Pressure

Estimating atmospheric pressure (1)

(Ireland)

You will need...

- ✓ luggage scales (or force meter, measuring up to 50 N)
- ✓ a 20 cm^3 syringe
- ✓ a plug to seal the nozzle of the syringe
- ✓ a length of string (ca. 30 cm)

A suitable plug can be made from a short length (2 cm) of clear plastic tubing (e.g. Tygon). Heat one end of the tubing and when it become soft squeeze the softened with pliers for a few seconds.

Follow these steps

1. Expel all air from the syringe and then seal the nozzle.
2. Record the force (F) required to pull the plunger to the 5, 10, 15 and 20 cm^3 marks.

Measuring the force may be facilitated by attaching a loop of string to the flange at the top of the plunger.

So what happened?

You should notice that the required to pull the plunger to the 5, 10, 15 and 20 cm^3 marks are roughly the same — typically about 30 N, or about 3 kg using the luggage scales).

Can you explain why?

Explanation

Since there is a negligible amount of air in the syringe there is negligible pressure on the inside of the plunger.

However, pressure on the other side of the plunger is atmospheric pressure. Its value does not change as the plunger is being pulled.

Estimate atmospheric pressure

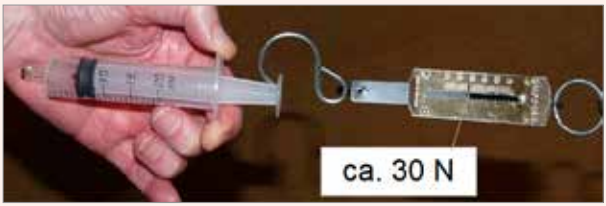
Pressure is **force** per unit **area** ($P = F/A$). To measure atmospheric pressure we need to find the value of the area ***A***, the area of cross-section of the plunger. This can be found by measuring the internal diameter (d); the radius is half of that value ($r = d/2$) and $A = \pi r^2$.

Calculate the pressure in N cm^{-2} and N m^{-2}.

Notes

1. Within the limits of measurement, the values are all the same. This is because atmospheric pressure is pushing the plunger in while there is little or no force pushing it out.
2. An **alternative way to find the area** of cross-section is to divide the marked volume (V) of the syringe by the length of the scale on the syringe (h).
   If the length of the scale on a 20 cm^3 syringe is 6.5 cm then the area of cross-section is 20 / 6.5 or about 3 cm^2.
   If the force was 30 N then the pressure exerted by the atmosphere is 30 N / 3 cm^2 or 10 N cm^{-2} or 100,000 N m^{-2}
3. This can be written in the following equivalent forms: 100,000 Pa, 100 kPa or 1000 hPa.

   (100,000 pascals, = 100 kilopascals = 1000 hectopascals)



Estimating atmospheric pressure (2)

(This method presumes Boyle's Law)

(Ireland)

You will need...

- ✓ bathroom scales
- ✓ a 20 cm^3 syringe
- ✓ a plug to seal the nozzle of the syringe

Follow these steps

1. Set the plunger at the 20 cm^3 mark. Then plug the syringe.
2. Invert the syringe and press the plunger against the bathroom scales. Record the 'weight' when the volume has been reduced to 10 cm^3.
3. Remember that, on Earth, the weight of a kilogram is about 10 newtons.
   So convert the kilogram readings to newtons by multiplying by 10.
4. Find the area of cross-section of the plunger as described in the previous experiment.
   ($A = \pi r^2$. or $A = V / h$)

5. Calculate the excess pressure required to halve the volume of the air in the syringe.
   What does this excess pressure represent?

Teacher Notes

Magdeburg hemispheres are a pair of hemispheres which fit together to form an air-tight seal.. They were used to demonstrate the magnitude of atmospheric pressure.

When the hemispheres were joined and the air was pumped out, the sphere contained a vacuum and could not be pulled apart by teams of horses.

When the air was allowed in the hemispheres were easily separated.

They were designed by a German scientist, Otto von Guericke, to demonstrate the air pump that he had invented, and the concept of atmospheric pressure.

What next

Estimate atmospheric pressure by measuring the diameter (*d*)of a suction cup and the force required to pull the suction cup from a smooth flat surface (*F*)

Pressure = force / area