GRAVITATION

ARCHIMEDES PRINCIPLE

Archimedes principle

Archimedes principle states that

Anybody completely or partially submerged in a fluid is buoyant up by a force equal to the weight of the fluid displaced by the liquid".

In other words

When a body is partially or completely immersed in a fluid, the fluid exerts an upward force on the body equal to the weight of the fluid displaced by the body.

Experimental verification of Archimedes principle

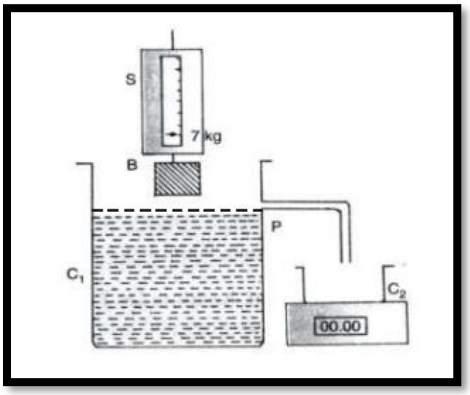
Consider a container C_1 filled with water up to the level from where pipe P extends out. The other end of pipe P opens to a small container C_2 placed on a weighing balance which measure 00.00 [after the placement of the container C_2]. A block B hangs on a spring balance S which shows a reading of 7 kg.

(a) If we partially immerse the block in water, we observe some water flows out from C_1 to C_2 through P. The weighing machine shows a reading 1 kg and the loss of reading in spring balance is $7 - 6 = 1$kg. This means that weight of water displaced by the block is equal to loss in weight of block.

(b) Now we completely immerse the block in water, we observe that the weight of water displaced by the block is 5 kg and the reading in spring balance is 2 kg. The loss of weight of block is $7 - 2 = 5$ kg. Again, we reach the same conclusion that weight of water displaced by the block is equal to the loss in weight of block.

(c) What happens when the block is further immersed? No more water will be displaced by the block and therefore reading shown by weighing machine and spring balance remains unchanged.

Why the spring balance shows a loss in weight of the block when Fig. A block of 7 kg hanging on the block is immersed in water? This is because of buoyant force on spring balance acting vertically upwards. The loss in weight is equal to the buoyant force.



Conclusion 1:

Buoyant force ∝ volume of liquid displaced (V).

If two bodies of different material have same volume, the buoyant force acting on them, when completely immersed in water, is same. Instead of water if we take a liquid lighter than water then the volume displaced by the block on complete immersion will be the same but the buoyant force will be less. This is because the density of lighter liquid is less than that of water.

We know that Density $= \frac{Mass}{Volume}$

$\therefore$ Mass = Density × Volume For lighter liquids, the mass of the liquid displaced is less even when the volume displaced is the same.

Conclusion 2:

Buoyant force $\propto$ Density of liquid

i.e., Buoyant force $\propto$ d

It has also been found that buoyant force also depends on the acceleration due to gravity

Conclusion 3:

Buoyant force $\propto$ g

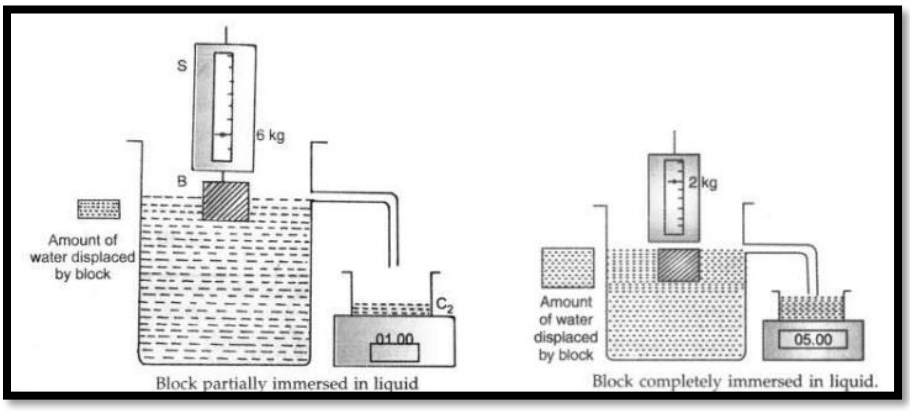
If we combine all the three, we get

Buoyant force $\propto$ V dg

$\Rightarrow$ Buoyant force $\propto$ mg [mass = V $\times$ d]

$\Rightarrow$ Buoyant force $\propto$ Weight of the liquid displaced

Note: A body placed in a gaseous medium is also acted by the upthrust equal to the weight of the gas displaced.



The above facts has been summarized in Archimedes principle which states that the upward force acting on a solid body which is partially or completely immersed in a fluid, is equal to the weight of the fluid displaced. This upward force is called buoyant force or upthrust.

Newton's Thought

Three cubes A, B, C of equal size are made of ice, aluminum and iron respectively. All these cubes are placed in water. Which one of the three cubes experiences greatest buoyant force on it?

Explanation

The buoyant force depends only on the density of the fluid and the volume of the fluid displaced. The buoyant force on an object does not depend on the object's density or its weight. Thus, the buoyant force on each cube is the same, because each cube has the same volume and displaces the same amount of water.