Gas Pressure Sensor

(Order Code GPS-BTA or GPS-DIN)

The Vernier Gas Pressure Sensor can be used to monitor pressure changes in gas-law experiments in chemistry and physics, such as Boyle's law (pressure *vs.* volume) and Gay-Lussac's law (pressure *vs.* absolute temperature). Vapor pressure of various liquids and solutions can be monitored using this sensor. Biology teachers can use the Gas Pressure Sensor to monitor the production or consumption of oxygen or carbon dioxide gases in an enclosed atmosphere. The following is a partial list of activities and experiments that can be performed using this sensor.

- Investigate the relationship between pressure and volume, Boyle's law.
- Measure vapor pressure of liquids.
- Study the effect of temperature on gas pressure, Gay-Lussac's law.
- Monitor the production of O_2 during photosynthesis of an aquatic plant in a closed system.
- Determine the rate of transpiration for a plant under different conditions.
- Determine the rate of respiration in germinating pea or bean seeds.
- Monitor the pressure of a confined air pocket as water moves in and out of a semi-permeable membrane by osmosis.
- Study the effect of temperature and concentration on the rate of decomposition of H_2O_2.
- Study human respiratory patterns using the Vernier Respiration Monitor Belt.

Gas Pressure Sensor Accessories

Included with your Gas Pressure Sensor are accessories to allow you to connect it to a reaction container, such as an Erlenmeyer flask. Check to be sure that each of these items is included:

- two tapered valve connectors inserted into a No. 5 stopper.
- one tapered valve connector inserted into a No. 1 stopper.
- one two-way valve
- two Luer-lock connectors (white) connected to either end of a piece of plastic tubing.
- one 20-mL syringe
- two transpiration tubing clamps (white)

Here is a summary of some of the uses of the accessories included with your Gas Pressure Sensor:

The white stem on the end of the Gas Pressure Sensor Box has a small threaded end called a *luer lock.* With a gentle half turn, you may attach the plastic tubing to this stem using one of the Luer connectors already mounted on both ends of the tubing. The Luer connector at the other end of the plastic tubing can then be connected to one of the stems on the rubber stoppers that are supplied, as shown in Figure 1.

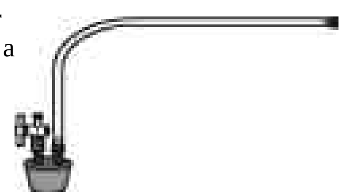


Figure 1

The stopper can then be inserted into a flask or test tube to provide an airtight container to investigate a confined gas, as shown in Figure 2. Note: The 2nd valve on the rubber stopper is shown in a closed position.

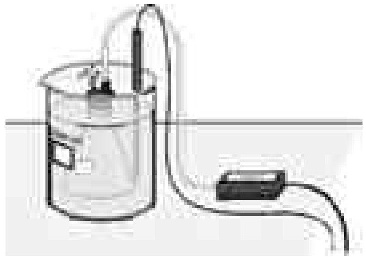


Figure 2

You can also attach the 20-mL plastic syringe included with the Gas Pressure Sensor directly to this stem, as shown here.

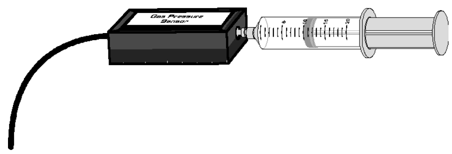


Figure 3

NOTE: This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

Using the Gas Pressure Sensor with a Computer

This sensor can be used with a Macintosh® or PC computer and any of the following lab interfaces: Vernier LabPro™, Universal Lab Interface, or Serial Box Interface. Here is the general procedure to follow when using this sensor with a computer:

1. Connect the Gas Pressure Sensor to the appropriate port on the interface.
2. Start the data collection software on the computer. If you are using a Power Macintosh or Windows® computer, run Logger *Pro*™ software. If you are using older Macintosh, MS-DOS®, or Windows 3.1 computers, run the Data Logger program.
3. Open an experiment file for the Gas Pressure Sensor, and you are ready to collect data.

