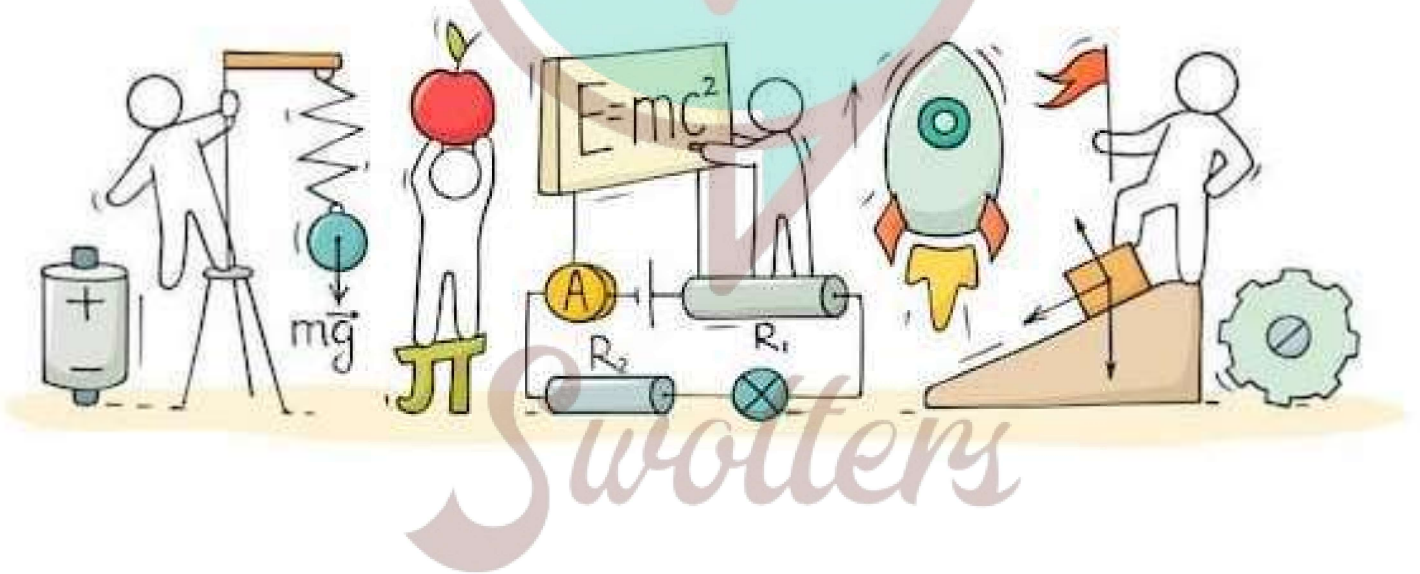


PHYSICS

Chapter 10: Mechanical Properties of Fluids



Important Questions

Multiple Choice questions-

1. Plants get water through the roots because of

- (a) Capillarity
- (b) Viscosity
- (c) Gravity
- (d) Elasticity

2. Water rises up to a height h_1 in a capillary tube of radius r . the mass of the water lifted in the capillary tube is M . if the radius of the capillary tube is doubled, the mass of water that will rise in the capillary tube will be

- (a) M
- (b) $2M$
- (c) $M/2$
- (d) $4M$

3. A number of small drops of mercury coalesce adiabatically to form a single drop. The temperature of drop

- (a) Increases
- (b) Is infinite
- (c) Remains unchanged
- (d) May decrease or increase depending upon size

4. When a soap bubble is charged

- (a) It contracts
- (b) It expands
- (c) It does not undergo any change in size
- (d) None of these

5. A liquid is kept in a glass vessel. If the liquid solid adhesive force between the liquid and the vessel is very weak as compared to the cohesive force in the liquid, then the shape of the liquid surface near the solid should be

- (a) Concave
- (b) Convex
- (c) Horizontal

(d) Almost vertical

6. A capillary tube is placed vertically in a liquid. If the cohesive force is less than the adhesive force, then

(a) The meniscus will be convex upwards

(b) The liquid will wet the solid

(c) The angle of contact will be obtuse

(d) The liquid will drip in the capillary tube

7. When there are no external forces, the shape of a liquid drop is determined by

(a) Surface tension of the liquid

(b) Density of liquid

(c) Viscosity of liquid

(d) Temperature of air only

8. Water can rise up to a height of 12 cm in a capillary tube. If the tube is lowered to keep only 9 cm above the water level then the water at the upper end of the capillary will

