Upthrust and Archimedes' Principle

Practice Problem 1:

Question 1.
A solid of density 2700 kgm' and of volume 0.0015 m3 ¡s completely immersed in alcohol of density 800 kgm'.Calculate :

1. Weight of solid in SI system.
2. Upthrust on solid in SI system.
3. Apparent weight of solid in alcohol.
4. Will the apparent weight of solid be less or more, if it is immersed completely in brine solution? Give a reason, [g = 10 ms^{-2}]

Answer:
Density of solid = ρ= 2700 kgm^3
Volume of solid = V = 0.0015 m^3
Density of alcohol = ρ' = 800 kgm^3

1. Mass of solid = m = V x p
   m = 0.0015 x 2700 = 4.05 kg
   Weight of solid = mg = 4.05 x 10 = 40.5 N
2. Volume of alcohol displaced = Volume of solid
   V = 0.0015 m^3
   Mass of alcohol displaced = m' = V x p'
   m' = 0.0015 x 800 = m' = 1.2 kg
   Upthrust = Weight of alcohol displaced
   = m'g= 1.2 x 10= 12N
3. Apparent weight of solid in alcohol
   = Actual weight of solid – Upthrust
   = 40.5 -12 = 28.5 N
4. When a solid is immersed completely in brine solution, then upthrust acts on it in upward direction, as a result, its apparent weight of solid will be less than actual weight of solid will be less than actual weight of solid.

Question 2.
A stone of density 3000 kgm^3 is lying submerged in water of density 1000 kgm^3. If the mass of stone in air is 150 kg, calculate the force required to lift the stone. [g = 10 ms^2]

Answer:
Density of stone =ρ = 3000 kgm^3
Density of water = ρ' = 1000 kgm^3

Mass of stone = m = 150 kg
Acceleration due to gravity = g = 10 ms^{-2}

$$\text{Volume of stone} = V = \frac{m}{\rho}$$

$$V = \frac{150}{3000} = \frac{1}{20} = 0.05\ m^3$$

Actual weight of stone = mg = 150 x 10 = 1500 N
Volume of water displaced = Volume of stone
V = 0.05 m^3
Mass of water displaced = m' = V x p'
m' = 0.05 x 1000 = 50 kg
Upthrust = m'g = 50 x 10 = 500 N
Force required to lift the stone
= Actual weight of stone – upthrust
= 1500 -500 = 1000 N

Question 3.
A solid of area of cross-section 0.004 m^2 and length 0.60 m is completely immersed in water of density 1000 kgm^3. Calculate :

1. Wt of solid in SI system
2. Upthrust acting on the solid in SI system.
3. Apparent weight of solid in water.
4. Apparent weight of solid in brine solution of density 1050 kgm^3.
   [Take g = 10 N/kg; Density of solid = 7200 kgm^3]

Answer:
Area of cross-section of solid = A = 0.004 m^2
Length of the solid = l = 0.60 m
Density of water = p' = 1000 kgm^3
Acceleration due to gravity = g = 10 ms^{-2}
Density of solid = p = 7200 kgm^3
(1) Volume of solid = V = A x l
V = 0.004 x 0.60 = 0.0024 m^3
Mass of solid = m = V x p
m = 0.0024 x 7200 = 17.28 kg
Weight of the solid = mg = 17.28 x 10 = 172.8 N
(2) Volume of water displaced = Volume of solid
= V = 0.0024 m^3
Mass of water displaced = m' = V x p'
m' = 0.0024 x 1000 = 2.4 kg
Upthrust = Weight of water displaced

= m’g = 2.4 x 10 = 24 N
(3) Apparent weight of solid=Actual weight of solid – upthrust
= 172.8-24= 148.8 N
(4) Density of brine solution =ρ_b= 1050 kgm^3
Volume of brine solution displaced = Volume of solid = V
V = 0.0024 m^3
Mass of brine solution displaced
= m_b = V x ρ_b = 0.0024 x 1050
m_b = 2.52 kg
Upthrust acting on solid in brine solution = Weight of brine solution displaced -$m_b g$
= 2.52 x 10 = 25.2 N
Apparent weight of solid in brine solution
= Actual weight – Upthurst
= 172.8-25.2= 147.6 N

Practice Problem 2:

Question 1.
A solid of density 7600 kgm^3 is found to weigh 0.950 kgf in air. If 4/5 volume of solid is completely immersed in a solution of density 900 kgm^3, find the apparent weight of solid in liquid.

Answer:
Weight of solid in air = 0.950 kgf
∴ Mass of solid in air = m = 0.950 kg
Density of solid =ρ = 7600 kgm^3

$$\therefore \text{ Volume of solid} = V = \frac{m}{\rho}$$

$$V = \frac{0.950}{7600} = 0.000125 \text{ m}^3$$

Density of solution = $\rho' = 900\ kgm^{-3}$

$\because \frac{4}{5}$ volume of solid is completely immersed in the given solution.

$\therefore$ Volume of solution displaced = $V = \frac{4}{5} \times$ Volume of solid

$V' = \frac{4}{5} \times 0.000125$

$V' = 0.0001\ m^3$

Mass of solution displaced = $m' = V' \times \rho'$

$m' = 0.0001 \times 900$

$m' = 0.09$ kg

Upthrust = Weight of solution displaced

$= m'g$

$= 0.09 \times 10 = 0.9\ N = \frac{0.9}{10}$ kgf

$= 0.09$ kgf

Apparent weight of solid in liquid
= Actual weight – Upthrust
= 0.950-0.09 = 0.860 kgf

Question 2.
A glass cylinder of length 12×10^{-2} m and area of crosssection $5 \times 10^{-4}\ m^2$ has a density of 2500 kgm^{-3}. It is immersed in a liquid of density 1500 kgm^{-3}, such that 3/8. of its length is above liquid. Find the apparent weight of glass cylinder in newtons.

