1.FORCES IN FLUIDS

Fluids

Substance that can flow is called fluids. Hence liquids and gases together are generally known as fluids.

Buoyancy

When a body immersed partially or completely in a fluid, the fluid exerts an upward force on the body. This force is known as buoyancy.

When a body is in a liquid, there are two forces experiences on it. They are its weight acting downward and buoyancy acting upwards. If weight of the body is less than the buoyancy on it when it is completely immersed, it raises up and floats on the surface of the liquid.

The raising of air bubble from the bottom bed of pool of water and raising of hydrogen balloon in air are our familiar experiences. Here the buoyancy on the air bubble/hydrogen balloon is greater than their weight. That is why they rises up.

But in the cases of an iron nail or a granite piece, its weight is greater than buoyancy. So it sinks down. Due to the buoyancy, every objects experience loss of weight when it is put in a liquid.

Buoyancy is equal to loss of weight.

Therefore Buoyancy = Weight of the body in air – Weight of the body in the fluid.

Example: When a stone of weight of 6 N was immersed in water, its weight became 4N. Calculate the buoyancy experienced on the stone by the water.

Solution: Buoyancy = Loss of weight = 6 – 4 = 2N

Factors influencing buoyancy

Density of the fluid and volume of the immersed object are the factors influencing buoyancy. Buoyancy increases with increase of density. That is, saline water can exert more buoyancy than that of fresh water.

Similarly buoyancy also increases with increase of volume of the object immersed in the fluid.

Archimedes' Principle

When an object is immersed partially or fully in a fluid, the buoyancy experienced on it will be equal to the weight of the displaced fluid.

Experiments related to Buoyancy

Principle of floatation.

A body floats on a fluid when its weight is equal to the weight of the displaced fluid. This is called the principle of floatation.

When a ripe coconut is put in water it dips a portion of its body into the water for displacing as much water whose weight is equal to weight of the coconut.

That is, the weight of displaced water is equal to the weight of the coconut. Then net force on the coconut becomes zero and hence it floats on the water.

Relative density

Relative density of a substance is the ratio of density of the substance and water.

It denotes how many times the density of water is the density of a substance.

Relative density = Density of substance/Density of water.

Density of water is 1000 kg/m^3. But relative density of water is ONE.

Relative densities of kerosene, ice, etc are less than ONE.

Hydrometer is used to measure relative density of a liquid. Lactometer is also a hydrometer.

Hydrometers work on the principle of floatation.

Note: *Relative density has NO unit.*

Pascal's Law

Pascal's law is the working principle of excavator,hydraulic brake, hydraulic jack etc. in which a large output force is made available by applying a small force.

The pressure applied at any point of a liquid at rest in a closed system will be experienced equally at all parts of the liquid.

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Working of Hydraulic jack

The schematic diagram of hydraulic jack is shown.

When a small force (F_1) is applied on the small piston X, the resulting force (F_2) is available below the piston Y.

According to Pascal's Law, the pressure developed below the piston X, ($P_1 = F_1/A_1$) and below the piston Y, ($P_2 = F_2/A_2$) will be equal. Where A_1 & A_2 are the area of cross sections the pistons X and Y respectively.
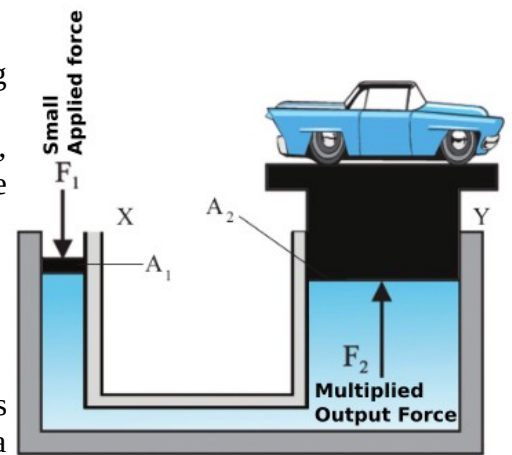
That is, $F_1/A_1 = F_2/A_2$

Or $F_2 = F_1(A_2/A_1)$ ...... (a) .

