RADIANT 2026

Physics

Upthrust in Fluid, Archimedes' Principle and Flotation

Lecture - 02

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Topics *to be covered*

1. Experimental Verification of Archimedes' Principle
2. Density and Relative Density
3. Determination of Relative Density of a Solid Substance by Archimedes' Principle

Recap *of previous lecture*

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


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Density = $\frac{\text{Mass}}{\text{Volume}}$

for d

↑ D ∝ M ↑

↑↓ D ∝ $\frac{1}{V \uparrow\downarrow}$

Konstant
Klear

Relative Density and Its Measurement by Archimedes' Principle

The density of a substance is its mass per unit volume. i.e.,

$$\text{Density of a substance} = \frac{\text{Mass of the substance}}{\text{Volume of the substance}}$$

It is a **scalar** quantity and is represented by the letter ρ (rho) or *d*.

If mass of a substance is M and its volume is V, its density is

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

Unit of Density

A → kg/m

B → kg/m^2

C → kg/m^3

D → ABC

Relative Density and Its Measurement by Archimedes' Principle

Unit of density

$$\text{Unit of density} = \frac{\text{Unit of mass}}{\text{Unit of volume}}$$

In S.I. system, unit of mass is kg and unit of volume is m^3, so S.I. unit of density is kg m^{-3}. In C.GS. system, unit of mass is g and unit of volume is cm^3, so C.GS. unit of density is g cm^{-3} (or gram per cubic centimeter).

Relationship between S.I. and C.GS. units

$$1\text{kg m}^{-3} = \frac{1\text{ kg}}{1\text{ m}^3} = \frac{1000\ g}{(100\text{cm})3}$$

$$= 1/1000\text{ g cm}^{-3}$$

Thus

$1\text{ kg m}^{-3} = 10^{-3}\text{ g cm}^{-3}$ or $1\text{ g cm}^{-3} = 1000\text{ kg m}^{-3}$

Effect of Temperature on Density

Most of the substances expand on heating and contract on cooling, but their mass remains unchanged. Therefore, density of most of the substances decreases with the increase in temperature and increases with the decrease in temperature.

Exception

- The behaviour of water is however very different due to its uneven expansion. Water when cooled from a high temperature, contracts up to 4°C thereafter it expands below 4°C up to 0°C. Thus the density of water gradually increases when it is cooled up to 4°C, and then starts decreasing when it is cooled further below 4°C up to 0°C. Thus,
- The density of water is maximum at 4°C, equal to 1 g cm^{-3} or 1000 kg m^{-3}.

Relative Density

[R.D. = $\frac{\rho_s}{\rho_w} = \frac{m_s}{m_w}$ Ps Pw W ms mw = FOR SAME VOLUME]

We have read that density of water at 4°C is 1 g cm^{-3} (or 1000 kg m^{-3}). Treating it as a standard, the density of a substance can be compared with the density of water at 4°C and the ratio so obtained is termed as the relative density of that substance. Thus,

Relative Density

The relative density (R.D.) of a substance is the ratio of the density of that substance to the density of water at 4°C.

i.e., R.D. $= \frac{\text{Density of substance } (\rho_s)}{\text{Density of water at 4°C } (\rho_w)}$

$= \frac{\text{Mass of unit volume of substance}}{\text{Mass of unit volume of water at 4°C}}$

$= \frac{\text{Mass of substance (ms)}}{\text{Mass of an equal volume of water at 4°C (mw)}}$

$RD = \frac{\rho_s}{\rho_w}$

Relative Density

Thus,

Relative density of a substance is also defined as the ratio of the mass of substance to the mass of an equal volume of water at 4°C.

Unit of relative density: Since relative density is a pure ratio, it has no unit.

RD

(i) kg/m^3

(ii) kg/m^2

(iii) kg/m

(iv) No Unit

Relative Density

(i) In C.G.S. system, density of water at 4°C is 1 g cm^{-3}, so the relative density of a substance is equal to the numerical value of density of that substance. Thus

$$\text{R.D.} = \frac{\text{Density of substance in g cm}^{-3}}{1.0 \text{ g cm}^{-3}}$$

or $\text{Density in g cm}^{-3} = \text{R.D}$

(ii) In S.I. system, density of water at 4°C is 1000 kg m^{-3}, so its relative density is

$$\text{R.D.} = \frac{\text{Density of substance in kg m}^{-3}}{1000 \text{ kg m}^{-3}}$$

or $\text{Density in kg m}^{-3} = (\text{R.D.}) \times 1000$

Relative Density

Examples:

(i) The density of copper is $8.9\ g\ cm^{-3}$, its R.D. is 8.9.

(ii) The density of mercury is $13.6 \times 10^3\ kg\ m^{-3}$, its R.D. is 13.6.

(iii) The R.D. of silver is 10.8, its density in C.G.S. unit is $10.8\ g\ cm^{-3}$ and in S.I. unit is $10.8 \times 10^3\ kg\ m^{-3}$.

Difference Between Density and Relative Density

Density	Relative density
1. Density of a substance is the mass per unit volume of that substance.	1. Relative density of a substance is the ratio of density of that substance to the density of water at 4°C.
2. It is expressed in g cm^{-3} or kg m^{-3}.	2. It has no unit.

Question

Complete the following sentences:

(i) Mass = Volume × density $\rho = \frac{m}{V}$ $m = \rho \times V$

(ii) S.I. unit of density is kg/m^3

(iii) Density of water is 1000 kg m^{-3}.

(iv) Density in kg m^{-3} = ____ × density in g cm^{-3}.

Question

Relative density of a substance is expressed by comparing the density of that substance with the density of:

Mark

(A) 100°C
(B) 1°C
(C) 4°C
(D) ∞°C

A air

B mercury

C water

D iron

Question

The density of water is:

A $1000\ g\ cm^{-3}$

B $1\ kg\ m^{-3}$

C $1\ g\ cm^{-3}$

D none of these

Question

The density of water is:

A $1000\ g\ cm^{-3}$

B $1\ kg\ m^{-3}$

C $1\ g\ cm^{-3}$

D none of these

Ans. **(C)** $1\ g\ cm^{-3}$

Question

The S.I. unit of upthrust is:

A Pa

B N

C kg

D $kg\ m^2$

Question

The property of a liquid to exert an upward force on a body immersed in it is called:

A buoyancy

B pressure

C friction

D viscosity


Thank You