Answer:
Length of glass cylinder = l = 12×10^{-2} m
Area of cross-section = A = $5 \times 10^{-4}\ m^2$
Volume of glass cylinder = V = A x l
V= $5 \times lo^{-4} \times 12 \times 10^{-2}$
V= 0.00006 m^3
Acceleration due to gravity = g = 9.8 m/s^2
Density of glass cylinder = ρ = 2500 kgm^3

Density of liquid = $\rho' = 1500\ kgm^{-3}$

$\because \frac{3}{8}$ length of glass cylinder is above the liquid

$\therefore$ Length of glass cylinder inside the liquid $= 1 - \frac{3}{8} = \frac{8-3}{8} = \frac{5}{8}$

$\therefore$ Volume of liquid displaced by glass cylinder $= \frac{5}{8} \times$ Volume of glass cylinder

$$V' = \frac{5}{8} = 0.00006$$

$$V' = \frac{0.0003}{8} = 0.0000375\ m^3$$

Mass of glass cylinder = m = V x ρ
m = 0.00006 x 2500 m
= 0.15 kg
Weight of glass cylinder = mg = 0.15 x 10=1.5 N
Mass of liquid displaced by glass cylinder = V' x ρ'
m'= 0.0000375 x 1500
m' = 0.05625 kg
Upthrust = Weight of liquid displaced by the glass cylinder
= m'g = 0.05625 x 10 = 0.5625 N
Apparent weight of glass cylinder in liquid = Actual weight of glass cylinder – Upthrust
= 1.5 – 0.5625 = 0.9375 N

Practice Problems 3:

Question 1.
A solid weighs 0.08 kgf in air and 0.065 kgf in water.Find
(1) R.D. of solid
(2) Density of solid in SI system. [Density of water = 1000 kgm^3]

Answer:
Weight of solid in air = 0.08 kgf
Weight of solid in water = 0.065 kgf
Density of water = 1000 kgm^3
(1) Relative density (RD) of solid
= Weight of solid in air

wt. of solid in air-wt. of solid in water

$$= \frac{\text{Weight of solid in air}}{\text{wt. of solid in air} - \text{wt. of solid in water}}$$

$$\text{R.D.} = \frac{0.08}{0.08 - 0.065}$$

$$\text{R.D.} = \frac{0.08}{0.015} = 5.3333$$

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

$$5.3333 = \frac{\text{Density of solid}}{1000}$$

$$\text{Density of solid} = 5.3333 \times 1000 = 5333.3\ \text{kgm}^{-3}$$

Question 2.

A solid of R.D. = 2.5 is found to weigh 0.120 kgf in water. Find the wt. of solid in air.

Answer:

Relative density of solid = R.D. = 2.5

Weight of solid in water = W' = 0.120 kgf

Weight of solid in air = W = ?

$$\text{R.D.} = \frac{\text{Weight of solid in air}}{\text{wt. of solid in air} - \text{wt. of solid in water}}$$

$$\text{R.D.} = \frac{W}{W - W'}$$

$$2.5 = \frac{W}{W - 0.120}$$

$$2.5\ W - 2.5 \times 0.120 = W$$

$$2.5\ W - 0.3 = W$$

$$2.5\ W - W = 0.3$$

$$1.5\ W = 0.3$$

$$W = \frac{0.3}{1.5} = 0.20\ \text{kgf}$$

So, weight of solid in air = 0.20 kgf.

Question 3.
A solid of R.D. 4.2 is found to weigh 0.200 kgf in air. Find its apparent weight in water.

Answer:
Relative density of solid = R.D. = 4.2
Weight of solid in air = W = 0.200 kgf

$$R.D. = \frac{\text{Weight of solid in air}}{\text{wt. of solid in air} - \text{wt. of solid in water}}$$

Also, wt. of solid in air – Wt. of solid in water = Upthrust

$$R.D. = \frac{\text{Wt. of solid in air}}{\text{Upthrust}}$$

$$4.2 = \frac{0.200}{\text{Upthrust}}$$

$$\text{Upthrust} = \frac{0.200}{4.2} = 0.0476 \text{ kgf}$$

So, apparent wt. of solid in water = wt. of solid in air – Upthrust

$$= 0.200 - 0.0476 = 0.1524 \simeq 0.15 \text{ kgf}$$

Practice Problems 4:

Question 1.
A sinker is found to weigh 56.7 gf in water. When the sinker is tied to a cork of weight 6 gf, the combination is found to weigh 40.5 gf in water. Calculate R.D. of cork.

Answer:
Weight of sinker in water = 56.7 gf
Weight of cork = 6 gf
Wt. of sinker in water + Wt. of cork in air
= 56.7 + 6 = 62.7 gf …(1)
Wt. of cork in water + Wt. of sinker in water = 40.5 gf …(2)
Subtract eq. (1) from eq. (2)

Wt. of cork in air – Wt. of cork in water = 62.7 – 40.5 = 22.2 gf

$$\therefore \text{ R.D. of cork} = \frac{\text{Weight of cork in air}}{\text{wt. of cork in air} - \text{wt. of cork in water}}$$

$$= \frac{6}{22.2} = 0.27$$

Question 2.
A solid lighter than water is found to weigh 7.5 gf in air. When tied to a sinker the combination is found to weigh .If the sinker alone weighs 72.5 gf in water, find R.D. of solid.

Answer:
Weight of solid in air = 7.5 gf
Weight of sinker in water = 72.5 gf
Wt. of sinker in water + Wt. of solid in air
= 72.5 + 7.5 = 80.0 gf ...(1)
Wt. of solid in water + Wt. of sinker in water = 62.5 gf ...(2)
Subtract eq. (1) from eq. (2)
Wt. of solid in air – Wt. of solid in water = 80- 62.5 = 17.5 gf.

$$\therefore \text{ R.D. of solid} = \frac{\text{Weight of solid in air}}{\text{Wt. of solid in air} - \text{Wt. of solid in water}}$$

$$= \frac{7.5}{17.5} = 0.428$$

Practice Problems 5:

Question 1.
An aluminium cube of side 5 cm and RD. 2.7 is suspended by a thread in alcohol of relative density 0.80. Find the tension in thread.

Answer:
Side of an aluminium cube = l = 5 cm
Volume of aluminium cube = V = Z^3 = $(5)^3$ =125 cm^3
Relative density of aluminium = R.D. = 2.7
Relative density of alcohol = R.D. = 0.80
Density of water = 1 g cm^{-3}

$$\text{R.D. of aluminium} = \frac{\text{Density of aluminium}}{\text{Density of water}}$$

$$2.7 = \frac{\text{Density of aluminium}}{1}$$

Density of aluminium $= \rho = 2.7 \text{ g cm}^{-3}$
Mass of aluminium = V x ρ
m = 125 x 2.7 = 337.5 g
Wt. of aluminium cube acting downwards = 337.5 gf
Volume of alcohol displaced = Volume of cube = V = 125 cm^3
Upthrust due to alcohol = V x $\rho_{alcohol}$ x g

$$\text{Now R.D. of alcohol} = \frac{\rho_{alcohol}}{\text{Density of water}}$$

$$0.80 = \frac{\rho_{alcohol}}{1}$$

$$\rho_{alcohol} = 0.80 \text{ g cm}^{-3}$$

$\Rightarrow$ Upthrust due to alcohol $= V \times \rho_{alcohol} \times g$
$= 125 \times 0.80 \times g = 100$ gf
So tension in thread = Wt. of aluminium cube – Upthrust
$= 337.5 - 100 = 237.5$ gf

Question 2.
A cube of lead of side 8 cm and R.D. 10.6 is suspended from the hook of a spring balance. Find the reading of spring balance. The cube is now completely immersed in sugar solution of R.D. 1.4. Calculate the new reading of spring balance.

