Respiration Monitor Belt

(Order Code RMB)

The Respiration Monitor Belt is used to measure human respiration rates. It must be attached to the Vernier Gas Pressure Sensor (see Figure 1), which is then connected to any of the Vernier interfaces (Vernier LabPro®, LabQuest®2, LabQuest®, LabQuest® Mini, Go! ® Link, SensorDAQ®), Vernier EasyLink®, or TI-Nspire™ Lab Cradle. The following are some of the activities and experiments that can be performed using the Respiration Monitor Belt:

- Study the resting respiration pattern of students.
- Investigate respiration patterns that have been interrupted by simple activities such as holding of breath.
- Compare respiration rates of athletes and non-athletes.
- Compare respiration rates of females and males.
- Monitor respiration rates, including recovery time, before and after vigorous exercise.
- Compare respiration rate and heart rate (using a Vernier Heart Rate Monitor).
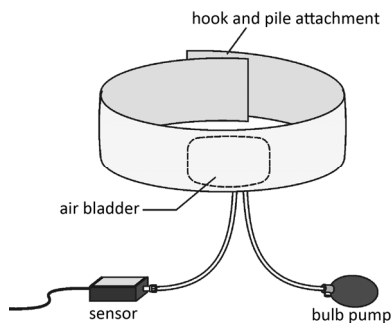

Figure 1

Collecting Data with the Respiration Monitor Belt

This sensor can be used with the following interfaces to collect data:

- Vernier LabQuest 2 or LabQuest as a standalone device or with a computer
- Vernier LabQuest Mini with a computer
- Vernier LabPro with a computer or TI graphing calculator
- Vernier Go!Link
- Vernier EasyLink
- Vernier SensorDAQ
- CBL 2™
- TI-Nspire™ Lab Cradle

Data-Collection Software

This sensor can be used with an interface and the following data-collection software.

- **Logger *Pro* 3** This computer program is used with LabQuest, LabQuest Mini, LabPro, or Go!Link.
- **Logger *Pro* 2** This computer program is used with ULI or Serial Box Interface.
- **Logger Lite** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go!Link.
- **LabQuest App** This program is used when LabQuest is used as a standalone device.
- **DataQuest™ Software for TI-Nspire™** This calculator application for the TI-Nspire can be used with the EasyLink or TI-Nspire Lab Cradle.
- **EasyData App** This calculator application for the TI-83 Plus and TI-84 Plus can be used with CBL 2™, LabPro, and Vernier EasyLink. We recommend version 2.0 or newer, which can be downloaded from the Vernier web site, www.vernier.com/easy/easydata.html, and then transferred to the calculator. See the Vernier web site, www.vernier.com/calc/software/index.html for more information on the App and Program Transfer Guidebook.
- **DataMate program** Use DataMate with LabPro or CBL 2™ and TI-73, TI-83, TI-84, TI-86, TI-89, and Voyage 200 calculators. See the LabPro and CBL 2™ Guidebooks for instructions on transferring DataMate to the calculator.
- **LabVIEW** National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. It is used with SensorDAQ and can be used with a number of other Vernier interfaces. See www.vernier.com/labview for more information.

How to Use the Respiration Monitor Belt

Follow this procedure to make measurements with the Respiration Monitor Belt connected to a Gas Pressure Sensor and a Vernier interface, Vernier EasyLink, or CBL 2™:

1. Set up the Respiration Monitor Belt.

- If you are collecting data with a computer, start Logger *Pro*, open an experiment file set up for the Respiration Monitor Belt.
- If you are collecting data with a LabQuest 2 or LabQuest as a standalone device, launch the LabQuest App and set up a Respiration Monitor.
- If you are collecting data with a calculator, run the DataQuest, DataMate or EasyData program and select a Respiration sensor.

2. Select one member of the group as the test subject. Wrap the Respiration Monitor Belt snugly around the test subject's chest. Press the hook and pile strips together at the back. Position the belt on the test subject so that the belt's air bladder is resting over the base of the rib cage and in alignment with the elbows as shown in Figure 2.
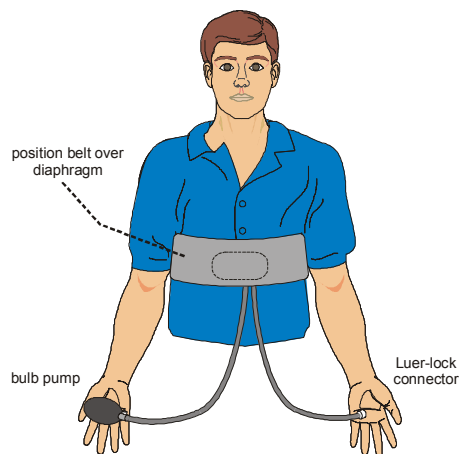

Figure 2

3. Attach the Respiration Monitor Belt to the Gas Pressure Sensor. There are two rubber tubes connected to the bladder. One tube has a white Luer-lock connector at the end and the other tube has a bulb pump attached. Connect the Luer-lock connector to the stem on the Gas Pressure Sensor with a gentle half turn.

