# CLASS IX

## TERM II

## THRUST & PRESSURE

**THRUST -**

It is the total force exerted by a body perpendicular to another surface.

SI unit of thrust is Newton (N)

**PRESSURE -**

It is the perpendicular force (thrust) acting per unit area of the surface.

$$\text{Pressure} = \frac{\text{Normal force}}{\text{Area}}$$

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

$$\boxed{P = F/A}$$

$P \propto F \rightarrow$ Pr. ↑ses if force ↑ses keeping area constant.

$P \propto \frac{1}{A} \rightarrow$ Pr. ↑ses if area ↓ses keeping thrust constant.

SI unit of Pr. $= \frac{N}{m^2}$ or Pascal (Pa).

Application of Pressure -

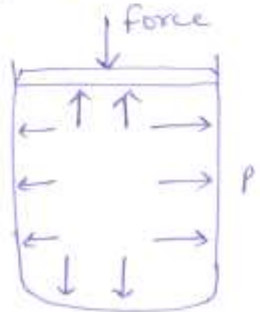
1. Railway tracks are laid on wider wooden, cemented or iron sleepers.
2. Tip of a needle is made sharp.
3. It is easier to cut with a sharp knife than with a blunt knife.
4. School bags are provided with wide straps.
5. A camel can walk easily on sand as compared to human beings.
6. The tyres of trucks are made wider than the tyres of a bicycle or a car.
7. Foundations of high rise buildings or a dam are made wider.

PRESSURE in FLUIDS -

FLUIDS - Substances which can flow.

eg: water, air

- Solid objects exert pressure due to their weights.
- Fluids exerts pr. on the walls of container in which they are enclosed in all direction.




- Pr. at any point in a fluid ↑ses with depth.
- Inside any liquid, pr. is directed in all directions.

Mathematical expression for Pr. in fluids-

$$P = \frac{F}{A}$$

$$= \frac{W}{A} \quad \text{[ where, } W = \text{wt. of fluid]}$$

$$= \frac{mg}{A}$$

We Know, Density, $\rho = \frac{m}{V}$

$$\boxed{m = V\rho}$$

V = Vol. = Area of cross section 'A' x ht. of fluid inside container 'h'.

$$= A \times h$$

$$\therefore \quad m = V\rho$$
$$= A \times h \times \rho$$

$$\text{Pr.} \Rightarrow P = \frac{mg}{A} = \frac{A \times h \times \rho \times g}{A}$$

$$\boxed{P = h\rho g}$$

Fluid pr. depends on -
ht 'h', density 'ρ' and acc. due to gravity 'g'.

Give Reasons -

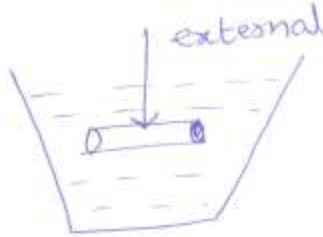
(1) Why is walls of a dam made thicker at bottom?

→ liquid pr. ↑ses with depth. Hence, max. pr. is applied at bottom of dam.

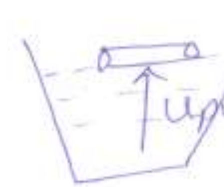
(2) Why do divers use special protective suit for diving in sea?

→ liquid Pr. ↑ses with depth. Since, pr. is very high, the divers body will crush so to avoid this they wear special protective suit.

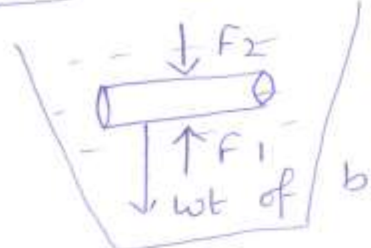
BUOYANCY -




Bottle rises up itself when released inside water.




Forces acting on bottle -




$$F_2 + W = F_1$$

$$F_2 = F_1 - W$$

External applied force = Upward force − wt. of body

Buoyancy is the tendency of a liquid to exert an upward force on a body immersed partially or wholly on it.

