PHYSICS

BOOKS - ICSE

UPTHRUST IN FLUIDS, ARCHIMEDES' PRINCIPLE AND FLOATATION

EXAMPLES

1. A body weighs 200 gf in air and 190 gf when completely immersed in water. Calculate:

(i) the loss in weight of the body in water.

(ii) the upthrust on the body.

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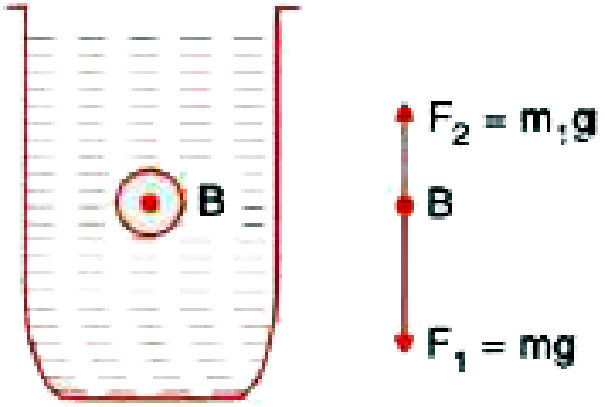
2. A small stone of mass m(=200g) is held under water in a jar and is allowed to fall as shown in fig. the forces acting on stone are also shown.



(i) What does F_2 represent ?

(ii) What does m_1 represent?

(iii) What is the net force acting on stone?

(iv) What is the acceleration of stone as it falls through water? Neglect the force due to viscosity. Assume that the volume of stone $= 80cm^3$, density of water $= 1.0gcm^{-3}$ and acceleration due to gravity $g = 10ms^{-2}$

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3. A piece of iron of density $7.8 \times 10^3 kgm^{-3}$ and volume $100 cm^3$ is completely immersed in water $\left(\rho = 1000 kgm^{-3}\right)$. Calculate (i) the weight of iron piece in air (ii) the upthrust and (iii) its apparent weight in water . $\left(g = 10 ms^{-2}\right)$

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4. A metal cube of side 5 cm and density $7.9gcm^{-3}$ is suspended by a thread and is immersed completely in a liquid of density $1.1gcm^{-3}$, Find (a) the weight of cube (b) the upthrust on cube and (c) the tension in thread. (Take g=10ms−2)

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5. A solid of density ρ has weight W. Show that its apparent weight will be $W[1-(\rho_L/\rho)]$

when it is completely immersed in a liquid of densilty ρ_L.

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6. Relative density of silver is 10.5. What is the density of silver in S.I. unit? What assumption do you make in your calculations.

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7. A Solid weighs 50 gf in air and 44 gf when completely immersed in water. Calculate:

(i) the upthrust,

(ii) the volume of the solid, and

(iii) the relative density of the solid.

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8. A solid weighs 30 gf in air and 26 gf when completely immersed in a liquid of relative

density 0.8. Find : (i) the volume of solid, and (ii) the relative density of solid.

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9. A solid body weighs 2.10 N in air. Its relative density is 8.4. How much will the body weigh if placed

(i) in water

(ii) in a liquid of relative density 1.2?

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10. A body weighs 82.1 gf in air, 75.5 gf in water and 73.8 gf in a liquid. A. Find the relative density of the liquid. B. How much will it weigh if immersed in a liquid of relative density 0.87 ?

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11. A block of wood of volume $25cm^3$ floats on water with $20cm^3$ of its volume immersed. Calculate (i) the density, and (ii) the weight of block of wood.

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12. A block of iron floats on mercury. Find the fractionof volume which remains immersed in mercury. (Densities of iron and mercury are $7.8gcm^{-3}$ and $13.6gcm^{-3}$ respectively).

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13. An iceberg floats on fresh water with a part of it outside the water surface. Calculate the

fraction of the volume of the iceberg which is below the water surface.

Given : density of ice $= 917 kgm^{-3}$, density of fresh water $= 1000 kgm^{-3}$

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14. A block of wood floats on water with $\frac{2}{5}$ th of its volume above the water surface. Calculate the density of wood.

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15. A piece of wood of volume $200cm^3$ and density $0.84gcm^{-3}$ floats in a liquid of density $1.05gcm^{-3}$

(i) What volume of wood will remain above the surface of liquid?

(ii) What force must be exerted on wood to keep it totally submerged?