If Area of cross section of Y is 10 times greater than that of X,

 (A_2/A_1) = 10.

From the equation (a), it is seen that the output force F_2 is 10 times greater than applied force F_1. That is, by adjusting cross sectional area of the pistons, we can make available large output force by applying a small input force.

Surface tension

Due to mutual attraction of the liquid molecules, its free surface of a liquids is stretched like a membrane. The force responsible for this is called surface tension.

The following are due to surface tension of water.

i. Small insects can move along the surface of water.

ii. Paper clip, coin, iron needle, blade etc can float on the water surface.

Surface tension varies with respect to nature of the liquid. Surface tension of soap water is less than that of fresh water.

Cohesive force and Adhesive force.

There is an attractive force between molecules of all the substances. The attraction between the molecules of the same substances are called cohesive force. It is due to the cohesive force, the two liquid drops coalesce to form a single drop.

Adhesive force is the force of attraction between the molecules of different substances.

Capillarity.

The rise or depression of a liquid in a narrow tube or a minute hole is capillarity.

Mercury is a liquid that shows capillary depression. Capillary rise depends on the diameter of the tube. It increases with decrease in the diameter.

Capillary rise occurs when   adhesive force between glass tube and liquid molecule is greater than cohesive force of liquid molecules. If cohesive force is greater than that of adhesive force, there will be capillary depression.
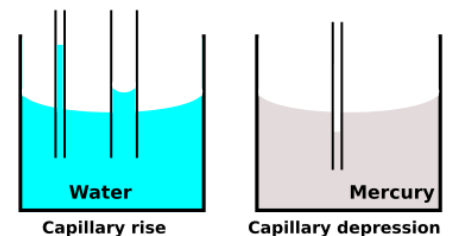
Viscosity and Viscous Force

Viscosity is the characteristic property of a liquid to oppose its flow. The force responsible for this property is called viscous force. It is the frictional force between layers of liquid in motion. On the basis of viscosity, liquids are classified into viscous liquids and mobile liquids. Liquids of greater viscosity are called viscous liquid and those having lower viscosity are called mobile liquid. Honey, Glycerine etc. are examples for viscous liquids and kerosene, water, petrol etc are examples for mobile liquids. Viscosity of a liquid decreases with temperature.

FORCES IN LIQUIDS - PRACTICE QUESTIONS WITH ANSWERS

1. What is buoyancy?

Ans. It is the upward force exerts on a body which is partially of fully immersed in a fluid.

2. What are the forces acting on a stone immersed in water.

Ans. i. Weight of the stone. ii. Buoyancy.

3. When a stone is immersed in water, it weight appears to be decreased. Why?

Ans. Because buoyancy is   experienced opposite to the direction of the weight of the stone.

4. The weight of a stone in air is 80 N and that in water is 55 N. What is the buoyancy experienced on the stone.

Ans. Buoyancy = Loss of weight = 80 -55 = 25 N.

5. It is taken fresh water, kerosene and saline water in three separate beakers.

a. Identify the most denser and least denser liquid.

b. In which of the liquid, does a stone experience greatest loss of weight while it is immersed in the liquid. Why?

Ans. a. Saline water is most denser and kerosene is least denser liquid.

b. Greatest buoyancy can be provided by saline water as its density is greatest. Hence loss of weight will be maximum in saline water.

6. It is taken a wooden block and iron block of masses 100 g each.

a. Of the two which will have greater volume?

b.If these blocks are weighed while immersed in water, which will have greater loss of weight?

c. In which block does it experience more buoyancy?

Ans.a. Wooden block.   b. Wooden block.   c. Since volume of wooden block is greater it will displace more water. Therefore it will experience more buoyancy.

7. What are the factors which influence buoyancy?

Ans. Density of the fluid and volume of the immersed object.

8. The weights of a stone were 60 gwt,50gwt and 45gwt when it was weighed by immersing in three different liquids. If these liquids were saline water, fresh water and coconut oil, which might be the liquid in which the weight be 60gwt. Justify your answer.

Ans. 60gwt will be in coconut oil. Because the least denser liquid among them is coconut oil. Hence least loss of weight (buoyancy) will be from this liquid.

