1) Gravitation :-

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

i) Gravitation may be the attraction of objects by the earth.

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.

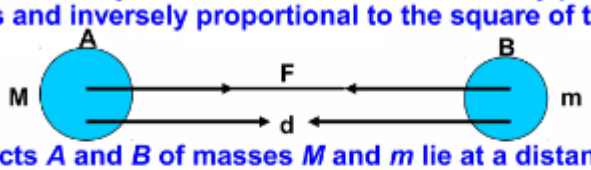
ii) Gravitation may be the attraction between objects in outer space.

Eg :- Attraction between the earth and moon.

Attraction between the sun and planets.

2) Universal law of gravitation :-

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.'



Let two objects *A* and *B* of masses *M* and *m* lie at a distance *d* from each other. Let *F* be the force of attraction between them.

According to the universal law of gravitation the force between the objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

$F \propto M \times m$ and $F \propto \frac{1}{d^2}$ Combining the two equations $F \propto \frac{M \times m}{d^2}$

Or $F = G \frac{M \times m}{d^2}$ where *G* is a constant of proportionality called universal gravitation constant

Cross multiplying we get $F \times d^2 = G\, M \times m$ or $G = \frac{F \times d^2}{M \times m}$

The SI unit of *G* is N m^2 kg^{-2} and its value is 6.673×10^{-11} N m^2 kg^{-2}

3) Free fall :-

The earth attracts objects towards it due to gravitational force. When an object falls towards the earth due to the earth's gravitational force it is called free fall.

When an object falls towards the earth there is a change in its acceleration due to the gravitational force of the earth. So this acceleration is called 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.

$F = mg$ or $mg = G\frac{M \times m}{d^2}$ or $g = G\frac{M}{d^2}$ where *M* is the mass of the

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*

$mg = G\frac{M \times m}{\quad}$ or $g = G\frac{M}{\quad}$ The value of *g* is $9.8\ ms^{-2}$

4a) Mass :-

The mass of a body is the measure of its inertia. If the mass of a body is more its inertia is more.

The mass of a body is constant and does not change from place to place.

The SI unit of mass is kg.

b) Weight :-

The weight of a body is the force with which the earth attracts the body.

The force with which a body is attracted by the earth depends on its mass *m* and acceleration due to gravity *g*.

$F = m \times g$

Since weight of a body is the force with which the earth attracts the body, $W = m \times g$

Since *g* at a place is constant , $W \propto m$

The weight of a body changes from place to place.

The SI unit of weight is the same as force – Newton (N).

c) Weight of an object on the moon :-

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.

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 ($1/6^{th}$) of its weight on the earth.

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

5) Thrust and pressure :-

a) Thrust :-

Thrust is the force acting on an object perpendicular to the surface.

Eg :- When you stand on loose sand the force (weight) of your body is acting on an area equal to the area of your feet. When you lie down, the same force acts on an area equal to the contact area of the whole body. In both cases the force acting on the sand (thrust) is the same.

b) Pressure :-

Pressure is the force acting on unit area of a surface.

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

Eg :- The effect of thrust on loose sand is larger while standing than while lying down.

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

6a) Pressure in fluids (Liquids and gases) :-

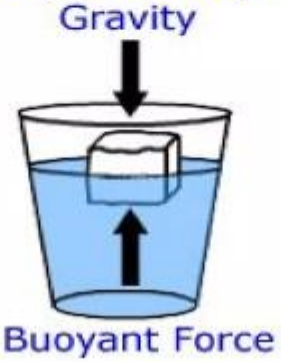
Fluids exert pressure on the base and walls of the container. Fluids exert pressure in all directions. Pressure exerted on fluids is transmitted equally in all directions.

b) Buoyancy (Upthrust) :-

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

The force of gravity pulls the object downward and the buoyant force pushes it upwards.

The magnitude of the buoyant force depends upon the density of the fluid.



c) Why objects float or sink in water ?

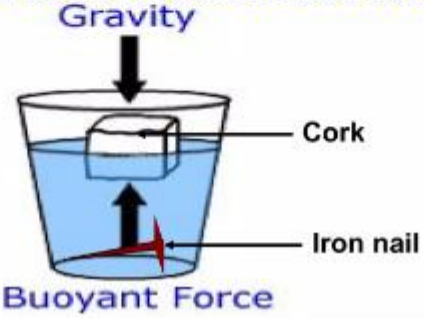
If the density of an object is less than the density of a liquid, it will float on the liquid and if the density of an object is more than the density of a liquid, it will sink in the liquid.

Activity :-

Take some water in a beaker. Take a piece of cork and an iron nail of the same mass. Place them on the water. The cork floats and the nail sinks.

The cork floats because the density of cork is less than the density of water and the upthrust of water is more than the weight of the cork.

The nail sinks because the density of the iron nail is more than the density of water and the upthrust of water is less than the weight of the nail.



7) 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.'

Archimedes principle has many uses. It is used in designing ships and submarines, Hydrometers used to determine the density of liquids, lactometers used to determine purity of milk etc.

8) Density and relative density :-

i) Density :- The density of a substance is the mass of a unit volume of the substance.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

The unit of density is kilogram per metre cube (kg m^{-3}).

ii) Relative density :- The relative density of a substance is the ratio of the density of a substance to the density of water.

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

Since relative density is a ratio of similar quantities, it has no unit.