Weight and Mass

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Weight

Weight is a force caused by gravity acting on an object's mass. On Earth, it measures the pull of the Earth on the object. It is measured in **newtons (N)**.

Mass

Mass measures the amount of matter in an object. It is measured in **kilograms (kg).**
The value of mass does not change from place to place.

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Weight, Mass and Gravitational Field Strength Equation

Weight always acts vertically downwards. Its size does not just depend on the mass of the object, but on the strength of gravity at that place.
The strength of gravity in a particular place is called the **gravitational field strength (g)** and is defined as **the weight per unit mass**. It is measured in **Nkg^{-1}. On Earth, g = 10 Nkg^{-1}.**

From the definition:

gravitational field strength = $\frac{\text{weight}}{\text{mass}}$

In symbol form: $\mathbf{g = \frac{W}{m}}$ $\mathbf{W = mg}$ $\mathbf{m = \frac{W}{g}}$

Quantity	Symbol	SI Unit
weight	W	N
mass	m	kg
gravitational field strength	g	Nkg^{-1}

Example: A girl has a mass of 70 kg on Earth (g = 9.8 Nkg^{-1})

a) **Calculate her weight on i) Earth and ii) the moon where g = 1.6 Nkg^{-1}.**
b) **What is her mass on the moon?**

Solution

a) i) W = ? W = mg
m = 70 kg W = 70 x 9.8
g = 9.8 Nkg^{-1} W = 686 N

ii) W = ? W = mg
m = 70 kg W = 70 x 1.6
g = 1.6 Nkg^{-1} W = 112 N

b) m = 70 kg (mass does not change)

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W = m g Calculations - During Interplanetary Flight

The value for g is not always constant. It changes as you travel:

- further away from the centre of the earth;
- to a different planet, moon or star.

Every planet, moon and star has their own gravitational field strength.

Planet, Moon or Star	Value for g / Nkg^{-1}
Mercury	4
Venus	9
Earth	9.8
Earth's Moon	1.6
Mars	4
Jupiter	26
Saturn	11
Uranus	11
Neptune	12
Sun	270

Example: An un-manned space rocket of mass 20000 kg travels from Earth to Mars, Jupiter, Saturn and Uranus.

a) Calculate the rocket's weight on Mars.

b) What is the mass of the rocket on Jupiter?

c) Of the 4 planets (including Earth) visited by the rockets, on which planets would the weight of the rocket be the same? Explain your answer.

Solution

a)) W = ?
m = 20000 kg
g = 4 Nkg^{-1}

W = mg
W = 20000 x 4
W = 80000 N

b) m = 20000 kg

c) Saturn and Uranus. The values for g on both planets are the same with the mass of the rocket remaining constant.

During interplanetary flight there is no need for the engines to be kept on. Since space is a vacuum there is no friction acting on the space vehicle. With no unbalanced forces acting on the vehicle it will continue to move at a steady velocity (Newton's First Law of Motion).