9. Does a ship that enters the ocean from a fresh water lake sink more or rise more? Justify your answer.

Ans. It will rise more. Because buoyancy from salt water is greater than that from fresh water.

10. When an object is fully immersed in a liquid, it will displace the liquid equal to the volume of the object.

a. What is the relation between weight of displaced liquid and buoyancy?

b. Identify the principle related to this.

c. State the principle.

Ans. a. Buoyancy and weight of displaced liquid will be equal.

b. Archimedes principle.

c. When an object is immersed partially or fully in a fluid, the buoyancy experienced on it will be equal to the weight of the displaced fluid.

11. Explain the reason on the basis of buoyancy why hydrogen balloon rises in air .

Ans. Because the buoyancy experiences on the balloon is greater than the weight of the balloon and hydrogen in it.

12. A dry coconut is floating in water.

a. What are the forces experience on the coconut?

b. How do the forces relate?

Ans.a. Weight of the coconut and the buoyancy.

b. In a floating body, its weight and buoyancy will be equal.

13. Density of fresh water is $1000kg/m^3$.

a. What do you mean by this?

b. Name a liquid having density less than that of water.

**Ans**.a.It means that the mass of one cubic metre water is 1000 kg.

b. Kerosene/coconut oil.

14.When a stone of 200 N weight is immersed in liquid as shown, it weight becomes 140 N.

a. Predict the weight of displaced liquid collected in the jar?

b. State the principle used to find the answer.

Ans.a. Weight of displaced liquid = loss of weight = 200 – 140 = 60 N.

b. Archimedes principle: When an object is immersed partially or fully in a fluid, the buoyancy experienced on it will be equal to the weight of the displaced fluid.
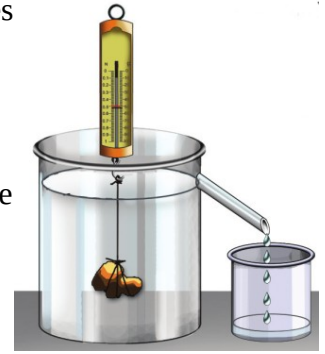
15. a. What is relative density?

b. Write down expression for the same.

c. What is the relative density of water?

d. Name the device used to measure relative density.

e. What is the working principle of hydrometer?

f. Name the device used to measure relative density of milk.

Ans.a.Relative density of a substance is the ratio of the density of the substance to the density of water.

b. Relative density = density of the substance/density of water

c. One.   d. Hydrometer.   e. Law of floatation.   f. Lactometer.

16. State Pascal's Law.

b. Give the names of two devices work on this law.

Ans.a. The pressure applied at any point of a liquid at rest in a closed system will be experienced equally at all parts of the liquid.

b. Hydraulic brake, Excavator, Hydraulic lift.

17. Model of a hydraulic lift is shown.

a. What is the working principle of this device?

b. In this device, where should the object to be lifted is placed?

c. If cross sectional area of X is 0.05 m^2 and that of Y is 0.6 m^2, calculate the force obtained at Y when 10N is applied at X.

a. Pascal's Law.

b. Above the tube of greater cross sectional area. (Above Y)

c. A_x = 0.05 m^2, A_y = 0.6 m^2, f_x= 10 N, F_Y= ?

Since $F_Y/ f_x = A_y/A_x$, $F_Y/10 = 0.6 /0.05$ Or F_Y= 0.6x10/0.05 = 120 N

18. Schematic diagram of a hydraulic lift is given.

Here A_1 = 2cm^2 , A_2 = 10 cm^2, F_1 = 10 N

(P_1 & P_2 are pressure)

a. Find out the correct relation/relations.

