot of the default animation after some *Heavy Species* molecules have been pumped into the container:



A. You will notice that the reading of the Pressure gauge is not constant. Explain why this is so. What would be necessary for the pressure reading to be more constant? How would you present a value for the pressure that also expresses your observed variations?

There are many options for controlling the animation. We shall describe two of them.

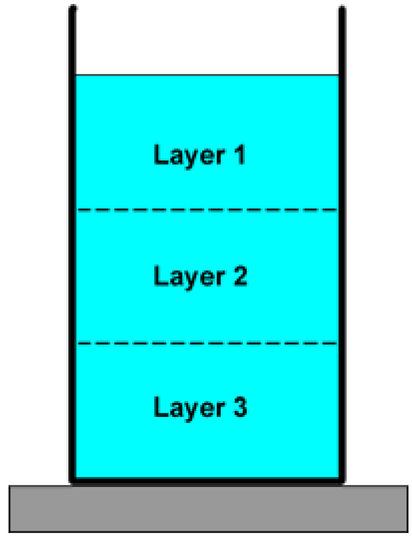


1. By default the acceleration due to gravity *g* is zero. You may introduce a non-zero value of *g* with the **Gravity** slider.
2. By clicking on the **Measurement Tools** button you may turn on the **Layer tool**. This tool measures the pressure in the gas at a specified height; you may drag the position of the measurement with the mouse. You can also specify the time over which the value of the pressure is averaged.

Here are some suggested explorations.

B. Use the **Layer tool** with various settings of the Averaging Time. Describe what happens. If this was not part of your answer to Part A, should it have been?
C. With **Gravity** set to 0, predict how the pressure in the gas varies with height. Check your prediction using the **Layer tool**. Were you correct? If the pressure varies with height, does it vary is the height, the height squared, one over the height, or what?
D. Introduce a non-zero **Gravity**. Predict how the pressure varies with the height. Check your prediction. Were you correct? If the pressure varies with height, does it vary is the height, the height squared, one over the height, or what? [This is a difficult question; your answer may be qualitative, and will be marked based on effort!]

Activity 3 (20 minutes)



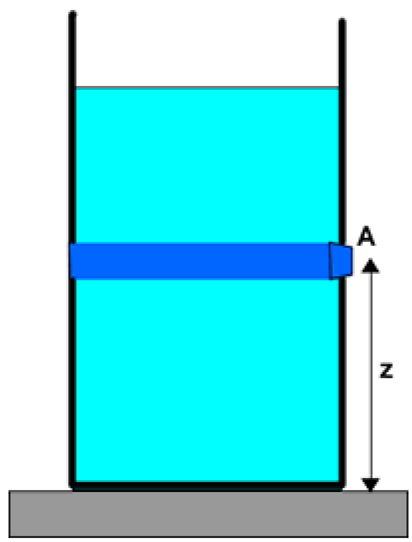
A rigid rectangular container filled with water is at rest on a table as shown. Two imaginary boundaries divide the water into three layers of equal volume. No material barrier separates the layers.

A. Draw a free body diagram for each layer. The label for each force should include:
   - A description of the force, and
   - The object on which the force is exerted, and
   - The object exerting the force.

B. Rank the magnitude all the *vertical* forces you have drawn for Part A, from the smallest to the largest. Explain how you determined the ranking.

C. Rank the magnitude of all the *horizontal* forces you have drawn for Part A, from the smallest to the largest. Explain how you determined the ranking.

Activity 4 (10 minutes)

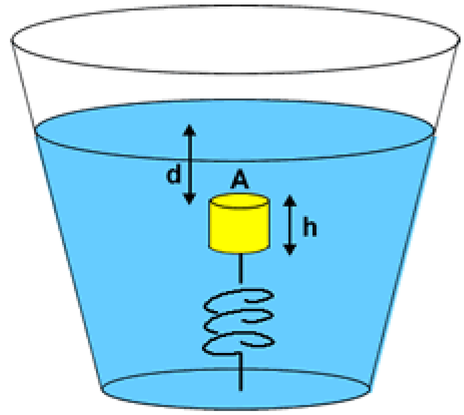


A small square hole of area **A** is cut in the side of the container of Activity 2. The centre of the hole is a height **z** above the tabletop. Consider the rectangular section of water of area **A** aligned with the hole, as shown.

A. Draw a free body diagram of all the forces acting on the rectangular section of water.

B. What will happen to the water just inside the hole?

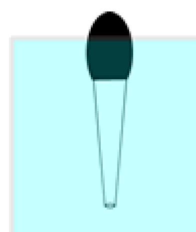
Activity 5 (20 minutes)



A bucket of water has a spring soldered to the bottom. Attached to the other end of the spring is a cylindrical cork of mass *m*, height **h** and area **A** which is stationary below the surface of the water, as shown. The top of the cork is a depth **d** below the surface of the water. The spring has a spring constant *k* and is stretched a distance **x** from its equilibrium position. The density of the water is ρ.

A. Draw a free body diagram of all the vertical forces acting on the cork. Evaluate the magnitude of those forces. Determine **x**, the amount that the string is stretched from its equilibrium position.
B. Imagine you are holding the bucket by its handle, which is not shown. You go to the top of the CN tower and step off, still holding the bucket. As you and the bucket fall towards the ground what is the motion of the cork? Does it move towards the bottom of the bucket, towards the top, or stay where it is? Explain.

