

L'il Sucker

The World's most amazing suction cup

Atmospheric pressure is the pressure at any point in the Earth's atmosphere.

In most circumstances atmospheric pressure is closely approximated by the hydrostatic pressure caused by the weight of air above the measurement point.

As elevation increases, there are exponentially fewer and fewer air molecules. Therefore, atmospheric pressure decreases with increasing altitude at a decreasing rate. The following relationship is a first-order approximation:

$$\log_{10} P \approx 5 - \frac{h}{15500}$$

where P is the pressure in pascals and h the height in metres. This shows that the pressure at an altitude of 30 km is about 1% of that at sea level.

Here is an indication of Altitude vs. % Air pressure:

ALTITUDE	% of 1 atm
0 m	100 %
3 000 m	69.2 %
5 000 m	53.4 %
8848 m (Mt. Everest)	31.1 %
10 000 m (commercial airlines)	26.2 %
30 000 m	1.1 %

A column of air, 1 square metre in cross section, measured from sea level to the top of the atmosphere ($\pm 30\text{km}$) would weigh approximately 100kN or 10 metric tons.

Thus: The pressure exerted on a $1\text{m} \times 1\text{m} = 1\text{m}^2$ area is approximately 10 tons (at sea level)!

Students find this hard to grasp and teachers even harder to demonstrate. Fortunately the L'il Sucker comes to our rescue.

"Why don't we get crushed by this force?"

According to Newton's Third Law we exert an equal pressure on the atmosphere. The air inside our bodies is at the same atmospheric pressure as the air outside our bodies. An equilibrium of forces exist and we can move about freely. The same is true for a sheet of paper on a table. As long as we have equal air pressure on both sides of the sheet, the paper can be picked up. If we could seal off the side touching the table, then an equilibrium exists between the table top and the air column stacked on top of the paper. The paper is squashed between the two and can't move as with the L'il Sucker.

Pressure (symbol: p) is the force per unit area applied on a surface in a direction perpendicular to that surface.

Mathematically $p = F/A$

where:

p is the pressure in Pascal

F is the force in Newton

A is the area in m^2 .



The World's Most Amazing Suction Cup

Required:

- ◆ One L'il Sucker rubber ring
- ◆ A mug, soda can or plastic glass
- ◆ Smooth, flat surface



- 1 Slide the bottom of the object through the cloth side.
- 2 Slide the ring up the base of the object approx. 2 cm
- 3 Flip the rubber side down, pulling evenly to within 1 cm of the bottom of the object.
- 4 Press onto any smooth surface. Adjust if necessary.
- 5 To release: Lift the edge of the ring.

L'il Sucker was invented by American Mike Adjeleian. It is sold commercially to hold containers and prevent them from spilling.

In the classroom it is great for teaching students the "truths" about air pressure:

"There is no suction force – it's the air stacked on top that pushes the can and ring down!"

Get your students to confirm the following calculations:

$$\text{Area of a ring} = \pi r^2 = (3.1416)(0.0556)^2 = 0.0097 \text{ m}^2$$

At sea level

$$\begin{aligned} p = F/A \quad \text{thus} \quad F = pA &= (101.3 \text{ kN/m}^2)(0.0097 \text{ m}^2) \\ &= 0.983 \text{ kN} \\ &= 983 \text{ N} \quad \text{or} \quad 100.3 \text{ kg} \end{aligned}$$

With its radius of 55.6 mm (including the internal holder opening) it will require 100 kg to equal the air pressure and lift the suction cup from a smooth surface at sea level!



Safety: Warn students not to get their nose or head in the way when exerting extreme force to lift the cup.

References:

- The Handy Physics Answer Book, P E Gundersen, Visible Ink Press, 1999
- Wikipedia

See suction cup museum at: www.suctioncupmuseum.com

