Texas Instruments

Exploring Physics and Math with the CBL™ System

48 Lab Activities Using CBL and the TI-82

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Using the TI-92 with Exploring Physics and Math with the CBL™ System ..... Removable Card

The programs listed in the appendix are available on the Macintosh and IBM-compatible diskettes located at the back of the workbook. Use TI-GRAPH LINK to download these programs to the TI-82 from a computer.

ACTIVITY 27:

Elasticity of Gases: Pressure and Volume

Introduction

Gases are elastic. That is to say, a gas tends to expand or contract so as to fill its container. Consequently, increasing or decreasing the volume of a fixed mass of gas can have an effect on its pressure. This relationship is summarized in Boyle's law, which states that the volume, V, of a gas varies inversely with its pressure, p, when the temperature of the gas remains constant. Stated mathematically:

$$pV = constant$$

when the temperature of the gas does not change.

In this experiment, you will investigate the relationship between pressure and volume for a given mass of air at a fixed temperature.

Equipment Required

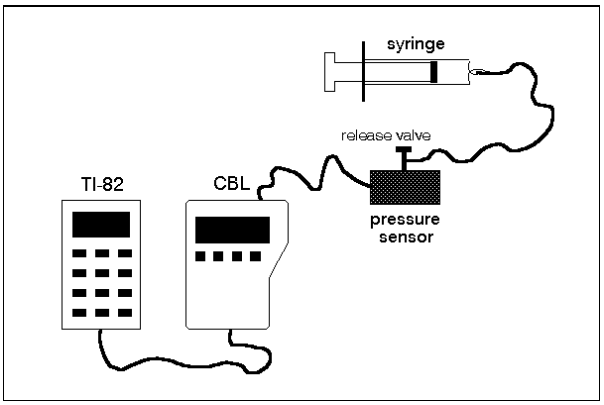
- CBL unit
- TI-82 graphics calculator with a unit-to-unit link cable
- Vernier pressure sensor (PS-DIN) with CBL DIN adapter
- Airline tubing
- Large hypodermic syringe

Program Listing

This experiment requires that you download or enter the PRESSURE program, listed in the appendix and contained on the diskette, into your TI-82 calculator.

Equipment Setup Procedure

1. Connect the CBL unit to the TI-82 calculator with the unit-to-unit link cable using the I/O ports located on the bottom edge of each unit. Press the cable ends in firmly.
2. Connect the pressure sensor to the Channel 1 (CH1) input on the top edge of the CBL unit.
3. Turn on the CBL unit and the calculator.



Equipment Setup

The CBL system is now ready to receive commands from the calculator. The TI-82 will store pressure values (in atmospheres) to list L4, and corresponding volumes (in cubic centimeters) to list L2.

Instructions

1. Attach the short piece of tubing at the end of the hypodermic syringe to the three-way valve on the pressure sensor as shown in the setup diagram.
2. Make sure the CBL and the TI-82 are turned on. Start the PRESSURE program on the TI-82 and select PRESSURE-VOL from the PRESSURE OPTIONS menu.
3. Open the release valve to expose the pressure sensor port to atmospheric pressure, and pull the plunger all the way out to maximize the amount of air in the syringe. With the release valve still open, press [ENTER] to zero the probe. Enter **8** when prompted for the number of data points to collect.
4. Close the release valve and adjust the plunger so that the volume of air in the syringe is 20 cubic centimeters. Enter **20** for the volume and press [ENTER] to collect the corresponding pressure reading.
5. Adjust the plunger to read 18 cubic centimeters and enter **18** when prompted for volume. Press [ENTER] to collect the corresponding pressure data. Continue in this manner until a total of eight data points have been collected.
6. After the data has been collected, a plot of pressure (in atmospheres) versus volume (in cubic centimeters) will appear on the calculator screen. Save the resulting graph to a PIC variable to print later with TI-GRAPH LINK.

Analysis

1. Print the PIC variable for this experiment using the TI-GRAPH LINK and affix it in your lab notebook. Be sure to include appropriate scales and axes labels on the printout.
2. Perform a power regression on the collected data from the STAT CALC menu on your TI-82 calculator. Because the volume data has been stored in list L2 and pressure data has been stored in list L4, the appropriate regression command is PwrReg L2, L4. Record the regression equation and correlation coefficient in your lab notebook.
3. Does the equation obtained in Step 2 agree with the mathematical model relating pressure and volume as described in the introduction section?

Repeat the experiment. This time, open the release valve and set the syringe to a position near the middle to start. Take data as the volume in the syringe is compressed and expanded. Record all relevant data as before.