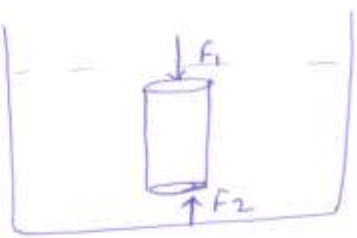
## BUOYANT FORCE – (UPTHRUST)

The upward force exerted by the liquid on a body immersed in it.

Factors on which Upthrust depends on –

1. Density of fluid
2. The vol. of fluid displaced by the body

## CAUSE OF BUOYANT FORCE (BF)




Net force $= F_2 - F_1$

= Upward Force – Downward force

Net force in Upward direction is the **BUOYANT FORCE** which reduces **Weight** of the body.

**DENSITY** - Mass existing per unit volume.

$$\rho = \frac{m}{V}$$

Unit of '$\rho$' $= kg/m^3$

cgs unit is $g/cm^3$.

## RELATIVE DENSITY (RD)

It is the ratio of density of substance to density of water at 4°c.

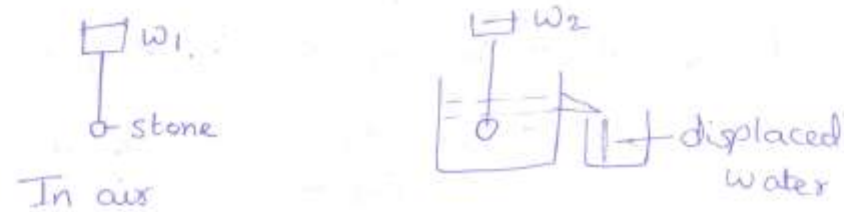
$$RD = \frac{\rho \text{ of a substance}}{\rho \text{ of water at } 4^\circ c}$$

It has **no unit** since it is the ratio of 2 similar quantities.

## ARCHIMEDES' PRINCIPLE

When a body is partially or fully immersed in a liquid, it experiences an upthrust whose magnitude is equal to the weight of the liquid displaced by the body.

Upthrust = Wt. of liquid displaced
= Loss in wt. of body
= wt. of body in air − wt. of body in liquid




Loss in wt. of stone = $W_1 - W_2$

= wt. of displaced water

Loss in wt. is because of buoyant force.

## APPLICATIONS OF A.P. -

(1) Used in designing of ships.

(2) Working of Lactometer (to check purity of milk) and Hydrometer (to determine density of liquids) is based on A.P

(3) A.P. is used to determine Relative Density of a substance.

Buoyant Force (BF) = wt. of liquid displaced

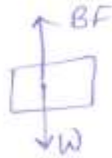
= Mass of liquid displaced × g

= density × vol. × g

$$\boxed{BF = \rho V g}$$

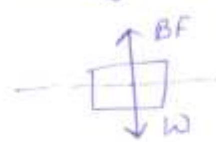
CASES -

① If W > B.F , body will sink




(W > BF)

② If BF > W , body will rise to surface




(BF > W)

③ If W = BF , object will float in the liquid

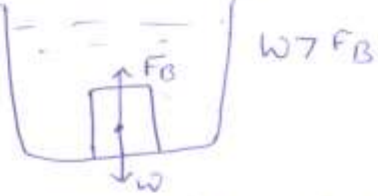
Whenever an object is immersed wholly or partially in a fluid, there is an apparent decrease in its weight and this apparent decrease in weight is equal to the weight of fluid displaced by the object.

Application of Archimedes principle -

1. Used in designing ships and submarines.
2. We can determine the values of relative density of solids and liquids.
3. Hydrometers — used to determine density of liquids, are based on this principle
4. Lactometer - used to determine the purity of milk.

