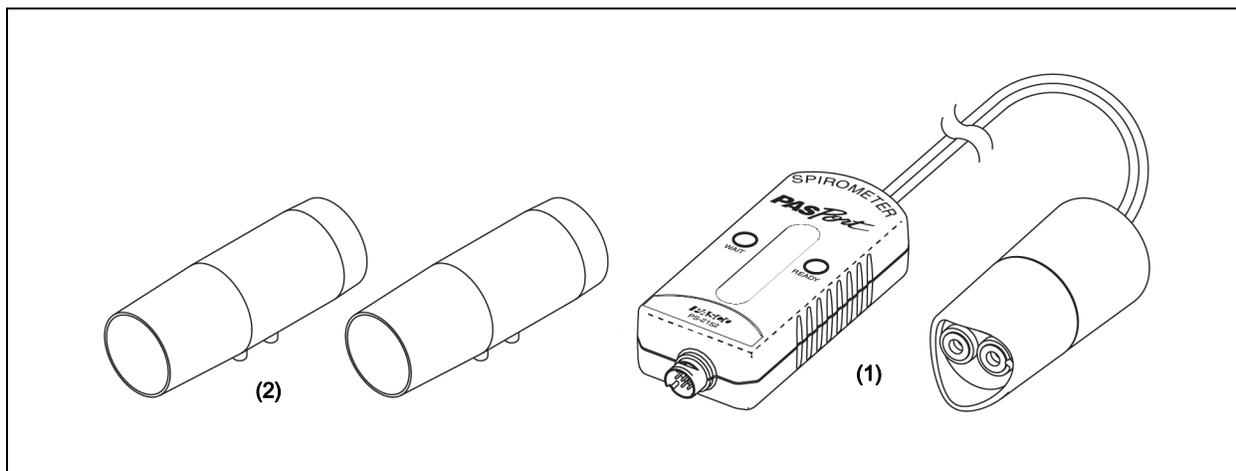


Spirometer

PS-2152



For Educational Use Only! Note: This is not a medical device. It is designed for educational use only and should not be used in any medical process such as life support or patient diagnosis. It is also not intended for use in graduate research or industry including industrial control or any type of industrial testing.

Included Equipment

- (1) Electronics enclosure and handle
- (2) Single-use mouthpiece (2 included)

Part Number

- PS-2152
- (see below)

Additional Equipment Required

- PASCO interface See PASCO catalog or www.pasco.com
- PASCO Data Collection Software See PASCO catalog or www.pasco.com

Additional Equipment Recommended

- Additional single-use mouthpieces PS-2522 (10-pack)

Introduction

The PASPORT Spirometer allows students to collect accurate air-flow data from a pulmonary function test (PFT). The subject breathes through a sanitary, single-use mouthpiece as data is recorded and

displayed on your computing device. From the graphed data students can measure tidal volume, forced expiratory volume, and other important lung volumes and capacities.

Safety

Read the instructions before using this product. Students should be supervised by their instructors. When using this product, follow the instructions in this manual and all local safety guidelines that apply to you.

Do not share mouthpieces.

In medical settings, pulmonary function tests are performed under the supervision of a medical professional. When using a spirometer without medical supervision, use extra caution. A person with a medical condition that may be affected by a pulmonary function test should not use the PASCO Spirometer. Discontinue use if the subject encounters breathing difficulty or discomfort.

How it works

When the test subject breathes through the mouthpiece, a screen in the mouthpiece induces a minute resistance to the air flow. This resistance leads to a pressure differential across the screen that is measured via two air lines that lead to a differential pressure transducer in the electronics enclosure. The Spirometer contains onboard reference data of differential pressures from known flow rates (a non-linear relationship). It determines the test subject's flow rate by comparing the measured differential pressure to the stored reference data. It calculates volume exchanged by integrating the flow rate over time.

Sensor Setup

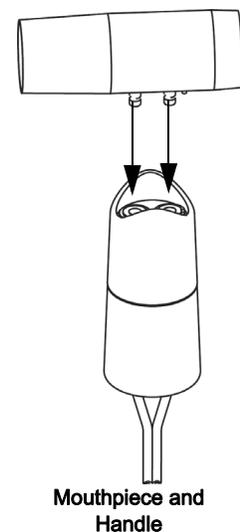
Connect a mouthpiece to the handle; note the small pin on the mouthpiece and the aligning notch on the handle. Connect the electronics enclosure of the sensor to your PASPORT interface.

