Class – IX Chapter - Floatation [Gravitation]

Contents:

Learning Objectives: The students will:

1. Understand the difference between Thrust and Pressure.
2. Apply Pressure to daily life.
3. Explain Pressure in fluids.
4. Understand Buoyancy.
5. Understand and explain Archimedes Principle.
6. Applies Archimedes Principle on floating objects.
7. Understand relation between Density of a Solid and Density of a Liquid.

Key Terms :

1. Thrust 2. Pressure 3. Pascal 4. Buoyancy 5. Archimedes Principle 6. Relative Density

LIST OF PRACTICALS

1. To determine the density of a solid (denser than water) by using spring balance and a measuring cylinder.
2. To establish the relation between loss in weight of a solid when fully immersed in (i) tap water (ii) strongly salty water, with weight of water displaced by it taking at least two different solids.
3. To Calculate the pressure exerted by a wooden block on sand.

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Q. What is weight ?

Answer: Weight is the force acting vertically downwards. weight of an object is the force due to gravitational attraction of the earth.

Q. What is thrust?

Answer: The force acting on an object perpendicular to the surface is called thrust.

The thrust on unit area is called pressure. Thus, Pressure = thrust /area ----------(i)

Substituting the SI unit of thrust and area in Eq. (i), we get,

The SI unit of pressure = N/m^2

In honour of scientist Blaise Pascal, the SI unit of pressure is called Pascal, denoted by " Pa"

Q.What are the factor on which pressure depends on?

Answer: The effect of thrust depends on the area on which it acts[inversely] and magnitude of force[directly]

Q. Define I Pascal?

Answer: One Pascal is pressure act on unit are on application of 1 Newton force OR, A unit of pressure equal to one newton per square meter

Q. Give the reason:

(a) Why does a nail has a pointed tip? (b) Why does a Knife have sharp edges?

(c) Why do buildings have wide foundations?

Answer: (a) This is because the pointed tips on nail distribute thrust (force) on a smaller area and exerts a larger pressure.

(b) This is because the sharp edges of Knife distribute thrust (force) on a smaller area and exerts a larger pressure. This help to cut easily.

(c) This is because wide foundations of buildings distribute thrust (force) on a larger area and exerts a smaller pressure. This prevent sinking in ground.

Q. What is fluid?

Answer: All liquids and gases are called fluids as they can flow. Fluid exerts pressure on the base and walls of the container in which they are enclosed due to its weight. Fluid pressure is transmitted undiminished in all directions.

Q. Upon what factors does liquid pressure depend on ?

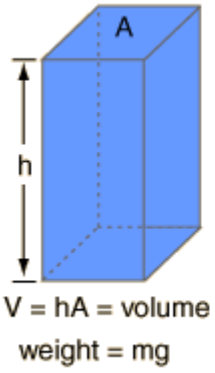
Answer: The pressure exerted by a static fluid depends only upon the depth of the fluid, the density of the fluid, and the acceleration of gravity.

$P = \rho gh$

$\rho = m/V$ = fluid density

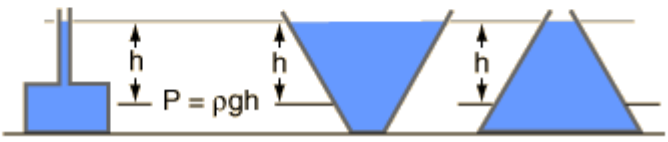
g = acceleration of gravity

h = depth of fluid



Static fluid pressure does not depend on the shape, total mass, or surface area of the liquid.

$$\text{Pressure} = \frac{\text{weight}}{\text{area}} = \frac{mg}{A} = \frac{\rho Vg}{A} = \rho gh$$



Q. What do you mean by buoyancy?

Ans: All objects experience an up thrust when they are immersed in a fluid called a force of buoyancy. The magnitude of this buoyant force depends on the density of the fluid.