## LAWS OF FLOATATION -

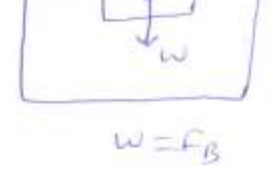
1) If weight W is greater than the buoyant force ($W > F_B$), then net force acting on the object is in downward direction, the object sinks in the given fluid.




eg: Iron nail, metallic ball, stone etc. sink in water.

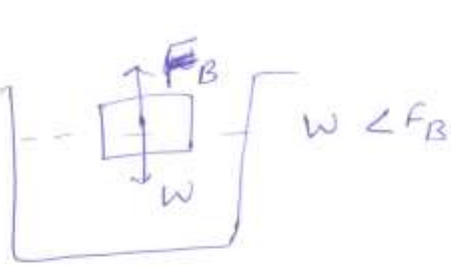
2) If weight W is equal to buoyant force ($W = F_B$), net force acting is zero. Which means object will neither float nor sink but remain fully immersed in the fluid just below its surface.

eg: plastic bottle or mug filled with water remains immersed



3) If weight W is less than buoyant force ($W < F_B$), net force on object acts in upward direction and the object floats.

eg: cork, wooden block, wax piece etc. floats when dropped on water surface.




## CONDITION OF FLOATATION

An object floats only if weight of fluid displaced by immersed part of object is equal to weight of object.

In Terms of Density -

① If density of object is greater than density of fluid, object will sink.
eg. steel needle sinks in water because its density is more than waters density.

② If density of object is less than density of fluid, object floats.
eg: Wooden block floats on water.

Application -

① An ice cube floats on water
(bcoz density of ice < density of water)

② It is easier to swim in seawater than freshwater
(bcoz seawater density > freshwater density)

## PRINCIPLE of FLOATATION -

Upthrust = wt. of liquid displaced

$= \rho \times vol. \times g$

$= V_l \rho g$ (where, $V_l$ = vol. of liquid)

wt. = Mass of object × g

= density of object × Vol. of object × g

$$W = \sigma V_o g$$

(i) Upthrust equal to wt. of object

$$\rho V_l g = \sigma V_o g$$

But, $V_l = V_o$

$$\therefore \rho = \sigma$$

If density of liquid = density of object the object will float just below the surface of liquid.

(ii) Upthrust < wt

$$\rho V_\ell g < \sigma V_o g$$

$$\boxed{\rho < \sigma}$$

$$\because V_\ell < V_o$$

Object will sink if density of object is more than density of liquid.

eg: Iron sinks because its density is more than water.

(iii) Upthrust > wt

$$\rho V_\ell g > \sigma V_o g$$

$$\boxed{\rho > \sigma}$$

$$\because V_\ell > V_o$$

Object floats partially on the surface of liquid if its density is less than density of liquid.

eg: Cork has less density than water hence floats on water.

* For an object to float on water its $RD \leq 1$.

## FORMULAE

Upthrust $= W = mg$

Liquid pr. $= P = h\rho g$

Relative Density,

$$RD = \frac{\text{Density of Substance}}{\text{Density of water at } 4^\circ c}$$

or, $$RD = \frac{\text{Mass of substance}}{\text{Vol. of substance}} \times \frac{\text{Vol. of water at } 4^\circ c}{\text{Mass of water}}$$

Density of water at $4^\circ C = 1\ g/cm^3$

or, $1000\ Kg/m^3$

$$RD = \frac{\text{wt. of solid in air}}{\text{wt. of water displaced by solid}}$$

or, $$RD = \frac{\text{wt of solid in air}}{\text{Loss of wt. of solid in water}}$$

and Loss of wt. of solid in water

= wt. of solid in air

− wt. of solid in water

## DENSITY -

It is defined as Mass per unit volume.

$$\text{Density } (\rho) = \frac{\text{Mass}}{\text{volume}} = \frac{m}{V}$$

SI unit of density is $kg/m^3$ or $kgm^{-3}$.

Density remains same at constant temperature and pressure.

$\rho_{solids} > \rho_{liquids} > \rho_{gases}$.

Density helps to determine the purity of any substance.

