The Thomas Alleyne Academy

# Knowledge Organiser - Matter

Science Department

**KPI 9PM 1:** Describe the factors that affect pressure in fluids

**Pressure in fluids**

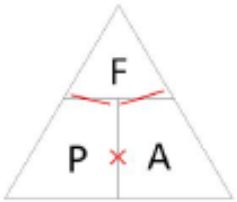
Liquids and gases are fluids. A fluid is able to change shape and flow from place to place. Fluids exert pressure on surfaces, and this pressure acts at 90° to those surfaces – we say that it acts normal to the surface.

**Pressure on surfaces**

You may have been warned about swinging around on one leg of a chair. Apart from the risk that you will damage the chair or hurt yourself, the chair leg can damage the floor. This is because it puts too much pressure on the floor.

**Calculating pressure**

Pressure = Force ÷ Area




To calculate pressure, you need to know two things:
the force or weight exerted
the surface area over which the force or weight is spread

**Example**

A force of 20 N acts over an area of 4 $m^2$. Calculate the pressure.
pressure = force ÷ area
= 20 N ÷ 4 $m^2$ = 5 $N/m^2$
Notice that the unit of pressure here is $N/m^2$ (newtons per square metre). Sometimes you will see another unit being used. This is called the pascal and it has the symbol Pa.
1 Pa = 1 $N/m^2$, so in the example above the pressure is 5 Pa.

**Pressure in liquids**

Liquid pressure is exerted on the surface of an object in a liquid. This pressure causes upthrust. An object placed in a liquid will begin to sink. As it sinks, the liquid pressure on it increases and so the upthrust increases. For a floating object, the upthrust is equal and opposite to the object's weight. An object will continue to Sink if its weight is greater than the maximum upthrust.


**Atmospheric pressure**

The atmosphere exerts a pressure on you, and everything around you. You may have seen a demonstration of the effects of this atmospheric pressure.
The Magdeburg hemispheres are two metal cups that fit together. If most of the air is removed from inside them using a vacuum pump, it is almost impossible to pull them apart again. The pressure of the atmosphere acting on their outside surface pushes them tightly together. Once the air is let back in, the pressure inside equals the pressure outside again, and the cups can easily be separated.

The effects of pressure can be seen in the collapsing can experiment. Here some water is boiled in an empty drinks can and steam fills the can. If the can is turned upside down in a trough of cold water, the steam condenses and the air pressure inside goes down. The pressure of the air outside the can suddenly crushes the can.

Atmospheric pressure changes with altitude. The higher you go:
- the lower the weight of the air above you
- the lower the atmospheric pressure

**Pressure in liquids**

Just like the atmosphere, liquids exert pressure on objects. The pressure in liquids changes with depth. The deeper you go:

- the greater the weight of liquid above
- the greater the liquid pressure

Pressure in a liquid increases with depth so the jet coming from the bottom of the bucket travels further sideways.

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**KPI 9PM 2:** Describe the motion of particles in different states of matter and link this to different behaviours

## Particles:

All substances are made from particles. The arrangement, movement and closeness of these particles explain many of their properties

| State | Solid | Liquid | Gas |
|---|---|---|---|
| Diagram |  |  |  |
| Arrangement of particles | Regular arrangement | Randomly arranged | Randomly arranged |
| Movement of particles | Vibrate about a fixed position | Move around each other | Move quickly in all directions |
| Closeness of particles | Very close | Close | Far apart |

## Brownian Motion

Gas particles move very quickly. However, a smell does not travel this fast. This is because its particles collide with each other and with particles of air very frequently. They change direction randomly when they collide, so it takes much longer to travel from one place to another. Their random motion because of collisions is called Brownian motion.

## Diffusion

If someone is cooking in the kitchen, the smell travels around the house to other rooms. This is because of diffusion.

- The movement of particles from an area of high concentration to an area of low concentration.
- Diffusion does not happen in solids – the particles in a solid can only vibrate and cannot move from place to place.

## Expansion and contraction

Substances expand (increase in size) when they get warmer, and they contract (decrease in size) when they get cooler. This property can be useful. For example:

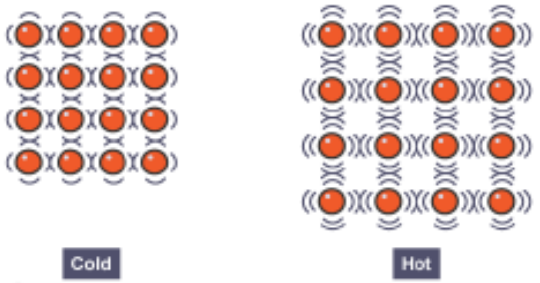
- Thermometers work because the liquid inside them expands and rises up the tube when it gets hotter.
- Metal parts can be fitted together without welding, using shrink fitting.

The expansion and contraction of materials can also cause problems. For example, bridges expand in the summer heat and need special joints to stop them bending out of shape.

## What do the particles do?

When substances expand or contract, their particles stay the same size. It is the space between the particles that changes:

- the particles in a solid vibrate more when it is heated, and take up more room
- the particles in a liquid move around each other more when it is heated, and take up more room
- the particles in a gas move more quickly in all directions when it is heated, and take up more room




**Remember, the particles themselves never expand.**

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**KPI 9PM 3:** Compare and explain differences in density between solids, liquids and gases

## Density:

The density of an object or substance is its mass divided by its volume:

**density = mass ÷ volume**

$$\text{density } \rho = \frac{\text{mass } m}{\text{volume } v}$$

The units of density depend on the units used for mass and volume, but are usually:
g/cm³ (if mass is measured in g and volume in cm³)
The more dense a substance is, the heavier it feels for its size. The table shows three examples:

| Substance | Density in g/cm³ |
|---|---|
| Steel | 7.82 |
| Water | 1.00 |
| Air | 0.0013 |

Notice that the solid (steel) is the most dense, the gas (air) is the least dense, and the density of the liquid (water) is in between.

## Measuring density

You need to know two things to measure the density of a substance:
- the mass of a sample of some of it
- the volume of that sample

The mass is measured using a balance. The volume of a liquid is easily measured using a measuring cylinder. The volume of a solid can be measured by:
- measuring the side of a cube or block of the substance, then using mathematics to calculate its volume, or
- using a displacement can (also called a eureka can) – the sample is lowered into a container of water and the volume of water it displaces or pushes out of the way is the same as the volume of the object

## Density Properties

### Solids

The particles in solids are very close together. They are tightly packed, giving solids high densities.

### Liquids

The particles in liquids are close together. Although they are randomly arranged, they are still tightly packed, giving liquids high densities. The density of a substance as a liquid is usually only slightly less than its density as a solid.
Water is different from most substances: it is less dense as a solid than as a liquid, because its particles move apart slightly on freezing. This is why ice cubes and icebergs float on liquid water.

### Gases

The particles in gases are very far apart, so gases have a very low density.