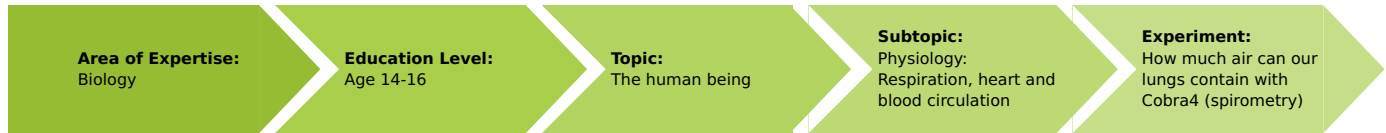


How much air can our lungs contain with Cobra4 (spirometry) (Item No.: P8001060)

Curricular Relevance



Difficulty



Intermediate

Preparation Time



10 Minutes

Execution Time



30 Minutes

Recommended Group Size



2 Students

Additional Requirements:

- iPad or Android tablet

Experiment Variations:

- Alternatively, use a PC with measureLAB (14580-61)
- Alternatively, use a Cobra4 Mobile-Link (12620-10)
- Alternatively, use a Cobra4 Xpert-Link (12625-99) + PC + measureLAB (14580-61)

Keywords:

Lung, Spirometer, Tidal volume, Expiratory reserve volume, Inspiratory reserve volume

Teacher information

Introduction

Principle

This experiment serves to introduce spirometry. In it, the students are to determine their vital capacities and compare and discuss them with each other, whereby the vital capacities determined may differ greatly between the various students. It is to be mentioned here that the effect which training can have in increasing the vital capacity is, compared to the volume due to body size, relatively small. The most important factors for the determination of the volume of the lungs are physique and age. Tall people generally have a greater lung volume than shorter people (see experiment "Does the lung volume depend on how tall you are?", experiment no. P8001260). With regard to age, the maximum lung volume is reached at an age of about 20. Older people have a reduced lung volume.

A difference is generally made between two ways of breathing, normal breathing and forced breathing. Normal breathing is the name given to breathing which occurs unconsciously when the body is not exerted in any way. Forced breathing occurs when one intentionally breathes in and out. Normal breathing is used in this experiment to determine tidal air (TV). Forced breathing is required for the determination of the inspiratory (IRV) and expiratory (ERV) reserve volumes.

It would be practical to combine this experiment with experiment "Direct determination of lung volume from a spirogram" (experiment no. P8001160) in which the vital capacity is measured directly. Should it not be possible to carry out both of them because of lack of time, two test students could carry out this and the following experiment. It should become clearly noticeable that the vital capacities determined in this experiment differ from those directly measured in experiment P8001160. (The equipment required for both experiments is the same.)

About the underlying technology: the turbine is coupled to a light barrier. Breathing into the spirometer causes it to revolve and the instrument calculates the volume of air breathed-in in litres from the revolutions of the turbine. The turbine used is a consumable popular in medical diagnostics. Still, all measurements taken with this equipment are not to be used to draw conclusions about the health status of the test persons. For more information, please read the warning information.



Fig. 1: Using the spirometer to determine various measured values
(left: measurement by using Cobra4 Wireless/USB-Link, on the right: Cobra4 Mobile-Link)

Tasks

1. Determine your tidal volume (**TV**)
2. Determine your expiratory reserve volume (**ERV**)
3. Determine your inspiratory reserve volume (**IRV**)

Equipment

Experiment with iPad or Android tablet

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
2	Cobra4 Sensor-Unit Spirometry, Pulmonary volume and Wind Speed	12675-00	1
3	Disposable turbine with cardboard-mouthpiece, set of 50 (for Cobra4 Sensor-Unit Spirometry)	12675-11	1
4	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
Additional material:			
	Android-Tablet or iPad		1
	PHYWE measure App		

Android

iPad



Experiment with PC

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
2	Cobra4 Sensor-Unit Spirometry, Pulmonary volume and Wind Speed	12675-00	1
3	Disposable turbine with cardboard-mouthpiece, set of 50 (for Cobra4 Sensor-Unit Spirometry)	12675-11	1
4	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
5	Software measureLAB	14580-61	1
Additional material:			
	PC		1

Experiment with Cobra4 Xpert-Link and PC

Position No.	Material	Order No.	Quantity
1	Cobra4 Xpert-Link	12625-00	1
2	Cobra4 Xpert Connect	12625-01	1
3	Cobra4 Sensor-Unit Spirometry, Pulmonary volume and Wind Speed	12675-00	1
4	Disposable turbine with cardboard-mouthpiece, set of 50 (for Cobra4 Sensor-Unit Spirometry)	12675-11	1
5	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
6	Software measureLAB	14580-61	1
Additional material:			
	PC		1

Warning information

Warning

The apparatus used is not a medical measuring instrument. The measured values obtained with it are only to be used to provide an understanding of spirometry. Deviations in measured values between students, or from the values given in the figures which are used here as examples, are not to be considered to be a pointer to a possible illness. A pulmonary function test which is carried out by a physician is the only means of obtaining a medically relevant diagnosis.

Notes on the procedure

Make sure that the students carry out the experiment in the standing position, as this is a necessary condition of the experiment. The behaviour of the lungs with regard to volume is different when sitting compared to when standing. Should some students stand up and others sit down, this would cause an unnecessary difficulty in comparing the values for different tested students.

Further to this and for reason of hygiene, ensure that each student uses an unused, originally packaged cardboard mouthpiece and a new FlowMir turbine for the experiment.

