Spirometry Lab

GOALS
1. Introduction to a pulmonary function test
2. Overview and demonstration of how to use the PASCO spirometer sensor to perform pulmonary function test
3. Perform a pulmonary function test using the PASCO spirometer sensor and SPARK SLS
4. Plot the data and complete table using the data collected during the pulmonary function test
5. Check for comprehension by answering questions

INTRODUCTION
A person's size, sex, age, and physical condition cause changes in respiratory volumes. The terms given to respiratory volumes that are measured are defined below. Respiratory volumes can be measured by an instrument called a spirometer. A "wet" spirometer consists of a plastic bell within a tank that air can be added or removed. The outer tank contains water and has a tube running through it to carry air above the water level. The wet spirometer is used to measure most respiratory volumes, but cannot directly measure inspired volumes. The PASCO Spirometer allows students to collect accurate air-flow data from a pulmonary function test. The student will breathe through a sanitary, single-use mouthpiece as data is recorded and displayed on the SPARK Science Learning System. A variety of measurements can be collected including: tidal volume, expiratory reserve volume, inspiratory reserve volume, forced expiratory volume after 1 sec, and vital capacity.

TERMS
Tidal volume (TV): volume of one breath, or the amount of air moved into and out of the lungs during quiet breathing

Minute Respiratory Volume (MRV): MRV=TV x respirations/min

Expiratory Reserve Volume (ERV): amount of air moved out of lungs during forced expiration (beyond tidal expiration)

Inspiratory Reserve Volume (IRV): amount of air moved into the lungs during a forced inspiration (beyond tidal inspiration)

Forced Expiratory Volume in one second (FEV$_{1.0}$): volume of air moved out of the lungs in the first second of a forceful expiration following a maximum expiration

Vital Capacity (VC): maximum movable amount of air contained by the lungs (VC=TV+IRV+ERV)

Predicted Vital Capacity (predicted VC): average volume dependent upon height, gender and age (p. 131-132 in lab manual)

%Vital Capacity (%VC): (VC / predicted VC) x 100%

FEV$_{1.0}$%: (FEV$_{1.0}$/ VC) x 100%
Lung Volume vs. Time

*from PASCO scientific 012-08856A Spirometer Instruction Manual
PULMONARY FUNCTION TEST PROCEDURES

*Safety remark: Do not share mouthpieces. A person with a medical condition that may be affected by a pulmonary function test should not participate as a test subject. If a subject encounters breathing difficulty or discomfort, the pulmonary function test should be discontinued.

Getting Started

Materials Needed: PASCO disposable mouthpiece, SPARK SLS, and spirometer sensor

1. Assign Team and record on page 12. Then turn on SPARK SLS. (hold down power button until unit turns on).

2. Connect white disposable mouthpiece to the handle of the spirometer sensor; note the small pin on the mouthpiece and the aligning notch on the handle.
3. Gently plug in spirometry sensor in one of two spaces at the upper edge of the SPARK SLS.

4. Use stylus to select the “Open” tab on the bottom left of the screen.

5. Use stylus to select “Saved Work” tab at top of the screen.
6. Use stylus to select “Spirometry Lab 2014” from the list of available choices.

7. **Practice without mouthpiece.** Have the test subject perform the following sequence of breathing with a nose clip or pinch nose so that all breathing is done through the mouth:

   * breathe quietly for about 4 breaths
   * perform a forced inspiration followed immediately by a maximum-effort forced expiration (try to fill lungs to maximum capacity then exhale as fast and completely as possible)
   * breathe quietly for two breaths

**Data Collection**

8. At this time, the mouthpiece should still remain on the table away from air currents including expired air.

**Read through steps 9-12 before starting as there should be minimal time lapse once data collection has started.**

9. When ready to start data collection, use the stylus to click arrow in the green box (or press the button to the top right or top left of the touchscreen). **WAIT to pick up the mouthpiece until the green READY indicator on the sensor is illuminated.**
10. The tapered end of the mouthpiece should be placed between the test subject’s front teeth with the lips creating a seal to ensure that all inspired and expired air flows through the mouthpiece.

11. Without looking at the display, the test subject should be instructed to perform the sequence of breathing as practiced in step 7:

* breathe quietly for about 4 breaths

* perform a forced inspiration followed immediately by a maximum-effort forced expiration (try to fill lungs to maximum capacity then exhale as fast and completely as possible)

* breathe quietly for two breaths

12. Stop data collection by using the stylus to click on the orange arrow or pressing the blue blinking button to the top right or top left of the touchscreen.

13. If the baseline appears to start drifting upward, consider hiding that run by clicking on the number in legend of the upper right of the graph and unchecking the box. Then restart the data collection procedure at step 8.
Data Analysis

14. Use the stylus to click on the graphing icon ( ) on the lower left side of the touchscreen just above the arrow in the green box (a graph tool will turn orange after it is clicked). This will bring up a graphing palette.

15. Autoscale the data by clicking on the “scale to fit” tool . Once scaled to fit, your data should look similar to the graph on p. 3. If your data is hidden by the graph palette, place the stylus in an open area of the graph and slide to the left. If the data goes out of view, just press the “scale to fit” tool once more.

16. Observe the subject’s pattern of breathing on the graph and compare it to the graph on p. 3. To begin measurements, first use the stylus to click the “select” tool.

17. To measure tidal volume, use the stylus to touch in succession, the valley and subsequent peak of one of the initial quiet breaths. Note: a yellow line will now appear between the two points. A dashed rectangle also encloses the area. The boundaries of the box connect the x, y coordinates of the two points. Perform step 18 before clicking “OK”.

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18. For a magnified view of the selected points, expand the x-axis by pointing to a number on the scale and drag to the right. The upper and lower horizontal lines of the dashed rectangle represent the boundaries. The selected points can be adjusted (if needed) by placing the stylus on one of the two boxes with red crossed lines and dragging it in the desired direction. The red dashed rectangle will change in size as the coordinates are adjusted. When satisfied, use the stylus to click “OK”.

19. Use the stylus to click the “coordinates” tool . A box will appear with x and y coordinates and differences. The box can be moved by clicking inside the box and dragging to another location. Record the difference between y1 and y2 (with units): dy=_____. Deselect the “coordinates” tool so it is inactive and the coordinates box is removed. Note: the x-axis will need to be compressed to have the same image as the two pictures shown.
20. Annotate the result. Use the stylus to click the “T” tool . This brings up a digital keyboard. Use the stylus to label the measurement and include the value (TV=xx units). This text box can be dragged to a position that does not obscure the graph. Finally, deselect the “select” tool so it becomes inactive (the tool will turn blue).

Exit the activity

1. Use the stylus to click the “home” icon at the top left of the touchscreen.

2. A pop-up window will state that the item is unsaved. Click “NO”.

3. At the completion of data collection, gently remove the mouthpiece from the handle by pulling straight out of handle. **Do NOT jigggle or twist.** Save until the end of the lab at which time it can be disposed of in the waste basket.
The graph below is a record of a pulmonary function test from a 56 year old male (5'7" height), label tidal volume, expiratory reserve volume, inspiratory reserve volume, and vital capacity. Based on the graph, fill in the following data and show any calculations:

- tidal volume ______________
- inspiratory reserve volume ______________
- expiratory reserve volume ______________
- vital capacity ______________  %vital capacity ______________

*each square is 0.125L

Based on the % Vital Capacity, how would you describe this person’s pulmonary function? Why?