Using the Gas Pressure Sensor with TI Graphing Calculators

This sensor can be used with a TI Graphing Calculator and any of the following lab interfaces: LabPro, CBL 2™, or CBL™. Here is the general procedure to follow when using this sensor with a graphing calculator:

1. Load a data-collection program onto your calculator:
   - LabPro or CBL 2 - Use the DataMate program. This program can be transferred directly from LabPro or CBL 2 to the TI Graphing Calculator. Use the calculator-to-calculator link cable to connect the two devices. Put the calculator into the Receive mode, and then press the Transfer button on the interface.
   - Original CBL - Use the CHEMBIO program. This program is available free on our web site at www.vernier.com. Our programs can also be obtained on disk. (Contact us for more information.) Load the program into a calculator using TI-GRAPH LINK™.

2. Use the calculator-to-calculator link cable to connect the interface to the TI Graphing Calculator using the I/O ports located on each unit. Be sure to push both plugs in firmly.
3. Connect the Gas Pressure Sensor to any of the analog ports on the interface. In most cases, Channel 1 is used.
4. Start the data-collection program, and you are ready to collect data.

Specifications

- Pressure range: 0 to 210 kPa (0 to 2.1 atm or 0 to 1600 mm Hg)
- Maximum pressure that the sensor can tolerate without permanent damage: 4 atm
- 12-bit resolution (LabPro, ULI II, Serial Box Interface): 0.05 kPa (0.0005 atm or 0.40 mm Hg)
- 10-bit resolution (CBL or CBL 2): 0.2 kPa (0.002 atm or 1.6 mm Hg)
- Sensing element: SenSym SDX30A4
- Combined linearity and hysteresis: typical ±0.2% full scale
- Response time: 100 microseconds

This sensor is equipped with circuitry that supports auto-ID. When used with LabPro or CBL 2, the data collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor. This greatly simplifies the setup procedures for many experiments. Auto-ID is required for the Quick Setup feature of LabPro and CBL 2 when the unit operates remotely from the computer or calculator.

If you purchased the GPS-DIN, you will find a BTA-DIN adapter in the box with your sensor. Use the adapter to connect the sensor to a Serial Box Interface or ULI. The auto-ID feature is not supported in these older interfaces.

How the Gas Pressure Sensor Works

The active sensor in this unit is the SenSym SDX30A4 pressure transducer. It has a membrane which flexes as pressure changes. This sensor is arranged to measure absolute pressure. One side of the membrane is a vacuum, while the other side is open to the atmosphere. The sensor produces an output voltage which varies in a linear way with absolute pressure. It includes special circuitry to minimize errors caused by changes in temperature. We provide an amplifier circuit that conditions the signal from the pressure transducer. With this circuit, the output voltage from the Gas Pressure Sensor will be linear with respect to pressure, with 0.00 volts corresponding to 0 kPa (0 atm) and 4.6 volts corresponding to the sensor’s maximum pressure, 210 kPa (2.1 atm).

Pressure Units

Pressure can be measured in many different units. We quote values here in several of the units shown below. Some equivalent values for 1 atmosphere are:

1 atmosphere	= 101.325 kPa
	= 760 mm Hg
	= 29.92 in. of Hg (at 0°C)
	= 14.70 psi
	= 1013 millibar

Do I Need to Calibrate the Gas Pressure Sensor? “No.”

We feel that you should not have to perform a new calibration when using the Gas Pressure Sensor in the classroom. We have set the sensor to match our stored calibration before shipping it. You can simply use the appropriate calibration file that is stored in your data-collection program from Vernier in any of these ways:

1. If you ordered the GPS-BTA version of the sensor, and you are using it with a LabPro or CBL 2 interface, then a calibration (in kPa) is automatically loaded when the Gas Pressure Sensor is connected.
2. If you are using Logger *Pro* software (version 2.0 or newer) on a Power Macintosh or Windows computer, open an experiment file for the Gas Pressure Sensor, and its stored calibration will be loaded at the same time. **Note:** If you have an earlier version of Logger *Pro*, a free upgrade is available from our web site.
3. If you are using Data Logger software (version 4.6 or newer) on an older PC or Macintosh computer, open an experiment file for the Gas Pressure Sensor, and its stored calibration will be loaded at the same time. **Note:** If you have an earlier version of Data Logger, contact us about a free upgrade.
4. Any version of the DataMate program (with LabPro or CBL 2) has stored calibrations for this sensor.
5. Any version of the CHEMBIO, PHYSICS, or PHYSCI programs (for CBL), version 4/1/00 or newer, have stored calibrations for this sensor. Go to our web site at www.vernier.com to download a current version.

Stored Calibration Values for the Gas Pressure Sensor[1]

kPa	slope = 46.48	intercept = 0
atm	slope = 0.4587	intercept = 0
mm Hg	slope = 348.63	intercept = 0

If you would like to perform your own calibrations, follow the steps described here. The standard calibration procedure we use with all of our sensors is a 2-point calibration. For the **first calibration point** perform the following operation:

- Open the 3-way valve on the sensor to the atmosphere, so it equilibrates to

[1] If you want to manually enter the calibration values for a different unit of pressure in Logger Pro or DataMate programs, here are some additional calibration values: in. Hg (slope = 13.74, intercept = 0), millibar (slope = 464.7, intercept =0), or psi (slope = 6.743, intercept = 0)

atmospheric pressure. When the voltage reading displayed on the computer, calculator, or CBL screen stabilizes, enter the atmospheric pressure, as recorded with a barometer.

For the **second calibration point**, do *one* of the following:

- Use the syringe provided with the Gas Pressure Sensor to produce a pressure very near zero. Before connecting the syringe, push its plunger all the way in to the 0-mL mark. Connect the syringe directly to the Gas Pressure Sensor stem. To produce near-zero pressure, pull the plunger out to the 20-mL position. If your syringe and valve have a tight seal, the pressure will be ~ 0 kPa (0 atm or 0 mm Hg).
- Apply pressure with a pump, measuring it at the same time with a pressure gauge.
- Before connecting the syringe, move the plunger on the syringe so that the syringe volume is set at 10 mL. Connect the syringe to the stem of the Gas Pressure Sensor. Move the syringe plunger so that the voltage reading displayed on the computer or calculator is 3.0 volts. Enter a value of 139.4 kPa as the value (or 1.376 atm, or 1045.9 mm Hg) for this calibration point.[2]

Suggested Experiments

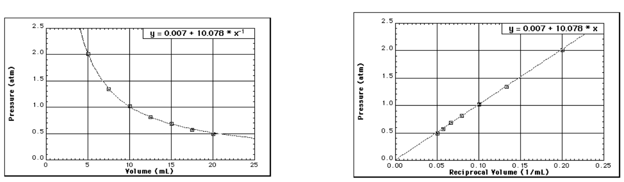
We have a wide variety of experiments already written for use with the Gas Pressure Sensor in our chemistry, biology, and physical science lab books. These lab books can be purchased for $35 each. Here are some of the experiments you can perform with your Gas Pressure Sensor.

Boyle's Law (Pressure *vs.* Volume)

Experiment 6, *Chemistry with Computers*, *Chemistry with Calculators*
Experiment 30, *Physical Science with Computers*, *Physical Science with Calculators*

Boyle's law is a classic physics and chemistry concept that can be easily demonstrated using the Gas Pressure Sensor. One easy way to do this is to use the plastic syringe included with the sensor. Before connecting the syringe to the sensor, move its syringe to the 10-mL volume mark. Connect the plastic syringe to the white stem on the end of the Gas Pressure Sensor box, with a *gentle* 1/2 turn. (See Figure 3.)

