CH- GRAVITATION

a force is necessary to produce motion in a body. The earth attracts all the objects towards its centre. The force with which the earth pulls the objects towards it is called the gravitational force of earth or gravity.

Universal law of gravitation:-

every body in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

$$F \propto m_1 m_2 \quad \text{..... (1)}$$

$$F \propto 1/r^2 \quad \text{.....(2)}$$

Combining 1 and 2 we get:

$$F = G\frac{m_1 m_2}{r^2}$$

If we double the distance between two bodies , the gravitational force becomes one fourth and if we halved the distance between two bodies, then the gravitational force becomes four times.

UNITS OF GRAVITATIONAL CONSTANT:-

$$Nm^2/kg^2$$

The force of gravitation is a vector quantity. The gravitational constant G is numerically equal to the force of gravitation which exist between two bodies of unit masses kept at a unit distance from each other. The value of universal gravitational constant G has been found to be :

$$6.674 \times 10^{-11}\text{Nm}^2/\text{kg}^2$$

Though the various objects on this earth attract one another constantly, they do not cause any motion because the gravitational force of attraction between them is very small.

Free fall

The falling of a body from a height towards the earth under the gravitational force of earth is called free fall. The acceleration of an object falling freely towards the earth does not depends on the mass of the object.

Acceleration due to gravity: when the object is dropped from some height, a uniform acceleration is produced in it by the gravitational pull of the earth.

The universal acceleration produced in a freely falling body due to gravitational force of earth.

The acceleration due to gravity , $g = 9.8\text{m/s}^2$.

When a body is dropped freely, it falls with an acceleration of 9.8m/s^2 and when a body is thrown vertically upwards, it undergoes a retardation of 9.8m/s^2.

General equation of motion	Equations of motion for freely falling bodies
(i) $v = u + at$ changes to	$v = u + gt$
(ii) $s = ut + \frac{1}{2}at^2$ changes to	$h = ut + \frac{1}{2}gt^2$
(iii) $v^2 = u^2 + 2$ as changes to	$v^2 = u^2 + 2gh$

a. When a body is falling vertically downwards, its velocity is increasing, so the accelerarion due to gravity, g, is taken as positive. + 9.8 m / s^2 .
b. When a body is falling vertically upwards, its velocity is decreasing , so the accelerarion due to gravity, g, is taken as negative. - 9.8 m / s^2 .
c. When a body is dropped freely from a height, its initial velocity 'u' is zero.
d. When a body is thrown vertically upwards, its final velocity 'v' becomes zero.
e. The time taken by a body to rise to the highest point is equal to the time it takws to fall from the same height.

MASS :-

The mass of a body is the quantity if matter contained in it. It is a scalar quantity.
The SI unit of of mass is kilogram. The mass of a body cannot be zero.

WEIGHT :-

The weight of the body is the force with which is attracted towards the centre of the earth. Weight is a vector quantity, the weight of the body is not constant, it changes from place to place. The weight of the body can be zero.
Whatever be the weight of a body on the surface of earth, itsweight became zero when it is taken to the centre of the earth.

	Mass	Weight
1.	Mass of a body is the measure of its inertia.	Weight of the body is the force with which it is attached towards the earth ($W = m \times g$).
2.	Its S.I. unit is kg.	Its S.I. unit is Newton.
3.	It remains constant everywhere.	Its value changes from the place to place.
4.	It can be measured by common balance.	It is measured by spring balance.

WEIGHT OF ANOBJECT ON THE MOON:-

The weight of the object on the moon will be about one-sixth of what it is on the earth.

THRUST AND PRESSURE

The effect of the force depends on the area of the object on which it acts. The weight of the body is also a force which acts downwards.

Pressure depends on 2 factors

i. Force applied
ii. area over which force acts

the same force can produce different pressures depending on the area Over which it acts, when a force acts over a large area of an object it produces a small pressure but if the same force acts over a small area of the object it produces a large pressure.