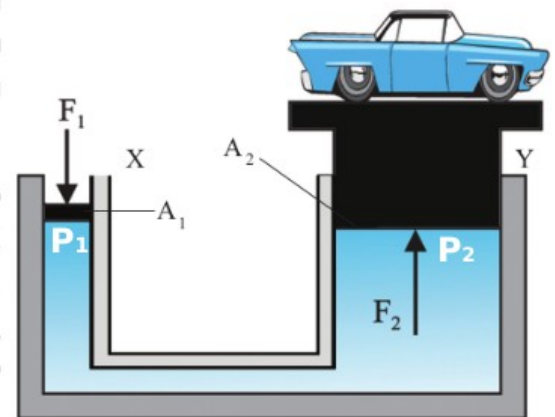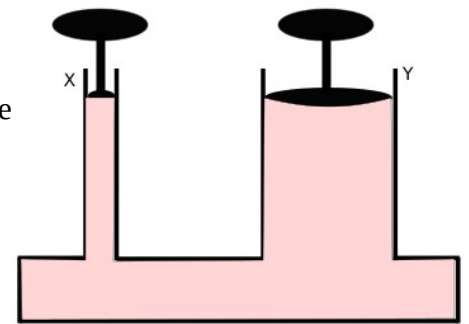i. $P_1 = P_2$ ii. $P_1 > P_2$ iii. $P_1 < P_2$ ii. $F_1 > F_2$ iv. $F_1 < F_2$.

b. Find the value of F_2.

Ans.a. i. $P_1 = P_2$ & iv. $F_1 < F_2$.

b. We have $F_2 / F_1 = A_2/A_1$

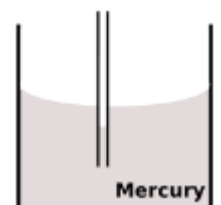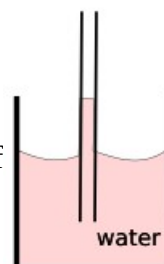Then $F_2 / 10 = 10/2$ =

Or F_2 = 50N

19. See the figure.

a.Name the phenomena related to this.

b. Draw the liquid level, if the liquid were mercury instead of water.

Ans.a. Capillary rise.   b.

20. a. What is the relation between radius of the capillary and capillary rise?

b. Give example for a liquid that shows capillary depression.

c. Explain what are adhesive force and cohesive force?

Ans.a. Capillary rise increases with decrease of radius.

b. Mercury.

c. The attraction between the molecules of the same substances are called cohesive force.

Adhesive force is the force of attraction between the molecules of different substances.

21.Some objects float in water but some other objects sink down. At what situation an object floats in water?

Ans. When weight of the body becomes equal to buoyancy, it will float in water.

22. Fill in the blanks.

a. It occurs ...... if adhesive force is less than cohesive force.

(capillary depression/capillary rise)

b. Capillary rise .... when diameter of the capillary increases. (increases/decreases)

c.It is due to ...., liquid drops combine to form single one.   (Adhesive force/Cohesive force)

d. The ability to flow is .... for viscous liquids. (more/less)

e. It is due to ...... liquid drops becomes spherical. (viscosity/surface tension)

f. Buoyancy is ...... in denser liquids.   (more/less)

Ans.a. Capillary depression   b. decreases c. Cohesive force d. less e. Surface tension   f. more.

23. It is customary to plough the land before the beginning of the summer.

a. What is the need of it?   b. Explain the science behind it.

Ans. a. It is for preserving moisture in the soil by blocking capillary rise.

b. When the land is ploughed, the gap between soil grain increases. So water preserved in the soil does not rise to the surface of the earth by capillarity and doesn't evaporate it.

24.Viscous force is the frictional force between the layers of liquid in motion.

a. What is viscosity?   b. What is the relation between viscosity of a liquid and its ability to flow?

c. Give two examples for viscous liquids. d. What is meant by mobile liquid?

e. What is the relation between viscosity of a liquid and its temperature?

Ans.a. Viscosity is the characteristic property of a liquid to oppose the relative motion between different layers.

b. Ability to flow decreases when viscosity increases.   c. Honey, Glycerine.

d. Less viscous liquids are called mobile liquids.

e. Viscosity decreases with increase of temperature.

25. It is massaged the body of electrocuted person. What is the science behind it?

Ans.The body temperature of the person who gets electric shock falls suddenly. As a result, the viscosity of the blood increases, causing hindrance to the flow of blood. When massage, body becomes warm and the viscosity of the blood reverts to the normal level.

26. One drop each of cold honey and hot honey are put on a glass plate and when the glass plate is tilted, the hot honey flow down speedily than that of cold one. What inference do you get from this?

Ans. Viscosity of a liquid decreases when temperature increases.