Answer:
Length of side of cube = l = 8 cm
Volume of cube $= \beta = (8)^3 = 512 \text{ cm}^3$
$V = 512 \text{ cm}^3$
Relative density of lead cube = R.D. = 10.6 Relative density of sugar solution = R.D. 1.4

Density of water = 1 g cm^{-3}

$$\text{R.D. of lead} = \frac{\text{Density of lead}}{\text{Density of water}}$$

$$10.6 = \frac{\rho_{lead}}{1}$$

$\rho_{lead} = 10.6 \times 1 = 10.6\ gcm^{-3}$

Mass of lead = m = V × ρ_{lead}

m = 512 × 10.6 = 5427.2 g

Wt. of led cube = mg

= 5427.2 × g = 5427.2 gf

Volume of sugar solution displaced = Volume of lead cube

= V = 512 cm^3

$$\text{R.D. of sugar solution} = \frac{\text{Density of sugar solution}}{\text{Density of water}}$$

$$1.4 = \frac{\rho_{sugar}}{1}$$

$\rho_{sugar} = 1.4 \times 1 = 1.4\ g\ cm^{-3}$

Upthrust due to sugar solution = $V \times \rho_{sugar} \times g = 512 \times 1.4 \times g$

= 716.8 g = 716.8 gf

Now reding of spring balance = Actual weight – Upthrust

= 5427.2 – 716.8 = 4710.4 gf

Practice Problems 1:

Question 1.

A hollow cylinder of copper of length 25 cm and area of cross-section 15 cm^2, floats in water with 3/5 of its length inside water. Calculate :

(1) apparent density of hollow copper cylinder.

(2) wt. of cylinder.

(3) extra force required to completely submerge it in water.

Answer:
(1) Length of hollow cylinder of copper = h_{cu}= l= 25 m
Length of hollow cylinder of copper inside water

$$= h_{water} = \frac{3}{5} l$$

$$h_{water} = \frac{3}{5} \times 25$$

$$h_{water} = 15 \text{ cm}$$

Area of cross-section of hollow cylinder of copper = 15 cm^2
Density of water = ρ_{water} = 1 g cm^{-3}
Apparent density of hollow copper cylinder = ρ_{cu} = ?
By law of flotation :

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

$$25 \times \rho_{cu} = 15 \times 1$$

$$\rho_{cu} = \frac{15}{25} = 0.6 \text{ g cm}^{-3}$$

(2) Volume of cylinder = V = A × h_{cu} = 15 × 25 = 375 cm^3
Mass of hollow cylinder of copper = V × ρ_{cu}

$$m = Ah_{cu} \times \rho_{cu}$$

$$m = 15 \times 25 \times 0.6$$

$$m = 225 \text{ g}$$

Weight of hollow cylinder of copper = mg

$$= 225 \times g = 225 \text{ gf}$$

(3) Total upthrust when hollow copper cylinder is completely immersed in water = V ρ_{water} g

$$= 375 \times 1 \times g = 375 \text{ gf}$$

Extra force requird to submerge complete the cylinder in water = Upthrust – down thrust

$$= 375 - 225 = 150 \text{ gf}$$

Question 2.
A cork cut in the form of a cylinder floats in alcohol of density 0.8 gcm^{-3}, such that 3/4 of its length is outside alcohol. If the total length of cylinder is 35 cm and area of cross-section 25 cm^2, calculate :
(1) density of cork

(2) wt. of cork
(3) extra force required to submerge it in alcohol

Answer:

(1) Density of alcohol = $\rho_{alcohol}$ = 0.8 g cm^{-3}
Total length of cork cylinder = h_{cork} = 35 cm
Area of cross-section of cork cylinder = A = 25 cm^2

$\because$ $\frac{3}{7}$ of the length of cork cylinder is outside the alcohol

$\therefore$ Length of cork cylinder inside alcohol = $\left(1-\frac{3}{7}\right)l$

$$h_{alcohol} = \frac{7-3}{7} \times 35$$

$$h_{alcohol} = 4 \times 5 = 20 \text{ cm}$$

Density of water = ρ_{water} = 1 g cm^{-3}
By law of floatation :
$h_{cork} \times \rho_{cork} = h_{alcohol} \times \rho_{alcohol}$
$35 \times \rho_{cork} = 20 \times 0.8$

$$\rho_{cork} = \frac{20 \times 0.8}{35} = 0.457 \text{ g cm}^{-3}$$

(2) Volume of cork = V = A h_{cork}
V = 25 × 35 = 875 cm^3
Mass of cork = m = V × ρ_{cork}
m = 875 × 0.457
m = 399.9 g $\simeq$ 400 g
Wt. of cork = mg = 400 × g = 400 gf

(3) Total upthrust when cork is completely immersed in water
= V $\rho_{alcohol}$ × g
= 875 × 0.8 × g = 700 g = 700 gf

Extra force required to submerge complete the cork in alcohol = Upthrust – down thrust
= 700 – 400 = 300 gf

Practice Problems 2:

Question 1.
A cylinder made of copper and aluminium floats in mercury of density 13.6 gem^{-3}, such that 0.26th part of it is below mercury. Find the density of solid.

Answer:
Density of mercury = ρ_{Hg} =13.6 $g.cm^{-3}$
Density of solid cylinder = ρ_{solid} = ?
0.26th part of the cylinder is below mercury
Let V_{solid} = Volume of solid cylinder
Volume of mercury displaced by immersed part of the solid cylinder

$$= V_{Hg} = 0.26\ V_{Solid}$$

By law of floatation :
Weight of the solid cylinder = Weight of mercury displaced by immersed part of solid cylinder

$$V_{solid} \times \rho_{solid} \times g = V_{Hg} \times \rho_{Hg} \times g$$
$$V_{solid} \times \rho_{solid} = 0.26\ V_{solid} \times 13.6$$

$$\rho_{solid} = 0.26 \times 13.6$$
$$\rho_{solid} = 3.536\ gcm^{-3}$$

So, density of solid = 3.536 $g\ cm^{-3}$

Question 2.
An iceberg floats in sea water of density 1.17 g cm^{3}, such that 2/9 of its volume is above sea water. Find the density of iceberg.

