You Don't Weigh What You Think

Why mass and weight are not the same thing at all

You step on the scales and read your "weight" in kilograms. Two everyday words, used as if they mean the same thing – and in physics they are two genuinely different quantities that happen to feel identical only because you've never left Earth.

EXAM LINKS *AQA A-level Physics (7408): 3.4 Mechanics and materials – forces, weight (W = mg), mass, gravitational field strength.*

In everyday life, "mass" and "weight" are used interchangeably. You ask how much someone weighs and they answer in kilograms; a bag of sugar is sold by "weight" but labelled in grams. Nobody is confused, and nothing goes wrong – on Earth. But this comfortable blurring hides a genuine physics distinction, and the moment you leave the Earth's surface, the two quantities go their separate ways.

Getting this distinction straight is one of the first jobs of A-level Mechanics, because almost every force question depends on it.

Two different quantities

Your **mass** is the amount of matter you are made of. It is measured in kilograms, and it does not change depending on where you are. Take your mass to the Moon, to Mars, to deep space – it stays exactly the same, because you are still made of the same stuff.

Your **weight** is something quite different: it is the *force* of gravity pulling on that mass. Because it is a force, it is measured not in kilograms but in **newtons**. And it is calculated as $\boldsymbol{W = mg}$, where m is your mass and g is the gravitational field strength wherever you happen to be. Change g, and your weight changes even though your mass has not.

The same person, three different weights

On Earth, g is about 9.8 N kg^{-1}. On the Moon it is only about 1.6 N kg^{-1} – roughly a sixth. So an astronaut with a mass of 80 kg weighs about 784 N on Earth but only about 130 N on the Moon. Same astronaut, same amount of matter, but they weigh six times less – which is exactly why the Apollo astronauts could bounce around so easily in heavy suits. On Jupiter, where gravity is stronger, that same person would weigh far *more*. Their mass never budged once.

What your bathroom scales actually measure

Here's the twist that catches everyone. Your bathroom scales do not measure your mass. They measure the **force** you push down on them with – your weight, in newtons – and then quietly divide by 9.8 and print a number in kilograms, assuming you're on Earth. Take the same scales to the Moon and they'd read a sixth of your "weight", even though you are identical. The kilograms on the display are really a weight measurement wearing a mass costume. A proper measurement of mass uses a balance, which compares your mass against a known mass – and a balance gives the same answer anywhere in the universe, because gravity pulls equally on both sides.

Why it matters at A-level and beyond

This isn't pedantry. In A-level Mechanics you will constantly need weight as a force (in newtons) to work out how things accelerate, balance or fall – and plugging in kilograms where newtons belong is one of the most common ways to get a force question wrong. More deeply, the fact that gravitational field strength g also happens to be the acceleration of free fall (9.8 m s^{-2}) is not a coincidence – it is a clue that mass and gravity are linked in a profound way, the very thread Einstein pulled on to build his theory of gravity. A distinction that everyday language throws away turns out to sit close to the deepest ideas in physics.

Terms explained

Mass The amount of matter in an object, measured in kilograms; it does not change with location.

Weight The force of gravity acting on an object's mass, measured in newtons; it changes with gravitational field strength.

Newton (N) The SI unit of force. Weight, being a force, is measured in newtons, not kilograms.

Gravitational field strength (g) The gravitational force per kilogram of mass at a given location; about 9.8 N kg^{-1} on Earth, 1.6 N kg^{-1} on the Moon.

W = mg The equation linking weight to mass and gravitational field strength.

Balance A device that compares an unknown mass against known masses; unlike scales, it gives the same reading regardless of location.

Key points

- Mass (kilograms) is the amount of matter; it never changes with location.
- Weight (newtons) is the force of gravity on that mass, given by W = mg.
- Change the gravitational field strength g, and weight changes while mass stays the same.
- Bathroom scales measure weight (a force) and convert it to kilograms assuming Earth's gravity.
- Confusing the two – using kilograms where newtons are needed – is a very common error in force calculations.

Think about …

- An astronaut travels from Earth to the Moon. State what happens to their mass and to their weight, and explain the difference.
- Explain why bathroom scales would give the "wrong" reading on the Moon, but a balance would not.
- A 2 kg bag of apples is described as "weighing 2 kg". Rewrite this statement using the correct physics terms and units.
- The gravitational field strength g (in N kg^{-1}) has the same value as the acceleration of free fall (in m s^{-2}). Suggest why this might be more than a coincidence.