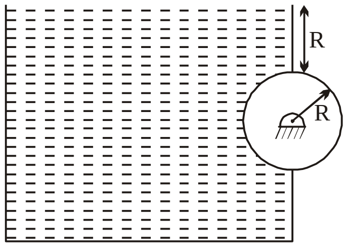
Supplement Questions of **FLUID MECHANICS**

Paragraph for question nos. 1 to 3

A cylinder of radius R is kept embedded along the wall of A dam as shown. Take density of water as ρ. Take length as L.



1. The vertical force exerted by water on the cylinder is

(A) $\rho\pi R^2 Lg$ (B) $\frac{\rho\pi R^2 Lg}{2}$ (C) zero (D) None of these

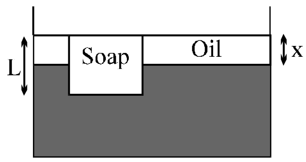
2. The net torque exerted by liquid on the cylinder is

(A) $\frac{2\rho R^3 Lg}{3}$ (B) $\frac{\rho R^3 Lg}{3}$ (C) $\frac{\rho R^3 Lg}{2}$ (D) 0

3. The force exerted by liquid on the cylinder in horizontal direction is [Neglecting atmospheric pressure].

(A) $2R^2\rho gL$ (B) $R^2\rho gL$ (C) $4R^2\rho gL$ (D) $1.61\ R^2\rho gL$

4. A rectangular bar of soap has density 800 kg/m^3 floats in water of density 1000 kg/m^3. Oil of density 300 kg/m^3 is slowly added, forming a layer that does not mix with the water. When the top surface of the oil is at the some level as the top surface of the soap. What is the ratio of the oil layer thickness to the soap's thickness, x/L ?

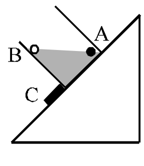


(A) $\frac{2}{10}$ (B) $\frac{2}{7}$ (C) $\frac{3}{10}$ (D) $\frac{3}{8}$

5. A small body with relative density d_1 falls in air from a height 'h' on to the surface of a liquid of relative density d_2 where $d_2 > d_1$. The time elapsed after entering the liquid to the instant when it comes to instantaneous rest inside liquid :

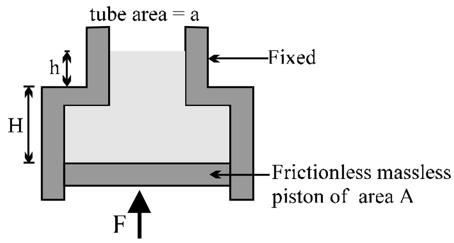
(A) $\sqrt{\frac{2h}{g}}\frac{d_2}{d_1}$ (B) $\sqrt{\frac{2h}{g}}\frac{d_1}{d_2 - d_1}$ (C) $\sqrt{\frac{2h}{g}}\frac{d_1}{d_2}$ (D) $\sqrt{\frac{2h}{g}}\frac{d_2 - d_1}{d_1}$

6. An open cubical vessel is standing on an inclined plane, angle 45°, as seen in figure. Its walls are thin and it is kept from sliding down by a small wedge (C). The vessel is filled to its half with mercury and an iron sphere is floating on the surface from point A in the direction of point B. When does the vessel tip over ?



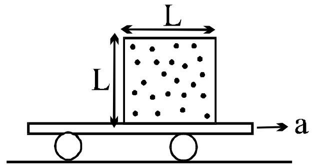
(A) When the sphere is at A
(B) When the sphere is at B
(C) When the sphere is at mid point of A and B
(D) In all the positions of the sphere, the probability of tipping is equal

7. The force F needed to support the liquid of density ρ and the vessel on top in figure is:



(A) ρg[ha–(H–h)A] (B) ρg (H+h) A (C) ρg HA + ρgha (D) ρg (H–h) A

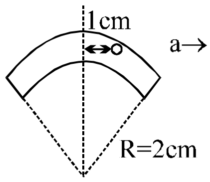
8. A cubical sealed vessel with edge L is placed on a cart, which is moving horizontally with an acceleration 'a' as shown in figure. The cube is filled with a ideal fluid having density ρ. The gauge pressure at the centre of the cubical vessel is