Answer:
Density of sea water =ρ_w = 1.17 g cm^{-3}

Density of solid ice berg $=\rho_i$ = ?

$\frac{2}{9}$th volume of iceberg is above the sea water

$\therefore$ Volume of iceberg inside water $= V_i = \left(1-\frac{2}{9}\right)V$

Where V = Total volume of iceberg

$\Rightarrow V_i = \frac{9-2}{9}V = \frac{7}{9}V$

$\Rightarrow$ Volume of sea water displaced by immersed partof the iceberg

$= V_w = \frac{7}{9}V$

By law of floatation :

Weight of iceberg = Weight of sea water displaced by iceberg

$V_i \times \rho_i \times g = V_w \times \rho_w \times g$

$V \times \rho_i = \frac{7}{9}V \times 1.17$

$\Rightarrow \rho_i = \frac{7}{9} \times 1.17 = 0.91\ gcm^{-3}$

$\Rightarrow$ Density of iceberg = $0.91\ g\ cm^{-3}$

Practice Problems 3:

Question 1.
A wooden block floats in alcohol with 3/8 of its length above alcohol. If it is made to float in water, what fraction of its length is above water? Density of alcohol is $0.80\ g\ cm^{-3}$.

Answer:
Let length of wooden block = x

Let length of wooden block = x

$\therefore$ Length of the block above alcohol = $\frac{3}{8}x$

Length of the block below alcohol = $x - \frac{3}{8}x = \frac{8x-3x}{8} = \frac{5x}{8}$

Density of water = ρ_w = 1 gcm^{-3}

Density of alcohol = $\rho_{alcohol}$ = 0.80 gcm^{-3}

By the law of floatation :

$h_{block} \times \rho_{block} = h_{alcohol} \times \rho_{alcohol}$

$x \times \rho_{block} = \frac{5x}{8} \times 0.80$

$\rho_{block} = \frac{5}{8} \times 0.80$

$\rho_{block} = 0.5$ gcm^{-3}

When block is floating in water :

By law of floatation :

$h_{block} \times \rho_{block} = h_{water} \times \rho_w$

$x \times 0.5 = h_{water} \times 1$

$h_{water} = 0.5\,x$ or $\frac{1}{2}x$

So, length of block below water = $\frac{1}{2}x$

Length of block above water = $x - \frac{1}{2}x = \frac{x}{2}$

Fraction of the block above the water = $\frac{x}{2} \times \frac{1}{x} = \frac{1}{2}$ part

$\Rightarrow \frac{1}{2}$th part of wooden block is above the water.

Question 2.

A hollow metal cylinder of length 10 cm floats in alcohol of density 0.80 g cm^{-3}, with 1 cm of its length above it. What length of cylinder will be above copper sulphate solution of density 1.25 g cm^{-3}?

Answer:
Length of hollow metal cylinder = x= 10 cm
1 cm length of cylinder is above the alcohol
∴Length of the cylinder below alcohol = (10-1) = 9cm
Density of alcohol =$\rho_{alcohol}$ = 0.80 g cm^{-3}
Density of copper sulphate solution = ρ_{CuS04} = 1.25 g cm^{-3}
When block floats in alcohol By the law of floatation :

$$h_{block} \times \rho_{block} = h_{alcohol} \times \rho_{alcohol}$$
$$10 \times \rho_{block} = 9 \times 0.80$$
$$\rho_{block} = \frac{9 \times 0.80}{10} = 0.72 \text{ g cm}^{-3}$$

When block is floats in copper sulphate solution :

By law of floatation :

$$h_{block} \times \rho_{block} = h_{CuSO4} \times \rho_{CuSO4}$$
$$10 \times 0.72 = h_{CuSO4} \times 1.25$$
$$h_{CuSO4} = \frac{7.2}{1.25} = 5.76 \text{ cm}$$

Length of metal block below copper sulphate solution = 5.76 cm
So, length of metal block above copper sulphate solution
= 10 – 5.76 = 4.24 cm

Practice Problems 4:

Question 1.
What fraction of an iceberg of density 910 kgm^{-3} will be above the surface of sea water of density 1170 kgm^{-3}?

Answer:
Let volume of iceberg = V_i = x
Volume of iceberg inside sea water = V_w
Density of iceberg = ρ_i = 910 kmg^{-3}
Density of sea waer = ρ_w = 1170 kgm^{-3}
By law of floatation:
Weight of icebeig = Weight of sea water displaced by the iceberg

$$V_i \times \rho_i \times g = V_w \times \rho_w \times g$$
$$x \times 910 = V_w \times 1170$$

$$V_w = x \times \frac{910}{1170}$$

$$V_w = \frac{7}{9}x = \frac{7}{9}x$$

Volume of iceberg inside sea water = Volume of sea water displaced by iceberg

$$= V_w = \frac{7}{9}x = \frac{7}{9}x$$

Volume of iceberg above the sea water $= x - \frac{7}{9}x$

$$= \left(1 - \frac{7}{9}\right)x = \frac{9-7}{9}x$$

$$= \frac{2}{9} \times \text{Volume of iceberg}$$

Fraction of iceberg above sea water $= \frac{2}{9}x \times \frac{1}{x} = \frac{2}{9}$ part

$\Rightarrow \frac{2}{9}$th part of iceberg is above the sea water.

Question 2.
What fraction of metal of density 3400 kgm^{-3} will be above the surface of mercury of density 13600 kgm^{-3}, while floating in mercury?

Answer:
Density of metal $= \rho_m$ = 3400 kgm^{-3}
Density of mercury = p_{Hg} = 13600 kgm^{-3}
Let volume of metal = x
and volume of metal inside mercury = y
By law of floatation:

Weight of mercury displaced by metal = wt. of metal

$$V_{Hg} = \rho_{Hg} \times g = V_{metal} \times \rho_{metal} \times g$$

$$y \times 13600 = x \times 3400$$

$$y = \frac{3400}{13600} x = \frac{1}{4} x$$

Volume of metal inside mercury = Volume of mercury displaced

$$y = \frac{1}{4} \times \text{Volume of metal}$$

Volume of metal above the surface of mercury $= x - y$

$$= x - \frac{1}{4}x = \left(1 - \frac{1}{4}\right)x = \frac{4-1}{x}x = \frac{3}{4}x$$

Fraction of metal above surface of mercury $= \frac{3}{4} \times \frac{1}{x} = \frac{3}{4}$

$\Rightarrow \frac{3}{4}$ th part of metal lies above the surface of mercury.

