LAB 5 FORCE, PRESSURE and Volume by R.E. Tremblay

Purpose: To distinguish between force and pressure and to determine the relationship between the pressure and volume of a confined gas.

Materials: Syringe and mounting block, 5 kg of mass in 0.5 kg increments, vernier caliper, graph paper.

Discussion: Pressure is defined as force per unit area.
An inspection of the equation $P \equiv \frac{F}{A}$, reveals that pressure is directly proportional to the applied force and inversely proportional to the area of contact. For example, if the force applied to an object is kept constant and the surface area in contact is cut in half, the pressure doubles. A sharp knife cuts better than a dull knife because a sharp knife with its smaller contact area, applies a large pressure to the object being cut. The small area of the knife edge increases the pressure applied with any given force. On the other hand, If you keep the contact area constant but double the applied force, the pressure will double.
In this experiment, you will examine the relationship between the pressure of a confined gas and its volume. When you add weights to the platform block, the air pressure in the container will increase. The total air pressure in the container will equal the pressure from the weights plus that due to the outside atmospheric pressure.

The general gas law shows the relationship between pressure, volume, temperature and the number of gas molecules in a sealed container.

$$PV = nRT$$

P pressure; Units are $\frac{N}{m^2}$ named pascals

V volume; Units are liters or milliliters (ml)

n number of moles of gas; there are $6.022x10^{23} molecules$ in one mole.

R gas constant $8.31\frac{joule}{mole \bullet kelvin}$

Temperature in kelvins

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Solving the general gas law for pressure, we see that the pressure in the container is inversely proportional to the volume of the confined gas.

$$P = \frac{nRT}{V}$$

In this lab, we will try to verify the fact that the pressure of a confined gas is inversely proportional to its volume.

Please view the linked Pressure Lesson, before continuing.

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Lab preparation: Name ________________

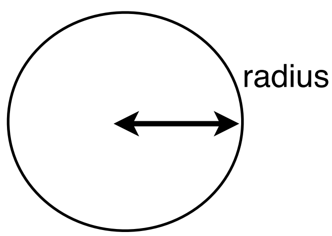
Hand this page in, before the beginning of the lab.

Background information that you need to know

1. The area of a circle can be determined by the following equation:

$$Area = \pi r^2$$, where r is the radius of a circle.

The radius of a circle is the distance from the center of a circle to the edge of the circle. The radius is equal to one-half the diameter of a circle.



2. There are 100 cm in one meter. You should be able to convert back and forth between these two sets of units.

ex. Let’s convert 3.25 centimeters to meters.

$$3.25cm \bullet \frac{1m}{100cm} = 0.0325m$$

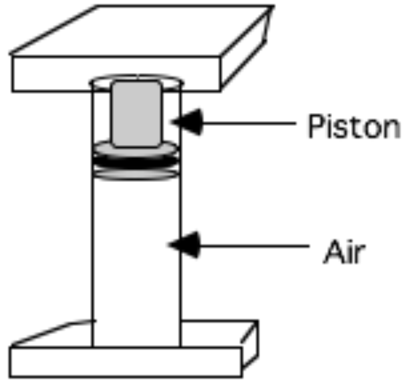
Problem: If we measure the diameter of a circle to equal 2.36 cm, determine the area of the circle in square meters.

Show your work here

Enter you answer here ____________________________

Lab. 5 continued

Procedure:



1. Measure the diameter of the syringe opening with the vernier caliper. Convert the diameter to meters and enter the value into your data sheet.

2. Determine the area of the syringe opening in square meters. Use the equation for the area of a circle. $Area = \pi r^2$ Know by heart.

3. Remove the end cap on the bottom of the cylinder and move the piston of the syringe to approximately the 35 ml mark. Do not get the rubber gasket dirty. The grease on it prevents the air molecules from escaping during the experiment. If air escapes, you will have to start the experiment over. Replace the end cap. Push the syringe in. It should bounce back close to its original position. Mount the syringe in the holder in an upright position.

4. Place a 5.0 kg mass on the piston and gently push the piston into the syringe. Allow the piston to slide to its equilibrium position. Record the volume of the confined gas next to the appropriate force on the data sheet. Be careful that the weight does not fall off and break your toe. I hate when that happens.

The weight of the mass (Wt=mg), is the **force on the piston**. The weights of the masses have already been calculated and entered in your data sheet.

5. Repeat step 4 with a total of 4.5 kg mass, then 4.0 kg mass etc., until the total mass is 0 kg.

6. Calculate the pressure caused by the weight of the masses and enter the value in the chart. Ex. using the 5.0 kg mass

$$\text{Pressure} \equiv \frac{Force}{Area} = \frac{weight}{Area} = \frac{mg}{Area} = \frac{5.0kg \bullet 9.8\frac{m}{s^2}}{Area} = \frac{49N}{Area}$$

7. Add the atmospheric pressure to the pressure from the masses to determine the **total pressure.** Enter the sum in the data sheet under total pressure.

8. Make a graph of the total pressure versus $\frac{1}{Volume}$. Remember that the total pressure is the pressure due to the weight of the masses plus the atmospheric pressure.

9. Use your graph to predict the volume of the confined gas if the total pressure is 120,000 N/m^2.

10. Use your graph to predict the total pressure of the gas if the volume in the syringe is 15 ml.

11. Attach a sheet showing all work.

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Lab 5 pressure <u>Data sheet</u>: Name________________Section _____

Atmospheric pressure = 101,000 N/m^2
Diameter of syringe opening =_______________meters
Area of syringe opening = ________________ m^2

Force on piston due to mass (Newtons)	Pressure (pascals)	Total Pressure (Pascals)	Volume of gas (ml)	1/Volume (ml^{-1})
49				
44.1				
39.2				
34.3				
29.4				
24.5				
19.6				
14.7				
9.8				
4.9				
0				

Predicted volume when total pressure is 120,000 pascals_____________

Predicted total pressure when the volume is 15 ml _____________