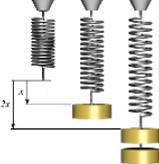
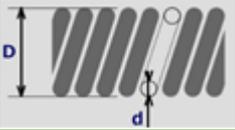
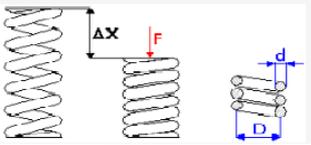
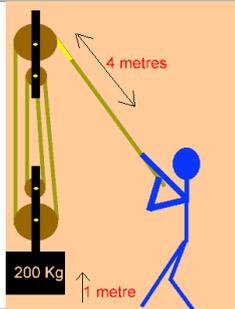


<b>Spring Basic Concepts</b>	
	<p>Springs are mechanical parts included in many everyday objects</p>
	<p>Spring Constant is the ratio between the force actuating in a spring and the caused displacement</p>
	<p>Spring stiffness is the value of the spring constant</p>
	<p>The Spring constant depends on the material, the number of turns per unit length (n), the turns' diameter (D), the wire diameter (d)</p>
 <p style="text-align: center;"><math>F = k\Delta x</math></p> <hr style="width: 20%; margin: auto;"/> $k = \frac{G d^4}{8 n D^3}$	<p>Spring constant, K  Actuating force, F  Caused displacement, <math>\Delta x</math>  Transverse elastic modulus, G  Number of turns per unit length, n  Turn diameter, D  Wire diameter, d</p>

Note: Pictures from internet resources

## Pulleys & Sheaves

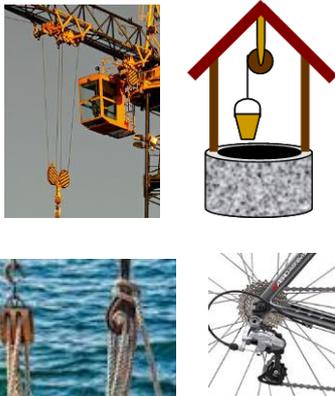


A pulley is a mechanism regularly used to change the direction of a force and/or to increase the effect of that force when moving loads, and to move a load from one place to another. Changing the force direction can help to use the gravity in user favor

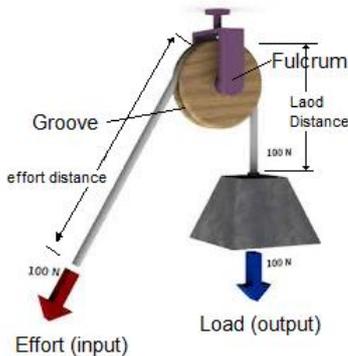


A sheave is one of the components of a pulley. It is, very often, a wheel with a groove along its surface through where a belt, a rope, or a cable passes through.

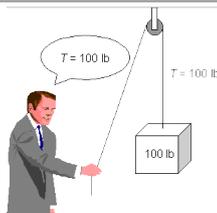
The belt, the rope, or the cable, is the other component of the pulley



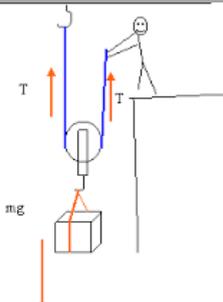
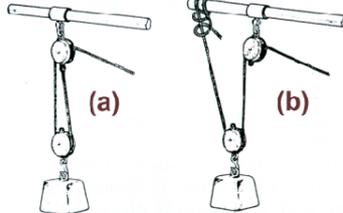
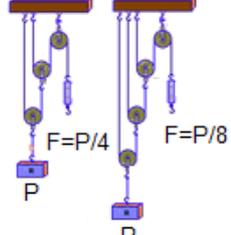
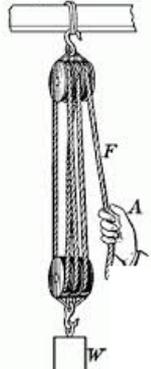
Pulleys have been used since ever in many everyday tasks, in cranes, in ships, in bikes, ...



The fulcrum is the axle of the pulley. The load is the pulley's input and the applied force or effort is the pulley output. The rope passes through the groove and serves to redirect the force direction and to transmit indirectly the applied force to the load

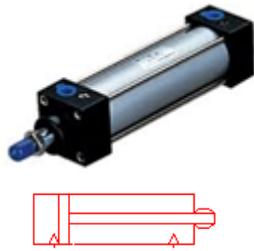


For an ideal fixed pulley the mechanical advantage is 1 this is, it redirects the force direction for moving the load and the applied effort is equal, in value, to the load

