Air.

Properties:

- Air is not nothing.
- Air is strong: air pressure.
- The velocity of air has consequences: high and low pressure.

Air is not nothing.

Thanks to air…

- We can breathe. Air contains over twenty percent oxygen. This is needed to burn nutrients in our body to have energy.
- There is wind, which is moving air.
- There is sound. Sound is nothing but movement, which comes to us through air.
- There can be airplanes. The air carries them.
- There are clouds. A cloud is nothing more than a volume of air filled with condensed or frozen drops of water. Hot air can contain more vapour than cold air.

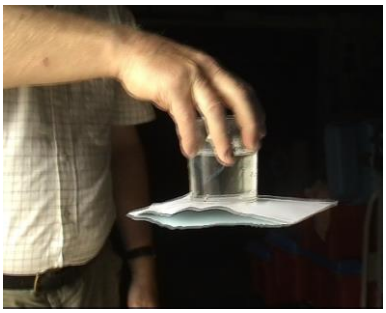
Air is strong: air pressure.

Air pressure is the weight the air puts on a surface.
The force of the wind in a certain area is determined by the differences in air pressure. (Law of Pascal: pressure applied to an enclosed fluid is transmitted undiminished to every point in the fluid and to the walls of the container.)

The velocity of air.

The law of Bernoulli tells us that the acceleration of a fluid or gas is always accompanied by a diminishing pressure. So, fast air has a low pressure.

1. A glass upside down.



Material:

A glass, water, a reasonably thick piece of paper.

Action:

Fill the glass with water and cover it with the piece of paper.
Now slowly turn the glass upside down, while pushing the paper against it.
Finally, let go of the paper.

What will happen?

The paper sticks to the glass so the water stays in.

Why?

The air pressure in the glass inclines because the air gets a little more space when the piece of paper bends. The air pressure outside the glass is now higher than the pressure on the inside. The air outside pushes so hard against the paper that it will not fall.

2. The obstinate balloon.

Material:

A plastic bottle, a balloon.

Action:

1. Blow a little air into the balloon. Try to push it into the bottle.
2. Put the empty balloon over the bottleneck and try to blow it up like this.

What will happen?

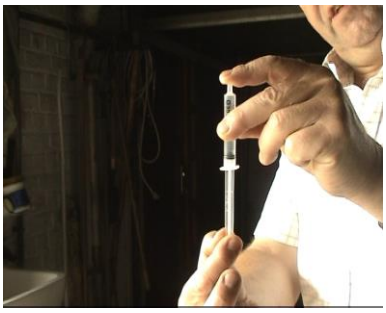
1. The balloon can not be pushed into the bottle in this way.
2. Also this method doesn't work.

Why?

In both cases there is air in the bottle. This prevents the balloon from getting into the bottle.

So: air is not nothing!
A little trick is to put a small hole in the bottom of the bottle. Then try the second method again. Now you can blow up the balloon. When you blow, the air in the bottle is pushed out through the hole so the balloon gets enough space to become bigger.

3. Comparing syringes.



Material:

Three syringes of different volumes, without needles.

Action:

Take one of the syringes and close its opening off with your finger while the plunger is closed. There is practically no air in the syringe at this point. Now pull the plunger. Try this with the different syringes.

What will happen?

When you pull the plunger, you notice some resistance. The bigger the syringe, the more difficult it will be to pull the plunger.
When you pull the plunger hard and then you let go, the plunger jumps back.
This goes faster when you're using a bigger syringe.

Why?

There is practically no air in the syringe when you start pulling. Because you have closed the opening with your finger, no air can get into the syringe. When pulling, you give the very small amount of air in the syringe more space, so its pressure drops. The pressure of the air surrounding the syringe is higher than that inside. This surrounding air pushes the plunger back in with some force. This force is not only determined by the air pressure in the environment – which is the same for all three syringes – but also by the size of the surface on which the air can push (the size of the plunger). Since a bigger syringe has a bigger surface, the air can push it back with a greater force.

