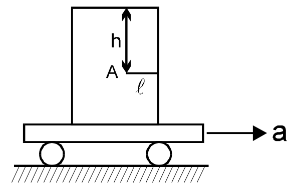
EXERCISE-1

SECTION (A) : MEASUREMENT AND CALCULATION OF PRESSURE

A 1. The atmospheric pressure at a height of 6km decrease to nearly half its value at the sea level, though the height of the atmosphere is more than 100 km. Explain why?

A 2. The passengers are advised to remove the ink from their pens while going up in an aeroplane. Explain why?

A 3. A cart supports a cubic tank filled with a liquid of density ρ up to its top. The cart moves with a constant acceleration 'a'. Determine the pressure at point 'A' which is at a depth 'h' and a distance ℓ from the front wall, if the tank is tightly closed with a lid. In uniform motion the lid does not exert any pressure on the liquid.



A 4. The density of ocean water may be taken to vary according to the expression

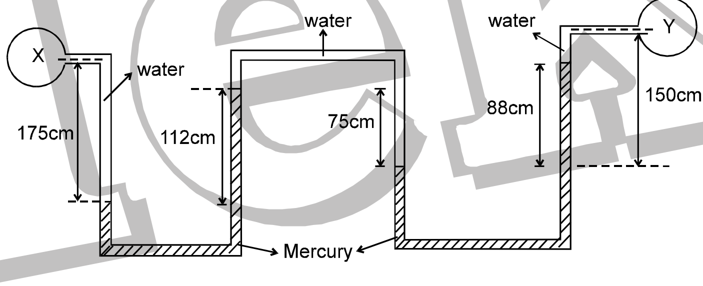
$$d = d_0 + c\sqrt{h}$$

where d_0 = the density at the sea-level and h is the depth below the sea surface. Calculate the pressure as a function of depth.

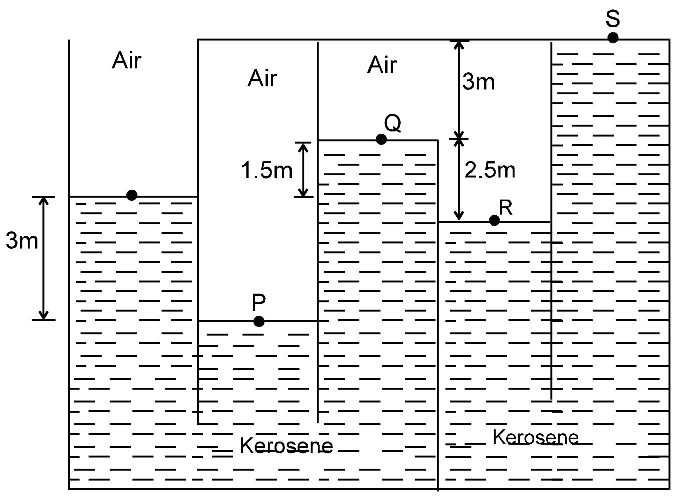
A 5. A hydraulic press has a ram (weight arm) 12.5 cm in diameter and plunger (Force arm) of 1.25 cm diameter. What force would be required on the plunger to raise a weight of 1 tonn on the ram.

A 6. Pressure 3 m below the free surface of a liquid is 15KN/m^2 in excess of atmosphere pressure. Determine its density and specific gravity. [g = 10 m/sec^2]

A 7. Two U-tube manometers are connected in series as shown in figure. Determine difference of pressure between X and Y. Take specific gravity of mercury as 13.6.



A 8. The container shown below holds kerosene and air as indicated. Compute the pressure at P, Q, R and S in KN/m^2 Take specific gravity of kerosene as 0.8.



SECTION (B) : ARCHEMEDIES PRINCIPLE AND FORCE OF BUOYANCY

B 1. A boy is carrying a fish in one hand and a bucket full of water in the other hand. He then place the fish in the bucket and thinks that in accordance with Archimedes's principle he is now carrying less weight as weight of fish will reduce due to upthrust. Is he thinking right ?

B 2. It is easier to swim in sea water than in river water. Explain why ?

B 3. Ice flows in water nine tenth of its volume submerged. What is the fractional volume submerged for an iceberg floating on a fresh water lake of a (hypothetical) planet whose gravity is ten times of earth ?

B 4. If the body is non-homogeneous, then the body rotates in the fluid why ?

B 5. A cube of wood supporting a 200 gm mass just floats in water. When the mass is removed the cube rise by 2 cm. Find the size of cube

B 6. A solid ball of density half that of water falls freely under gravity from a height of 19.6 m and then enter water. Upto what depth will the ball go ? How much time will it take to come again to the water surface? Neglect air resistance and viscosity effects in water.

B 7. A balloon filled with hydrogen has a volume of 1000 liters and its mass of 1kg. What would be volume of the block of a very light material which it can just lift? One litre of the material has a mass of 91.3 gm. (Density of air = 1.3 gm/litre)

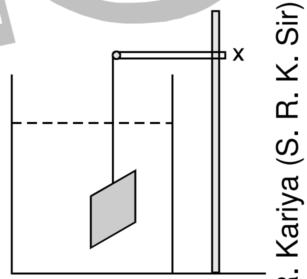
B 8. An expansible balloon filled with air floats on the surface of a lake with 2/3 of its volume submerged. How deep must it be sunk in the water so that it is just in equilibrium neither sinking further nor rising? It is assumed that the temperature of the water is constant and that the height of the water barometer is 9 meters.

B 9. A piece of brass (alloy of copper and zinc) weighs 12.9 g in air. When completely immersed in water it weighs 11.3 g. What is the mass of copper contained in the alloy? Specific gravities of copper and zinc are 8.9 and 7.1 respectively.

B 10. A glass beaker is placed partially filled with water in a sink . It has a mass of 390 gm and an interior volume of 500 cm^3 . When water starts filling the sink, it is found that if beaker is less than half full it will float . But if it is more than half full, it remains on the bottom of the sink, as the water rises to its rim . What is the density of the material of which the beaker is made ?

B 11. An iceberg of density 915 kg/m^3 extends above the surface of sea water of density 1030 kg/m^3. What percentage of the total volume of iceberg is visible to an obserber.

B 12. A metallic plate having shape of a square is suspended as shown in figure. The plate is made to dip in water such that level of water is well above that of the plate. The point 'x' is then slowely raised at constant velocity. Sketch the variation of tension T in string with the displacement 's' of point x.



B 13. A rod of length 6 m has a mass of 12 kg. If it is hinged at one end at a distance of 3 m below a water surface,

(i) What weight must be attached to the other end of the rod so that 5 m of the rod is submerged?

(ii) Find the magnitude and direction of the force exerted by the hinge on the rod. The specific gravity of the material of the rod is 0.5.

SECTION (C) : CONTINUITY EQUATION & BERNOULLI THEOREM AND THEIR APPLICATION

C 1. During wind storm, light roofs are blown off. Why ?

C 2. Explain why two stream lines cannot cross each other ?

C 3. Why does the velocity increases when water flowing in a broader pipe enters a narrow pipe ?

C 4. A man standing on the platform just near the railway line be sucked in by a fast moving train. Explain.

C 5. Air is streaming past a horizontal airplane wing such that its speed is 120 ms^{-1} over the upper surface and 90 ms^{-1} at the lower surface. If the density of air is 1.3 kgm^{-3} , find the difference in pressure between the top and bottom of the wing. If the wing is 10 m long and has an average width of 2 m. Calculate the gross lift of the wing.

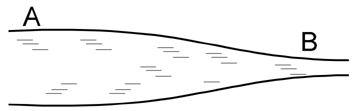
C 6. A liquid is kept in a cylindrical vessel which is rotated along its axis. The liquid rises at the sides. If the radius of the vessel is 0.05 m and the speed of rotation is 2 rev per sec. Find the difference in the height of the liquid at the centre of the vessel and at its sides.

C 7. The pressures of water in a water pipe when tap is open and closed are respectively 3×10^5 N/m^2 and 3.5×10^5 N/m^2. If tap is opened, then find out-

(a) velocity of water flowing

(b) rate of volume of water flowing if area of cross-section of tap is 2 cm^2.

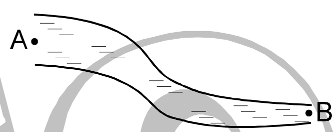
C 8. Water flows through a horizontal tube of variable cross-section (figure). The area of cross-section at A and B are 4 mm^2 and 2 mm^2 respectively. If 1 cc of water enters per second through A, find (a) the speed of water at A, (b) the speed of water at B and (c) the pressure difference $P_A - P_B$.



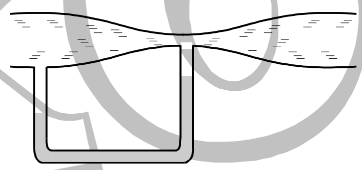
C 9. Suppose the tube in the previous problem is kept vertical with A upward but the other conditions remain the same. The separation between the cross-section at A and B is 15/16 cm. Repeat parts (a), (b) and (c) of the previous problem. Take g = 10 m/s^2.

C 10. Suppose the tube in the previous problem is kept vertical with B upward. Water enters through B at the rate of 1 cm^3/s. Repeat part (a), (b) and (c). Note that the speed decreases as the water falls down.

C 11. Water flows through a tube shown in figure. The areas of cross-section at A and B are 1 cm^2 and 0.5 cm^2 respectively. The height difference between A and B is 5 cm. If the speed of water at A is 10 cm/s find (a) the speed at B and (b) the difference in pressures at A and B.