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16. The volume of a balloon is $1000m^3$. It is filled with helium of density $0.18kgm^{-3}$. What

maximum load can it life. Density of air is $1.29 kgm^{-3}$

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17. Two identical blocks A and b of different materials float on water such that 90% of A and 15% of B remain submerged inside water. Compare:

(i) density of A and B.

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EXERCISE 5(A)

1. What do you understand by the term upthrust of a fluid?

Describe an experiment to show its existence.

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2. In what direction and at what point does the buoyant force on a body due to a liquid, act?

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3. What is meant by the term buoyancy?

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4. Define upthrust and state its S.I. unit.

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5. What is the cause of upthrust? At which point it can be considered to act?

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6. Why is a force needed to keep a block of wood inside water?

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7. A piece of wood if left under water, comes to the surfce. Explain the reason.

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8. Describe an experiment to show that a body immersed in a liquid appears lighter than it really is.

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9. Will a body weigh more in air or in vacuum when weiged with a spring balance? Give a reasonfor you answer.

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10. a metal solid cylinder tied ot a thread is hanging from the hook of a spring balance. The cylinder is gradually immersed into water contaned in a jar. What changes do you expect in the readings of spring balance? Explain your answer.

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11. A body dipped into a liquid experiences an upthrust. State two factors on which upthrust on the body depends.

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12. How is the upthrust related to the volume of the body submerged in a liquid?

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13. A bunch of feathers and a stone of the same mass are released simultaneously in air. Which will fall faster and why? How will your observation be different if they are released simultaneously in vacuum?

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14. A body experiences an upthrust F_1 in river water and F_2 in sea water when dipped up to the same level.

Which is more F_1 or F_2?Give reason

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15. A small block of wood is held completely immersed in (i) water (ii) glycerine and then

released. In each case, what do you observe? Expain the difference in your observation in the two cases.

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16. A body of volume V and density ρ is kept completely immersed in a liquid of density ρ_L. If g is the acceleration due to gravity, write expressions for the following

(i) the weight of the body.

(ii) the upthrust on the body.

(iii) the apparent weight of the body in liquid,

(iv) the loss in weight of the body.

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17. A body held completely immersed inside a liquid experiences two forces: (i) F_1, the force due to gravity and (ii) F_2 the buoyant force. Draw a diagram showing the direction of these forces acting on the body and state the conditions when the body will float or sink.

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18. Complete the following sentences:

Two balls, one of iron and the other of aluminium experience the same upthrust when dipped completely in water if.....

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19. Complete the following sentences:

An empty tin container with its mouth closed has an average denstiy equal to that of a liquid. The container is taken 2 m below the

surface of that liquid and is left there. Then the container will.....

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20. Complete the following sentences:

A piece of wood is held under water. The upthrust on it will be .....the weight of the wood piece.

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21. Prove that the loss in weight of a body when immersed wholly or partially in a liquid is equal to the buoyant force (or upthrust) and this loss is because of the difference in pressure exerted by liquid on the upper and lower surfaces of the submerged part of the body.

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22. A sphere of iron and another of wood the same radius are held under water. Compare the upthrust on the two spheres.

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23. A shpere of iron and another of wood, both of same radius are placed on the surface of water. State which of the two will sink? Give reason to your answer.

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24. How does the density of material of a body determine whether it will float or sink in water?

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25. A body of density ρ is immersed in a liquid of density ρ_L.State condition when the body will (i) float (ii) sink in liquid.

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26. It is easier to lift a heavy stone under water than in air. Explain.

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27. State Archimedes, principle.

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28. Describe an experiment to verify Archimedes' principle.

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EXERCISE 5(A) (Multiple Choice Question)

1. A body will experience minimum upthrust when it is completely immersed in

A. turpentine

B. water

C. glycerine

D. mercury

Answer: A

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2. The S.I. unit of upthrust is

A. Pa

B. Na

C. kg

D. kgm^2

Answer: A::B

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3. A body of density ρ sinks in a liquid of density ρ_L.The densities ρ and ρ_L are related as:

A. $\rho = \rho_L$

B. $\rho < \rho_L$

C.

D. nothing can be said

Answer: C

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EXERCISE 5(A) (Numerical)

1. A body is volume $100cm^3$ weighs 5 kgf in air. It is completely immersed in a liquid of density $1.8 \times 10^3 kgm^{-3}$. Find (i) the upthrust due to liquid and (ii) the weight of the body in liquid.

