



ATOMIC ENERGY CENTRAL SCHOOL-KAKRAPAR

CLASS- IX

SUBJECT- PHYSICS

NAME OF THE CHAPTER- GRAVITATION

MODULE-2

Subtopic-

Free fall

Relation between 'g' and 'G'

Difference between 'g' and 'G'

Mass and Weight

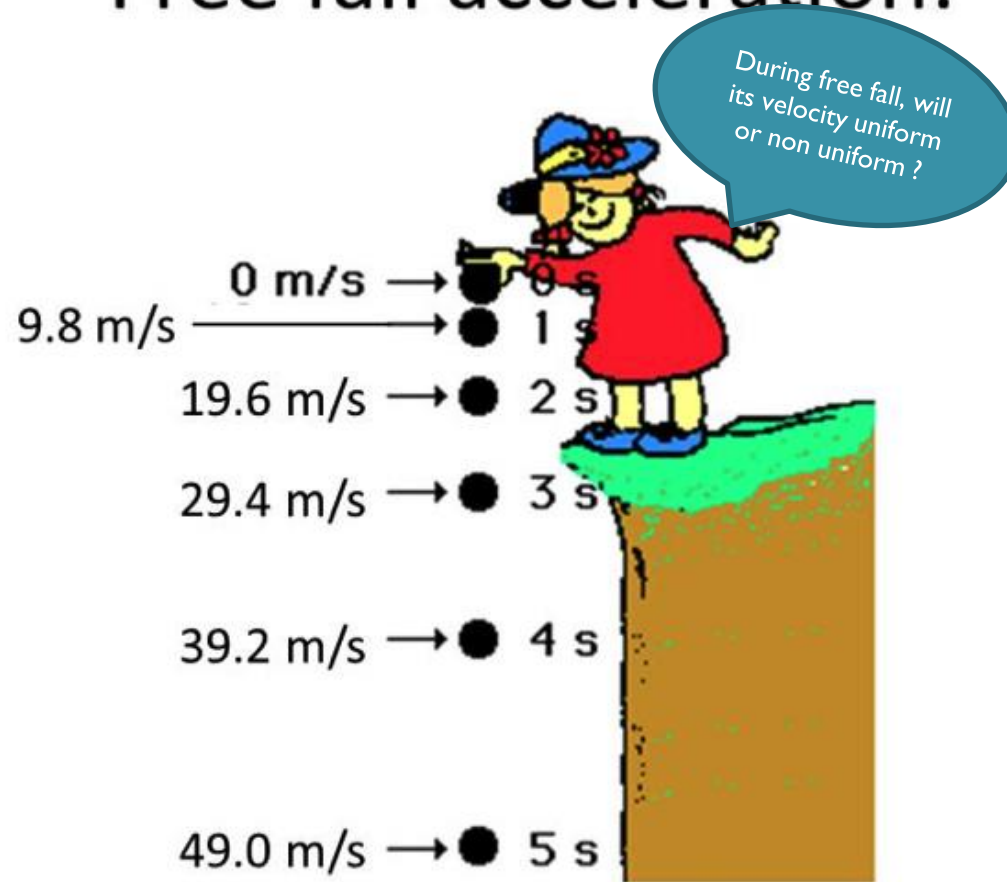
Free fall

Whenever objects fall towards the earth under the force of gravitation, we say that the objects are in free fall.

Is there any change in the velocity of falling objects? There will be a change in the magnitude of the velocity. Any change in velocity involves acceleration. Whenever an object falls towards the earth, acceleration is involved. This acceleration is due to the earth's Gravitational force. Therefore, this acceleration is called the acceleration due to the gravitational force of the earth (or acceleration due to gravity). It is denoted by g . The unit of g is the same as that of acceleration, that is, m s^{-2}

During the free fall velocity of an object linearly increases with time. It means free fall is an example of Non uniform velocity

Free fall acceleration:



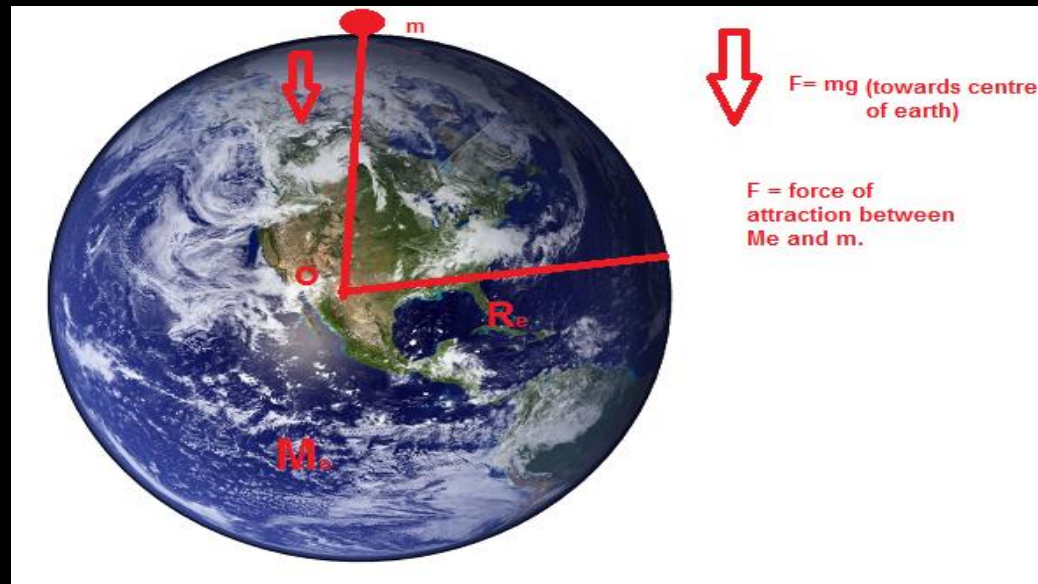
Relation between 'g' and 'G'