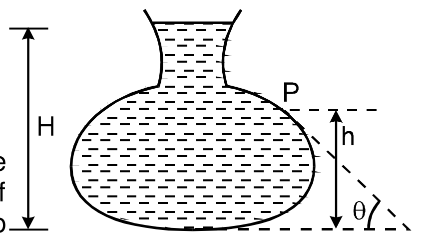
C 12. Water flows through the tube shown in figure. The areas of cross-section of the wide and the narrow portion of the tube are 5 cm^2 and 2 cm^2 respectively. The rate of flow of water through the tube is 500 cm^3/s. Find the difference of mercury levels in the U-tube. (density of mercury = 13.6 gm/cm^3)



EXERCISE-2

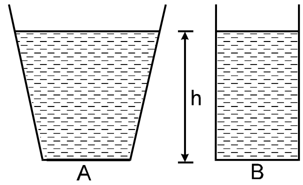
SECTION (A) : MEASUREMENT AND CALCULATION OF PRESSURE

A 1. Figure here shown the vertical cross-section of a vessel filled with a liquid of density ρ. The normal thrust per unit area on the walls of the vessel at point. P, as shown, will be
(A) $h\rho g$
(B) $H\rho g$
(C) $(H - h)\rho g$
(D) $(H - h)\rho g \cos\theta$



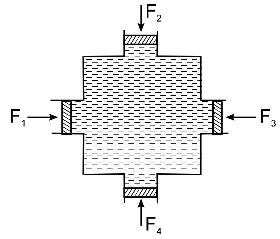
A 2. In a hydraulic lift, used at a service station the radius of the large and small piston are in the ratio of 20 : 1. What weight placed on the small piston will be sufficient to lift a car of mass 1500 kg ?
(A) 3.75 kg (B) 37.5 kg (C) 7.5 kg (D) 75 kg.

A 3. Two vessels A and B of different shapes have the same base area and are filled with water up to the same height h (see figure). The force exerted by water on the base is F_A for vessel A and F_B for vessel B. The respective weights of the water filled in vessels are W_A and W_B. Then
(A) $F_A > F_B$; $W_A > W_B$ (B) $F_A = F_B$; $W_A > W_B$
(C) $F_A = F_B$; $W_A < W_B$ (D) $F_A > F_B$; $W_A = W_B$



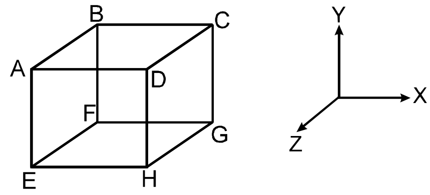
A 4. In the figure shown water is filled in a symmetrical container. Four pistons of equal area A are used at the four opening to keep the water in equilibrium. Now an additional force F is applied at each piston. The increase in the pressure at the centre of the container due to this addition is

(A) $\frac{F}{A}$ (B) $\frac{2F}{A}$ (C) $\frac{4F}{A}$ (D) 0



A 5. The cubical container ABCDEFGH which is completely filled with an ideal (nonviscous and incompressible) fluid, moves in a gravity free space with a acceleration of

$$a = a_0\ (\hat{i} - \hat{j} + \hat{k})$$



where a_0 is a positive constant. Then the only point in the container where pressure is maximum, is

$$a = a_0\ (\hat{i} - \hat{j} + \hat{k})$$

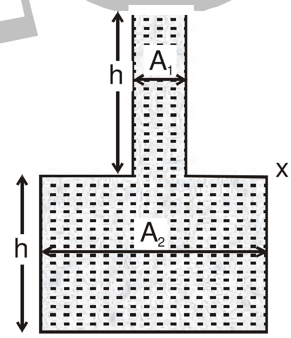
(A) B (B) C (C) E
(D) F

A 6. Pressure gradient in the horizontal direction in a static fluid is represented by (z–direction is vertically upwards, and x-axis is along horizontal,d is density of fluid) :

(A) $\frac{\partial p}{\partial z} = -\,dg$ (B) $\frac{\partial p}{\partial x} = dg$ (C) $\frac{\partial p}{\partial x} = 0$ (D) $\frac{\partial p}{\partial z} = 0$

A 7. Following are some statements about buoyant force: (Liquid is of uniform density)
(i) Buoyant force depends upon orientation of the concerned body inside the liquid.
(ii) Buoyant force depends upon the density of the body immersed.
(iii) Buoyant force depends on the fact whether the system is on moon or on the earth.
(iv) Buoyant force depends upon the depth at which the body (fully immersed in the liquid) is placed inside the liquid.
Of these statements :
(A) Only (i), (ii) and (iv) are correct. (B) Only (ii) is correct.
(C) Only (iii) and (iv) are correct. (D) (i), (ii) and (iv) are incorrect.

A 8*. The vessel shown in Figure has two sections of area of cross-section A_1 and A_2. A liquid of density ρ fills both the sections, up to height h in each. Neglecting atomospheric pressure,
(A) the pressure at the base of the vesel is 2 h ρ g
(B) the weight of the liquid in vessel in equal to 2 h ρ g
(C) the force exerted by the liquid on the base of vessel is 2 h ρ g A_2
(D) the walls of the vessel at the level X exert a force h ρ g ($A_2 - A_1$) downwards on the liquid.



SECTION (B) : ARCHEMEDIES PRINCIPLE AND FORCE OF BUOY-ANCY

B 1. A block of density 2000 kg/m^3 and mass 10 kg is suspended by a spring stiffness 100 N/m. The other end of the spring is attached to a fixed support. The block is completely submerged in a liquid of density 1000 kg/m^3 If the block is in equilibrium position.
(A) the elongation of the spring is 1 cm.
(B) the magnitude of buoyant force acting on the block is 50 N.
(C) the spring potential energy is 12.5 J.
(D) magnitude of spring force on the block is greater than the weight of the block.

B 2. A cubical block of wood of edge 10cm and mass 0.92kg floats on a tank of water with oil of rel. density 0.6 to a depth of 4cm above water. When the block attains equilibrium with four of its sides edges vertical :
(A) 1 cm of it will be above the free surface of oil.
(B) 5 cm of it will be under water.
(C) 2 cm of it will be above the common surface of oil and water.
(D) 8 cm of it will be under water.

B 3. The density of ice is x gm/cc and that of water is y gm/cc. What is the change in volume in cc, when m gm of ice melts ?

(A) M (y – x) (B) (y – x)/m (C) mxy (x – y) (D) m (1/y – 1/x)

B 4. A block weighs 15 N in air and 12 N when immersed in water. The specific gravity of the block is :
(A) 0.8 (B) 0.25 (C) 5/4 (D) 5

B 5. The reading of a spring balance when a block is suspended from it in air is 60 newton. This reading is changed to 40 newton when the block is submerged in water. The specific gravity of the block must be therefore :
(A) 3 (B) 2 (C) 6 (D) 3/2

B 6. A body is floating in a liquid. The upthrust on the body is :
(A) equal to weight of liquid displaced (B) zero
(C) less than the weight of liquid displaced (D) (weight of body) – (weight of liquid displaced)

B 7. A concrete sphere of radius R has a cavity of radius r (pack with sawdust). The specific gravities of concrete and sawdust are respectively 2.4 and 0.3. For this sphere to float with its entire volume submerged under water, the ratio of mass of concrete to mass of sawdust will be :
(A) 8 (B) 4 (C) 3 (D) zero

B 8. Two identical cylindrical vessels with their bases at the same level, contain same liquid of density ρ. The height of the liquid in one vessel is h_1 and that in the other vessel is h_2. The area of either base is A. The work done by gravity in equalizing the levels when the two vessels are connected is :
(A) $(h_1 - h_2) g \rho$ (B) $(h_1 - h_2) g A \rho$ (C) $\frac{1}{2}(h_1 - h_2)^2 g \rho$ (D) $\frac{1}{4}(h_1 - h_2)^2 g A \rho$

B 9. We have two different liquids A and B whose relative densities are 0.75 and 1.0 respectively. If we dip solid objects P and Q having relative densities 0.6 and 0.9 in these liquids, then :
(A) P floats in A and Q sink in B (B) P sinks in A and Q floats in B
(C) P floats in B and Q sinks in A (D) P sinks in B and Q floats in A

B 10. A cubical box of wood of side 30 cm weighing 21.6 kg floats on water with two faces horizontal. The depth of immersion of box is :
(A) 30 cm (B) 12 cm (C) 6 cm (D) 24 cm

B 11. A small ball of density ρ is immersed in a liquid of density $\sigma(\sigma > \rho)$ to a depth h and released. The height above the surface of water up to which the ball will jump is :
(A) $\frac{\sigma h}{\rho}$ (B) $\left(\frac{\sigma}{\rho} - 1\right)h$ (C) $\left(1 - \frac{\rho}{\sigma}\right)h$ (D) $\frac{\rho h}{\sigma}$

B 12. A block of volume V and of density σ_b is placed in liquid of density $\sigma_l(\sigma_l > \sigma_b)$, then block is moved upward due to buoyant force upto a height h. The increase in potential energy is :
(A) $\sigma_b Vgh$ (B) $(\sigma_b + \sigma_l)Vgh$ (C) $(\sigma_b - \sigma_l)Vgh$ (D) none of these