(When you remove a used mouthpiece, pull it straight out from the handle without rocking or wiggling it.)

Data Collection

- For information about collecting, displaying, and analyzing data, refer to the Online Help System for the PASCO Data Collection Software.

Your PASCO interface and data collection software will record Flow Rate and Max Flow Rate (in liters/second) and Total Flow (in liters), at a sampling rate of 50 Hz. *Flow Rate* is the rate at which air flows through the mouthpiece. Air expired from the lungs is measured as positive flow, inspired air as negative. *Max Flow Rate* is the maximum exhaled flow rate measured during the test. The sensor calculates

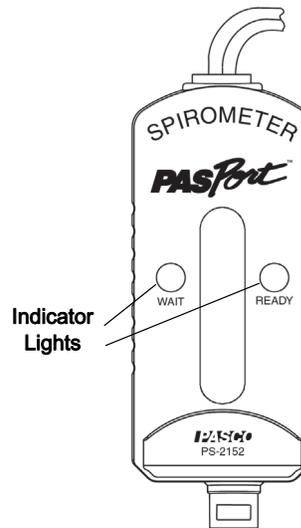


Flow Volume by integrating Flow Rate data over time. Flow Volume is the net volume of expired air (total expired volume minus total inspired volume).

Connect the sensor to the interface and connect the interface to your computing device (such as a computer, tablet, or smart phone). Launch the data collection software. Set up a graph display of “Total Flow” versus “Time” to show the Pulmonary Function Test (PFY) data.

Pulmonary Function Test Procedure

1. Use a nose clip or have the test subject hold his or her nose to ensure that all breathing is done through the mouth.
2. Hold the mouthpiece of the Spirometer stationary and away from air currents (including expired air). Start data collection; note the flashing red WAIT indicator on the sensor. Wait until the green READY indicator is illuminated before you move the mouthpiece or expose it to air currents.
3. After the green READY indicator has illuminated, place the tapered end of the mouthpiece *between the test subjects's front teeth* with the lips creating a seal to ensure that all inspired and expired air flows through the mouthpiece.
4. Have the test subject perform the following sequence of breathing:
 - Breathe quietly for about four breaths
 - Perform a forced inspiration followed immediately by a maximum-effort forced expiration*.
 - Breathe quietly for two breaths.
5. Stop data collection.



**When performing the forced inspiration and expiration, the subject should try to fill his or her lungs to maximize capacity, then exhale as fast and completely as possible.*