Q. Have you ever drawn water from a well and felt that the bucket of water is heavier when it is out of the water? Give reason

Answer: All objects experience an upward force when they are immersed in a fluid. This force is called Force of buoyancy. This buoyancy force makes bucket lighter inside water

Q. In what direction does the buoyant force on an object immersed in a liquid act?

Answer: the buoyant force on an object immersed in a liquid act in upward direction.

Q. Why does a block of plastic released under water come up to the surface of water?

Answer: This is because when the bottle is immersed, the upward force exerted by the water on the bottle that is upthrust is greater than its weight due to gravitational force.

Q. An iron nail sinks and a cork floats when placed on the surface of water. Give reason?

Answer: The cork floats while the nail sinks. This happens because of the difference in their densities.

The density of cork is less than the density of water. This means that the up thrust of water on the cork is greater than the weight of the cork. So it floats

Q. Why does an object float or sink when placed on the surface of water?

Answer: objects of density less than that of a liquid float on the liquid. The objects of density greater than that of a liquid sink in the liquid.

Q. Why is it difficult to hold a school bag having a strap made of a thin and strong string?

Answer: A school bag having a strap made of a thin and strong string distribute weight of bag on small area and exert large pressure This why it is difficult to hold a school bag having a strap made of a thin and strong string?

Q. The elongation of the rubber string due to the weight of a piece of stone suspended from it decreases as the stone is immersed in water why?

Answer: This is due to a force of buoyancy that acts on the stone in upward direction. However, no further change is observed once the stone gets fully immersed in the water.

Q. why a further decrease in the elongation of the string was not observed as the stone was fully immersed in water?

Ans: According to Archimedes' principle the upward force act on a body is maximum when it is completely immersed. The upward force never gets increased or decreased no matter how deep you keep that body in water.

Q. State the Archimedes' principle? Write some application?

Answer: Archimedes' principle is as follows:

When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

Archimedes principle also states that: "When a body is immersed in a liquid, an upward thrust, equal to the weight of the liquid displaced, acts on it."

Thus, when a solid is fully immersed in a liquid, it loses weight which is equal to the weight of the liquid it displaces.

Weight of the solid in air - Weight of solid when immersed in liquid = Loss in weight of the solid.

Loss in weight of the solid = Weight of the liquid displaced

The more the density of liquid in which the solid is immersed, the less is the weight of the liquid displaced on immersing the solid.

Archimedes' principle has many applications. It is used in designing ships and submarines. Lactometers, which are used to determine the purity of a sample of milk and hydrometer used to determining density of liquid.

Q. What do you mean by density and relative density?

Ans: the density of a substance is defined as mass of a unit volume. The unit of density is kilogram per metre cube (kg m–3).

The density of a given sample of a substance can help us to determine its purity . This is because the density of a given substance, under specified conditions, remains the same. Therefore the density of a substance is one of its characteristic properties. It is different for different substances. Density of a substance with respect to the density of water. The relative density has no unit because the relative density is a ratio of similar quantities.

Relative density = Density of a substance /Density of water

When a body is partly or completely in water then:

Loss in weight of the body = Weight of water displaced by the body = Buoyant Force or up-thrust exerted by water on the body.

Volume of the water displaced = Volume of the body immersed in water.

Q. Relative density of silver is 10.8. The density of water is 103 kg/ m^3.What is the density of silver in SI unit?

Answer: Density of silver = Relative density of silver x density of water = 10.8 x 10^3 kg/m^3.

Q. The volume of 50 g of a substance is 20 cm3. If the density of water is 1 g cm^{-3}, will the substance float or sink?

Answer: Density of substance = m/v = 50/20 g cm^{-3} = 2.5 g cm^{-3}

but, the density of water is 1 g cm^{-3}

Since Density of substance is greater than the density of water so it will sink

Q. The volume of a 500 g sealed packet is 350 cm3. Will the packet float or sink in water if the density of water is 1 g cm–3? What will be the mass of the water displaced by this packet?

