RADIANT 2026

Physics

Upthrust in Fluid, Archimedes' Principle and Flotation

Lecture - 03

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Topics *to be covered*

1. Relative Density
2. Determination of Relative Density of a Solid Substance by Archimedes' Principle
3. Principle of Floatation

Recap *of previous lecture*

1. Buoyanqcy and Upthrust
2. Characteristic Properties of Upthrust
3. Archimedes' Principle


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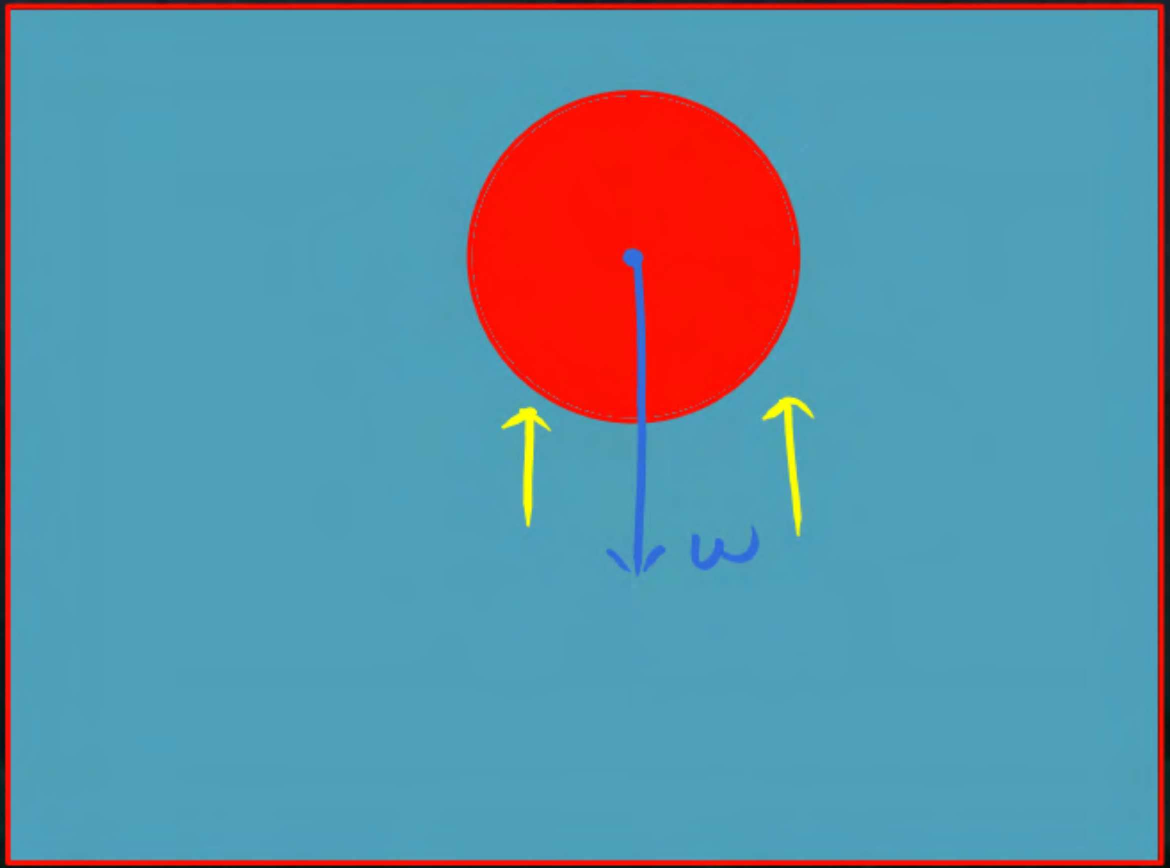
hysics Wallah

(A) 40°C

(B) 4°C

(C) 400°C

(D) 0°C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Principle of Floatation

We have read that when a body is immersed in a liquid, the following two forces act on it:

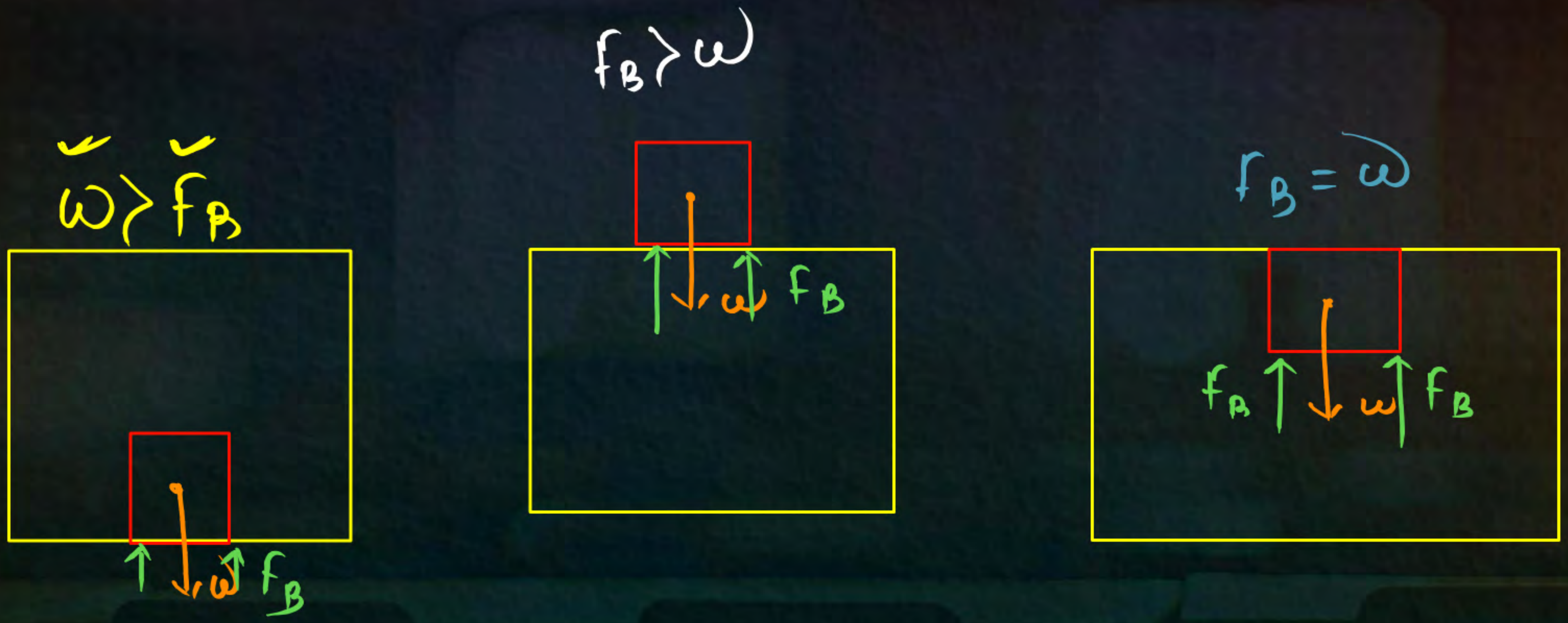
(i) The weight W of body acting vertically downwards, through the centre of gravity G of the body. This force has a tendency to sink the body.

Principle of Floatation

(ii) The upthrust FB of the liquid acting vertically upwards, through the centre of buoyancy B i.e., the centre of gravity of the displaced liquid. The upthrust (or buoyant force) is equal in magnitude to the weight of the liquid displaced. This force has a tendency to make the body float. Figure shows the two forces W and FB acting on a body floating on a liquid.

