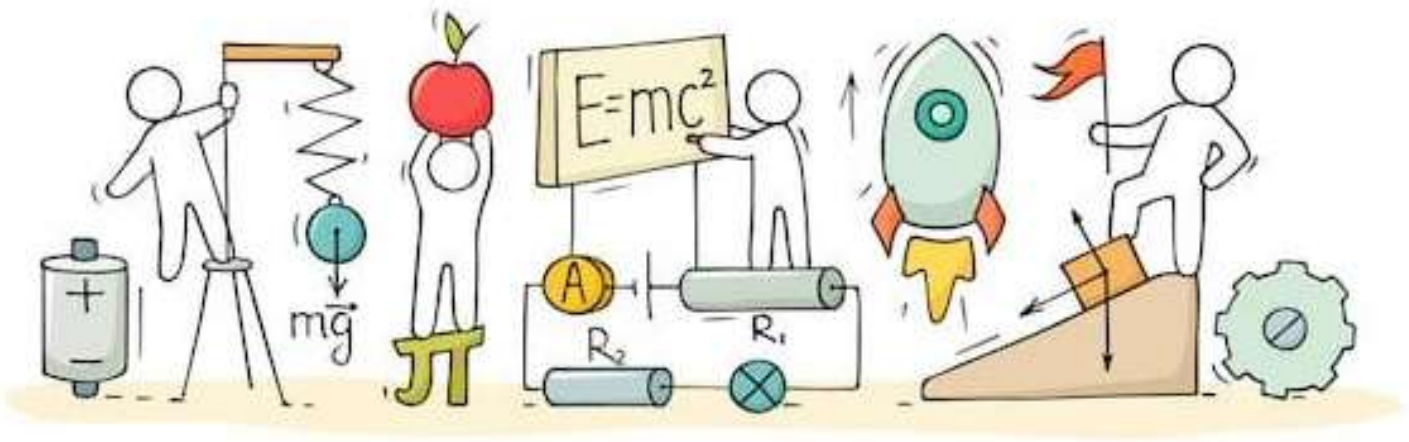
PHYSICS

Chapter 10: Mechanical Properties of Fluids



Mechanical Properties of Fluids

Top Formulae

Pressure of a fluid having density ρ at height h	$P = h\rho g$
Gauge pressure	= total pressure – atmospheric pressure
Pascal's law: (*in hydraulic lift*)	$\frac{F_1}{a_1} = \frac{F_2}{2}$
Surface tension and surface energy are related as	$S = F/2\ell$
Work done	= surface tension × increase in area
Excess of pressure inside the liquid drop	$p = P - P_o = \frac{2S}{r}$
Excess of pressure inside the soap bubble	$p = P - P_o = \frac{4S}{r}$
Total pressure in the air bubble at a depth h below the surface of liquid of density ρ	$P = P_o + h\rho g + \frac{2S}{r}$
In case of capillary action	Ascent / descent formula, $h = \frac{2S\cos\theta}{r\rho g}$, where θ is the angle of contact.
Newton's viscous dragging force	$F = \eta A\frac{dv}{dx}$, where η is coefficient of viscosity, A is the area of layer of liquid and $\frac{dv}{dx}$ is the velocity gradient.
Stoke's law	$F = 6\pi\eta rv$
Terminal velocity	$v = \frac{2r^2(\rho - \sigma)g}{9\eta}$, where ρ and σ are the densities of the spherical body and medium, respectively; r is the radius of the spherical body.
Reynold's number	$R_N = \frac{\rho Dv}{\eta}$, where D is the diameter of the tube and v is the velocity of liquid flow through the tube.

Bernoulli's theorem	Pressure energy per unit mass + potential energy per unit mass + kinetic energy per unit mass = constant $\frac{P}{\rho} + gh + \frac{1}{2}v^2 = \text{constant}$
Venturi meter, volume of liquid flowing per second	$V = a_1 a_2 \sqrt{\frac{2\rho_m gh}{\rho(a_1 \quad a^2)}}$, where a_1 and a_2 are the areas of cross-section of bigger and smaller tube; h is the difference of pressure head at the two tubes of a Venturi meter.
Velocity of efflux: Torricelli's law	$v = \sqrt{2gh}$

