

What air is made of and why it presses

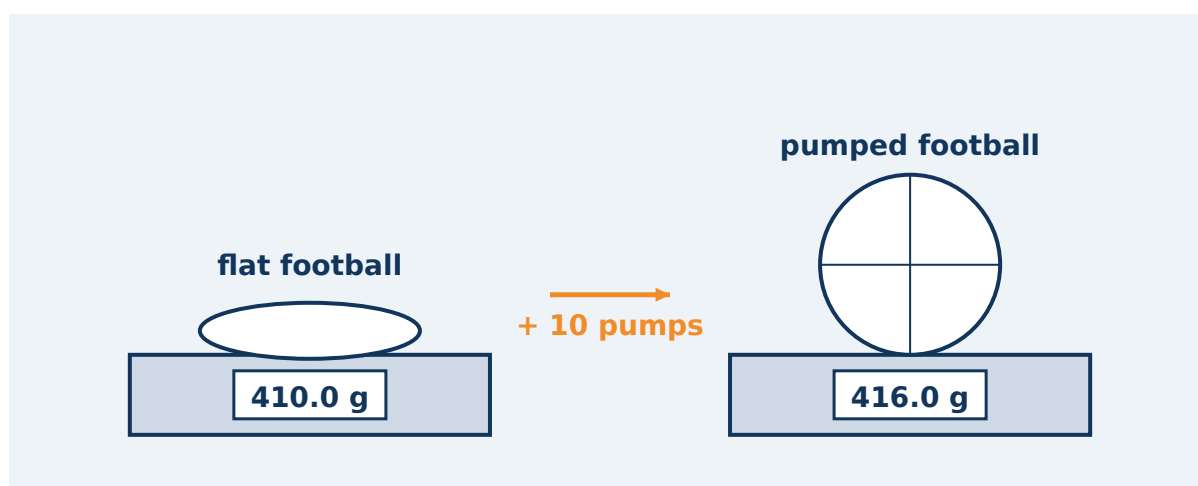
Grade 7 science (Year 8 · Class 7) · Lesson

Quick answer: Air is a mixture of gases, mainly 78 % nitrogen and 21 % oxygen, and it has mass: about 1.2 kg per cubic metre. Atmospheric pressure is the push of the air above us, about 101 kPa at sea level. A barometer measures it, and it falls as height increases.

Level: Grade 7 science (Year 8 · Class 7) · **Curriculum:** MS-ESS2-5

Does air have mass?

Air is invisible, but it is matter, so it has mass. Weigh a flat football, pump air into it and weigh it again: the reading rises. A gas is made of particles, and particles have mass.



The extra 6.0 g is the mass of the air added by 10 pumps.

Formula

$$m = \rho \times V$$

m is the mass in kilograms (kg), ρ is the density in kg/m^3 and V is the volume in m^3 . Near sea level, the density of air is about 1.2 kg/m^3 .

Worked example

Find the mass of air in a classroom 8.0 m long, 6.0 m wide and 3.0 m high.

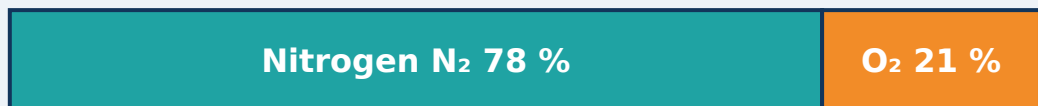
$$V = 8.0 \times 6.0 \times 3.0 = 144 \text{ m}^3. \quad m = \rho \times V = 1.2 \times 144 = 172.8. \quad \mathbf{m \approx 173 \text{ kg}}$$

What is air made of?

Air is a mixture of gases. Nearly four-fifths is nitrogen, and about one-fifth is oxygen, the gas that animals need to breathe. The rest is mostly argon with a trace of carbon dioxide and a variable amount of water vapour.

Definition

The **atmosphere** is the layer of gases that surrounds the Earth and is held in place by gravity. Most of its mass lies within about 10 km of the surface.

Dry air by volume

argon, carbon dioxide and traces: about 1 %

The composition of dry air.

