CLASS – 11

WORKSHEET- MECHANICAL PROPERTIES OF FLUIDS

A. FLUID AND PASCAL'S LAW

(1 Mark Questions)

1. Pressure at a point inside a liquid does not depend on
(a) the nature of the liquid (b) shape of the container
(c) the depth of point below the surface of the liquid
(d) acceleration due to gravity at that point

Ans. (d)
According to this the pressure at a point inside the liquid is independent of the shape or size of the container of the liquid.

2. The dams of water reservoir are made thick near the bottom. Why?

Sol. The pressure in the liquid increases with depth. Thus, as depth increases, more and more pressure is exerted by water on the wall of a dam. A thicker wall is required to withstand a greater pressure, therefore, the wall of the dam is made with the thickness increasing towards base.

3. The blood pressure in human is greater at the feet than at the brain. Why?

Sol. Blood pressure depends on the height. At the feet, the height of the blood column is more as compared to that at the brain. Hence, blood pressure in humans is greater at the feet than at the brain.

4. It is painful to walk barefooted on the ground with edged pebbles. Why?

Sol. It is painful to walk bare – footed on a road covered with pebbles having sharp edges because they have small area and since: Pressure = force/Area. Area is less i.e. pressure is more. It means out feet exert greater pressure on pebbles and in turn pebbles exert equal reaction on the feet.

5. What do you mean by average pressure (P_{av})?

Sol. Average pressure is defined as the normal force acting per unit area. P_{avg} =- area, SI Unit: Nm^{-2} (Newton/meter ^{2}) or Pascal It is a scalar.

6. Why deep water runs deep still?

Sol. Where depth is more, speed is less and vice versa. Hence, deep water runs slow.

(2 Marks Questions)

7. Why air bubbles in a liquid moves in upward direction?

Sol. The fluids move from higher pressure to lower pressure and a fluid pressure increases with depth. Hence pressure at the top is less than that at the bottom and so the air bubble will rise from bottom to top.

8. Why is it difficult to stop bleeding from a cut in human body at high altitudes?

Sol. The atmospheric pressure is low at high altitudes. Due to greater pressure difference in blood pressure and the atmospheric pressure at high altitude, it is difficult to stop bleeding from a cut in the body.

9. On what principles working of hydraulic brakes are based? State the principles.

Sol. Hydraulic brakes are based on the principle of Pascal's law. It states that if gravity is neglected, the pressure in a fluid at rest is same at all points.

10. A hydraulic automobile lift is designed to lift cars with a maximum mass of 3000 kg. The area of cross-section of the piston carrying the load is 425 cm^2. What maximum pressure would the smaller piston have to bear?

Sol. Maximum Pressure which the piston would have to bear is

$$P_{max} = \frac{\text{Maximum wt of car}}{\text{Area of piston}} = \frac{3000\times 9.8}{425\times 10^{-4}} = 6.92\times 10^5 \text{ N/m}^2.$$

(3 Marks Questions)

11. The drop of liquid of density ρ is floating with 1/4th inside the liquid A of density ρ_1 and remaining in the liquid B of density ρ . Then, find the relation between the densities of liquid A and B.

Sol. Upthrust in liquid A, $F_1 = \frac{1}{4} V\rho_1 g$; Upthrust in liquid B, $F_2 = \frac{3}{4} V\rho_2 g$

Where V is the volume of drop of liquid

Therefore $\frac{F_1}{F_2} = \frac{\rho_1}{3\rho_2}$

For floatation, $\frac{1}{4} V\rho_1 g + \frac{3}{4} V\rho_2 g = V\rho g \Rightarrow \rho_1 + 3\rho_2 = 4\rho$.

12. Explain why:

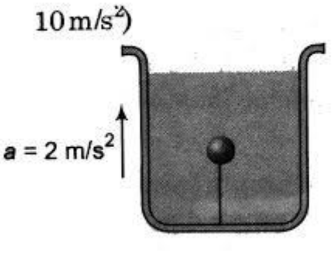
(a) A balloon filled with helium does not rise in air indefinitely but halts after a certain height (Neglect winds).

(b) The force required by man to raise his limbs immersed in water is smaller than the force for the same movement in air.

Sol. (a) A balloon filed with helium goes on rising in air as long as the weight of the air displaced by it (i.e. upthrust) is greater than the weight of filled balloon. We know that the density of air decreases with height. Therefore the balloon halts after attaining a height at which density of air is such that the weight of air displaced just equals the weight of helium filled balloon.

(b) Water exerts much more upthrust on the limbs of man than air. So the net weight of limbs in water is much less than that in air. Hence the force required by a man to raise his limbs immersed in water is smaller than the force for the same movement in air.

13. A solid sphere of mass m = 2kg and density of 0.5×10^3 kg/m^3 is held stationary relative to a tank filled with water as shown in figure. The tank is accelerating vertically upward with acceleration 2m/s^2.



(a) Calculate the tension in the thread connecting the sphere and the bottom of the tank.

(b) If the thread snaps, calculate the acceleration of the sphere with respect to the tank (density of water is $\rho = 1000$ kg/m^3 and $g = 10$ m/s^2).

Sol. Density of sphere, $\sigma = 0.5\times10^3$kg/m^3

(a) Here $\rho = 10^3$kg/m^3, $g = 10$m/s^2, $a = 2$m/s^2, $m = 2$kg

Volume of sphere $V = m/\sigma$.

Weight of sphere in accelerating medium = $\sigma V(g + a)$

Upthrust on sphere due to liquid, $\rho V(g + a)$

As the block is held stationary, $T = (\rho - \sigma)\frac{m}{\sigma}(g + a) = \frac{0.5\times10^3\times2\times12}{0.5\times10^3} = 24$N

(b) If the thread snaps, T = 0

F_{net} - F_{up} – W = (ρ □ σ) V(g + a)

$= 0.5\times10^3 \times \frac{2}{0.5\times10^3} \times 12 = 24$N

Acceleration of sphere = 24/2 = 12m/s^2.

14. A U-tube contains water and methylated spirit separated by mercury. The mercury columns in the two arms are in level with 10.0 cm of water in one arm and 12.5 cm of spirit in the other. What is the specific gravity of the spirit?

Sol. Since the mercury column in the two arms is in the level, therefore,

Pressure of spirit = Pressure of water $\Rightarrow \rho_s g h_s = \rho_w g h_w \Rightarrow \rho_s/\rho_w = h_w/h_s$

But, ρ_s = density of spirit, ρ_w = density of water,

h_s = height of spirit = 12.5 cm = 12.5×10^{-2}m and

h_w = height of water = 10 cm = 10×10^{-2} m

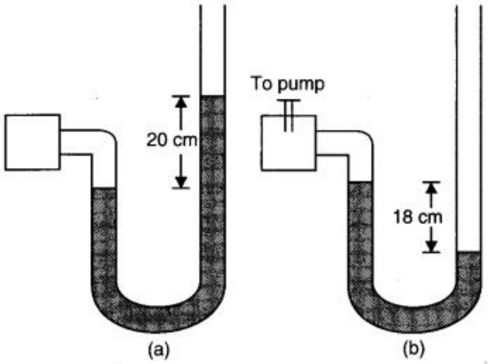
From the relation

$\rho_s/\rho_w = h_w/h_s = \{10 \times 10^{-2}\}/\{12.5 \times 10^{-2}\} = 0.8$ i.e., sp gravity of spirit $= \rho_s/\rho_w = 0.8$.

15. In the previous Qs if 15.0 cm of water and spirit each are further poured into the respective arms of the tube, what is the difference in the levels of mercury of the two arms? Specific gravity of mercury = 13.6.