Answer: Density of substance = m/v = 500/350 g cm^{-3} = 1.42 g cm^{-3}

But, the density of water is 1 g cm^{-3}

Since Density of substance is greater than the density of water so it will sink

Volume of water displaced = volume of substance = 350cm^3

The mass of the water displaced by this packet = density of water x Volume of water displaced

= 1 g cm^{-3} x 350cm^3 = 350gm

Q. Why will a sheet of paper fall slower than one that is crumpled into a ball?

Ans. Unfolded sheet has large surface area as compared to the similar sheet crumpled into a ball. Thus, unfolded sheet will experience more friction due to air as compared to the one crumpled into a ball, no matter same force of gravity acts upon them.

It is the larger friction of air which slows down the unfolded sheet, and hence, it falls slowly as compared to sheet crumpled into a ball

Q. Why does a mug full of water feel lighter inside water?

Ans. Due to the force of buoyancy of water which acts upward on the mug full of water, it feels lighter inside the water.

Q. A perpendicular force of 50 N acting on a surface generates a pressure of 250 Pa. Calculate the area of cross-section of the surface on which pressure is acting.

Ans. Area of cross-section, A = P/F = 250/50=0.2 m^2.

Q. When we stand on loose sand, our feet go deep into the sand. But when we lie down on the sand our body does not go that deep in the sand. Why? [2011 (T-II)]

Ans. Smaller the surface area, more is the pressure exerted for the same amount of force. So when we stand on loose sand, then surface area of contact is smaller, thus our feet go deep into the sand due to larger pressure exerted on the sand. But when we lie down the area of surface of contact is larger thus our body does not go to the deep in the sand due to smaller pressure exerted on the sand.

Q. Why is it easy to walk on sand with flat shoes, than with high heel shoes?

Answer: It is because in case of flat shoes, area of contact is larger than area of contact of high heel shoes. Thus flat shoes exerts less pressure on sand and hence they do not sink in the sand but high heel shoes do sink

Q. Loaded test-tube placed in pure milk sinks to a certain mark (M). Now some water is mixed with the milk. Will the test tube sink more or less? Explain. [2011 (T-II)]

Ans. As density of milk is greater than density of water, so when some water is mixed with milk, then amount of buoyant force is decreased at some extent. Consequently test tube will sink more.

Q.If two equal weights of unequal volumes are balanced in air, what will happen when these are completely dipped in water? [2011 (T-II)]

Ans. In given two equal weights whose volume is greater, then its density is smaller so it exerts larger upwards force by the water. But whose volume is smaller, then its density is greater so it exerts smaller upwards force by the water.

Q. A steel needle sinks in water but a steel ship floats. Explain how. [2011 (T-II)]

Ans. The density of steel needle is greater than density of water so it experiences smaller upward force by the water, this is why it sinks in the water. While density of steel ship is smaller than density of water, so it experiences larger upward force by water, consequently, steel ship floats in water.

Q. A dining hall has dimensions 50 m × 15 m × 3.5 m. Calculate the mass of air in the hall. (Given, density of air = 1.30 kg/m3) [2011 (T-II)]

Ans. Volume of dining hall = 50 m × 15 m × 3.5 m = 2625 m^3

Thus, mass of air in hall = Volume of hall × density of air = 2625 m3 × 1.30 kg/m3 = 3412.50 kg.

Q. Give reason: (a) A truck or a motor bus has much wider tyres (b) we feel lighter when we swim?

Ans. (a) Wider tyres distribute force over large area of contact , and reduce the pressure on the ground.

(b) When we swim in water an upthrust (buoyant) force acts on our body by the water, which reduces our weight, so we feel lighter.

Q. You have a bag of cotton and an iron bar, each indicating a mass of a 100 kg when measured on weighing machine. In reality, one is heavier than the other. Can you say which one is heavier and why? [2010 (T-II)]

Ans. Iron bar is heavier, because it has larger density thus a smaller frictional force acts on it, by the atmosphere while density of bag of cotton is smaller so a larger frictional force acts on it which reduces its weight by a very small amount.

Q. Account for the statement: “camel walks easily on sand but it is difficult for a man to walk on sand though a camel is much heavier than a man”. **[2011 (T-II)]**

Ans. The feet of a camel distribute weight on large surface area and exerts small pressure on the surface of sand .This is why it does not sink in sand. . While feet of a man has very small surface area and distribute weight on small area, so he exerts larger pressure on sand and is likely to sink in sand.