Gas	Symbol	Share of dry air
Nitrogen	N ₂	78 %
Oxygen	O ₂	21 %
Argon	Ar	0.9 %
Carbon dioxide	CO ₂	0.04 %

What is atmospheric pressure?

Air particles move randomly and collide with every surface. Each collision pushes a little, and billions of collisions a second add up to a steady push. We call it pressure. Atmospheric pressure is caused by the weight of the column of air above you, and it pushes in all directions, not just downwards.

Formula

$$p = F \div A$$

p is the pressure in pascals (Pa), F the force in newtons (N) and A the area in square metres (m²). 1 Pa = 1 N/m², 1 kPa = 1000 Pa and 1 hPa = 100 Pa.

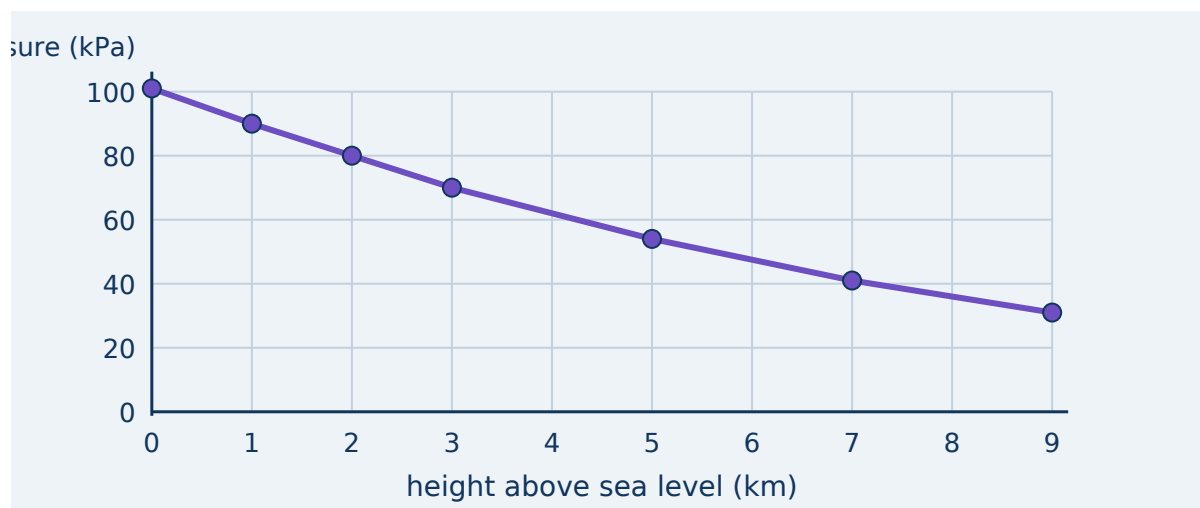
Worked example

At sea level atmospheric pressure is about 101 000 Pa. Find the force of the air on a window of area 0.20 m².

$F = p \times A = 101\,000 \times 0.20 = 20\,200$. **F = 20 200 N**. The window does not break, because the air inside pushes back equally.

Why does air pressure fall as you climb?

