1. Forces of Fluids

Let us assess

1. Question

The weight of a piece of stone in air is 120 N and its weight in water is 10 N. Calculate the buoyancy, experienced by the stone.

Answer

Buoyancy is the upthrust on the immersed body, by the water displaced. It acts in a direction opposite to the weight. So the weight of an immersed object reduces in water, by an amount equal to the upthrust.

Given,

Weight of a piece of stone in air = 120 N

Weight in water = 10 N

Weight in water = Weight in air-Buoyant force

Thus, buoyancy = Weight in air- Weight in water

= 120-10 = 110 N.

2. Question

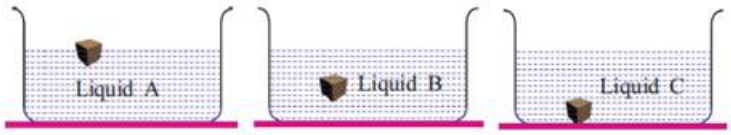
A body which floated in water, sank when put in kerosene. Why did it happen?

Answer

A body floats in a liquid when the buoyant force (weight of displaced liquid) is more than or equal its weight in air. There's a net force in the upward direction. The opposite happens when a body sinks, the weight of the liquid displaced is less than the weight of the body in air. Kerosene is less dense than water. So the same body displaces a greater weight of water than of kerosene, and hence floats in water but sinks in kerosene. The buoyancy is greater in water than in kerosene for a given body.

3. Question

Observe the figures of an object placed in different liquids.



a. Compare the gravitational force and the buoyance acting on the body when it is in the liquids A, B and C.

b. If the body is a solid substance, which is the liquid whose density is equal to that of the solid?

Answer

a. The body sinks deepest in C, less deep in B, and floats in A. So the buoyant force is largest in A, then B and then C; it acts against the weight and pushes the body upward. The gravitational force which acts downward, is thus highest in C, followed by B, followed by A.

b. Liquid A has density equal to the solid. That's why the gravitational force (weight of body in air) is equal to the buoyant force (i.e. the weight of displaced liquid), and the body floats.

4 A. Question

A body of weight 1000 N sinks in water. The weight of the liquid overflowed is 250 N.

What will be the weight of the body in water?

Answer

Given;

Weight of liquid overflowed = Weight of water displaced by the body

= Buoyant force

= 250 N

Weight in air = 1000 N

Weight of the body in water = Weight in air- Buoyant force

= 1000 N-250 N

= 750 N

4 B. Question

A body of weight 1000 N sinks in water. The weight of the liquid overflowed is 250 N.

A body of the same weight as above floats in water. What is its weigh in water? What will be the weight of the water displaced?

Answer

Since it floats in water, the weight of water displaced is equal to its weight in air.

Weight in water = Weight in air-Buoyant force

Since weight of water = buoyant force,

Weight in water = 0.

And weight of water displaced = weight in air = 1000 N.

5. Question

The area of one end of a U-tube is 0.01 m^2 and that of the other end is 1m^2. When a force was applied on the liquid at the first end the force experienced at the other end is 20000 N. What is the force applied on the liquid at the first end?

Answer

According to Pascal's law, pressure is transmitted in a fluid undiminished in all directions.

So pressure is the same in all parts of the U-tube.

Given,

Force at second end, F_2 = 20000 N

Area at first end, A_1 = 0.01 m^2

Area at second end, A_2 = 1 m^2

$$\frac{\text{Force}}{\text{Area}} = \text{constant}$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2} = \frac{20000}{1}\text{Pa}$$

$$F_1 = 20000 \times A_2$$

$$= 20000 \times 0.01$$

$$= 200\ \text{N}$$

6. Question

Write down the reason for the following:

a. Ink can be blotted with chalk.

b. Sweat can be blotted with tissue paper.

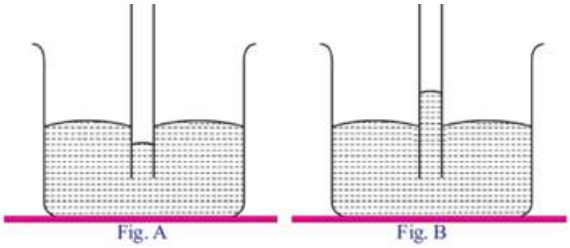
Answer

These phenomena occur due to capillary action. The ink rises up in the capillaries found within a piece of chalk, i.e. the nooks and crevices in the structure of a piece of chalk. Same goes for sweat and tissue paper. A piece of tissue paper has several paths within itself which act as capillaries.

Sweat rises up in these capillaries and gets absorbed.

7. Question

Which is the correct figure? Why?



Answer

Fig. B is correct.

A very thin tube act as a capillary tube. When this tube is dipped into water or any liquid in a container, then, certain amount of water forms upper meniscus into the tube. Then the adhesive force between water and tube walls increases, pulling water upwards. This is called capillary action.

So the level of water in capillary tube must be higher than water level in container.

Extended activities

1. Question

Prepare a table of substances of density less than that of water.

Answer

Substance	Density
Kerosene	0.81 g/cc
Ice	0.92 g/cc
Wood	0.85 g/cc

Water has a density of 1 g/cc.

2. Question

Float a knitting needle on the surface of water.