Q. An object of 40 N weight when immersed in water loses 10 N weight. Will the object float or sink? Why?

Ans. Weight of object = 40 N

Buoyant force = Decrease in weight in water = 10 N

Thus, weight of object > Buoyant force, thus, object will sink in water

Q. Why is it easier to swim in sea water than in river water? **[2011 (T-II)]**

Ans. Density of sea water is greater than density of river water. So when one swim in sea water then he experiences a larger buoyant force in comparison to the river water, which makes him easy to swim in sea water.

Q. Lead has greater density than iron and both are denser than water. Is the buoyant force on a lead object greater than, or lesser than or equal to the buoyant force on an iron object of the same volume? Explain your answer giving reason. [2011 (T-II)]

Ans. The buoyant force on a lead object is lesser than the buoyant force on iron object. It is because, lead has greater density so it displaces lesser amount of water, consequently, lesser amount of buoyant force is acting on the lead object in comparison to an iron object.

Q. Why are railway tracks laid on large sized concrete sleepers? Explain. [2011 (T-II)]

Ans. Larger is the surface area of a body, lesser is the pressure it exerts on the ground. As the sleepers increase the area of contact of rail many a times, this reduces the pressure on the surface of ground by the train.

Q. What happens when : [2011 (T-II)]

(a) Buoyant force exerted by the fluid is less than the weight of the body?

(b) Buoyant force exerted by the fluid is equal to the weight of the body?

Ans. (a) Body sinks in the fluid. (b) Body just floats in the fluid.

Q. The relative density of a substance is greater than 1, what does it signify? **[2011 (T-II)]**

Answer: The relative density of a substance is greater than 1 signifies that density of the substance is greater than density of water.

Q. A sphere of mass 5 kg and volume 2.2 × 10–4 m3 is completely immersed in water. Find the buoyant force exerted by water on the sphere. Density of water = 1000 kg/m^3 (Given : g = 9.8 ms–2). **[2011 (T-II)]**

Ans. Here, volume of sphere = Volume of water displaced = 2.2×10^{-4} m^3

(∵ Sphere is completely immersed in water)

Mass of the water displaced = Volume × Density = $2.2 \times 10^{-4} m^3 \times 1000$ kg m–3 = 2.2×10^{-1} kg

Thus, buoyant force exerted by water = weight of water displaced = mg

$= 2.2 \times 10^{-1}$ kg × 9.8 m/s^2 = 21.56 × 10–1 N = 2.156 N

Q. The mass of an empty 40 litre petrol tank of a vehicle is 8.0 kg. What will be its mass when filled completely with a fuel of density 700 kg/m3. **[2011 (T-II)]**

Ans. Volume of petrol tank = 40 litre = 40 ÷1000 m^3 = 1/25 m^3

Density of fuel = 700 kg/m3

Thus, mass of fuel = Volume × Density = 1/25 m3 × 700 kg/m3 = 28 kg

Mass of petrol tank = mass of fuel + mass of tank = 28 kg + 8 kg **=** 36 kg

Q. A bar of gold is found to have a mass of 100 g and weight of 0.98 N at some place. When the bar is taken to some place at the equator, it is found that the mass remains 100 g, but the weight is less than 0.98 N. Explain the above observations.

Ans. (i) The mass of the gold bar is a constant quantity, and hence, will remain same anywhere and everywhere.

(ii) The weight of the gold bar decreases because the acceleration due to gravity is least at the equator. As the weight is the product of mass and acceleration due to gravity, therefore, its value decreases at the equator.

Q. Give reason: An egg sinks in fresh water but floats in highly salty water.

Answer: The density of salt water is more than that of fresh water which results in more buoyancy. This is the reason why an egg shell floats in salt water but sinks in fresh water.

Board Questions

Q, (i) when an object is immersed in a fluid, name the two forces acting on it? (ii) On which factor the magnitude of the upward force acting on this object depends? (iii) When will this object sink?