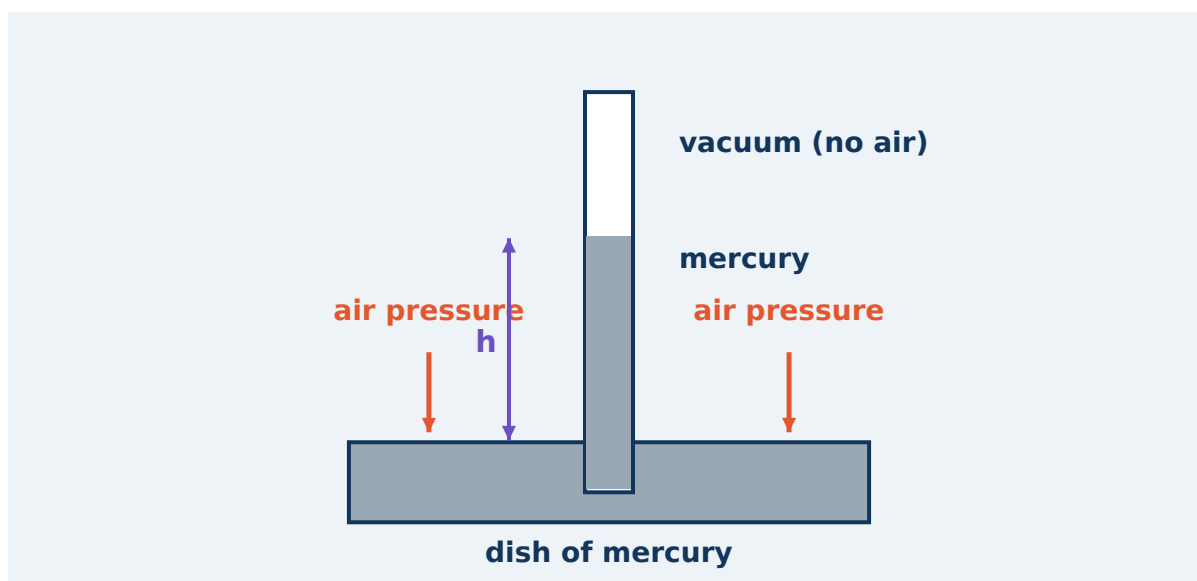
On a mountain there is less air above you, so the weight of the air column is smaller and the air is thinner. The graph shows that pressure drops quickly at first and then more slowly. At the height of Mount Everest the pressure is only about one-third of the value at sea level, which is why climbers carry oxygen.



Air pressure falls as height increases.

How does a barometer measure pressure?

A barometer measures atmospheric pressure. In a mercury barometer, a closed glass tube full of mercury is turned upside down in a dish of mercury. The mercury sinks until the pressure of the column equals the push of the air on the dish, leaving a vacuum above it. At sea level the column stands about 760 mm high. A metal-box (aneroid) barometer uses a sealed, flexible box that squashes as pressure rises.



A mercury barometer: the height h of the column measures the pressure.

Standard pressure equals 760 mm of mercury, or 101.3 kPa, or 1013 hPa. Pressure falling steadily often means cloud and rain are coming; rising pressure often means clearing, drier

weather.

Worked example

A weather station in Nairobi reads 1008 hPa. Convert this to pascals and kilopascals.

$1008 \times 100 = 100\,800$ Pa and $100\,800 \div 1000 = 100.8$ kPa. **100 800 Pa = 100.8 kPa**

Common mistake

Do not think that the atmosphere only presses downwards, or that a gas has no mass. Air pushes equally in every direction at a point, and an inflated ball is heavier than a flat one.

Lina's tip

When you convert pressure units, write the chain: hPa $\times$ 100 gives Pa, then $\div$ 1000 gives kPa. Check your answer is sensible: sea-level pressure should come out near 101 kPa.

Key points to remember

- Air is about 78 % nitrogen, 21 % oxygen, 0.9 % argon and 0.04 % carbon dioxide.
- Air has mass: the density of air near sea level is about 1.2 kg/m^3 .
- Pressure $p = F \div A$, measured in pascals ($1 \text{ Pa} = 1 \text{ N/m}^2$).
- Atmospheric pressure at sea level is about $101 \text{ kPa} = 1013 \text{ hPa} = 760 \text{ mm of mercury}$.
- Atmospheric pressure decreases as height above sea level increases.

What air is made of and why it presses: frequently asked questions

Does air have mass?

Yes. Air is a mixture of gases made of particles, and particles have mass. One cubic metre of air near sea level has a mass of about 1.2 kg.

What gases make up air?

Air is about 78 % nitrogen and 21 % oxygen. The remaining 1 % is mostly argon, with a tiny amount of carbon dioxide and a variable amount of water vapour.

What is atmospheric pressure?

Atmospheric pressure is the force the air exerts on each unit of area, caused by the weight of the air above. At sea level it is about 101 000 Pa.

How does a barometer work?

A mercury barometer balances the weight of a column of mercury against the push of the air. At sea level the column is about 760 mm high, and it rises and falls as the pressure changes.

Why is air pressure lower on a mountain?

There is less air above you on a mountain, so the weight of the air column is smaller. The air is

also thinner because it has fewer particles in each cubic metre.