



What is pneumatics?

What does pneumatic mean?

The term 'pneumatic' is based on the Greek word 'pneumatikos,' meaning 'coming from the wind!' Pneumatic is defined as the use of pressurized air to do work. Pneumatic machines have been used for many years. In fact, 2,000 years ago a famous Greek inventor, Hero of Alexandria made a large variety of pneumatic machines, including a pneumatic catapult.

Why use pneumatics?

If you have ever been to the dentist and had your teeth drilled or polished, you may have had a close encounter with a pneumatic machine without even knowing it! Pneumatic dental instruments are often the preferred choice of dentists because of the instruments' high momentum and smooth operation.

Some of the benefits of using pneumatic systems are:

- Pneumatic machines can be very small, light, fast, and powerful.
- Air is light and free compared to hydraulic fluid.
- You can very easily store compressed air.
- Pneumatic machines are safe even when their air hoses or individual parts get wet.
- If a pneumatic machine is overloaded, the machine will stop, continue compressing, or release the air through a pressure release valve.

Some of the dangers of pneumatic systems are:

- If there is a hose leak in hydraulic machines, fluid can cause the surrounding area to become slippery and dangerous.
- Note that any fluid, even air, under high pressure can potentially be dangerous!

How does it work?

Consider an empty container, such as container A. Even though it may look empty, it is actually full of air molecules. Air molecules are invisible, but they still possess weight and mass, and exert pressure. container A's pressure matches the air pressure of the room it is in.

Once the container is sealed (container B) the molecules trapped inside exert pressure when squeezed or 'compressed' as they collide with each other and the sides of the container. It is the empty space and the elasticity of the impact between the air molecules and the container that allows for the air to be compressed. The force of the air molecules acting on a surface, such as the piston, is called pressure.

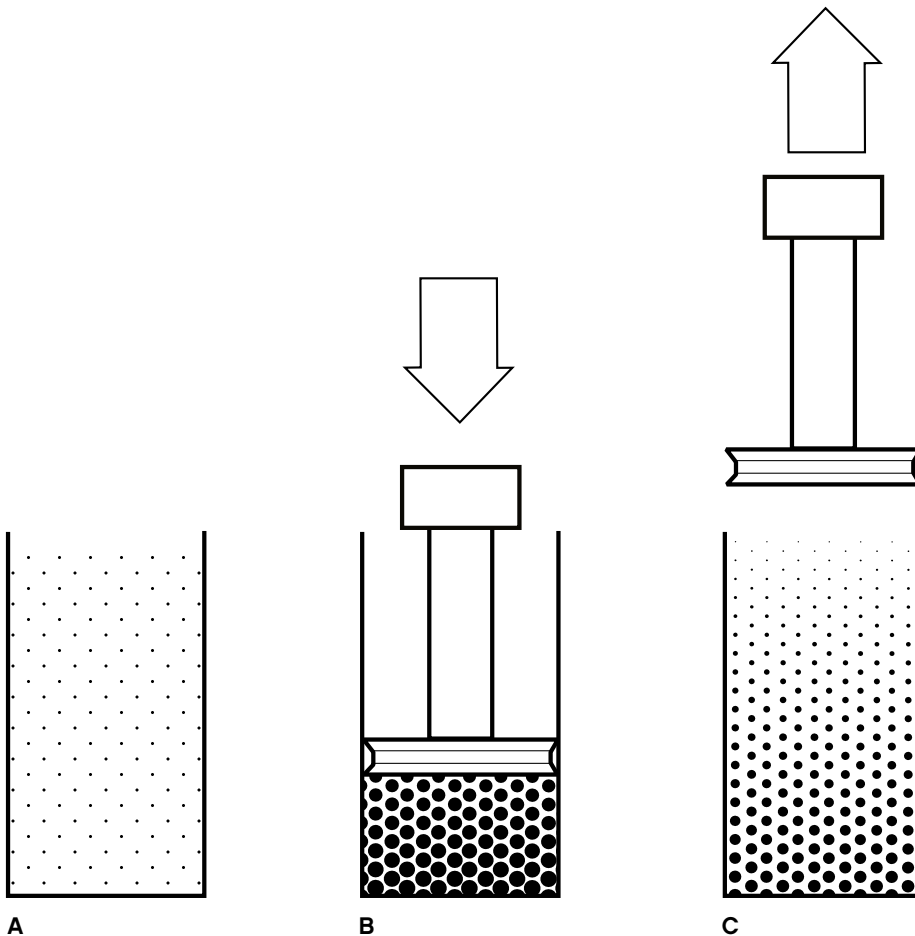
The amount of pressure the air molecules exert depends on the number of molecules and amount of collisions that occur between the molecules and the inside surface of the container. Air molecules that are compressed contain potential energy.