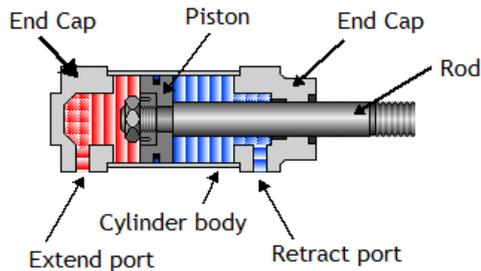
	<p>A free pulley redirects the force and the mechanical advantage is 2. However, it is not comfortable to use it!</p>
	<p>Combining a fixed pulley with a free one, the system offers an effort half the load value. The mechanical advantage is 2.</p>
	<p>Combining a fixed pulley with different free pulleys the system offers an effort as a fraction of the load value. The mechanical advantage is given by <math>P/2^n</math> where <math>n</math> is the number of free pulleys</p>
	<p>Other complex pulley systems are often used and need more extended analysis for evaluating the mechanical advantage and for understanding other parameters as length of used rope, object rise, work, acceleration, velocity, ...</p>

Figures from internet resources

## Pneumatic Cylinder basics

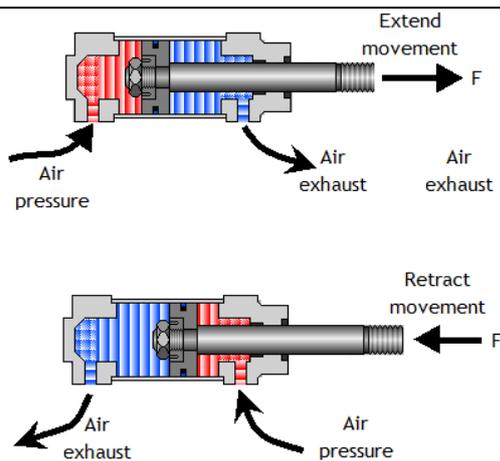


Pneumatic cylinders are one of the most common pneumatic actuators used in many industrial applications that require linear motion. A pneumatic Cylinder is an actuator that uses the energy of compressed air to convert it in mechanical energy, in the form of a linear movement.



Cylinder components and operating characteristics:

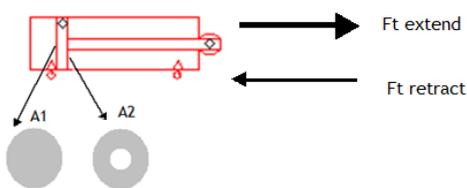
Cylinders operate typically at pneumatic pressures up to 10 bar ( $10^6 \text{ N/m}^2$ ).  
Wide range of sizes, diameters from 2.5 mm up to 320 mm.  
Strokes from 1 mm up to 2000 mm.  
Available forces from 2N up to 4500N (at 6bar)  
Velocity of piston rod from 0.1 m/s up to 1.5 m/s.



How it works

The compressed air acting on a piston inside a cylinder moves the piston and the rod along a linear path. By providing compressed air to one chamber of the cylinder, and removing the air from the other chamber, it is possible to extend or retract the piston rod.

The force that is available to produce the movement is dependent on the air pressure and on the size of the actuator



$F_t \text{ on extended mov.} = p \times A1$

$F_t \text{ on retract mov.} = p \times A2$

$F_t \text{ ext.} > F_t \text{ ret}$

Actuating force

The theoretical force available for the extend and retract movements is dependent on the pneumatic pressure and size of piston and rod.

$$F_t = p \times A$$

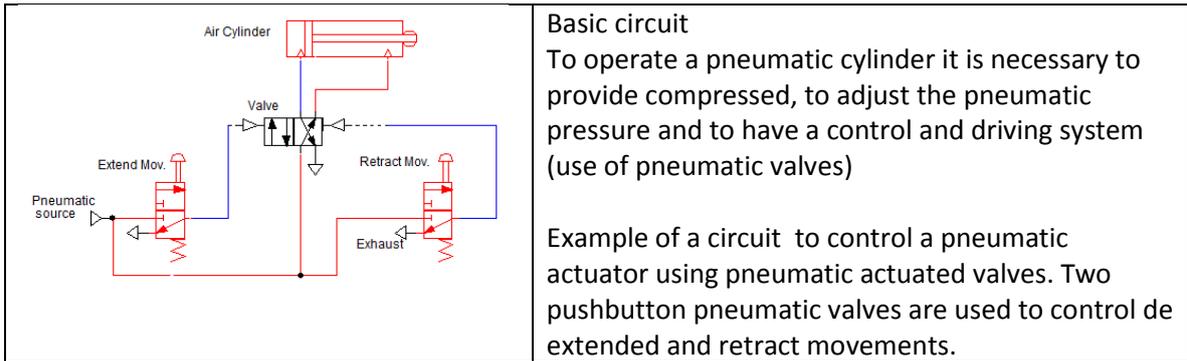
Where

$F_t$ - theoretical force [N]

$p$  – air pressure [ $\text{N/m}^2$ ]

$A$  – area of acting pressure [ $\text{m}^2$ ]

In practical terms, the effective force a pneumatic cylinder can exert is considered to be 60% -80% of the theoretical force due to pneumatic and friction losses.



**Basic circuit**

To operate a pneumatic cylinder it is necessary to provide compressed, to adjust the pneumatic pressure and to have a control and driving system (use of pneumatic valves)

Example of a circuit to control a pneumatic actuator using pneumatic actuated valves. Two pushbutton pneumatic valves are used to control de extended and retract movements.