

## CHAPTER 10- “GRAVITATION”

### KEY CONCEPTS

1	Gravitation
2	Universal Law Of Gravitation
3	Free Fall
4	To Calculate The Value Of G
5	Mass & Weight
6	Weight Of The Object On Moon
7	Thrust & Pressure
8	Pressure In Fluids
9	Buoyancy
10	Why Objects Float Or Sink When Placed On The Surface Of Water?
11	Archimedes’s Principle
12	Relative Density

**Gravity** is one of the most basic forces in the universe. It plays a fundamental role not only in the structure of our solar system but also in the way objects behave on Earth. In this section, we will talk about gravity on a small scale. We will discuss topics such as weight, free fall, and ballistics. We will learn the physics of phenomena we experience daily and take for granted

### 1.Gravitation

Gravitation is the force of attraction between two objects in the universe.

Gravitation may be the attraction of objects by the earth.

This force is proportional to the product of masses of the objects and inversely proportional to the square of the distance between them. It is independent of medium.

$$\text{Gravitational force} = \frac{GMm}{r^2}$$

Eg :- If a body is dropped from a certain height, it falls downwards due to earth's gravity.

If a body is thrown upwards, it reaches a certain height and then falls downwards due to the earth's gravity.

- Gravitation may be the attraction between objects in outer space.

Eg :- Attraction between the earth and moon.

Attraction between the sun and planets.

## GRAVITY

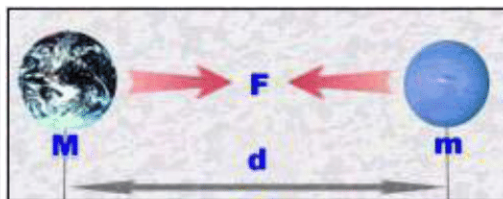
- A natural force that pulls all objects toward the center of the earth
- keeps the moon orbiting
- It holds stars together . . .
- And binds galaxies together for billions of years ....Prevents Planets from losing their atmospheres.

**2.Universal law of gravitation:** - "Inverse square law"- *All bits of matter attract all other bits of matter.....*

- The universal law of gravitation states that, 'Every object in the universe attracts every other object with a force which is directly proportional to product of the masses and inversely proportional to the square of the distance between them.'

**F = Gravitational force**  
**G = Universal gravitational constant**  
**d = Distance between M and m**  

$$F = G \frac{Mm}{d^2}$$



- The SI unit of  $G$  is  $\text{N m}^2 \text{ kg}^{-2}$  and its value is  $6.673 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
- The strength of the gravitational attraction between two objects depends on two factors:

### 3. Free Fall

- With negligible air resistance, falling objects can be considered freely falling.  
objects of different shapes accelerate differently (stone vs feather)



### 4 .To calculate the value of" $g$ "(acceleration due to gravity)

- The acceleration due to gravity is denoted by  $g$ .
- The unit of  $g$  is same as the unit of acceleration  $ms^{-2}$
- From the second law of motion, force is the product of mass and acceleration.

$$F = ma$$

- For free fall, force is the product of mass and acceleration due to gravity.

$$F = mg \text{ or } mg = \frac{GMm}{r^2}$$

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

where  $M$  is the mass of the

Earth and  $d$  is the distance between the object and the earth.

- For objects near or on the surface of the earth  $d$  is equal to the radius of the earth  $R$
- $F = mg$  or  $mg = \frac{GMm}{r^2}$
- or  $g = \frac{GM}{r^2}$

## 5. Mass and Weight:

- Mass is a fundamental, universal property. You have the same amount of mass no matter where you are in the Universe.
- Weight is not fundamental its value depends on circumstances in the Universe. Weight is a force. It is the resultant gravitational force exerted on a body with mass  $m$  by all the other bodies on the Universe.

$$\text{Weight} = F_g = G m M_e / R^2 = mg$$

where  $M_e$  is the mass of the Earth and  $R$  is the radius of the Earth.

## 6. Weight Of The Object On Moon

- The mass of the moon is less than the mass of the earth. So the moon exerts lesser force on the objects than the earth.
- The weight of an object on the moon is one sixth ( $1/6^{\text{th}}$ ) of its weight on the earth.
- The weight of an object on the earth is the force with which the earth attracts the object and the weight of an object on the moon is the force with which the moon attracts the object.

Celestial body	Mass (kg)	Radius (m)
Earth	$5.98 \times 10^{24}$	$6.37 \times 10^6$
Moon	$7.36 \times 10^{22}$	$1.74 \times 10^6$

## 7. Thrust & Pressure

- Thrust is the force acting on an object perpendicular to the surface.
- Pressure is the force acting on unit area of a surface

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$$

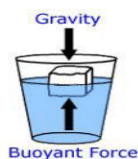
- The SI unit of thrust is  $\text{N/m}^2$  or  $\text{N m}^{-2}$ . It is called Pascal (Pa).

## 8. Pressure In Fluids

- Fluids exert pressure in all directions
- Pressure exerted on fluids is transmitted equally in all directions.

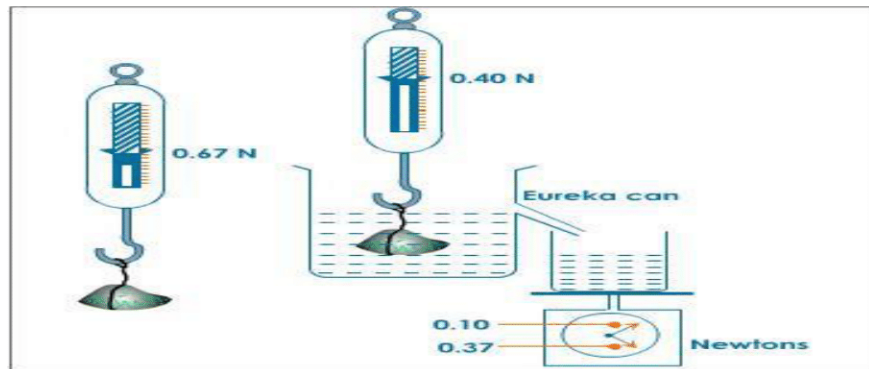
## 9. Buoyancy

When an object is immersed in a fluid it experiences an upward force called buoyant force. This property is called buoyancy or upthrust.



## 11. Archimedes Principle

- Archimedes' principle states that, When a body is partially or fully immersed in a fluid it experiences an upward force that is equal to the weight of the fluid displaced by it.'



## 12 .Relative density

- The relative density of a substance is the ratio of the density of a substance to the density of water. It is a ratio of similar quantities and has no unit.