If the hand and piston are removed (container C), the compressed air will expand until the pressure inside and outside the container are the same.

Using a controlled airflow circuit, the force of expanding air can be converted into kinetic energy that can power and operate a system.

Hint:
For explanations of specific words, turn to the glossary.

Did you know?
If you want to know more about how to calculate pressure, we suggest you start with Boyle's Law.





Inside the LEGO® Pneumatic Elements

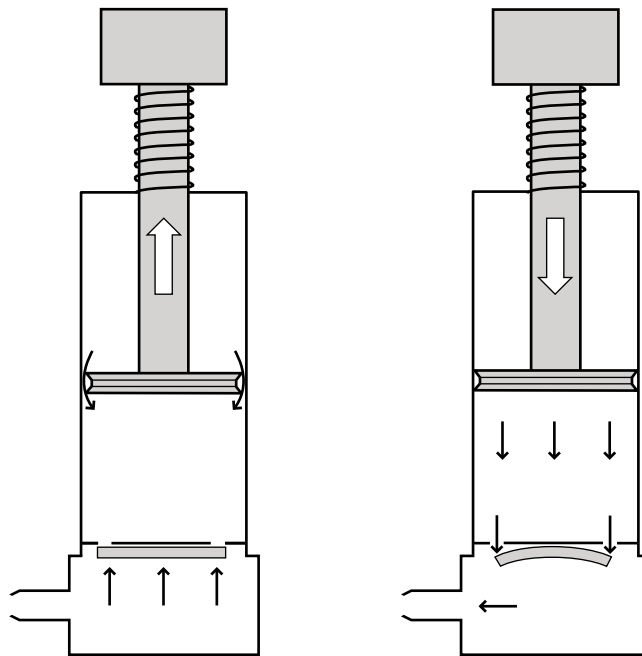
Pumps, cylinders, and valves are the basic components of any pneumatic system. Even though industry uses a much larger variety of components, most operations can be performed with just these three basic components.

The Pump

The pump is used to compress air. To control the airflow inside the pump a specially designed piston and a flexible diaphragm are used.

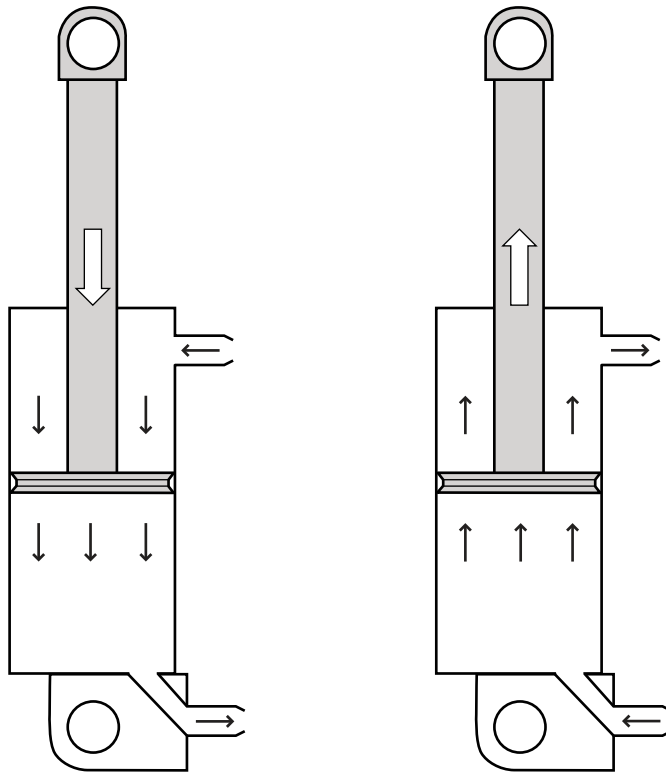
On the down stroke, the seal of the pump's piston becomes airtight. The compressed air bends the flexible diaphragm allowing air to flow through to the outlet port.