Please make it clear to the students how they are to breathe in and out for the determination of the various measured values should this not be clear to them from the text.

How much air can our lungs contain with Cobra4 (spirometry) (Item No.: P8001060)

Introduction

Principle and task

Principle

Lungs are organs which enable carbon dioxide (CO₂) to be exhaled and oxygen (O₂) to be absorbed. Contraction of the diaphragm connected to the lungs causes them to stretch so that air is drawn into them from the surroundings. When the diaphragm subsequently relaxes, the lungs return to their original position and air is passively breathed out.

In the following experiment, the lung volume, which is the volume of air which the lungs can take in, is to be determined. A **spirometer** is used for this measurement. Spirometers are frequently used by physicians to determine irregularities in the functioning of lungs.

The maximum volume of air breathed out on maximum exhalation is called the **vital capacity (VC)**. The vital capacity is made up of the sum of three volumes, **tidal volume (TV)** + **inspiratory reserve volume (IRV)** + **expiratory reserve volume (ERV)**:

$$(1) \quad VC = TV + IRV + ERV$$

TV is the volume which is inhaled during normal breathing. IRV is the volume which can be additionally inhaled further to that inhaled on normal breathing. ERV is the volume which can be additionally expired after normal expiration. When air is ventilated out of the lungs, however, there is always still a certain amount of air in them. This amount of air has a volume of about 1.2 litres and is called the residual volume.



Fig. 1: Using the spirometer to determine various measured values

Tasks

1. Determine your tidal volume (**TV**)
2. Determine your expiratory reserve volume (**ERV**)
3. Determine your inspiratory reserve volume (**IRV**)

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
2	Cobra4 Sensor-Unit Spirometry, Pulmonary volume and Wind Speed	12675-00	1
3	Disposable turbine with cardboard-mouthpiece, set of 50 (for Cobra4 Sensor-Unit Spirometry)	12675-11	1
4	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
Additional material:			
	Android-Tablet or iPad		1
	PHYWE measure App		

Android

iPad



Warning information

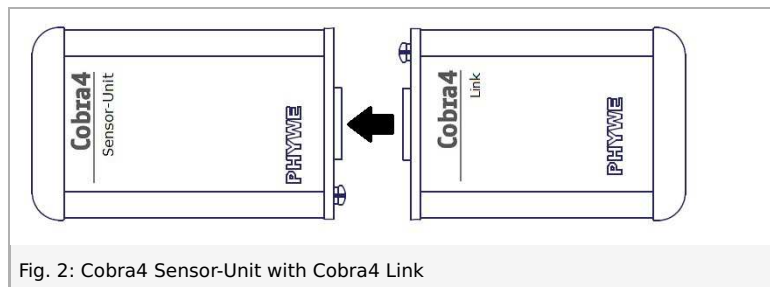
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Set-up and procedure

Set-up



- Plug the spirometer unit onto Cobra4 Wireless/USB-Link.



- Take a turbine out from its packaging and insert it into the opening of the spirometer unit with a brief and gentle turning movement. Make sure that only one person uses one turbine to avoid the possible transfer of diseases. Each test person must have her or his own turbine and cardboard tube!
- Take a new cardboard tube from its original packaging and plug it in the turbine which was previously fitted in position. Possibly the cardboard tube is already fixed to the turbine.
- The measurement instruments so assembled should now be as shown in the Figure 1.

Procedure

The following experiments are all to be carried out in a standing position so that the results of one student can be compared with those of other students.

- Start PHYWE measureAPP  and switch on the Cobra4 Wireless/USB-Link. The sensor is detected automatically.
 - Select the Cobra4 Sensor-Unit Spirometry in the measureAPP . The measurement automatically shows the volume as a function of time.
-
- **Measurement 1 (TV - tidal volume):** Stand upright and hold your breath.
 - Put the spirometer mouthpiece into your mouth so that it is surrounded by your lips without leaving any gap inbetween. No air is to escape through your nose, so pinch your nostrils together if necessary.
 - Start the measurement. Breathe normally as usual.
 - Measure the normal volume breathed out as your tidal volume (**TV**) in litres.
 - When you have finished expiring air, stop and save the measurement.



- **Measurement 2 (ERV - expiratory reserve volume):** While standing, breathe out as much as possible without exerting yourself.
- Put the mouthpiece into your mouth so that it is completely enclosed by your lips. No air is to escape through your nose so pinch your nostrils together if necessary.
- Start the measurement.
- Breathe out the residual air by pressing it out as much as you can.
- Measure the pressed-out air volume as your expiratory reserve volume (**ERV**) in litres.
- When you have finished expiring air, stop and save the measurement.