(a) Overflow

(b) From a convex surface

(c) From a flat surface

(d) From a concave surface

9. Rain drops are spherical in shape because of

(a) Surface tension

(b) Capillary

(c) Downward motion

(d) Acceleration due to gravity

10. When the angle of contact between a solid and a liquid is 90° , then

(a) Cohesive force $>$ Adhesive force

(b) Cohesive force $<$ Adhesive force

(c) Cohesive force = Adhesive force

(d) Cohesive force \gg Adhesive force

Very Short:

1. State the law of floatation?

2. The blood pressure of humans is greater at the feet than at the brain?

3. Define surface tension?
4. Define surface tension?
5. Oil is sprinkled on sea waves to calm them. Why?
6. Oil is sprinkled on sea waves to calm them. Why?
7. The diameter of ball A is half that of ball B. What will be their ratio of their terminal velocities in water?
8. Define viscosity?
9. Give two areas where Bernoulli's theorem is applied?
10. What is conserved in Bernoulli's theorem?

Short Questions:

1. A glass bulb is balanced by an iron weight in an extremely sensitive beam balance covered by a bell jar. What shall happen when the bell jar is evacuated?
2. It is easier to swim in seawater than in river water. Why?
3. Does Archimedes' Principle hold in a vessel in free fall or in a satellite moving in a circular orbit?
4. A block of wood floats in a pan of water in an elevator. When the elevator starts from rest and accelerates downward, does the block float higher above the water surface? What happens when the elevator accelerates upward?
5. The thrust on a human being due to atmospheric pressure is about 15 tons. How can a human being withstand such an enormous thrust while it is impossible for him to carry a load of even one ton?
6. Why are sleepers used below the rails? Explain.
7. The passengers are advised to remove the ink from their pens while going up in an airplane. Explain why?
8. Why does a sinking ship often turn over as it becomes immersed in water?
9. Explain why a balloon filled with helium does not rise in the air indefinitely but halts after a certain height?
10. A light ball can remain suspended in a vertical jet of water flow?
11. In the case of an emergency, a vacuum brake is used to stop the train. How does this brake work?
12. Why does dust generally settle down in a closed room?
13. How will the rise of a liquid be affected if the top of the capillary tube is closed?
14. What are buoyancy and the center of buoyancy?

15. Under what conditions:

- Centre of buoyancy coincides with the center of gravity?
- The center of buoyancy does not coincide with the center of gravity?

Long Questions:

- A copper cube of mass 0.50 kg is weighed in water ($\rho = 10^3 \text{ kg m}^{-3}$). The mass comes out to be 0.40 kg. Is the cube hollow or solid? Given density of copper = $8.96 \times 10^3 \text{ kg m}^{-3}$.
- A piece of pure gold ($\rho = 19.3 \text{ g cm}^{-3}$) is suspected to be hollow. It weighs 38.250 g in air and 33.865 g in water. Calculate the volume of the hollow portion in gold, if any.
- A glass plate of length 20 cm, breadth 4 cm, and thickness 0.4 cm weighs 40 g in air. If it is held vertically with the long side horizontal and the plate half breadth immersed in water, what will be its apparent weight, the surface tension of water = 70 dyne cm^{-1} .
- What is the work done in blowing a soap bubble of diameter 0.07 m?
- If $3.6960 \times 10^3 \text{ J}$ of work is done to blow it further, find the new radius. Surface tension of soap solution is 0.04 Nm^{-1} .

Assertion Reason Questions:

1. **Directions:**

- If both assertion and reason are true and the reason is the correct explanation of the assertion.
- If both assertion and reason are true but reason is not the correct explanation of the assertion.
- If assertion is true but reason is false.
- If the assertion and reason both are false.

Assertion: It is easier to spray water in which some soap is dissolved.

Reason: Soap is easier to spread.

2. **Directions:**

- If both assertion and reason are true and the reason is the correct explanation of the assertion.
- If both assertion and reason are true but reason is not the correct explanation of the assertion.
- If assertion is true but reason is false.
- If the assertion and reason both are false.