Top Concepts

- Fluid has the property of flow. The fluid does not have any resistance to change of its shape. The shape of a fluid is governed by the shape of its container.
- A liquid is incompressible and has a free surface of its own. A gas is compressible and it expands to occupy all the space available to it.
- Liquids and gases together are known as fluids.
- Pressure at a point is force per area, and it is a scalar quantity. The unit of pressure is pascal (Pa). Its SI unit is N m^{-2}.
- Average pressure P_{av} is defined as the ratio of the force to area.

$$P_{av} = \frac{F}{A}$$

- Pascal, the unit of pressure, is the same as N m^{-2}. Other common units of pressure are:

  1 atm = 1.01 × 10^5 Pa

  1 bar = 10^5 Pa

  1 torr = 133 Pa = 0.133 k

  Pa 1 mm of Hg = 1 torr = 133 Pa

- Pressure is defined as normal force per unit area.

$$P = \frac{dF_{\perp}}{dA}$$

- The pressure difference between two points in a static fluid of uniform density r is proportional to the depth h.
- **Pascal's law:** A change in pressure at any point in an enclosed fluid at rest is transmitted undiminished to all points in the fluid.
- Gauge pressure measures the excess pressure above the atmospheric pressure.
- Flow of a fluid whose density is independent of both position and time is said to be incompressible.
- If the frictional forces in a moving fluid are negligible, then the flow is called non-viscous.
- If a fluid element has a non-zero angular velocity at every point, then the flow is said to be non-rotational.
- Orderly flow of a fluid is called streamlined or steady flow.
- In streamlined flow, every liquid element crossing a point has the same velocity.
- Disorderly flow of a fluid is called turbulent flow.
- A streamline is defined as a curve such that the tangent to any point on the curve gives the direction of fluid flow at that point.
- Like in a steady or streamline flow, no two streamlines ever cross each other.
- The greater the spacing between streamlines in a region, the smaller is the fluid velocity there.
- A bundle of streamlines forming a tubular region is called a tube of flow.
- When the flow is incompressible, non-viscous, steady and non-rotational, it is called ideal fluid flow.
- **Equation of continuity:** The product of area of cross section and velocity remains constant throughout the flow.
- In case of varying density or compressible liquids, the equation of continuity modifies to product of the density, area of cross section and velocity of the flow remaining constant as opposed to Av = constant.
- If the fluid velocity is less than a certain limiting value called critical velocity, then the

flow is steady or streamlined. As the speed of the fluid exceeds the critical velocity, it becomes turbulent.

- Equation of continuity tells us that fluid speed is greater in narrow regions as compared to wider regions.
- If the speed of a fluid element increases as it flows, then the pressure of the fluid must decrease and vice versa. This is one implication of Bernoulli's principle.
- Bernoulli was the first one to relate this pressure difference to velocity changes.
- Bernoulli also explained the relation between the height of a fluid and changes in pressure and speed of the fluid.
- Bernoulli's principle: Along a streamline, the sum of the pressure, the kinetic energy per unit volume and the potential energy per unit volume remains constant.
- Bernoulli's principle holds true in the case of ideal fluid flow, which is incompressible, irrotational and streamlined.
- Bernoulli's principle, which results from conservation of energy, relates the height, pressure and speed of an ideal fluid whether it is a liquid or a gas.
- The speed of outflow of a liquid from a hole in an open tank is called the speed of efflux.
- Vlocity of a freely falling fluid is $\mathrm{v} = \sqrt{2\mathrm{gh}}$ This is called Torricelli's law.
- A Venturi meter is a device used to measure the flow speed of an incompressible liquid.
- According to Bernoulli's principle, the pressure above the wing is lower than the pressure below it because the air moves faster above the wing. This higher pressure at the bottom compared to the top applies an upward force to the wing to lift it upwards. This is called dynamic lift.
- Magnus effect is the curving in the path of the ball introduced due to the difference in pressure above and below the ball.
- The speed of efflux from a hole in an open tank is given by $\sqrt{2gh}$.
- An ideal fluid is incompressible and non-viscous.
- Viscosity describes a fluid's internal resistance to flow and may be thought of as a measure of fluid friction.