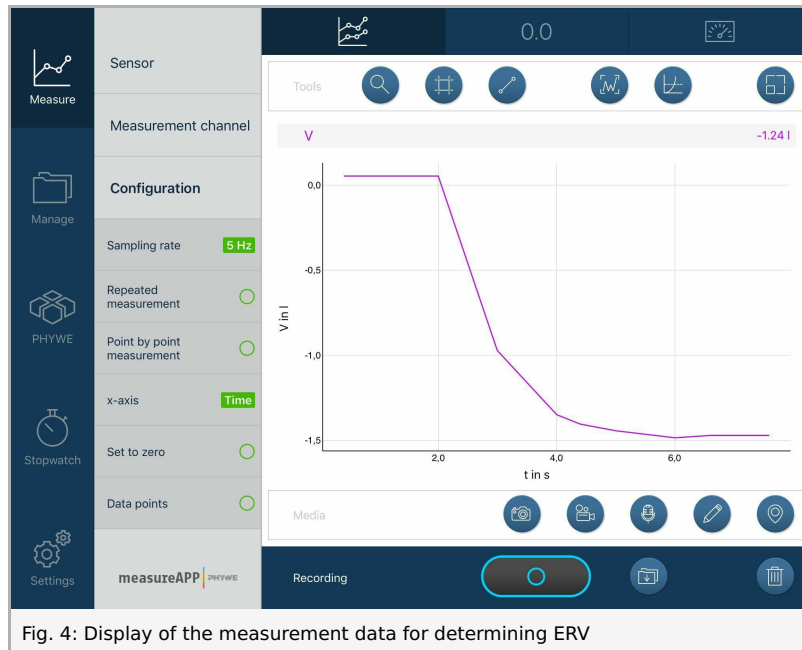


Fig. 4: Display of the measurement data for determining ERV

- **Measurement 3 (IRV - inspiratory reserve volume):** While standing, breathe in as much as possible without exerting yourself and hold your breath.
- Put the mouthpiece into your mouth so that it is completely enclosed by your lips. No air is to escape through your nose so pinch your nostrils together if necessary.
- Start the measurement.
- Breathe in air as much as you can by forcefully drawing it in.
- Measure the drawn-in inspired air volume as inspiratory reserve volume (**IRV**) in litres.
- When you have finished breathing in air, end and save the measurement.

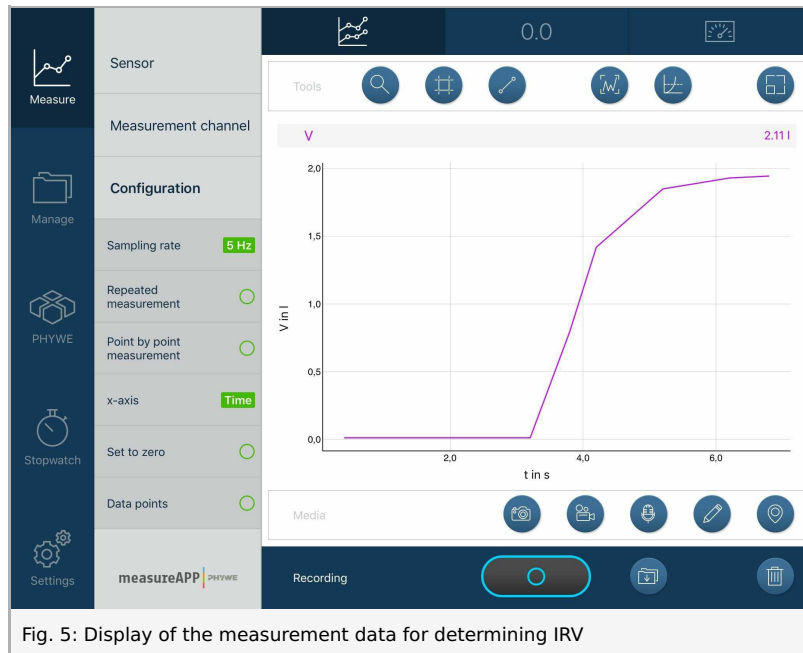



Fig. 5: Display of the measurement data for determining IRV

Result and evaluation


Results

- Measurement 1:** What is the volume of your breath (TV) in litres? You can use the Survey tool  to examine this volume in the graph.

TV =




Fig. 5: Measurement data for determining TV

- Measurement 2:** What is your expiratory reserve volume (ERV) in litres? You can use the Survey tool  to examine this volume in the graph.

ERV =



Fig. 6: Measurement data for determining ERV

- Measurement 3:** What is your inspiratory reserve volume (IRV) in litres? You can use the Survey tool  to examine this volume in the graph.

IRV =



Fig. 7: Measurement data for determining IRV

Evaluation

- What is your vital capacity (VC) in litres? Calculate it using formula (1) from the introduction.

VC =

Example:

$$VC = TV + IRV + ERV = 0,5 \text{ l} + 1,5 \text{ l} + 1,9 \text{ l} = 3,9 \text{ l}$$

- What is the greatest volume of air that your lungs can take in? Take the residual volume into consideration.

.....

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Introduction

Principle and task

Principle

Lungs are organs which enable carbon dioxide (CO₂) to be exhaled and oxygen (O₂) to be absorbed. Contraction of the diaphragm connected to the lungs causes them to stretch so that air is drawn into them from the surroundings. When the diaphragm subsequently relaxes, the lungs return to their original position and air is passively breathed out.

In the following experiment, the lung volume, which is the volume of air which the lungs can take in, is to be determined. A **spirometer** is used for this measurement. Spirometers are frequently used by physicians to determine irregularities in the functioning of lungs.

The maximum volume of air breathed out on maximum exhalation is called the **vital capacity (VC)**. The vital capacity is made up of the sum of three volumes, **tidal volume (TV)** + **inspiratory reserve volume (IRV)** + **expiratory reserve volume (ERV)**:

$$(1) VC = TV + IRV + ERV$$

TV is the volume which is inhaled during normal breathing. IRV is the volume which can be additionally inhaled further to that inhaled on normal breathing. ERV is the volume which can be additionally expired after normal expiration. When air is ventilated out of the lungs, however, there is always still a certain amount of air in them. This amount of air has a volume of about 1.2 litres and is called the residual volume.