Practice Problems 5:

Question 1.
A balloon of volume 1000 m^3 is filled with a mixture of hydrogen and helium of density 0.32 kgm^{-3}. If the fabric of balloon weighs 40 kgf and the density of cold air is 1.32 kgm^{-3}, find the tension in the tope, which is holding the balloon to ground.

Answer:
Volume of balloon = V = 1000 m^3
Density of mixture of hydrogen and helium =ρ = 0.32 kgm^3
Density weight of empty balloon = 40 kgf
Density of cold air = p' = 1.32 kgm^3
Volume of balloon=Volume of mixture of hydrogen and helium gas
= Volume of cold air displaced by balloon
= V= 1000 m^3
Weight of mixture of hydrogen and helium gas in balloon = $V\rho g$
= 1000 x 0.32 x g = 320 kgf
Down thrust = Weight of empty balloon + Weight of mixture of hydrogen and helium gas
= 40+ 320 = 360 kgf
Upthrust = Weight of cold air displaced by balloon = $V\rho' g$
= 1000 x 1.32 x g= 1320kgf

Tension in the rope = Upthrust – downthrust
= 1320-360 = 960 kgf

Question 2.
A balloon of volume 800 cm^3 is filled with hydrogen gas of density 9 x 10^{-5} gem^{-3}. If the empty balloon weighs 0.3 gf and density of air is 1.3 x 10^{-3} gem^{-3}, calculate the lifting power of balloon.

Answer:
Volume of balloon = V = 800 cm^3
Density of hydrogen gas = p_H = 9 x 10^{-5} g cm^{-3}
Weight of empty balloon = 0.3 gf
Density of air = ρ_a = 1.3 x 10^{-3} g cm^{-3}
Weight of hydrogen gas in balloon = $V\rho_H g$
= 800 x 9 x 10^{-5} x g
= 72 x 10^{-3}gf
= 0.072 gf
Volume of balloon = Volume of hydrogen gas in the balloon = Volume of air displaced by balloon.
Downthrust = Wt. of empty balloon + wt. of hydrogen gas in balloon
= 0.3 + 0.072 = 0.372 gf
Upthrust = Wt. of air displaced by balloon
= $V\rho_a g$
= 800 x 1.3 x $1o^{-3}$ x g
= 8 x 1.3 x $1o^{-1}$ x g
= 10.4 x 10^{-1} x g = 1.04 gf
Lifting power of balloon = Upthrust – Down thrust
=1.04-0.372 = 0.668 gf

Question 3.
A balloon of volume 120 m^3 is filled with hot air, of density 38 kg^{-3}. If the fabric of balloon weighs 12 kg, such that an additional equipment of wt. x is attached to it, calculate the magnitude of Density of cold air is 1.30 kgm^{-3}.

Answer:
Volume of balloon = V = 120 m^3
Density of hot air = $\rho_{hot\ air}$ = 0.38 kgm^{-3}
Mass of empty balloon = 12 kg
Weight of the empty balloon = 12 kgf
Weight of the additional equipment attached with the balloon
=x kgf
Density of cold air = $\rho_{coldair}$ = 1.30 Kgm^3
Volume of balloon=Volume of hot air inside the balloon=Volume

of cold air displaced by balloon = V = 120 m^3 Weight of hot air = Vρ_{hotair} g
= 120 x 0.38 x g = 45.6kgf
Weight of empty balloon + Weight of hot air inside the balloon +
Weight of equipment = Downthrust
12 + 45.6 + x = Downthrust
Downthrust = 57.6 + x
Upthrust = Weight of cold air diplaced by balloon
=V$\rho_{coldair}$ g
= 120 x 1.30 xg= 156kgf
By law of floatation :
Downthrust = Upthrust
57.6+x= 156
x= 156-57.6
x =98.4 kgf

Practice Problems 6:

Question 1.
A test tube weighing 17 gf, floats in alcohol to the level P. When the test tube is made to float in water to the level P, 3 gf of the lead shots are added in it. find the R.D. of alcohol.

Answer:
When tube floats in alcohol :
Weight of test tube = 17 gf
By law of floatation :

Weight of alcohol displaced by test tube = Weight of test tube = 17 gf
When tube floats in water :
When test tube is made to float in water to the same level, as in alcohol then 3g lead stones are added in it.
∴ Weight of test tube = 17 gf + 3 gf = 20 gf
Weight of water displaced by test tube = 20 gf
Volume of alcohol displaced = Volume of water displaced

∴ R.D. of alcohol

$$= \frac{\text{Weight of alcohol displaced}}{\text{Weight of equal volume of water displaced}}$$

$$= \frac{17}{20} = 0.85$$

Question 2.
A test tube loaded with lead shots, weighs 150 gf and floats upto the mark X in water. The test tube is then made to float in alcohol. It is found that 27 gf of lead shots have to be removed, so as to float it to level X. Find R.D. of alcohol.

Answer:
When tube floats in water :
Weight of test tube = 150 gf
By law of floatation:
Weight of water displaced = Weight of test tube = 150 gf
When test tube floats in alcohol :
When test tube is made to float in alcohol, then 27 gf of lead shots have to removed, so that it can float upto the same level as in water.
∴Weight of test tube in alcohol = 150 – 27 = 123 gf
By law of floatation:
Weight of alcohol displaced by test tube = Weight of test tube in alcohol = 123 gf
As volume of alcohol displaced = Volume of water displaced
∴ R.D. of alcohol

$$= \frac{\text{Weight of alcohol displaced}}{\text{Weight of equal volume of water displaced}}$$

$$= \frac{123}{150} = 0.82$$

QUESTIONS BASED ON ICSE EXAMINATIONS
(A) Objective Questions

Multiple Choice Questions.
Select the correct option.