B 13. The mass of a balloon with its contents is 1.5 kg. It is descending with an acceleration equal to half that of acceleration due to gravity. If it is to go up with the same acceleration keeping the volume same, its mass should be decreased by :
(A) 1.2 kg (B) 1 kg (C) 0.75 kg (D) 0.5 kg

B 14. A body measures 5 N in air and 2 N when put in water. The buoyant force is :
(A) 7 N (B) 9 N (C) 3 N (D) none of these

B 15. A body of uniform cross-sectional area floats in a liquid of density thrice its value. The portion of exposed height will be :
(A) 2/3 (B) 5/6 (C) 1/6 (D) 1/3

B 16. An egg when placed in ordinary water sinks but floats when placed in brine. This is because
(A) density of brine is less than that of ordinary water
(B) density of brine is equal to that of ordinary water
(C) density of brine is greater than that of ordinary water
(D) None of these

B 17. A ball floats on the surface of water in a container exposed to the atmosphere. When the container is covered and the air is partially removed, then the ball
(A) rises (B) gets immersed more in water
(C) remains immersed at its former depth (D) may rise or sink

B 18. A boat 3 m long 2 m wide is floating in a lake. When a man climbs over it, it sinks 1 cm into the lake. The mass of the man is

(A) 60 kg (B) 64 kg (C) 70 kg (D) 72 kg

B 19. An iceberg is floating partially immersed in sea water. The density of sea water is 1.03 g cm^{-3} and that of ice is 0.92 g cm^{-3}. The approximate percentage of total volume of iceberg above the level of sea water is
(A) 8 (B) 11 (C) 34 (D) 89

B 20. A boat with scrap iron is floating in a lake. If the scrap iron is thrown in the lake, the water level will
(A) go up (B) go down (C) remain unchanged (D) none of these

B 21. A metallic sphere floats in an immiscible mixture of water ($\rho_w = 10^3$ kg/m^3) and a liquid ($\rho_L = 13.5 \times 10^3$) with (1/5)th portion by volume in the liquid. The density of the metal is :
(A) 4.5×10^3 kg/m^3 (B) 4.0×10^3 kg/m^3 (C) 3.5×10^3 kg/m^3 (D) 1.9×10^3 kg/m^3

B 22. Two bodies are in equilibrium when suspended in water from the arms of a balance. The mass of one body is 36 g and its density is 9 g/cc. If the mass of the other is 48 g, its density in g/cc is :
(A) 4/3 (B) 3/2 (C) 3 (D) 5

B 23. A and B are two metallic pieces. They are fully immersed in water and then weighed. Now they show same loss of weight. The conclusion therefore is
(A) A and B have same weight in air (B) A and B have equal volumes
(C) the densities of the materials of A and B are the same
(D) A and B are immersed to the same depth inside water.

B 24. A boat floating in a tank is carrying passengers. If the passengers drink water, how will it affect the water level of the tank?
(A) it will go down (B) it will rise
(C) it will remain unchanged (D) it will depend on atmospheric pressure

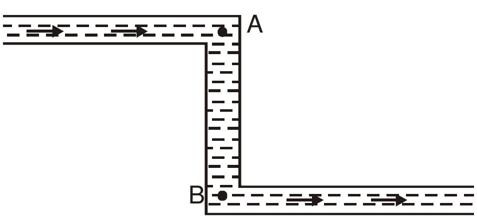
B 25. In order that a floating object be in a stable equilibrium, its centre of buoyancy should be
(A) vertically above its centre of gravity (B) vertically below its centre of gravity
(C) horizontally in line with its centre of gravity (D) may be anywhere

B 26. A block of iron is kept at the bottom of a bucket full of water at 2°C. The water exerts buoyant force on the block. If the temperature of water is increased by 1°C the temperature of iron block also increases by 1°C. The buoyant force on the block by water
(A) will increase (B) will decrease (C) will not change
(D) may decrease or increase depending on the values of their coefficient of expansion

B 27. A block of silver of mass 4 kg hanging from a string is immersed in a liquid of relative density 0.72. If relative density of silver is 10, then tension in the string will be:[take g = 10 m/s^2]
(A) 37.12 N (B) 42 N (C) 73 N (D) 21 N

B 28.* A spring balance reads W_1 when a ball of mass m is suspended from it. A weighing machine reads W_2 when a beaker of liquid is kept on the pan of balance. When the ball is immersed in liquid, the spring balance reads W_3 and the weighing machine reads W_4.
The two balances are now so arranged that the suspended mass is inside the liquid in a beaker. Then
(A) $W_3 > W_1$ (B) $W_4 > W_2$ (C) $W_3 < W_1$ and $W_4 > W_2$ (D) $W_3 > W_1$ and $W_4 < W_2$

B 29.* In the figure, an ideal liquid is flowing through the tube which is of uniform area of cross-section. The liquid has velocities v_A and v_B, and pressures P_A and P_B at points A and B respectively. Then
(A) $v_B > v_A$
(B) $v_B = v_A$
(C) $P_B > P_A$
(D) $P_B = P_A$



SECTION (C) : CONTINUITY EQUATION AND BERNOULLI THEOREM & THEIR APPLICATION

C 1. The total area of cross–section is 0.25 m^2. If the blood is flowing at the rate of 100 cm^3/sec, then the average velocity of flow of blood through the capillaries is :
(A) 0.4 mm/sec. (B) 4 mm/sec. (C) 25 mm/sec. (D) 400 mm/sec.

C 2. An incompressible fluid flows steadily through a cylindrical pipe which has radius 2R at point A and radius R at point B further along the flow direction. If the velocity at point A is v, its velocity at point B will be :
(A) 2v (B) v (C) v/2 (D) 4v

C 3. Water from a tap (at the end of a horizontal pipe) emerges vertically downwards with an initial speed of 1.0 ms^{-1}. The cross-sectional area of the tap is $10^{-4} m^2$. Assume that the pressure is constant throughout

the stream of water and the flow is steady. The cross-sectional area of the stream 0.15 m below the tap is :
(A) 5.0×10^{-4} m^2 (B) 1.0×10^{-5} m^2 (C) 5.0×10^{-5} m^2 (D) 2.0×10^{-5} m^2

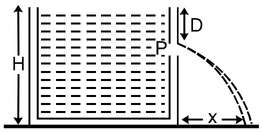
C 4. Water is flowing through a horizontal pipe of non-uniform cross-section. At the extreme narrow portion of the pipe, the water will have :
(A) maximum speed and least pressure (B) maximum pressure and least speed
(C) both pressure and speed maximum (D) both pressure and speed least

C 5. An aeroplane gets an upward lift due to a phenomenon best described by the :
(A) Archimedes's principle (B) Bernoulli's principle
(C) Buoyancy principle (D) Pascal's law

C 6. A horizontal pipe line carries water in a streamline flow. At a point along the pipe where cross-sectional area is 10 cm^2, the velocity of water is 1 m/s and pressure is 2000 Pa. The pressure of water at another point where cross-sectional area is 5 cm^2 ,is : (Density of water = 1000 kg/m^3)
(A) 250 Pa (B) 500 Pa (C) 1000 Pa (D) 2000 Pa

C 7. In Bernoulli's theorem which of the following is conserved ?
(A) Mass (B) Energy (C) Linear momentum (D) Angular momentum

C 8. A tank is filled with water up to height H. Water is allowed to come out of a hole P in one of the walls at a depth D below the surface of water. Express the horizontal distance x in terms of H and D :



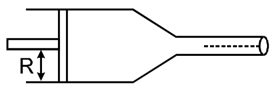
(A) $x = \sqrt{D(H-D)}$ (B) $x = \sqrt{\dfrac{D(H-D)}{2}}$ (C) $x = 2\sqrt{D(H-D)}$ (D) $x = 4\sqrt{D(H-D)}$

C 9. A cylindrical vessel is filled with water up to height H. A hole is bored in the wall at a depth h from the free surface of water. For maximum range h is equal to :
(A) H (B) 3H/4 (C) H/2 (D) H/4

C 10. A water barrel having water up to a depth d is placed on a table of height h. A small hole is made on the wall of the barrel at its bottom. If the stream of water coming out of the hole falls on the ground at a horizontal distance R from the barrel, then the value of d is :
(A) $\dfrac{4h}{R^2}$ (B) $4hR^2$ (C) $\dfrac{R^2}{4h}$ (D) $\dfrac{h}{4R^2}$

C 11. An aeroplane of mass 3×10^4 kg and total wing area of 120 m^2 is in a level flight at some height. The different in pressure between the upper lower surface of its wings, in kilo pascals is :
(A) 2.5 (B) 5.0 (C) 10.0 (D) 12.5

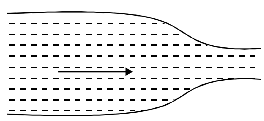
C 12. A piston of a syringe pushes a liquid with a speed of 1 cm/sec. The radii of syringe tube and the needle are R = 1 cm and r = 0.5 mm respectively. The velocity of the liquid coming out of the needle is

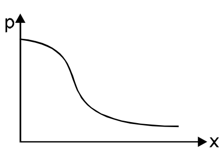


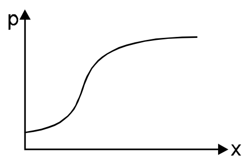
(A) 2 cm/sec (B) 400 cm/sec (C) 10 cm/sec (D) None of these