Fig. 1: Using the spirometer to determine various measured values

Tasks

1. Determine your tidal volume (**TV**)
2. Determine your expiratory reserve volume (**ERV**)
3. Determine your inspiratory reserve volume (**IRV**)

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
2	Cobra4 Sensor-Unit Spirometry, Pulmonary volume and Wind Speed	12675-00	1
3	Disposable turbine with cardboard-mouthpiece, set of 50 (for Cobra4 Sensor-Unit Spirometry)	12675-11	1
4	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
5	Software measureLAB	14580-61	1
Additional material:			
	PC		1

Warning information

Caution!

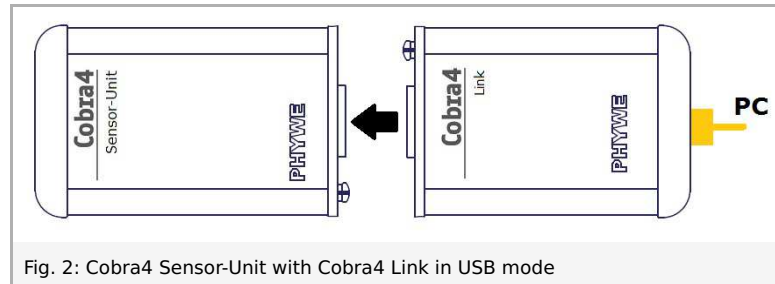
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Set-up and procedure

Set-up

Note: In the procedure described here the USB mode of Cobra4 Wireless/USB-Link is used, requiring a USB cable. If you want to use the wireless mode, please refer to its operating manual how to connect it to the computer wirelessly.





- Plug the spirometer unit onto the Cobra4 Wireless/USB-Link.
Connect the Wireless/USB-Link to the PC using the USB cable.



- Take a turbine out from its packaging and insert it into the opening of the spirometer unit with a brief and gentle turning movement. Make sure that only one person uses one turbine to avoid the possible transfer of diseases. Each test person must use her or his own turbine and cardboard tube!
- Take a new cardboard tube from its original packaging and plug it in the turbine which was previously fitted in position. Possibly the cardboard tube is already fixed to the turbine.
- The measurement apparatus so assembled should now be as shown in the Figure 1.

Procedure

The following experiments are all to be carried out in a standing position so that the results of one student can be compared with those of other students.

- Switch on the Cobra4 Wireless/USB-Link and then start PHYWE measureLAB . The sensor is detected automatically.
 - Select the Cobra4 Sensor-Unit Spirometry in PHYWE measureLAB . All pre-settings required for directly recording the measurement readings are loaded when you select the experiment in the home screen of measureLAB. The measurement automatically shows the volume as a function of time.
-
- **Measurement 1 (TV - tidal volume):** Stand upright and hold your breath.
 - Put the spirometer mouthpiece into your mouth so that it is surrounded by your lips without leaving any gap inbetween. No air is to escape through your nose, so pinch your nostrils together if necessary.
 - Start the measurement . Breathe normally as usual.
 - Measure the normal volume breathed out as your tidal volume (**TV**) in litres.
 - When you have finished expiring air, stop  and save the measurement.

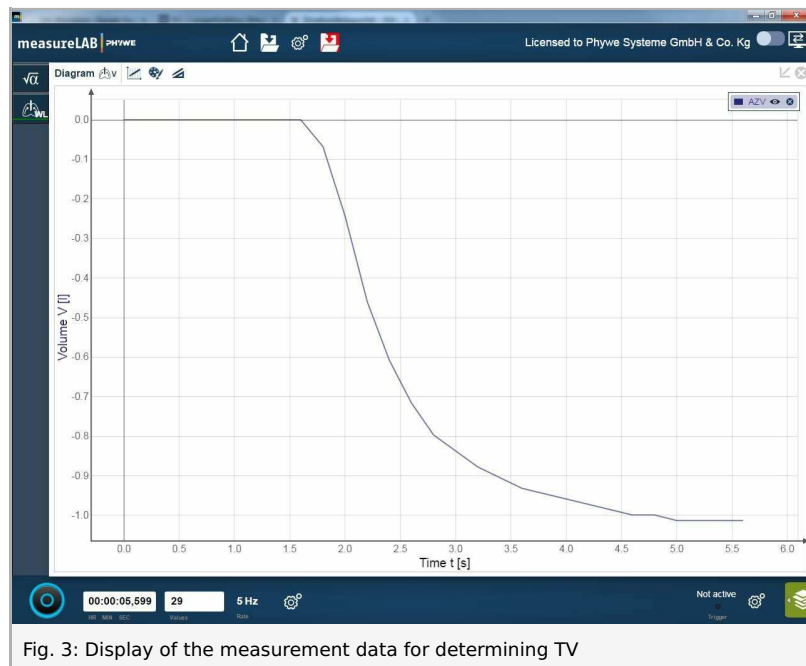




Fig. 3: Display of the measurement data for determining TV

- **Measurement 2 (ERV - expiratory reserve volume):** While standing, breathe out as much as possible without exerting yourself.
- Put the mouthpiece into your mouth so that it is completely enclosed by your lips. No air is to escape through your nose so pinch your nostrils together if necessary.
- Start the measurement .
- Breathe out the residual air by pressing it out as much as you can.
- Measure the pressed-out air volume as your expiratory reserve volume (**ERV**) in litres.
- When you have finished expiring air, stop  and save the measurement.

