Student Experiments

Manual

AIR PRESSURE

P9160-4V

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MELS02	“Magdeburg Hemispheres”
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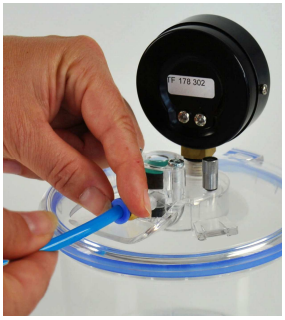
USING THE VACUUM CHAMBER

Consider following points before using the vacuum chamber:

- Check whether the gasket (blue ring) is placed uniformally in the gauge of the upper section of the base part
- Put the cover centrally on the chamber (not colaterally displaced)

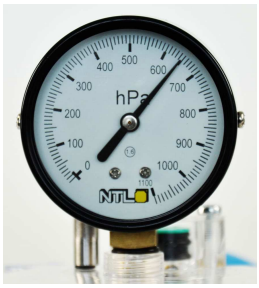


- Stick the blue hose into the valve
- Caution: after the first resistance, the hose has to be laterally moved a further 3-4mm – finally the hose fits perfectly!

- Stick the other hose ending with the white adapter on the gas syringe by using firm pressure.

- Hold the gas syringe with one hand and pull the grip of the syringe with the other hand.

When pushing the syringe, the lower valve closes and the air escapes via the upper valve.



With every extraction you will see from the Manometer that the pressure in the chamber declines. The scale of the Manometer also shows you negative pressure!

- The lower the pressure the more you have to work when pumping.

If neccessary the hose can be removed from the valve:

- Press the blue plastics ring inwards – and pull the hose out.

EVIDENCE OF AIR PRESSURE

MELS 01

Required Kit:
P9902-4V Air pressure

Material:
1x Syrings plastics, 120ml
1x Manometer, SE

EVIDENCE OF AIR PRESSURE

MELS 01

When driving down a hill you can feel in your ears the air pressure increasing.
Also when a plane is landing the pressure gets increased inside the plane – this may cause discomfort. With the syringe you can easily change the pressure.

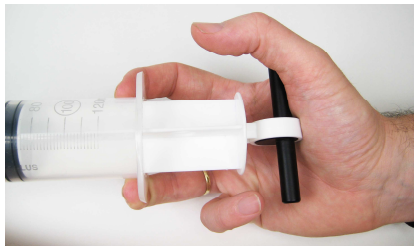
Experiment 1:

Position the syringe somewhere between 30 and 40ml. Hold the syringe with one hand and close the hole with one finger. Press the plunger slightly and then pull it. You will feel over- and underpressure directly on your finger.

Experiment 2:

You can prove and measure the generated pressure with a Manometer (in hecto pascal).
The pointer position at zero indicates the normal air pressure of approx. 1000 hPa
A Pointer position at -1000 hPa then means an actual pressure of 1000 -1000 = 0 hPa (vacuum), a pressure of 1000 + 1000 = 2000 hPa, which means that the pressure has doubled.

Part 1:
Shift the plunger fully inside the syringe and stick the Manometer on it.
Pull the plunger and read off the value on the Manometer.

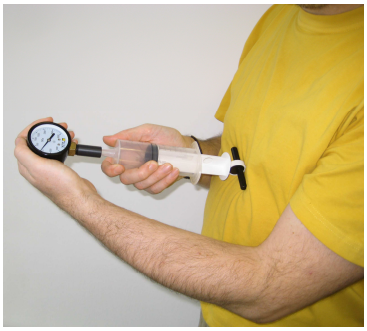


Part 2: Move the plunger to 70 -80ml and stick the Manometer on the syringe.

Hold the syringe and also the Manometer with one hand (the left one) and press the plunger with the grip inside...

a) by holding up the syringe with ring-and forefinger
b) by pushing the grip on your stomach

Read off the value on the Manometer while adjusting the plunger.