On the return stroke the piston seal allows air to flow past the piston and back into the barrel of the pump. At the same time, the flexible diaphragm snaps back into place and stops any compressed air from flowing back into the pump barrel.



The Cylinder

The pneumatic cylinder works by converting the force of expanding air (potential energy) into movement (kinetic energy). When air enters the cylinder, the force of the expanding air will either force the piston up or down, depending on which air port the air has entered from. All LEGO® cylinders are double-acting cylinders, meaning compressed air can enter the cylinder through two air ports.



Did you know?

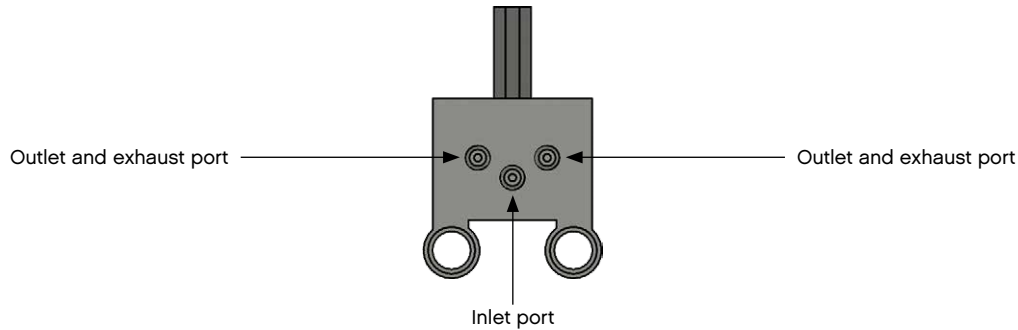
The smaller the cylinder the greater the pressure it needs to operate. This is due to the smaller area of the piston. Pressure is force divided by area. As the area gets smaller, dividing the force by the area leads to a greater value for the pressure.

$$\text{pressure} = \text{force} \div \text{area}$$

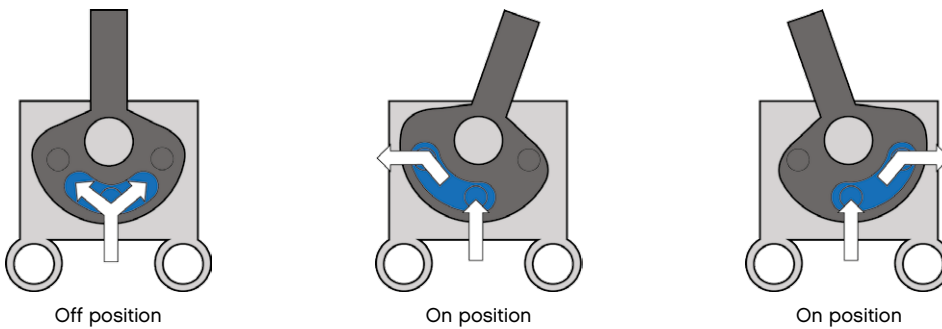
The Three-Position Valve

The valve receives compressed air from the pump or tank through the inlet port. The valve directs the airflow through one of the two outlet ports to other pneumatic elements or simply stops the airflow. The rubber valve seal has a specially designed chamber to direct air from the inlet port to one of the two outlet ports.

The outlet port that is not being used for compressed air is automatically opened, allowing air from a cylinder to escape.