Sol. If ρ_m be the density of mercury, then $\rho_s/\rho_w = 13.6$
On pouring 15 cm of water and spirit on both sides,
Height of water column $= (10 + 15) = 25$ cm $= 25 \times 10^{-2}$ m
If h_1 and h_2 be the heights of mercury from the bottom of U-tube,
then $\rho_w \times 25 \times 10^{-2} \times g + h_1\rho_w g = \rho_s \times 275 \times 10^{-5} \times g + h_2\rho_m g$
Dividing both sides by $\rho_w g$, we get
$25 \times 10^{-2} + h_1.\rho_m/\rho_w = \rho_s/\rho_w \times 27.5 \times 10^{-2} + h_2.\rho_m/\rho_w$
or $25 \times 10^{-2} + h_1 \times 13.6 = 0.8 \times 27.5 \times 10^{-2} + h_2 \times 13.6$
$\Rightarrow 13.6(h_2 - h_1) = 25 \times 10^{-2} - 0.8 \times 27.5 \times 10^{-2} = 3 \times 10^{-2}$
or, $h_2 \times h_1 = \{3 \times 10^{-2}\}/\{13.6\} = 0.00221$ m $= 0.221$ cm

16. The manometer reads the pressure of a gas in an enclosure as shown in figure. When some of the gas is removed by a pump, the manometer reads as in figure (b).



The liquid used in the manometers is mercury and the atmospheric pressure is 76 cm of mercury.
(i) Give the absolute and gauge pressure of the gas in the enclosure for cases (a) and (b) in units of cm of mercury.
(ii) How would the levels change in case (b) if 13.6cm of water (immiscible with mercury) are poured into the right limb of the manometer? (Ignore the small change in volume of the gas).

Sol. Here atmospheric pressure, P = 76mm of Hg
(i) In case (a) Pressure head, h = +20cm of Hg, Absolute pressure = P + h = 76 + 20 = 96cm of Hg, Gauge pressure = h = 20cm of Hg,
In case (b) Pressure head, h - - 18cm of Hg, Absolute pressure = P + h = 76 – 18 = 58cm of Hg, Gauge pressure = h = - 18cm of Hg

(ii) As $h_1\rho_1 g = h_2\rho_2 g$

$= h_1 = 13.6 \times g = 13.6\times1\times g$

Or $h_1 = 1\text{cm}$

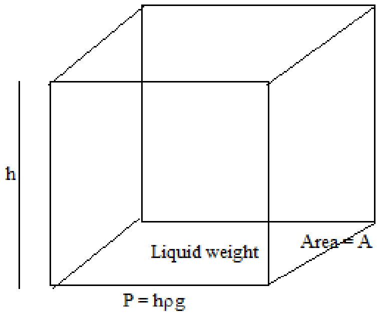
Therefore as 13.6cm of water is poured in right limb, it will displace mercury level by 1cm in the left limb, so that difference of levels in the two limbs will become 19cm.

(5 Marks Questions)

17. (a) Derive an expression for the pressure exerted by a liquid column of height h.

(b) A column of water 40cm high supports a 30cm column of an unknown liquid. What is the density of the liquid?

Sol. (a) Consider the vessel of height h and cross sectional area A filled with a liquid of density ρ. The weight of the liquid column exerts a downward thrust on the bottom of the vessel and the liquid exerts pressure.



Weight of liquid column, W = Mass of liquid × g × volume × density × g

$= Ah \times \rho \times g = Ah\rho g$

Pressure exerted by the liquid column on the bottom of the vessel is

$$P = \frac{\text{Thrust}}{\text{Area}} = \frac{W}{A} = \frac{Ah\rho g}{A} \text{ or } P = h\rho g$$

Thus the pressure exerted by a liquid column at rest is proportional to (I)height of liquid column and (ii) density of the liquid.

(b) As $h_1\rho_1 g = h_2\rho_2 g$

So, $\rho_2 = \frac{h_1}{h_2} \times \rho_1 = \frac{0.40}{0.30} \times 10^3 = 1.33\times10^4 \text{kg m}^{-3}$.

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B. FLUID DYNAMICS

(1 Mark Questions)

1. Why are straws used to suck soft drinks?

Sol. When we suck through the straw, the pressure inside the straw becomes less than the atmospheric pressure. Due to the pressure difference, the soft drink rises in the straw and we are able to take the soft drink easily.

2. Streamline flow is more likely for liquids with
(a) high density and high viscosity (b) low density and low viscosity
(c) high density and low viscosity (d) low density and high viscosity
Ans. (d)

3. When the flow parameters of any given instant remain same at every point, then flow is said to be
(a) laminar (b) steady state (c) turbulent (d) quasi-static
Ans. (b)

4. An ideal flow of any fluid must satisfy
(a) Pascal law (b) Stoke's law
(c) Continuity equation (d) Bernoulli's theorem
Ans. (c)

5. When does the flow of liquid become turbulent?
Sol. If the velocity of a liquid at a point changes and the rate of flow exceeds the critical velocity, then the flow becomes turbulent.

6. Why does velocity increase when water flowing in a broad pipe enters a narrow pipe?
Sol. In a stream-line flow of a liquid according to equation of continuity av = a constant where a is the area of cross-section and v is the velocity of the liquid flow. When water flowing in broader pipe enters a narrow pipe the area of cross-section of the water decreases therefore the velocity of water increases.

7. Dynamic lift due to spinning is
(a) Magnus effect (b) Doppler effect (c) Pascal effect (d) Toricelli's effect
Ans. (a)

8. Bernoulli's equation for steady, non-viscous incompressible flow expresses the
(a) conservation of linear momentum (b) conservation of angular momentum
(c) conservation of energy (d) conservation of mass
Ans. (c)

9. Applications of Bernoulli's theorem can be seen in
(a) dynamic lift of aeroplane (b) hydraulic press
(c) helicopter (d) none of these
Ans. (a)

10. A cylinder of height 20m is completely filled with water. The velocity of efflux of water through a hole on the side wall of the cylinder near its bottom is (take g = 10 ms^{-2})
(a) 10 ms^{-1} (b) 20 ms^{-1} (c) 25.5 ms^{-1} (d) 5 ms^{-1}

Sol. (b)
v = $\sqrt{2gh} = \sqrt{2 \times 10 \times 20}$ = 20 ms^{-1}.

11. When air is blown between two balls suspended close to each other they are attracted towards each other. Why?

Sol. On blowing air between the two balls, the air velocity increases, decreasing pressure. The pressure on the outer side of the ball being more will exert forces on the balls, so they move towards each other.

12. Why two ships moving in parallel directions close to each other get attracted?

Sol. As speed of water between the ships is more than outside them pressure between them gets reduced & pressure outside is more so the excess pressure pushes the ships close to each other therefore they get attracted.

13. Does it matter if one use gauge pressure instead of absolute pressure in applying Bernoulli’s equation?

Sol. No, it does not matter if one uses gauge pressure instead of absolute pressure while applying Bernoulli's equation. The two points where Bernoulli's equation is applied should have significantly different atmospheric pressures.

(2 Marks Questions)

14. What is the difference between streamline and turbulent flow?

Sol. Streamline flow: The flow in which path taken by a fluid particle under a steady flow is a streamline indirection of the fluid velocity at that point.

Turbulent flow: The flow in which velocity of fluid is greater than its critical velocity and the motion of particles becomes irregular is called turbulent flow.

15. Explain, why when we try to close a water tap with our fingers, fast jets of water gush through the openings between our fingers.

Sol. This can be explained from the equation of continuity i.e. $a_1v_1 = a_2v_2$. S we try to close a water tap with our fingers, the area of cross section of the outlet of water het is reduced considerably as the openings between our fingers provide constriction)i.e., regions of smaller area).

The velocity of water increases greatly and fast jets of water came through the openings between our fingers.