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2. A body weighs 450 gf in air and 310 gf when completely immersed in water. Find:

(i) the volume of the body

(ii) the loss in weight of the body, and

(iii) the upthrust on the body. State the assumption made in part (i)

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3. You are provided with a hollow iron ball A of volume $5cm^3$ and mass 12 g and a solid iron

ball B of mass 12 g. Both are plced on the surface of water contained in a largetub. A. Find upthrust on each ball. B. Which ball will sink? Give reason for your answer. (Density of iron $= 8.0gm^{-3}$)

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4. A solid of densit $5000kgm^{-3}$ weights 0.5 kgf in air. It is completely immersed in water of density $1000kgm^{-3}$. Calculate the apparent weight of the solid in water.

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5. Two spheres A and B each of volume $100cm^3$ are placed on water (density $= 1.0cm^{-3}$) . The sphere A is made of wood of density $0.3gcm(-3)$). The sphere A is made of wood of density $0.3gcm^{-3}$ and the sphere B is made of iron of density $8.9gcm^{-3}$.

a. Find: (i) the weight of each sphere and (ii) the upthrust on each sphere.

(b) Which sphere will float? Give reason.

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6. The mass of a block made of certain material is 13.5 kg and its volume is $15 \times 10^{-3} m^3$. Calculate upthrust on the block if it is held fully immersed in water.

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7. A piece of brass weighs 175 gf in air and 150 gf when fully immersed in water. The density of water is $1.0 gcm^{-3}$. (i) What is the volume of the brass piece ?

(ii) Why does the brass piece weigh less in water?

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8. A metal cube of edge 5 cm and density $9.0cm^{-3}$ is suspended by a thread so as to be completely immersed in a liquid of density $1.2gcm^{-3}$. Find the tension in thread. (Take $g = 10ms^{-2}$)

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9. A block of wood is floating on water with its dimensions $50cm \times 50cm \times 50cm$ inside water. Calculate the buoyant force acting on the block. Take $g = 9.8Nkg^{-1}$

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10. A body of mass 3.5 kg displaces $1000cm^3$ of water when fully immersed inside it. Calculate : (i) the volume of body (ii) the upthrust on body and (iii) the apparent weight of body in water.

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EXERCISE 5(B)

1. Define the term density.

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2. What are the units of density in (i) C.G.S and (ii) S.I. system?

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3. Express the relationship between the C.G.S. and S.I. units of density.

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4. The density of iron is $7800 \mathrm{kg\ m^{-3}}$. What do you understand by this statement?

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5. Write the density of water at $4^{\circ} C$.

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6. How are the (i) mass, (ii) volume, and (iii) densilty of a metallic piece affected, if at all with increase in temperatur?

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7. Water is heated from $0^{\circ}C$ ato $10^{\circ}C$. How does the density of water change with temperature?

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8. Complete the following sentences:

(i) Mass = ... $\times$ density

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9. Complete the following sentences:

S.I. unit of density is.....

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10. Complete the following sentences:

Density of water is .....kgm^{-3}

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11. Complete the following sentences:

Density in kgm^{-3}= ..... $\times$ density in gcm^{-3}

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12. What do you understand by the term relative density of a substance?

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13. What is the unit of relative density?

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14. Differentiate between density and relative density of a substance.

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15. With the use of Archimedes' Principle, state how you will find relative density of a solid denser than water and insoluble in it. How will

you modify your experiment if the solid is soluble in water?

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16. A body weighs W gf in air and W_1 gf when it is completely immersed in water. Find (i) volume of the body (ii) upthrust on the body. (iii) relative density of material of the body.

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17. Describe an experiment, using Archimedes' principle, to find relative density of a liquid.

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18. A body weighs W_1 gf in air and when immersed in a liquid, it weighs W_2 gf, while it weighs W_3 gf on immersing it in water. Find (i) Volume of the body (ii) upthrust due to liquid (iii) relative density of the solid and (iv) relative density of the liqudi.

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EXERCISE 5(B) (Multiple Choice Question)

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

A. air

B. mercury

C. water

D. iron

Answer: C

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2. What is the unit of relative density?