1.The force experienced by a body when partially or fully immersed in water is called:
(a) aparent weight
(b) upthrust
(c) down thrust
(d) none of these

2. When a body is floating in a liquid :
(a) The weight of the body is less than the upthrust due to immersed part of the body
(b) The weight of body is more than the upthrust due to the immersed part of the body
(c) The weight of body is equal to the upthrust due to the immersed part of the body
(d) none of the above

3. With the increase in the density of the fluid, the upthrust experienced by a body immersed in it :
(a) decreases
(b) increases
(c) remains same
(d) none of these

4. The apparent weight of a body in a fluid is :
(a) equal to weight of fluid displaced
(b) volume of fluid displaced
(c) difference between its weight in air and weight of fluid displaced
(d) none of the above

5. The phenomenon due to which a solid experiences upward force when immersed in water is called :
(a) floatation
(b) buoyancy
(c) density
(d) none of these

6. When an object sinks in a liquid, its :
(a) buoyant force is more than the weight of object
(b) buoyant force is less than the weight of object
(c) buoyant force is equal to the weight of the object
(d) none of the above

7. The SI unit of density is :
(a) gem^{-3}
(b) $kgem^{-3}$
(c) kgm^{-3}
(d) gm^{-3}

8. When a body is wholly or partially immersed in a liquid, it experiences a buoyant force which is equal to :
(a) volume of liquid displaced by it
(b) weight of liquid displaced by it
(c) both (a) and (b)
(d) none of the above

9. The ratio between the mass of a substance and the mass of an equal volume of water at 4°C is called :
(a) relative density

(b) density
(c) weight
(d) pressure

10. A body has density 9.6 gcm $^{-3}$. Its density in SI system is :
(a) 96 kgm^{-3}
(b) 960 kgm^{-3}
(c) 9600 kgm^{-3}
(d) 96,000 kgm^{-3}
Ans:
Explanation :
Density = 9.6 g cm^{-3}

$$= \frac{9.6}{10^3} \times 10^6 \text{ kgm}^{-3} = 9600 \text{ kgm}^{-3}$$

(B) Subjective Questions

Question 1.
A wooden block floats in water with two third of its volume submerged.
(1) Calculate density of wood.
(2) When the same block is placed in oil, three quarter of its volume is immersed in oil. Calculate the density of oil.
Answer:
(1) Let vol. of wood = V

Vol. of wood submerged $v' = \frac{2}{3}$ V

$$\frac{d_S}{d_w} = \frac{v'}{V} = \frac{\frac{2}{3}V}{V} = \frac{2}{3}$$

$$d_S = \frac{2}{3} d_W = \frac{2}{3} \times 1000 = 667 \text{ kg m}^{-3}$$

but $d_W = 1000$ kg m^{-3}
Density of wood $d_S = 667$ kg m^{-3}

(2) Now $\frac{d_S}{d_L} = \frac{v'}{V}$

$$\frac{\frac{2000}{3}}{d_L} = \frac{\frac{3}{4}V}{V} = \frac{3}{4} \Rightarrow \frac{2000}{3d_L} = \frac{3}{4}$$

$$\Rightarrow d_L = \frac{2000 \times 4}{3 \times 3} = \frac{8000}{9} = 889 \text{ kg m}^{-3}$$

$\therefore$ Density of oil = 889 kg m^{-3}

Question 2.
A.metal cube of 5cm edge and relative density 9 is suspended by a thread so as to be completely immersed in a liquid of relative density 1.2. Find the tension in the thread.

Answer:
Volume of metal cube = $(\text{side})^3 = 5^3 = 125\text{cm}^3$
Density of cube = 9 g cm^{-3}
Weight of cube acting downward = mg = v × d
$F_1\downarrow$= 125 x 9 = 1125 gf
Density of liquid d_L– 1.2 g cm^{-3}
.’. Upthrust due to liquid in the upward direction.
$F_2\uparrow$ = v d_L= 125 x 1.2 = 150.0 gf Tension in the string = Net downward force = $F_1 - F_2$
= 1125- 150 = 975 gf= 9.75 N

Question 3.
A weather forecasting plastic balloon of volume 15 m^3 contains hydrogen of density 0.09 kgm^{-3}. The volume of equipment carried by the balloon is negligible compared to its own volume. The mass of the empty balloon is 7.15 . kg. The balloon is floating in air of density 1.3 kgm^{-3}.
(1) Calculate the mass of hydrogen in balloon.
(2) Calculate the mass of hydrogen and the balloon.
(3) If the mass of equipment is x kg, write down the total mass of hydrogen, the balloon and the equipment,
(4) Calculate the mass of air displaced by balloon.
(5) Using the law of floatation, calculate the mass of equipment.

Answer:
Volume of Hydrogen V = 15 m^3
Density of hydrogen = d= 0.09 kg m^{-3}
(1) Mass of hydrogen in balloon = Vd= 15 × 0.09
= 1.35 kg
The mass of empty balloon alone = 7.15 kg
(2) The mass of hydrogen and balloon = 1.35 + 7.15
= 8.50 kg
Mass of equipment = x kg
(3) Total mass of hydrogen + Balloon + Equipment
= (8.50 + :c) kg
Density of air = 1.3 kg m^{-3}
(4) Mass of air displaced by balloon = v x d=15 x 1.3
= 19.5 kg
(5) According to law of floatation
Total downward wt. = UPTHRUST

8.5+x= 19.5
Mass of equipment **x = 11 kg**

Question 4.
(a) State the principle of floatation.
(b) The mass of a block made of certain material is 1.35 kg and its volume is 1.5×10^{-3} m^3.

1. Find the density of block.
2. Will this block float or sink? Give reasons for your answer.

Answer:
(a) PRINCIPLE OF FLOATATION : "When a solid is floating in a fluid, the weight of whole solid acting vertically downward at its CENTRE OF GRAVITY, is equal to the weight of fluid displaced by the IMMERSED part of solid acting upward, at its CENTRE OF BUOYANCY or at the centre of the BULK OF LIQUID displaced."

OR

"The weight of a floating body is equal to the weight of the liquid displaced by its SUBMERGED part."

