TENDER HEART HIGH SCHOOL, SECTOR-33'B, CHD. 20.5.24

CLASS- IX SUBJECT- PHYSICS

CHAPTER-5 [Upthrust, Archimedes' Principle] TEACHER- Charanjeet kaur

Good Morning Students! This lesson is of class-IX, for the subject of 'Physics', Topic - 'Reason for upthrust' which is covered in Chapter-5 'Upthrust in Fluids, Archimedes' Principle and Floatation', of your textbook, titled - 'Concise Physics by Selina Publications'.

REASON FOR UPTHRUST:

The upthrust on the object is due to the difference in pressures due to liquid on the two faces of block (as shown in figure-1). Students, as we have learnt in Chapter-4, $F = P \times A$, so, upthrust $= (P_2 - P_1)\,A$.

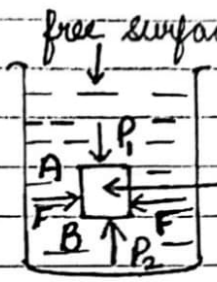

FIGURE-1

However, the thrust (F) on the side walls of body get neutralised as they are equal in magnitude and opposite in directions.

Thus, $F_B = V \rho_L g$ ✓

where, V = volume of liquid displaced by object
= volume of object submerged in liquid

(Take a break of 5 minutes and observe figure-2 as shown below).

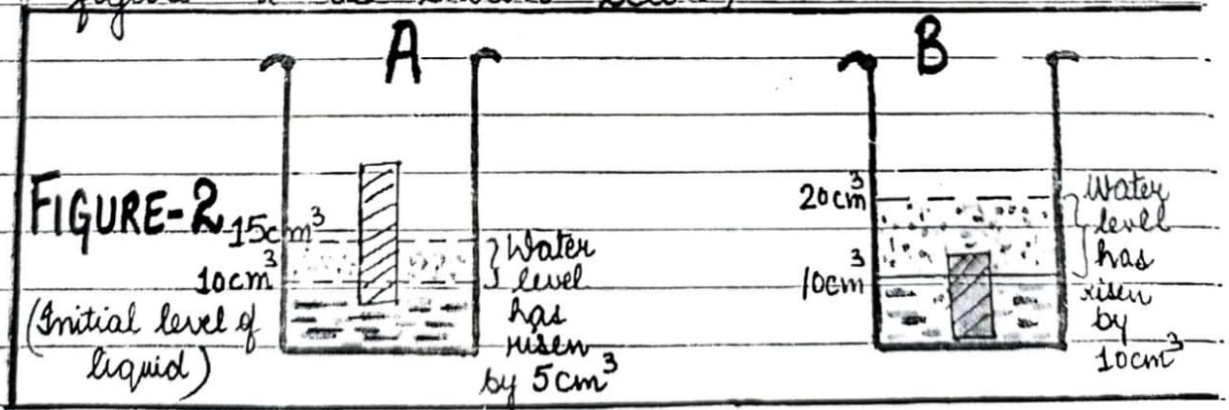

FIGURE-2

Students, if an object is partially immersed in a beaker containing 10 cm^3 or 10 mL of water (as shown in figure-2), then it is observed that water level rises to 15 cm^3 (15 mL). This means

that the object has displaced 5 cm^3 of H_2O and thus the volume of the object immersed in water is 5 cm^3 (see figure-2 part A). But if whole of the object is immersed in H_2O (as shown in figure-2 part B), then the water level rises to 20 cm^3 (20 ml). It means that in this case, water displaced by the object is 10 cm^3 (10 ml) and thus the volume of the whole object (totally immersed in liquid) is 10 cm^3. So, in short we have:

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CASE-A

Initial level of H_2O = **10 cm^3**
Object Immersed — partial
Water displaced = 5 cm^3 = 5 mL
(from 10 to 15 cm^3)
So, volume of object immersed in H_2O = 5 cm^3

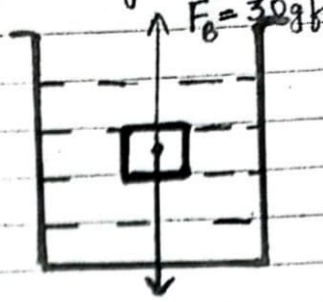
CASE-B

Initial level of H_2O = **10 cm^3**
Object Immersed — total
Water displaced = 10 cm^3 = 10 mL
(from 10 to 20 cm^3)
Volume of object immersed in H_2O = **10 cm^3**

ARCHIMEDES' PRINCIPLE — It states that when a body is immersed partially or completely in a liquid, it experiences an upthrust, which is equal to the weight of the liquid displaced by it.
(This principle applies to liquid as well as gases). In other words, the volume of liquid displaced by the body is equal to the volume of the submerged part of the body, so the body experiences an upthrust equal to the weight of the liquid displaced by it.

