Density and pressure

Density

> **The density of a substance is defined as its mass per unit volume.**

$$\rho = \frac{m}{V}$$

The symbol is not p, it is the Greek letter ‘rho’, and the SI unit is $kg\,m^{-3}$.

Example:

- Find the density of an object with mass 200 kg and volume 2 cubic meters.

$$\rho = \frac{m}{V}$$
$$\rho = \frac{200}{2}$$
$$\rho = 100\ kg\,m^{-3}$$

Pressure

> **Pressure is defined as force per unit area, where the force F acts perpendicularly to the area A.**

$$p = \frac{F}{A}$$

The symbol of pressure is p, and its SI unit is pascal, or newton per square meter $(N\,m^{-2})$

Pressure in a liquid

The deeper an object goes down a liquid, the more the pressure is. Why? Well, there is more liquid mass acting on the object the deeper it is.

$p = \rho g h$ where ρ is the density of the liquid, g is the gravitational acceleration, and h is the depth.

The change in pressure will change with depth, and so

$\Delta p = \rho g \Delta h$

A fluid at rest is in equilibrium. This means that pressure in any point of the fluid must act in **all directions** at that point. This is important later in **upthrust**.

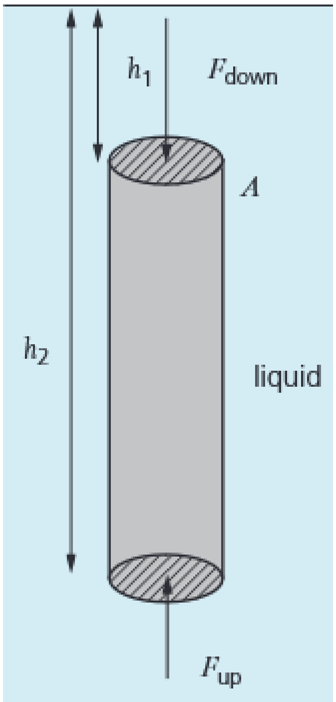
Pressure is proportionate to the depth below the surface of the liquid. If an external pressure, such as atmospheric pressure, acts on the surface of the liquid, this must be taken into account when calculating the **absolute pressure**.

> **The absolute pressure is the sum of the external pressure and pressure due to the depth below the surface of the liquid.**

Upthrust

When an object is immersed in a fluid, it appears to weight less than when in a vacuum. Try lifting a stone underwater and it’s easier!

The reason for this is because the fluid provides an **upthrust** or **buoyancy force**. This force acts upwards.



Let's say this cylinder is underwater. The bottom of the cylinder is at a depth of h_2 and the top is at h_1, so already there is a pressure difference.

$\Delta p = \rho g \Delta h \rightarrow \rho g(h_2 - h_1)$

This difference means that there is a bigger force acting upwards(because fluids apply pressure in all directions!) which we call upthrust or buoyancy force.

We also have to consider the area of the cylinder A.

So, the upthrust formula is:

$F_b = \rho g A \Delta h$ where Δh can be replaced with the length of the object l leading to:

$F_b = \rho g A l \rightarrow F_b = \rho g V$ where V is the volume displaced by the object (because area into length is volume).