DPP - Daily Practice Problems

Chapter-wise Sheets

Date : ______ **Start Time :** ______ **End Time :** ______

PHYSICS

CP09

SYLLABUS : Mechanical Properties of Fluids

Max. Marks : 180 **Marking Scheme :** (+4) for correct & (–1) for incorrect answer **Time : 60 min.**

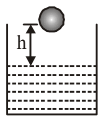
INSTRUCTIONS : This Daily Practice Problem Sheet contains 45 MCQs. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. The density of water at the surface of ocean is ρ. If the bulk modulus of water is B, what is the density of ocean water at a depth where the pressure is nP_0, where P_0 is the atmospheric pressure ?

(a) $\frac{\rho B}{B-(n-1)P_0}$ (b) $\frac{\rho B}{B+(n-1)P_0}$

(c) $\frac{\rho B}{B-nP_0}$ (d) $\frac{\rho B}{B+nP_0}$

2. A ball of radius r and density ρ falls freely under gravity through a distance h before entering water. Velocity of ball does not change even on entering water. If viscosity of water is η the value of h is given by



(a) $\frac{2}{9}r^2\left(\frac{1-\rho}{\eta}\right)g$ (b) $\frac{2}{81}r^2\left(\frac{\rho-1}{\eta}\right)g$

(c) $\frac{2}{81}r^4\left(\frac{\rho-1}{\eta}\right)^2 g$ (d) $\frac{2}{9}r^4\left(\frac{\rho-1}{\eta}\right)^2 g$

3. Two parallel glass plates are dipped partly in the liquid of density 'd' keeping them vertical . If the distance between the plates is 'x', surface tension for liquids is T and angle of contact is θ, then rise of liquid between the plates due to capillary will be

(a) $\frac{T\cos\theta}{xd}$ (b) $\frac{2T\cos\theta}{xdg}$ (c) $\frac{2T}{xdg\cos\theta}$ (d) $\frac{T\cos\theta}{xdg}$

4. A liquid is allowed to flow into a tube of truncated cone shape. Identify the correct statement from the following

(a) The speed is high at the wider end and high at the narrow end

(b) The speed is low at the wider end and high at the narrow end

(c) The speed is same at both ends in a streamline flow

(d) The liquid flows with uniform velocity in the tube

5. A wide vessel with a small hole at the bottom is filled with water (density ρ_1, height h_1) and kerosene (density ρ_2, height h_2). Neglecting viscosity effects, the speed with which water flows out is :

(a) $[2g(h_1+h_2)]^{1/2}$ (b) $[2g(h_1\rho_1+h_2\rho_2)]^{1/2}$

(c) $[2g(h_1+h_2(\rho_2/\rho_1))]^{1/2}$ (d) $[2g\,(h_1+h_2(\rho_1/\rho_2))]^{1/2}$

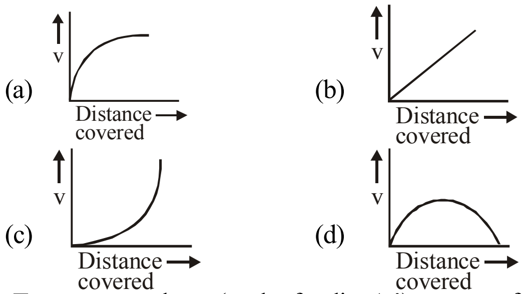
RESPONSE GRID 1. ⓐⓑⓒⓓ 2. ⓐⓑⓒⓓ 3. ⓐⓑⓒⓓ 4. ⓐⓑⓒⓓ 5. ⓐⓑⓒⓓ

Space for Rough Work

6. A capillary tube of radius r is immersed vertically in a liquid such that liquid rises in it to height h (less than the length of the tube). Mass of liquid in the capillary tube is m. If radius of the capillary tube is increased by 50%, then mass of liquid that will rise in the tube, is

(a) $\frac{2}{3}$m (b) $\frac{4}{9}$m (c) $\frac{3}{2}$m (d) $\frac{9}{4}$m

7. A lead shot of 1 mm diameter falls through a long column of glycerine. The variation of its velocity v with distance covered is represented by



8. Two mercury drops (each of radius 'r') merge to form bigger drop. The surface energy of the bigger drop, if T is the surface tension, is :

(a) $4\pi r^2T$ (b) $2\pi r^2T$

(c) $2^{8/3}\pi r^2T$ (d) $2^{5/3}\pi r^2T$

9. Wax is coated on the inner wall of a capillary tube and the tube is then dipped in water. Then, compared to the unwaxed capillary, the angle of contact θ and the height h upto which water rises change. These changes are :