Conclusion (fill in the gaps):

When pulling the plunger, the space for the gas particles, and the pressure _____ .
decreases/increases

When pressing the plunger, the space for the gas particles, and the pressure _____
decreases/increases

"MAGDEBURG HEMISPHERES"

MELS 02

Required Kit:
P9902-4V Air pressure

Material:
1x Magdeburg Circler, SE

"MAGDEBURG HEMISPHERES"

MELS 02

Generally, huge forces occur when normal air pressure interacts with a lower pressure. These forces are studied in this experiment. In 1654 Otto Guericke, major of Magdeburg, was demonstrating the experiment with two hemispheres. Now, experience by yourself the huge power of air pressure on the earth's surface.

Preparations:

Take the Magdeburg discs and press them lightly together
Do not wet or lick them, always use them dry.

Experiment:

Try to pull the discs apart by pulling on the grips

The circles easily separate when you let air inside by softly bending the edge of one disc.

Conclusion (fill in the gaps):

If air pressure is acting _____, huge forces are appearing.
collateral / from everywhere in the same way / single-edged

The magnitude of the force depends on
_____
the dimension of the circles / on the applied pressure

to press the circles together.

Advice:
Later, during another experiment, the discs are placed in the vacuum chamber followed by reducing the pressure around them.

AIR PRESSURE MEASUREMENT

MELS 03

Required Kit:
P9902-4V Air pressure

Material:
1x Syringe plastics, 120ml
1x Vacuum hose plastics, SE
1x Vacuum chamber complete, 1000ml

AIR PRESSURE MEASUREMENT

MELS 03

To act in time and also to avoid trouble, you will often watch and read off the values on meters such as a speedometer.
This can be the speed when driving as well as reading the temperature to diagnose whether there is a risk of frost. Another example would be to observe the pressure of liquids/gases to ensure that nothing explodes or to guarantee that enough power gets generated at a specific pressure level (hydraulic power units).

Preparations:
Check the instructions on how to use the vacuum chamber.

Experiment:

If the chamber is ready prepared and the syringe is connected, press the plunger fully in and finally pull it out until 100ml is reached. As a result you have reduced the air volume by 1/10 and pressure is reduced by 1/10, for 100hPa. The pressure in the chamber is now 1000 hPa – 100hPa.

Now, continue with evacuating air from the chamber and watch the vacuummeter and the valves.
Note: the more the pressure inside the chamber decreases, the more the outer air pressure becomes noticeable and it gets harder. At a pressure level of 200hPa=1000hPa-200hPa it gets harder and harder to pull out more air.

Task:
At which pressure level is it still possible to remove the cover more or less easily?

_____
900hPa / 800hPa / 600hPa

Conclusion:

With a Manometer (in this case a Vacuummeter, as only small pressure gets measured) you can measure air pressure.

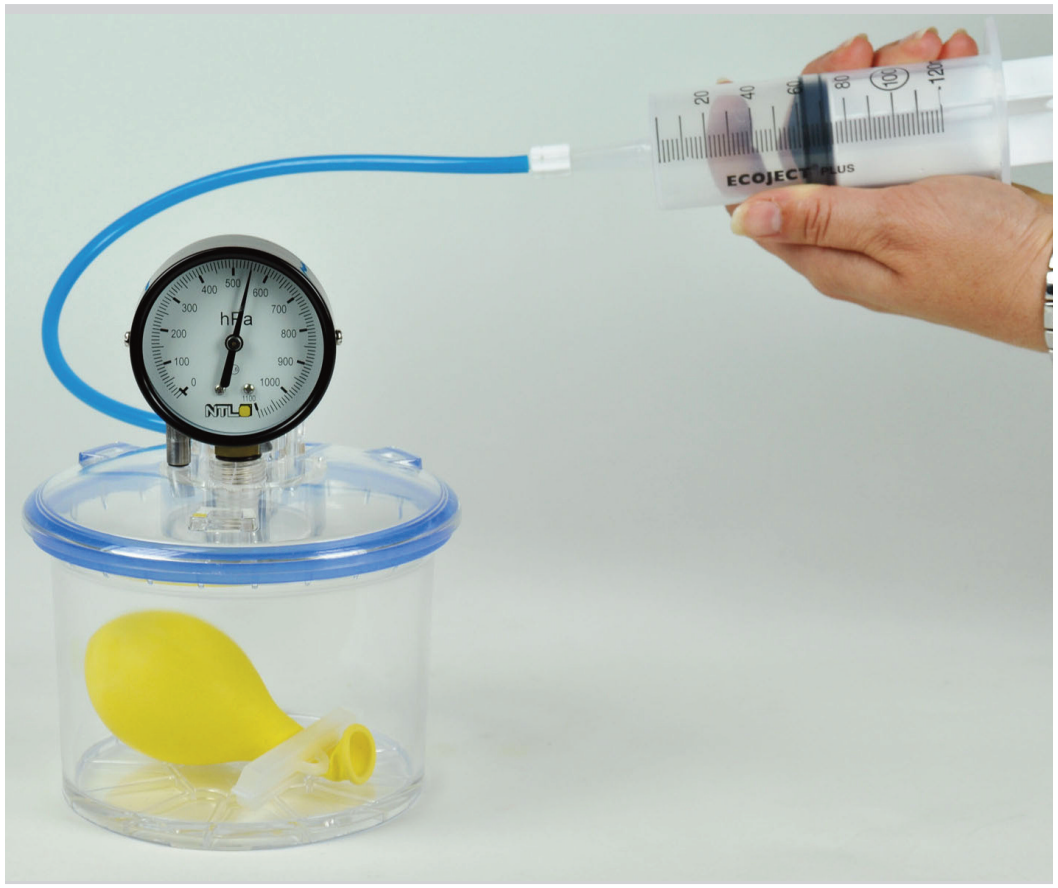
Advice:
Meters for measuring air pressure are also called Barometers.