4. Have the test subject sit upright in a chair. Close the shut-off screw of the bulb pump by turning it clockwise as far as it will go. Pump air into the bladder by squeezing on the bulb pump. Fill the bladder as full as possible without causing discomfort for the test subject.

5. The pressure reading displayed in the meter should increase about 6 kPa above the initial pressure reading (e.g., at sea level, the pressure would increase from about 100 to 106 kPa). At this pressure, the belt and bladder should press firmly against the test subject's diaphragm. Pressures will vary, depending upon how tightly the belt was initially wrapped around the test subject.

6. As the test subject breathes in and out normally, the displayed pressure alternately increases and decreases over a range of about 2–3 kPa. If the range is less than 1 kPa, it may be necessary to pump more air into the bladder. **Note**: If you still do not have an adequate range, you may need to tighten the belt.

Once normal breathing of the test subject results in pressure changes of 2–3 kPa or more, you are ready to begin doing an experiment.

Calibration

You should never have to perform a new calibration for the Respiration Monitor Belt using the Gas Pressure Sensor. Any experiments we describe in this booklet or in the *Biology with Vernier* lab manuals will use a stored Vernier calibration.

Suggested Experiments

### Monitoring Human Respiratory Patterns

You can study respiratory patterns and examine how certain stimuli and conditions affect those patterns. First, set up an experiment as described in the previous two sections. It is very important that the test subject be positioned so he or she cannot directly view the computer or calculator screen. Once the test subject is breathing in a relaxed manner, begin collecting data. This graph displays a typical resting respiratory pattern using the Respiration Monitor Belt with a Gas Pressure Sensor.
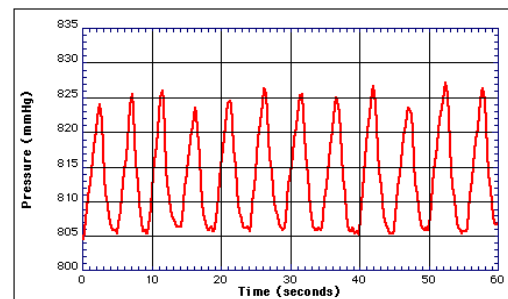
You may want to examine the data to determine either respiration rate or the respiration period. Using the Examine or Analyze features of the Vernier data-collection programs (or Trace on a TI calculator), you can examine a portion of the data from the peak of one respiration cycle to the peak of another. In the graph below, the darkened segment of the data is selected so that the time between two peaks can be determined from Statistics. Using the time between the 2nd and 9th peaks (42.00 s – 7.07 s = 34.93 s), the respiration rate or respiration period can be calculated:

Respiration rate = 7 breaths / 34.93 s = 0.200 breaths/s = 12.0 breaths/min

Respiration period = 34.93 s / 7 breaths = 4.99 s/breath
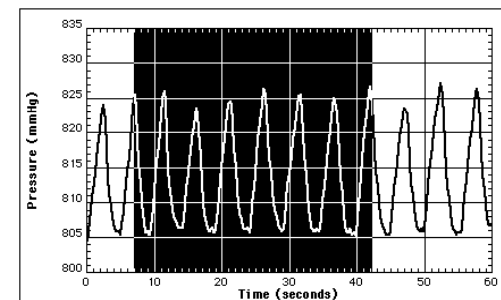

Respiration Interrupted by Holding of Breath

In this exercise, the test subject is instructed to breathe in a relaxed manner, hold his or her breath after about 20 seconds, then resume breathing after about one minute (40 additional seconds). Data collected in this manner is shown here:
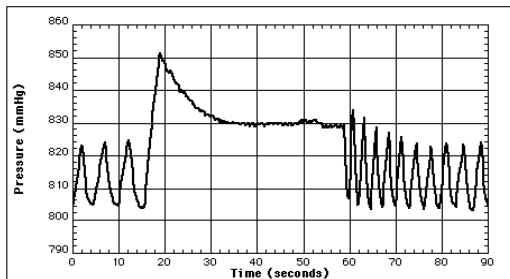
Now determine the respiration period (or respiration rate), as described in the previous section. Select data in the regions prior to and following the holding of breath, as shown in the following graphs. Then calculate the respiration period for each:

Before holding of breath: 10.60 s / 2 breaths = 5.30 s/breath

After holding of breath: 27.44 s / 9 breaths = 3.05 s/breath
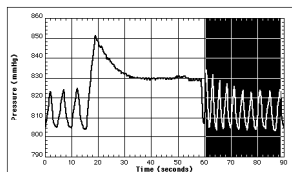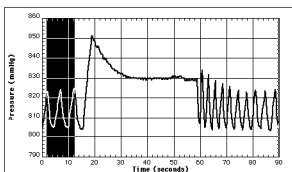
Students can easily observe the decrease in respiration period (or increase in respiration rate) due to holding breath. Students can also investigate the recovery of respiration rate—the respiration period increased from 2.50 to 3.76 s/breath between 60 and 90 seconds in the data shown here.

