Physics 233 **Lab 10**
November **Gas Processes**

Goals

1. To study the behavior of gasses behave when they are compressed.
2. To learn how to analyze data obeying a power law.
3. To write another complete lab report.

Equipment:

Pasco adiabatic gas law apparatus (shown below), cables, power supply, LabPro computer interface, carbon dioxide, argon

Reading:

- Chapter 10 (Power-Law Fitting and Log-Log Graphs) of the lab reference manual
- Review chapter T3
- Review chapter 3 (How to Write a Lab Report) of the lab reference manual

Pre-Lab Problems: Answer problems 1-3 in WebAssign (no need to copy into your notebook); answer problem 4 in your notebook.

1. Do problems 10.1, 10.2, and 10.3 (these are closely related) from the lab reference manual.
2. Suppose that you compress a gas very *slowly*.
   a. What type of process do you expect this to be? Why?
   b. What will happen to the temperature of the gas?
   c. How do you expect the pressure and volume to be related mathematically?
3. Suppose that you compress a gas very *quickly*.
   a. What type of process do you expect this to be? Why?
   b. What will happen to the temperature of the gas?
   c. How do you expect the pressure and volume to be related mathematically?
4. Which of the two processes listed above will you use to determine the adiabatic index, γ, for a gas? How will you find γ using pressure and volume data? (Be specific. You should use a plot of all of the data, not a single measurement.)

Note about the Apparatus:

- The computer interface will read voltages (0-5 V) from the sensors every millisecond. These voltages are converted into pressure, volume, and temperature readings using the calibration information given on the side of the apparatus.
- The pressure and volume sensors respond quickly, but the pressure measurements lag slightly (a few milliseconds) behind the volume measurements. You will correct for this problem.

- The unavoidable thermal inertia of the temperature sensor causes the temperature measurements to lag behind by 30-50 ms. You will not do quantitative analysis of the temperature data.

Lab Procedure:

1. Connect the pressure sensor to "CH1" of the LabPro, the volume sensor to "CH2", and the temperature sensor to "CH3". In *LoggerPro*, use the file "GasLaw-Slow" for the slow compressions and "GasLaw-Quick" for the quick ones.
2. First, perform experiments with air in the apparatus.
   - Make sure that the limit pins are in place. Raise the piston with one of the valves open. Close the valve before releasing the piston.
   - Collect data while compressing the air very slowly. Record the volume and pressure data for twenty times during the compression process that are approximately evenly spaced. For this slow experiment, there is no problem with a lag between volume and pressure data. Estimate uncertainties.
   - Repeat the experiment while compressing the air quickly (less than 0.1 s). Record the volume and pressure data during the compression process. Also, determine the time delay between the minimum of the volume and the maximum of the pressure. Correct the pressure data by shifting it backward by the delay time. If the compression takes longer than 0.1 s or the time delay is greater than 5 ms, do the experiment again.
3. Carefully follow the procedure below to change the gas in the apparatus.
   - The flow of gas must be kept at a low level to avoid breaking the temperature sensor (fine wires at the bottom of the piston). Transfer the gas from the cylinder where it is under high pressure into a mylar balloon.
   - Remove the piston limit pins so the range of volumes is as large as possible.
   - Start with the piston down. Connect the balloon to one of the valves.
   - With the second valve closed, fill the cylinder to maximum volume with the gas by gently squeezing the balloon as you slowly raise the piston.
   - Close the incoming valve. While pressing down on the piston, open the second valve and expel the gas through it. Close the valve immediately.
   - Repeat the previous two steps nine more times, ending with the cylinder full.
   - Keep the balloon attached to the input valve. If some gas escapes during the experiment, simply add more.
   - Replace the limit pins after changing the gas in the apparatus.
4. Repeat the slow and quick compression experiments with carbon dioxide and argon.

Post-Lab Assignment:

1. Use your measurements to determine the adiabatic index for each gas. You should use the corrected pressures. Be sure to find uncertainties, too.
2. Write a complete lab report for this experiment. It should be typed. Follow the instructions given in the laboratory manual. Be sure to include the following:
   - In the theory section, be sure to discuss what you expect the experiments (both slow and quick compression) to show and why (give equations).

- In the analysis section, be sure to compare all of your results (for all three gasses and for both slow and quick compression) to those you expected and note any variations. Discuss both random and systematic errors. Think about what would cause the second kind of error in this experiment.