(a) θ increases and h also increases
(b) θ decreases and h also decreases
(c) θ increases and h decreases
(d) θ decreases and h increases

10. A rain drop of radius 0.3 mm has a terminal velocity in air = 1 m/s. The viscosity of air is 8×10^{-5} poise. The viscous force on it is

(a) 45.2×10^{-4} dyne (b) 101.73×10^{-5} dyne
(c) 16.95×10^{-4} dyne (d) 16.95×10^{-5} dyne

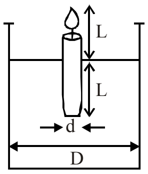
11. A water tank of height 10m, completely filled with water is placed on a level ground. It has two holes one at 3 m and the other at 7 m from its base. The water ejecting from

(a) both the holes will fall at the same spot
(b) upper hole will fall farther than that from the lower hole
(c) upper hole will fall closer than that from the lower hole
(d) more information is required

12. Two capillary of length L and 2L and of radius R and 2R are connected in series. The net rate of flow of fluid through them will be (given rate to the flow through single capillary, $X = \frac{\pi PR^4}{8\eta L}$)

(a) $\frac{8}{9}$X (b) $\frac{9}{8}$X (c) $\frac{5}{7}$X (d) $\frac{7}{5}$X

13. A candle of diameter d is floating on a liquid in a cylindrical container of diameter D (D >> d) as shown in figure. If it is burning at the rate of 2 cm/hour then the top of the candle will

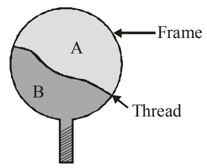


(a) remain at the same height
(b) fall at the rate of 1 cm/hour
(c) fall at the rate of 2 cm/hour
(d) go up at the rate of 1 cm/hour

14. An isolated and charged spherical soap bubble has a radius r and the pressure inside is atmospheric. T is the surface tension of soap solution. If charge on drop is $X\,\pi r\sqrt{2rT\varepsilon_0}$ then find the value of X.

(a) 8 (b) 9 (c) 7 (d) 2

15. A thread is tied slightly loose to a wire frame as in figure and the frame is dipped into a soap solution and taken out. The frame is completely covered with the film. When the portion A is punctured with a pin, the thread



(a) becomes concave towards A
(b) becomes convex towards A
(c) remains in the initial position
(d) either (a) or (b) depending on the size of A w.r.t. B

16. Which of the following expressions represents the excess of pressure inside the soap bubble?

(a) $P_i - P_o = \frac{s}{r}$ (b) $P_i - P_o = \frac{2s}{r}$

(c) $P_i - P_o = \frac{2s}{r} + h\rho g$ (d) $P_i - P_o = \frac{4s}{r}$

17. A spherical solid ball of volume V is made of a material of density ρ_1. It is falling through a liquid of density ρ_1 ($\rho_2 < \rho_1$). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed v, i.e., $F_{viscous} = -kv^2$ ($k > 0$). The terminal speed of the ball is

(a) $\sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$ (b) $\frac{Vg\rho_1}{k}$

(c) $\sqrt{\frac{Vg\rho_1}{k}}$ (d) $\frac{Vg(\rho_1 - \rho_2)}{k}$

18. Select the correct statements from the following.

(a) Bunsen burner and sprayers work on Bernoulli's principle
(b) Blood flow in arteries is explained by Bernoulli's principle
(c) A siphon works on account of atmospheric pressure.
(d) All are correct

RESPONSE GRID					
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Space for Rough Work

19. The wetability of a surface by a liquid depends primarily on
(a) surface tension
(b) density
(c) angle of contact between the surface and the liquid
(d) viscosity

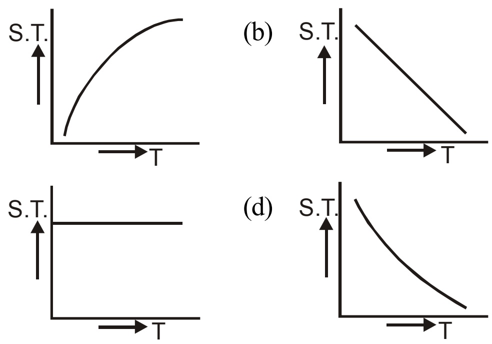
20. The relative velocity of two parallel layers of water is 8 cm/sec. If the perpendicular distance between the layers is 0.1 cm, then velocity gradient will be
(a) 80/sec (b) 60 /sec (c) 50/sec (d) 40/sec