C 13. There is a small hole near the bottom of an open tank filled with a liquid. The speed of the water ejected does not depend on :
(A) area of the hole (B) density of the liquid
(C) height of the liquid from the hole (D) acceleration due to gravity

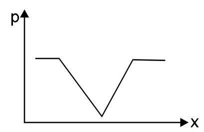
C 14. Water flows through a frictionless duct with a cross-section varying as shown in figure. Pressure p at points along the axis is represented by:



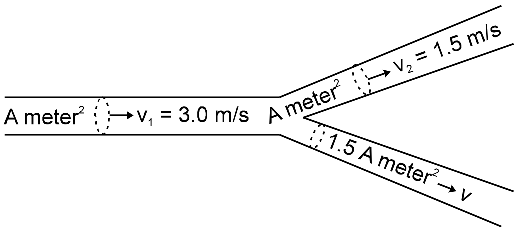
(A) 

(B) 

(C) 

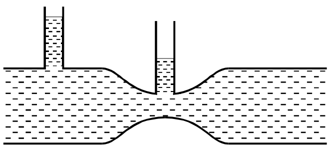
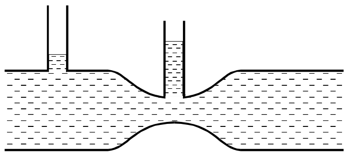
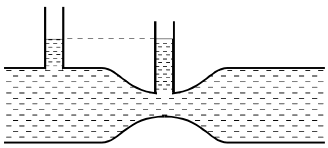
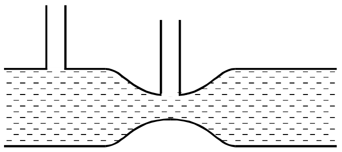
(D) 

C 15. An incompressible liquid flows through a horizontal tube as shown in the figure. Then the velocity ' v ' of the fluid is:

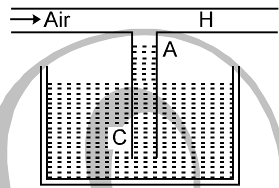


(A) 3.0 m/s (B) 1.5 m/s (C) 1.0 m/s (D) 2.25 m/s

C 16. For a fluid which is flowing steadily, the level in the vertical tubes is best represented by

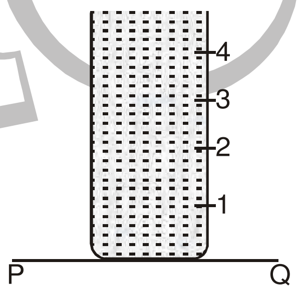
(A) 
(B) 
(C) 
(D) 

C 17. Figure shows a capillary tube C dipped in a liquid that wets it. The liquid rises to a point A. If we blow air through the horizontal tube H, what will happen to the liquid column in the capillary tube?



(A) Level will rise above A (B) Level will fall below A
(C) Level will remain at A (D) remain at the same level

C 18.* A cylindrical vessel of 90 cm height is kept filled upto the brim. It has four holes 1, 2, 3, 4 which are respectively at heights of 20cm, 30 cm, 40 cm and 50 cm from the horizontal floor PQ. The water falling at the maximum horizontal distance from the vessel comes from



(A) hole number 4 (B) hole number 3
(C) hole number 2 (D) hole number 1.

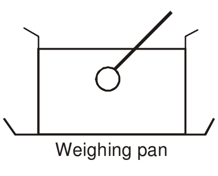
EXERCISE-3

1. A 10 cm side cube weighing 5N is immersed in a liquid of relative density 0.8 contained in a rectangular tank of cross section a area 15cm x 15cm. If the tank contained liquid to a height of 8 cm before the immersion, the level of the liquid surface is :

(A) $\frac{100}{9}$ cm (B) $\frac{97}{9}$ cm (C) 10 cm (D) 11 cm

2. A hemispherical bowl just floats without sinking in a liquid of density 1.2×10^3 kg/m^3. If outer diameter and the density of the bowl are 1 m and 2×10^4 kg/m^3 respectively, then the inner diameter of the bowl will be (outer surface is in contact with the liquid) :
(A) 0.94 m (B) 0.97 m (C) 0.98 m (D) 0.99 m

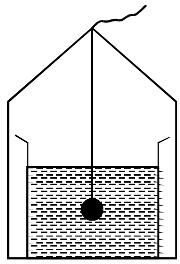
3. A vessel with water is placed on a weighing pan and it reads 600 g. Now a ball of mass 40 g and density 0.80 g cm^{-3} is sunk into the water with a pin of negligible volume, as shown in figure keeping it sunk. The weighing pan will show a reading :



(A) 600 g (B) 550 g (C) 650 g (D) 632 g

4. A beaker with a liquid of density 1.4 g cm^{-3} is in balance over one pan of a weighing machine. If a solid

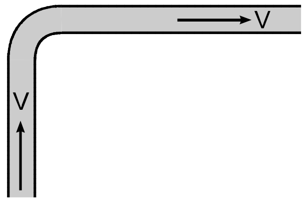
of mass 10 g and density 8 g cm^{-3} is now hung from the top of that pan with a thread and sinking fully in the liquid without touching the bottom, the extra weight to be put on the other pan for balance will be:
(A) 10.0 g
(B) 8.25 g
(C) 11.75 g
(D) – 1.75 g



5. The time period of a simple pendulum is T. The pendulum is oscillated with its bob immersed in a liquid of density σ. If the density of the bob is ρ and viscous effect is neglected, the time period of the pendulum in this case will be

(A) $\left(\frac{\rho}{\rho-\sigma}\right)^{1/2}T$ (B) $\left(\frac{\sigma}{\rho-\sigma}\right)^{1/2}$ (C) $\left(\frac{\rho}{\sigma}\right)^{1/2}T$ (D) $\left(\frac{\sigma}{\rho}\right)^{1/2}T$

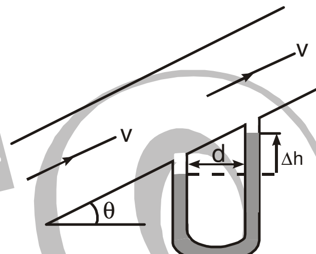
6. A fire hydrant delivers water of density ρ at a volume rate L. The water travels vertically upward through the hydrant and then does 90^0 turn to emerge horizontally at speed V. The pipe and nozzle have uniform cross-section throughout. The force exerted by the water on the corner of the hydrant is
(A) ρVL (B) zero
(C) 2ρVL (D) $\sqrt{2}\rho VL$



7. A mercury manometer is connected as shown in the figure. The difference in height Δh is: (symbols have usual meaning) ($\rho_{Hg} >> \rho$)

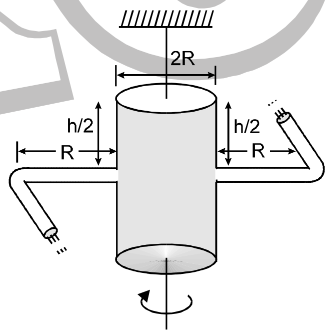
(A) $\frac{\rho\, d \cot\theta}{\rho_{Hg}}$ (B) $\frac{\rho\, d \tan\theta}{\rho_{Hg}}$

(C) $\frac{\rho\, d \sin\theta}{\rho_{Hg}}$ (D) none of these

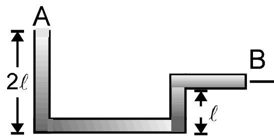


8. A cylindrical container of radius ' R' and height ' h' is completely filled with a liquid. Two horizontal L shaped pipes of small cross-section area ' a ' are connected to the cylinder as shown in the figure. Now the two pipes are opened and fluid starts coming out of the pipes horizontally in opposite directions. Then the torque due to ejected liquid on the system is:

(A) 4 a g h ρ R (B) 8 a g h ρ R
(C) 2 a g h ρ R (D) none of these



9. A tube in vertical plane is shown in figure. It is filled with a liquid of density ρ and its end B is closed. Then the force exerted by the fluid on the tube at end B will be : [Neglect atmospheric pressure and assume the radius of the tube to be negligible in comparison to ℓ]
(A) 0 (B) $\rho g\ell A_0$
(C) $2\rho g\ell A_0$ (D) Cannot be determined

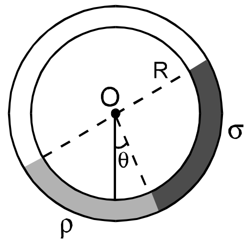


(cross section area = A_0)

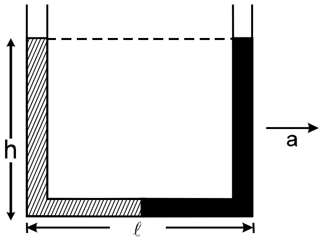
10. A small uniform tube is bent into a circular tube of radius R and kept in the vertical plane. Equal volumes of two liquids of densities ρ and σ (ρ > σ) fill half of the tube as shown. θ is the angle which the radius passing through the interface makes with the vertical.

