

Lung Volumes and Capacities

OBJECTIVES

In this experiment, you will

- Obtain graphical representation of lung capacities and volumes.
- Compare lung volumes between males and females.
- Correlate lung volumes with clinical conditions.

MATERIALS

computer
Vernier computer interface
Logger Pro
Vernier Spirometer

disposable mouthpiece
disposable bacterial filter
nose clip

PROCEDURE

Important: Do not attempt this experiment if you are currently suffering from a respiratory ailment such as the cold or flu.

1. Connect the Spirometer to the Vernier computer interface. Open the file “19 Lung Volumes” from the *Human Physiology with Vernier* folder.
2. Attach the larger diameter side of a bacterial filter to the “Inlet” side of the Spirometer. Attach a gray disposable mouthpiece to the other end of the bacterial filter (see Figure 2).

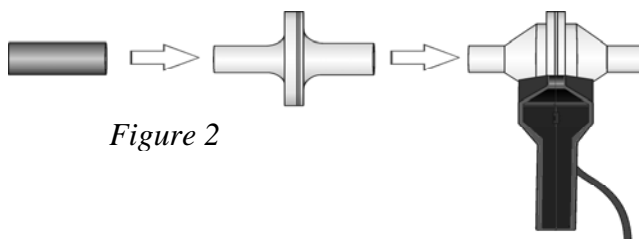


Figure 2

3. Hold the Spirometer in one or both hands. Brace your arm(s) against a solid surface, such as a table, and click to zero the sensor. **Note:** The Spirometer must be held straight up and down, as in Figure 2, and not moved during data collection.
4. Put on the nose plug.
5. Click to begin data collection.
6. Taking normal breaths, begin data collection with an inhalation and continue to breathe in and out. After 4 cycles of normal breathing (tidal volume) fill your lungs as deeply as possible (maximum inspiration) and exhale as fully as possible (maximum expiration). *It is essential that maximum effort be expended when performing tests of lung volumes.*
7. Follow this with at least one additional recovery breath.
8. Click to end data collection.
9. Click the Next Page button, , to see the lung volume data. If the baseline on your graph has drifted, use the Baseline Adjustment feature to bring the baseline volumes closer to zero, as in Figure 3.
10. Collect inhalation and exhalation data.

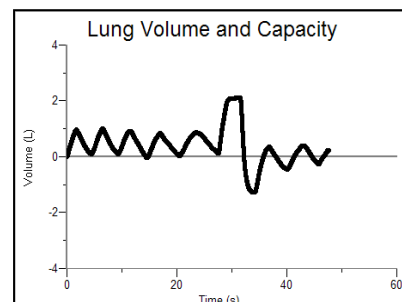


Figure 3

11. Select a representative **peak** and valley in the Tidal Volume portion of your graph. Place the cursor on the **peak** and click and drag down to the **valley** that follows it. Enter the Δy value displayed in the lower left corner of the graph to the nearest 0.1 L as Tidal Volume in Table 1.
12. Move the cursor to the **peak** that represents your maximum inspiration. Click and drag the cursor down to the **peak** of the tidal volume that you used in Question 10. Enter the Δy value displayed in the lower left corner of the graph to the nearest 0.1 L as Inspiratory Reserve Volume in Table 1.
13. Move the cursor to the **valley** that represents your maximum expiration. Click and drag the cursor up to the **valley** of the tidal volume that you used in Question 10. Enter the Δy value displayed in the lower left corner of the graph to the nearest 0.1 L as Expiratory Reserve Volume in Table 1.
14. Next you need to find the time interval of 1 breath. A breath is measured using the graph of your Tidal Volume. A breath is measured from **valley to valley** or **peak to peak**. Drag your cursor from one valley of your normal breath straight across to the next valley of your normal breath. Record your Δx . Record this time interval in Table 2.
15. Calculate the Vital Capacity and enter the total to the nearest 0.1 L in Table 1.

$$VC = TV + IRV + ERV$$

16. Calculate the Total Lung Capacity and enter the total to the nearest 0.1 L in Table 1. (Use the value of 1.5 L for the RV.)

$$TLC = VC + RV$$

DATA

Table 1	
Volume measurement (L)	Individual (L)
Tidal Volume (TV)	
Inspiratory Reserve (IRV)	
Expiratory Reserve (ERV)	
Vital Capacity (VC)	
Residual Volume (RV)	≈1.5
Total Lung Capacity (TLC)	

Table 2	
Time Interval of 1 Breath (seconds)	
$\Delta x = \frac{1 \text{ Breath}}{\text{Time (sec.)}}$	

BACKGROUND

Measurement of lung volumes provides a tool for understanding normal function of the lungs as well as disease states. The breathing cycle is initiated by expansion of the chest. Contraction of the diaphragm causes it to flatten downward. If chest muscles are used, the ribs expand outward. The resulting increase in chest volume creates a change in pressure between atmospheric pressure and alveolar pressure that draws air in through the nose and mouth. Normal exhalation is passive, resulting from “recoil” of the chest wall, diaphragm, and lung tissue.