## RELATIVE DENSITY -

It is the ratio of the density of the substance to density of water under similar conditions.

$$\text{Rel. Density } (R.D.) = \frac{\text{Density of Substance}}{\text{Density of water}}$$

$$R.D = \frac{\rho_{substance}}{\rho_{water}}$$

R.D expresses density of substance in comparision with that of water.

Unit -

Since, RD is the ratio of 2 densities. Hence, no unit.

R.D is unitless quantity.

## EXAMPLES

① A solid of density $1600 \, kg/m^3$ is found to weigh $0.40 \, kgf$ in air. If $\frac{5}{8}$ vol. of solid is completely immersed in brine solution of density $1200 \, kgm^{-3}$. Find apparent weight of solid in brine.

→ Wt. of solid in air = $0.40 \, kgf$

∴ Mass of solid in air = $0.40 \, kg$

$$\text{Vol. of solid} = \frac{m}{\rho} = \frac{0.40}{1600}$$

$$= 0.00025 \, m^3$$

Vol. of brine solution displaced =

$$\frac{5}{8} \times 0.00025 = 0.00015625 \, m^3$$

∴ Mass of brine displaced = $V \times \rho$

$$= 0.00015625 \times 1200$$

$$= 0.1875 \, kg$$

Upthrust due ~~due~~ to brine solution = $W = mg$

$$= 0.1875 \, kgf$$

Apparent wt. of solid = $0.4000 - 0.1875$

$$= 0.2125 \, kgf$$

(2) A solid weighs 0.850 kgf in air and 0.575 kgf in water. Find
(i) RD of solid
(ii) Density of solid in SI system.
[Density of water = 1000 kg/m³]

→ (i) R.D. of solid = $\frac{\text{wt. of solid in air}}{\text{wt. of solid in air} - \text{wt. of solid in water}}$

$= \frac{0.850 \text{ kgf}}{(0.850 - 0.575) \text{ kgf}}$

$= \frac{0.850}{0.275} = 3.09$

(ii) R.D. of solid = $\frac{\text{Density of solid}}{\text{Density of water}}$

Density of solid = R.D. of solid × Density of water

$= 3.09 \times 1000 \text{ kg/m}^3$

$= 3090 \text{ kg/m}^3$

③ A block of wood of length 50 cm and area of crosssection 10 $cm^2$, floats in water with $\frac{3}{5}$ of its length above water. Calculate

(i) Density of wood

(ii) wt. of wood

(iii) Extra force required to completely submerge it in water.

→ (i) Length of wood outside water =

$$\frac{3}{5} \times 50 = 30 cm$$

∴ Length of wood inside water =

$$50 - 30 = 20 cm$$

By Law of floatation,

$$h_{wood} \times \rho_{wood} = h_{water} \times \rho_{water}$$

$$50 cm \times \rho_{wood} = 20 cm \times 1 g/cm^3$$

$$\therefore \rho_{wood} = \frac{20}{50} \times 1$$

$$= 0.40 g/cm^3$$

(ii) Volume of wood = $50 \times 10 = 500 cm^3$

$$\therefore \text{Mass of wood} = V \times \rho$$

$$= 500 \times 0.40$$

$$= 200 g$$

$$\therefore \text{wt. of wood} = mg$$

$$= 200 \times g = 200 gf$$

(iii) Total upthrust when wood is completely immersed in water

$$V \rho g = 500 \times 1 \times g$$
$$= 500 gf$$

$\therefore$ Extra force reqd. =

Upthrust − Downward force

$= 500gf - 200gf$

$= \underline{\underline{300 gf}}$

(4) A block of wood floats in brine solution of density 1.20 $g/cm^3$, such that $\frac{3}{8}$th of its volume is above brine. Calculate the density of wood.

→ Let volume of block = V

$\therefore$ Volume of block above brine solution, $x = \frac{3}{8} V$

$\therefore$ Volume of block below brine solution $= V - \frac{3}{8} V$

$= \frac{5}{8} V$