(A) $\theta = \tan^{-1}\left(\frac{\rho-\sigma}{\rho+\sigma}\right)$ (B) $\theta = \tan^{-1}\left(\frac{\sigma-\rho}{\sigma+\rho}\right)$

(C) $\theta = \tan^{-1}\left(\frac{\rho}{\rho+\sigma}\right)$ (D) $\theta = \tan^{-1}\left(\frac{\rho}{\rho-\sigma}\right)$



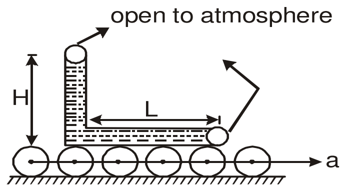
11. A U-tube of base length "l" filled with same volume of two liquids of densities ρ and 2ρ is moving with an acceleration "a" on the horizontal plane. If the height difference between the two surfaces (open to atmosphere) becomes zero, then the height h is given by:



(A) $\frac{a}{2g}\ell$ (B) $\frac{3a}{2g}\ell$ (C) $\frac{a}{g}\ell$ (D) $\frac{2a}{3g}\ell$

12. You are studying for an exam on the eight floor of your luxurious apartment building. You look out from the window and notice that one of your neighbours is giving a party on the ground-floor terrace and has placed a huge punch bowl full of an interesting looking beverage (specific gravity 1) directly below your window. You quickly string together 80 drinking straws to form a giant straw that can reach the punch bowl 80 feet below. You dip the straw into the punch and begin to suck. When you use a single drinking straw to drink something, it takes you 0.1 seconds to raise the liquid to your lips. But when you use this giant drinking straw,
(A) you find that you can't raise the liquid to your lips no matter how hard you try.
(B) it takes you 8 seconds (80 times 0.1 second) to raise the liquid to your lips.
(C) it takes you 800 seconds (80 divided by 0.1 scond) to raise the liquid to your lips.
(D) it takes you 640 seconds (80 times 80 times 0.1 second) to raise the liquid to your lips.

13. A narrow tube completely filled with a liquid is lying on a series of cylinders as shown in figure. Assuming no sliding between any surfaces, the value of acceleration of the cylinders for which liquid will not come out of the tube from anywhere is given by



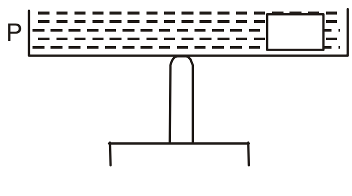
(A) $\frac{gH}{2L}$ (B) $\frac{gH}{L}$ (C) $\frac{2gH}{L}$ (D) $\frac{gH}{\sqrt{2}L}$

14. A piece of cork of mass m and density ρ is completely immersed in a liquid of density ρ_0, where $\rho_0 > \rho$. It is attached to the bottom of the vessel containing the liquid by a light string. The whole system moves up with an acceleration = a. The tension in the string is

(A) $m(g+a)\left(1-\frac{\rho_0}{\rho}\right)$ (B) $m(g+a)\left(\frac{\rho_0}{\rho}-1\right)$

(C) $mg\left(\frac{\rho_0}{\rho}-1\right)$ (D) $m(g-a)\left(\frac{\rho_0}{\rho}-1\right)$

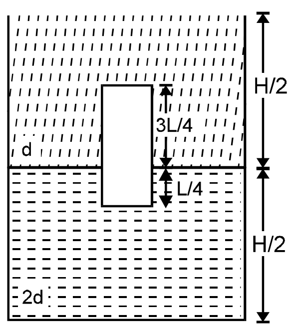
15. An open pan P filled with water (density ρ_w) is placed on a vertical rod, maintaining equilibrium. A block of density ρ is placed on one side of the pan as shown. Water depth is more than height of the block.



(A) Equilibrium will be maintained only if $\rho < \rho_w$.
(B) Equilibrium will be maintained only if $\rho \le \rho_w$.
(C) Equilibrium will be maintained for all relations between ρ and ρ_w
(D) Equilibrium will not be maintained in all cases.

16. The centre of buoyancy of a floating object is
(A) at the centre of gravity of the object.
(B) at the centre of gravity of the submerged part of the object.
(C) at the centre of gravity of the remaining part outside the fluid of the object.
(D) at the centre of gravity of the fluid displaced by the submerged part of the object.

17. A container of a large uniform cross-sectional area A resting on a horizontal surface holds two immiscible, non-viscous and incompressible liquids of densities 'd' and '2d' each of height (1/2)H as shown. The smaller density liquid is open to atmosphere. A homogeneous solid cylinder of length L $\left(<\frac{1}{2}H\right)$ cross-sectional area (1/5) A is immersed such that it floats with its axis vertical to the liquid-liquid interface with length (1/4) L in denser liquid. If D is the density of the solid cylinder then :



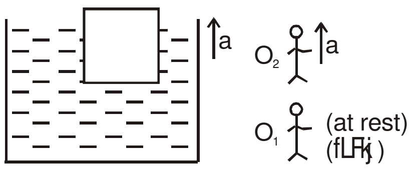
(A) $D = \frac{3d}{2}$ (B) $D = \frac{d}{2}$ (C) $D = \frac{2d}{3}$ (D) $D = \frac{5d}{4}$

18. A vessel contains oil (density = 0.8 gm/cm^3) over mercury (density = 13.6 gm/

cm^3). A uniform sphere floats with half its volume immersed in mercury and the other half in oil. The density of the material of sphere in gm/cm^3 is:

(A) 3.3 (B) 6.4 (C) 7.2 (D) 12.8

19. A block is partially immersed in a liquid and the vessel is accelerating upwards with an acceleration "a". The block is observed by two observers O_1 and O_2 , one at rest and the other accelerating with an acceleration "a" upward. The total buoyant force on the block is :



(A) same for O_1 and O_2 (B) greater for O_1 than O_2
(C) greater for O_2 than O_1 (D) data is not sufficient

20. There is a hole of area A at the bottom of cylindrical vessel. Water is filled up to a height h and water flows out in t second. If water is filled to a height 4h, it will flow out in time equal to

(A) t (B) 4t (C) 2t (D) t/4

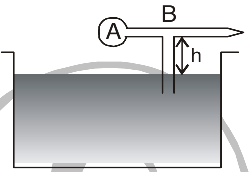
21. A cylindrical vessel of 92 cm height is kept filled up to the brim. It has four holes 1,2,3,4 which are respectively at heights of 20 cm, 30 cm, 46 cm and 80 cm from the horizontal floor. The water falling at the maximum horizontal distance from the vessel comes from :

(A) hole no.4 (B) hole no.3 (C) hole no.2 (D) hole no.1

22. A light cylindrical vessel is kept on a horizontal surface. Its base area is A. A hole of cross sectional area a is made just at its bottom side. The minimum coefficient of friction necessary for preventing the sliding of the vessel due to the impact force of the emerging liquid is (a << A)

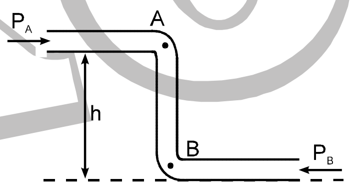
(A) varying (B) a/A (C) 2a/A (D) None of these

23. The figure shows a model of perfume atomizer. When the bulb A is compressed, air flows through the narrow tube consequently pressure at the position of the vertical tube reduce. The liquid (perfume) rise in through the vertical tube and emerges through the end. If the excess pressure applied to the bulb in this process be Δp then the minimum speed of air in the tube to lift the perfume is (ρ_a is density of air and ρ is density of perfume).



(A) $\sqrt{\dfrac{2[\Delta p + \rho gh]}{\rho_a}}$ (B) $\sqrt{\dfrac{2[\Delta p - \rho gh]}{\rho_a}}$ (C) $\sqrt{\dfrac{\Delta p + \rho gh}{\rho_a}}$ (D) None of these

24. Figure shows an ideal fluid flowing through a uniform cross-sectional tube in the vertical tube with liquid velocities v_A & v_B and pressure P_A & P_B. Knowing that tube offers no resistance to fluid flow following is true.



(A) $P_B > P_A$ (B) $P_B < P_A$ (C) $P_A = P_B$ (D) none of these

25. Bernoulli's equation can be written in the following different forms (column A). Column B lists certain units each of which pertains to one of the possible forms of the equation. Match the unit associated with each of the equations :

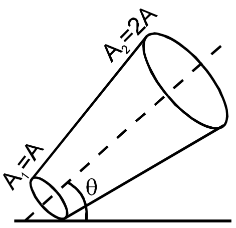
Column A	Column B
(a) $\dfrac{v^2}{2g} + \dfrac{p}{\rho g} + z$ = constant	(i) Total energy per unit mass
(b) $\dfrac{\rho V^2}{2} + P + \rho gz$ = constant	(ii) Total energy per unit weight
(c) $\dfrac{V^2}{2} + \dfrac{P}{\rho} + gz$ = constant	(iii) Total energy per unit volume

(A) a–(i), b–(ii), c–(iii) (B) a–(iii), b–(i), c–(iii)
(C) a–(ii), b–(iii), c–(i) (D) a–(iii), b–(iii), c–(i)

26. A large open tank has two small holes in the wall. One is a square hole of side 'L' at a depth '4y' from the top and the other is a circular hole of radius 'R' at a depth 'y' from the top. When the tank is completely filled with water, the quantities of water flowing out per second from both holes are the same. Then, 'R' is equal to:

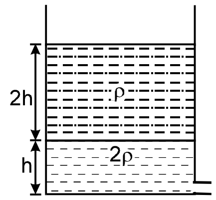
(A) $\dfrac{L}{\sqrt{2\pi}}$ (B) $2\pi L$ (C) $\sqrt{\dfrac{2}{\pi}}\,.\,L$ (D) $\dfrac{L}{2\pi}$