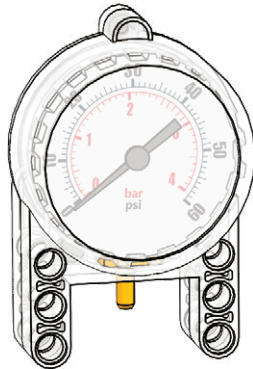


Valves Controlling the Direction of the Compressed Air



The Manometer

A manometer is an instrument for measuring pressure. Using the manometer allows you to follow the rise or drop in air pressure created by your actions. The LEGO® manometer gives you a pressure reading in both bar and psi (pounds per square inch).

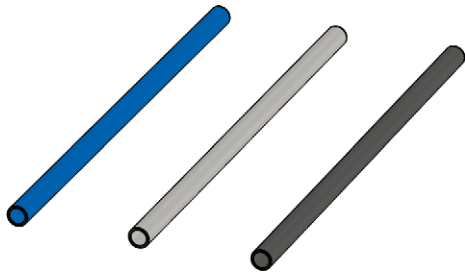


Tubes, T-pieces, and Air Tank

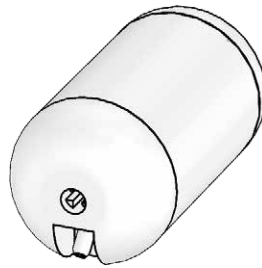
The flexible tubes, which come in different lengths and colors, are used to transport the compressed air between the pneumatic elements. The colors help you find errors, and trace and describe the airflow. The tubes are specially designed to leak air at the connections if the pressure becomes too high.

T-pieces allow air to flow to several tubes at the same time.

The air tank is used for storing air under pressure.