ACTIVITY 31:

Newton's Law of Cooling

Introduction

As soon as a hot cup of coffee is poured, it begins to cool. The cooling process is rapid at first, and then levels off. After a long period of time, the temperature of the coffee eventually reaches room temperature. Temperature variations for such cooling objects were summarized by Newton. He stated that the rate at which a warm body cools is approximately proportional to the temperature difference between the temperature of the warm object and the temperature of its surroundings. Stated mathematically:

$$\frac{\Delta T}{\Delta t} = -k(T - C)$$

where ΔT represents the object's temperature change during a very small time interval, Δt. T is the body's temperature at some instant, C is the surrounding temperature, and k is a proportionality constant. This equation can be solved for T using advanced techniques:

$$T - C = (T - T_o)e^{-kt}$$

where T_o is the body's temperature when $t = 0$.

In this exercise, you will investigate temperature variations for a cooling object and attempt to verify the mathematical model developed by Newton.

Equipment Required

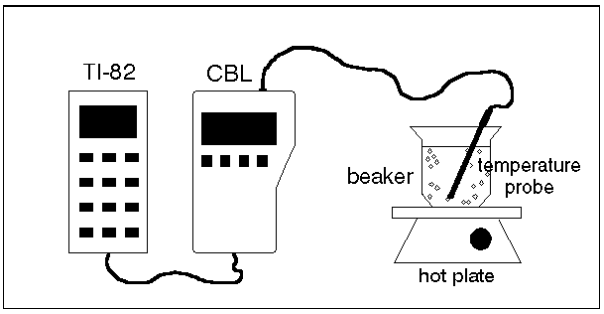
- CBL unit
- TI-82 graphics calculator with a unit-to-unit link cable
- TI temperature probe
- Hot plate
- Medium beaker
- Water
- Ice

Program Listing

This experiment requires that you download or enter the CBL and TEMP programs, listed in the appendix and contained on the diskette, into your TI-82 calculator.

Equipment Setup Procedure

1. Connect the CBL unit to the TI-82 calculator with the unit-to-unit link cable using the I/O ports located on the bottom edge of each unit. Press the cable ends in firmly.
2. Connect the temperature probe to the Channel 1 (CH1) input on the top edge of the CBL unit.
3. Turn on the CBL unit and the calculator.



Equipment Setup

The CBL system is now ready to receive commands from the calculator. The TI-82 will store temperatures (in degrees Celsius) to list L4, and corresponding times (in seconds) to list L2.

Instructions

1. Determine the room temperature by reading the laboratory thermometer and record this value as C in your lab notebook.
2. Fill a medium beaker with water and place it on a hot plate. While the water is heating to boiling, start the CBL program on the TI-82 and select TEMPERATURE from the CBL MAIN MENU. Select AUTO SCALE from the WINDOW OPTIONS menu. Enter one second when prompted for the data collection time interval.
3. When the water begins to boil, place the temperature probe in the beaker for several seconds. Remove the temperature probe from the boiling water and press [ENTER] to start collecting data. The probe should remain exposed to the air while the temperature data is being collected. Avoid placing the probe directly on the tabletop, and isolate it from any drafts to avoid conduction and evaporation effects.
4. Observe the resulting variations in temperature on the TI-82 display as the data is being collected. After the CBL has finished collecting data, you may want to adjust *Ymax* and *Ymin* in the WINDOW on the TI-82 to create an appropriate viewing window. When you are satisfied with the graph, save it to a PIC variable to be printed later with TI-GRAPH LINK.

Analysis

1. Print the PIC variable for this experiment using TI-GRAPH LINK and affix it in your lab notebook. Be sure to include appropriate scales and axes labels on the printout.
2. According to Newton's law of cooling, the quantity $y = T - C$ varies exponentially with time. To model this relationship you must first subtract room temperature from the collected temperature values. To do this, press [2nd] [L4] [−] [ALPHA] **C** [STO▸] [2nd] [L4] [ENTER] at the home screen, where C is the room temperature value that you recorded earlier in your lab notebook.
3. Perform an exponential regression on the collected data from the STAT CALC menu on your TI-82. Because the times have been stored in list L2 and the temperature data has been stored in list L4, the appropriate regression command is ExpReg L2, L4. Record the regression equation and correlation coefficient in your lab notebook.
4. Does the equation obtained in Step 3 match the mathematical model relating temperature and time described in the introduction section? That is to say, do temperature and time appear to vary exponentially?

Repeat this experiment at least two more times. Record all relevant data in your lab notebook. For one trial, start with the temperature probe in an ice bath and allow it to warm up when removed from the bath. Is this relationship exponential? If it is, use your calculator to find an appropriate regression equation for this data.