27. A portion of a tube is shown in the figure. Fluid is flowing from cross-section area A_1 to A_2. The two cross-sections are at distance 'l' from each other. The velocity of the fluid at section A_2 is $\sqrt{\frac{g\ell}{2}}$. If the pressures at A_1 & A_2 are same, then the angle made by the tube with the horizontal will be:



(A) 37º (B) $\sin^{-1}\frac{3}{4}$ (C) 53º (D) none of these

28. The velocity of the liquid coming out of a small hole of a vessel containing two different liquids of densities 2ρ and ρ as shown in figure is



(A) $\sqrt{6gh}$ (B) $2\sqrt{gh}$ (C) $2\sqrt{2gh}$ (D) $\sqrt{gh}$

29. There is a small hole in the bottom of a fixed container containing a liquid upto height 'h'. The top of the liquid as well as the hole at the bottom are exposed to atmosphere. As the liquid comes out of the hole. (Area of the hole is 'a' and that of the top surface is 'A') :

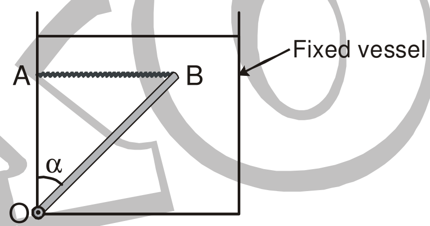
(A) the top surface of the liquid accelerates with acceleration $= g$

(B) the top surface of the liquid accelerates with acceleration $= g\frac{a^2}{A^2}$

(C) the top surface of the liquid retards with retardation $= g\frac{a}{A}$

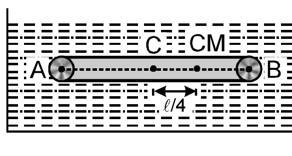
(D) the top surface of the liquid retards with retardation $= \frac{ga^2}{A^2}$

30. A uniform rod OB of length 1m, cross-sectional area 0.012 m^2 and relative density 2.0 is free to rotate about O in vertical plane. The rod is held with a horizontal string AB which can withstand a maximum tension of 45 N. The rod and string system is kept in water as shown in figure. The maximum value of angle α which the rod can make with vertical without breaking the string is



(A) 45º (B) 37º (C) 53º (D) 60º

31. A non uniform cylinder of mass m, length ℓ and radius r is having its cetnre of mass at a distance $\ell/4$ from the centre and lying on the axis of the cylinder. The cylinder is kept in a liquid of uniform density ρ. The moment of inertia of the rod about the centre of mass is I. The angular acceleration of point A relative to point B just after the rod is released from the position shown in figure is



(A) $\frac{\pi\rho g\ell^2 r^2}{I}$ (B) $\frac{\pi\rho g\ell^2 r^2}{4I}$ (C) $\frac{\pi\rho g\ell^2 r^2}{2I}$ (D) $\frac{3\pi\rho g\ell^2 r^2}{4I}$

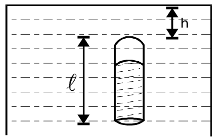
EXERCISE-4

1. An open and wide glass tube is immersed vertically in such a way that a length 0.05 m extends above the mercury level. The open end of the tube is then closed and the tube is raised further by 0.43 m. Calculate the length of the air column above the mercury level in the tube.

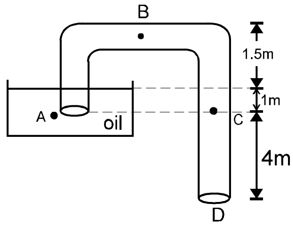
2. A cylindrical wooden float whose base area S = 4000 cm^2 and the altitude H = 50 cm drifts on the water surface. Specific weight of wood d = 0.8 gf/cm^3.
What work must be performed to take the float out of the water ?

3. A test-tube of length 'ℓ' is filled with air and is lowered into a mercury bath to a depth 'ℓ' such that mercury rises to height h into the tube. If mercury barometer also reads 'ℓ'. Then find out h in terms of 'ℓ'.

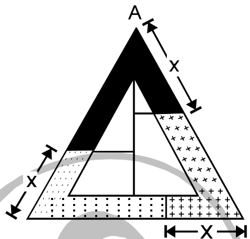
4. A glass tube of length $\ell = 21$cm and cross section $A = 0.5\text{cm}^2$ is closed at one end and contains air. The tube is inverted with the closed end held up and is then inserted inside a tank containing mercury. The tube is held with its upper end at a depth h = 15cm below the free surface of the mercury. What force is required to hold the tube in this position ?
$P_{atm} = 75$cm of Hg.
Tube mass is negligible, $\rho_{Hg} = 13.6$ g/cc.



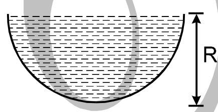
5. A siphon tube is discharging a liquid of specific gravity 0.9 from a reservoir as shown in figure.
(a) Find the velocity of the liquid through the siphon.
(b) Find the pressure at the highest point B.
(c) Find the pressure at the points A (outside the tube) and C.
State and explain the following
(d) Would the rate of flow be more, less or the same if the liquid were water.
(e) Is there a limit on the maximum height of B above the liquid level in the reservoir.
(f) Is there a limit on the vertical depth of the right limit of the siphon.



6. A closed tube in the form of an equilateral triangle of side ℓ contains equal volumes of three liquids which do not mix and is placed vertically with its lowest side horizontal. Find 'x' in the figure if the densities of the liquids are in A.P.



7. Compute the work which must be performed to pump the water out of a hemispherical reservoir of radius R = 0.6 m.

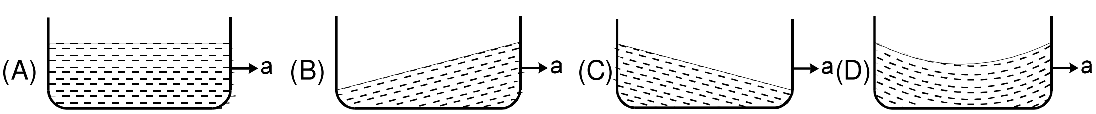


8. A solid cylinder of radius R = 10 cm and of mass M = 2kg floats in water with its axis vertical. Show that if it is slightly depressed and released, it will exectute SHM and find its period.

9. A ball of density d is dropped on to a horizontal solid surface. It bounces elastically from the surface and returns to its original position in a time t_1. Next, the ball is released and it falls through the same height before striking the surface of a liquid of density d_L.
(a) If $d < d_L$, obtain an expression (in terms of d , t_1 and d_L) for the time t_2 the ball takes to come back to the position from which it was released.
(b) Is the motion of the ball simple harmonic?
(c) If $d = d_L$, how does the speed of the ball depend on its depth inside the liquid ?
Neglect all frictional and other dissipative forces. Assume the depth of the liquid to be large.

EXERCISE-5

1. A vessel containing water is given a constant acceleration 'a' towards the right along a straight horizontal path. Which of the following diagrams in figure represents the surface of the liquid? **[I.I.T. 1981]**

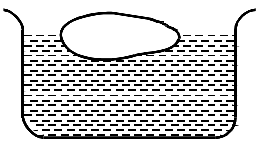


2. Two identical cylindrical vessels with their bases at the same level each contain a liquid of density ρ. The height of the liquid in one vessel iis h_2 and other vessels h_1, the area of either base is A. The work done by gravity in equalizing the levels when the two vessels are connected will be : **[I.I.T. 1981'4]**

(A) $\frac{gA\rho}{4}(h_1 - h_2)^2$ (B) $\frac{gA\rho}{4}(h_1 + h_2)^2$ (C) $\frac{gA\rho}{4}(h_1 + h_2)$ (D) $\frac{gA\rho}{4}(h_1 - h_2)$

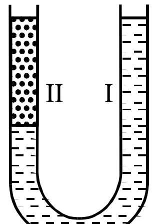
3. A body floats in a liquid contained in a beaker. The whole system as shown in figure falls freely under gravity. The upthrust on the body is : **[IIT - 1982 - 3]**
(A) zero

(B) equal to the weight of the liquid displaced
(C) equal to the weight of the body in air
(D) equal to the weight of the immersed portion of the body



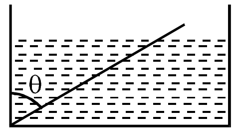
4. A U-tube of uniform cross-section (see figure) is partially filled with a liquid I. Another liquid II which does not mix with liquid I is poured into one side. It is found that the liquid levels of the two sides of the tube are the same, while the level of I has risen by 2 cm. If the specific gravity of liquid I is 1.1, the specific gravity of liquid II must be : **[I.I.T. 1983]**

(A) 1.12 (B) 1.1 (C) 1.05 (D) 1.0



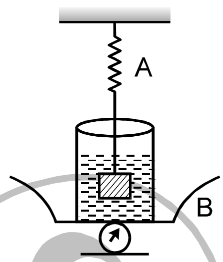
5. A wooden plank of length 1 m and uniform cross-section is hinged at one end to the bottom of a tank as shown in figure. The tank is filled with water upto a height 0.5 m. The specific gravity of the plank is 0.5. The angle θ that the plank makes with the vertical in the equilibrium position will be (Exclude the case $\theta = 0°$) **[I.I.T. 1984' 8]**

(A) 30º (B) 40º (C) 60º (D) 45º



6. The spring balance A reads 2 kg with a block m suspended from it. A balance B reads 5 kg when a beaker with liquid is put on the pan of the balance. The two balances are now so arranged that the hanging mass is inside the liquid in the beaker as shown in the figure. In this situation : **[IIT - 1985 ' 2]**