In magnitude, W = volume of body × density of body × g

and F_B = volume of submerged part of body × density of liquid × g



ω > f_B
f_B > ω
f_B = ω
f_B
ω

Application of the Principle of Floatation

(i) Floatation of iron ship

An iron nail sinks in water while a ship floats: If we place an iron nail on the surface of water, it sinks. This is because the density of iron is greater than that of water, so the weight of nail is more than the upthrust of water on it.

On the other hand, ships are also made of iron, but they do not sink. This is because the ship is hollow and the empty space in it contains air which makes its volume large and average density less than that of water. Therefore, even with a small portion of ship submerged in water, the weight of water displaced by the submerged part of ship becomes equal to the total weight of ship and therefore it floats.

Application of the Principle of Floatation

A loaded ship is submerged more while an unloaded ship is less submerged: When cargo is loaded on a sailing ship, its weight increases, so it sinks further to displace more water till the weight of water displaced by its submerged part becomes equal to the weight of loaded ship. If cargo is unloaded, the ship will rise in water till the weight of water displaced balances the weight of unloaded ship.

Application of the Principle of Floatation

(ii) Floatation of human body

The average density of human body depends on the proportion of its constituents like bone, blood, muscles and fat in him as each constituent has different density. Further, it also depends on the amount of air in his lungs at that time. The average density of body with empty lungs is 1.07 g cm^{-3}, while with lungs filled with air is 1.00 g cm^{-3}. A good swimmer can float on water, like a floating object, with his lungs filled with air and nose and mouth projecting just above the water surface. The weight of water displaced by him is then nearly equal to his own weight. Thus, he can swim with a very little effort.

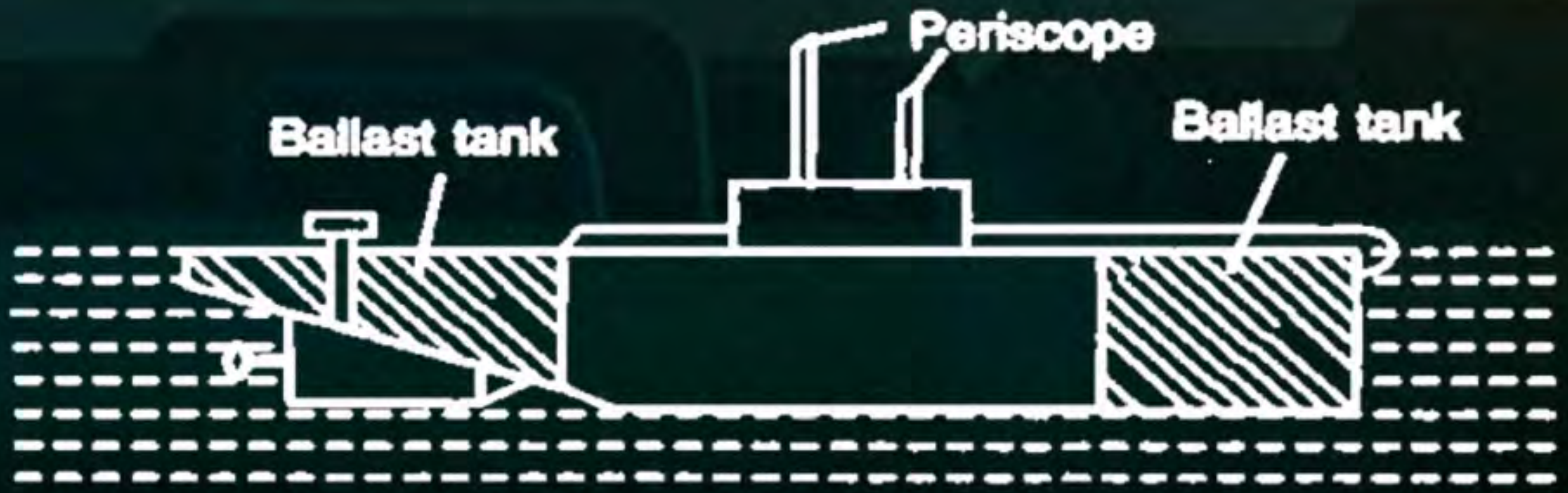
Application of the Principle of Floatation