16. The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down. Explain how.

Sol. As the stream falls, its speed v will increase and hence its area of cross section a will decrease, according to equation of continuity, i.e., av = constant. That is why the stream will become narrow. When the stream will go up, its speed will decrease, hence its area of cross section will increase i.e., it will become broader and spreads out like fountain.

17. Explain why, to keep a piece of paper horizontal you should blow over, not under it.

Sol. If we blow over a piece of paper, velocity of air above the paper becomes more than that below it. As KE of an air above the paper increases, so in accordance with Bernoulli's theorem, ($P + \frac{1}{2} \rho v^2$ = constant), its pressure energy and hence its pressure decreases. Due to greater value of pressure below the piece of paper = atmospheric pressure, it remains horizontal and does not fall. On the other hand, if we blow under the paper, the pressure on the lower side decreases. The atmospheric pressure above the paper will therefore bend the paper downwards. So the paper will not remain horizontal.

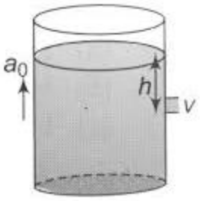
18. Mention any three applications of Bernoullis principle.

Sol. (i) Venturi meter: If is device used to measure the speed of a liquid flowing steadily in a paper.

(ii) Atomizer or sprayer: When air is forced through the nozzle with large velocity, the pressure near the nozzle become low and oil or paint is forced up the tube.

(iii) Magnus effect: The dynamic lift due to spinning is called Magnus effect. The dynamic lift is a force that acts on a body because of its motion through a fluid. It is a consequence of Bernoulli's theorem according to which pressure is low where speed is high and v\ice versa.

19. For the area a of the hole is much lesser than the area of the base of a vessel of liquid, find velocity of efflux v of the liquid if vessel is accelerating as shown in figure. (a_0 = vertical acceleration)



Sol. Effective value of acceleration due to gravity $(g + a_0)$

Required velocity of efflux, $v = \sqrt{2(g + a_0)h}$

20. Why we cannot remove a filter paper from a funnel by blowing air into narrow end?

Sol. When air is blown into the narrow end its velocity in the region between filter pipe and glass increases. This decreases the pressure. The filter paper gets more firmly held with the wall of the funnel.

21. In streamline flow, water entering a pipe having diameter of 2cm and the speed of water is 1.0 m/s. Eventually, the pipe tapers to a diameter of 1cm. Calculate the speed of water where diameter of pipe is 1cm.

Sol. Given that, $r_1 = 2/2 = 1$cm, $v_1 = 1.0$ ms^{-1} = 100 cms^{-1}, $r_2 = ½ = 0.5$cm

$A_1v_1 = A_2 v_2$ or $(\pi r_1^2)v_1 + (\pi r_2^2)v_2$

Therefore $v_2 = \left(\frac{r_1}{r_2}\right)^2 v_1 = \left(\frac{1}{0.5}\right)^2 \times 100 = 400$ cms^{-1}.

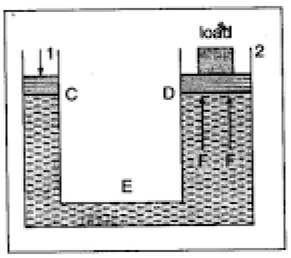
22. Can Bernoulli’s equation be used to describe the flow of water through a rapid in river? Explain.

Sol. Bernoullis equation cannot be used to describe the flow of water through a rapid in a river because of the turbulent flow of water. This principle can only be applied to a streamline flow.

(3 Marks Questions)

23. State Pascal’s law of fluid pressure. Explain the working of hydraulic lift with suitable diagram.

Sol. Pascal’s law: If gravity effect is neglected the pressure is a fluid is same for all points.



Hydraulic lift: It is used to lift heavy loads. Its working is based on Pascal’s law. A simple hydraulic lift is shown in figure. Here C and D are two cylinders of different areas of cross section. They are connected to each other with a pipe E. Each cylinder is provided with airtight frictionless piston. Let a, and A be the areas of cross section of the pistons in C and D respectively, where a <<A. The cylinders are filed with an incompressible liquid.

Let a downward force f be applied on the piston of C. Then the pressure exerted on the liquid, p = f/a. According to Pascal’s law, this pressure is transmitted equally to piton of cylinder D.

Therefore upward force acting on the piston of cylinder D will be, F = PA = $\frac{f}{a}A = f\frac{A}{a}$.

24. State and prove equation of continuity for fluids.

Sol. It states that during the streamlined flow of the non viscous and incompressible fluid through a pipe of varying cross section, the normal fluid velocity (av) remains constant throughout the flow.

Consider a non viscous and incompressible liquid flowing steadily between the sections A and B of a pipe of varying cross section. Let a_1 be the area of cross section, $v_1$fluid velocity, ρ_1 fluid density at section A; and the values of corresponding quantities at section B be a_2, v_2 and ρ_2.

As m = volume × density = Area of cross section × length × density

Therefore mass of fluid that flow through section A in time Δt, $m_1 = a_1v_1\Delta t\rho_1$

Mass of fluid that flows through section B in time Δt, $m_2 = a_2v_2\Delta t\rho_2$

By conversation of mass, $m_1 = m_2$ or $m_1 = a_1v_1\Delta t\rho_1 = m_1 = a_2v_2\Delta t\rho_2$

As the fluid is incompressible, so $\rho_1 = \rho_2$ and hence $a_1v_1 = a_2v_2$ or av = constant.

This is equation of continuity.

25. The cylindrical tube of spray pump has a cross section of 8.0 cm^2 on one end of which has 40 fine holes each of diameter 1.0mm. If the flow of liquid inside the tube is 1.5m min^{-1}, what is the speed of ejection of the liquid through the holes?

Sol. Here cross section of the tube, $a_1 = 8.0cm^2 = 8.0\times10^{-4}\ m^2$

The speed of liquid in the tube, $v_1 = 1.5\ m\ min^{-1} = \frac{1.5}{60}ms^{-1} = 0.025\ ms^{-1}$

Diameter of a hole, $D = 1.0mm = 10^{-3}m$

Therefore cross of a hole, $\frac{\pi D^2}{4} = \frac{\pi}{4}\times(10^{-3})^2 = \frac{\pi}{4}\times10^{-6}m^2$

Therefore total cross section of 40 holes, $a_2 = \frac{\pi}{4}\times10^{-6}\times40m^2$

If v_2 is the speed of ejection of the liquid through the holes, then $a_1v_1 = a_2v_2$

Or $v_2 = \frac{a_1v_1}{a_2} = \frac{8.0\times10^{-4}\times0.025}{\left(\frac{\pi}{4}\right)\times10^{-6}\times40} = 0.637\ ms^{-1}$

26. Find the velocity of efflux of water from an orifice near the bottom of a tank in which pressure is 500 gf/sq cm above atmosphere.

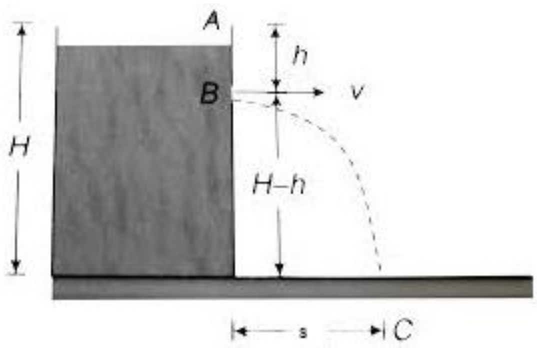
Sol. Pressure at orifice, $P = 500\ gf\ cm^{-2} = \frac{500}{1000}x\times9.8\times(100)^2Nm^{-2} = 500\times9.8\ Nm^{-2}$

Let h be the height of the orifice below the surface. As P = hρg

Therefore, $h = \frac{P}{\rho g} = \frac{500\times98}{10^3\times9.8} = 5m$

The velocity of efflux, $v = \sqrt{2gh} = \sqrt{2\times9.8\times5} = 9.899\ ms^{-1}$.