Let two object one of them is Earth having mass M_e radius of earth R_e , so according to universal law of gravitation

$$F = G m_e \cdot m / R_e^2$$

Then according to Newton second law, force acting on the small object mass(m) is given by

$$F = mg$$



Relation between G and g



M

Weight of the object is the gravitational force acting on it.

weight of the object = gravitational force

$$\cancel{mg} = \frac{GM_e \cancel{m}}{R_e^2}$$

$$g = \frac{GM_e}{R_e^2} \dots\dots\dots(1)$$

Calculation of the value of 'g' on earth surface.

$G = 6.7 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$, mass of the earth,
 $M = 6 \times 10^{24} \text{ kg}$, and radius of the earth,
 $R = 6.4 \times 10^6 \text{ m}$.

$$\begin{aligned} g &= G \frac{M}{R^2} \\ &= \frac{6.7 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \times 6 \times 10^{24} \text{ kg}}{(6.4 \times 10^6 \text{ m})^2} \\ &= 9.8 \text{ m s}^{-2}. \end{aligned}$$

Thus, the value of acceleration due to gravity of the earth, $g = 9.8 \text{ m s}^{-2}$.

Calculation of the value of 'g' on Moon surface.

The Acceleration Due to Gravity:

So what is g for the moon, on the surface of the moon?

$$g_{\text{moon}} = \frac{G \times m_{\text{moon}}}{(d_{\text{moon}})^2}$$

$$g_{\text{moon}} = \frac{(6.673 \times 10^{-11} \text{ N} \times \text{m}^2 / \text{kg}^2) \times (7.3477 \times 10^{22} \text{ kg})}{(1737100 \text{ m})^2}$$

$$g_{\text{moon}} = 1.62 \text{ m/s}^2$$

Equation's of Motion under the influence of acceleration due to gravity

As g is constant near the earth, all the equations for the uniformly accelerated motion of objects become valid with acceleration a replaced by g , hence

The equations will be

1. $v = u - gt$	u = initial velocity
2. $s = ut - \frac{1}{2}gt^2$	g = acceleration due to gravity
3. $v^2 = u^2 - 2gs$	t = time
	s = displacement
	v = final velocity

where u and v are the initial and final velocities and s is the displacement covered in time, t . In applying these equations, we will take acceleration, g to be positive for downward motion. The acceleration, g will be taken as negative for upward motion.

Difference between 'g' and 'G'

Acceleration due to Gravity (g)	Universal Gravitational Constant (G)
An acceleration produced on a freely falling body due to the gravitational force of earth is known as acceleration due to gravity.	Gravitational constant G is numerically equal to the force of gravitation that exists between two bodies of unit mass kept at a unit distance from each other.
Value of g near earth's surface is 9.8 ms^{-2} . It may vary from place to place.	Value of G is $6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$ and it is an universal constant
Depends upon the distance between the masses	Independent of the distance between the masses
SI unit is ms^{-2}	SI unit is $\text{Nm}^2\text{kg}^{-2}$

Mass and Weight

Mass is a measure of the number of atoms or amount of matter contained in an object.

SI unit of Mass is Kg.

While weight is a Force of attraction provided by Earth on unit mass object.

Weight = Mass x Acceleration due to gravity

Or $w = m.g$

SI unit of weight is Newton

Difference between Mass and Weight

Difference Between Mass and Weight

Mass

- It is a measure of the number of atoms or amount of matter in an object.
- It is constant for a body and does not change with a place.
- Measured using a beam balance.
- Its S.I. unit is kilogram (kg).

Weight

- It is a force exerted by an object of fixed mass due to gravity.
- It is not constant for a body, but it changes from place to place.
- Measured using a spring balance.
- Its S.I. unit is Newton (N) and kilogram-force (kgf) where $1 \text{ kgf} = 9.8 \text{ N}$

What we have learnt?

- ❖ The law of gravitation states that the force of attraction between any two objects is proportional to the product of their masses and inversely proportional to the square of the distance between them. The law applies to objects anywhere in the universe. Such a law is said to be universal.
- ❖ Gravitation is a weak force unless large masses are involved.
- ❖ Force of gravitation due to the earth is called gravity.
- ❖ The force of gravity decreases with altitude. It also varies on the surface of the earth, decreasing from poles to the equator.
- ❖ The weight of a body is the force with which the earth attracts it.
- ❖ The weight is equal to the product of mass and acceleration due to gravity.
- ❖ The weight may vary from place to place but the mass stays constant.
acceleration experienced by an object is independent of its mass. This means that all objects hollow or solid, big or small, should fall at the same rate. According to a story, Galileo dropped different objects from the top of the Leaning Tower of Pisa in Italy to prove the same.

Worksheet based on Module-2

- ❖ Mass of an object is 10 kg. What is its weight on the earth? An object weighs 10 N when measured on the surface of the earth. What would be its weight when measured on the surface of the moon?
- ❖ *What are the differences between the mass of an object and its weight?*
- ❖ *Why is the weight of an object on the moon $1/6$ th its weight on the earth?*
- ❖ *Give any three difference between g and G .*
- ❖ *How does the value of g changes form pole to equator?*
- ❖ *What is SI unit of weight?*



THANK YOU