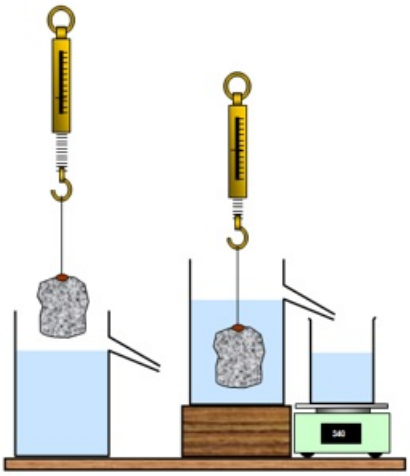
Answer

Usually metal needles sink into water because they have higher density than that of water. However, when it is put horizontally, the weight of the volume of liquid displaced by the immersed part is more than the weight of the needle, so it can float since the buoyant force is greater than its weight in this orientation.

3. Question

Using a spring balance, water and overflow jar find out the densities of substances of different shapes and sizes and tabulate.

Answer



Volume of displaced water = volume of stone

After finding the weight of the object and its volume using the technique shown in the figure, we tabulate them. Then we find the mass of the object by dividing the weight by the acceleration due to gravity (g) because W = mg. Then on dividing mass by volume of the object we get the density.

4. Question

Using a hydrometer find out adulterated liquids.

Answer

We can measure the relative density of a given liquid using a hydrometer. If there is a difference in density from the known standard value, the liquid must be adulterated. Hydrometers are calibrated for different uses, such as a lactometer for measuring the density (creaminess) of milk, a saccharometer for measuring the density of sugar in a liquid, or an alcoholometer for measuring higher levels of alcohol in spirits.

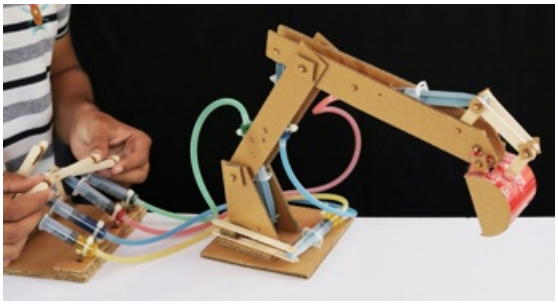
Lactometer

Alcoholomet

5. Question

Using syringes and rubber tubes of different sizes, make models of hydraulic lifts and exhibit.

Answer



Your model could look something like this.

Get a 20 ml syringe, a 100 ml syringe, some rubber tubing and vegetable oil. The syringes can be purchased at most pharmacies, while the rubber tubing is available at aquarium shops. Remove the needles from the syringes. The needles will not be needed for the construction of the model.

2. Fill the Syringes

Fill the syringes half full with vegetable oil. Do this by dipping the nozzle of the syringe into a bowl of vegetable oil and slowly pulling the plunger until the barrel of the syringe is approximately half full. Make sure that there are no bubbles in the barrel of the syringe, as this can affect the operation of the model. If bubbles form when you are filling the syringes, push the oil out of the syringe and redo the filling process.

Wipe away any excess oil with a paper towel and push the plungers down just far enough so that there is no air in the nozzle of the syringes.

3. Attach the Tubing

Insert the nozzle of the larger syringe into one end of the rubber tubing. If you have difficulty getting the end of the tubing to fit over the syringe nozzles, submerge the ends of the tubing in hot water for a few minutes. This will expand the rubber tubing and also make it softer and more malleable.

Push down on the large syringe's plunger until oil nearly reaches the end of the tubing, leaving just a centimeter or so of tubing empty so that you have something to hold on to. Don't push down on the plungers when inserting the nozzles of the syringes into the tubing or oil may be pushed out of the syringes, creating quite a mess.

Now attach the free end of the tubing to the nozzle of the smaller syringe in the same way.

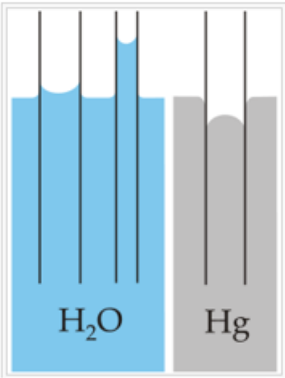
4.Testing

Operate the completed model by pushing down on one or the other plunger. The other plunger will rise. When you push down the plunger of the smaller syringe, the plunger of the larger one will rise a smaller distance but with greater force. Because its barrel has a larger diameter and therefore a larger volume, the (incompressible) fluid moves its plunger through a smaller distance. But because it moves over a smaller distance it generates a larger force. This is a "mechanical advantage," similar to how pulling the rope of a pulley with small force for a large distance can lift a large weight a small distance.

6. Question

Collect capillary tubes of different diameters. Find the capillary rise and depression of different liquids and record.

Answer



Do this for as many liquids as possible and all different radii of capillary tubes.

7. Question

Collect different types of sand and find out their water absorbing capacity. Record your findings.

Answer

Textural class	*Water holding capacity, inches/foot of soil*
Coarse sand	0.25 - 0.75
Fine sand	0.75 - 1.00
Loamy sand	1.10 - 1.20
Sandy loam	1.25 - 1.40
Fine sandy loam	1.50 - 2.00
Silt loam	2.00 - 2.50
Silty clay loam	1.80 - 2.00
Silty clay	1.50- 1.70
Clay	1.20 - 1.50

8. Question

Can egg be floated on water? Find out through an activity.

Answer

The density of an egg is more than water. So the buoyant force (upthrust due to water displaced by it) is not large enough to counter the weight of the egg. But if you add some salt to the water, its density increases. Now the density is high enough for the buoyant force to outweigh the weight of the egg and thus it floats.