Ans: (i) when an object is immersed in a fluid, the two forces acting on it are gravitational force and buoyant force

(ii) the upward force acting on this object depends on : Volume of the block and Density of the fluid

(iii) the object will sink when it has a higher density than the fluid in which it is immersed.

Q. A cube of side 5cm is immersed in water and then in saturated salt solution. In which case will it experience a greater buoyant force. If each side of the cube is reduced to 4cm and then immersed in water compare the force experienced by the cube, as compared to the first case. Give reasons for each case.

Answer: When any body floats on the liquid :

the net buoyant force = weight of the liquid displaced ($V\rho g$)

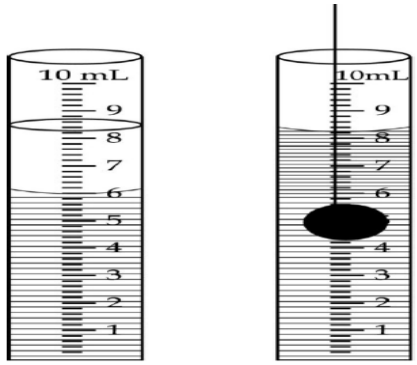
Here $V = a^3$ and ρ is density of the liquid

So the cube will experience a greater buoyant force in the saturated salt solution because the density of the salt solution is greater than that of water.

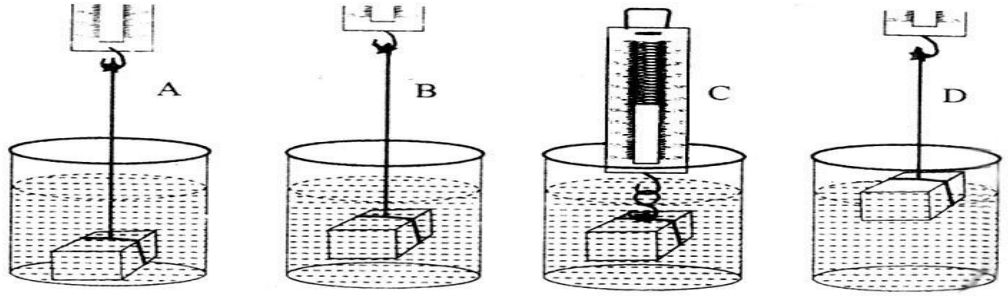
If each side of cube is reduced and then immersed in water, buoyant force will also decrease by above given relation So, the net buoyant force becomes = $V'\rho g$ where V' be the new volume, V = 64 cm3.

The smaller cube will experience lesser buoyant force as its volume is lesser than the initial cube.

Q. The water level in a measuring cylinders, before and after immersing solid in it, is shown in the figure. The volume of the given solid in mL is Ans: 8.2ml-6ml=2.2 ml



Q. The correct experimental set up for determining the mass of a solid in water is shown in figure



(a) A (b) B (c) C (d) D

Ans: (b) B

Note: The solid block should be completely immersed in water of the measuring cylinder before observing its volume. The solid block should not touch the brim and sides of the beaker.

Q. While establishing the relation between the loss in weight of a solid when fully immersed in two liquids of different density, you are provided cubes of aluminium and iron, each of side 4cm and two spring balances. Balance A has a range of 0 – 250g and a least count of 2.5g, while balance B has a range of 0-1000 g and a least count of 10g. The preferred option for mass measurement would be to use balance :

(a) A for both the cubes (b) B for both the cubes

(c) A for the aluminium cube and balance B for iron cube

(d) A for the iron cube and balance B for aluminum cube.

Answer: (C) Density of iron is greater than Aluminum.

Q. While establishing the relation between the loss in weight of a solid when immersed in tap water and strongly salty water, an iron ball is hanged from the hook of a spring balance. It is first kept in air, then fully immersed in tap water and then immersed in salty water. The reading of the spring balance will be

(a) minimum in air (b) minimum when immersed in tap water

(c) minimum when immersed in salty water (d) equal in all the cases.

