DEFINITION

Any object placed in the field of the gravitational pull of the Earth experiences the gravitational force. Acceleration due to gravity is defined as the acceleration gained by an object because of the force of gravity acting on it. It is represented by 'g' and is measured in terms of m/s2. Acceleration due to gravity is a vector quantity, that is, it possesses both magnitude as well as direction.

FORMULA

The acceleration due to gravity acting on any object can be given using the following equation:

$$g = \frac{GM}{(r+h)^2}$$

Here, G is the universal gravitational constant whose value is fixed and is equal to 6.673 × 10-11 N.m2/Kg2. M is the mass of the body whose gravitational pull is acting on the object under consideration, r is the radius of the planet and h is the height of the object from the surface of the body.

When the object is on or near the surface of the body, the force of gravity acting on the object is almost constant and the following equation can be used.

$$g = \frac{GM}{r^2}$$

DERIVATION

From the Newton's Second Law of Motion, we can write

F=ma

Here, F is the force acting on the object, m is its mass and 'a' is the acceleration.

Also, as per Newton's Law of Gravity, we can write,

$$F_g = \frac{GM_m}{(r+h)^2}$$

It is the gravitational force acting between two bodies lying in the gravitational field of each other. This force acts inwards and is attractive in nature. Each of the two bodies experience the same force directed towards the other.

Using the Newton's second law of motion, in order to find the acceleration of the body under this condition,

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

Here, m is the mass of the object for which the acceleration due to gravity is to be calculated.

$$a = g = \frac{GM_m}{(y+h)^2 m}$$

$$g = \frac{GM}{(y+h)^2}$$

Also, when the object is on or near to the surface the value of g becomes constant and does not change considerably with the height. Hence, we can write,

$$g = \frac{gM}{r^2}$$

SOLVED EXAMPLES

Example 1: Given the mass and the diameter of the moon is 7.35×10^{22} kg and 3.48×10^{6} m respectively, compute the acceleration due to gravity for an object placed at its surface.

Solution:

As given in the question, the diameter of the moon = 3.48×10^{6} m

r = diameter/2 = 3.48 × 106 /2 = 1.74 × 106m = 1740000 m

Also, the mass of moon = 7.35 × 1022 kg

Using the formula for acceleration due to gravity, we write,

$$g = \frac{gM}{r^2}$$

Upon substituting the values, we get,

$$g = \frac{(6.673\times10^{-11})(7.35\times10^{22})}{1740000}$$

g=1.620 m/sec2

The acceleration due to gravity is calculated to be 1.620 m/sec2.

Example 2: Given that the mass and the radius of the earth are 5.98x 1024 kg and 6.38 x 106 m respectively. A satellite orbits the earth at a distance of 250 km above the surface. Calculate the acceleration due to gravity experienced by the satellite.

Solution:

It can be seen that, the satellite is present at a considerable height from the surfa ce of the Earth, hence the height cannot be neglected. Using the first formula, we can write,

$$R = r + h = (6.38 \times 10^6 m) + (250 km)$$

= 6380 km + 250 km = 6630 km = 6,630,000 m

Using the formula for acceleration due to gravity, we write,

$$g = \frac{GM}{(y+h)^2}$$

Upon substituting the values, we get,

$$g = \frac{(6.673\times10^{-11})(5.98\times10^{24})}{6630000^2}$$

g=9.07 m/sec2