When the pressure in the chamber e.g. has halved, then in the course of one stroke only half of air volume gets transported outside. Consequently, the pressure declines by 50hPa. Generally speaking, with every stroke the pressure inside the chamber declines by 1/10 of the existing inner level.

AIR PRESSURE EFFECT - EXTERNAL PRESSURE DIMINISHED

MELS 04

Required Kit:
P9902-4V Air pressure



Material:
1x Syringe plastics, 120ml
1x Vacuum hose plastics, SE
1x Vacuum chamber complete, 1000ml
1x Balloons
1x Clamp for balloons
1x Magdeburg circler, SE

AIR PRESSURE EFFECT - EXTERNAL PRESSURE DIMINISHED

MELS 04

You will have experienced, during the "Magdeburg Hemispheres" experiment, that forces occur when there is a difference between the outer and inner pressure level. In this experiment the outer pressure was higher than the inner one. With the help of the vacuum chamber the effect can be neutralized or reversed. When pumping up a tyre, the inner pressure gets higher than the outer one. This effect is equal when the inner pressure stays unchanged while the outer pressure is declining.

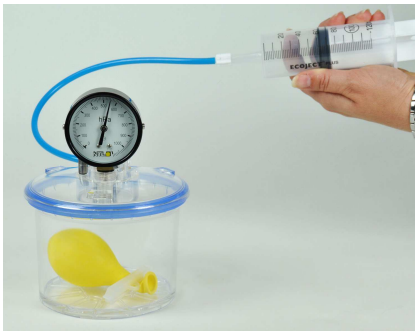
Preparations:
Put 1. The connected Magdeburg hemispheres, 2. the locked balloon 3. a paper base (if existing) and a chocolate marshmallow on it in the vacuum chamber.
Check the first page on how to use the vacuum chamber.

Note. Do not wet the Magdeburg hemispheres. Always use them dry.

Experiment 1: connected Magdeburg hemispheres

Reduce the pressure in the chamber and read off the value on the vacuummeter when inner pressure = outer pressure. You may need to shake the chamber.
Result: the hemispheres fall apart.