4. Balloon in a bottle.


Material:

A glass bottle, a vacuum pump with accompanying rubber cork, a balloon.

Action:

Blow a tiny bit of air in the balloon and make a knot. Put it in the bottle.
Close the bottle with the rubber cork and use the vacuum pump to remove the air.

What will happen?

The balloon grows bigger.

Why?

Since there is less air in the bottle surrounding the balloon, the pressure is lower than the air pressure inside the balloon. This enclosed air can now take more space in the bottle because the surrounding air doesn't push so hard anymore.

5. Bottle competition.


Material:

A bucket, two identical bottles filled with the same amount of water.

Action:

Try to compete with an other person in emptying the bottles as quickly as possible. You can try to hold the bottle upside down or to give it a certain slope. You can also turn the bottle upside down and give it a good spin.

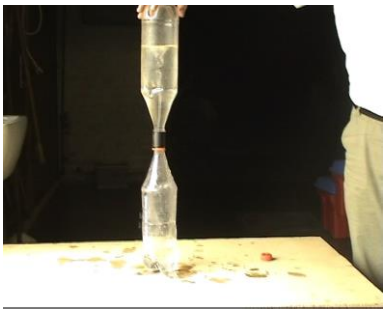
What will happen?

A bottle that is poured out by giving it a certain slope will be empty sooner than a bottle that is turned completely upside down. Unless you give the vertical bottle a spin. Then it will be empty before the sloped bottle is.

Why?

When water is poured out of the bottle, the pressure of the air that is in the bottle drops. New air will want to get into the bottle. Of course it needs a way to get in. When the bottle is held upside down, the air can not get in while the water gets out. So a bit of water will come out, then a bit of air will go in, followed by a bit of water coming out,… This takes a lot of time. The bottle will be empty sooner when it is held with a certain slope. In this way, air can come into the bottle at the same time water is being poured out. The fastest way to empty the bottle though, is to turn it upside down and spin it. A whirlpool is created. The water moves close to the edges of the bottle and in the middle an opening is made through which air can get in.

6. Whirlpool in a bottle.



Material:

Two plastic bottles with holes in the caps. The caps are glued into a fitting tube (for instance the box of a photoroll).

Action:

Fill one bottle with water and screw the glued construction on it. On top of this, you put the second bottle, which is empty.
Turn everything upside down.
When the water is in the lower bottle, turn everything around again and give the full upper bottle a good spin.

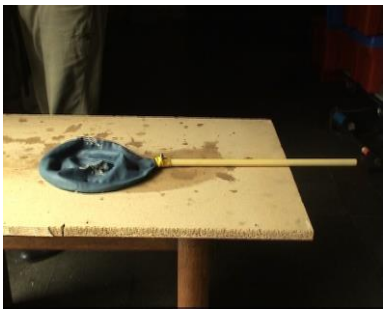
What will happen?

At first the water has a difficult time moving from the upper to the lower bottle. When you give the full bottle a spin, it can move more easily.

Why?

The ‘empty’ bottle is in fact filled with air. When water comes in, air is pushed out. The air has to move through the same hole as the water. When you don’t spin the bottle, the water and the air can not pass through the opening at the same time. When the bottle is spun, the water moves close to the edges of the bottle and in the middle an opening is made through which air can pass. You have made a whirlpool.

7. Strong air.



Material:

A big balloon or plastic bag of which the opening is attached to a tube, a large weight (for instance a bucket with water).

Action:

First lift the heavy weight by hand.
Then put it on the empty balloon or bag and blow air into the balloon or bag through the tube. Is this easier or harder than lifting the weight by hand?

What will happen?

Blowing air into the balloon in order to lift the weight seems easier than lifting it by hand.

Why?

You need to exercise a force onto the weight to lift it. The magnitude of this force is determined by pressure, but also by the size of the surface you exercise this force onto. So, when pressure is exercised onto a large surface (for instance, using a big balloon) a larger force is created than when the same pressure is exercised onto a small surface (for instance, using a few fingers).
This idea is used in the hydraulic lift.