21. Choose the correct statement
(a) Terminal velocities of rain drops are proportional to square of their radii
(b) Water proof agents decrease the angle of contact between water and fibres
(c) Detergents increase the surface tension of water
(d) Hydraulic machines work on the principle of Torricelli's law

22. When a ball is released from rest in a very long column of viscous liquid, its downward acceleration is 'a' (just after release). Its acceleration when it has acquired two third of the maximum velocity is a/X. Find the value of X.
(a) 2 (b) 3 (c) 4 (d) 5

23. A ring is cut from a platinum tube 8.5 cm internal and 8.7 cm external diameter. It is supported horizontally from the pan of a balance, so that it comes in contact with the water in a glass vessel. If an extra 3.97. If is required to pull it away from water, the surface tension of water is
(a) 72 dyne cm^{-1} (b) 70.80 dyne cm^{-1}
(c) 63.35 dyne cm^{-1} (d) 60 dyne cm^{-1}

24. Which of the following graph represents the variation of surface tension with temperature over small temperature ranges for water?



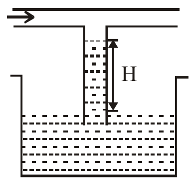
25. When a large air bubble rises from the bottom of a lake to the surface, its radius doubles. If the atmospheric pressure is equal to that of a column of water of height H, then depth of the lake is
(a) H (b) 2H (c) 7H (d) 8H

26. What is the velocity v of a metallic ball of radius r falling in a tank of liquid at the instant when its acceleration is one -half that of a freely falling body ? (The densities of metal and of liquid are ρ and σ respectively, and the viscosity of the liquid is η).
(a) $\frac{r^2 g}{9\eta}(\rho - 2\sigma)$ (b) $\frac{r^2 g}{9\eta}(2\rho - \sigma)$
(c) $\frac{r^2 g}{9\eta}(\rho - \sigma)$ (d) $\frac{2r^2 g}{9\eta}(\rho - \sigma)$

27. Two pieces of metals are suspended from the arms of a balance and are found to be in equilibrium when kept immersed in water. The mass of one piece is 32 g and its density 8 g cm^{-3}. The density of the other is 5 g per cm^3. Then the mass of the other is
(a) 28 g (b) 35 g (c) 21 g (d) 33.6 g

28. A block of material of specific gravity 0.4 is held submerged at a depth of 1m in a vessel filled with water. The vessel is accelerated upwards with acceleration of $a_o = g/5$. If the block is released at $t = 0$, neglecting viscous effects, it will reach the water surface at t equal to ($g = 10\ m/s^2$) :
(a) 0.60 s (b) 0.33 s (c) 3.3 s (d) 1.2 s

29. Figure shows a capillary rise H. If the air is blown through the horizontal tube in the direction as shown then rise in capillary tube will be

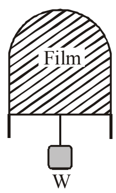


(a) = H
(b) > H
(c) < H
(d) zero

30. A small spherical ball falling through a viscous medium of negligible density has terminal velocity v. Another ball of the same mass but of radius twice that of the earlier falling through the same viscous medium will have terminal velocity
(a) v (b) v/4 (c) v/2 (d) 2v

31. Two non-mixing liquids of densities ρ and nρ (n > 1) are put in a container. The height of each liquid is h. A solid cylinder of length L and density d is put in this container. The cylinder floats with its axis vertical and length pL(p < 1) in the denser liquid. The density d is equal to :
(a) {1 + (n + 1)p}ρ (b) {2 + (n + 1)p}ρ
(c) {2 + (n – 1)p}ρ (d) {1 + (n – 1)p}ρ

32. A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5×10^{-2} N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is



(a) 0.0125 Nm^{-1} (b) 0.1 Nm^{-1}
(c) 0.05 Nm^{-1} (d) 0.025 Nm^{-1}

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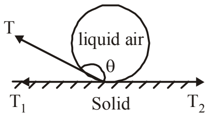
	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ
	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ	31. ⓐⓑⓒⓓ	32. ⓐⓑⓒⓓ	

Space for Rough Work

33. Two liquids of densities d_1 and d_2 are flowing in identical capillary tubes uder the same pressure difference. If t_1 and t_2 are time taken for the flow of equal quantities (mass) of liquids, then the ratio of coefficient of viscosity of liquids must be

(a) $\frac{d_1 t_1}{d_2 t_2}$ (b) $\frac{t_1}{t_2}$ (c) $\frac{d_2}{d_1}\frac{t_2}{t_1}$ (d) $\sqrt{\frac{d_1 t_1}{d_2 t_2}}$