Experiment 2: balloon



Seal an unused balloon with the clamp and put it into the vacuum chamber
Reduce the pressure and watch what happens to the balloon.
Release the pressure and watch the effect of the increasing outer pressure

Experiment 3:

Same as experiment 2 but with a chocolate marshmallow on a paper base

Conclusion:
Force action at different pressure levels always acts from the_____to
lower / higher
the _____pressure level.
lower / higher

AIR PRESSURE EFFECT - WATER BOILS AT 60 DEGREES

MELS 05

Required Kit:
P9902-4V Air pressure

Material:
1x Syringe plastics, 120ml
1x Vacuum hose plastics, SE
1x Vacuum chamber complete, 1000ml
1x Capsule plastics with cover

AIR PRESSURE EFFECT - WATER BOILS AT 60 DEGREES

MELS 05

When boiling meat, potatoes, rice etc. they become soft; one has to add water and heat it. The food becomes soft quicker when the water temperature is higher. In a pressure cooker the pressure increases because the steam and the gas bubbles increase the pressure and so the water boils at a higher temperature - as a result cooking time gets shortened.
If a liquid is exposed to a lower pressure level then it should boil at a lower temperature.

Preparations:
Fill hot water (circa 60-70°C) into the plastic container and position it in the vacuum chamber

Experiment:

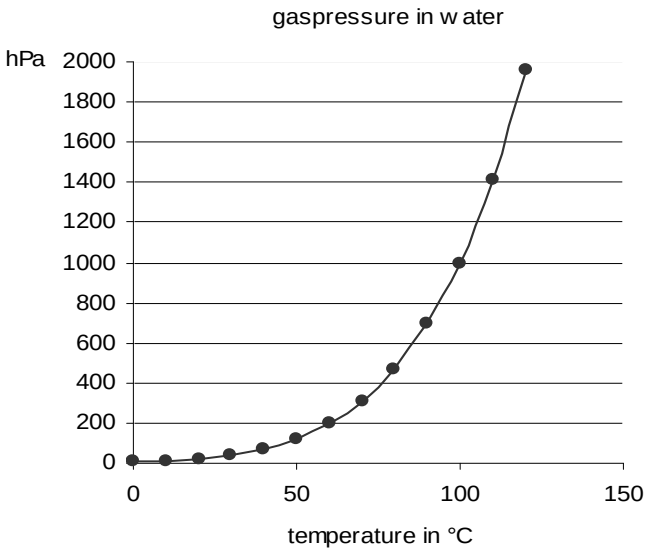
Reduce the pressure in the chamber and watch the liquid bubbling.

Task:

At which pressure level did the water start boiling? _____

With regards to above question, which temparature can be read off from the adjoining diagram? _____

Note: A pressure of 200 hPa relates to -800 hPa on the vacuummeter



Conclusion:
The boiling temperature of water is _____ at a lower outer pressure level
lower / higher

A _____ steam pressure in water is enough to generate bubbles.
lower / higher

AIR PRESSURE EFFECT - INTERNAL PRESSURE DIMINISHED

MELS 06

Required Kit:
P9902-4V Air pressure

Material:
1x Bubble burster, SE
1x Clamping ring for bubble burster
1x Plastic film for bubble burster
1x Syringe plastics, 120ml
1x Vacuum hose plastics, SE
1x Vacuum chamber complete, 1000ml

AIR PRESSURE EFFECT - AIR PRESSURE REDUCED

MELS 06

If you stick your finger into your mouth, grip it tightly with your lips and finally bend it in a way that you can remove it quickly out of your mouth – then you can hear a "pop". When quickly pulling a cork from a bottle, the "pop" is much louder. If the difference between inner and outer pressure level is very big, the pressure equalisation occurs very quickly. In that event, the "pop" changes into a bang, this action is called "implosion"

Preparations:

Tighten the plastic film on the recessed side (for the clamping ring) with the clamping ring over the bubble burster and fix it. Fit the blue sealing ring to the other end of the tube.

After you have screwed in the ventilation screw and the hose is connected, turn the cover of the vacuum chamber around – a second person holds the cover

Stick the syringe on the hose.

Position the bubble burster on the rounded depression/cut

Experiment:

As the bubble burster takes a smaller space than the vacuum chamber, less syringe movements are necessary to reduce the pressure inside the bubble burster. Watch the vacuumeter!
You can watch the force of the outer pressure which is inversely directional from the outside. The plastic film behaves the same way cellophane plastic film on a jam jar reacts – then the plastic film tears loudly – bang!!!!

Conclusion:
Due to the impact of outer air pressure, vessels in which a lower pressure level is existing can be crushed. At the moment of demolition, air is infiltrating (= Implosion). The suddenly appearing air interchange (like the reverse action mentioned above) also generates a loud bang.