27. Water stands at a depth H in a tank whose side walls are vertical as shown in the figure. A hole is made on one side of the walls at a depth h below the water surface.



(a) At what distance s from the foot of the wall does the emerging stream of water strike the floor?

(b) For what value of h this range is maximum?

Sol. (a) Velocity of efflux, $v = \sqrt{2gh}$

Time taken by the liquid to touch the ground, i.e. to travel a vertical distance (H – h) is given by

$(H - h) = \frac{1}{2} gt^2$ or $t = \sqrt{\frac{2(H-h)}{g}}$

Thus $s = vt = \sqrt{2gh} \times \sqrt{\frac{2(H-h)}{g}}$ or $s = 2\sqrt{h(H-h)}$

(b) For s to be maximum, ds/dh = 0

Or $\frac{d}{dh}[2\sqrt{h(H-h)}] = 0$

Or $2 \times (1/2)\,(Hh - h^2)^{-1/2}\,(H - 2h) = 0$

Or $\frac{H-2h}{\sqrt{Hh-h^2}} = 0$ or $h = H/2$.

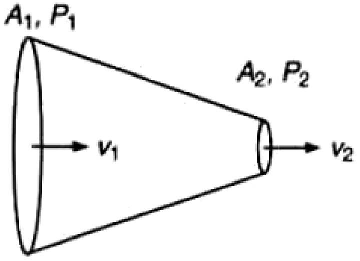
28. Calculate the rate of flow of glycerine of density 1.25×10^3 kg m^{-3} through the conical section of pipe if the radii of its ends are 0.1m and 0.04m and pressure drop across its length is 10 Nm^{-3}.

Sol.

$$A_1 v_1 = A_2 v_2$$

$$\frac{v_1}{v_2} = \frac{A_2}{A_1} = \frac{\pi r_2^2}{\pi r_1^2} = \left(\frac{r_2}{r_1}\right)^2$$

$$= \left(\frac{0.04}{0.1}\right)^2 = \frac{4}{25} \quad \ldots(i)$$



From Bernoulli's equation,

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

$$v_2^2 - v_1^2 = \frac{2(P_1 - P_2)}{\rho}$$

$$v_2^2 - v_1^2 = \frac{2 \times 10}{1.25 \times 10^3}$$

$$= 1.6 \times 10^{-2} \text{ m}^2/\text{s}^2 \quad \ldots\text{(ii)}$$

Solving Eqs. (i) and (ii), we get $v_2 = 0.128$ m/s

Rate of volume flow through the tube

$$Q = A_2 v_2 = (\pi r_2^2)v_2$$

$$= \pi(0.04)^2(0.128)$$

$$= 6.43 \times 10^{-4} \text{ m}^3/\text{s}$$

29. In a test experiment on a model aero-plane in a wind tunnel, the flow speed on the upper and lower surfaces of the wing are 70 ms^{-1} and 63 ms^{-1} respectively. What is the lift of the wing if its area is 2.5 m^2? Density of air = 13 kg m^{-3}.

Sol. Here, $v_1 = 70 \text{ ms}^{-1}$, $v_2 = 63\text{ms}^{-1}$, $\rho = 1.3 \text{ kg m}^{-3}$ and $A = 2.5 \text{ m}^2$

Now, using Bernoulli's theorem (for constant height)

$P_1 + 1/2\ \rho v_1^2 = P_2 + 1/2\ \rho v_2^2$

$\Rightarrow P_2 - P_1 = 1/2\ \rho(v_1^2 - v_2^2)$

$= 1/2 \times 1.3 \times [(70)^2 - (63)^2] = 605.15 \text{ Nm}^{-2}$

Lift on the wings is, $F = (P_2 – P_1) \times A = 605.15 \times 2.5$

$= 1.51 \times 103 \text{ N} \cong 1512.9\text{N}$.

(5 Marks Questions)

30. What is laminar flow of a liquid? Distinguish between the velocity profiles of non viscous and viscous liquids?

Sol. Laminar flow: When the velocity of the flow of liquid is less than its critical velocity, the liquid flows steadily. Each layer of the liquid slides over the other layer. It behaves as if different laminas are sliding over one another. Such a flow is called laminar flow.

The surface obtained by joining the heads of the velocity vectors for the particles in a section of a flowing liquid is called a velocity profile.

(i) Velocity profile for non viscous liquid: In case of a non viscous liquid, the velocity of all the particles at any section of a pipe is same, so the velocity profile is plane.

(ii) Velocity profile of a viscous liquid: When a viscous liquid flows through a pipe, the velocity of layer at the axis is maximum, the velocity decreases as we go towards the wall of the pipe and becomes zero for the layer in contact with the pipe. Hence the velocity profile for a viscous liquid is parabolic.

31. The bottom of a cylindrical vessel line has a hole of diameter d. The diameter of the vessel is D. Find the velocity with which the water level in the vessel drops in terms of the height h of this level.

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32. State and Proof Bernoulli's theorem.

Sol. Bernoulli's theorem states the principle of conservation of energy for standard fluids.

This theorem is the basis for many engineering applications.

Proof

Let's consider a tube of flow CD as shown in figure A. Let, at point C, α_1 be the cross-sectional area, v_1 be the velocity of the liquid and P_1 be the pressure. On the other hand, let α_2 be the pressure, v_2 be the velocity and P_2 be the pressure at the point D. Let, h_1 and h_2 be the heights of the tube by which the tube is raised.

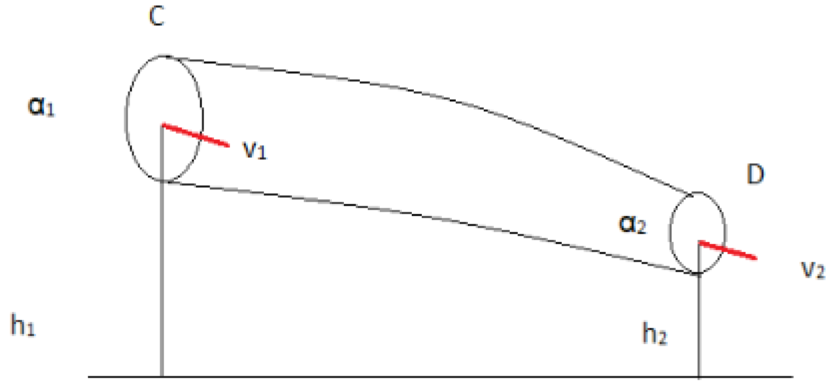


Figure A

The force exerted by the liquid at C is $P_1\alpha_1$.

The work done by the mass entering the tube through the cross-sectional area α_1 at the point C per unit time is P_1V.

Where, $V= \alpha_1 v_1$ is the volume of the liquid entering C.

The work done is stored in liquid and is called pressure energy.

So, the pressure energy per unit volume at the end C is P_1.

If m is the mass of the liquid entering at the point C per unit time, then the pressure energy of the liquid at C= m (P_1/ρ).

where pressure energy per unit mass is P_1/ρ

and ρ is the density of the liquid.

The kinetic energy of the liquid at the point C is $\frac{1}{2} mv_1^2$

The potential energy of the liquid at the point C is mgh_1

So, the total energy at the point C is given by,

$$mP_1/\rho + \tfrac{1}{2} mv_1^2 + mgh_1 \qquad (1)$$

Similarly, the total energy at the point D is given by,

$$mP_2/\rho + \tfrac{1}{2} mv_2^2 + mgh_2 \qquad (2)$$

From the principle of conservation of energy,

$$m P_1/\rho + \tfrac{1}{2} mv_1^2 + mgh_1 = mP_2/\rho + \tfrac{1}{2} mv_2^2 + mgh_2$$

$$\text{or, } P_1/\rho + 1/2\, v_1^2 + gh_1 = P_2/\rho + 1/2\, v_2^2 + gh_2$$

or, $P/\rho + \frac{1}{2} v^2 + gh = \text{constant}$

This is Bernoulli's theorem.

