

Why weight changes from planet to planet

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

Quick answer: Mass is the amount of matter in an object, measured in kilograms, and it never changes. Weight is the force of gravity pulling on that mass, measured in newtons, and it is found with $W = m \times g$. Because g is different on each planet, the same object has a different weight on Earth, the Moon and Mars.

Level: Grade 7 science (Year 8 · Class 7) · **Curriculum:** MS-PS2-4

What is the difference between mass and weight?

People say "weight" when they mean "how heavy", but in science mass and weight are different quantities.

Definition
Mass is the amount of matter in an object. It is measured in kilograms (kg) and is the same everywhere in the universe.

Definition
Weight is the force of gravity pulling on an object. It is measured in newtons (N) and depends on where the object is.

Feature	Mass	Weight
What it is	Amount of matter	Pull of gravity (a force)
Unit	Kilogram (kg)	Newton (N)
Measured with	Balance	Spring scale
On the Moon	Unchanged	About six times smaller

How do you calculate weight?

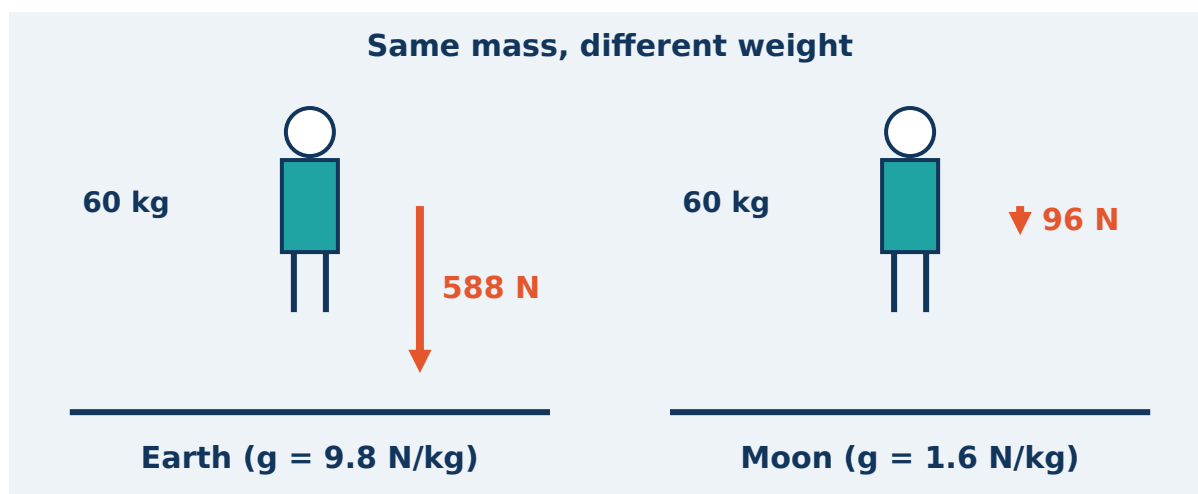
On any planet, the weight of an object is proportional to its mass. The multiplier is the gravitational field strength, g , which tells you how many newtons of gravity act on each kilogram.

Formula
 $W = m \times g$
 W is the weight in newtons (N), m is the mass in kilograms (kg) and g is the gravitational field strength in newtons per kilogram (N/kg). On Earth $g = 9.8 \text{ N/kg}$.

Worked example 1

Zanele in Durban buys a bag of flour with a mass of 4.0 kg. Calculate its weight on Earth.

$$W = m \times g = 4.0 \text{ kg} \times 9.8 \text{ N/kg} = \mathbf{39.2 \text{ N}}.$$

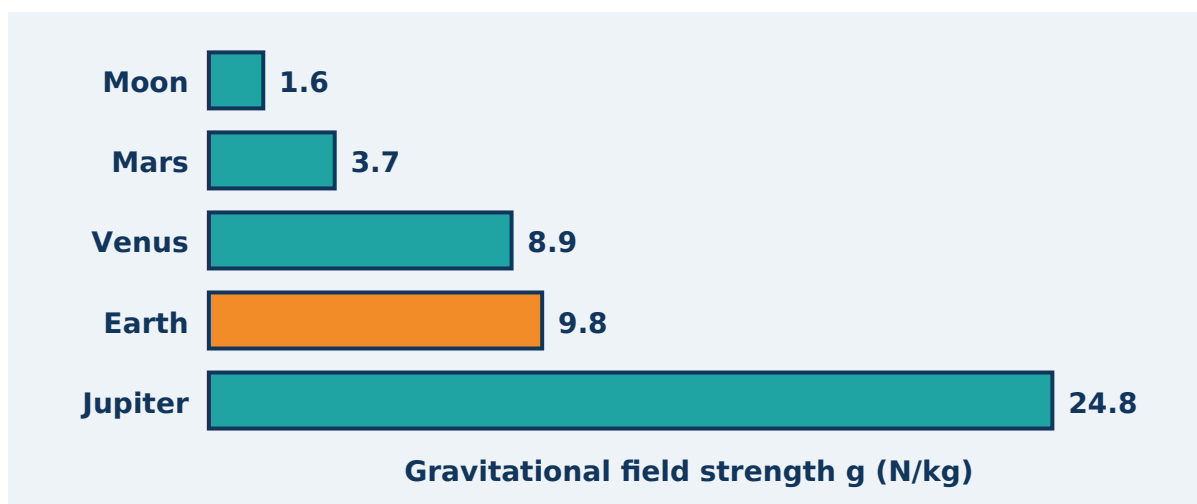


A 60 kg person has the same mass on Earth and on the Moon, but the weight arrow is much shorter on the Moon.