Advice:
Underpressure also occurs when water/steam condenses in a locked cooking pot. This effect of air pressure was also used in the very first existing steam engines.

FREE FALL - FREE FALL TUBE

MELS 07

Required Kit:
P9902-4V Air pressure

Material:
1x Free fall tube incl. falling bodies
1x Syringe plastics, 120ml
1x Vacuum hose plastics, SE
1x Vacuum chamber complete, 1000ml

FREE FALL - FREE FALL TUBE

MELS 07

A ski jumper is not interested in simply falling down when doing his jump – this more applies to a diver who tries to make his fall more interesting by showing some screws and salti. The ski jumper is better able to make use of the aerodynamic forces because of the high speed of the jump. You can gather that the frictional forces, appearing when a body is falling, make it very difficult to explain the fall mathematically.

For this reason the naturally unexisting free fall – a fall without air resistance – was created. With the help of an optimally evacuated free fall tube, it is possible to create nearly those conditions which are necessary to simulate free fall.

Preparations:

Put the feather and the red ball into the fall tube and position the tube on the cover of the vacuum chamber. Make sure you have fitted the small blue seal.

Experiment:

Turn around the fall tube together with the cover and watch the fall of the feather and the ball.
Re-position the fall tube again and fix the hose and the syringe at the valve on the cover. Finally, reduce the pressure in the tube as much as possible.
Now quickly invert the tube and observe the feather and ball falling.

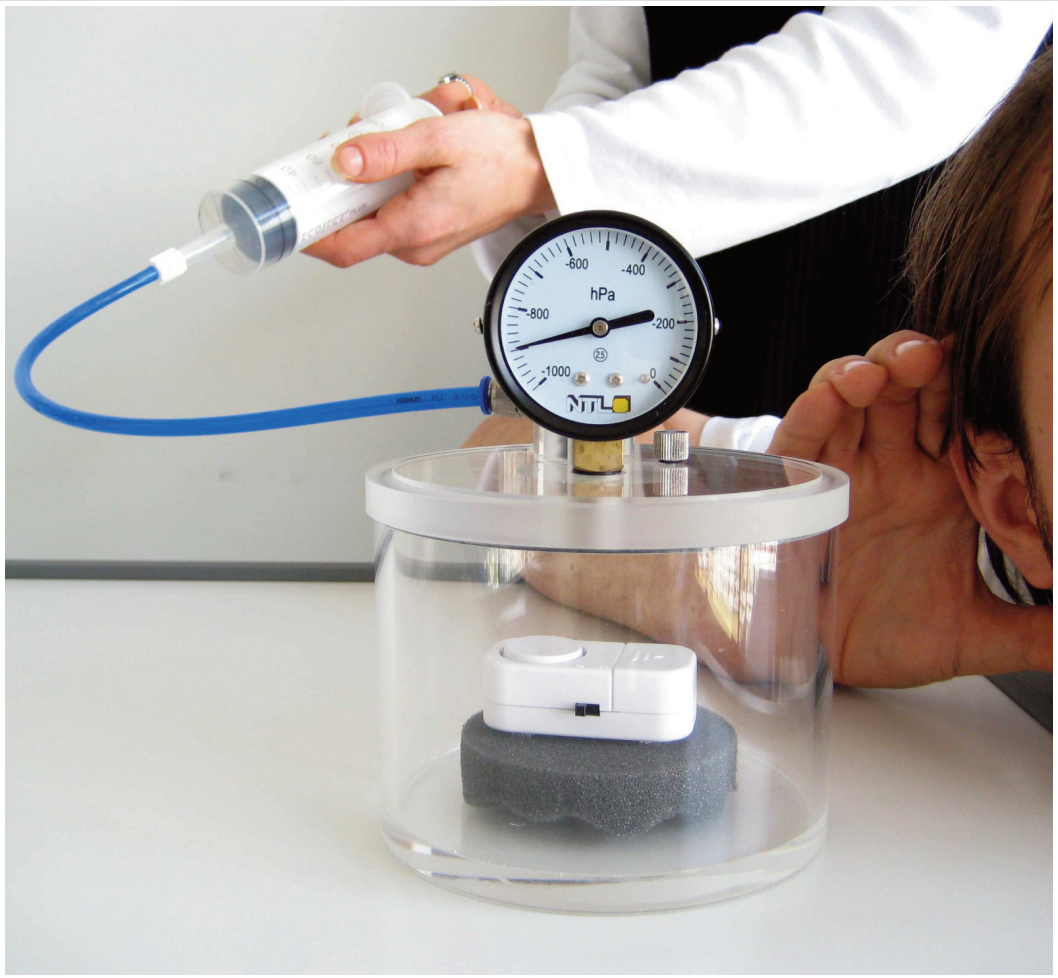
Task:

If an astronaut puts up his umbrella after he leaves a spaceship, would he then lag behind the spaceship?
Find out about Neil Armstrong's experiment on the moon.

TRANSMISSION OF SOUND IN A VACUUM

MELS 08

Required Kit:
P9902-4V Air pressure



Material:
1x Syringe plastics, 120ml
1x Vacuum hose plastics, SE
1x Vacuum chamber complete, 1000ml
1x Signaller (alarm annunicator)
1x Sound-absorbing pad

TRANSMISSION OF SOUND IN A VACUUM

MELS 08

The purpose of a sounder or bell is to be heard. At night no one is interested in hearing loud noises. But what is the relation to air pressure?
Sound generally gets transmitted in air because of the movement of air particles. (see Implosion, Explosion).
But what happens if there are less or no particles existing? Right now listen what happens or to put it another way; don't hear what happens!

Preparations:

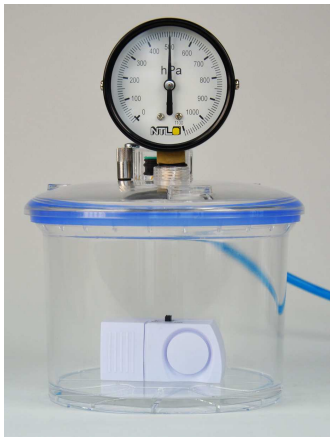
Put the sound absorbing pad into the vacuum chamber
Prepare the cover of the vacuum chamber
Switch on the sounder and put it on the sound-absorbing pad

Experiment 1:

Position the cover slowly on the vacuum chamber and notice how the noise level reduces slowly.
Pump out as much air as possible from the chamber whilst noting the audibility of the alarm.
Let the air slowly inflow again and listen carefully.

Experiment 2:

Execute the experiment again – but without sound-absorbing pad (see picture)



Conclusion (fill in the gaps):

In a vacuum _____ sound transmission!

there is no / there is a good

The lack of air around the sound source reduces the outward transmission of the sound _____.

hardly ever / relative intensively / fully

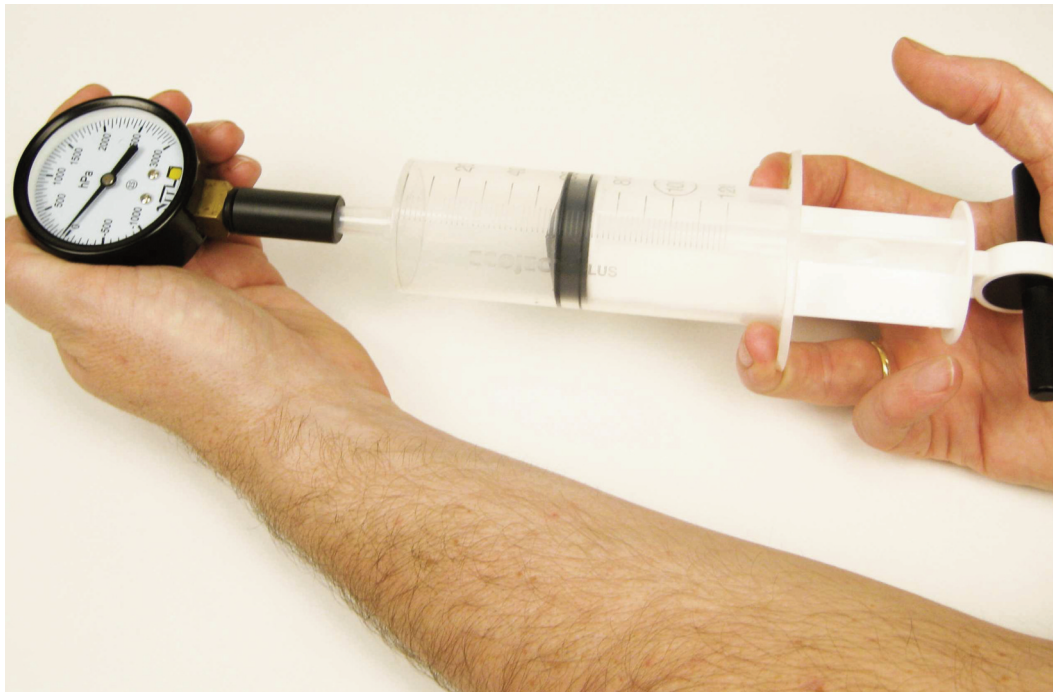
When sound source is connected to the bottom (without absorbing layer) the sound will be transmitted _____

