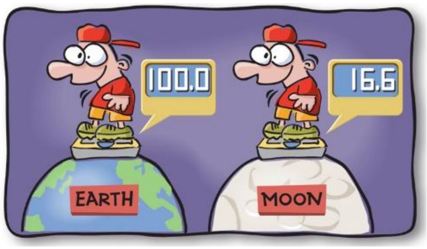
UNIT 4 MASS, WEIGHT AND GRAVITY.



KEY CONCEPTS

- Gravity make objects fall and astronomical objects orbit others.
- Newton defined the universal law of gravitation.
- Acceleration of falling objects due to gravity does not depend on their mass.
- Mass and weight are completely different concepts.
- Weight is a force, so it is measured with the dynamometer.

1. THE FORCE OF GRAVITY: THE MECHANISM OF THE UNIVERSE

All the planets and other bodies in our Solar System move in orbits around the Sun. At the same time, satellites like our Moon orbit planets. Nowadays there is also a large number of artificial satellites (communication, weather, TV, military) that orbit the Earth.

If no force acts on an object, it will remain stationary or move in a straight line at the same speed. So we might ask ourselves why the Moon and artificial satellites go around the Earth in the way that they do.

1.1. The force of gravity

The 17th century physicist sir **Isaac Newton**, got the brilliant idea that the force that make some astronomical bodies go around others was the same force that makes a fruit fall to the ground when it comes off from a tree.

Gravity is a property of matter that depend on its mass. As Newton stated:

$$F = G \cdot \frac{M \cdot m}{d^2}$$

The **gravitational force**, or gravity, is a force of **attraction** between two bodies with masses *M* and *m*, separated by a distance *d*, which is proportional to the distance between them squared.

In this equation, the proportionality constant *G* is called the **universal gravitational constant**, the value of which is:

$$G = 6.67 \cdot 10^{-11}\ Nm^2/kg^2$$

1.2. Acceleration of falling objects

Forces transmit acceleration to objects with a mass *m* according to the equation:

$$F = m \cdot a$$

Imagine that an object with mass *m* is raised to a certain height *h* from the ground. If we apply the gravitational force formula, we can demonstrate that **gravitational acceleration** on Earth's surface is: **g = 9.8 m/s^2**

All objects, regardless of their mass, fall to the ground with the same acceleration, g = 9.8 m/s^2. For this reason, they take the same amount of time to reach the ground when dropped from the same height.

2. WEIGHT IS A FORCE

As we have seen, all planets attract anything that is on or above its surface. This property is called **gravity**. Gravity causes acceleration in all objects that fall freely from a height. Gravitational acceleration is represented by letter ***g***, and it increases as gravity increases.

The **weight** of an object is the force of attraction that the Earth (or other celestial bodies) exerts on it.

If all objects fall because of the force that Earth exerts on them, we can calculate this force from the equation:

$$F = m \cdot a$$

We know that weight is a force, so we can calculate it in the same way. But remember that bodies that experience this force, are under a specific acceleration: gravitational acceleration. Therefore we can rewrite the equation:

$$\boldsymbol{W = m \cdot g \quad / \quad P = m \cdot g}$$

An object's weight depends on its **mass** and the **gravity** of the place where it is.

It is important **not to confuse** an object's weight with an object's mass. **Mass** is an invariable quantity that depends on the amount of matter an object has and it is always constant. However, **weight depends** on **gravity**. So, an object can weigh different amounts on different places on the Earth's surface or on other planet.

Weight is a **force**: its unit of measurement in the SI is the **newton** (**N**). But weight can be represented by the **kilogram-force**, or **kilopond** (**kp**). One kilopond is the weight of an object with a mass of 1 kg., on Earth. If, on average, a mass of 1 kg weighs 9.8 N on Earth, we can deduce the following: **1 kilopond = 9.8 newtons.**