The pressure inside the syringe is now equal to atmospheric pressure at the volume you selected. You are now set to collect pressure-volume data. Take data as you change the volume. The syringe is marked in volume units (mL). You can both increase and decrease the volume. Sample data collected with this sensor and the syringe are shown here:



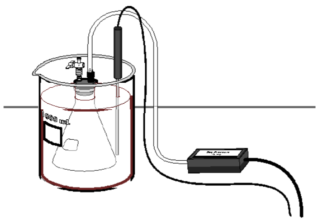
Sample Boyle's Law Data

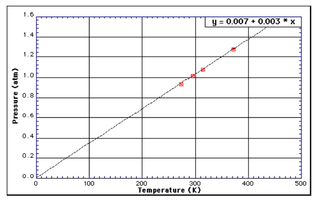
[2] This provides a way to enter other units of pressure. At 3 V, for example, you can also use 41.17 in. Hg, 20.22 psi, or 1394 millibar.

Gay-Lussac's Law (Pressure *vs.* Absolute Temperature)

Experiment 7, *Chemistry with Computers, Chemistry with Calculators*
Experiment 31, *Physical Science with Computers, Physical Science with Calculators*

To investigate the relationship between gas pressure and temperature (when volume is constant), connect the white, threaded adapter end of the long piece of plastic tubing can be connected to the white stem on the sensor box with a full turn. The other end can be connected to the rubber stopper apparatus (included with your Gas Pressure Sensor), which is in turn inserted into a 125-mL Erlenmeyer flask. This provides a constant-volume gas sample.

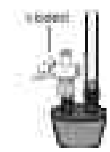




Temperature data can be collected using a Temperature Probe along with the Gas Pressure Sensor. Place the flask in water baths of different temperatures. Take data on how the pressure changes with temperature changes. Remember that all temperatures should be measured using the Kelvin temperature scale. Using the same apparatus, pressure and temperature data may be extrapolated to determine a Celsius temperature value for absolute zero.

Vapor Pressure Measurements

Experiment 10, *Chemistry with Computers, Chemistry with Calculators*



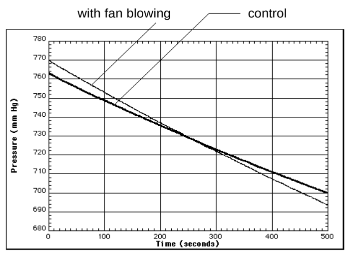
The Gas Pressure Sensor can be used to collect vapor pressure data. The Gas Pressure Sensor is connected to the short stem that protrudes from the rubber stopper. Draw 2 to 3 mL of the liquid to be vaporized up into the syringe. With the 2-way valve closed, screw the syringe onto the 2-way valve. Once the system is closed and you have begun monitoring pressure, open the 2-way valve, squirt the liquid into the 125-mL Erlenmeyer flask and close the valve. Vapor pressure data can easily be collected using any of our interfaces and data collection programs. Gently swirl the flask. Once the system equilibrates, the flask can be placed in water baths of varying temperature to investigate the relationship between vapor pressure and temperature (a temperature probe can be connected to the second port of the interface).

Rate of Plant Transpiration

Experiment 10, *Biology with Computers, Biology with Calculators*

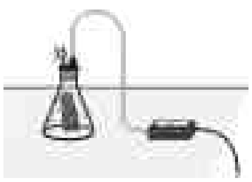
This experiment allows students to see how environmental factors such as heat, wind, temperature, and light affect the process of transpiration in plants. This is done by recording the change in pressure inside a tube filled with water (see figure). As the plant takes in water, the pressure of an air pocket inside the tube decreases. To perform this activity, cut a leafy plant stem at its base and insert the stem into a 20-cm piece of plastic tubing. Fill the tubing with water. Connect the tubing to the Gas Pressure Sensor. Seal the stem in the tubing using one of the transpiration tubing

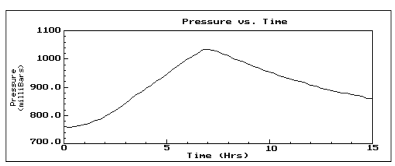
clamps that came with this sensor. Secure the plant and tubing with a ring stand in an upright position with the Gas Pressure Sensor elevated above the plant base. Connect the sensor to your interface box and run the data-collection program. Collect data for 10 minutes with the plant under room conditions. Refill the water in the tube and repeat the experiment with the plant exposed to a different condition. The resulting graph shows a near linear drop in pressure as time progresses. When different factors such as wind are added, the graph of pressure change shows a larger negative slope.