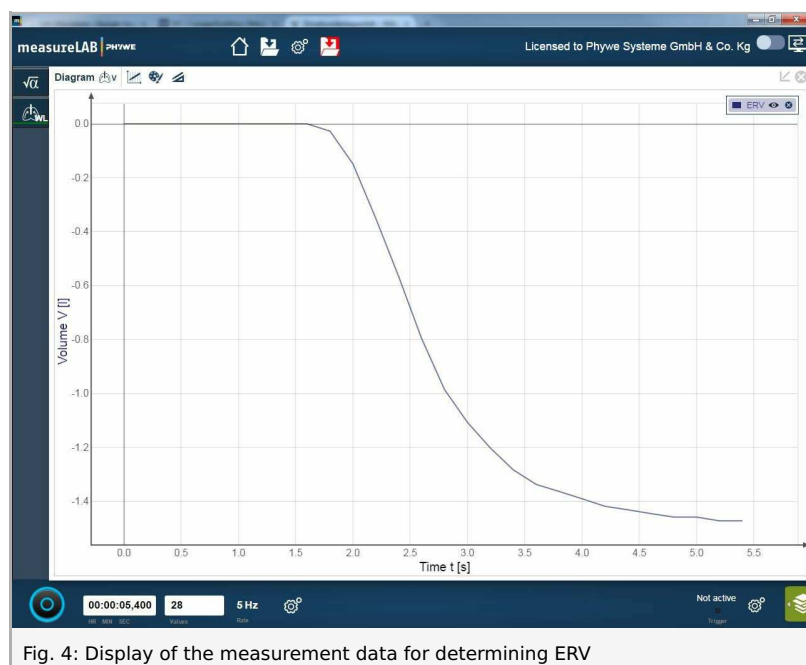




Fig. 4: Display of the measurement data for determining ERV

- **Measurement 3 (IRV - inspiratory reserve volume):** While standing, breathe in as much as possible without exerting yourself and hold your breath.
- Put the mouthpiece into your mouth so that it is completely enclosed by your lips. No air is to escape through your nose so pinch your nostrils together if necessary.
- Start the measurement .
- Breathe in air as much as you can by forcefully drawing it in.

- Measure the drawn-in inspired air volume as inspiratory reserve volume (**IRV**) in litres.
- When you have finished breathing in air, end  and save the measurement.

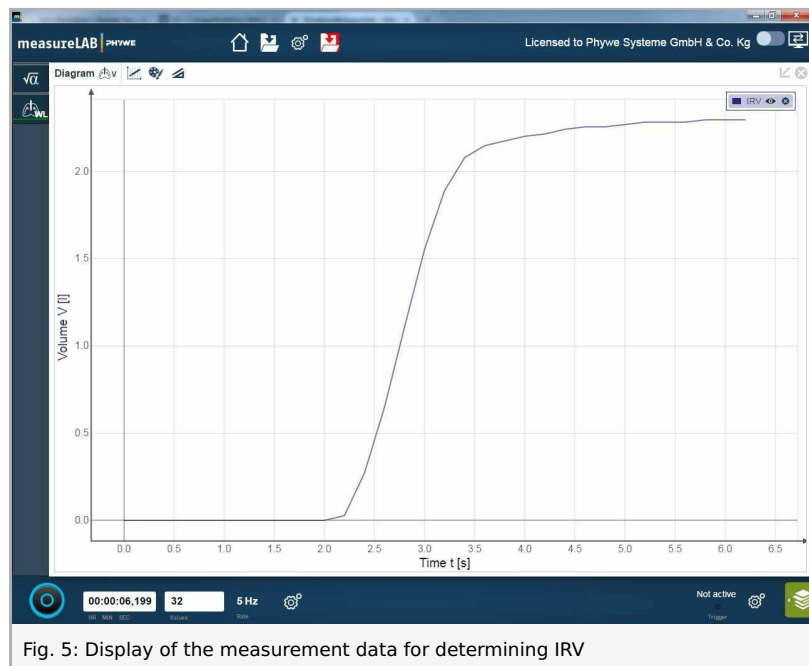



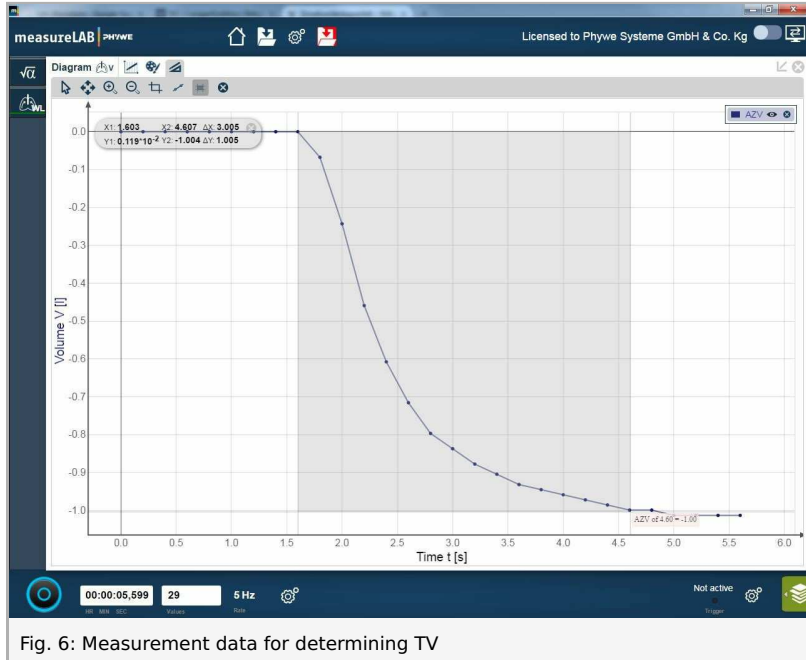
Fig. 5: Display of the measurement data for determining IRV