8. Make a rocket.

Material:

A plastic bottle, a cork with the valve of the tire of a bicycle in it, a bicycle pump.

Action:

Close the bottle with the cork. Blow air into the bottle using the pump and valve.

What will happen?

The bottle flies away.

Why?

More and more air is pushed into the bottle. The pressure inside becomes too big. The cork is pushed out of the bottle. A stream of air comes out which launches the bottle like a rocket.

9. The diver.



Material:

A plastic bottle filled with water, a pipette with some paperclips attached to it to make it heavier.

Action:

The pipette or diver floats because there is a bubble of air in it.
Make sure the bottle is closed well. Push softly with both hands on the sides of the bottle.

What will happen?

The diver sinks deeper into the bottle.

Why?

When you push, the pressure in the bottle increases. The air in the pipette is squeezed together so more water can get into the pipette. It becomes heavier and sinks.
When you stop pushing, the air bubble is allowed a bit more space again. Some of the water leaves the pipette and it can float again.
Submarines use this idea to go up and down. When the double walls of the submarine are filled with water, it goes down. When air under high pressure is pumped in between the double walls, the water is pushed out and the boat goes up.

10. ‘Blow-pressure’.


Material:

A three metres long, thin, translucent tube, water.

Action:

Fill about a third of the tube with water. Make it a U-shape with one leg shorter than the other. Mark the height of the water. (Note that the watermark is equally high on both sides of the tube.)
Now try to make the water come out of the tube on the long side by blowing into the short side.

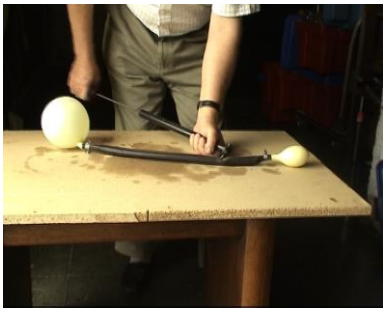
What will happen?

The watermark goes down on the short side where you're blowing. It goes up on the other side. You can measure the difference.

Why?

The pressure on the side where you're blowing is higher than the normal air pressure, which is actually pushing on the water in the long side of the tube. That's why the watermark on that side will go up.
The 'blow-pressure' can be expressed in centimetres water pressure (the difference in height measured).
The normal air pressure is 1013 hectoPascal (hPa) or 1 bar or 10 metres water pressure.
A healthy person has a lung volume of 4 to 5 litres. The lung pressure is 10 percent higher than the normal air pressure.

11. Blowing up balloons.



Material:

A piece of the inner tube of the tire of a bicycle with a valve, two balloons, a bicycle pump.

Action:

Attach the two balloons on to the tube on both sides of the valve.
Try to blow up the balloons with the bicycle pump, using the valve.

What will happen?

The two balloons will not become equally big. The air tends to go to one side only.

Why?

The air will search the way with less resistance. (This is the balloon that is already stretched most.)

12. The tube with the hole that does not leak.

Material:

A bucket with water. Two tubes that are connected to each other by a thinner tube. In this thinner tube there is a small hole.

Action:

Put one end of the construction in the water and suck some water up. Now remove the end from the bucket and let the water run. Do this again, but close the bottom tube with your finger so the water can not get out.

What will happen?

The first time, no water comes out of the small hole in the thin tube.
When the end of the tube is closed, the thinner tube does leak.

Why?

The tube with the hole is thinner than the other two tubes. Because of the narrowing, the water starts to run faster. This causes a lower pressure in the thin tube. The pressure is lower than the surrounding air pressure. Because of this, air will come in through the hole. When air comes in, the water can not get out through the same hole.
When the lower tube is closed, the water stops running. The pressure in the thin tube is now higher than the air pressure, so the water escapes through the hole. You can now clearly see the leak.

13. Strong breath.

Material:

A tube attached to a flat disk with a hole in it (for instance a CD), a piece of paper or polystyrene.

