

CHAPTER 3	Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas	BLM 3.2.3
HANDOUT		

In this investigation, you will observe the change in the volume of air trapped inside a syringe when you apply pressure to the plunger of the syringe and thus to the trapped air. You will use your data to determine the relationship between the pressure on the trapped air and its volume.

### Prediction

Predict what will happen to the air inside the syringe when you place weights on top of the plunger of the syringe.

### Safety Precautions

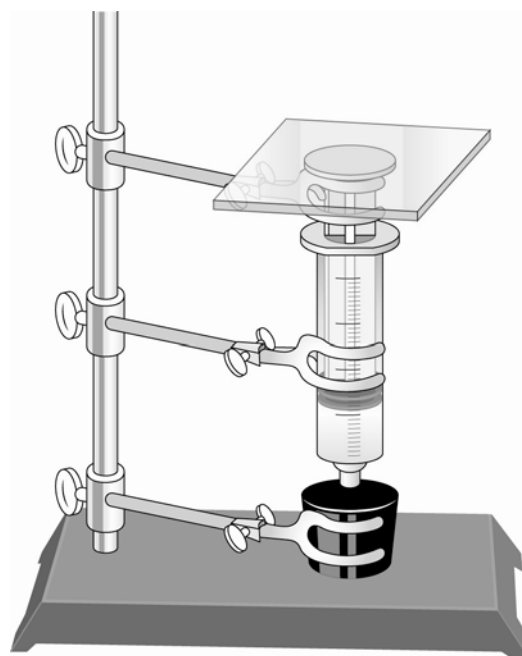
- Be careful to centre all of the books that are used for weights so they do not fall.
- Your teacher might choose to do this investigation as a demonstration.

### Materials

- 60 mL syringe
- square piece of plexiglass (about 15 to 20 cm on a side)
- glue (strong)
- retort stand
- 3 clamps
- rubber stopper
- scale (with range up to 100 N)
- weights (such as heavy books) totaling a mass of at least 6 kg
- barometer

### Procedure

1. Obtain a 60 mL syringe and measure the internal diameter. Calculate the radius. From the radius, calculate the cross sectional area of the syringe ( $A = \pi r^2$ ).
2. Ensure that the plunger is air tight but slides freely. You might have to lubricate the plunger.
3. Glue the plexiglass platform onto the top of the plunger. Be sure to centre the platform.
4. Determine the weight of the plunger-platform assembly. If the scale or balance that you are using reports mass in kilograms, convert to weight in newtons (N) by multiplying the mass by 9.81.



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- Insert the tip of the syringe into a small hole that has been drilled in the rubber stopper. The hole does NOT penetrate the stopper. It should be just deep enough to fit the tip of the syringe. The fit must be air tight.
- Assemble the apparatus as shown in the diagram. Notice that the rubber stopper is placed firmly against the base of the retort stand. The clamps on the stopper and the syringe are tight. However, the uppermost clamp is not touching the plunger. It is in place to prevent the plunger from falling in the event that it should begin to tip over. When you insert the plunger into the syringe, trap as much air as possible.
- Record your data in the following table.

Atmospheric pressure _____					
Cross sectional area of syringe in $\text{m}^2$ ( $A = \pi r^2$ ) _____					
Number of objects	Weight of added object, N	Total weight on platform, N	Total pressure, kPa (atmospheric pressure plus pressure due to objects)	Inverse of Pressure, 1/P (1/kPa)	Volume, mL
1 (plunger and platform)	0 N				
2					
3					
4					

- Read the current atmospheric pressure from the barometer and record the value. (Atmospheric pressure should not be corrected for altitude.)
- Record the weight of the plunger-platform apparatus and the volume of air in the syringe with the plunger in place.
- Calculate the pressure caused by the plunger platform apparatus by dividing the weight (force) by the cross sectional area of the plunger.

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11. Calculate the total pressure by adding the atmospheric pressure to the pressure due to the weight of the plunger-platform apparatus. Record the total pressure.
  
12. Determine the weight of the object (such as a heavy book) that you will be adding to the platform.
13. Record the weight in your table. (Recall: weight is mass times 9.81.)
14. Very carefully place the object on the platform. Be sure to centre the object on the platform. Observe and record the volume of the air in the syringe.
15. Calculate the total weight of platform plus object, the pressure due to the weight of the platform plus object (similar to Step 10), and total pressure on the air in the syringe (similar to Step 11). Record the data.
16. Repeat Steps 12 to 14 with more objects until you have added at least 60 N of weight to the platform.
17. Plot a graph of total volume,  $V$  ( $y$ -axis) versus pressure,  $P$  ( $x$ -axis).
18. Plot a graph of total volume,  $V$  ( $y$ -axis) versus the inverse of the pressure,  $1/P$  ( $x$ -axis).

### Analysis

1. What is the manipulated (independent) variable in this investigation? What is the responding (dependent) variable?
  
2. Which graph,  $V$  versus  $P$  or  $V$  versus  $1/P$ , appears to give the straightest line?
  
3. If the plunger and the rubber stopper had not given air tight seals, how would this have affected your data?

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4. How might a change in temperature have affected your results?

5. What do you call the variables of amount of air and temperature in this experiment?

### Conclusion

6. Describe the type of relationship that exists between volume and pressure.