- A viscous fluid flows fastest at the centre of the cylindrical pipe and is at rest at the surface of the cylinder.
- Viscosity is internal friction in a fluid.
- Surface tension is due to molecular forces.
- The difference in energy of bulk molecules and surface molecules gives rise to surface tension.
- Drops have a spherical shape because a spherical shape has the minimum surface area for a given volume of a free liquid.
- Surface tension is also responsible for the wiggling of soap bubbles.

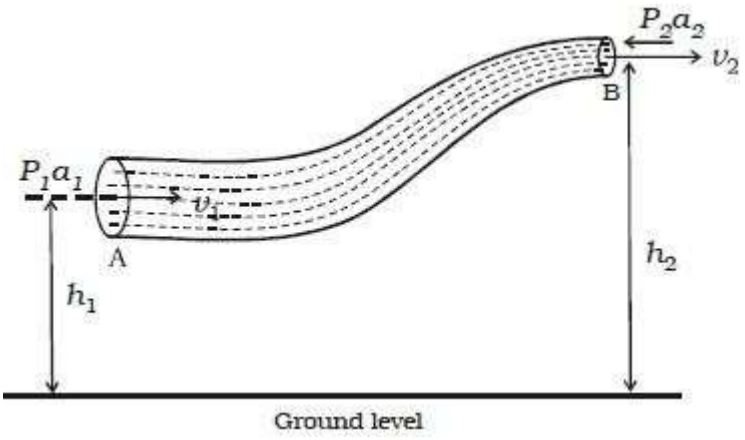
  Greater the attractive force between molecules of a liquid, greater is its surface tension and greater is its resistance to an increase in the surface area.
- Surface tension can be quantitatively defined as the energy required per unit increase in surface area.
- The angle of contact is the angle formed between the solid/liquid interface and the liquid/ vapour interface, and it has a vertex where the three interfaces meet.
- When the contact angle is acute, the liquid wets the solid. Example: Water on a glass surface
- When the contact angle is obtuse, the liquid does not wet the solid. Example: Water on flower petals
- The angle of contact is a good measure of cleanliness of a surface. Organic contamination increases the angle of contact.
- The surface tension of a liquid decreases with the rise in temperature because molecules get extra energy to overcome their mutual attraction.
- Due to surface tension, the liquid surface squeezes itself to minimum surface area.
- The greater the surface tension of the liquid, greater is the excess pressure required for bubble formation inside it.
- Capillary action is the tendency of a liquid to rise in narrow tubes due to surface tension.
- The height of a liquid column rising in a capillary tube depends:
  - On its contact angle θ

- Directly on its surface tension S
- Inversely on its density ρ
- Inversely on radius r of the tube

- Addition of detergent in water lowers the surface tension which helps with the cleansing action.