34. Let T_1 be surface tension between solid and air, T_2 be the surface tension between solid and liquid and T be the surface tension between liquid and air. Then in equilibrium, for a drop of liquid on a clean glass plate, the correct relation is (θ is angle of contact)



(a) $\cos\theta = \frac{T}{T_1 + T_2}$ (b) $\cos\theta = \frac{T}{T_1 - T_2}$

(c) $\cos\theta = \frac{T_1 + T_2}{T}$ (d) $\cos\theta = \frac{T_1 - T_2}{T}$

35. A uniform rod of density ρ is placed in a wide tank containing a liquid of density $\rho_0 (\rho_0 > \rho)$. The depth of liquid in the tank is half the length of the rod. The rod is in equilibrium, with its lower end resting on the bottom of the tank. In this position the rod makes an angle θ with the horizontal

(a) $\sin\theta = \frac{1}{2}\sqrt{\rho_0 / \rho}$ (b) $\sin\theta = \frac{1}{2}.\frac{\rho_0}{\rho}$

(c) $\sin\theta = \sqrt{\rho / \rho_0}$ (d) $\sin\theta = \rho_0 / \rho$

36. A spherical ball of iron of radius 2 mm is falling through a column of glycerine. If densities of glycerine and iron are respectively 1.3×10^3 kg/m^3 and 8×10^3 kg/m^3. η for glycerine = 0.83 Nm^{-2} sec, then the terminal velocity is

(a) 0.7 m/s (b) 0.07 m/s (c) 0.007 m/s (d) 0.0007 m/s

37. A water film is formed between two straight parallel wires of 10 cm length 0.5 cm apart. If the distance between wires is increased by 1 mm. What will be the work done ? (surface tension of water = 72 dyne/cm)

(a) 36 erg (b) 288 erg (c) 144 erg (d) 72 erg

38. A waterproofing agent changes the angle of contact

(a) from obtuse to acute.
(b) from acute to obtuse.
(c) from obtuse to $\pi/2$.
(d) from acute to $\pi/2$.

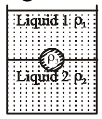
39. A thin metal disc of radius r floats on water surface and bends the surface downwards along the perimeter making an angle θ with vertical edge of the disc. If the disc displaces a weight of water W and surface tension of water is T, then the weight of metal disc is:

(a) $2\pi r T + W$ (b) $2\pi r T\cos\theta - W$
(c) $2\pi r T\cos\theta + W$ (d) $W - 2\pi r T\cos\theta$

40. A tank has a small hole at its botom of area of cross-section a. Liquid is being poured in the tank at the rate Vm^3/s, the maximum level of liquid in the container will be (Area of tank = A)

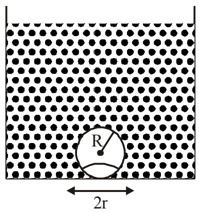
(a) $\frac{V}{gaA}$ (b) $\frac{V^2}{2gAa}$ (c) $\frac{V^2}{gAa}$ (d) $\frac{V}{2gaA}$

41. A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 and, ρ_2 respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure. Which of the following is true for ρ_1, ρ_2 and ρ_3?



(a) $\rho_3 < \rho_1 < \rho_2$ (b) $\rho_1 > \rho_3 > \rho_2$
(c) $\rho_1 < \rho_2 < \rho_3$ (d) $\rho_1 < \rho_3 < \rho_2$

42. On heating water, bubbles being formed at the bottom of the vessel detach and rise. Take the bubbles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If $r \ll R$ and the surface tension of water is T, value of r just before bubbles detach is: (density of water is ρ_w)



(a) $R^2\sqrt{\frac{2\rho_w g}{3T}}$ (b) $R^2\sqrt{\frac{\rho_w g}{6T}}$ (c) $R^2\sqrt{\frac{\rho_w g}{T}}$ (d) $R^2\sqrt{\frac{3\rho_w g}{T}}$

43. The lift of an air plane is based on

(a) Torricelli's theorem
(b) Bernoulli's theorem
(c) Law of gravitation
(d) conservation of linear momentum

44. The cylindrical tube of a spray pump has radius, R, one end of which has n fine holes, each of radius r. If the speed of the liquid in the tube is V, the speed of the ejection of the liquid through the holes is :

(a) $\frac{VR^2}{nr^2}$ (b) $\frac{VR^2}{n^3 r^2}$ (c) $\frac{V^2 R}{nr}$ (d) $\frac{VR^2}{n^2 r^2}$

45. Drops of liquid of density ρ are floating half immersed in a liquid of density σ. If the surface tension of liquid is T, the radius of the drop will be