(A) the balance A will read more than 2 kg
(B) the balance B will read more than 5 kg
(C) the balance A will read less than 2 kg and B will read more than 5 kg
(D) the balance A and B will read 2 kg and 5 kg respectively



7. A thin tube of uniform cross-section is sealed at both ends. It lies horizontally, the middle 5 cm containing mercury and the two equal end containing air at the same pressure P. When the tube is held at an angle of 60° with the vertical direction, the length of the air column above and below the mercury column are 46 cm and 44.5 cm respectively. The pressure P in centimeters of mercury (The temperature of the system is kept at 30°C) will be **[I.I.T. 1986' 6]**

(A) 75.5 cm (B) 75 cm (D) 0.75 cm (D) 0.075 cm

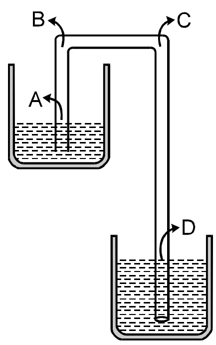
8. Figure shows a siphon in action. The liquid flowing through the siphon has a density of 1.5 g/cc. (points ABCD are inside the pipe).
(I) the pressure difference between points B and C : **[Roorkee 1986]**

(A) 1 N/m^2

(B) 2 N/m^2

(C) 0.1 N/m^2

(D) Zero



9. A liquid is kept in a cylindrical vessel which is rotated along its axis. The liquid rises at the sides. If the radius of the vessel is 0.05 m and the speed of rotation is 2 rev/s, The difference in the height of the liquid at the centre of the vessel and its sides will be ($\pi^2 = 10$) : **[Roorkee 1987]**

(A) 3 cm (B) 2 cm (C) 3/2 cm (D) 2/3 cm

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

(I) Distance from the foot of the wall does the emerging stream of water strike the floor and the value of h for maximum range will be :

(A) $x = 2\sqrt{h(H-h)}$, h = H/2 (B) $x = 2\sqrt{h(H+h)}$, H = h

(C) $x = \sqrt{h(H+h)}$, H = h/2 (D) $x = 2\sqrt{(H+h)}$, H = 3h/2

(II) Maximum range will be :

(A) x maximum = H (B) x maximum = H/2
(C) x maximum = 3H/2 (D) None of these **[Roorkee 1988]**

11. A vessel contains oil (density = 0.8 gm/cm³) over mercury (density = 13.6 gm cm³). A homogeneous sphere floats with half its volume immersed in mercury and the other half in oil. The density of the material of the sphere in gm/cm³ is : **[IIT - 1988 ' 2]**
(A) 3.3 (B) 6.4 (C) 7.2 (D) 12. 8

12. A cylindrical tank of height 0.4 m is open at the top and has a diameter 0.16 m. Water is filled in it up to a height of 0.16 m. how long it will take to empty the tank through a hole of radius 5×10^{-3} m in its bottom. **[Roorkee 1990]**
(A) 46.26 sec. (B) 4.6 sec. (C) 462.6 sec. (D) .46 sec.

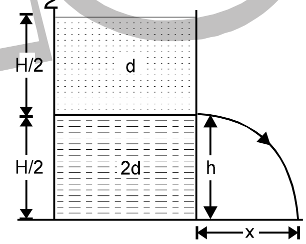
13. A solid ball of density half that of water falls freely under gravity from a height of 19.6 m and then enters water. **[Roorkee 1991]**
(I) up to what depth will the ball go :
(A) 1.96 m (B) 19.6 m (C) 9.8 m (D) 9.6 m
(II) Time taken to come again to the water surface will be. (Neglect air resistance and viscosity effects in water. (g = 9.8 m/s²) :
(A) 4 s (B) 3 s (C) 2 s (D) 3/2 s

14. If the radii of its ends are 0.1 m and 0.04 m and the pressure drop across its length is 10 N//m².then rate of flow of glycerine of density 1.25×10^3 kg/m³ through the conical section of a pipe will be : **[Roorkee 1991]**
(A) 62.8×10^{-4} m³/s (B) 6.28×10^{-4} m³/s (C) $.628\times10^{-4}$ m³/s (D) 62.8×10^{4} m³/s

15. An open end wide tube is immersed vertically in mercury in such way that a length 0.05 m extends above the mercury level. The open end of the tube is then closed and the tube is raised further by 0.43 m. the length of the air column above the mercury level in the tube will be : **[Roorkee 1992]**
(A) h = 1 m (B) h = .1 m (C) h = 2 m (D) h = 3/2 m

16. A horizontal pipe line carries water in a streamline flow. At a point along the pipe where the cross-sectional area is 10 cm², the water velocity is 1 ms⁻¹ and the pressure is 2000 Pa. The pressure of water at another point where the cross-sectional area is 5 cm² will be :.
[Density of water = 10^3 kg. m⁻³] **[JEE - 94, 2]**

17. A container of large uniform cross–sectional area A resting on a horizontal surface, holds two immiscible, non–viscous and incompressible liquids of densities d and 2d , each of height $\frac{H}{2}$ as shown in figure. The lower density liquid is open to the atmosphere having pressure P_0.



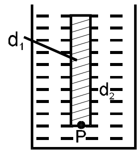
(a) A homogeneous solid cylinder of length L $\left(L<\frac{H}{2}\right)$ cross–sectional area $\frac{A}{5}$ is immersed such that it floats with its axis vertical at the liquid–liquid interface with the length $\frac{L}{4}$ in the denser liquid. Determine:
(i) The density D of the solid and (ii) The total pressure at the bottom of the container.
(b) The cylinder is removed and the original arrangement is restored. A tiny hole of area s (s << A) is punched on the vertical side of the container at a height h $\left(h<\left(\frac{H}{2}\right)\right)$. Determine :
(i) The initial speed of efflux of the liquid at the hole
(ii) The horizontal distance x travelled by the liquid initially and
(iii) The height h_m at which the hold should be punched so that the liquid travels the maximum distance x_m initially. Also calculate x_m.
[Neglect air resistance in these calculations] **[JEE - 95, 10]**

18. A cylindrical tank 1m in radius rests on a platform 5m high. Initially the tank is filled with water to a height of 5m. A plug whose area is 10^{-4} m² is removed from an orifice on the side of the tank at the bottom. Calculate the following : **[REE - 95, 5]**
(a) Initial speed with which the water flows from the orifice ;
(b) Initial speed with which the water strikes the groundand
(c) Time taken to empty the tank to half its original value.

19. A stream of gas (density = 1.8 kg/m⁻³) is escaping through a small opening at one end of a large cylinder under the action of excess pressure (relative to atmospheric pressure) $\Delta p = 10^3$ Nm⁻². The escape velocity will be **[REE - 96]**

(A) $\frac{1}{3}ms^{-1}$ (B) $\frac{10}{3}ms^{-1}$ (C) $\frac{100}{3}ms^{-1}$ (D) $\frac{1000}{3}ms^{-1}$

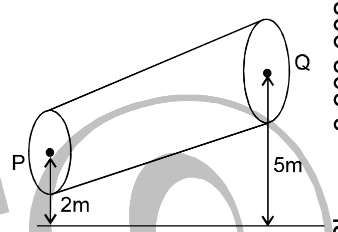
20. A thin rod of length L and area of cross–section S is pivoted at its lowest point P inside a stationary, homogeneous and non–viscous liquid (Figure). The rod is free to rotate in a vertical plane about a horizontal axis passing through P. The density d_1 of the material of the rod is smaller than the entity d_2 of the liquid. The rod is displaced by a small angle θ from its equilibrium position and then released. Show that the motion of the rod is simple harmonic and determine its angular frequency in terms of the given parameters.



[JEE - 96, 5]

21. A large open top container of negligible mass and uniform cross–sectional area A has a small hole of cross–sectional area $\frac{A}{100}$ in its side wall near the bottom. The container is kept on a smooth horizontal floor and contains a liquid of density ρ and mass m_0. Assuming that the liquid starts flowing out horizontally through the hole at t = 0, calculate
(a) The acceleration of the container and
(b) Its velocity when 75 % of the liquid has drained out. **[JEE - 97,5]**

22. A non-viscous liquid of constant density 1000 kg/m³ flows in a streamline motion along a tube of variable cross section. The tube is kept inclined in the vertical plane as shown in the figure. The area of cross-section of the tube at two points P and Q at heights of 2 meters and 5 meters are respectively 4×10^{-3} m² and 8×10^{-3} m². The velocity of the liquid at point P is 1 m/s. Find the work done per unit volume by the pressure and the gravity forces as the liquid flows from point P to Q. **[JEE - 97]**



23. Water is flowing continuously from a tap having a bore of internal diameter 8×10^{-3} m. Calculate the diameter of the water stream at a distance 2×10^{-1} m below the tap. Assume that the water velocity as it leaves the tap is 4×10^{-1} m/s. **[REE - 97]**

24. A stream of water flowing from a tap becomes narrower as it falls. This can be explained by
(A) Viscosity (B) Surface tension
(C) Conservation of energy (D) Conservation of volume flux **[REE - 97]**

25. Water from a tap emerges vertically downwards with an initial speed of 1.0 ms⁻¹. The cross-sectional area of the tap is 10^{-4} m². Assume that the pressure is constant throughout the stream of water, and that the flow is steady. The cross-sectional area of the stream 0.15 m below the tap is : **[JEE - 98]**
(A) 5.0×10^{-4} m² (B) 1.0×10^{-5} m² (C) 5.0×10^{-5} m² (D) 2.0×10^{-5} m²