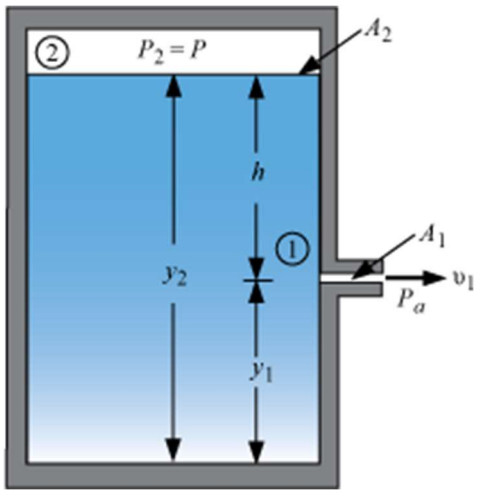
Diagrams

Flow of an ideal fluid through a pipe of varying cross-sections

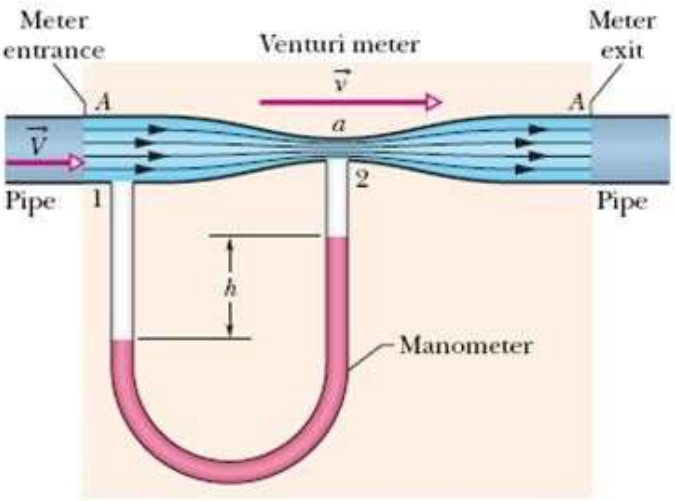


Flow of an ideal fluid through a pipe of varying cross-sections

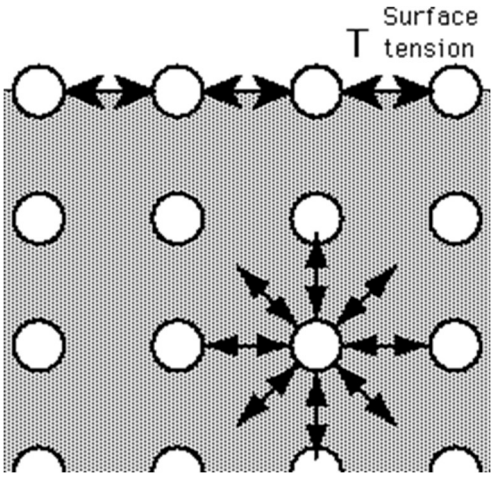
Torricelli's law



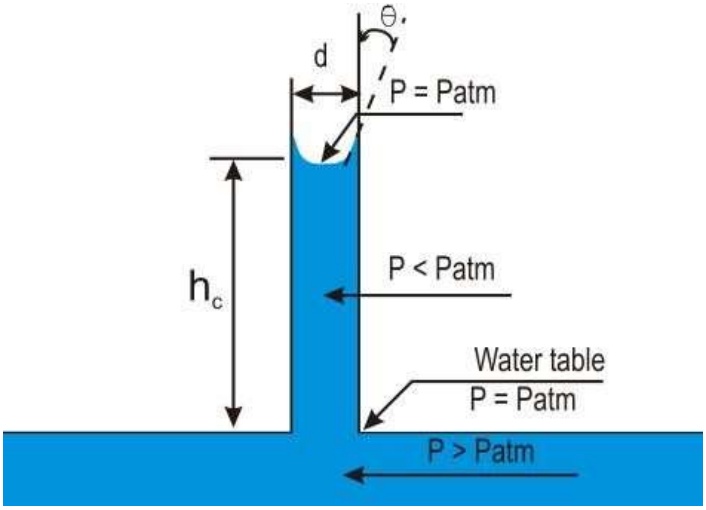
Venturi meter



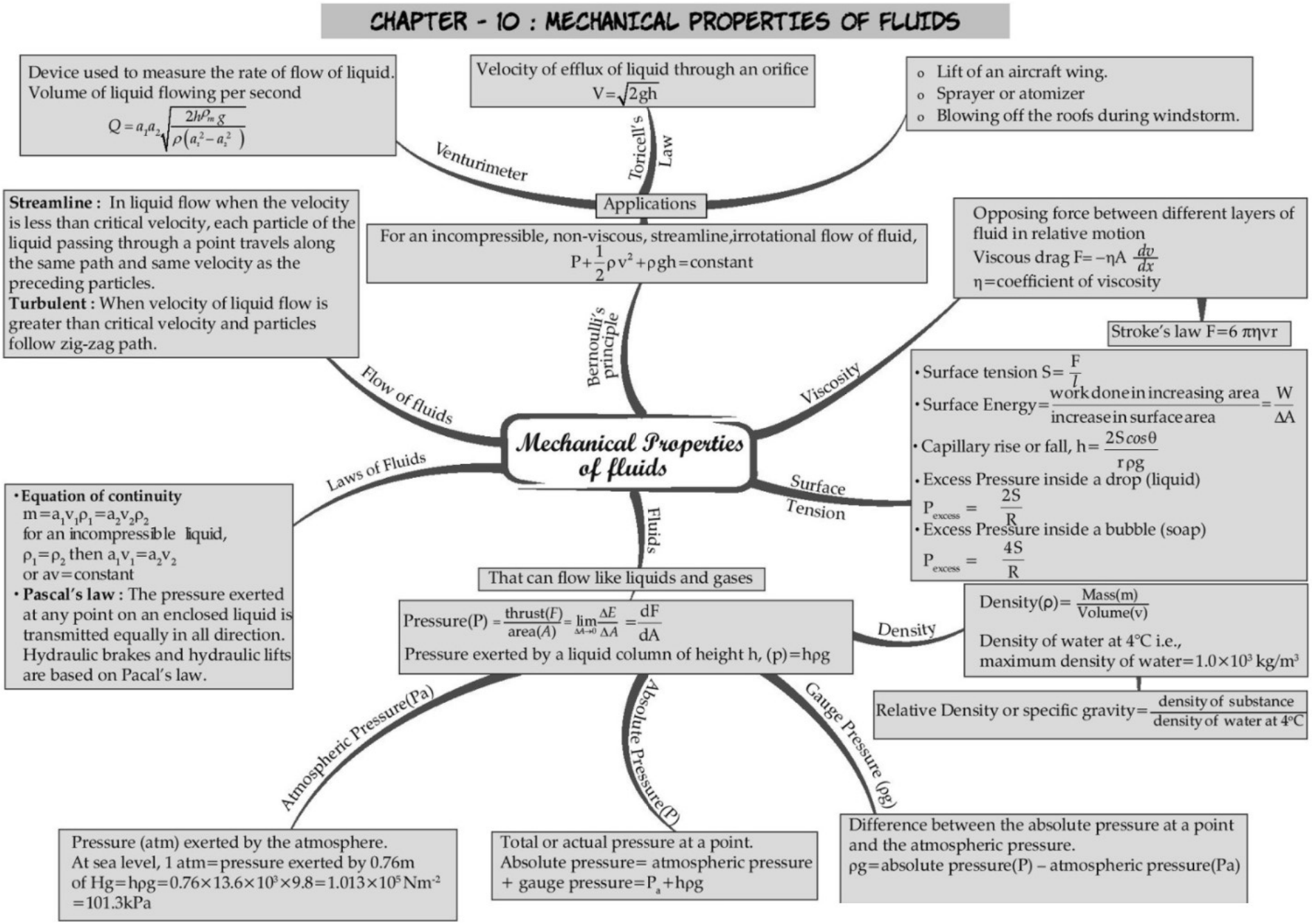
Surface tension



Capillary rise



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 h1 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 >> 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 1 block floats 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 human being can 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 f pens while going up in an airplane. Explain why?
8. Why a sinking ship often turns 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 dust generally settles 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:

(a) Centre of buoyancy coincides with the center of gravity?

(b) The center of buoyancy does not coincide with the center of gravity?

Long Questions:

1. A copper cube of mass 0.50 kg is weighed in water ($\rho = 10^3$ kg m^{-3}). The mass comes out to be 0.40 kg. Is the cube hollow or solid? Given density of copper = 8.96×10^3 kg m^{-3}.
2. A piece of pure gold ($\rho = 9.3$ g cm^{-3}) is suspected to be hollow. It weighs 38.250 g in air and 33.865 in water. Calculate the volume of the hollow portion in gold, if any.