Assertion: The angle of contact of a liquid decrease with increase in temperature.

Reason: With increase in temperature, the surface tension of liquid increase.

✓ Answer Key:

Multiple Choice Answers-

1. Answer: (a) Capillarity
2. Answer: (b) 2M
3. Answer: (d) May decrease or increase depending upon size
4. Answer: (b) It expands
5. Answer: (b) Convex
6. Answer: (b) The liquid will wet the solid
7. Answer: (a) Surface tension of the liquid
8. Answer: (c) From a flat surface
9. Answer: (a) Surface tension
10. Answer: (c) Cohesive force = Adhesive force

Very Short Answers:

1. Answer: Law of floatation states that a body will float in a liquid, if weight of the liquid displaced by the immersed part of the body is at least equal to or greater than the weight of the body.
2. Answer: The height of the blood column in the human body is more at the feet than at the brain as since pressure is directly dependent on height of the column, so pressure is more at feet than at the brain.
3. Answer: It is measured as the force acting on a unit length of a line imagined to be drawn tangentially anywhere on the free surface of the liquid at rest.
4. Answer: Archimedes's Principle will not hold in a vessel in free – fall as in this case, acceleration due to gravity is zero and hence buoyant force will not exist.
5. Answer: Since the surface tension of sea-water without oil is greater than the oily water, therefore the water without oil pulls the oily water against the direction of breeze, and sea waves calm down.
6. Answer: Since the cohesive forces between the oil molecules are less than the adhesive force between the oil molecules and the drop of oil spreads out and reverse holds for drop of water.
7. Answer: The terminal velocity is directly proportional to the square of radius of the ball, therefore the ratio of terminal velocities will be 1:4.
8. Answer: Viscosity is the property of a fluid by virtue of which an internal frictional force comes into play when the fluid is in motion and opposes the relative motion of its different

layers.

9. Answer: Bernoulli's theorem is applied in atomizer and in lift of an aero plane wing.
10. Answer: According to Bernoulli's theorem, for an incompressible non – Viscous liquid (fluid) undergoing steady flow the total energy of liquid at all points is constant.

Short Questions Answers:

1. Answer: The upthrust on the bulb is larger than the upthrust on the iron weight. When the bell jar has evacuated the upthrust on both the bulb and the iron weight become zero. Clearly, the bulb is affected more than the iron weight. Thus the pan containing the bulb shall go down.
2. Answer: Due to the presence of salt, the density of seawater is more than that of river water. Hence seawater offers more upthrust as compared to river water. Therefore a lesser portion of our body is submerged in, seawater as compared to river water. Hence it is easier to swim in sea-water than in river water.
3. Answer: A vessel in free fall or in a satellite moving in a circular orbit is in the state of weightlessness. It means the value of 'g' is zero. Thus the weight of the vessel and upthrust will be zero. Hence Archimedes' Principle does not hold good.
4. Answer: When the elevator accelerates downward, the weight of the block of wood decreases. Hence it will float higher above the water's surface.
5. Answer: There is a large number of pores and openings on the skin of a body. Through these openings, air goes within the system and there is free communication between the inside and the outside. The presence of; the air inside the body counterbalances the pressure outside.
6. Answer: When sleepers are placed below the rails, the area of the cross- p section is increased. We know that $P = \frac{F}{A}$, so when the train runs on the rails, the pressure exerted on the ground due to the weight of the train is small because of a large area of cross-section of the sleeper. Hence the ground will not yield under the weight of the train.
7. Answer: With the increase in height, the atmospheric pressure decreases. The ink in the pen is filled at the atmospheric pressure on the surface of the earth. So as the plane rises up, the pressure decreases \ and the ink will flow out of the pen from higher pressure to the low 'pressure region. This will spoil the clothes of passengers.
8. Answer: When the ship is floating, the metacenter of the ship is above the center of gravity. While sinking the ship takes in water and as a result, the center of gravity is raised above the metacenter. The ship turns over due to the couple formed by the weight and the buoyant force.
9. Answer: The balloon initially rises in the air because the weight of the displaced air i.e> upthrust is greater than the weight of the helium and the balloon. Since the density of air

decreases with height, therefore, the balloon halts at a particular height where the density of air is such that the weight of air displaced is just equal to the weight of helium gas and the balloon. Hence the net force acting on the balloon is zero and the balloon stops rising.