In normal breathing at rest, approximately one-tenth of the total lung capacity is used. Greater amounts are used as needed (i.e., with exercise)

Lung volumes can be altered by disease. There are 2 categories for lung disease, obstructive lung disease and restrictive lung disease. People with obstructive and restrictive lung disease share the same main symptom: shortness of breath with exertion.

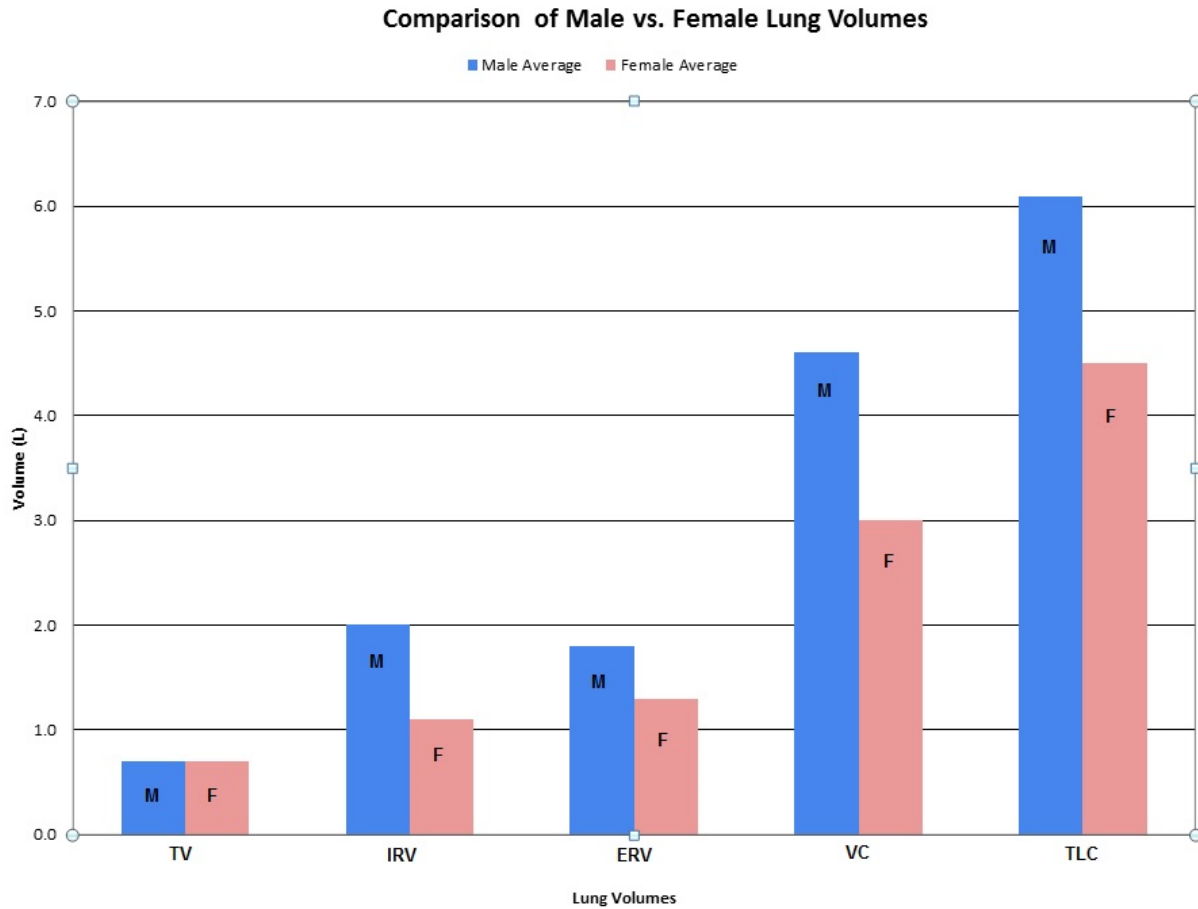
Obstructive lung diseases include conditions that make it hard to exhale all of the air in the lungs. People with obstructive lung disease have shortness of breath due to difficulty exhaling all the air from the lungs. Because of damage to the lungs, damage to tissues of the lungs, or narrowing of the airways inside the lungs, exhaled air comes out more slowly than normal making breathing difficult. At the end of a full exhalation, an abnormally high volume of air may still remain in the lungs.