3. A glass plate of length 20 cm, breadth 4 cm, and thickness 0.4 cm weights 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}.
4. What is the work done in blowing a soap bubble of diameter 0.07 m?
5. If 3.6960×10^3 J of work is done to blow it further, find the new radius. Surface tension of soap solution is 0.04 Nm1.

Assertion Reason Questions:

1. **Directions:**

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) 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:**

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) 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, ma = 0.5 kg

   mass in water, mw = 0.4 kg …. (ii)

   ρ of water = 10^3 kg m^3.

   ∴ From (i) and (ii), we get

$$(0.5 - 0.4)\,g = V \times 10^3 \times g$$

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

Now $$\text{density of cube} = \frac{m_a}{V} = \frac{0.5}{10^{-4}}\ kg\ m^{-3}$$

$$= 5 \times 10^3\ kg\ m^{-3}$$

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

2. Answer: Density of pure gold, ρ = 9.3 g cm^3,

   mass of gold piece, M = 3 8.250 g

   ∴ volume of the gold piece, $V = \frac{M}{P} = \frac{38.250}{9.3}$

   = 4.113 cm^3

   Also mass of gold piece in water

   m' = 33.865 g

   ∴ apparent loss in mass of the gold piece in water = (M – m')

   = (38.250 – 33.865)g

   = 4.3.85 g

   ρ_{water} = 1 g Cm^{-3}

   ∴ volume of displaced water $= \frac{m}{\rho} = \frac{4.385}{1} cm^{-3}$

   = 4.385 cm^{-3}

   ∴ volume of the hollow portion in the gold piece

   = 4.385 – 4.113

   = 0.272 cm^{-3}.