A. gcm^{-3}

B. kgm^{-3}

C. m^3kg^{-1}

D. no unit

Answer: D

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3. The density of water is :

A. $1000gcm^{-3}$

B. $1kgm^{-3}$

C. $1gcm^{-3}$

D. None of these

Answer: C

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EXERCISE 5(B) (Numerical)

1. The density of copper is $8.83 gcm^{-3}$. Express it in kgm^{-3}.

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2. The relative density of mercury is 13.6. State its density in (i) C.G.S unit (ii) S.I. unit.

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3. The density of iron is $7.8 \times 10^3 \mathrm{kg\,m^{-3}}$

What is its relative density?

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4. The relative density of silver is 10.8. Find its density.

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5. Calculate the mass of a body whose volume is $2m^3$ and relative density is 0.52

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6. Calculate the mass of air in a room of dimensions 4.5 m x 3.5 m x 2.5 m if the density of air at N.T.P. is $1.3\mathrm{kgm}^{-3}$

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7. A piece of stone of mass 113 g sinks to the bottom in water contained in a measuring cylinder and water level in cylinder rises from 30 ml to 40 ml. Calculate R.D. of stone.

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8. A body of volume $100cm^3$ weighs 1 kgf in air. Find (i) its weight in water and (ii) its relative density

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9. A body of mass 70kg, when completely immersed in water, dispaces $20{,}00 cm^3$ of water. Find : (i) the weight of body in water and (ii) the relative density of material of body.

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10. A solid weighs 120 gf in air and 105 gf when it is completely immersed in water. Calculate the relative density of solid.

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11. A solid weighs 32 gf in air and 28.8 gf in water.

Find the volume of solid

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12. A body weighs 20 gf in air and 18.0 gf in water. Calculate relative density of the material of body.

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13. A solid weighs 1.5 kgf in air and 0.9 kgf in a liquid of density $1.2 \times 10^3 kgm^{-3}$. Calculate R.D. of solid.

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14. A jeweller claims that he makes ornaments of pure gold that has a relative density of 19.3. He sells a bangle weighing 25.25 gf to a person. The clever customer weighs the bangle when immersed in water and finds that

it weighs 23.075 gf in water. With the help of suitable calculations, find out whether the ornament is made of pure gold or not.

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15. A piece of iron weighs 44.6 gf in air. If the density of iron is $8.9 \times 10^3 kgm^{-3}$, find the weight of iron piece when immersed in water.

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16. A piece of stone of mass 15.1 g is first immersed in a liquid and it weighs 10.9 gf. Then on immersing the piece of stone in water, it weighs 9.7 gf. Calculate the weight of the piece of stone in air

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EXERCISE 5(c)

1. State the principle of floatation.

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2. When a piece of wood is suspended from the hook of a spring balance, it reads 70 gf. The wood is now lowered into water.What reading do you expect on the scale of spring balance?

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3. A solid iron ball of mass 500 g is dropped in mercury contained in a beaker.

Will the ball float or sink? Give reasons.

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4. How does the density of material of a body determine whether it will float or sink in water?

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5. Explain why an iron nail floats on mercury, but it sinks in water.

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6. A body floats in a liquid with a part of it submerged inside liquid. Is the weight of floating body greater than, equal to or less than upthrust?

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7. A homogeneous block floats on water a. Partly immersed b. completely immersed. In

each case state the position of centre of buoyancy B with respect to the centre of gravity G of the block.

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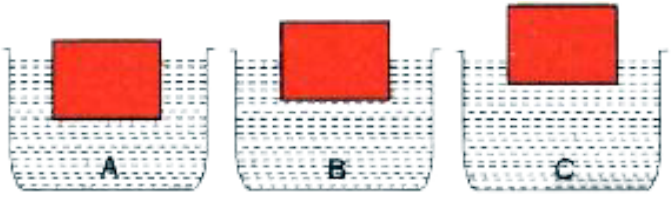
8. Fig shows the same block of wood floating in three different liquids A,B and C of densities ρ_1, ρ_2 and ρ_3 respectively. Which liquid has the highest density? Give reason for your

answer.



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9. What is the centre of buoyancy? State its position for a floating body with respect to the centre of gravity of the body.

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10. A balloon filled with helium gas floats in a big closed jar which is connected to an evacuating pump. What will be your observation, if air from jar is pumped out? Explain your answer.

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11. A block of wood is so loaded it just floats in water at room temperature. What change will occur in the state of floatation, if

a. some salt is added to water

b.water is heated?