Procedure Notes

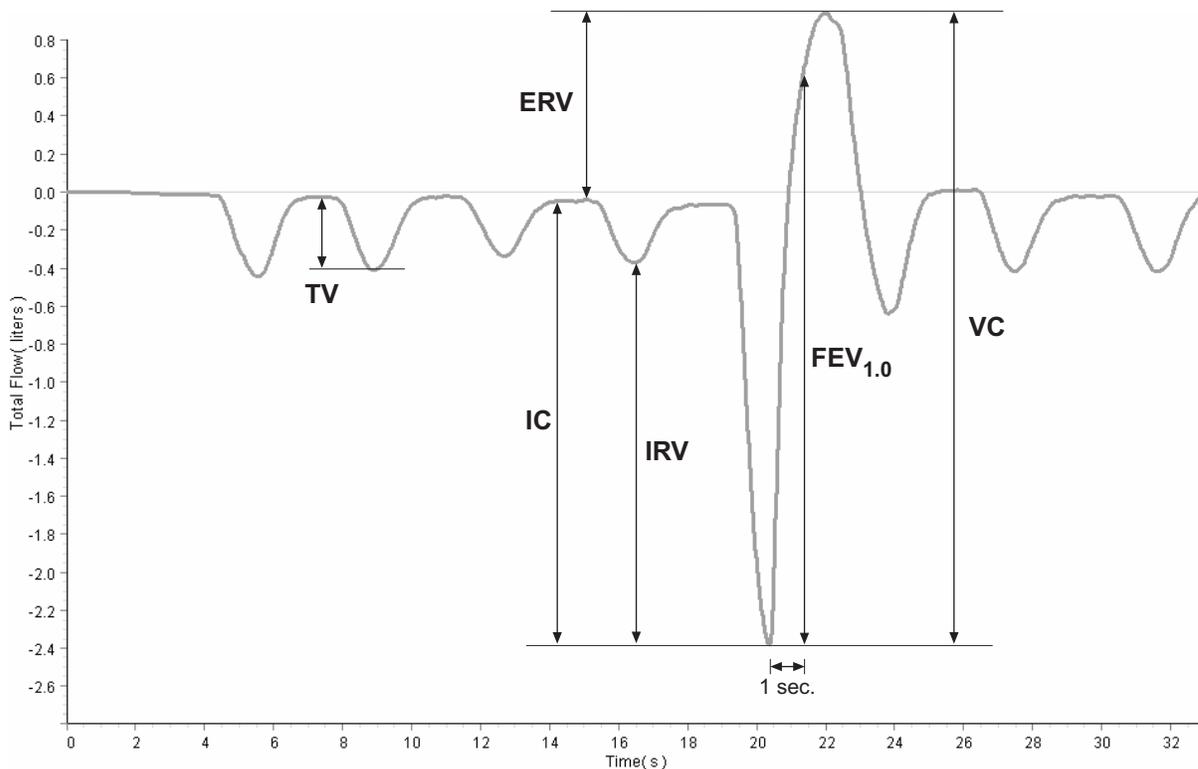
Observing the following conditions will allow you to collect consistent and accurate data.

- You may need to run the test a few times in order to get satisfactory data.
- The subject should sit up or stand comfortably.
- Talk the subject through each inspiration and expiration (this will prevent the subject from being distracted by counting breathes or remembering the sequence.)

- Do not allow the test subject to see the data as it is collected.
- Use a nose clip, or have the subject pinch his or her nose during the test.
- Place the mouthpiece and handle on a table before you start data collection. Do not pick it up until the red WAIT indicator has stopped blinking and the green READY indicator is illuminated. While the WAIT indicator is blinking, the sensor is measuring the ambient pressure in order to establish a baseline reading. It is important not to expose the sensor to any pressure change or airflow during the wait period.
- The electronics enclosure contains a high-resolution differential pressure sensing element that is sensitive to orientation. The orientation with respect to vertical or horizontal is not important, but it must remain constant during the wait period and data collecting.
- Single-use mouthpieces are intended for a single test occasion, which may include several tests with the same individual. However, with each test, liquid and particles can accumulate on the screen of the mouthpiece, which increase the resistance to air flow, leading to unrealistically high readings of Flow Rate and Total Volume in subsequent tests. Replace the mouthpiece if you observe evidence of screen contamination. For the most accurate results, use a new mouthpiece for every test.

Interpretation of PFT Data

Total Flow vs. Time



Total Flow is the *net volume* of air that flows *out* from the lungs through the Spirometer, equal to the total expired volume minus the total inspired volume. View the graph of Total Flow vs. Time. Four specific lung volumes and two lung capacities can be interpreted from this graph.*

*Use the built in analysis tools in the data collection software to measure the quantities from the graph

Tidal Volume (TV) is the volume of one breath, or the amount of air moved into and out of the lungs during quiet breathing (breathing without effort).

Expiratory Reserve Volume (ERV) is the amount of air moved out of the lungs during a forced expiration, beyond the level of tidal expiration.

Inspiratory Reserve Volume (IRV) is the amount of air moved into the lungs during a forced inspiration, beyond the level of tidal inspiration.