People with restrictive lung diseases have difficulty fully expanding their lungs with air. They cannot fully fill their lungs with air, which means that the total volume of air their lungs can hold has been affected. Their lungs are limited or prevented from fully expanding making it difficult for them to take a full breath. Restrictive lung disease most often results from a condition causing stiffness in the lungs themselves. In other cases, stiffness of the chest wall, weak muscles, or damaged nerves may cause the restriction in lung expansion.

ANALYSIS QUESTIONS

1. On your graph, label the Tidal Volume, Inspiratory Reserve Volume, Expiratory Reserve Volume, Vital Capacity, Residual Volume, and Total Lung Capacity.
2. Using Δx from Table 2, calculate one of your group member's **Pulmonary Ventilation**, which is the volume of air in and out of the lungs per minute, during **normal quiet breathing**. Set up your problem like a dimensional analysis problem. Write out the equation and then show your work. Don't forget your units.

Look at the graph of the comparison between average male and female lung volumes and answer the following questions.

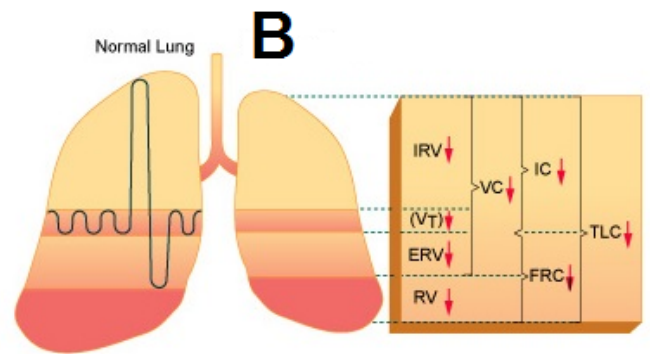
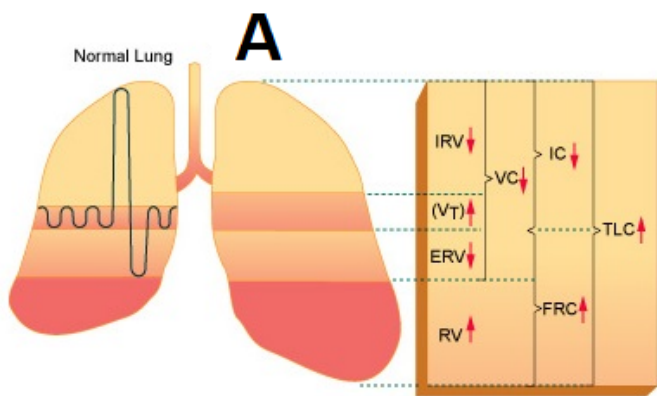


3. Using the bar graph, fill in the table of the approximate lung volumes.

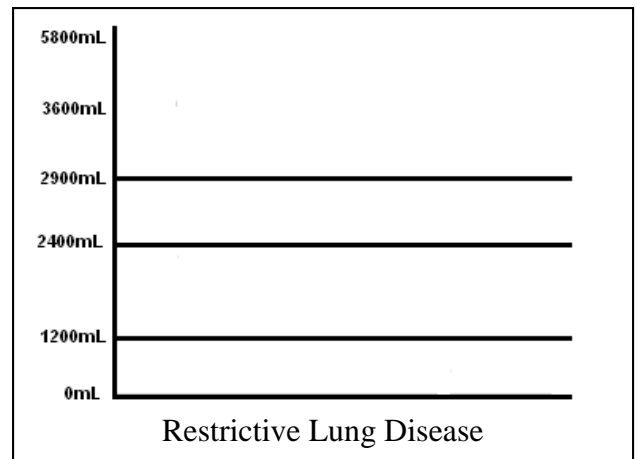
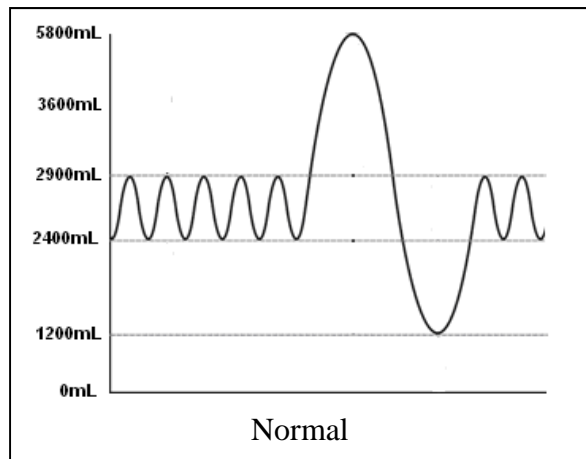
Volume measurement (L)	Male (L)	Female (L)
Tidal Volume (TV)		
Inspiratory Reserve (IRV)		
Expiratory Reserve (ERV)		

