Trust:-

The force acting normally (perpendicular) on a surface is called thrust. The thrust is a vector quantity and is measured in the units of force i.e., Newton (N) and kilogram force.

Pressure:-

Pressure is defined as the thrust acting per unit area of a body mathematically we have

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

Pressure is measured in **SI** in Newton per square metre (Nm^{-2}) or Pascal. And it is also measured in bar and millibars. ($1bar=10^5 N\backslash m^2$ and 1 millibar = $10m\backslash s^2$).

Examples of the applications of the concept of pressure:-

1. The army tank has a large weight. Therefore to avoid large pressure on the ground its weight is distributed throughout the tank. This is done by making the tank run on a steel track track than on wheels. The steel tracks reduce the pressure of the ground.
2. A school bag has wide straps made of thick canvas. This is done to distribute the entire weight of the bag over a larger area. This in turn will produce a small pressure.
3. The tip of a needle is made sharp so that the force applied on it acts on a small area. This increases the pressure on it and hence it can easily pierce the cloth.

The concept of Buoyancy:-

When a body is immersed in a fluid (liquid or gas) it exerts an upward force on the body. This upward force is called up thrust or buoyant force (U or F_B) and the phenomenon is termed as buoyancy.

It is a common experience that when a piece of cork is placed in water it floats with two-fifth of its volume inside water. If the cork piece is pushed into water and released it comes to the surface as if it has been pushed by some one from inside.

Factors on which Buoyancy Depends:-

Upthrust depends upon the following two factors.

(i) The volume of the body submerged in the fluid

(ii) The density of fluid in which the body is immersed.

(i) It is found that greater The volume of a body greater is the upthrust it experiences when placed inside a fluid. Fore example place a small piece of wood in water and experience the upthrust. Now replace the piece of wood with a bigger piece. What do you fined? It is noted that now you have to apply a greater force in pushing it into water. This is due to the fact that the upthrust acting on the piece of wood has increased. This is due to the increase in the volume of the piece.

(ii) It is also found that greater The density of the fluid greater is the upthrust it applies on the body. For example when a piece of wood is pushed into different fluids, different forces have to be applied to do so. The denser the fluid more is the forced required pushing a body into it. This is the reason that we apply more force to push a body into salt water than into ordinary water.

Cause of Buoyancy:-

When a fluid (either liquid or a gas) is at rest, it exerts a force perpendicular to any surface in contact with it, such as a container wall or a body immersed in a fluid. This is the force that you feel pressing on your legs when you dangle them in a swimming pool. While the fluid as a whole is at rest, the molecules that make up the fluid are in motion; the force exerted by the fluid is due to the molecules colliding with their surroundings. This force per unit area is termed as pressure.

The pressure at all points and in all directions in a liquid is same. It increases with the depth of the fluid. When a body say a block, is immersed in a liquid the pressure experienced by it is found to be greater at its bottom surface than its top surface. The difference in this pressure is the upthrust.

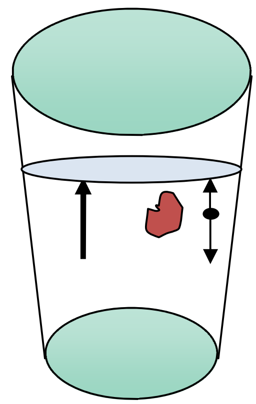
Effect of Buoyancy on Bodies of Different Weights:-

When a body is partially or fully immersed in a fluid, then following vertical forces are experienced by it.

(a) Its weight (W) acting vertically downwards through the centre of the body. (b) Force of buoyancy (U or B or F_B) or upthrust, acting vertically upwards through the centre of gravity of the body.

The following three cases arise:

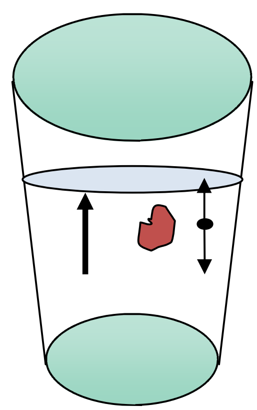
1. **When W < U, the body floats :** In this case the body will rise above the surface of the liquid to the extent that the weight of the liquid displaced by its immersed part equals the weight of the body. Then the body will float with only a part of it immersed in the liquid. In this case Vpg<Vo g or p<o] (figure. a), thus if a cork, which has a density less than that of water will rise in water till a portion of it is above water. Similarly a ship floats in water since its density is less than the density of water.



(a)

2. **When W>U, the body sinks:** If p and o represent the densities of the body and the fluid respectively and V the volume of the body (which is also the volume of the fluid displaced) then Vpg>Vo g or p>o i.e., the body sinks in the fluid in case its density is greater than the density of the fluid. (Fig. b) an iron nail has greater density than water, therefore it sinks in water.

