Chapter 11: Force and pressure

Knowledge organiser

Pressure

Pressure is the force acting per square metre on a surface.

The unit of pressure is the **pascal** (Pa), which is equal to one newton per square metre.

Pressure can be calculated using:

L $\text{pressure (Pa)} = \frac{\text{force (N)}}{\text{area (m}^2\text{)}}$

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

When a force acts over a:

- large surface area, the pressure is reduced (e.g., caterpillar tracks on a tank)
- small surface area, the pressure is increased (e.g., knife edge).

Pressure in a substance

A **fluid** is a liquid or gaseous substance that can flow.

When the particles of a fluid collide with a surface, such as in a container, they exert a force at right angles (normal) to the surface.

Pressure at depth

The pressure in a liquid increases with the depth of the liquid because:

- the pressure at any point in a liquid is due to the weight of the liquid above that point
- the weight of a liquid depends on its **density**.

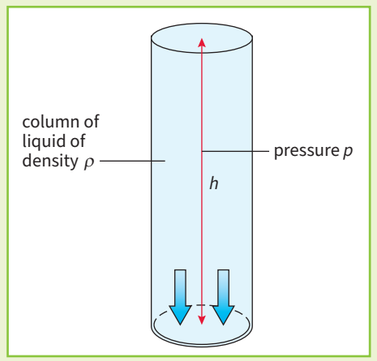
Calculating pressure in a column of water

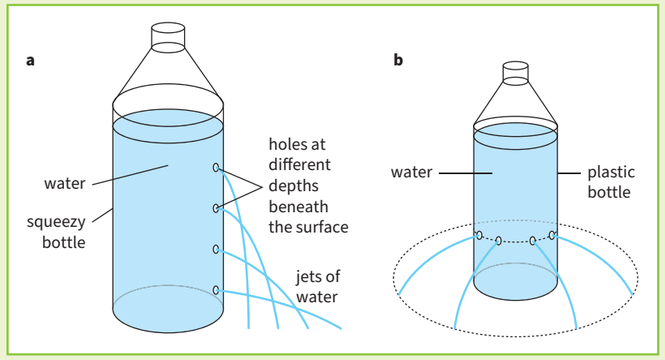
The pressure caused by a column of liquid can be calculated using:

pressure (Pa) = height of the column (m) × density of the liquid (kg/m^3) × gravitational field strength (N/kg)

$$p = h \rho g$$

To calculate the difference in pressure at different depths in a liquid, calculate the pressure at each depth (h) and subtract the smaller value from the larger one.

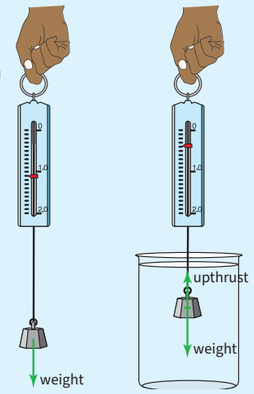




a) Pressure increases with depth b) Pressure is the same at the same depth

Measuring upthrust

Measure the weight of an object in air using a newtonmeter. Repeat with the object completely in water. The difference between the two readings is the upthrust.



Upthrust

An object that is partially or completely submerged in a fluid experiences a greater pressure on its bottom surface than its top surface.

This difference in pressure creates an upwards resultant force on the submerged object, known as **upthrust**.

Floating and sinking

An object will sink if its weight is greater than the upthrust.

An object will float if its weight is equal to the upthrust.

Whether an object in a fluid will float or sink depends on its density because:

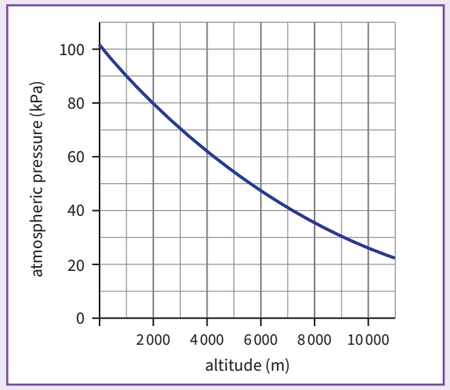
- the upthrust on an object is equal to the weight of the fluid it **displaces** (pushes out of the way)
- an object that is *more dense* than the fluid will sink because its weight is greater than the weight of the liquid displaced (and so greater than the upthrust)
- an object that is *less dense* than the fluid will float because its weight is less than the weight of the fluid displaced (and so less than the upthrust).

Atmospheric pressure

Atmospheric pressure is caused by air molecules colliding with surfaces. This decreases as height above a surface (**altitude**) increases because:

1. there are fewer air molecules in total above the surface as height increases, so the weight of air above the surface decreases
2. density of the atmosphere decreases with altitude, so there are fewer air molecules per cubic metre.

These both mean that atmospheric pressure decreases with increasing altitude because there is less **weight** of air above the surface.



The Earth's atmosphere

The Earth is surrounded by a thin (relative to the size of the Earth) layer of air known as the atmosphere.

Air is a fluid, so there is pressure in the atmosphere – this is called **atmospheric pressure**. As the altitude increases (e.g., walking to the top of a mountain), the concentration of oxygen in the atmosphere will decrease.

Key terms

Make sure you can write a definition for these key terms.

altitude · atmosphere · atmospheric pressure · density · displace · fluid · gravitational field strength · pascal · pressure · upthrust · weight

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Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P11 questions	Answers
1	What is a fluid?	a substance that can flow (liquid or gas)
2	What is the unit of pressure that is equal to one newton per square metre?	pascal (Pa)
3	Why does the pressure in a liquid increase with depth?	pressure at any point in a liquid is due to the weight of the liquid above that point
4	Why does the pressure in a liquid depend on the density of the liquid?	pressure is due to the weight of the liquid, and the weight of a liquid depends on its density
5	What is upthrust?	the resultant force due to the difference in pressure between the top and bottom surfaces of an object submerged in a fluid
6	What will an object placed in a fluid do if its weight is equal to the upthrust?	float
7	What will an object placed in a fluid do if its weight is greater than the upthrust?	sink
8	Why does an object that is more dense than a fluid sink if it is placed in the fluid?	weight of the object is greater than the weight of the fluid displaced, so the weight of the object is greater than the upthrust
9	Why does an object that is less dense than a fluid float if it is placed in the fluid?	weight of the object is less than the weight of the fluid displaced, so the weight of the object is less than the upthrust
10	Does an object that is partially submerged in a fluid experience a greater pressure on its bottom or top surface?	bottom
11	What is the Earth's atmosphere?	the layer of air that surrounds the Earth
12	What is atmospheric pressure caused by?	air molecules colliding with surfaces
13	Why does atmospheric pressure decrease with increased altitude?	the density of the air decreases, fewer air molecules as you go higher – there is less weight of air above a surface and fewer air molecules so density of the atmosphere decreases
14	How does the height of the atmosphere compare to the radius of the Earth?	it is smaller

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