Result and evaluation

Results

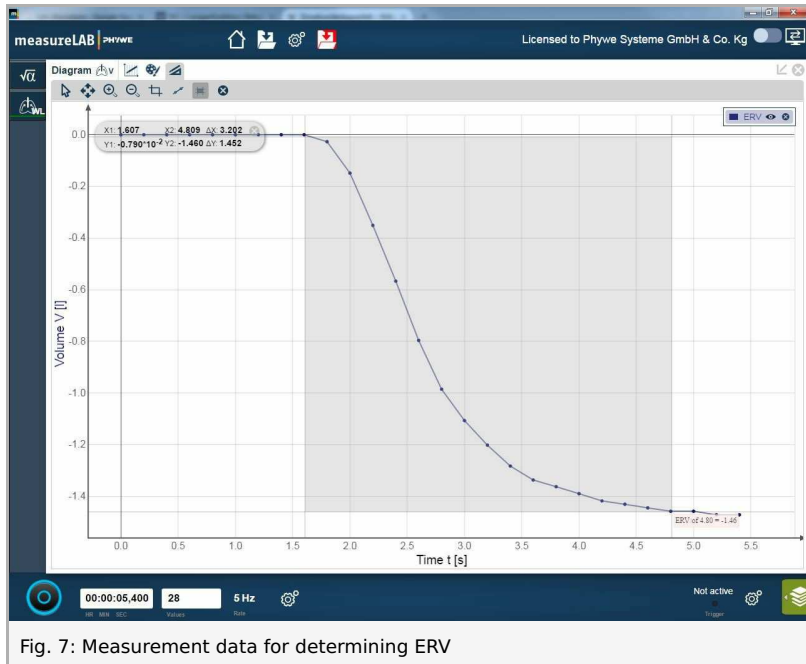
- Measurement 1:** What is the volume of your breath (TV) in litres? You can use the Survey tool  to examine this volume in the graph.


TV =



- Measurement 2:** What is your expiratory reserve volume (ERV) in litres? You can use the Survey tool  to examine this volume in the graph.

ERV =



- Measurement 3:** What is your inspiratory reserve volume (IRV) in litres? You can use the Survey tool  to examine this volume in the graph.

IRV =



Fig. 8: Measurement data for determining IRV

Evaluation

- What is your vital capacity (VC) in litres? Calculate it using formula (1) from the introduction.

VC =

Example:

$$VC = TV + IRV + ERV = 01,0 \text{ l} + 1,45 \text{ l} + 2,26 \text{ l} = 4,71 \text{ l}$$

- What is the greatest volume of air that your lungs can take in? Take the residual volume into consideration.

.....

Introduction

Principle and task

Principle

Lungs are organs which enable carbon dioxide (CO₂) to be exhaled and oxygen (O₂) to be absorbed. Contraction of the diaphragm connected to the lungs causes them to stretch so that air is drawn into them from the surroundings. When the diaphragm subsequently relaxes, the lungs return to their original position and air is passively breathed out.

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Fig. 1: Using the spirometer to determine various measured values

Tasks

1. Determine your tidal volume (**TV**)
2. Determine your expiratory reserve volume (**ERV**)
3. Determine your inspiratory reserve volume (**IRV**)

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra4 Xpert-Link	12625-00	1
2	Cobra4 Xpert Connect	12625-01	1
3	Cobra4 Sensor-Unit Spirometry, Pulmonary volume and Wind Speed	12675-00	1
4	Disposable turbine with cardboard-mouthpiece, set of 50 (for Cobra4 Sensor-Unit Spirometry)	12675-11	1
5	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
6	Software measureLAB	14580-61	1
Additional material:			
	PC		1

Warning information

Caution!

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Set-up and procedure

Set-up

- Plug the spirometer unit onto the Xpert Connect.

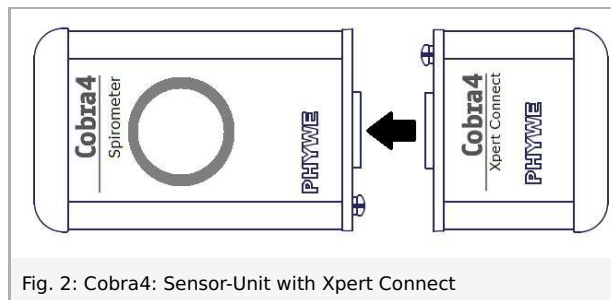


Fig. 2: Cobra4: Sensor-Unit with Xpert Connect

- Connect the Cobra4 Xpert-Link to the Cobra4 Xpert Connect, to the PC and to the electrical outlet.