Tubes



Air tank

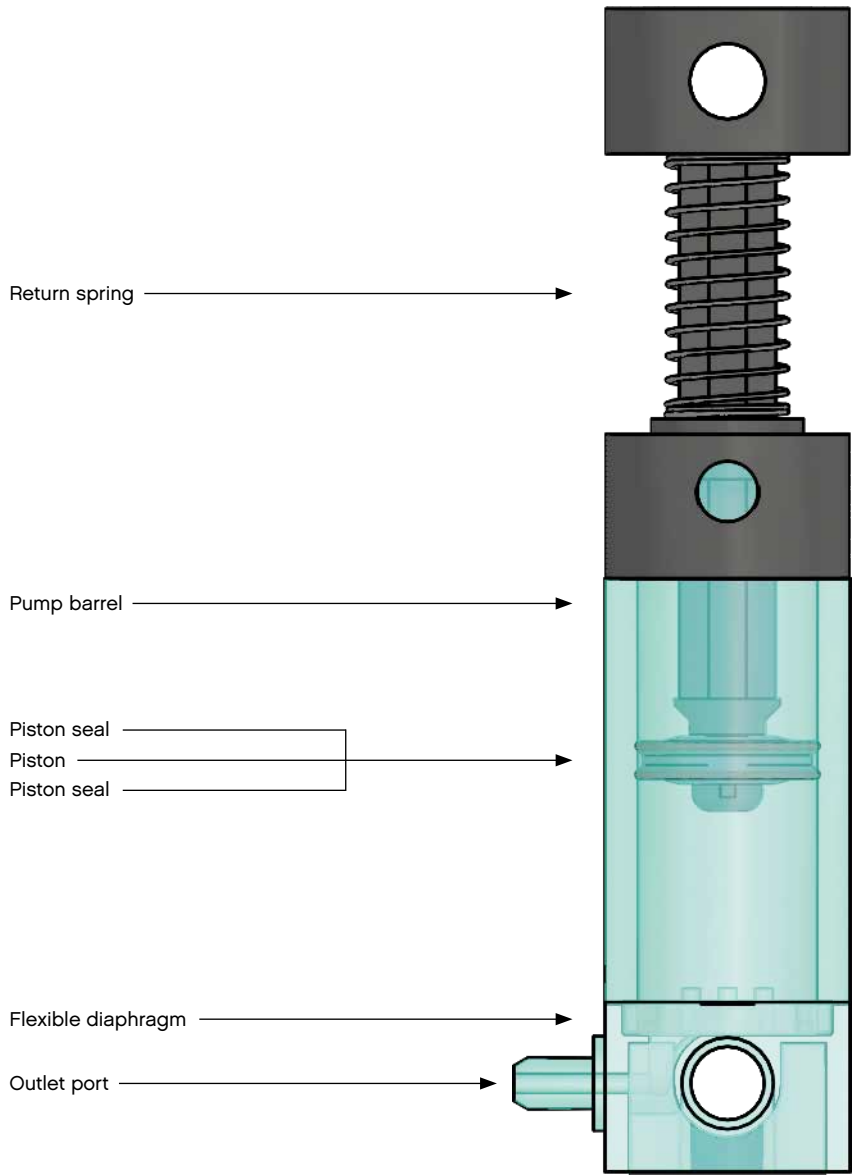


T-piece

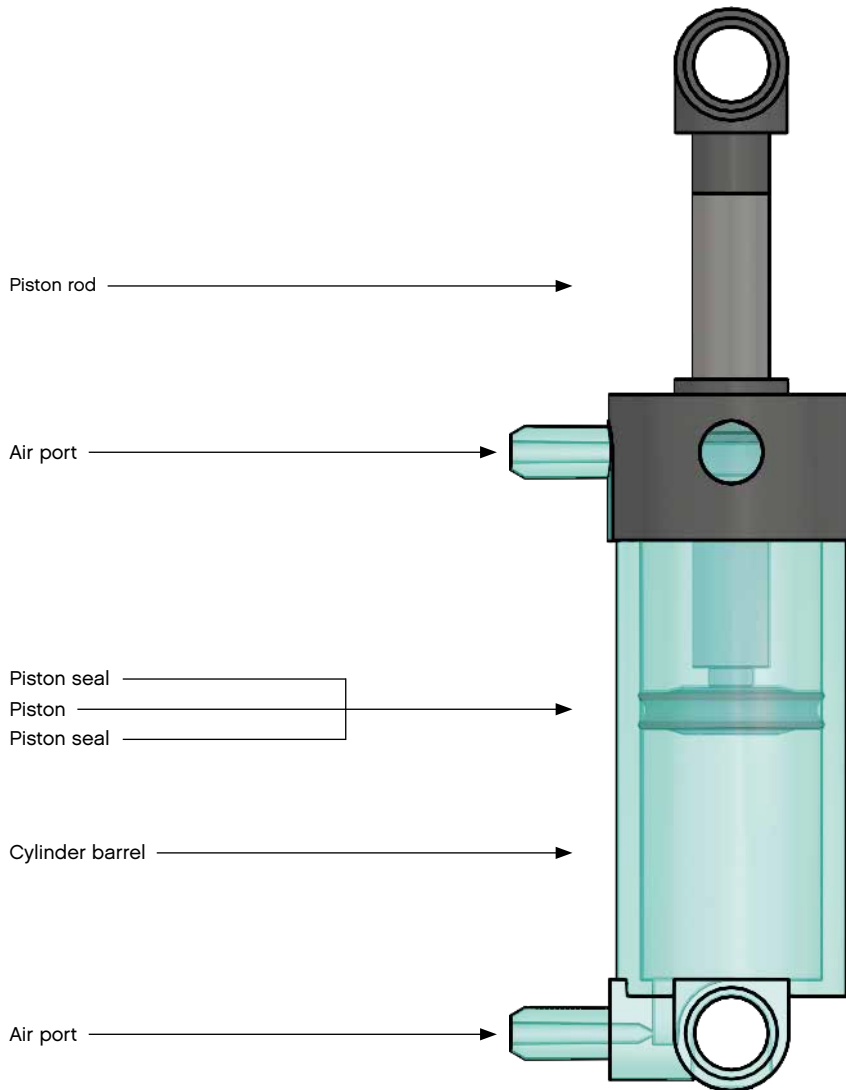
◀ Hint:

The LEGO models use tubing according to the following rules:
Blue tubes are used to transport air between the pump, air tank, and valve.
Light grey tubes are used to transport air between the valve and bottom cylinder air port.
Black tubes are used to transport air between the valve and top cylinder air port.

The Pump



The Cylinder



The Three-Position Valve