(a) $\sqrt{\frac{3T}{g(3\rho - \sigma)}}$ (b) $\sqrt{\frac{6T}{g(2\rho - \sigma)}}$ (c) $\sqrt{\frac{3T}{g(2\rho - \sigma)}}$ (d) $\sqrt{\frac{3T}{g(4\rho - 3\sigma)}}$

RESPONSE GRID

33. ⓐⓑⓒⓓ 34. ⓐⓑⓒⓓ 35. ⓐⓑⓒⓓ 36. ⓐⓑⓒⓓ 37. ⓐⓑⓒⓓ
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43. ⓐⓑⓒⓓ 44. ⓐⓑⓒⓓ 45. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM DPP CHAPTERWISE CP09 - PHYSICS

Total Questions	45	Total Marks	180
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	45	Qualifying Score	60
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS — PHYSICS SOLUTIONS — DPP/CP09

1. (a) Bulk modulus,

$$B = -\frac{\Delta P}{\left(\frac{\Delta V}{V_0}\right)} \Rightarrow \Delta V = -V_0\frac{\Delta P}{B}$$

or $V - V_0 = -V_0\frac{\Delta P}{B}$ (Here V_0 = volume at the surface and V = volume at the depth)

or $V = V_0 - V_0\frac{\Delta P}{B} \Rightarrow V = V_0\left(1-\frac{\Delta P}{B}\right)$

$\therefore$ Density, $\rho' = \frac{m}{V} = \frac{m}{V_0\left(1-\frac{\Delta P}{B}\right)}$

$$= \frac{m}{\frac{m}{\rho}\left(1-\frac{nP_0 - P_0}{B}\right)} \quad (\because \Delta P = nP_0 - P_0)$$

$$\rho' = \frac{\rho B}{B-(n-1)P_0}$$

2. (c) Velocity of ball when it strikes the water surface

$v = \sqrt{2gh}$ ...(i)

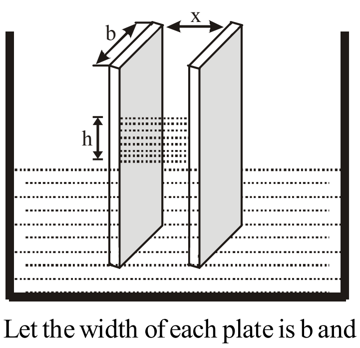
Terminal velocity of ball inside the water

$v = \frac{2}{9}r^2 g\frac{(\rho-1)}{\eta}$ ...(ii)

Equation (i) and (ii) we get $\sqrt{2gh} = \frac{2}{9}\frac{r^2 g}{\eta}(\rho-1)$

$$\Rightarrow h = \frac{2}{81}r^4\left(\frac{\rho-1}{\eta}\right)^2 g$$

3. (b)



Let the width of each plate is b and due to surface tension liquid will rise upto height h then upward force due to surface tension.

= 2Tbcosθ ...(i)

Weight of the liquid rises in between the plates

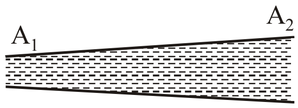
= Vdg = (bxh)dg ...(ii)

Equating (i) and (ii) we get, 2T cosθ = xhdg

$$\therefore h = \frac{2T\cos\theta}{xdg}$$

4. (b) The theorem of continuity is valid.

$\therefore A_1v_1\rho = A_2v_2\rho$ as the density of the liquid can be taken as uniform.



$\therefore A_1v_1 = A_2v_2$

$\Rightarrow$ Smaller the area, greater the velocity.

5. (c) $P_a + \frac{1}{2}\rho_1 v_1^2 + 0 = P_a + \frac{1}{2}\rho_2 v_2^2 + (\rho_1 gh_1 + \rho_2 gh_2)$

As $v_2 << v_1$, $\therefore v_1 = \sqrt{2g(h_1+h_2)\left(\frac{\rho_2}{\rho_1}\right)}$.

6. (c) $h = \frac{2T\cos\theta}{r\rho g} \Rightarrow h \propto \frac{1}{r} \Rightarrow \frac{h_2}{h_1} = \frac{r_1}{r_2} = \frac{2}{3}$

$$\left(\because r_1 = r,\quad r_2 = r + 50\% \text{ of } r = \frac{3}{2}r\right)$$

New mass $m_2 = \pi r_2^2 h_2\rho = \pi\left(\frac{3}{2}r_1\right)^2\left(\frac{2}{3}h_1\right)\rho$

$$= \frac{3}{2}\left(\pi r_1^2 h_1\right)\rho = \frac{3}{2}m$$

7. (a) When a body falls through a viscous liquid, its velocity increases due to gravity but after some time its velocity becomes uniform because of viscous force becoming equal to the gravitational force. Viscous force itself is a variable force which increases as velocity increases, so curve (a) represents the correct alternative.