$P/\rho g + v^2/2g + h = \text{constant}$

$P/\rho g$ is called the pressure head

$v^2/2g$ is called the velocity head

h is called elevation head.

C. VISCOSITY

(1 Mark Questions)

1. With increase in temperature the viscosity of

(a) liquids increases and of gases decreases (b) liquids decreases and of gases increases

(c) both liquids and gases increases (d) both liquids and gases decreases

Ans. (b)

2. After terminal velocity is reached, the acceleration of a body falling through a viscous fluid is

(a) zero (b) equal to g (c) less than g (d) more than g

Ans. (a)

After terminal velocity is reached, the net acceleration of the body falling through a fluid is zero because the body after attaining terminal velocity will continue moving with same velocity through the viscous medium.

3. Two balls A and B have radii in the ratio 1:4. What will be the ratio of their terminal velocities in a liquid?

Sol. Terminal velocity, V = r^2

Therefore, $\frac{v_A}{v_B} = \left(\frac{r_A}{r_B}\right)^2 = \left(\frac{1}{4}\right)^2$ = 1:16.

4. Is viscosity a vector?

Sol. It is the property of liquid which is equal to the magnitude of dragging force per unit area between the two layers of liquid whose velocity gradient is unity. So it has no direction (only magnitude of force) so it is not vector.

5. Which fall faster a big raindrops or small raindrops and why?

Sol. The raindrop moves with terminal velocity due to the viscous drag of the air. The terminal velocity of the drop varies as the square of its radius. Hence, a bigger drop has a higher terminal velocity than a smaller one.

6. Define viscosity.

Sol. Viscosity is resistance of a fluid (liquid or gas) to a change in shape, or movement of neighbouring portions relative to one another. Viscosity denotes opposition to flow.

7. Define the coefficient of viscosity of a liquid.

Sol. The coefficient of viscosity of a fluid is defined as the tangential force per unit area, when the change of velocity per unit distance at right angles to the velocity is unity.

8. What is the net weight of a body when it falls with terminal velocity through a viscous medium?

Sol. When a body falls through a viscous medium with 1st terminal velocity, it is moving with a constant velocity. It means no resultant force is acting on the body, since the gravity pull has been balanced by viscous drag and buoyance of medium. Therefore, the effective weight of body becomes zero.

9. The pressure is increased on a gas, then what would be its effect on the viscosity?

Sol. Viscosity decreases with an increase in density. Viscosity decreases with an increase in pressure.

(2 Marks Questions)

10. A small metal sphere of radius a is falling with a velocity v through vertical column of a viscous liquid. If the coefficient of viscosity of the liquid is η, then find an opposing force on the sphere.

Sol. Stock established that if a sphere of radius a moves with velocity v through a fluid of viscosity η, then the viscous force opposing the motion of the sphere is $F = 6\ \pi\eta av$.

11. What is kinematic viscosity?

Sol. The ratio between the coefficient of viscosity, η (also called absolute viscosity, dynamic viscosity or simply viscosity) and the density ρ of a liquid is called the kinematic viscosity. Thus, kinematic viscosity- η/ρ.

12. What is Reynolds number?

Sol. Reynolds number is a dimensionless quantity that is used to determine the type of flow pattern as laminar or turbulent while flowing through a pipe. Reynolds number is defined by the ratio of inertial forces to that of viscous forces.

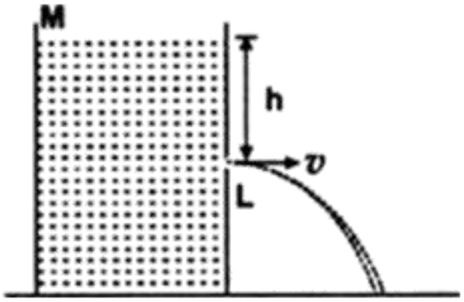
13. What is the importance of Reynolds number?

Sol. The Reynolds number (Re) helps predict flow patterns in different fluid flow situations by measuring the ratio between inertial and viscous forces. At low Reynolds numbers, flows tend to be dominated by laminar (sheet-like) flow, while at high Reynolds numbers flows tend to be turbulent.

(3 Marks Questions)

14. State and prove Toricelli's theorem.

Sol. According to the Torricelli's theorem, the velocity that is attained by water when it starts flowing out of a hole to the ground due to the force of gravity would be equal to the velocity of water that it attains when allowed to fall freely through the height from the top liquid surface to the hole. This is also often termed Torricelli's equation or Torricelli's law in fluids.



Torricelli's law states that the speed of efflux, *v*, of a fluid through a sharp-edged hole at the bottom of a tank filled to a depth *h* is the same as the speed that a body (in this case a drop of water) would acquire in falling freely from a height *h*, i.e. $v = \sqrt{(2gh)}$,

where *g* is the acceleration due to gravity. This last expression comes from equating the kinetic energy gained, $\frac{1}{2}\ mv^2$, with the potential energy lost, *mgh*, and solving for *v*.

$\frac{1}{2} mv^2 = mgh$
$v^2 = 2gh$
$v = \sqrt{(2gh)}$

15. Define terminal velocity. Derive an expression for it.

Sol. Terminal velocity is maximum constant velocity a acquired by the body which is falling freely in a viscous medium.

When a small spherical body falls freely through viscous medium then 3 forces acts on it:-

1) Weight of body acting vertically downwards
2) Up thrust due to buoyancy = weight of liquid displaced
3) Viscous drag (FV) acting in the direction opposite to the motion of body.

Let s = Density of material, r = Radius of spherical body

So = Density of Medium.

True weight of the body = w = volume x density x g

$$W = \frac{4}{3}\pi r^3 sg$$

Up ward thrust F_T =
Volume of Medium displaced

$$= \frac{4}{3}\pi r^3 sog$$

V = Terminal velocity of body

Acc. to stoke's law

$$F_V = 6\pi\eta rv$$

When the body attains terminal velocity, thon

$$F_T + F_V = W$$

$$= \frac{4}{3}\pi r^3 sog + 6\pi\eta rv = \frac{4}{3}\pi r^3 sg$$

$$V = \frac{2r^2(s - So)g}{9\eta}$$

1) V directly depends on radius of body and difference of the pressure of material and medium.

2) V inversely depends of co-efficient of viscosity.

16. Show that Reynolds number represents the ratio of the inertial force per unit area to the viscous force per unit area.

Sol. Consider a narrow tube having a cross sectional area A. Suppose a fluid flows through it with a velocity v for a time interval Δt.

Length of the fluid = velocity × time = $v\Delta t$

Volume of the fluid flowing through the tube in time Δt = $Av\Delta t$

Mass of fluid, Δm = volume × density = $Av\Delta t \times \rho$

Inertial force acting per unit area of the fluid = $\frac{F}{A} = \frac{\text{Rate of chane of momentum}}{A}$

$= \frac{\Delta m \times v}{\Delta t \times A} = \frac{Av\Delta tp \times v}{\Delta t \times A} = \rho v^2$

Viscous force per unit area of the fluid= η × velocity of gradient = $\eta \frac{v}{D}$

$\frac{\text{Inertial force per unit area}}{\text{Viscous force per unit area}} = \frac{\rho v^2}{\eta v/D} = \frac{\rho vD}{\eta} = R_e$

Thus Reynolds number represents the ratio fo the inertial force per unit area to the viscous force per unit area.