27. An object which can float in water sinks down when it is put in kerosene. Why?

Ans. Since density of kerosene is less, it cannot provide sufficient buoyancy to balance the weight of the object. Hence it sinks down.

28.It is seen a solid object placed in a liquid. The density of the object is .... that of the liquid.

(greater / less/ same as)

Ans. same as

29. When a stone of 200 gwt is fully immersed in water, 50gwt of water is overflowed.

a. What will be the weight of the stone while it is in water?

b. If the stone is immersed in kerosene, what will be change in the quantity of overflowed kerosene?

 c. What will be change in the weight of overflowed kerosene? Justify the answer.

Ans.a. Weight in water = 200 – 50 = 150 gwt.

b. The volume of overflowed kerosene will be same as that of overflowed water.

c. As the density of kerosene is less than that of water, weight of overflowed kerosene will be less than that of water.
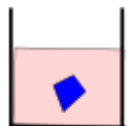
30. The ratio of the cross sectional area of the tubes of a closed U tube which is filled with water is 1:20.

a. If $1N/m^2$ pressure is applied at the first tube, what will be the pressure at the second tube?

b. What will be the force experienced at the second tube, when 10 N is applied at the first tube?

c. State the law that helped you to find the answer.

Ans.a. The same pressure ($1N/m^2$) experienced at the second tube.

b. The force available at the large tube = 20x10 = 200 N.

c. State Pascal's Law.
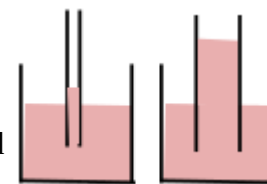
31. It is marked the capillary rise in two capillary tubes of different radii in water. Find out the error in the marking if any. Justify your answer.

Ans. Capillary rise should be higher in narrow tube. Because capillary rise increases with decrease of diameter.

32. Fill the second pair according to the relation of the first pair.

a. Spherical shape of liquid drops: Surface tension; Chalk blots ink: ....

b. Kerosene: mobile liquid; Honey: ....

c. unit of density: kg/m^3 ; unit of relative density : ....

d. Hydraulic brake: Pascal's law; Hydrometer: ....

Ans.a. capillary rise   b. Viscous liquid.   c. No uni. d. Law of floatation.

33. Check whether the following statements are TRUE or FALSE. Correct the false statements.

a. Capillary rise increases with increase of diameter of the capillary.

b.It is due to capillary rise oil rises up along the wick of the lamp.

c. Hydrometer is a device used to measure density of liquid.

d. The working principle of hydrometer and lactometer are the same.

e. Hydrometer sinks deeper when it is put in a liquid of density less than that of water.

f. If an iron block and wooden block of same mass are fully immersed in water, greater buoyancy will be experienced in wooden block.

g. The quantity of water displaced by an iron block and copper block of the same mass will be same if they are completely immersed in water.

a. False. Capillary rise decreases with increase of diameter of the capillary.

b.True.   c. False. Hydrometer is a device used to measure relative density of liquid.

d. true. e. True. f. True. g. False. Iron will displace more water. [Since the size of the iron block will be greater (because density of iron is less), it can displace more water]

34. It is shown an iron block and copper block of the same mass.

a. Identify copper block and Iron block.

b. If they are completely immersed in water, in which block does greater buoyancy experience?
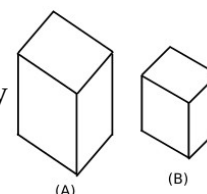
Hint:Density of copper is greater than that of Iron.

Ans. a. A - Iron block,   B – Copper block.

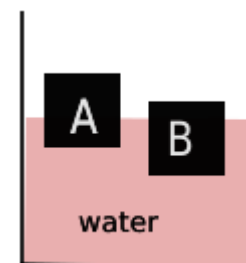b. In iron block (Because size of iron block is larger than copper block)

35.Two solid blocks float on water as shown.

a. Identify the block in which greater buoyancy is experienced? Justify.

b. Identify the object which experiences more loss of weight.

Ans.a. As B displaces more liquid than that of A, B will be experienced more buoyancy.

b. Loss of weight is greater in B. Because it is in this block more buoyancy is experienced.

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