8. (c) Sum of volumes of 2 smaller drops

= Volume of the bigger drop

$2.\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \Rightarrow R = 2^{1/3}r$

Surface energy = $T.4\pi R^2$

$= T4\pi 2^{2/3}r^2 = T.2^{8/3}\pi r^2$.

9. (c) Angle of contact θ

$$\cos\theta = \frac{T_{SA} - T_{SL}}{T_{LA}}$$

when water is on a waxy or oily surface

$T_{SA} < T_{SL}$ cos θ is negative i.e., $90° < \theta < 180°$

i.e., angle of contact θ increases

And for $\theta > 90°$ liquid level in capillary tube fall. i.e., h decreases

10. (a) $F = 6\pi\eta r v$

$= 6 \times 3.14 \times (8\times10^{-5}) \times 0.03 \times 100$

$= 4.52 \times 10^{-3}$ dyne

11. (a) Velocity of water from hole = $v_1 = \sqrt{2gh}$

Velocity of water from hole B

$v_2 = \sqrt{2g(H_0 - h)}$

Time of reaching the ground from hole B

$t_1 = \sqrt{2(H_0 - h)/g}$

Time of reaching the ground from hole A

$t_2 = \sqrt{2h/g}$

12. (a) Fluid resistance is given by $R = \dfrac{8\eta L}{\pi r^4}$

When two capillary tubes of same size are joined in parallel, then equivalent fluid resistance is

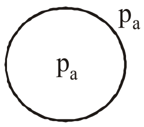
$$R_S = R_1 + R_2 = \frac{8\eta L}{\pi R^4} + \frac{8\eta \times 2L}{\pi(2R)^4} = \left(\frac{8\eta L}{\pi R^4}\right) \times \frac{9}{8}$$

$$\text{Rate of flow} = \frac{P}{R_S} = \frac{\pi P R^4}{8\eta L} \times \frac{8}{9} = \frac{8}{9} X \quad \left[\text{as } X = \frac{\pi P R^4}{8\eta L}\right]$$

13. (b) The candle floats on the water with half its length above and below water level. Let its length be 10 cm with 5 cm below the surface and 5 cm above it. If its length is reduced to 8 cm, it will have 4 cm above water surface. So we see tip going down by 1 cm.

$\therefore$ rate of fall of tip = 1 cm/hour.

14. (a) Inside pressure must be $\dfrac{4T}{r}$ greater than outside pressure in bubble.



This excess pressure is provided by charge on bubble.

$$\frac{4T}{r} = \frac{\sigma^2}{2\varepsilon_0}; \quad \frac{4T}{r} = \frac{Q^2}{16\pi^2 r^4 \times 2\varepsilon_0} \quad \left[\sigma = \frac{Q}{4\pi r^2}\right]$$

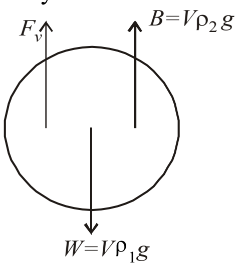
$Q = 8\pi r\sqrt{2rT\varepsilon_0}$

15. (a) Because film tries to cover minimum surface area.

16. (d)

17. (a) The condition for terminal speed (v_t) is

Weight = Buoyant force + Viscous force



$$\therefore V\rho_1 g = V\rho_2 g + kv_t^2 \qquad \therefore v_t = \sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$$

18. (d) According to Bernoulli's theorem, when velocity of liquid flow increases, the pressure decreases.

19. (c) Wetability of a surface by a liquid primarily depends on angle of contact between the surface and liquid. If angle of contact is acute liquids wet the solid and vice-versa.

20. (a) dv = 8 cm/s and dx = 0.1 cm

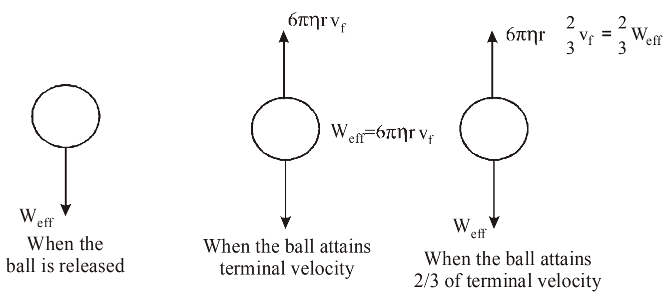
Velocity gradient $= \dfrac{dv}{dx} = \dfrac{8}{0.1} = 80/s.$

21. (a) Terminal velocities of rain drops are proportional to square of their radii.