(b) Mass of block = m = 1.35 kg
Volume of block = V = 1.5×10^{-3} m^3

(1) $$\text{Density of block} = \frac{m}{V} = \frac{1.35}{1.5\times10^{-3}} = 900 \text{ kgm}^{-3}$$
(2) Density of block (900 kgm^{-3}) is less than density of water (1000 kgm^{-3})
.'. Block will float in water

Question 5.
(a) State Archimedes' Principle.
(b) A block of mass 7 kg and volume 0.07 m^3 floats in a liquid of density 140 kg/m^3. Calculate :

1. Volume of block above the surface of liquid.
2. Density of block.

Answer:
(a) ARCHIMEDES' PRINCIPLE : "Whenever a body is immersed in a liquid (fluid), wholly or partially, it loses weight equal to the weight of liquid displaced by it."
(b) Mass of block = m = 7 kg

Volume of block = V = 0.07 m^3
Density of liquid =ρ_l = 140 kgm^{-3}
Let V' = Volume of block immersed in the liquid
By law of floatation:
Weight of block = Weight of liquid displaced by the immersed pa

$$V'\rho g = V'\rho_l g$$

$$V' = \frac{\rho}{\rho_l} V$$

$$\text{Density of block} = \rho = \frac{m}{V} = \frac{7}{0.07} = 100 \text{ kg m}^{-3}$$

From (1)

$$V' = \frac{100V}{140} = \frac{5}{7}V = \frac{5}{7} \times 0.7$$

$$V' = \frac{1}{20} = 0.05 \text{ m}^3$$

Volume of block above the surface of liquid = V = V^1

$$= 0.07 - 0.05 = 0.02 \text{ m}^3$$

Question 6.
(a) A body whose volume is 100 cm^3 weighs 1 kgf in air. Find its weight in water.
(b) Why is it easier to swim in sea water than in river water?

Answer:
(a) Volume of body = V = 100 cm^3 = 10^{-4} m^3
Weight of body in air = 1 kgf
Density of water = p_w = 1000 kgm^3
We know volume of water displaced = Volume of body
= V = $10^{-4} m^3$
Upthrust = Weight of water displaced by body = $Vp_w g$
= 10^{-4} x 1000 x g .
= 10^{-1} kgf =0.1 kgf
Weight of body in water=Weight of body in air – Upthrust
= 1-0.1 =0.90 kgf
(b) With smaller portion of man's body submerged in sea water, the wt. of sea water displaced is equal to the total weight of body.
While to displace the same weight of river water, a larger portion of the body will have to be submerged in water. It is easier for man to swim in sea water.

Question 7.
Why does a ship made of iron not sink in water, while an iron nail sinks in it?

Answer:
Density of iron is more than density of water, therefore weight of iron nail is more than wt. of water displaced by it and nail SINKS. While shape of iron ship is made in such a way that it displaces MORE WEIGHT OF WATER than its own weight. Secondly the ship is HOLLOW and THE EMPTY SPACE contains AIR which makes the AVERAGE DENSITY OF SHIP LESS THAN THAT OF WATER and hence ship floats on water.

Question 8.
A solid of density 5000 kgm^{-3} weighs 0.5 kgf in air. It is completely immersed in a liquid of density 800 kgm^{-3}. Calculate the apparent weight of the solid in liquid.

Answer:
Density of solid, d_s = 5000 kg m^{-3}
Weight of body in air = 0.5 kgf
mg = 0.5 kgf
∴ m – 0.5 kg

$$\text{Volume of solid } V = \frac{m}{d_s} = \frac{0.5}{5000} = \frac{1}{10000} \text{ m}^3$$

$$\therefore \text{ Vol. of water displaced} = \frac{1}{10000} \text{ m}$$

$$\text{Density of water} = 800 \text{ kg m}^{-3}$$

$$\therefore \text{ Mass of water displaced} = V \times D$$

$$= \frac{1}{10000} \times 800 = \frac{8}{100} \text{ kg}$$

$$\text{Wt. of water} = 0.08 \text{ kg}$$

(1) Apparent weight of the solid in water = 0.5 – 0.08
= 0.42 kgf
(2) Apparent weight of body in liquid of density 800 kg m^{-3} is zero.
Density of solid is less than density of liquid i.e. upthrust is more than weight of body.

Question 9.
(a) A body dipped in a liquid experiences an upthrust. State the factors on which the upthrust depends
(b) While floating, is the weight of body greater than, equal to or less than upthrust?

Ans.
(a) Factors on which upthrust depends are :

1. Volume of body immersed in fluid.
   Upthrust is maximum when body completely immersed in the fluid.
2. Density of the fluid.
   Upthrust α density of fluid
   Larger the density of the fluid, large will be the upthrust acting on the body.

(b) When the body floats then weight of the body is equal to the upthrust acting on the body.

Question 10.
A sinker is first weighed alone under water. It is then tied to a cork and again weighed under water. In which of the two cases weight under water is less and why?

Answer:
Weight of sinker, when tied to a cork, under water is less than that when it is alone weighed under water. Because cork displaces more water than its own weight and hence large upthrust acts on the sinker.

Question 11.
A solid weighs 105 kgf in air. When completely immersed in water, it displaces 30,000 cm^3 of water, calculate relative density of solid.

Answer:
Weight of solid in air =105 kgf
Volume of solid = Volume of water displaced = 30000 cm^3
= 30000 x 10^{-6} m^3 = 0.03 m^3
p_w = Density of water = 1000 kgm^{-3}
Wt. of water displaced by solid .

$$= V\rho_w g = 0.03 \times 1000 \times g = 30 \text{ kgf}$$

$$\text{R.D. of solid} = \frac{\text{Weight of solid in air}}{\text{Weigh of water displaced by solid}}$$

$$= \frac{105}{30} = 3.5$$

Question 12.
A test tube loaded with lead shots weighs 25 gf and floats upto the mark X in water.

When the test tube is made to float in brine solution, it needs 5 gf more of lead shots to float upto level X. Find the relative density of brine solution.

Answer:
When test tube floats is water :
Weight of test tube = 25 gf
By law of floatation
Weight of water displaced = Weight of test tube = 25 gf
When test tube floats in brine solution, it needs 5 gf more of lead shots to float upto same level as in water.
Weight of test tube = 25 + 5 = 30 gf
By law of floatation :
Weight of brine solution displaced = Weight of test tube = 30 gf As, volume of brine solution displaced = Volume of water displaced

$$\therefore \text{ R.D. of brine solution} = \frac{\text{Weight of brine solution displaced}}{\text{Weight of water displaced}}$$

$$= \frac{30}{25} = 1.2$$

Question 13.
A wooden block is weighed with iron, such that combination just floats in water at room temperature. State your observations when :
(1) water is heated above room temperature
(2) water is cooled below 4°C. Give reasons to your answers in (1) and (2).

Answer:
(1) We know density of water decreases with rise in temperature and hence upthrust decreases.
(2) Density of water is maximum at 4°C. When water cooled below 4°C, then its density and hence upthrust acting on it decreases. So, wooden block weighed with iron, sinks more than earlier.

Question 14
A rubber ball floats in water with 2/7 of its volume above the surface of water. Calculate the average relative density of rubber ball.