Activity 7 (15 minutes)



Please do this Activity with all the apparatus in the supplied 50×30×10 cm dishpan to minimize the water spilled onto the tabletop.

You are supplied with a beaker. You should fill it with water nearly to the top. Place the supplied medicine dropper in the water with the squeeze bulb on top. Suck enough water up into the medicine dropper that it *just barely* floats.

You are supplied with an empty 2 liter plastic pop bottle. Fill it to the brim with water. Transfer the filled medicine dropper to the water in the pop bottle.

Screw the top tightly on the bottle. Squeeze the bottle. What happens to the medicine dropper? What happens when you quit squeezing the bottle? Explain why squeezing the bottle and increasing the pressure of all the fluids within would cause the observed motion. This is called a *Cartesian diver*.

The supplied toothpicks make it easy to “fish” the medicine dropper out of the bottle.

When you are finished with this Activity, *carefully* empty all the water into the sink.

Activity 9 (15 minutes)

A ship is in a canal lock, which is only a little bit larger than the ship itself. The ship is loaded with steel ingots, which are large bars of steel. The crew becomes angry with the captain of the ship and throws the steel ingots overboard into the water of the lock.

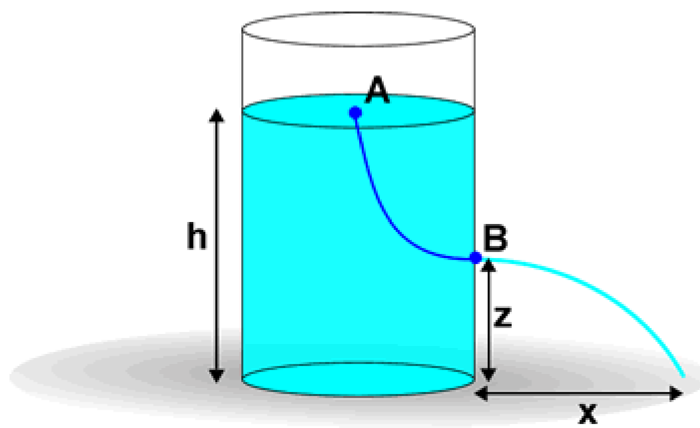
Does the level of the water in the lock rise, lower, or stay the same?

Check your prediction. You are supplied with a plastic tank which is about 30×20 cm and 12 cm deep, and a dishpan which is about 50×30 cm and 10 cm deep. Place the plastic tank in the dishpan and fill the tank about half-way with water. Place the supplied weight in the bottom of the supplied plastic boat and gently place it in the water. You may mark the height of the water in the tank with a small piece of masking tape. Carefully lift the boat out of the water, place the weight at the bottom of the tank, and put the boat back in the water.

When you are finished with this Activity, *carefully* empty the water into the sink.

Activity 10 (If You Have Time)

A cylinder with water of height **h** has a small hole cut in the side at height **z**. The water strikes the ground at **x**. The figure shows the streamline from the top of the water at **A** to just outside the hole **B**. Bernoulli's equation tells us that the quantity $p + \frac{1}{2}\rho v^2 + \rho g y$ is conserved along the streamline, and so has the same value at points **A** and **B.**



If the hole is small, it is reasonable to approximate that the speed of the water at **A** is zero. Since point A and B are in contact with the outside air, it is reasonable to approximate that the pressure is the same at point A and B, that of atmospheric pressure in the room.

A. What will be the shape of the stream of water emerging from the hole until it strikes the ground?
B. Without using any equations, describe how the speed of the water at **B** varies with **z**, How will the distance **x** depend on **z**?
C. Use Bernoulli's equation and your knowledge of projectile motion to derive the answers to Part B. For what value of **z** will **x** be a maximum? What approximations are you making? Are those approximations reasonable?
D. You are supplied a cylinder with small holes cut in it at values of **z** = 0.75 **h**, 0.50 **h**, and 0.25 **h**, where the height of the water **h** is indicated by a mark on the cylinder. Place the cylinder in the supplied 50×30×10 cm dishpan: place it on one end of the dishpan with the holes pointing towards the other end of the dishpan. Fill the cylinder with water to the mark. As the water level drops appreciably add water. Is what you see consistent with your results from Parts B and C?

Placing a strip of masking tape on the edge of the dishpan on which you can mark where the water lands is a convenient way to do this Part of the Activity.

When you are finished with this Activity, *carefully* empty the water into the sink.

This Student Guide was written by David M. Harrison, Dept. of Physics, Univ. of Toronto, May 2008.

The animation used in Activity 1 is from the Physics Education Technology (PhET) group at the University of Colorado, http://phet.colorado.edu/new/index.php. Activity 3 is based on Lillian McDermott et al., **Tutorials in Introductory Physics** (Prentice Hall, 20020, ST 219. Activities 6 and 9 are based on David M. Harrison and William Ellis, **Student Activity Workbook**, 3rd ed. (Norton, 2008), 18.4 and 18.6. The figure for Activity 6 is slightly modified from a figure from Wikipedia, http://en.wikipedia.org/wiki/Hydrometer, retrieved June 19, 2008.

Last revision: January 10, 2014 by Jason J.B. Harlow.