Terminal velocity of a body is given by

$v_T = \dfrac{2R^2}{9\eta}(d - \sigma)g$, or, $V \propto R^2$

22. (b)



When the ball is just released, the net force on ball is W_{eff} (= mg – buoyant force)

The terminal velocity v_f of the ball is attained when net force on the ball is zero.

$\therefore$ Viscous force $6\pi\eta r\, v_f = W_{eff}$

When the ball acquires $\dfrac{2}{3}$rd of its maximum velocity v_f

the viscous force is $= \dfrac{2}{3} W_{eff}$

Hence net force is $W_{eff} - \dfrac{2}{3} W_{eff} = \dfrac{1}{3} W_{eff}$

$\therefore$ required acceleration is a/3

23. (a) $(2\pi r_1 + 2\pi r_2)\sigma = mg$

$$\left[2\pi \times \frac{8.7}{2} + 2\pi \times \frac{8.5}{2}\right]\sigma = 3.97 \times 980$$

$\Rightarrow \sigma = 72 \text{ dyne cm}^{-1}$

24. (b) Over a small temperature ranges, S.T. of water decreases linearly with rise of temperature.

25. (c) Volume of air bubble $V = \dfrac{4}{3}\pi r^3$

We get, $V \propto r^3$

If r is 2 times, V becomes 8 times at the surface of lake.

Pressure at the surface of lake is given by

P_1 = 1 atmosphere, $V_1 = 8V$

$\Rightarrow P_1 = Hdg$ where, d = density of water

Pressure at the bottom of lake,

P_2 = Pressure of atmosphere + Pressure of water

$P_2 = Hdg + hdg = (H + h)\,dg$ where, h = depth of lake

Let final volume, $V_2 = V$.

Because temperature is constant, hence from Boyle's law

$P_1 V_1 = P_2 V_2 \Rightarrow Hdg \times 8V = (H + h)dg \times V \Rightarrow h = 7H.$

26. (c)

27. (b) Volume of first piece of metal = $\frac{32}{8} = 4\,cm^3$

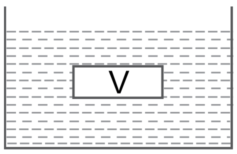
Upthrust = 4 gf

Effective weight = (32 – 4) gf = 28 gf

If m be the mass of second body, volume of second body is $\frac{m}{5}$

Now, $28 = m - \frac{m}{5} \Rightarrow m = 35$ g

28. (b) $g_{eff.} = 12\ m/s^2$, $= \frac{\rho_m}{\rho_w} = \frac{4}{10}$



$$a = \frac{V\rho_w \times 12 - V\rho_m \times 12}{V\rho_m} = 18\,m/s^2$$

$1 = \frac{1}{2} \times 18\,t^2$, $t = \frac{1}{3}$ s.

29. (b) Due to increase in velocity, pressure will be low above the surface of water.

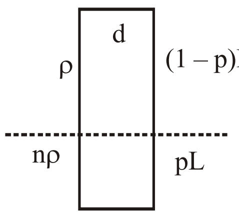
30. (c) If ρ is the density of the ball and ρ′ that of the another ball, *m* for the balls are the same, but $r' = 2r$

∴ $mg = 6\pi r\eta v$ (by Stoke's law)

or, $6\pi r\eta v = 6\pi 2r\eta v'$ So, $v' = \frac{v}{2}$

31. (d) As we know,

Pressure P = Vdg



Here, $LA\,d\,g = (pL)\,A\,(n\rho)g + (1-p)LA\,\rho\,g$

$\Rightarrow\ d = (1-p)\rho + pn\,\rho = [1 + (n-1)p]\rho$

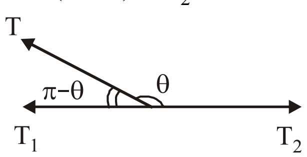
32. (d) At equilibrium, weight of the given block is balanced by force due to surface tension, i.e.,

2L. S = W

or $S = \frac{W}{2L} = \frac{1.5\times10^{-2}\,N}{2\times0.3\,m} = 0.025\,Nm^{-1}$

33. (a)

34. (d) $T_1 + T\cos(\pi - \theta) = T_2$



∴ $\cos(\pi - \theta) = \frac{T_2 - T_1}{T}$

∴ $-\cos\theta = \frac{T_2 - T_1}{T}$

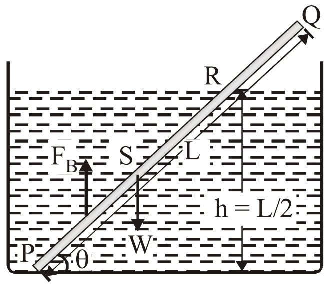
∴ $\cos\theta = \frac{T_1 - T_2}{T}$

35. (a) Let L = PQ = length of rod

∴ $SP = SQ = \frac{L}{2}$

Weight of rod, W = A*l*ρg.