10. Answer: The region where the ball and the vertical jet of water are in contact is a region of low pressure because of higher velocity. The pressure on the other side of the ball is larger. Due, to the pressure difference, the ball remains suspended.
11. Answer: Steam at high pressure is made to enter the cylinder of the vacuum brake. Due to high velocity, pressure decreases in accordance with Bernoulli's principle. Due to this decrease in pressure, the piston gets lifted. Hence the brake gets lifted.
12. Answer: Dust particles may be regarded as tiny spheres. They acquire terminal velocity after having fallen through some distance in the air. Since the terminal velocity varies directly as the square of the radius therefore the terminal velocity of dust particles is very small. So they settle down gradually.
13. Answer: The air trapped between the meniscus of the liquid and the closed end of the tube will be compressed. The compressed air shall oppose the rise of liquid in the tube.
14. Answer: 1. The upward thrust acting on the body immersed in a liquid is called buoyancy or buoyant force.
2. The center of buoyancy is the center of gravity of the displaced liquid by the body when immersed in a liquid.
15. Answer: (a) For a solid body of uniform density, the center of gravity coincides with the center of buoyancy.
(b) For a solid body having different densities over different parts, its center of gravity does not coincide with the center of buoyancy.

Long Questions Answers:

1. Answer: Let V be the volume of the cube, then according to Archimedes' principle,
Loss of weight in water = weight of water displaced (i)
Here, mass in air, $m_a = 0.5$ kg
mass in water, $m_w = 0.4$ kg (ii)
 ρ of water = 10^3 kg m^{-3} .
 \therefore From (i) and (ii), we get

$$(0.5 - 0.4) \text{ g} = V \times 10^3 \times \text{g}$$

$$\text{or} \quad V = \frac{0.1}{10^3} = 10^{-4} \text{ m}^3$$

$$\begin{aligned} \text{Now density of cube} &= \frac{m_a}{V} = \frac{0.5}{10^{-4}} \text{ kg m}^{-3} \\ &= 5 \times 10^3 \text{ kg m}^{-3} \end{aligned}$$

which is less than the density of copper ($8.96 \times 10^3 \text{ kg m}^{-3}$). So the cube must be hollow.

2. Answer: Density of pure gold, $\rho = 9.3 \text{ g cm}^3$,

mass of gold piece, $M = 38.250 \text{ g}$

$$\begin{aligned} \therefore \text{volume of the gold piece, } V &= \frac{M}{\rho} = \frac{38.250}{9.3} \\ &= 4.113 \text{ cm}^3 \end{aligned}$$

Also mass of gold piece in water

$$m' = 33.865 \text{ g}$$

$$\begin{aligned} \therefore \text{apparent loss in mass of the gold piece in water} &= (M - m') \\ &= (38.250 - 33.865) \text{ g} \\ &= 4.385 \text{ g} \end{aligned}$$

$$\rho_{\text{water}} = 1 \text{ g cm}^{-3}$$

$$\begin{aligned} \therefore \text{volume of displaced water} &= \frac{m}{\rho} = \frac{4.385}{1} \text{ cm}^{-3} \\ &= 4.385 \text{ cm}^{-3} \end{aligned}$$

\therefore volume of the hollow portion in the gold piece

$$\begin{aligned} &= 4.385 - 4.113 \\ &= 0.272 \text{ cm}^{-3}. \end{aligned}$$

3. Answer: Here, $l = 20 \text{ m}$, $b = 4 \text{ cm}$, $t = 0.4 \text{ cm}$, $T = 70 \text{ dyne cm}^{-1}$

Following three forces are acting on the plate:

1. Weight of the plate, $W = 40 \text{ grand}$ actings vertically downward.
2. Force due to surface tension acting vertically downward.