Rate of Photosynthesis

You can use the Gas Pressure Sensor to graph the pressure that occurs when oxygen gas is produce by photosynthesis. To do this, place an aquatic plant, such as Elodea, in a container filled mostly with water. Bubble your breath into the water to saturate it with carbon dioxide. Seal the container with the No. 1 single-hole stopper that came with the sensor. Connect the plastic tubing that comes with the Gas Pressure Sensor to the stopper. When the container is sealed, it should be nearly full, with a small air space trapped at the water’s surface. Connect the other end of the tubing to the sensor. Monitor the pressure in the container for a 12 to 24 hour period of time. You can see in the graph below that the pressure rises as the plant photosynthesizes. When there is no light, the plant enters photorespiration and the pressure drops as the oxygen is consumed by the plant.



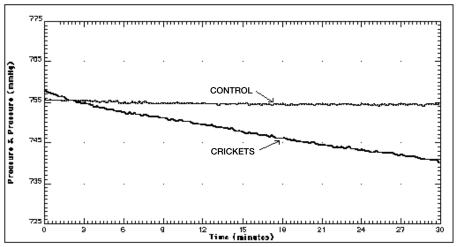


Measuring Respiration of Insects

Experiment 23, *Biology with Computers, Biology with Calculators*

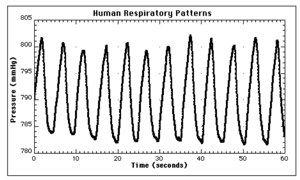
In this activity the Gas Pressure Sensor is used to measure the decrease in air pressure in a test tube as crickets consume oxygen for cellular respiration. Place a cotton ball saturated with potassium hydroxide at the bottom of a 20 x 150-mm test tube. Insert a dry cotton ball to keep the crickets away from the caustic potassium hydroxide. Place five adult crickets into the test tube. Firmly insert (twist) the No. 1 rubber stopper and stem into an 18 X 150-mm test tube. Connect a small section of plastic tubing to the rubber stopper, but don’t connect it to the Gas Pressure Sensor stem yet. Place the test tube in a water bath that is warmer or cooler than the room temperature. Allow 10 minutes for the temperature to equilibrate. When the tube has adjusted to the new temperature, connect the plastic tubing to the sensor stem, resulting in a closed gas

system. Collect data for 10 minutes. Repeat the procedure for a second temperature. Compare the data of the two collection runs. Below is a sample graph of crickets at room temperature. To serve as a control, a second run was made without the crickets.



Control of Human Respiration

Experiment 26, *Biology with Computers, Biology with Calculators*



The respiratory patterns of human subjects can be monitored and graphed using the Gas Pressure Sensor connected to the Respiration Monitor Belt. The Respiration Monitor Belt is sold separately by Vernier (RMB, $58). You can study how certain stimuli and conditions affect respiratory patterns. Study the effect of carbon dioxide concentration on respiration rate by having students breathe into a sealed bag for a period of time. This graph displays the respiratory patterns of a 25-year old male using the Gas Pressure Sensor and Respiration Monitor Belt.

Pressure in Liquids: Depth Measurements

If you measure the pressure at the end of a long plastic tube forced underwater, you can indirectly measure depth. Connect the tubing to the input port of the Gas Pressure Sensor and then put the end of the tube under water. The pressure reading will increase 9.775 kPa (0.0965 atm or 73.34 mm Hg) for every meter below the surface of the water.

Note: If you measure depth in this way, the depth you are measuring is to the top of the air, which extends up the tube for a short distance. If this measurement error bothers you, you can simply calibrate your depth measurement system when the end of the tube is at known depths and automatically correct for this.

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