(A) $\frac{L}{2}\rho g$ (B) $\frac{L}{2}\rho(g+a)$

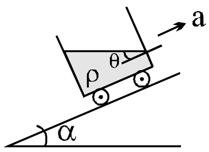
(C) $\frac{L}{2}\rho a$ (D) $\frac{L}{2}\rho(g-a)$

9. A bent arc shaped sealed glass tube filled with water is accelerated horizontally with acceleration a. A small air bubble inside it is found to be stuck at 1 cm from vertical axis. Neglect surface tension. What is the acceleration of the tube.



(A) $\frac{g}{\sqrt{3}}$ to right (B) $\frac{g}{\sqrt{3}}$ to left (C) $\sqrt{3}$ g to right (D) $\sqrt{3}$ g to left

10. A fluid container is containing a liquid of density ρ is accelerating upward with acceleration a along the inclined place of inclination α as shown. Then the angle of inclination θ of free surface is :



(A) $\tan^{-1}\left[\frac{a}{g\cos\alpha}\right]$ (B) $\tan^{-1}\left[\frac{a+g\sin\alpha}{g\cos\alpha}\right]$ (C) $\tan^{-1}\left[\frac{a-g\sin\alpha}{g(1+\cos\alpha)}\right]$ (D) $\tan^{-1}\left[\frac{a-g\sin\alpha}{g(1-\cos\alpha)}\right]$

11. A water barrel stands on a table of height h. If a small hole is punched in the side of the barrel at its base, it is found that the resultant stream of water strikes the ground at a horizonatl distance R from the barrel. The depth of water in the barrel is

(A) $\frac{R}{2}$ (B) $\frac{R^2}{4h}$ (C) $\frac{R^2}{h}$ (D) $\frac{h}{2}$

12. There is a 1mm thick layer of glycerine between a flat plate of area 100 cm^2 & a big fixed plate. If the coefficient of viscosity of glycerine is 1.0 kg/m-s then how much force is required to move the plate with a velocity of 7 cm/s?

(A) 3.5 N (B) 0.7 N (C) 1.4 N (D) None

13. A sphere of mass m is released from rest in a stationary viscous medium. In addition to the gravitational force of magnitude mg, the sphere experiences a retarding force of magnitude bν, where ν is the speed of the sphere and b is a constant. Assume that the buoyant force is negligible. Which of the following statements about the sphere is correct?

(A) Its kinetic energy decreases due to the retarding force.

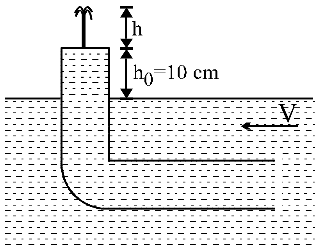
(B) Its kinetic energy increases to a maximum, then decreases to zero due to the retarding force.

(C) Its speed increases to a maximum, then decreases back to a final terminal speed.

(D) Its speed increases monotonically, approaching a terminal speed that depends on b but not on m.

(E) Its speed increases monotonically, approaching a terminal speed that depends on both b and m.

14. A bent tube is lowered into water stream as shown in the figure. The velocity of the stream relative to the tube is equal to V = 2 m/s. The closed upper end of the tube located at height h_0 = 10 cm above free surface of water has a small orifice. To what height h will the water get spurt?