Pressure is the force acting perpendicularly on a unit area of the object.

Pressure= force / area

The SI unit of measuring pressure is Newton per metre square. Also known as Pascal (Pa) .

$$1Pa = 1N/m^2$$

Force acting on a body perpendicular to its surface is called thrust. Thrust per unit area is called pressure.

EXAMPLES:-

- **Cutting and piercing:**
    - **Sharp knives and needles:** The force is applied over a small area, increasing pressure to easily cut or pierce materials.
    - **Blunt objects:** A blunt knife requires more force because the larger surface area of the edge results in less pressure.
- **Carrying loads:**
    - **Wide bag straps:** Distribute the weight of a heavy bag over a larger area of the shoulder, reducing pressure and discomfort.
    - **Pointed heels:** Narrow heels sink into soft ground more easily than wide, flat ones because the force is concentrated on a smaller area.
- **Using tools and devices:**

Pressure = Thrust / Area.

    - **Drinking with a straw:** When you suck on a straw, you lower the pressure inside it. The higher atmospheric pressure outside then pushes the liquid up into your mouth.
    - **Suction cups:** Pressing a suction cup against a surface forces the air out from under it, creating a low-pressure area. The higher external atmospheric pressure holds the cup firmly against the surface.
    - **Hydraulic systems:** A small force applied to a small area creates pressure. This pressure is transmitted through a fluid to a larger area, where it can generate a much larger force, as seen in car brakes and hydraulic jacks.
- **Vehicles and tires:**
    - **Large trucks:** Heavy vehicles have large, wide tires to spread their weight over a greater area, reducing the pressure on the ground and preventing them from sinking into soft surfaces.
    - **Tire pressure:** Properly inflated tires maintain the right pressure for optimal traction and fuel efficiency.

BUOYANCY:-

Weight of object = weight liquid displaced by it.

The tendency of a liquid to exert an upward force on the object placed in it. The upward force acting on an object immersed in a liquid is called buoyant force. The pressure exerted by a liquid increases with depth and acts in all directions.

Factors affecting buoyant force

i. Volume of object immersed in the liquid
ii. Density of the liquid

As the volume of solid immersed inside the liquid increases, the upward 'buoyant force' also increases.

The magnitude of buoyant force acting on a solid object does not depend on the nature of the solid object.

Even a very heavy material like an iron block floats in mercury because mercury exerts a very high buoyant force on iron block due to its very high density.

When an object is completely immersed in water, then the volume of water displaced will be equal to the volume of the object itself.

ARCHIMEDES' PRINCIPLE :-

When an object is wholly or partially immersed in a liquid, it experiences a buoyant force or upthrust force which is equal to the weight of liquid displaced by the object.

Buoyant force acting on an object = weight of liquid displaced by that object

The magnitude of buoyant force acting on an object immersed in a liquid is equal to the weight of liquid displaced by the immersed object.

Even gases exert an upward force on the objects placed in them. It is the buoyant force due to displaced air which makes a balloon rise in air.

WHY OBJECTS FLOATS OR SINK IN A LIQUID?

When an object is put in a liquid, then two forces acts on it:

a. Weight of the object acting downwards (which tends to pull down the object).
b. Buoyant force (or upthrust) acting upwards (which tends to push up the objects).

An object will float in a liquid if the weight of object is equal to the weight of liquid displaced by it.

Density :-

The density of a substance is defined as mass of the substance per unit volume. The SI unit of density is kg/m^3 .

$$density = \frac{mass}{volume}$$

RELATIVE DENSITY:-

The relative density of a substance is the ratio of its density to that of water.

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$$

Archimedes' Principle: ***"The upward buoyant force that is exerted on a body immersed in a fluid, whether partially or fully submerged, is equal to the weight of the fluid that the body displaces and acts in the upward direction at the center of mass of the displaced fluid".***

Applications of Archimedes' principle:

- ***Submarine***
- ***Hot-air balloon***
- ***Hydrometer***