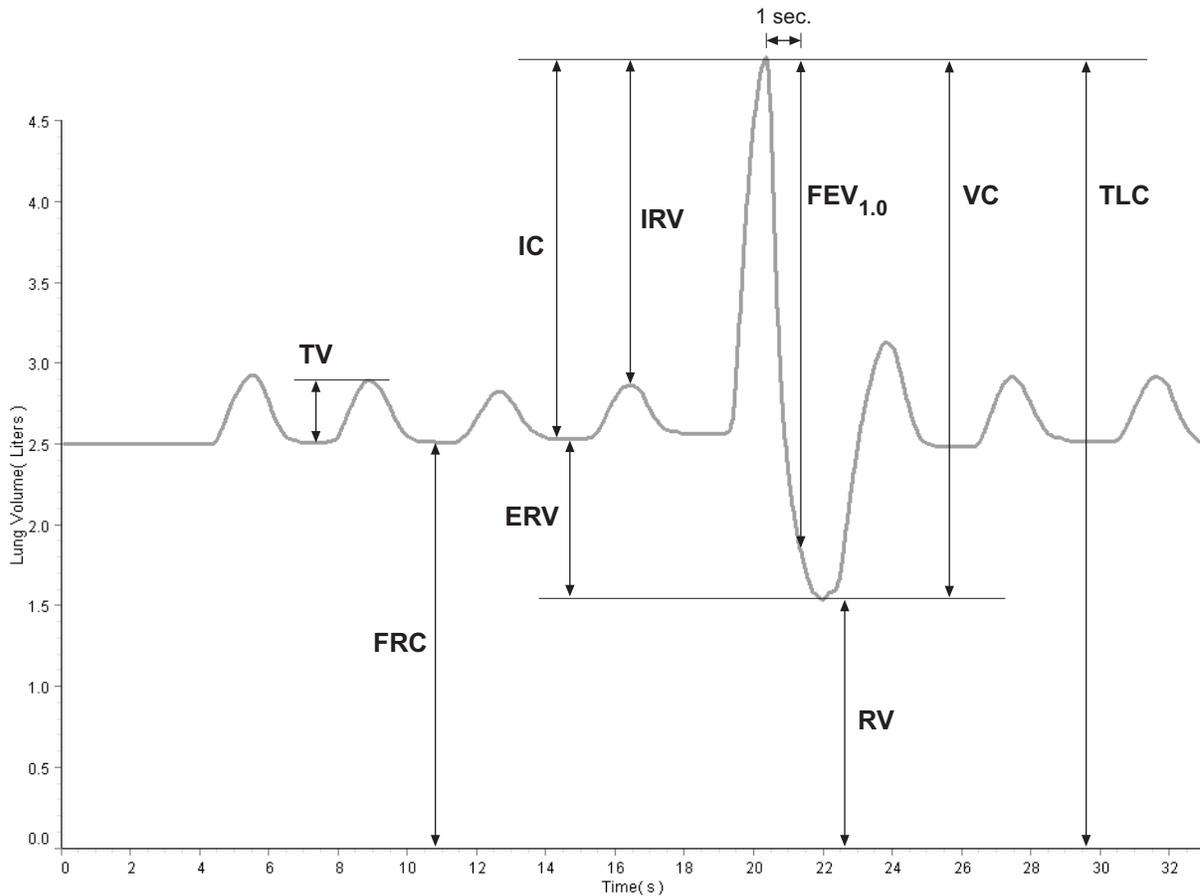
Forced Expiratory Volume in One Second ($FEV_{1.0}$) is the volume of air moved out of the lungs in the first second of a forceful expiration following a maximal inspiration.

Inspiratory Capacity (IC) is the maximum amount of air that can be inspired after a normal expiration ($IC = TV + IRV$).

Vital Capacity (VC) is the maximum *movable* amount of air contained by the lungs ($VC = TV + IRV + ERV$).

$FEV_{1.0}\% = FEV_{1.0} \div VC \times 100\%$ is a common comparison of $FEV_{1.0}$ to VC.

Lung Volume vs. Time



Lung Volume is the constantly-changing amount of air in the lungs. A spirometer can measure how it changes, but cannot directly measure its absolute value. Lung volume can be calculated if one of two specific absolute volumes, residual volume (RV) or functional residual capacity (FRC), is known or estimated.

Residual volume (RV) is the amount of air remaining in the lungs at the end of a forced expiration. A typical RV is 1.2 L.

Functional Residual Capacity (FRC) is the amount of air left in the lungs after a normal expiration ($FRC = RV + ERV$). A typical FRC is 2.5 liters.