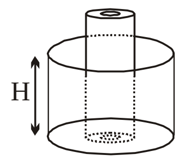


(A) 5 cm (B) 10 cm (C) 20 cm (D) 40 cm

15. A metal ball of density 7800 kg/m^3 is suspected to have a large number of cavities. Its weight 9.8 kg when weighed directly on a balance and 1.5kg less when immersed in water. The fraction by volume of the cavities in the metal ball is approximately :

(A) 20% (B) 30% (C) 16% (D) 11%

16. A hollow wooden cylinder of height 'h', inner radius R and outer radius 2R is placed in a cylindrical container of radius 3R. When water is poured into the container, the minimum height H of the container for which cylinder can float inside freely is



(A) $\frac{h\rho_{water}}{\rho_{water}+\rho_{wood}}$ (B) $\frac{h\rho_{wood}}{\rho_{water}}$ (C) h (D) $\frac{h^2}{R}$

17. Water jet coming out of a stationary horizontal tube at speed v strikes horizontally a massive wall moving in opposite direction with same speed. Water comes to rest relative to wall after striking. Treating A as cross-section of jet and density of water as ρ. Select the correct alternative(s)

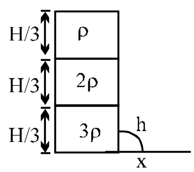
(A) force exerted on the wall is $2\rho Av^2$

(B) force exerted on the wall is $4\rho Av^2$

(C) rate of change of kinetic energy of water jet striking the wall is $8\rho Av^3$

(D) rate of change of kinetic energy of water jet striking the wall is zero.

18. A fixed container of large uniform cross sectional area A resting on a horizontal surface holds three immiscible, non-viscous and incompressible liquids of densities ρ, 2ρ and 3ρ each of height H/3 as shown. The liquid with lowest density is open to atmosphere (having pressure P_0). A tiny hole of area S (S < < A) is punched on the vertical side of the container at a height h (h < H/3). Determine

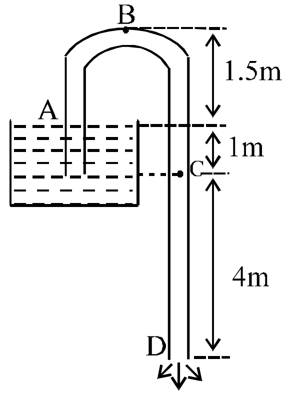


(i) the initial speed of efflux of the liquid through the hole.

(ii) the horizontal distance x travelled by the liquid initially

(iii) the height h_m (≤ H/3) at which the hole should be punched so that the liquid travels the maximum distance X_m.

19. A siphon tube is discharging a liquid of specific gravity 0.9 from a reservoir as shown in fig. find



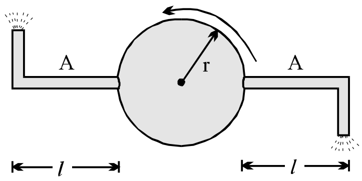
(a) find the velocity of the liquid coming out of siphon at D

(b) find the pressure at the highest point B

(c) find the pressure at point C, here $g = 10\ m/s^2$.

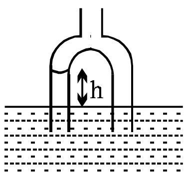
20. A cylindrical vessel filled with water upto height of H stands on a horizontal plane. The side wall of the vessel has a plugged circular hole touching the bottom. The coefficient of friction between the bottom of vessel and plane is μ and total mass of water plus vessel is M. What should be minimum diameter of hole so that the vessel begins to move on the floor if plug is removed (here density of water is ρ)?

21. Shows the top view of a cylindrical can mounted on a turntable. The can is filled with water. At a depth h below the water surface are two horizontal tubes of length l and cross-sectional area a, with right-angle bends at their ends. Show that, as the water jets emerge from the tubes, there is a torque τ exerted on the system given by the expression $t = 4\rho gh\ (r + l)a$, where ρ is the density of the water.

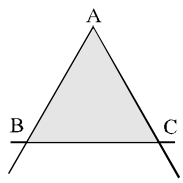


22. A cylinder with movable piston contains in it air under pressure P_1 and a soap bubble of radius r. Surface tension is T and temperature is maintained constant. Determine the pressure P_2 to which the air should be compressed by moving piston into cylinder for the soap bubble to reduce its radius to r/2.