Action:

Hold the piece of paper or polystyrene against the disk and blow through the hole. While blowing, let go of the paper or polystyrene.

What will happen?

As long as you blow, the piece of paper of polystyrene doesn't fall down.

Why?

The air moves in all directions between the disk and the paper or polystyrene. The air moves quickly so a low pressure occurs. The air pressure on the other side of the paper or polystyrene is normal and therefore larger. This surrounding air pushes the paper or polystyrene against the disk.

14. Fast air.

Material:

A light (copper) coin, a glass.

Action:

Put the coin on the edge of a table. Lay down the glass behind it, with the opening towards the coin. Try to blow the coin into the glass.

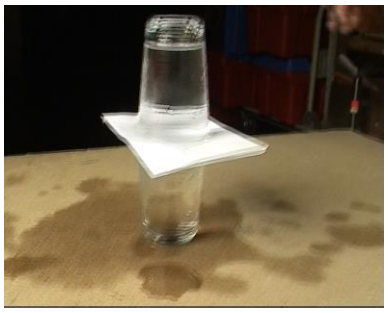
What will happen?

You can blow in different ways. You can try to blow underneath the coin, sideways or above the coin. Only the last method works.

Why?

When you blow horizontally above the coin, the air moves fast above it, so the pressure in this area will be low. The surrounding air pushes the coin slightly up, so it shoves into the glass.

15. The glass tower.



Material:

Two identical glasses filled with water, a straw or tube, a firm piece of paper.

Action:

Cover one glass with the piece of paper and put it upside down on the other glass. Then gently remove the paper. Try to blow some air between the two glasses with a straw or tube.

What will happen?

The glass you turn upside down will not leak because the air pressure inside is a bit lower than the air pressure outside (because the paper slightly bends).
When you blow some air between the glasses, an air bubble rises up in the upper glass and takes the space of a bit of water, that runs out.

16. Without hands: lifting a glass with air.

Material:

A balloon, a glass.

Action:

While you blow some air into the balloon, you hold it inside the glass. When you continue to blow it up, the opening of the glass is closed by the balloon. Blow some more air in the balloon.

What will happen?

You can lift the glass with the balloon.

Why?

When the balloon closes the glass, no air can get in or out anymore.
When you blow up the balloon even more, it can not expand into the glass because of the locked-up air, so it expands out of it. It also takes a different shape, so it takes up less space in the glass. This means more space for the locked-up air. The air pressure in the glass decreases. The surrounding air pressure is still normal, so higher. The surrounding air pushes the glass against the balloon.

17. Making dew and clouds.




Material:

A big plastic bottle with a bit of water on the bottom (the water has normal room temperature), a match.

Action:

1. Close the bottle and push it for a few moments.
2. Before putting the cap on the bottle, throw in a burning match. After quickly closing it, again push on the sides of the bottle for a few seconds.

What will happen?

1. Small drops of water appear on the sides of the bottle.
2. When you stop pushing, clouds (tiny drops of water) appear in the bottle.

Why?

1. In the bottle, the air is saturated with water (or vapour). When you push onto the bottle, there is less space for the air and for the vapour. Some of the vapour condenses into water drops.
2. By pushing onto the bottle, the vapour does not only condense onto the sides of the bottle, but also onto the dust that the burning match has caused. Tiny drops of water can cling onto these pieces of dust in the air. This is how clouds are formed.
This also reminds of smog in big cities.

18. The 'corkpusher'.



Material:

A 'corkpusher', a (colourless) glass bottle with cork, a bit of water at the bottom.

Action:

Push the pin of the 'corkpusher' through the cork and pump air underneath it.

What will happen?

The cork pops out of the bottle.
At the bottleneck, some dew is formed.

Why?

When more air is pushed into the bottle, the air pressure increases and pushes the cork out of the bottleneck.
The air is saturated with water (or vapour). With the cork, some air escapes from the bottle. This movement costs energy. This movement energy is actually transformed heat energy. So, opening the bottle cools the air down a bit. Cold air can contain less water (or vapour) than warm air, so some of the vapour condenses into tiny water drops. Dew is formed.