Answer:
Let volume of rubber ball = V

Let volume of rubber ball = V

Volume of rubber ball above the water surface = $\frac{2}{7}V$

Volume of rubber ball below the water surface = $V - \frac{2}{7}V$

$$= \frac{7V - 2V}{7} = \frac{5}{7}V$$

$\Rightarrow$ Volume of water displaced by the immersed part of the rubber ball = $\frac{5}{7}V$

by law of floatation :
Volume of rubber ball × density of rubber ball
= Volume of water displaced × density of water

$$V \times \rho = \frac{5}{7}V \times \rho_w$$

But, $\rho_w = 1 \text{ g cm}^{-3}$

$$\Rightarrow V \times \rho = \frac{5}{7}V = 1$$

$$\rho = \frac{5}{7} = 0.71 \text{ g cm}^{-3}$$

$$\text{Average relative density of rubber ball} = \frac{\text{Density of rubber ball}}{\text{Density of water}}$$

$$= \frac{\rho}{\rho_w} = \frac{0.71}{1} = 0.71$$

Question 15.
A cube of ice whose side is 4.0 cm is allowed to melt. The volume of water formed is found to be 58.24 cm^3. Find the density of ice.

Answer:
Side of ice cube = l = 4 cm
Volume of ice cube = V = β = $(4)^3$ = 64 cm^3
Volume of water = V = 5824 cm^3
Density of ice cube = ρ_i= ?
Density of water = ρ_w = 1 gem^{-3}
By law of floatation:
Volume of ice cube x Density of ice=Volume of water x Density of water
64 x ρ_i = 58.24 x 1

$$\rho_i = \frac{58.24}{64}$$

$$\rho_i = 0.91 \text{ g cm}^{-3}$$

Question 16.
A jeweller claims to make ornaments of pure gold of relative density 19.3. A customer buys from him a bangle of weight 25.25 gf. The customer then weighs the bangle under water and finds its weight 23.075 g with the help of suitable calculations explain whether the bangle is of pure gold or not.
[R.D. of gold is 11.61 and bangle is not of pure gold] Ans. R.D of pure gold = 19.3 ...given

Answer:
R.D of pure gold = 19.3

$$\text{Also R.D} = \frac{\text{weight of bangle in air}}{\text{wt. in air} - \text{wt. of bangle in water}}$$

$$\text{R.D of gold} = \frac{25.25}{25.25 - 23.075} = \frac{25.25}{2.175}$$

R.D of gold bangle = 11.75 which is not as 19.3
Hence, gold is not PURE.

Question 17.
(a) When a piece of ice floating in water melts, the level of water inside the glass remains same. Explain.
(b) An inflated balloon is placed inside a big glass jar which is connected to an evacuating pump. What will you observe when the evacuating pump starts working? Give a reason for your answer.

Answer:
(a) A piece of ice displaces an amount of water equal to its own weight. Volume of

water displaced is equal to volume of submerged part of ice cube. When ice cube melts, its volume decreases and gets occupied in that volume of water which is displaced by it. As a result, level of water inside the glass remains same when piece of ice (ice cube) melts.
(b) When evacuating pump starts working, pressure inside the glass jar reduces. As the pressure inside the balloon is more than pressure outside the balloon inside the glass jar, so balloon with burst.

Question 18.
(a) A trawler is fully loaded in sea water to maximum capacity. What will happen to this trawler, if moved to river water? Explain your answer.
(b) A body of mass 50 g is floting in water. What is the apparent weight of body in water? Explain your answer.

Answer:
(a) Density of sea water is more than the density of river water.So river water offers less upthrust to the trawler as compared to sea water.So, when a trawler is fully loaded sea water to maximum capacity, is moved to river water, it will sink.
(b) Mass of body = 50 g
Apparent weight of body = Weight of body in air – Weight of water displaced by body.
But when a body floats, then weight of body in air is equal to the weight of water displaced by the body.
=> Apparent weight of the body = 0

Question 19.
A body of mass 'm' is floating in a liquid of density 'p'
(1) what is the apparent weight of body?
(2) what is the loss of weight of body?

Answer:
Mass of body = m
Density of liquid = ρ
(1) Apparent weight of body = Weight of body in air – Weight of liquid displaces by body.
When a body floats in the liquid, then weight of the body in a liquid is equal to weight of liquid displaced by the body.
=> Apparent weight of body = 0
(2) Loss in weight of body is equal to the weight of liquid displaced by the body.

Question 20.
A block of wood of volume 25 cm^3 floats in water with 20 cm^3 of its volume immersed in water.
Calculate :

(1) density of wood
(2) the weight of block of wood.

Answer:
Volume of wooden block = V = 25 cm^3
Volume of wooden block immersed in water = 20 cm^3
Volume of water displaced by wooden block=volume of wooden block immersed in water = 20 cm^3
Density of water = ρ_{water} = 1 gcm^{-3}
Density of wooden block =ρ_{wood} = ?
By **law of floatation**:
Volume of wooden block x Density of wood=Volume of water displaced x Density of water

$$25 \times \rho_{wood} = 20 \times 1$$

$$\rho_{wood} = \frac{20}{25} = 0.8 \text{ g cm}^{-3}$$

$$\text{Weight of wooden block } V\rho_{wood}\, g = 25 \times 0.8 \times g = 20 \text{ gf}$$

Question 21.
A solid body weighs 2.10 N. in air. Its relative density is 8.4. How much will the body weigh if placed
(1) in water,
(2) in liquid of relative density 1.2?

Answer:
Weight of solid body in air = 2.10 N
R.D. of solid = 8.4

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

$$8.4 = \frac{\rho_{solid}}{\rho_{water}}$$

$$\rho_{solid} = 8.4 \times \rho_{water} = 8.4 \times 1000 = 8400 \text{ kgm}^{-3}$$

(1) $$\text{R.D. of solid} = \frac{\text{Weight of solid in air}}{\text{Weight of water displaced by body}}$$

$$8.4 = \frac{2.10}{\text{Weight of water displaced by body}}$$

$$\text{Weight of water displaced by body} = \frac{2.10}{8.4} = 0.25 \text{ N}$$

Weight of body in water = Weight of body in air – Weight of water displaced by body
= 2.10 -0.25 = 1.85 N

(2) Upthrust due to water = Weight of water displaced by body
= 0.25 N
Upthrust due to liquid = Upthrust due to water ×R.D. of liquid
= 0.25 x 1.2 = 0.30 N
Weight of body in liquid = Weight of body in air – Upthrust due to liquid
= 2.10-0.30= 1.80 N