3. Answer: Here, l = 20 m, b = 4 cm , t = 0.4 cm, T = 70 dyne cm-1

   Following three forces are acting on the plate:

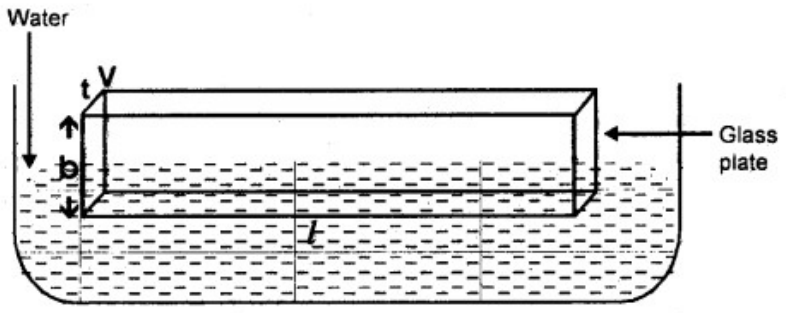
   1. Weight of the plate, W = 40 grand actings vertically downward.
   2. Force due to surface tension acting vertically downward.

   If F be the force due to surface tension, then

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

(iii) Upthrust, U = Vρg

$$\text{Now volume of water displaced} = l \times \frac{b}{2} \times t$$
$$= 20 \times \frac{4}{2} \times 0.4$$
$$= 16 \text{ cm}^3$$
$$\rho = 1 \text{ gm cm}^{-3}$$
$$g = 980 \text{ cm s}^{-2}$$
$$U = 16 \times 1 \times 980 \text{ dynes}$$
$$= \frac{16 \times 980}{980} \text{ gf} = 16 \text{ gf}$$



∴ Net weight = W + F – U

= 40 + 2.9143 – 16

= 26.9143 gf

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

Final radius of soap bubble, $r_2 = 0.035$ m (∵ $D_2 = 0.07$m)

Increase in surface area of soap bubble

$$= 2\left(4\pi r_2^2 - 4\pi r_1^2\right)$$
$$= 2 \times 4\pi\,[(0.035)^2 - 0]$$
$$= 8\pi \times 0.1225 \times 10^{-2}$$
$$= 0.0308 \text{ m}^2$$

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

∴ work done to blow soap bubble = increase in area × T

= 0.0308 × 0.04

= 1.232×10^{-3}

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

$$\therefore \quad 3.6960 \times 10^{-3} = 2\left[4\pi\left(r^2 - r_2^2\right)\right] \times T$$

$$= 2 \times 4\pi\,[r^2 - (0.035)^2] \times 0.04$$

$$\text{or} \qquad r^2 = 1225 \times 10^{-6} + \frac{3.69 \times 10^{-3}}{8\pi \times 0.04}$$

$$= 1.225 \times 10^{-3} + 3.67 \times 10^{-3}$$

$$= 4.875 \times 10^{-3}\ \text{m}$$

$$\therefore \qquad r = 0.07\ \text{m}.$$

Assertion Rason 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

      a. 9 : 1

      b. 1 : 3

c. 1 : 9

d. 3 : 1

ii. Which of the following statements is not true about surface tension?

a. A small liquid drop takes spherical shape due to surface tension.

b. Surface tension is a vector quantity.

c. Surface tension of liquid is a molecular phenomenon.

d. 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?

a. The value of angle of contact for pure water and glass is zero.

b. Angle of contact increases with increase in temperature of liquid.

c. 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.

d. Angle of contact depend upon the inclination of the solid surface to the liquid surface.

iv. Which of the following statements is correct?

a. Viscosity is a vector quantity.

b. Surface tension is a vector quantity.

c. Reynolds number is a dimensionless quantity.

d. Angle of contact is a vector quantity

v. A liquid does not wet the solid surface if the angle of contact is

a. 0°

b. equal to 45°

c. equal to 90°

d. 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) sublimes, 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