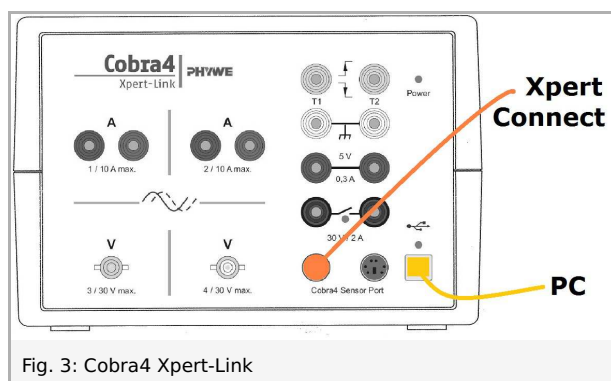


Fig. 3: Cobra4 Xpert-Link

- Take a turbine out from its packaging and insert it into the opening of the spirometer unit with a brief and gentle turning movement. Make sure that only one person uses one turbine to avoid possible transfer of diseases. Each test person must have her or his own turbine and cardboard tube!
- Take a new cardboard tube from its original packaging and plug it in the turbine which was previously fitted in position. Possibly the cardboard tube is already fixed to the turbine.
- The measurement apparatus so assembled should now be as shown in the figure 1.

Procedure

The following experiments are all to be carried out in a standing position so that the results of one student can be compared with those of other students.

- Start PHYWE measureLAB and switch on the Cobra4 Xpert-Link. The spirometry sensor is detected automatically.
 - Select the Cobra4 Sensor-Unit Spirometry in PHYWE measureLAB and then the channel volume V that you want to measure. All pre-settings required for directly recording the measurement readings are loaded when you select the experiment in the home screen of measureLAB. The measurement automatically shows the volume as a function of time.
-
- **Measurement 1 (TV - tidal volume):** Stand upright and hold your breath.
 - Put the spirometer mouthpiece into your mouth so that it is surrounded by your lips without leaving any gap inbetween. No air is to escape through your nose, so pinch your nostrils together if necessary.
 - Start the measurement . Breathe normally as usual.
 - Measure the normal volume breathed out as your tidal volume (**TV**) in litres.
 - When you have finished expiring air, stop and save the measurement.

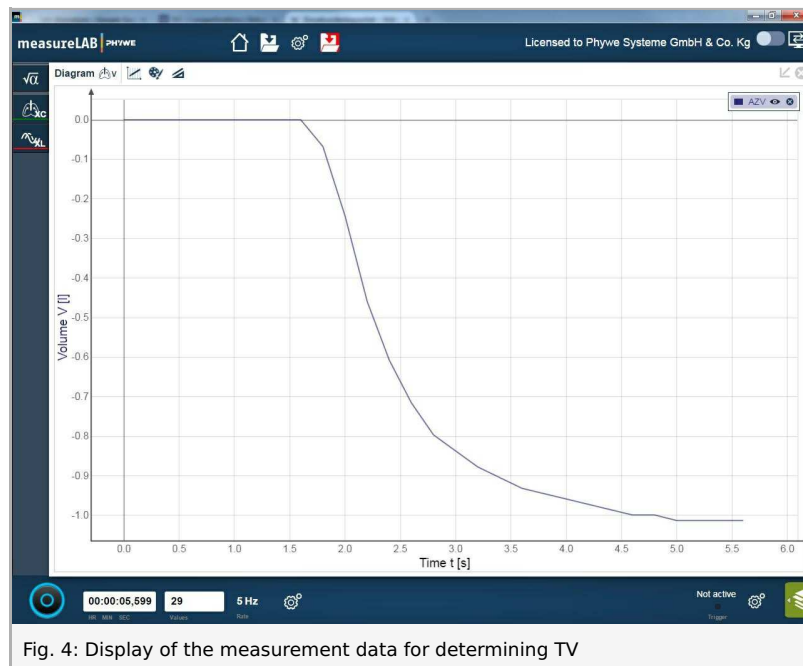




Fig. 4: Display of the measurement data for determining TV

- **Measurement 2 (ERV - expiratory reserve volume):** While standing, breathe out as much as possible without exerting yourself.
- Put the mouthpiece into your mouth so that it is completely enclosed by your lips. No air is to escape through your nose so pinch your nostrils together if necessary.
- Start the measurement .
- Breathe out the residual air by pressing it out as much as you can.
- Measure the pressed-out air volume as your expiratory reserve volume (**ERV**) in litres.
- When you have finished expiring air, stop  and save the measurement.