19. The fountain.

Material:

A thin, flexible tube (about one metre long), a bucket of water.

Action:

Put one end of the tube in the water. Hold the tube so that one quarter of its length is above your hand. Now swirl the top part around.

What will happen?

Water sprays out of the tube.

Why?

By quickly swirling the tube around in circles, the air around the top opening also moves fast. The air pressure of fast moving air is low. At the other end of the tube, in the water, the pressure is much higher than at the opening. The water is pushed up. Old perfume sprays work according to the same principle.

20. The long bag.

Material:

A long plastic bag (over two metres long, section of about twenty centimetres).

Action:

The purpose is to fill the bag with air by blowing.
Try to hold the bag to your mouth and blow.
Then try to hold the opening of the bag at a small distance of your mouth.
Blow again.

What will happen?

Using the second method, you can fill the bag with air in one breath.

Why?

When you hold the bag to your mouth, you can only fill it with the air from your lungs.
When you hold the bag at a certain distance, you also blow the air from your lungs into the bag. More importantly, you create fast moving air and thus low pressure. In this way, the surrounding air with normal pressure is sucked into the bag, along with the air from your lungs.

21. The magic ball.



Material:

A very light, small ball (a table tennis ball or a ball made out of polystyrene or cotton wool). A small cylinder shaped box in which the ball fits perfectly.

Action:

Put the ball in the box and try to blow it out.

What will happen?

You can only blow it out by blowing horizontally over the box opening.

Why?

By blowing this way, you create fast moving air above the box. The pressure of this air is lower than that of the air inside the box, underneath the ball. This enclosed air will push the ball out.

22. Racing bottles.


Material:

Two identical plastic bottles without a bottom. In the caps of both bottles is a hole through which a tube fits perfectly. One bottle has a long tube, the other one a short tube.

Action:

Have other people hold the bottles upside down, closing the tube at the lower end with a finger. Fill both bottles with the same amount of water. Then have the people remove there fingers at the same time.

What will happen?

The bottle with the long tube will be empty first.

Why?

The longer the tube, the greater the pressure at the opening. So, in the bottle with the long tube, the water is pushed out faster.
The deeper you dive under water, the higher the pressure. There are limits to the pressure a human body can take. A submarine has thick walls to be able to stand the pressure.
An extra ten metres under water means that the pressure increases with 1 bar.

23. The simplest water pump.




Material:

Two large cylinder shaped plastic bottles, two large marbles that can close the opening of the bottles, a bucket with water.

Action:

Fill one bottle with water, close it and put it in the freezer for one day. Then let the ice melt, empty the bottle and cut the bottom from the bottle.

Cut a slit in the side of the second bottle (vertically, 1 centimetre wide and 10 centimetre long). Push a marble through the slit. It must be large enough to close the opening of the bottle.
Put the other marble in the bottle without a bottom and shove the second bottle in. The bottlenecks must be pointing in the same direction. (Because the first bottle was in the freezer, it has expanded since ice takes up more space than water.)
Hold the first bottle with one hand and the second one with the other hand. Now push the bottleneck of the first bottle into the bucket of water and pull the second bottle partly out. Push it back in and repeat.

What will happen?

When you pull, water is sucked into the bottle.
When you push, the marble prevents the water from running back. Through the slit, the water runs out of the upper bottle.

Why?

In the first bottle, there is a closed space. By pulling the second bottle, this space increases resulting in a lower air pressure. The air pressure on the surface of the water in the bucket is normal, so larger. This air pushes the water into the bottle. (The marble doesn't prevent the flood of the water.)
By pushing the second bottle back into the first one, the pressure in this first bottle increases. But for the marble in the bottleneck, the water would flow back into the bucket. But now, the pressure in the first bottle makes sure the marble in the second bottle is pushed up so the water can flow into the upper bottle.
Now the pressure in the second bottle increases, but here, air and water can successively go through the slit. The water is being pumped up.

A soap pump works in this way.