(5 Marks Questions)

17. Explain how does a body attain a terminal velocity when it is dropped from rest in a viscous medium. Derive an expression for the terminal velocity of a small spherical body falling through a viscous medium.

Sol. When a body move downward in a liquid then on that body the viscous force of liquid { in upward direction} , the buoyant force {in upward direction,} and the weight of the body {in downward direction} these forces acts . When these three forces cancel the effect of each other than the body acquired terminal velocity.

Let us consider a spherical body of mass m and density . Let density of liquid be .

Now, mass of body is : m = volume× ρ or m = $4/3\ \pi r^3 \times \rho$

Now, mass of fluid liquid displaced: m = $4/3\ \pi r^3 \times \sigma$

At terminal velocity, the body is in equilibrium, so we can say that :

F_b +stroke force = W

$= 4/3\pi r^3\ \sigma\rho + 6\ \pi\eta rv = 4/3\pi r^3 \rho g$

Or $6\ \pi\eta rv = 4/3\pi r^3(\rho \ □\ \sigma)g$

Or $v = \frac{2}{9}\frac{r^2 g(\rho-\sigma)}{\eta}$

D. SURFACE TENSION

(1 Mark Questions)

1. Why is it easier to swim in sea than in the river water?

Sol. The reason is that the sea water contains salt and so its density is more than the density of river water. The weight of a man gets balanced by the less immersed part of his body in sea water as compared to river water. Thus, it is easier for a person to swim in sea water than in river water.

2. For a surface molecule,

(a) the net surface on it is non-zero
(b) the net force on it is zero
(c) there is net downward force
(d) there is net upward force

Ans. (b)

There is a net attractive force on molecules at surface acting downwards.

3. Angle of contact of a liquid with a solid depends on

(a) solid only
(b) liquid only
(c) both on solid and liquid
(d) orientation of the solid surface in liquid

Ans. (d)

4. 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

Ans. (b)

5. A rough sea can be calmed by pouring oil on the surface of sea. Explain.

Sol. Sprinkling oil reduces the surface tension of sea water due to which a net force acts from lesser surface tension to more surface area and the it clams the sea wave.

6. A 20cm capillary tube is dipped in water. The water rises upto 8cm. If the entire arrangement is put in a freely falling elevator, what will be the length of water column in the capillary tube?

Sol. In a freely falling elevator, the entire arrangement is in a state of weightlessness, i.e. g = 0. So after will rise in the tube $\left(h = \frac{2\sigma\cos\theta}{r\rho g}\right)$. The surface tension ($\sigma$) of hot water is less than that of cold water. Moreover, capillary tube expands in h is smaller in hot water than in cold water.

7. If a capillary tube is immersed at first in cold water and then in hot water, the height of capillary is smaller in second case. Why?

Sol. When a capillary tube is immersed in hot water, it expands. Therefore its radius increases. As 'S' decreases and 'r' increases, therefore, the height of capillary rise (h) will be smaller in hot water than in cold water.

8. Water rises in a capillary tube, whereas mercury falls in the same tube. Why?

Sol. The mercury has higher cohesive forces compared to adhesive forces. Therefore, the molecules of mercury are more attracted towards its own molecules than the capillary walls. So, level of mercury will fall.

9. Why are raindrops spherical?

Sol. Raindrops start to form in a roughly spherical structure due to the surface tension of water. This surface tension is the "skin" of a body of water that makes the molecules stick together. The cause is the weak hydrogen bonds that occur between water molecules.

10. Why the molecules of a liquid lying near the free surface possess extra energy?

Sol. The molecules in a liquid surface have a net downward force cohesion on them so work done in bringing them from within the body of liquid to the surface increases surface energy.

11. What makes rain coats water proof?

Sol. The coating used on raincoats is waterproof because, it reduces the adhesive force between the coating material and water particles. Consequently, cohesive forces dominate and water particles combine among themselves leaving the raincoat dry.

12. What is meant by term molecular range?

Sol. It is the maximum distance upto which a molecule can exert force of attraction on another molecule.

13. What is the value of surface tension at critical temperature?

Sol. At critical temperature, surface tension of liquid is zero as there is no interface present.

14. What is capillarity?

Sol. The rise and fall of a liquid in a tube of very fine pore is called capillarity.

15. How is the rise of liquid affected, if the top of the capillary tube is closed?

Sol. There will be a small rise in the capillary tube if the top of the capillary tube is closed. Because the rise of liquid in the capillary tube due to surface tension will be opposed by the downward force exerted by the compressed air above the liquid in the tube.

16. Name the material in which capillary height will descend instead of rising.

Sol. Paraffin wax.

17. Two soap bubbles have radii in the ratio 2:3. Find the ratio of the work done in blowing these bubbles.

Sol. Given $r_A:r_B = 2:3$

As work done in blowing a soap bubble is given by $W = T \times 2 \times 4\pi r^2$

Where T is surface tension of the soap solution

Therefore, $\frac{W_A}{W_B} = \left(\frac{r_A}{r_B}\right)^2 = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$

18. What is the effect of temperature on surface tension?

Sol. The surface tension of liquids generally decreases with increase of temperature and becomes zero at critical temperature (when meniscus between the liquid and the vapour disappears).

(2 Marks Questions)

19. Calculate the energy evolved when 8 droplets of water (surface tension 0.072 nm^{-1}) of radius ½ mm each combine into one.

Sol. Number of droplets, n=8n=8.

Radius of each of droplets, r=12mm $=5\times10^{-4}$m

Surface tension of water, T=0.072N/ m.

As the droplets combine to form into a bigger droplet, total energy released can be given as:

$\triangle E_{loss}=4\pi(n-n^{2/3})r^2T$

$=4\pi(8-8^{2/3})(5\times10^{-4})^2\times0.072$

$=9.0478\times10^{-7}$J

20. Mercury has an angle of contact equal to 140° with soda lime glass. A narrow tube of radius 1.00mm made of this glass is dipped in a through containing mercury. By what amount does the mercury dip down in the tube relative to the liquid surface outside? Surface tension of mercury at the temperature of experiment is 0.465 N/m. Density of mercury = 13.6×10^3 kg/m^3.

Sol. Angle of contact $\theta = 140°$

Radius of the tube, r = 1 mm = 10^{-3}m

Surface tension of mercury S = 0.465 N/m

Density of mercury, $\rho = 13.6 \times 103$ kg/m^3, g = 9.8 m/s^2

Let the Dip in height of mercury be h ,

Surface tension is given by,

$S = \rho_0 e^{-y/y_0}$

$\Rightarrow h = \frac{2S\cos\theta}{\rho g r} = \frac{2\times0.465\times\cos140°}{13.6\times10^3\times9.8\times10^{-3}}$ = -5.34mm

Negative sign indicates that mercury level, dips by 5.34 mm.

21. The excess pressure inside a soap bubble is thrice the excess pressure inside a second soap bubble. What is the ratio between the volume of the first and the second bubble?

Sol. $\frac{4s}{r_1} = \frac{3\times4s}{r_2}$ or $r_2 = 3r_1$

$$\frac{V_1}{V_2} = \frac{(\frac{4}{3})\pi r_1^3}{(\frac{4}{3})\pi r_2^3} = \left(\frac{r_1}{r_2}\right)^3 = \left(\frac{1}{3}\right)^3 = \frac{1}{27} = 1{:}27.$$

22. The surface tension and vapour pressure of water at 20°C is 7.28×10^{-2} Nm^{-1} and 2.33×10^{3}Pa respectively. What is the radius of the smallest spherical water droplet which can form without evaporating at 20°C?

Sol. The drop will evaporate if the water pressure is more than the vapour pressure. The membrane pressure (water).