The formula for Lung Volume is:

$$\text{Lung Volume} = V_0 - \text{TotalFlow}$$

V_0 is the lung volume when the subject first starts to breath through the Spirometer. Set V_0 equal to the subject's FRC, or 2.5 L. Once you have acquired data, you may need to adjust V_0 so that the graph reflects the subject's known or estimated FRC or RV.*

*See the Online Help for instructions on entering and graphing this calculation.

Factors That May Affect Results

In your graphs of Total Flow and Lung Volume, you may notice a slow drift or slight fluctuation in the baseline. These can be eliminated, in most cases, as described below. Note that slow baseline changes usually do not significantly affect the measurements of volumes and capacities that you take from the graphs.

- Air pressure changes in the environment during the measurement period can influence the sensor readings. Sources of such pressure changes include doors opening or closing, heating/cooling/ventilation systems starting or stopping, and air movement within the testing room. In most cases environmental pressure variation is tolerably low over the typical 30-second test period.
- The sensor calculates Total Flow by integrating the measured Flow Rate over time. Because of this time integration, a very small offset in the Flow Rate measurement may result in a noticeable upward or downward trend in the baseline of the Total Flow (or Lung Volume) data. This trend usually does not have a significant effect on the volume and capacity measurements taken from the graph, since each measurement is made between two data points recorded within a few seconds. In the data collection software you can eliminate the trend with this calculation:

$$\text{Total Flow} = \text{integral}((1 - \text{inrange}(0, .03, \text{abs}(\text{smooth}(10, R)))) * R)$$

- Define R as the Flow Rate. Use the calculated data in place of the data directly from the sensor. If the trend is still apparent, increase the “.03” parameter so that it is slightly larger than Flow Rate offset.

Troubleshooting

Problem	Solutions
Drift or fluctuation in the baseline of Total Flow or Lung Volume	Slow drift (less than 0.3 L in 30 s) is insignificant and can be ignored.
	Protect the mouthpiece from movement, air currents and pressure changes while the WAIT indicator is blinking.
	Do not move the electronics enclosure during the entire test.
	Use the calculation described above.
Large shift in baseline of Total Flow or Lung Volume after forced expiration	Use a nose clip or have the subject pinch his or her nose to prevent airflow through the nose.
	Ensure a good seal of the subject's lips around the mouthpiece.
	Replace the mouthpiece with an unused one.
Unrealistically high Total Flow or Flow Rate readings	Protect the mouthpiece from movement, air currents and pressure changes while the WAIT indicator is blinking.
	Replace the mouthpiece with an unused one.

Specifications

The spirometer is an educational instrument. It is not designed, tested, or intended for medical use.

Total Flow	5% accuracy when used as described above
Default Sampling Rate	50 Hz
Flexible Air Lines	90 cm

Technical Support

For assistance with any PASCO product, contact PASCO at:

Address: PASCO scientific
10101 Foothills Blvd.
Roseville, CA 95747-7100

Phone: +1 916 462 8384 (worldwide)
800-772-8700 (U.S)

Web: www.pasco.com

Email: support@pasco.com

Portions of this manual were reviewed by A. Greenwell and T. Kjos, Sacramento City College, Biology Department, Sacramento California USA..

Limited Warranty

PASCO scientific warrants the product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. PASCO will repair or replace, at its option, any part of the product, which is deemed to be defective in material or workmanship. The warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of a manufacturing defect or improper use by the customer shall be made solely by PASCO scientific. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damaged caused by improper packing of the equipment for return shipment will not be covered by the warranty.) Shipping costs for returning the equipment after repair will be paid by PASCO scientific.

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Product End of Life Disposal Instructions:

This electronic product is subject to disposal and recycling regulations that vary by country and region. It is your responsibility to recycle your electronic equipment per your local environmental laws and regulations to ensure that it will be recycled in a manner that protects human health and the environment. To find out where you can drop off your waste equipment for recycling, please contact your local waste recycle/disposal service, or the place where you purchased the product.



The European Union WEEE (Waste Electronic and Electrical Equipment) symbol (to the right) and on the product or its packaging indicates that this product **must not** be disposed of in a standard waste container.