3. **When W = U:** the resultant force acting on the body when fully immersed in the fluid is zero. The body is at rest anywhere within the fluid. The apparent weight of the body is zero for all such positions.



(b)

Thus, we find that a body will float when its weight is equal to the weight U of the fluid displaced i.e., the upthrust.

Principal of floatation:-

When a body floats, it is acted upon by two forces. These forces are

1. Its weight W acting downwards
2. The upthrust F_b or U acting vertically upwards.

Since the floating body is in equilibrium, the net force acting on it must be zero. Therefore the two forces

$$W = F_b$$

But, from Archimedes principal the upthrust F_b is equal to weight w of the liquid displaced by the immersed part of the body. Therefore

$$W = F_b = w \quad \text{or} \quad W = w$$

This equation is called principle of floatation or law of floatation.

Thus the principle of floatation states that for a body to float, the weight the principle of floatation states that W of a floating objects is equal to the weight w of the liquid displaced by it i.e., W = w

In other words the principle of floatation states that a floating object displaces its own weight of the fluid in which it floats.

Applications of the principle of Floatation:-

(a) Ships :

Although it is made of iron and steel which are materials denser than water a ship floats in water. This is due to the fact that a floating ship displaces a weight of water equal to its own weight including that of the cargo. The volume of the ship is much larger than the volume of the material with which it is made. Since the empty space in the ship contains air therefore its average density is less than the density of water. Thus a ship floats with a small section under water.

(b) Submarines:

A submarine sinks by taking water into its buoyancy tanks. Once submerged, the upthrust is unchanged but the weight of the submarine increases with the inflow of water and it sinks faster. To surface, compressed air is used to blow the water out of the tanks.

Each submarine is provided with ballast tanks. If the submarine has to submerge these tanks are filled with water. This makes the average density of he submarine greater than that of water as a result it sinks. When the submarine has to be surfaced, compressed air is blown into these tanks to expel the water. Again the average density of the submarine becomes less than that of water, hence it floats.

(c) Ballons:

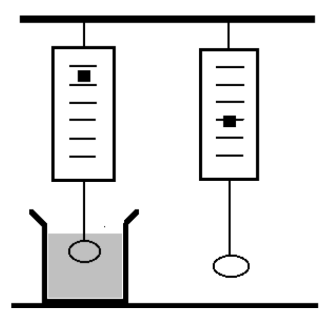
A balloon filled with hydrogen or hot air weight less than, the weight of air it displaces. The upthrust is therefore greater than its weight and resultant upward force on the balloon causes it to rise. Meteorological balloons, carrying scientific instruments called radiosondes are sent into the upper atmosphere. A small radio transmitter sends signals back to Earth which contains information about the temperature, pressure and humidity. They are racked by radar to give data on wind direction and speed.

Archimedes' Principle:-

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

For example: if a stone, on being immersed in water, displaces 100gms of water, then according to Archimedes' principle, the buoyant force acting on the stone will be equal to 100gm-weight.

Archimedes' Principle



Experimental Verification of Archimedes Principle:-

Suspend a solid; which does not dissolve in water, with the help of a thin thread from the hook of a spring balance. Notes down its weight.

Arrange a eureka can and fill it with water p to its spout. Arrange a measuring cylinder below the spout of eureka can.

Now immerse the solid gently into the water in eureka can. The water displaced by it gets collected in the measuring cylinder.

When water stops dripping through the spout, note the weight of the solid and the volume of water collected in the measuring cylinder. Since density of water is 1000 kg m^{-3}, the volume of water collected in the measuring cylinder gives the mass of the water displaced by the solid when it is completely immersed in water.

It is found that the weight of water displace by the solid is equal to the difference in weight of solid in air and in water (i.e., the loss in weight of the solid). This verifies the Archimedes' principle.

Density:-

The density of a substance is defined as its mass per unit volume.

$$\text{Density (d)} = \frac{\text{mass (m)}}{\text{Volume (V)}}$$

Unit of density: in cgs system, the unit of density is g cm^{-3} while the **SI** unit is kg m^{-3}**.** These units are related / as : 1gcm^{-3} = 1000 kgm^{-3} .

Relative Density:-

The relative density (RD.) of a substance is the ratio of the density of the substance to he density of water at 4^{o}C.

From definition, relative density of a substance is given as

$$RD = \frac{\text{Density of the substance}}{\text{Density of water at } 4^{o}C} = \frac{\text{mass of unit volume of water}}{\text{mass of unit volume of water at } 4^{o}C}$$

Thus, relative density is also defined as the ratio of the mass of the substance to the mass of an equal volume of water at 4^{o}C.

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