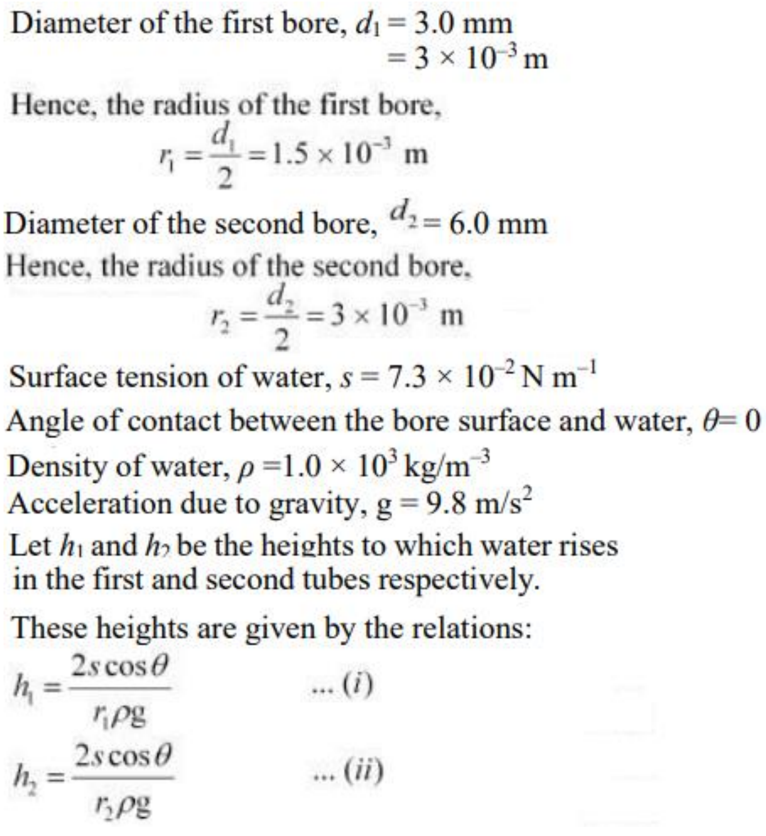
$P = \frac{2T}{r} = 2.33\times10^{3}$Pa

$\therefore r = \frac{2T}{P} = \frac{2(7.28\times10^{-2})}{2.33\times10^{3}} = 6.25\times^{-5}$m.

(3 Marks Questions)

23. The narrow bores of diameters 3.0mm and 6.0mm are joined together to form a U shaped tube open at both ends. If U tube contains water, what is the difference in its levels in the two limbs of the tube? Surface tension of water is 7.3×10^{-2} Nm^{-1}. Take the angle of contact to be zero, and density of water to be 1.0×10^{3} kg m^{-3} and g = 9.8 m/s^2.

Sol.



Diameter of the first bore, $d_1 = 3.0$ mm
$= 3 \times 10^{-3}$ m

Hence, the radius of the first bore,

$$r_1 = \frac{d_1}{2} = 1.5 \times 10^{-3} \text{ m}$$

Diameter of the second bore, $d_2 = 6.0$ mm

Hence, the radius of the second bore,

$$r_2 = \frac{d_2}{2} = 3 \times 10^{-3} \text{ m}$$

Surface tension of water, $s = 7.3 \times 10^{-2}$ N m^{-1}

Angle of contact between the bore surface and water, $\theta = 0$

Density of water, $\rho = 1.0 \times 10^3$ kg/m^{-3}

Acceleration due to gravity, g = 9.8 m/s^2

Let h_1 and h_2 be the heights to which water rises in the first and second tubes respectively.

These heights are given by the relations:

$$h_1 = \frac{2s\cos\theta}{r_1\rho g} \quad \text{... }(i)$$

$$h_2 = \frac{2s\cos\theta}{r_2\rho g} \quad \text{... }(ii)$$

The difference between the levels of water in the two limbs of the tube can be calculated as:

$$= \frac{2s\cos\theta}{r_1\rho g} - \frac{2s\cos\theta}{r_2\rho g}$$

$$= \frac{2s\cos\theta}{\rho g}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

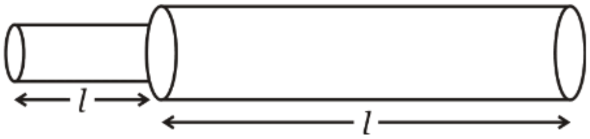
$$= \frac{2 \times 7.3 \times 10^{-2} \times 1}{1 \times 10^3 \times 9.8}\left[\frac{1}{1.5 \times 10^{-3}} - \frac{1}{3 \times 10^{-3}}\right]$$

$$= 4.966 \times 10^{-3} \text{ m}$$
$$= 4.97 \text{ mm}$$

Hence, the difference between levels of water in the two bores is 4.97 mm.

24. Three capillaries of internal radii 2r, 3r and 4r all of eh same length are joined end to end. A liquid passes through the combination and the pressure difference across this combination is 20.2 cm of mercury. What is the pressure difference across the capillary of internal radius 2r?

Sol. Here three capillary tubes are directly connected with each other and they are exerting pressure. By using the formula we can find the value of pressure. We can define capillary action as a phenomenon where ascension of liquids through a tube or cylinder takes place. This primarily occurs due to adhesive and cohesive forces.



Consider P, P_1,P_2 be the pressure exerted at the starting, joining and the ending of the capillary tube. These two tubes are joined in series(as shown)

So,

$\pi(P-P_1)(2r)^4/8\eta l=\pi(P_1-P_2)(4r)^4/8\eta l$

After solving this equation, we get-

$(P-P_1)=(P_1-P_2)16$ --- (1)

$P-17P_1=16P_2$ --- (2)

According to question,

$P-P_2=16$mm

After solving all the given equations, by substituting the given values of r and pressure. in the question. We get-

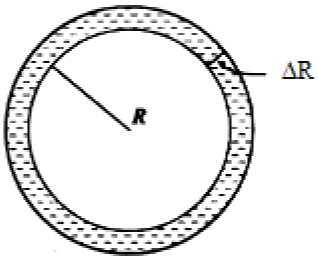
P1=256mm of Hg.

25. Two soap bubbles of radii a and b combine to form a single bubble of radius c. If P is the external pressure, then find the surface tension of the soap solution.

____

26. Derive an expression for the pressure difference across the soap bubble.

Sol. Excess pressure inside a soap bubble: Let us consider a liquid bubble (say a soap bubble) of radius R and let S be the surface tension of the liquid. We know that there is an excess pressure (P) inside the bubble and it acts normally outwards. Let the excess pressure increase the radius of the bubble from R to (R + ΔR) as shown.



Work done by the excess pressure, i.e., W = force × distance

= excess pressure × surface area × distance = $P \times 4\pi R^2 \times \Delta R$ i.e. $W = 4\pi PR^2 \times \Delta R$ ..(i)

The soap bubble has two free surfaces, one inside the bubble and the other outside it.

Total increase in the surface area of the bubble, i.e.,

$\Delta A = 2[4\pi(R + \Delta R)^2 = 4\pi R^2] = 8\pi[R^2 + (\Delta R)^2 + 2R \times \Delta R - R^2]$

$= 16\pi R\Delta R$ …(ii) (neglecting $(\Delta R)^2$ as it is very small)

We know that $S = W = W/\Delta A$ …(iii)

From equations (i), (ii) and (iii)

$S = \frac{4\pi PR^2\Delta R}{16\pi R\Delta R} = \frac{PR}{4}$ or $P = \frac{4S}{R}$

Since the excess pressure is inversely proportional to the radius of the bubble, it means smaller the bubble, greater the excess pressure inside it.

(5 Marks Questions)

27. Derive the ascent formula for rise of liquid in capillary tube. What will happen, if the length of the capillary tube is smaller than the height to which the liquid rises. Explain.

