CHAPTER-10

GRAVITATION

Module-1
Class-IX (PHYSICS)

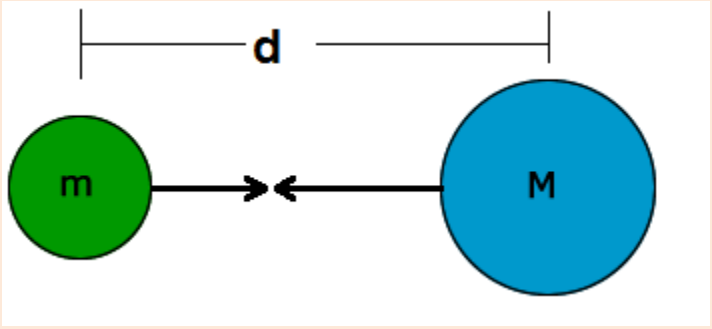
Dear children before starting this chapter, I would like to ask few questions;

1. When you drop a stone from a certain height then it will falls towards earth surface. Why?
2. When you throw a stone upward then it's come back to earth surface. Why?

The answer of the above question is Gravitational Force.

UNIVERSAL LAW OF GRAVITATION:

The Law of Universal Gravitation states that every object of mass in the Universe attracts every other object of mass with a force which is directly proportional to the product of their masses and inversely proportional to the square of the separation between their centers. This was then formalized into the *Universal Gravitation Equation*.



Let mass of small object is m and of big object is M, the distance between these two object is d.

According to the universal law of gravitation, the force between two objects is directly proportional to the product of their masses. That is

$F \propto M \times m$ ……*(1)*

and inversely proportional to the square of the separation between their centers

$F \propto \frac{1}{d^2}$ .....(2)

Combining above two equation

$F = \frac{G.M \times m}{d^2}$ .....(3)

Where G is the constant of proportionality and is called the Universal Gravitation constant.

Q.How does the force of gravitation between two objects change when the distance between them is increases to three times?

Ans . reduces 9 times

How to determine SI Unit of G?

From equation (3)

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

Or $F.d^2 = G.M \times m$

Or $$G = \frac{F.d^2}{M \times m} \quad \text{.....(4)}$$

$$G = \frac{Newton.\ Metre^2}{\text{kilogram .kilogram}} = N.m^2/kg^2$$

The accepted value of G is 6.673×10^{-11} N m^2 kg^{-2}

IMPORTANCE OF THE UNIVERSAL LAW OF GRAVITATION:

The universal law of gravitation successfully explained several phenomena which were believed to be unconnected:

(i) The force that binds us to the earth.

(ii) The motion of the moon around the earth.

(iii) The motion of planets around the Sun.

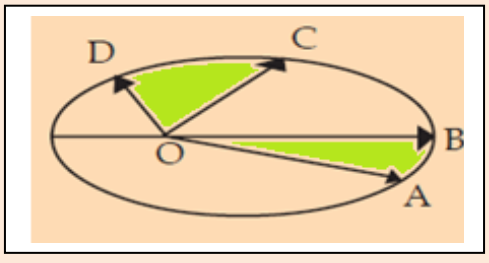
(iv) The tides due to the moon and the Sun.

Kepler's laws:

Johannes Kepler derived three laws, which govern the motion of planets. These are called Kepler's laws. These are:

1. The orbit of a planet is an ellipse with the Sun at one of the foci, as shown in the figure given below. In this figure O is the position of the Sun.
2. The line joining the planet and the Sun sweep equal areas in equal intervals of time. Thus, if the time of travel from A to B is the same as that from C to D, then the areas OAB and OCD are equal.
3. The cube of the mean distance of a planet from the Sun is proportional to the square of its orbital period *T*.

Or, $\frac{r^3}{T^2}$ = constant.



- ❖ It is seen that a falling apple is attracted towards the earth. Does the apple attract the earth? If so, we do not see the earth moving towards an apple. Why?

According to the third law of motion, the apple does attract the earth. But according to the second law of motion, for a given force, acceleration is inversely proportional to the mass of an object. The mass of an apple is negligibly small compared to that of the earth. So, we do not see the earth moving towards the apple. Extend the same argument for why the earth does not move towards the moon.