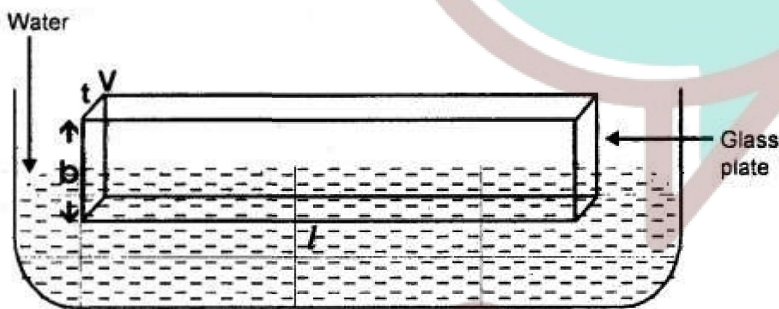
If F be the force due to surface tension, then

$$\begin{aligned}
 F &= T \times \text{length in contact with water} \\
 &= 70 [2 (\text{length} + \text{thickness})] \\
 &= 70 [2(20 + 0.4)] \\
 &= 70 \times (40.8) = 2856 \text{ dynes} \\
 &= \frac{2856}{980} \text{ gf} = 2.9143 \text{ gf.}
 \end{aligned}$$

(iii) Upthrust, $U = V\rho g$

$$\text{Now volume of water displaced} = l \times \frac{b}{2} \times t$$

$$\begin{aligned}
 &= 20 \times \frac{4}{2} \times 0.4 \\
 &= 16 \text{ cm}^3 \\
 \rho &= 1 \text{ gm cm}^{-3} \\
 g &= 980 \text{ cm s}^{-2} \\
 U &= 16 \times 1 \times 980 \text{ dynes} \\
 &= \frac{16 \times 980}{980} \text{ gf} = 16 \text{ gf}
 \end{aligned}$$



$$\begin{aligned}
 \therefore \text{Net weight} &= W + F - U \\
 &= 40 + 2.9143 - 16 \\
 &= 26.9143 \text{ gf}
 \end{aligned}$$

4. Answer: Here, initial radius of soap bubble, $r_1 = 0$

Final radius of soap bubble, $r_2 = 0.035 \text{ m}$ ($\because D_2 = 0.07\text{m}$)

Increase in surface area of soap bubble

$$\begin{aligned}
 &= 2(4\pi r_2^2 - 4\pi r_1^2) \\
 &= 2 \times 4\pi [(0.035)^2 - 0] \\
 &= 8\pi \times 0.1225 \times 10^{-2} \\
 &= 0.0308 \text{ m}^2
 \end{aligned}$$

surface tension of soap solution = $T = 0.04 \text{ Nm}^{-1}$

$$\begin{aligned} \therefore \text{work done to blow soap bubble} &= \text{increase in area} \times T \\ &= 0.0308 \times 0.04 \\ &= 1.232 \times 10^{-3} \end{aligned}$$

5. Answer: Let r be the new radius =?

$$\begin{aligned} \therefore 3.6960 \times 10^{-3} &= 2[4\pi(r^2 - r_2^2)] \times T \\ &= 2 \times 4\pi [r^2 - (0.035)^2] \times 0.04 \end{aligned}$$

$$\begin{aligned} \text{or } r^2 &= \frac{1225 \times 10^{-6}}{8\pi \times 0.04} + \frac{3.69 \times 10^{-3}}{8\pi \times 0.04} \\ &= 1.225 \times 10^{-3} + 3.67 \times 10^{-3} \\ &= 4.875 \times 10^{-3} \text{ m} \\ \therefore r &= 0.07 \text{ m.} \end{aligned}$$

Assertion Reason Answer:

1. (c) If assertion is true but reason is false.

Explanation:

When a liquid is sprayed, the surface area of the liquid increases. Therefore, work has to be done in spraying the liquid, which is directly proportional to the surface tension. Because on adding soap, surface tension of water decreases, the spraying of water becomes easy.

2. (c) If assertion is true but reason is false.

Explanation:

With increase in temperature surface tension of the liquid decreases and angle of contact also decreases.

Case Study Questions-

1. **Surface Tension**

The property due to which the free surface of liquid tends to have the minimum surface area and behaves like a stretched membrane is called surface tension. It is a force per unit length acting in the plane of interface between the liquid and the bounding surface i.e., $S = F/L$, where F = force acting on either side of an imaginary line on the surface and L = length of the imaginary line. Surface tension decreases with rise in temperature. Highly soluble impurities increase surface tension and sparingly soluble impurities decrease surface tension.