23. The figure shows an inverted U like tube with straight limbs of unequal radii $r_1 = 0.25$mm and $r_2 = 0.50$ mm. Both the open ends of the tube are immersed below the free surface of water. The air is pumped into the upper part of the tube at such pressure so that the water in the wider tube is at level with the water outside. Find the height h of water in the other limbs. Take angle of contact as zero and surface tension of water = 7×10^{-2} N/m.

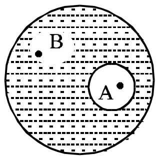


24. A soap film is formed on a vertical equilateral triangular frame ABC. Side BC can move vertically always remaining horizontal. If m is the mass of rod BC, and T is surface tension of soap film find



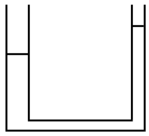
(a) the length of BC in equilibrium.
(b) the time period of small oscillations about the equilibrium position.

25. There is an air bubble of radius R inside a drop of water of radius 3R. Find the ratio of gauge pressure at point A to the gauge pressure at point B.



26. A long vertical capillary of radius R is dipped in a liquid having surface tension T. Find the gauge pressure at the mid point of the liquid column in the capillary. Take angle of contact θ.

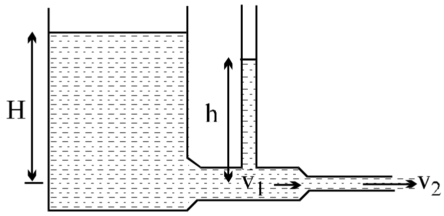
27. A U tube has 2 tubes of radius 1 mm and 1.5 mm what will be the difference in water level in two limbs? Given : Contact angle q = 0°, surface tension = 7.5×10^{-2} N/m.



28. Two equal drops of water fall through air with a steday velocity of 10 cm/s. If the drops coalesce. What will be the new terminal velocity.

29. Two balls of same material of density ρ but radius r_1 and r_2 are joined by a light inextensible vertical thread and released from a large height in a medium of coefficient of viscosity = η. Find the terminal velocity acquired by the balls. Also find the tension in the string connecting both the balls when both of them are moving with terminal velocity. Neglect buoyancy and change in acceleration due to gravity.

30. Water fills a reservoir, open to the atmosphere, to height H = 5m above the centerline of a horizontal exit pipe at the bottom of the reservoir. The first section of the pipe has radius r_1 = 2 cm, the unknown velocity there is v_1 and this section of the pipe has a manometer in which the water rises to an unknown height h above the centerline of the pipe.



The water leaves the second section of radius r_2 = 1 cm, with speed v_2. Assume the flow is incompressible, frictionless, irrotational, and steady. Also, assume the reservoir is so large compared to the pipe, that the water level in the reservoir is almost constant.

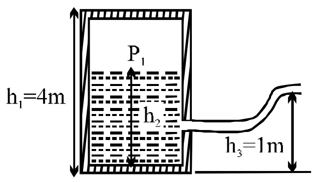
(a) What is the speed, v_2, of the water leaving the exit pipe?

(b) What is the speed, v_1, in the first section of the pipe?

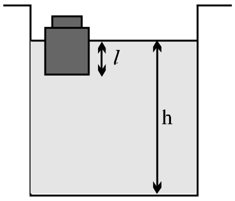
(c) What is the height, h, of the water in the manometer?

(d) What is the volume flow rate of the water flowing through the exit pipe?

31. A large tank of (height h_1 = 4m) water has a hose connected to it, as shown in figure. The tank is sealed at the top and has compressed air between the water surface & the top. When the water height h_2 is 3m, the gauge pressure of air $P_1 = 1 \times 10^5 N/m^2$. Assume that the air above the water surface expands isothermally. What is the velocity of flow out of the hose when h_2 has decreased to 2m? Assume ideal fluid flow. $P_{atm} = 10^5 N/m^2$

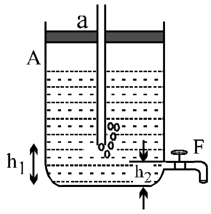


32. A wooden block (having cross-sectional area A), with a coin (having volume V and density d) placed on its top floats in water as shown in figure. If the coin is lifted and then dropped into water, find



(a) change in the submerged length (l) of the block.
(b) change in the water level (h) in container. Cross sectional area of the container is A_1 & density of water is ρ.