EFFECT OF UPTHRUST — The effect of upthrust is that the weight of body immersed in a liquid appears to be less than its actual weight.

Lets understand this with the following example:
If an object of weight 50 gf is wholly immersed in water and the water is exerting an upthrust of 3.0 gf in upward direction so, the net force exerted on the object
$= 50\,gf - 30\,gf = 20\,gf$.



Students, you must have experienced that while swimming you feel a little lighter. Actually, when an object is immersed in a liquid then its weight is reduced by the amount of the upthrust exerted. Students, the weight does not decreases but it appears to decrease and thus this is also also known as apparent weight.

So, in Numericals also,
Weight of a body in air = Real weight
" " " in liquid = Apparent wt.
Apparent wt. < Real weight
Loss in wt = Real wt − Apparent wt.
Loss in weight = upthrust (F_B)
$\therefore F_B$ = Real wt. − Apparent wt.
Also, weight of an object = mass × g = mg
$\because d = (\text{Volume} \times \rho)$ of object $\times g$
Real weight (R.W) = $V_{object} \times \rho_{object} \times g$ ——— (1)

upthrust (Buoyant force, F_B) = $V_{submerged\,object} \times \rho_{liquid} \times g$ ——— (2)

As we have studied earlier in this chapter about the case of floatation and sinking

Case of Sink : Real Weight > Upthrust
which means that [Density of object (ρ_o) > Density of liquid (ρ_L)]

{Floatation with Complete Immersion} : Real Weight = Upthrust
$\rho_{object} = \rho_{liquid}$

{Floatation with Partial Immersion of Object} Real Weight < Upthrust
$\rho_{object} < \rho_{liquid}$

So, it can be said that if the:
✓ density of object is MORE than density of liquid, then object will SINK.
✓ density of object is LESS than density of liquid, then object will FLOAT.

Now let us understand some numericals :—

(1) A body weighs 210gf in air and 180gf in water
Calculate (a) loss of wt. of body in water, and
(b) upthrust on the body.

Ans Real weight = 210gf (in air)
Apparent wt. = 180gf (in water)

(a) Loss in weight = 210gf − 180gf = 30gf
(b) Upthrust = loss in wt. = 30gf

(2) A piece of iron of density 8×10^3 kg/m^3 and Volume 150cm^3 is Completely immersed in water ($\rho_{water} = 1000$ kg/m^3). Calculate
(a) weight of piece in air ;
(b) the upthrust, and (c) Apparent wt. ($g = 10$m/s^2)

Solution :— $\rho = \frac{\text{mass}(m)}{\text{volume}(V)}$ (ρ = density)

$\rho_{of\ iron} = \frac{m}{\text{volume}}$

or mass of iron = $\rho_{of\ iron} \times$ volume of iron

mass of iron $= (150\ cm^3) \times (8 \times 10^3\ kg/m^3)$

$m = 150 \times (10^{-6}\ m^3) \times 8 \times 10^3\ kg/m^3$

$m = 1200 \times 10^{-3}\ kg = \underline{1.2\ kg}$

($1 cm^3 = 10^{-6}\ m^3$ → Learn this conversion)

a) Real weight $= mg = 1.2 \times 10 = 12\ N$

b) Upthrust, $F_B = V_{\text{object submerged}} \times \rho_{H_2O} \times g$

$f_B = (150 \times 10^{-6}\ m^3) \times (10^3\ kg/m^3) \times 10$

$= 150 \times 10^{-6} \times 10^4 = 150 \times 10^{-2}\ N$

$f_B = \underline{1.5\ N}$

c) Apparent weight = Real weight − F_B

$= 12\ N - 1.5N = \underline{10.5N}$

INSTRUCTIONS:

Students are required to read the given notes and then go through the theory of 5(a) from Physics Book.

HOMEWORK:

Students are required to try to solve numerical number - 1, 2, 4 and 7 given on Page Number 110 and 111.

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