Give reason

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12. A body of volume V and density P_S, floats with volume v inside a liquid of density P_L . Show that

$$\frac{v}{V} = \frac{P_S}{P_L}$$

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13. Two identical pieces, one of ice (density $= 900 kgm^{-3}$) and other of wood (density $= 300 kgm^{-3}$) float on water.

a. Which of the two will have more volume summerged inside water?

b. Which of the two will experience more upthrust due to water?

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14. Why is floating ice less submerged in brine than in water?

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15. A man first swims in sea water and then in river water.

(i) compare the weights of sea water and river water displaced by him.

(ii) Where does he find it easier to swim and why?

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16. An iron nail sinks in water while an iron ship floats on water.Explain the reason.

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17. What can you say about the average density of a ship floating on water in relation to the density of water?

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18. A piece of ice is floating in a glass vessel filled with water. How will the level of water in the vessel change when the ice melts ?

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19. A buoy is held inside water contained in a vessel by tying it with a thread to the base of the vessel. Name the three forces that keep the buoy in equilibrium and state the direction in which each force acts.

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20. A loaded cargo ship sails from sea water to river water? State and explain your observation.

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21. Explain the following:

a. Icebergs floating in sea are dangerous for ships.

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22. Explain the following:

An egg sinks in fresh water, but floats in a strong salt solution.

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23. Explain the following:

A toy balloon filled with hydrogen rises to the ceilling, but if filled with carbon dioxide sinks to the floor.

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24. Explain the following:

As a ship in harbour is being unloaded, it slowly rises higher in water.

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25. Explain the following:

A balloon filled with hydrogen rises to a certain height and then stops rising further.

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26. Explain the following:

A ship submerges more as it sails from sea water to river water.

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EXERCISE 5(c) (Multiple Choice Question)

1. For a floating body, its weight W and upthrust F_B on it are related as

A. $W > F_B$

B. $W < F_B$

C. $W = F_B$

D. nothing can be said

Answer: C

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2. A body of weight W is floating in a liquid. Its apparent weight will be :

A. equal to W

B. less than W

C. greater than W

D. zero

Answer: D

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3. A body floats in a liquid A of density ρ_1 with a part of it submerged inside liquid while in

liquid B of density ρ_2 totally submerged inside liquid. The densities ρ_1 and ρ_2 are related as :

A. $\rho_1 = \rho_2$

B. $\rho_1 < \rho_2$

C. $\rho_1 > \rho_2$

D. nothing can be said

Answer: C

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EXERCISE 5(c) (Numerical)

1. A rubber ball floats on water with its 1/3 rd volume outside water. What is the density of rubber?

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2. A block of wood of mass 24 kg floats on water. The volume of wood is $0.032m^3$ Find

a.the volume of block below the surface of water,

b.the density of wood.

(Denstiy of water $= 1000 kgm^{-3}$)

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3. A wooden cube of side 10 cm has mass 700g What part of it remains above the water surface while floating vertically on the water surface?

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4. A piece of wax floats in brine. What fraction of its volume will be immersed?

Density of wax = $0.95\ \mathrm{g\ cm^{-3}}$,

Density of brine = $1.1\ \mathrm{g\ cm^{-3}}$.

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5. If the density of ice is $0.9gcm^{-3}$, what portion of an iceberg will remain below the surface of water in a sea? (Density of sea water $= 1.1gcm^{-3}$)

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6. A piece of wood of uniform cross section and height 15 cm floats vertically with its height 10 cm in water and 12 cm in spirit. Find the density of (i) wood and (ii) spirit

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7. A wooden block floats in water with two third of its volume submerged. A. Calculate the density of wood.b. When the same block is

placed in oil, three - quarter of its volume in immersed in oil. Calculate the density of oil.

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8. The density of ice is $0.92 g cm^{-3}$ and that of sea water is $1.025 g cm^{-3}$ Find the total volume of an iceberg which floats with its volume $800 cm^3$ above water.

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9. A weather forcecasting plastic balloon of volume $15m^3$ contains hydrogen of density $0.09kgm^{-3}$. The volume of an equipment carried by the balloon is negligible compared to its own volume. The mass of empty balloon alone is 7.15 kg. The balloon is floating in air of density $1.3kgm^{-3}$. Calculate (i) the mass of hydrogen in the balloon. (ii) the mass of hydrogen and balloon, (iii) the total mass of hydrogen, balloonand equipment if the mass of equipment is x kg. (iv) the mass of air

displaced by balloon and (v) the mass of equipment using the law of floatation.

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