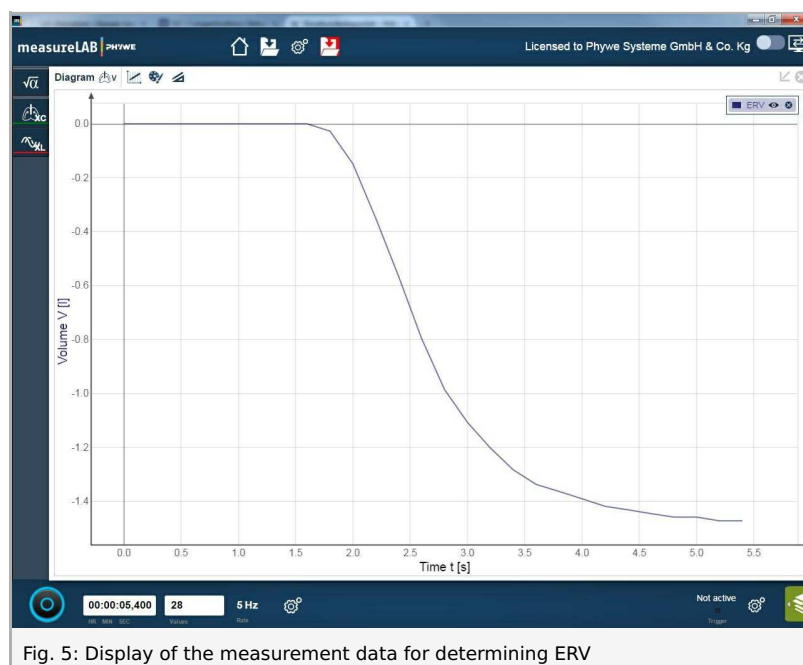




Fig. 5: Display of the measurement data for determining ERV


- **Measurement 3 (IRV - inspiratory reserve volume):** While standing, breathe in as much as possible without exerting yourself and hold your breath.
- Put the mouthpiece into your mouth so that it is completely enclosed by your lips. No air is to escape through your nose so pinch your nostrils together if necessary.
- Start the measurement .
- Breathe in air as much as you can by forcefully drawing it in.

- Measure the drawn-in inspired air volume as inspiratory reserve volume (**IRV**) in litres.
- When you have finished breathing in air, stop  and save the measurement.

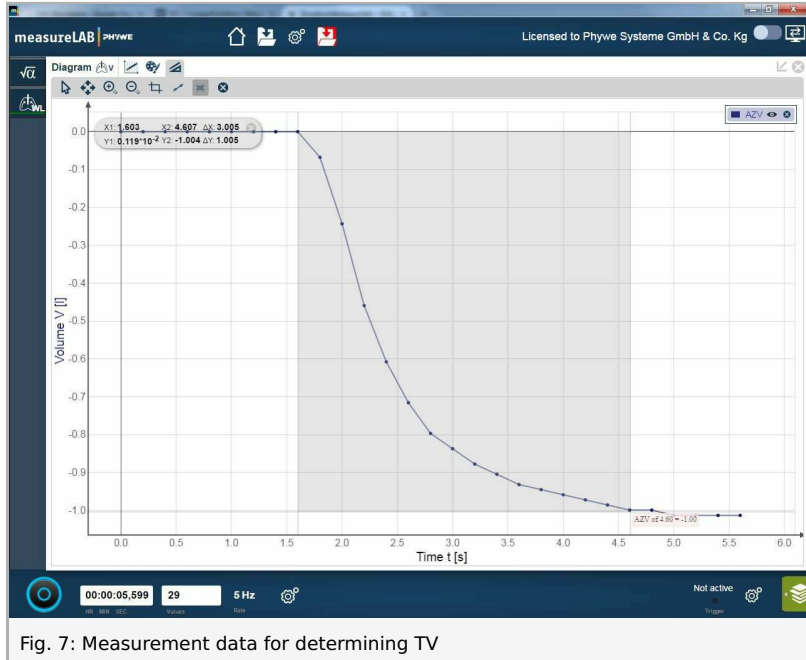



Result and evaluation

Results

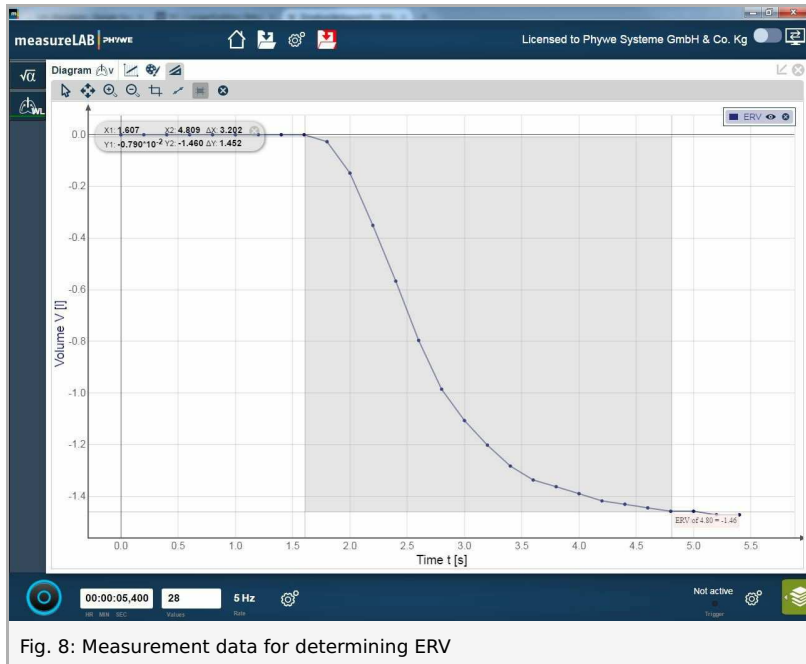
- Measurement 1:** What is the volume of your breath (TV) in litres? You can use the Survey tool  to examine this volume in the graph.


TV =



- Measurement 2:** What is your expiratory reserve volume (ERV) in litres? You can use the Survey tool  to examine this volume in the graph.

ERV =



- Measurement 3:** What is your inspiratory reserve volume (IRV) in litres? You can use the Survey tool  to examine this volume in the graph.

IRV =



Fig. 9: Measurement data for determining IRV

Evaluation

- What is your vital capacity (VC) in litres? Calculate it using formula (1) from the introduction.

VC =

Example:

$$VC = TV + IRV + ERV = 01,0 \text{ l} + 1,45 \text{ l} + 2,26 \text{ l} = 4,71 \text{ l}$$

- What is the greatest volume of air that your lungs can take in? Take the residual volume into consideration.

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