Ans: (c) minimum when immersed in salty water

Q. To compare the pressure exerted by a solid iron cuboid while resting on its three different faces, a student took an iron block of dimesions 15cm x 12cm x 8cm. He successively places it on the loose sand filled in a tray such that its side of dimensions, (i) 12cmx8cm (ii) 15cm x 8cm (iii) 15cm x 12cm lie on the sand. On the basis of his observations he may conclude that the pressure exerted by the iron cuboid is

(a) maximum when it lies on its side of dimensions 12cm x 8 cm

(b) maximum when it lies, on its side of dimensions 15cmx8cm

(c) maximum when it lies on its side of dimensions 15cm x 12 cm

(d) Same in all the three cases as the thrust is same. Answer: (a)

Note : The depression in sand is greater when the solid iron cuboid is placed on its least surface area. The pressure exerted by the smallest surface area is greater than the other surfaces with larger areas.

Q. If the mass of solid body is doubled, its density:
(a) Becomes twice (b) Becomes half (c) Does not change (d) Becomes four times
Ans: (c) Does not change
Q. Relatively density is same as:
(a) Ratio of mass of a given volume of the substance to the mass of same volume of water at 4°C.
(b) Ratio between density of substance and density of water.
(c) Specific gravity. (d) All of these. Ans: (d) All of these are correct
Q. Which one of the following liquids has the highest density?

(a) Mercury (b) Alcohol (c) Kerosene (d) Water Ans: (c) Mercury is a liquid metal

Q. To compare the pressure exerted by a cuboid, a student was given three cuboid made of iron, aluminium and wood respectively. The dimensions of each cuboid is 20cm x 15cm x10cm. To perform the experiment effectively the student should choose.
(a) aluminium cuboid (b) iron cuboid (c) wooden cuboid (d) any of the three cuboid
Ans: (b)
⇒ **Mass of a body is defined as:** The quantity of matter contained in the body. [*Mass is the measure of quantity of matter]*
Q. Relative density of a substance depends upon:

a) Mass of the substance.
b) Volume of the substance.
c) Shape of the substance.
d) Material of the substance.

Ans : (a) Density of a substance is one of its characteristic properties.

Q. The mass of a solid iron cube of side 4 cm is to be determined. Out of the four spring balances available, the one best suitable for this purpose would have what range? Density of iron is 7.8 g/cc.

a. Range = 0 to 100 g, and least count = 5g b. Range = 0 to 1000 g, and least count = 10g
c. Range = 0 to 100 g, and least count = 1g d. Range = 0 to 100 g, and least count = 25g
Ans: : Mass of the iron cube should come within the range of the spring balance. 4x4x4x7.8 =499.3 here option: b. Range = 0 to 1000 g, and least count = 10g

Q. Q. A body is just floating on the surface of a liquid. Density of the body is same as that of the liquid. The body is slightly pushed down. What will the body do?

a) Sink.
b) Oscillate about its mean position.
c) Float inside the surface of a liquid.
d) Remain floating on the surface of a liquid.

Answer: (a) It would sink

Q. A student is performing the experiment 'To determine the density of solid (denser than water), by using spring balance and measuring cylinder'. During the experiment, he observed that a few air bubbles were sticking to the solid when immersed in water. What will the presence of air bubbles lead to?

(a) No change in density. (b) Increase in density. (c) Decrease in density. (d) None of these.

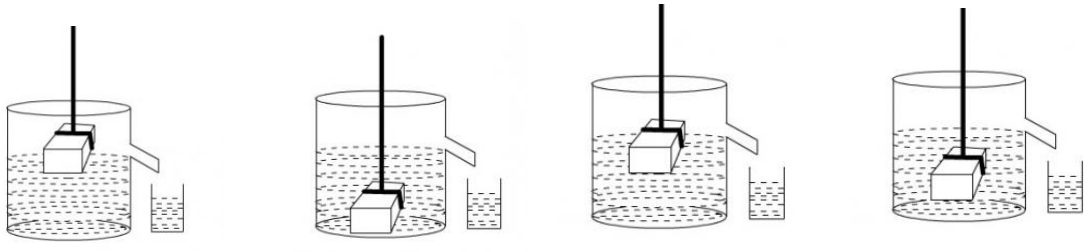
Answer: : Presence of air bubbles will increase the volume of displaced water.(c)

Q. A spring balance read 10 kg when a bucket of water was suspended from it. An iron piece having some mass is suspended by another string and immersed in the bucket with half of its volume. What will the reading of balance be?

