

Lesson Plan

Mass is a measure of how much matter there is in an object, while weight is a measure of the size of the pull of gravity on the object.

Mass is the amount of matter in an object. Mass is measured in kilograms (kg).

Weight is a force due to the pull of gravity on an object. Weight is a force and so is measured in newtons (N).

Gravitational field strength

On earth, the downward force of gravity on a 1 kg mass is 10 N.

This is called the gravitational field strength (g).

Gravitational field strength $g = 10 \text{ N/kg}$

The relationship between the weight of an object in N, its mass in kg and the gravitational field strength N/kg is given by the equation:

$$\text{Weight } W \text{ in N} = \text{mass } m \times \text{gravitational field strength } g$$

$$W = mg$$

W = weight in N

m = mass in kg

g = gravitational field strength in N/kg

$$g = 10 \text{ N/kg}$$

A mass of 1 kg has a weight of 10 N.

A mass of 6 kg has a weight of 60 N.

How big is a force of 1 N?

A force meter, also called a newton meter, is used to measure forces

An average apple has a mass of 100 g or 0.1 kg.

The weight of the apple is:

$$W = mg$$

$$m = 100 \text{ g} = 0.1 \text{ kg}$$

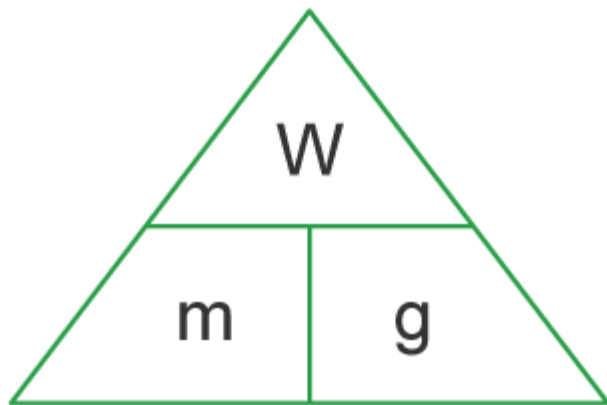
$$g = \text{gravitational field strength } g = 10 \text{ N/kg}$$

$$W = 0.1 \text{ kg} \times 10 \text{ N/kg}$$

$$W = 1 \text{ N}$$

So, a force of 1 N is the force need to lift an average sized apple off the ground.

The Wmg triangle



W = weight

m = mass

g = gravitational field strength

$W = mg$	$W = m \times g$
$m = \frac{W}{g}$	$m = W \div g$
$g = \frac{W}{m}$	$g = W \div m$

Find the weight of a person on Earth if they have a mass of 65 kg ($g = 10 \text{ N/kg}$)

- $W = mg$
- $m = 65 \text{ kg}$
- $g = \text{gravitational field strength } g = 10 \text{ N/kg}$
- $W = 65 \text{ kg} \times 10 \text{ N/kg}$
- $W = 650 \text{ N}$

The weight of the person is 650 N.

Gravitational pull on the Moon

The Moon has a smaller mass than the Earth and so the pull of gravity by the moon on an object is smaller than on the earth.

The moon has a smaller gravitational field strength.

On the Moon, $g = 1.6 \text{ N/kg}$.

In other words, a 1 kg mass has a weight on the Moon of 1.6 N.

Question

What is the weight of a 45 kg girl on:

1. the Earth, where $g = 10 \text{ N/kg}$
2. the Moon, where $g = 1.6 \text{ N/kg}$

The Earth

- $W = mg$
- $m = 45 \text{ kg}$
- $g = \text{gravitational field strength } g = 10 \text{ N/kg}$
- $W = 45 \text{ kg} \times 10 \text{ N/kg}$
- $W = 450 \text{ N}$

The weight of the girl on the Earth is 450 N

The Moon

- $W = mg$
- $m = 45 \text{ kg}$
- $g = \text{gravitational field strength } g = 1.6 \text{ N/kg}$
- $W = 45 \text{ kg} \times 1.6 \text{ N/kg}$
- $W = 72 \text{ N}$

The **weight** of the girl on the Moon is 72 N.

The **mass** of the girl is the same on the Earth and the Moon because the amount of matter in the girl is the same in both places.

However, the weight of the girl on the Earth is much greater than the weight of the girl on the Moon because the Earth's pull of gravity is much greater than the Moon's.

Question

- What is the mass of a person who weighs 120 N on the Moon? ($g = 1.6 \text{ N/kg}$)?

- What would the mass and weight of the same person be back on Earth where $g = 10 \text{ N/kg}$?

Acceleration of free fall - Higher

The acceleration of a falling object can be calculated using **Newton's Second Law**, $F = ma$

If a skydiver has a mass of 60 kg. Her weight is found using:

- $W = mg$
- $W = 60 \text{ kg} \times 10 \text{ N/kg}$
- $W = 600 \text{ N}$

If air resistance is ignored, the pull of gravity, 600 N, is the only force acting on the skydiver. Her acceleration is found using:

$$a = \frac{F}{m}$$

$$F = 600 \text{ N}$$

$$m = 60 \text{ kg}$$

$$a = \frac{600 \text{ N}}{60 \text{ kg}}$$

$$a = 10 \text{ m/s}^2.$$

Key points

- In the absence of air resistance all objects fall at the same rate regardless of their mass. Near the Earth the rate is the acceleration of free fall, 10 m/s^2 .
- Due to the Earth's gravity, the speed of an object dropped from a height will increase at a rate of 10 m/s every second as it falls.
- If there was no air resistance or drag, a feather and a hammer would fall at the same rate of 10 m/s^2 . Dropped from the same height, they would both hit the ground at the same time and travelling at the same speed.
- An object fired vertically upwards slows down at a rate of 10 m/s^2 . It experiences a retardation of 10 m/s^2 .