Acting at point S



And force of buoyancy,

$F_B = Al\rho_0 g$. [l = PR]

Which acts at mid-point of PR.

For rotational equilibrium.

$$Al\rho_0 g \times \frac{\ell}{2}\cos\theta = AL\rho g \times \frac{L}{2}\cos\theta$$

$$\Rightarrow \frac{l^2}{L^2} = \frac{\rho}{\rho_0} \Rightarrow \frac{l}{L} = \sqrt{\frac{\rho}{\rho_0}}$$

From figure, $\sin\theta = \frac{h}{l} = \frac{L}{2l} = \frac{1}{2}\sqrt{\frac{\rho_0}{\rho}}$

36. (b) Terminal velocity, $v_0 = \frac{2\,r^2(\rho - \rho_0)g}{9\eta}$

$$= \frac{2\times(2\times10^{-3})^2\times(8-1.3)\times10^3\times9.8}{9\times0.83} = 0.07\,ms^{-1}$$

37. (c) Work done = Surface tension × increase in area of the film

W = S × ΔA

Increase in area = Final area – initial area

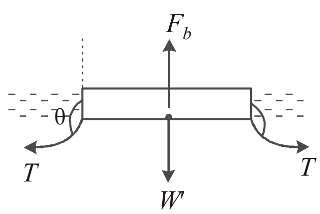
$= 10 \times (0.5 + 0.1) - 10 \times 0.5 = 1\ cm^2$

∴ W = 72 × 2 × 1 = 144 erg

[∵ There are 2 free surfaces; ∴ ΔA = 2 × 1].

38. (b) Waterproofing agents are used so that the material does not get wet. This means angle of contact is obtuse.

39. (c)



For floating disc, $F_{net} = 0$

or $F_b + 2\pi rT\cos\theta = W'$

or $W + 2\pi rT\cos\theta = W'$

40. **(b)**

41. **(d)** From the figure it is clear that liquid 1 floats on liquid 2. The lighter liquid floats over heavier liquid. Therefore we can conclude that $\rho_1 < \rho_2$

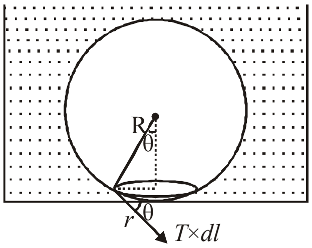
Also $\rho_3 < \rho_2$ otherwise the ball would have sink to the bottom of the jar.

Also $\rho_3 > \rho_1$ otherwise the ball would have floated in liquid 1. From the above discussion we conclude that

$$\rho_1 < \rho_3 < \rho_2.$$

42. **(a)** When the bubble gets detached,

Buoyant force = force due to surface tension



Force due to excess pressure = upthrust

Access pressure in air bubble = $\frac{2T}{R}$

$$\frac{2T}{R}(\pi r^2) = \frac{4\pi R^3}{3}\rho_w g$$

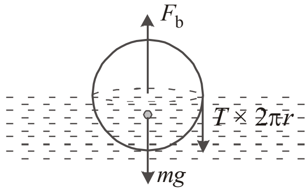
$$\Rightarrow \quad r^2 = \frac{2R^4 \rho_w g}{3T} \Rightarrow r = R^2\sqrt{\frac{2\rho_w g}{3T}}$$

43. **(b)** Bernoulli's theorem.

44. **(a)** Inflow rate of volume of the liquid = Outflow rate of volume of the liquid

$$\pi R^2 V = n\pi r^2 (v) \Rightarrow v = \frac{\pi R^2 V}{n\pi r^2} = \frac{VR^2}{nr^2}$$

45. **(c)** $T \times 2\pi r + mg = F_b$



or $\quad T \times 2\pi r + \rho \frac{4}{3}\pi r^3 g = \left[\frac{\frac{4}{3}\pi r^3}{2}\right]\sigma g$

$$\therefore \quad r = \sqrt{\frac{3T}{g(2\rho - \sigma)}}$$