GRAVITATION

ACCELERATION DUE TO GRAVITY OF THE EARTH

Definition of Gravity and Acceleration

Gravity is a force that attracts items to the earth's surface. Gravity causes things to accelerate as they descend to the ground. Acceleration is defined as a change in velocity, which measures the speed and direction of motion. The longer an object descends toward the ground, and gravity causes it to fall at a quicker and faster rate. Its velocity increases by 9.8 m/s2; therefore, an object's velocity is 9.8 m/s 1 second after it begins to fall. Its velocity is 19.6 m/s (9.8 m/s + 9.8 m/s) 2 seconds after it begins to fall, and so on.

The Formula of Acceleration Due to Gravity

The universal law of gravitation states that $f = GmM/(r+h)2$

Where f denotes the force between two bodies.

G ($6.67 \times 10\text{-}11$ Nm2/kg2) is the universal gravitational constant

m = the object's mass,

M is the earth's mass,

r is the earth's radius.

H = the height between the body and the earth's surface.

Because the size (h) is so little in comparison to the earth's radius, we rewrite the equation as follows: $GmM/r2 = f$

Now, if we combine the two phrases, we get

$GmM/r2 = mg$

$GM/r^2 = g$

As a result, the formula for gravitational acceleration is $g = GM/r^2$.

It is important to note that this is dependent on the earth's mass and radius. This enables us to comprehend the following:

Gravity accelerates all bodies at the same rate, regardless of their mass.

It's worth on Earth is determined by the mass of the planet, not the object's mass.

Factor affecting acceleration due to gravity

The following are some of the factors that influence the value of g:

- Variation of g with Height: Because the value of g is inversely proportional to the height above the earth's surface, it decreases as height increases.
- Variation of g with Depth: Because the value of g is proportional to the depth below the earth's surface, it rises with depth but falls to zero at the earth's centre.
- Variation in g due to the Earth's shape: The equator's value of g is lower than the pole's value of g.

Variation of g with Height

Consider a mass (m) at a height (h) above the earth's surface. $F = GMm / (R+h)^2$ is the gravitational force applied on the test mass now.

Where R and M are the earth's radius and mass, respectively. Then, at a given height, the acceleration due to gravity is 'h'.

So, $mg_h = GMm / (R+h)^2$

$g_h = GM / [R^2 (1+ h/R)^2]$ …… (1)

Acceleration due to gravity at earth's surface is (h=0), from equation(1) we get

g = GM/R2…… (2)

When we divide equations (2) and (1), we get gh = g (1+h/R)-2….. (3)

At a height above the earth's surface, acceleration is due to gravity. The value of g decreases with increasing object height and becomes 0 at an infinite distance from the planet, according to the preceding formula.

Variation of g with Depth

Assume that a body of mass m lies at a position B, where B is at a depth of h from the earth's surface and R – h is its distance from the centre.

gd = g (R – d)/R is the result now.

At this depth, the acceleration due to gravity (gd) is given by h < R or (1 – h/R) < 1

As a result, gd < g

And as we get closer to the centre of the earth, the acceleration (gd) diminishes, which is only felt when we are incredibly close to the centre of the planet. As a result, the value of g changes as a function of height and depth. However, the value of g varies even on the earth's surface. For instance, g is most significant near the poles and most minor at the equator.

Variation of g due to Earth's Shape

The earth is an oblate spheroid, not a fully spherical sphere. The earth's polar radius (radius near the poles) is 21 kilometres smaller than its equatorial radius (near the equator). The Earth is not spherical but rather bulged out, as depicted below.

The acceleration due to gravity is inversely equal to the square of the earth's radius, according to the formula. At the equator, the earth's radius is greater; at the equator, g is more minor. In the case of poles, the opposite is true.

Assume the earth's form is somewhat elliptical. As a result, the distances from the pole and the equator to the centre will be different.

As a result, the distance from the centre to the pole (RP) and the equator (RE) is RE > RP.

And based on observation, the relationship between RE and RP is g ∝ 1/R2.

Then, if G and M are constants in the acceleration formula, gP ∝ 1/RP2 and gE ∝ 1/RE2 are obtained.

As a result, gP > gE gives the gravitational accelerations at the equator and pole.

gP / gE = RE2 / RP2 is the gravitational acceleration relationship derived from the distances between the poles and the equator.

As a result, the gravitational acceleration at the equator is smaller than that at the pole.

Value Of Acceleration Due to Gravity On Pole and the Equator

It is $9.832 m/s^2$ at the poles and $9.780 m/s^2$ at the equator.

This formula can be used.

g (ß) = g– ш^2 (Rcosß)

Where

g (ß) is the gravitational acceleration at latitude ß

$g = 9.832 m/s^2$

ш is the earth's angular speed, and the earth's radius is R.

Conclusion

The acceleration due to gravity is less for an object placed at a height (h) than for one placed on the ground. The acceleration value due to gravity (g) decreases as depth increases. At the poles, the value of g is higher, while at the equator, it is lower.