- **It is easier for a man to swim in sea water than in fresh (or river) water:** The reason is that due to presence of minerals (salt etc.), the density of sea water (= 1.026 g cm^{-3}) is more than the density of fresh (or river) water (= 1.0 g cm^{-3}).
- Therefore, with a smaller portion of the body submerged in sea water, the weight of water displaced becomes equal to the total weight of the body, while to displace the same weight of fresh (or river) water, a large portion of his body will have to be submerged in water. So it becomes difficult to swim in river water.
- In the Dead Sea, the density of water is much more (= 1.16 g cm^{-3}), therefore, a man can easily.

Application of the Principle of Floatation

(iii) Floatation of submarines

A submarine is a fish shaped water-tight boat - provided with several ballast (or floatation) tanks in its front and rear parts. Figure. shows the - portion of a submarine to explain its floatation. It is provided with periscopes so that the diver could see above the water surface even when the submarine is well inside the water.



Application of the Principle of Floatation

- A submarine can be made to dive into the water or rise up to the surface of water as and when desired.
- If a submarine is to dive, its ballast tanks are filled with water so that the average density of submarine becomes greater than the density of sea water and the submarine dives into the water.
- If submarine is to rise, water from the ballast tanks is forced out into the sea by allowing the compressed air to enter the tank. This makes the average density of submarine less than that of sea water.
- As a result, the weight of water displaced by its partially small submerged part becomes equal to the weight of submarine and hence it rises up to the surface of water.

Application of the Principle of Floatation

(iv) Floatation of iceberg

- The density of ice is less than the density of water.
-]The density of ice is 0.917 g cm^{-3} and that of water is 1 g cm^{-3}.
- Therefore, huge masses of ice known as icebergs are able to float on water with their major part inside the water surface and only a small portion above the water surface.

Application of the Principle of Floatation

Volume of iceberg above the water surface while floating: If the total volume of an iceberg is V and the volume of iceberg submerged is v, then by the principle of floatation,

Weight of water displaced by the submerged part of iceberg = Total weight of iceberg

or $v \times \rho_{water} \times g = V \times \rho_{ice} \times g$

or $\frac{v}{V} = \frac{\rho_{ice}}{\rho_{water}}$

Application of the Principle of Floatation

Icebergs are dangerous for ships:

- Icebergs being lighter than water, float on water with their major part (nearly 90%) inside water and only a small part (≈10%) outside water.
- Since portion of iceberg inside the water surface depends upon the density of sea water, therefore for the driver of ship, it becomes difficult to estimate the size of iceberg.
- Thus an iceberg is very dangerous for the ship as it may collide with the ship and cause damage.

Application of the Principle of Floatation

(v) Floatation of fish

- ✓ Many species of fish have an organ called a swim bladder. It acts like the ballast (or floatation) tank of a submarine.
- ✓ When a fish has to rise up in water, it diffuses gas from its fluid into the bladder, so its volume increases and its average density decreases.
- ✓ This increases the volume of water displaced by the fish and so the up thrust on fish increases due to which it rises up. When the fish has to come down, it empties its bladder to the required extent, so its volume decreases and density increases.
- ✓ Hence upthrust on fish decreases and it sinks in water.

Application of the Principle of Floatation

(vi) Rising of balloons

When a light gas like hydrogen or helium (density much less than that of air) is filled in a balloon, the weight of air displaced by the inflated balloon (i.e., upthrust) becomes more than the weight of the gas filled balloon and it rises up.

The balloon does not rise indefinitely: The reason is that the density of air decreases with altitude. Therefore as the balloon gradually goes up, the weight of the displaced air (i.e., upthrust) decreases. It keeps on rising as long as the upthrust on it exceeds its weight. When upthrust becomes equal to its weight, it stops rising further.

Thank You