33. A vessel A filled with water communicates with the atmosphere through a narrow glass tube A passing through the throat of the vessel as in the given figure. A hole F is h_2 = 2cm from the bottom of the vessel.

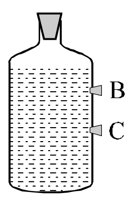


(a) Find the velocity with which the water flows out of the hole F if the distance between the end of the tube and the bottom of the vessel is h_1 = 10cm
(b) Also find the time in which the water level in vessel falls by 5 cm.
Given area of cross section of vessel is 1000 times the area of hole.

34. Bucket A contains only water ; an identical bucket B contains water, but also contains a solid object in the water. Consider the following four situations. Which bucket weighs more ?

Column-I	**Column-II**
(A) The object floats in bucket B, and the buckets have the same water level	(P) Bucket A
(B) The object floats in bucket B, and the buckets have the same volume of water	(Q) Bucket B
(C) The object sinks completely in bucket B, and the buckets have the same water level	(R) Both buckets have the same weight
(D) The object sinks completely in bucket B, and the buckets have the same volume of water	(S) The answer cannot be determined from the information given.

35. A bottle is filled with water, above which a little air at atmospheric pressure is present. Plugs are blocking the three small holes (A, B & C).



Column I	**Column II**
(A) A & C are opened	(P) Air comes into the bottle from upper most open hole
(B) B & C are opened	(Q) Water flows out of holes B & C
(C) Only C is opened	(R) Very little water comes out and the flow stops
(D) All the holes are opened	(S) Pressure of air inside bottle above the water remains unchanged.

ANSWER KEY

1. (B)
2. (D)
3. (C)
4. (B)
5. (B)
6. (D)
7. (B)
8. (B)
9. (A)
10. (B)
11. (B)
12. (B)
14. (B)
15. (C)
16. (B)
17. (BD)
18. (i) $\sqrt{\frac{2g}{3}(2H-3h)}$, (ii) $x=\sqrt{\frac{4h}{3}(2H-3h)}$, (iii) $h=\frac{H}{3}$
19. (a) 10 m/sec, (b) 4.15×10^4Pa, (c) 6.4×10^4Pa
20. $\sqrt{\frac{2\mu M}{\pi\rho H}}$
22. $P_2 = 8P_1 + \frac{24T}{r}$
23. 0.028 m
24. (a) $l=\frac{mg}{2T}$, (b) time period = $\pi\sqrt{\frac{\sqrt{3}m}{T}}$
25. 4
26. Gauge pressure = $\frac{T\cos\theta}{R}$
27. 5 mm
28. $10\times2^{2/3}$ cm/s
29. $\frac{2}{9}\frac{\rho g}{\eta}[r_1^2 - r_1 r_2 + r_2^2]$, $\frac{4}{3}\pi\rho g|r_1^2 r_2 - r_2^2 r_1|$
30. (a) 10 m/s, (b) 2.5 m/s, (c) 4.688 m, (d) 3.14×10^{-2} m^3/s
31. $V=\sqrt{2g}$ m/sec.
32. (a) $\Delta l=\frac{Vd}{A\rho}$, (b) $\Delta h=\frac{V}{A_1}-\frac{Vd}{A_1\rho}=\frac{V}{A_1}\left(1-\frac{d}{\rho}\right)$
33. (a) $\frac{4}{\sqrt{10}}$ m/s, (b) $\frac{25}{2}\sqrt{10}$ sec
34. (A)-R (B)-Q (C)-Q (D)-Q
35. (A) P, S, (B) P, Q, (C) R, (D) P,Q,S