- i. The excess pressure inside a soap bubble is three times than excess pressure inside a second soap bubble, then the ratio of their surface area is
- 9 : 1
 - 1 : 3

- c. 1 : 9
d. 3 : 1
- ii. Which of the following statements is not true about surface tension?
- A small liquid drop takes spherical shape due to surface tension.
 - Surface tension is a vector quantity.
 - Surface tension of liquid is a molecular phenomenon.
 - Surface tension of liquid depends on length but not on the area.
- iii. Which of the following statement is not true about angle of contact?
- The value of angle of contact for pure water and glass is zero.
 - Angle of contact increases with increase in temperature of liquid.
 - If the angle of contact of a liquid and a solid surface is less than 90° , then the liquid spreads on the surface of solid.
 - Angle of contact depend upon the inclination of the solid surface to the liquid surface.
- iv. Which of the following statements is correct?
- Viscosity is a vector quantity.
 - Surface tension is a vector quantity.
 - Reynolds number is a dimensionless quantity.
 - Angle of contact is a vector quantity
- v. A liquid does not wet the solid surface if the angle of contact is
- 0°
 - equal to 45°
 - equal to 90°
 - greater than 90°
2. A system is said to be isolated if no exchange or transfer of heat occurs between the system and its surroundings. When different parts of an isolated system are at different temperature a quantity of heat transfers from the part at higher temperature to the part at lower temperature. The heat lost by the part at higher temperature is equal to the heat gained by the part at lower temperature. Calorimetry means measurement of heat. When a body at higher temperature is brought in contact with another body at lower temperature, the heat lost by the hot body is equal to the heat gained by the colder body, provided no heat is allowed to escape to the surroundings. A device in which heat measurement can be done is called a calorimeter. It consists of a metallic vessel and stirrer of the same material, like copper or aluminium. The vessel is kept inside a wooden jacket, which contains heat insulating material. Matter normally exists in three states: solid, liquid and gas. A transition from one of these states to another is

called a change of state. Two common changes of states are solid to liquid and liquid to gas (and, vice versa). These changes can occur when the exchange of heat takes place between the substance and its surroundings. The change of state from solid to liquid is called melting and from liquid to solid is called fusion. It is observed that the temperature remains constant until the entire amount of the solid substance melts. That is, both the solid and the liquid states of the substance coexist in thermal equilibrium during the change of states from solid to liquid. The temperature at which the solid and the liquid states of the substance is in thermal equilibrium with each other is called its melting point. The change of state from liquid to vapour (or gas) is called vaporisation. It is observed that the temperature remains constant until the entire amount of the liquid is converted into vapour. That is, both the liquid and vapour states of the substance coexist in thermal equilibrium, during the change of state from liquid to vapour. The temperature at which the liquid and the vapour states of the substance coexist is called its boiling point. The change from solid state to vapour state without passing through the liquid state is called sublimation, and the substance is said to sublime. Dry ice (solid CO₂) sublimates, so also iodine. During sublimation both the solid and vapour states of a substance coexist in thermal equilibrium.

- i. Device used for measurement of heat is
 - a. Calorimeter
 - b. Thermometer
 - c. Both a and b
 - d. No one of these
- ii. The change of state from solid to liquid is called
 - a. Melting
 - b. Vaporization
 - c. Sublimation
 - d. None of these
- iii. Define melting point and boiling point
- iv. What is sublimation?
- v. Define fusion process

Case Study Answer-

1. Answer

- i. (c) 1 : 9
- ii. (b) Surface tension is a vector quantity.

- iii. (d) Angle of contact depend upon the inclination of the solid surface to the liquid surface.
- iv. (c) Reynolds number is a dimensionless quantity.
- v. (d) greater than 90°

2. Answer

- i. (a) Calorimeter
- ii. (a) Melting
- iii. The change of state from solid to liquid is called melting process and temperature at which conversion of solid into liquid happens is called as melting point.
The temperature at which the liquid and the vapour states of the substance coexist is called its boiling point.
- iv. The change from solid state directly into vapour state without passing through the liquid state is called sublimation, and the substance is said to sublime.

The change of state from liquid state to solid state is called as fusion process