through the plastic / not at all / very quietly

BOYLE-MARIOTT LAW

MELS 09

Required Kit:
P9902-4V Air pressure



Material:
1x Syringe plastics, 120ml
1x Manometer, SE

BOYLE-MARIOTT LAW

MELS 09

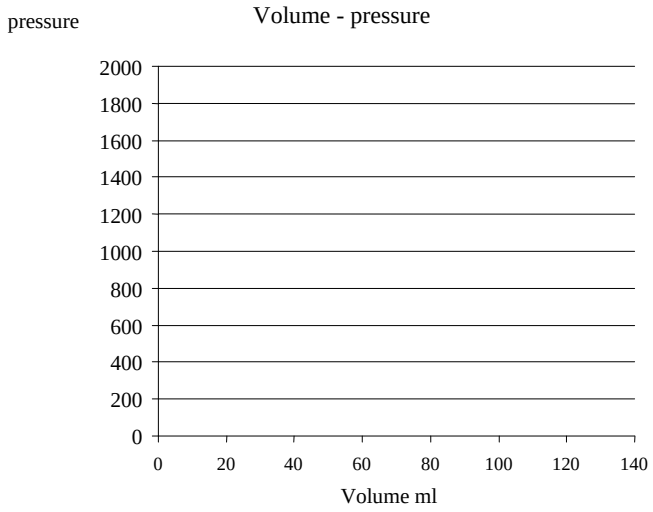
If you have found a law you can not only say what the final result will be but also predict what might happen when you change different factors: In what way will the pressure in the air change when changing the volume?
In 1662 the British physicist and chemist Robert Boyle and the French physicist Edme Mariott simultaneously worked out the Boyle – Mariott Law, which deals with gas pressure.

Preparations:
Set the syringe at 60ml (black plunger) and stick the Manometer on the top of the syringe

Experiment:

Holding the Manometer and the syringe tightly together, push the syringe plunger slowly in and read off the volume and the pressure. Repeat by pulling the syringe plunger out
Fill in the values in the chart below and also fill in the graph.

Volume ml	pressure hPa
60	1000
50	
40	
30	
70	
80	
90	
100	
110	
120	



Conclusion (fill in the gaps):

The higher the volume, _____ the pressure.

the higher / the smaller

The pressure is reacting _____ the volume does.