(a) Decrease (b) Increase (c) Remains the same (d) Another spring balance needed

Hint: The spring balance reads total mass suspended (b)

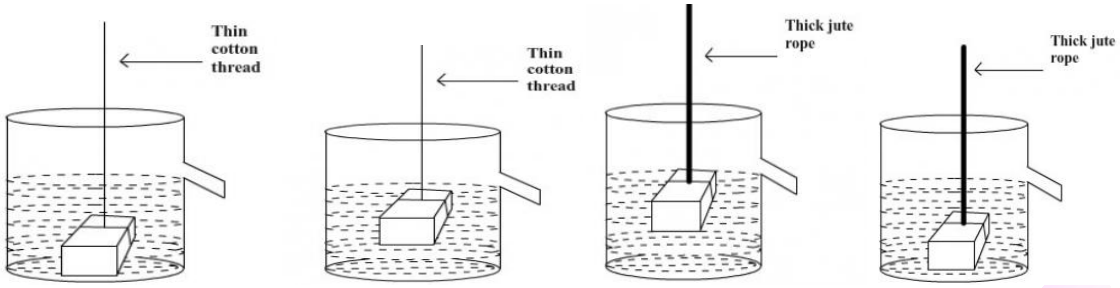
Q. When a body is floating in a liquid, then weight of the body is balanced by the upward thrust of liquid on the body. Due to this, the apparent weight of the body in the liquid is equal to?
(a) Weight of liquid displaced by the body. (b) Zero. (c) Weight of body outside the liquid.
(d) Sum of the weight of liquid displaced and weight of body.
Hint: Apparent weight gives the difference between the weight of body and the upward thrust (b)
Q. **Which is the best set-up for the experiment for measuring the loss of weight of a body immersed in a liquid?**



(A) (B) (C) (D)

Ans: (D) *Hint: The body should not rest or stay outside or partially outside a liquid*

Q. In the experiment to establish the relation between loss in weight of an immersed solid with the weight of water displaced by it, the correct setup is shown in which diagram?



(A) (B) (C) (D)

Ans: (b) The solid must be suspended in the centre of the overflow can and does not touches the bottom

Q. To compare the pressure exerted by a cuboid, a student was given four cuboids. Two cuboids are made of iron of dimensions 20 cm x 15 cm x 10 cm and 15 cm x 10 cm x 5 cm respectively. The other two cuboids are made of aluminium of dimensions 20 cm x 15 cm x 10 cm and 15 cm x 10 cm x 5 cm respectively. To perform the experiment effectively the student should use :

(a) aluminium cuboid of dimension 20 cm x 10 cm x 5 cm.

(b) aluminium cuboid of dimension 15 cm x 10 cm x 5 cm.

(c) iron cuboid of dimension 15 cm x 10 cm x 5 cm.

(d) iron cuboid of dimension 20 cm x 10 cm x 5 cm.

Answer: (c)

Q. compare the pressure exerted by a cuboid, Neha was given four solid cuboids made of plastic, wood, aluminium and brass. The dimensions of each cuboid are 15 cm x 10 cm x 5 cm : To perform the experiment effectively she should choose.

(a) plastic cuboid (b) aluminium cuboid (c) brass cuboid (d) wooden cuboid.

Answer: (b)

Q. A student using spring balance records the weight of a iron cube in air, in tap water and in concentrated solution of common salt in water. If his three readings taken in this order are W1, W2 and W3, he is likely to observe that

(a) W1> W2> W3 (b) W1> W2 = W3

(c) W1> W3> W2 (d) W1 = W2 < W3

Answer: (a) W1> W2> W3