____

28. Define surface tension and surface energy. Obtain a relation between them.

Sol. Surface Tension : The property of a liquid due to which its free surface tries to have minimum surface area is called surface tension. A small liquid drop has spherical shape due to surface tension. Surface tension of a liquid is measured by the force acting per unit length on either side of an imaginary line drawn on the free surface of liquid, then T = (F/L).

(1) It depends only on the nature of liquid and is independent of the area of surface or length of line considered.

(2) It is a scalar as it has a unique direction which is not to be specified.

(3) Dimension : $[MT^{-2}]$. (Similar to force constant)

(4) Units : N/m (S.I.) and Dyne/cm [C.G.S.]

Surface Energy : The potential energy of surface molecules per unit area of the surface is called surface energy.

Unit : Joule/m^2 (S.I.), erg/cm^2 (C.G.S.)

Dimension : $[MT^{-2}]$

$\therefore W = T \times \Delta A$ [ΔA = Total increases in area of the film from both the sides]

i.e., surface tension may be defined as the amount of work done in increasing the area of the liquid surface by unity against the force of surface tension at constant temperature.

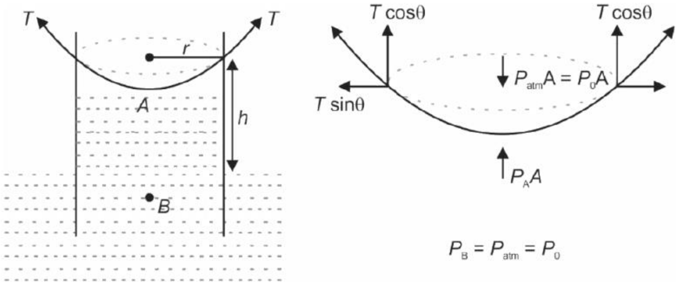
29. (i) What is the phenomenon of capillarity?

(ii) Derive an expression for the rise of the liquid in a capillary tube.

(iii) What will happen if length of the capillary tube is smaller than the height to which the liquid rest? Explain briefly.

Sol. (i) Capillary rise or capillarity is a phenomenon in which liquid spontaneously rises or falls in a narrow space such as a thin tube or in the voids of a porous material. Surface tension is an important factor in the phenomenon of capillarity.

(ii)



Let h be the rise in level in capillary and T be surface tension

For equilibrium. $T\cos\theta \times 2\pi r = (P_0 - P_A)\pi r^2$

$\frac{2T\cos\theta}{r} = P_0 - P_A$

Therefore, $P_A = P_0 - \frac{2T\cos\theta}{r}$ …(i)

Now, $P_b = P_A + \rho gh$ or $P_0 = \frac{2T\cos\theta}{r} + \rho gh$

$\frac{2T\cos\theta}{r} = \rho gh$

Therefore $h = \frac{2T\cos\theta}{r\rho g}$

h is the rise in liquid in collision, T = surface tension

(iii) When length of tube is less than the height of capillary rise, the liquid molecules on reaching top of the capillary come into contact with horizontal surface of the tube. The surface tension becomes horizontal. There is no vertical force to pull the liquid up and it stops rising.

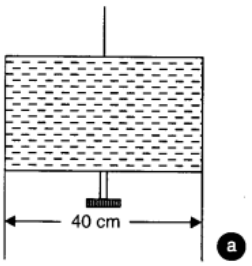
30. (a) If a capillary tube is immersed first in cold water and then in hot water, in which case height of water in the capillary tube is more? Give reason to support your answer.

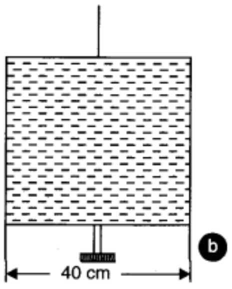
(b) Two soap bubbles of unequal sizes are blown at the ends of a capillary tube. Which one will grow at the expense of other? Give reason for your answer.

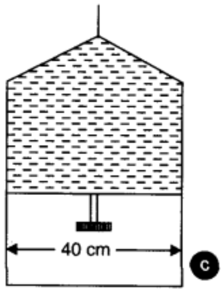
Sol. (a) The height upto which a liquid rises in capillary tube, is given by:- $h = 2s\cos\theta/r\gamma g$ Now, as the surface tension(s) of hot water is less than that of cold water, when a capillary tube is immersed in hot water, it expands. Therefore, its radius increases. As 'δ' decreases and 'r' increases, therefore the height of capillary size(h) will be smaller in hot water than in cold water.

(b) Excess pressure inside a soap bubble is inversely proportional to its radius, i.e., $p \propto 1/r$. Therefore, excess pressure inside a small bubble will be more than that inside a bubble. Hence, big bubble will grow at the cost of small bubble.

31. Figure shows a thin liquid film supporting a small weight = 4.5×10^{-2} N. What is the weight supported by a film of the same liquid at the same temperature in figures? Explain your answers physically.







Sol. Take case (a):

The length of the liquid film supported by the weight, l = 40 cm = 0.4 cm. The weight supported by the film, $W = 4.5 \times 10^{-2}$ N

A liquid film has two free surfaces.

Surface tension = $W/2l = 4.5 \text{ x } 10^{-2}/2 \text{ x } 0.4 = 5.625 \text{ x } 10^{-2}$ Nm^{-1}.

In all the three figures, the liquid is the same. Temperature is also the same for each case. Hence, the surface tension in figure (b) and figure (c) is the same as in figure (a), i.e., 5.625×10^{-2} Nm^{-1}.

Since the length of the film in all the cases is 40 cm, the weight supported in each case is 4.5×10^{-2} N.

E. ASSERTION REASON TYPE QUESTIONS:

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

1. Assertion: A fluid flowing out of a small hoe in a vessel supply a backward thrust on the vessel.

   Reason: According to equation of continuity, the product of area and velocity remain constant.

Ans. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

Due to small area of cross section of the bole, fluid flows out of the vessel with a large speed and thus the fluid possesses a large linear momentum/ As no external force acts on the system, in order to conserve linear momentum, the vessel acquires a velocity in backward direction or in other words a backward thrust results on the vessel.

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

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

Ans. (d) Both Assertion and Reason are false.

With the increase in temperature, the surface tension of liquid decrease. Due to which liquid surface on the solid becomes more flat. Consequently, the angel of contact of a liquid increases with the increase in temperature.

3. Assertion: All the raindrops hit the surface of the earth with the same constant velocity.

   Reason: An object falling through a viscous medium eventually attains a terminal velocity.

Ans. (e) Assertion is false but reason is true

When the rain drops of different sizes fall under gravity, they ultimately move with their terminal velocities due to viscous drag of air. As terminal velocity of drop varies as the square of its radius therefore a bigger drop will have a greater terminal velocity and hence fall faster than a smaller rain drop.

4. Assertion: An air pressure in a car increases during driving.

   Reason: Absolute zero degree temperature is not zero energy temperature.

Ans. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

During driving, the temperature of air inside the tyre increases due to motion. According to Gay Lassac's Law, P = T. Therefore, air pressure inside the tyre increases. The thermodynamic temperature may have non zero total energy but zero translational kinetic energy at particular temperature.

5. Assertion: Water is taken for heating purpose in hot water bottle.

   Reason: Specific heat of water is less than that of other liquids.

Ans. (c) Assertion is true but reason is false

Water has high specific heat (1.00 cal/g°C). Heat must be absorbed in order to break hydrogen bonds and heat is released when hydrogen bond forms. A calorie of heat cause a relatively small change in the temperature because most of heat energy is used to disrupt hydrogen bonds before the water molecule can begin moving faster. And when the temperature of water drops slightly, many additional hydrogen bonds form, releasing considerable amount of energy in the form of heat.