the reverse way / the same way

It is said: (with constant temperature) p x V = const

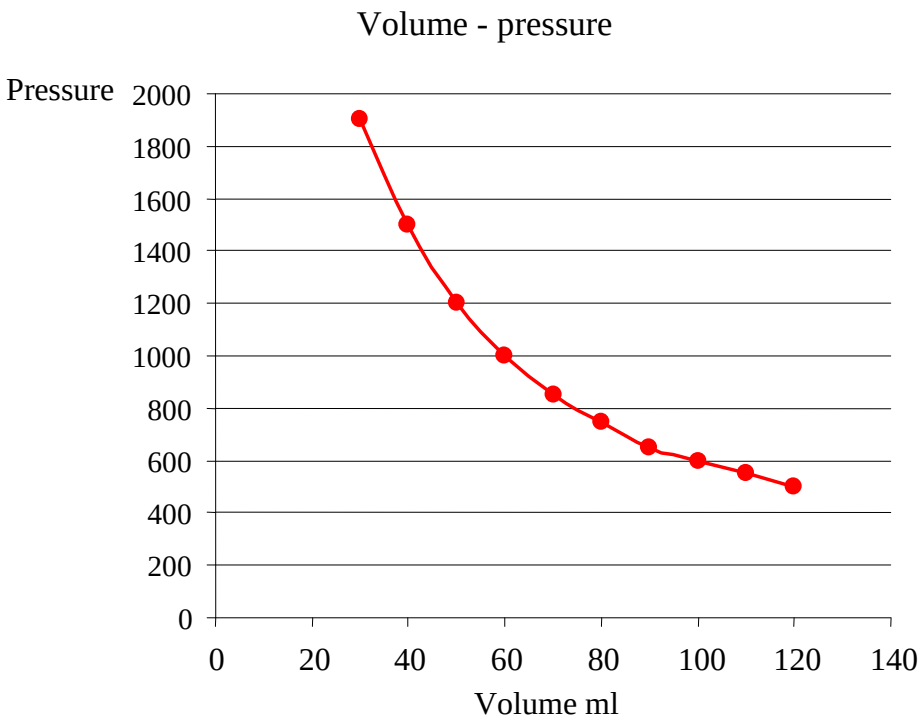
BOYLE-MARIOTT LAW

MELS 09

Advice:

Because of the existing air in the Manometer beyond the syringe, the doubled pressure is setting up at 29-28ml.

Real measurement example:



DETERMINATION OF THE WEIGHT OF AIR

MELS 10

Required Kit:
P9902-4V Air pressure

Material:
1x Syringe plastics, 120ml
1x Vacuum hose plastics, SE
1x Vacuum chamber complete, 1000ml

Additionally required:
Precise digital balance
Weighing range: at least 400g
Resolution: 0,1g

DETERMINATION OF THE WEIGHT OF AIR

MELS 10

From where is the air pressure coming? You already know about water pressure – you feel it when you are diving.
Water pressure exists because of the mass of water. At a depth of 1 metre, a mass of 1000kg is pressing on 1 m² = 10 000 N/m². At a 10 m water column it is already100 000N/m² or 1000 hPa.
The air pressure results from the mass of the air. So what mass does 1 litre of air have (1l= 1000cm^3 air)?

Preparations:

Prepare the balance ready for use. It is best to use a balance with 0.01g readability or better.

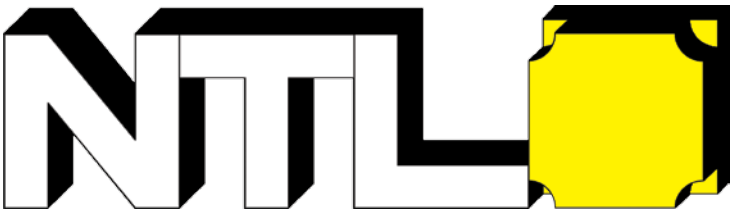
Experiment:

Position the vacuum chamber with attached cover – but without hose – on the balance and read off the mass. Now push the Tare button which will reset the balance to zero. Remove the chamber from the balance, connect the hose and the syringe with the vacuum chamber and evacuate. Finally remove the hose and position the chamber on the balance again. Read off the mass again – the difference of the measurements is the weight of 1 litre of air. Why is there a minus sign in front of the number?

Advice:

Just like the water pressure, pressure decreases from the bottom to the top. This is the same with the air pressure. But air pressure does not constantly decrease like water for the reason that air can easily be compressed. The mass of 1 litre of water is nearly always 1kg, whereas the mass of air at sea level and at 0°C is 1g.

At a residual pressure of 150 hPa only 85% of air is evacuated and as a consequence one measures a mass of 0,85 litre of air. A marked chart-value of 1,29 g /litre then cannot be achieved in the majority of cases, as one does not execute the experiments at a sea level and the temperature is not really 0°C.



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