4. Using the data from Question 3, calculate the Vital Capacity of the females. **Show your work.** Next, look at the actual Vital Capacity of females from the graph. Does your calculated Vital Capacity equal the Vital Capacity from the graph? What might account for the error between the calculated Vital Capacity and the actual Vital Capacity?
5. Look at the overall trend of the lung volumes between male and females. What is the trend based on this graph? Give an explanation as to why this trend occurs.

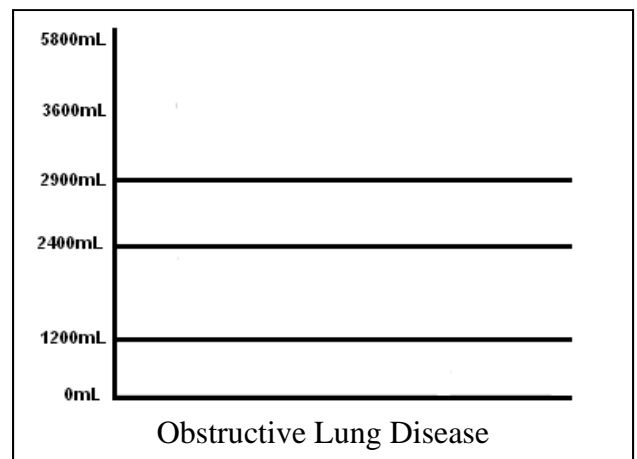
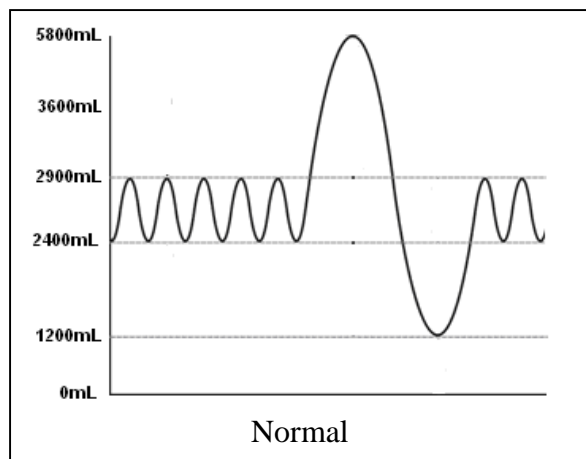
Based on the Background information and the illustration below, answer the following questions.



6. Which letter represents restrictive lung disease?
7. What single piece of evidence from the **background** information led you to your choice?
8. Based on the information provided to you in the above illustration, draw the spirogram of a person with a restrictive lung disease compared to a normal lung volume graph.



9. Which letter represents obstructive lung disease?
10. What single piece of evidence from the **background** information led you to your choice?
11. Based on the information provided to you in the above illustration, draw the spirogram of a person with an obstructive lung disease compared to a normal lung volume graph.



Patient Case Scenario

Harold Stenson is a 38 year old man, who has battled with extreme obesity his entire life. Harold is 5'10" and weighs 382 pounds. He has tried everything to lose weight. He has dieted and exercised to no prevail. Harold has opted to have gastric by-pass surgery to help him lose weight. Because of the additional weight, on his chest, Harold has difficulty breathing. He takes smaller, shallower breaths that at times seems like he is gasping for air.

12. **Which category of lung disease is exhibited by Harold?** Create a claim. Next, provide evidence from the scenario that supports your claim. Finally, provide a reason from the background that links your evidence to your claim. For your reason, think about what has Harold's obesity affected that is causing him to have difficulty in his breathing.

Guiding Question: Which category of lung disease is exhibited by this patient?	
Claim:	
Evidence #1:	Reason: (Background)
Evidence #2:	

13. Compared to a "Normal" spirogram, draw what Harold's spirogram would look like due to his lung disease.