Recovery of Respiration Rate after Vigorous Exercise

To investigate the effect of vigorous exercise on respiration rate, have the test subject jog in place for 2 minutes. Afterward, collect respiration data for 3 minutes, and analyze the data to see how the respiration rate changes. In the sample data shown in the graph below (*after* exercise), the following respiration rates were obtained at the beginning and end of data collection:

5 breaths (after exercising): 5 breaths / 12.48 s = 0.401 breaths/s = 24.0 breaths/min

5 breaths (after recovery): 5 breaths / 24.95 s = 0.200 breaths/s = 12.0 breaths/min
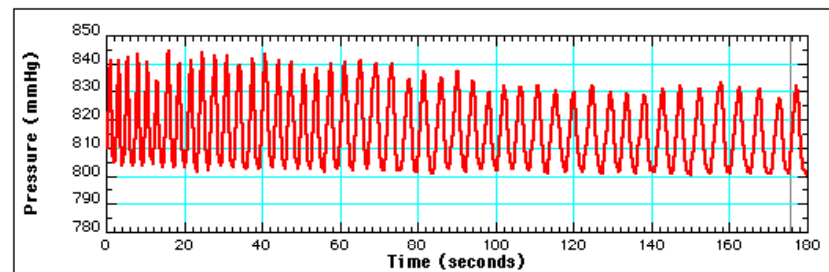
Comparing Respiration Rate and Heart Rate after Jogging

It is interesting to compare respiration rates with heart rates (measured with the Vernier Heart Rate Monitor). The following data were collected with a Respiration Monitor Belt and Gas Pressure Sensor connected to Port 1 of a Serial Box Interface and a Heart Rate Monitor connected to Port 2. The data-collection rate is set at 50 readings/s. The data shown here were collected after the test subject jogged in place for two minutes.
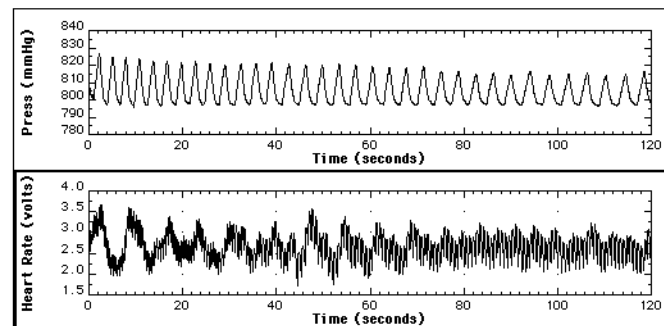
Because the heart-rate readings occur at a much higher rate than respiration rate, we have zoomed in to examine the data between 18 and 24 seconds (left-hand graphs below) and between 110 and 116 seconds (right-hand graphs).
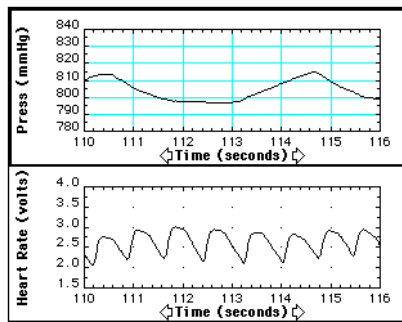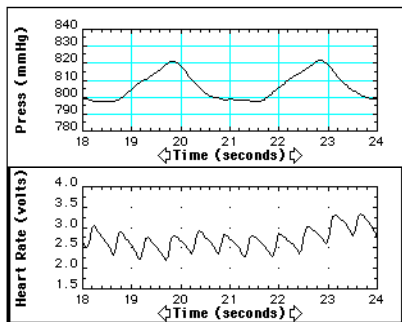
By comparing the respiration rate and heart rate at these two times, recovery rate can be investigated:

Respiration rate after exercise: 0.334 breaths/s = 20.0 breaths/min
Heart rate after exercise: 1.83 beats/s = 110 beats/min
Respiration rate after recovery: 0.236 breaths/s = 14.2 breaths/min
Heart rate after recovery: 1.33 beats/s = 79.8 beats/min

As can be seen from the calculations, both reparation rate and heart rate made a significant recovery in the two-minute time period over which data were collected—respiration rate improved from 20.0 to 14.2 breaths/min, or by 29.0%, and heart rate from 110 to 79.8 beats/min, or by 27.

Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use.
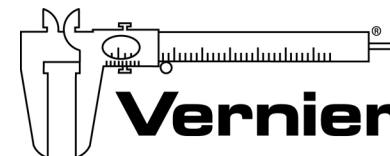
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