Why is gravity different on other planets?

Gravity is a non-contact force of attraction between objects with mass. The pull is greater when the object is more massive, and it gets weaker with distance. A planet with a bigger mass and a smaller radius pulls harder on everything at its surface. The Moon is small, so its surface gravity is much weaker than the Earth's.

Body	$g \text{ (N/kg)}$	Weight of a 10 kg object
Moon	1.6	16 N
Mars	3.7	37 N
Venus	8.9	89 N
Earth	9.8	98 N
Jupiter	24.8	248 N



Surface gravity of five bodies. The longer the bar, the stronger the pull of gravity on each kilogram.

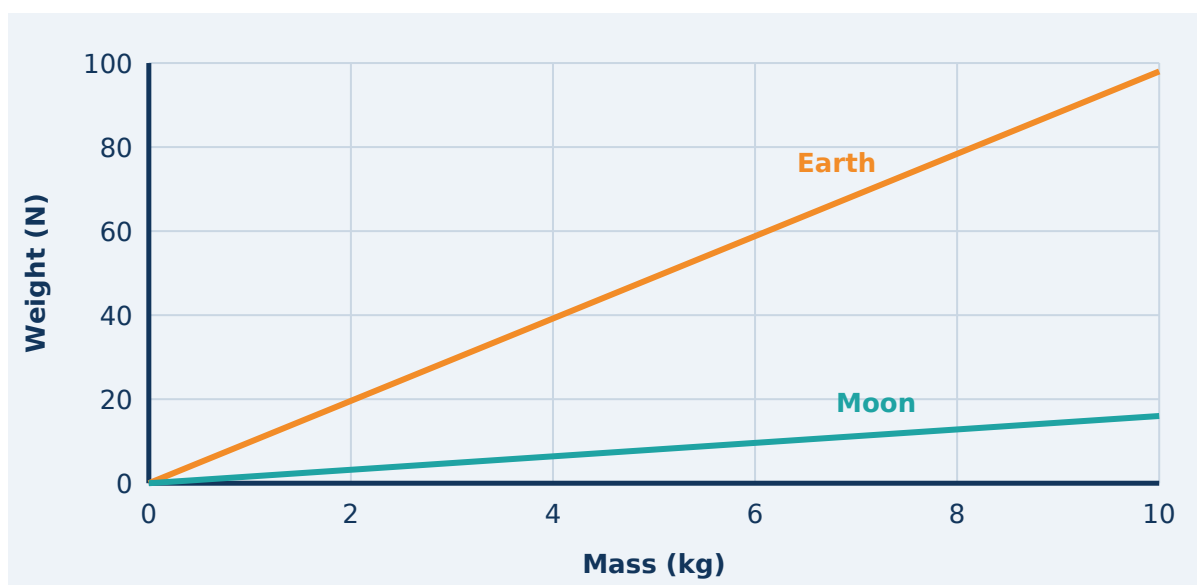
Worked example 2

An astronaut has a mass of 60 kg. Calculate her weight on the Moon, where $g = 1.6$ N/kg.

$W = 60 \times 1.6 = \mathbf{96\text{ N}}$. Her mass is still 60 kg.

What does a weight graph show?

If you plot weight against mass for objects on one planet, the result is a straight line through the origin. The gradient of the line is the gravitational field strength. On the Earth line in the figure, a 10 kg mass has a weight of 98 N, so the gradient is $98 \div 10 = 9.8$ N/kg. On the Moon line, $16 \div 10 = 1.6$ N/kg.



Weight against mass. The steeper line is Earth (gradient 9.8 N/kg) and the flatter line is the Moon (gradient 1.6 N/kg).

Worked example 3

An object has a weight of 49 N on Earth. Find its mass, then its weight on Mars ($g = 3.7$ N/kg).

$m = W \div g = 49 \div 9.8 = \mathbf{5.0\text{ kg}}$. On Mars: $W = 5.0 \times 3.7 = \mathbf{18.5\text{ N}}$.

Common mistake

The kilogram is not a unit of weight. A bathroom scale that says "60 kg" actually measures a force and divides by 9.8 to show the mass. Also, an object does not lose mass on the Moon: only its weight changes.

Lina's tip

Remember the order of the symbols: **$W = m \times g$** . To find the mass, divide the weight by g . A quick estimate on Earth: multiply the mass by 10 to get the weight in newtons.

Key points to remember

- Mass is measured in kilograms (kg) with a balance; weight is a force measured in newtons (N) with a spring scale.
- Weight: $W = m \times g$, where g is the gravitational field strength in N/kg.
- g is 9.8 N/kg on Earth, 3.7 N/kg on Mars and 1.6 N/kg on the Moon.
- Moving to another planet changes the weight of an object but not its mass.

Why weight changes from planet to planet: frequently asked questions

What is the difference between mass and weight?

Mass is the amount of matter in an object, measured in kilograms, and never changes. Weight is the pull of gravity on that mass, measured in newtons, and changes with the planet.

How do you calculate weight?

Multiply the mass in kilograms by the gravitational field strength g . For example, 5 kg on Earth weighs $5 \times 9.8 = 49$ N.

Why do astronauts weigh less on the Moon?

The Moon has less mass than Earth, so its gravity is only about one sixth as strong. The astronauts keep the same mass but their weight is much smaller.

What is gravitational field strength?

It is the force of gravity on each kilogram of mass at a place, measured in N/kg. On Earth it is 9.8 N/kg and on Mars it is 3.7 N/kg.

Which instrument measures weight?

A spring scale (newton meter) measures weight in newtons. A balance compares masses and measures mass in kilograms.