26. Two water pipes P and Q having diameters 2×10^{-2} m and 4×10^{-2} m, respectively, are joined in series with the main supply line of water. The velocity of water flowing in pipe P is
(A) 4 times that of Q (B) 2 times that of Q
(C) 1/2 times that of Q (D) 1/4 rimes that of Q **[REE - 98]**

27. A wooden stick of length ℓ, and radius R and density ρ has a small metal piece of mass m (of negligible volume) attached to its one end. Find the minimum value for the mass m (in terms of given parameters) that would make the stick float vertically in equilibrium in a liquid of density σ (>ρ). **[JEE - 99, 10]**

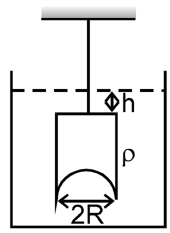
28. A large open tank has two holes in the wall. One is a square hole of side L at a depth y from the top and the other is a circular hole of radius R at a depth 4y from the top. When the tank is completely filled with water, the quantities of water flowing out per second from both holes are the same. Then radius R, is equal to : **[JEE - 2000]**

(A) $\frac{L}{\sqrt{2\pi}}$ (B) $2\pi L$ (C) L (D) $\frac{L}{2\pi}$

29. An air bubble in a water tank rises from the bottom to the top. Which of the following statements are true?
(A) Bubble rises upwards because pressure at the bottom is less than that at the top.
(B) Bubble rises upwards because pressure at the bottom is greater than that at the top.
(C) As the bubble rises, its size increases.
(D) As the bubble rises, its size decreases. **[REE-2000]**

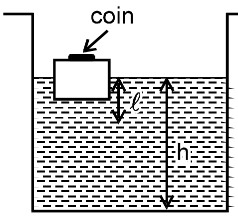
30. A cylindrical vessel filled with water upto a height of 2m stands on horizontal plane. The side wall of the vessel has a plugged circular hole touching the bottom. Find the minimum diameter of the hole so that the vessel begins to move on the floor if the plug is removed. The coefficient of friction between the bottom of the vessel and the plane is 0.4, and total mass of water plus vessel is 100 kg. **[REE - 01]**

31. A hemispherical portion of radius R is removed from the bottom of a cylinder of radius R. The volume of the remaining cylinder is V and its mass M. It is suspended by a string in a liquid of density ρ where it stays vertical. The upper surface of the cylinder is at a depth h below the liquid surface. The force on the bottom of the cylinder by the liquid is : **[I.I.T. 2001 S]**



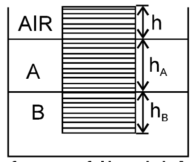
(A) Mg (B) Mg – Vρg (C) Mg + $\pi R^2 h\rho g$ (D) $\rho g(V + \pi R^2 h)$

32. A wooden block with a coin placed on its top, floats in water as shown in figure. The distance and h are shown here. After some time the coin falls into the water. Then : **[I.I.T. 2002 S]**



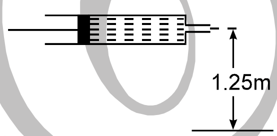
(A) ℓ decreases and h increase
(B) ℓ increases and h decreases
(C) both ℓ and h increases
(D) both ℓ and h decrease

33. A uniform solid cylinder of density 0.8 g/cm³ floats in equilibrium in a combination of two non-mixing liquids A and B with its axis vertical. The densities of the liquids A and B are 0.7g/cm³ and 1.2 g/cm³ respectively. The height of liquid A is h_A = 1.2 cm. The length of the part of the cylinder immersed in liquid B is h_B = 0.8 cm.



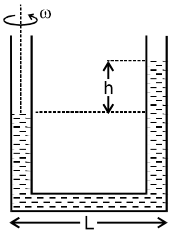
(a) Find the total force exerted by liquid A on the cylinder.
(b) Find h, the length of the part of the cylinder in air.
(c) The cylinder is depressed such a way that its top surface is just below the upper surface of liquid A and is then released. Find the acceleration of the cylinder immediately after it is released. **[JEE - 02]**

34. The piston and nozzle of syringe have diameters 8mm and 2mm respectively. The syringe filled with water is held horizontally at a height 1.25m (as shown in figure). If the piston is moved in with a constant speed of 0.25 ms^{-1} what is the horizontal range of the jet coming out of the nozzle? (Use g = 10 ms^{-2}.) **[JEE 2004, 2/60]**



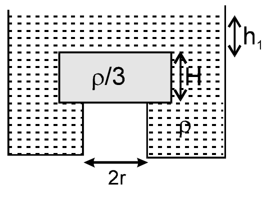
35. Water is filled in a container upto height 3m. A small hole of area 'a' is punched in the wall of the container at a height 52.5 cm from the bottom. The cross sectional area of the container is A. If a/A = 0.1 then v² is : (where v is the velocity of water coming out of the hole) **[I.I.T. 2005 S]**
(A) 50 (B) 51 (C) 48 (D) 51.5

36. A U tube is rotated about one of it's limbs with an angular velocity ω. Find difference in height H of the liquid (density ρ) level, where diameter of the tube d << L . **[I.I.T. 2005 '2]**



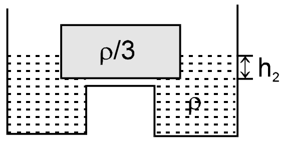
Passage :
A wooden cylinder of diameter 4r, height H and density ρ/3 is kept on a hole of diamete 2r of a tank, filled with liquid of density ρ as shown in the figure. **[I.I.T. 2006 '6]**

37. If level of the liquid starts decreasing slowly when the level of liquid is at a height h_1 above the cylinder the block starts moving up. At what value of h_1, will the block rise :



(A) $\frac{4h}{9}$ (B) $\frac{5h}{9}$ (C) $\frac{5h}{3}$ (D) Remains same

38. The block in the above question is maintained at the position by external means and the level of liquid is lowered. The height h_2 when this external force reduces to zero is



(A) $\frac{4h}{9}$ (B) $\frac{5h}{9}$ (C) Remains same (D) $\frac{2h}{3}$

39. If height h_2 of water level is further decreased, then
(A) cylinder will not move up and remains at its original position
(B) for h_2 = h/3, cylinder again starts moving up
(C) for h_2 = h/4, cylinder again starts moving up
(D) for h_2 = h/5 cylinder again starts moving up

ANSWER

EXERCISE - 1

SECTION (A) :

A 1. Density of air decreases with the height exponentially.

A 2. Pressure at heights gets reduced, resulting rising of ink and leakage.

A 3. $P = \rho\,(gh + a\ell)$ **A 4.** $p = p_a + d_0 gh + 2/3\ ch^{3/2}$

A 5. 10 kg (98.1 N)

A 6. 500 kg/m^3 , 0.5 **A 7.** 248 KN/m^2

A 8. at P = 124.9 KN/m^2 at R = 89.5 KN/m^2
at Q = 89.5 KN/m^2 at S = 46.4KN/m^2

SECTION (B) :

B 1. No **B 2.** it's density is high because of salt.

B 3. same

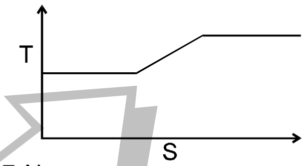
B 4. Centre of Buoyancy and centre of gravity are diffrent resulting torque.

B 5. 10 cm **B 6.** 19.6 m, 4 sec

B 7. 3.33 litre. **B 8.** h = 4.5 m

B 9. 7.61 g **B 10.** 2.78

B 11. 11.15% **B 12.**



B 13. (i) 2.33 kg (ii) – 56.7 N

SECTION (C) :

C 1. Due to high velocity of wind above roof, pressure decreases resulting upward force.

C 2. At a intersection point, fluid particle cannot have two velocities.

C 3. Can be explained by continuity equation.

C 4. Due to decrease in air pressure between person and train.

C 5. Due to decrease in pressure in between.

C 6. h = 2 cm **C 7.** (a) 10 m/s (b) 2×10^{-3} m^3/s

C 8. (a) 25 cm/s, (b) 50 cm/s (c) 94 N/m^2

C 9. (a) 25 cm/s, (b) 50 cm/s (c) zero

C 10. (a) 25 cm/s, (b) 50 cm/s (c) 188 N/m^2

C 11. (a) 20 cm/s, (b) 485 N/m^2

C 12. 2.13 cm

EXERCISE - 2

SECTION (A) :

A 1.	C	**A 2.**	A	**A 2.**	B	**A 4.**	A
A 5.	A	**A 6.**	A	**A 7.**	D	**A 8.**	ACD

SECTION (B) :

B 1.	BC	**B 2.**	CD	**B 3.**	D	**B 4.**	D
B 5.	A	**B 6.**	A	**B 7.**	B	**B 8.**	D
B 9.	C	**B 10.**	D	**B 11.**	B	**B 12.**	C
B 13.	B	**B 14.**	C	**B 15.**	A	**B 16.**	C
B 17.	C	**B 18.**	A	**B 19.**	B	**B 20.**	B
B 21.	C	**B 22.**	C	**B 22.**	B	**B 24.**	C
B 25.	A	**B 26.**	A	**B 27.**	A	**B 28.**	BC
B 29.	BC						

SECTION (C) :

C 1.	A	**C 2.**	D	**C 3.**	C	**C 4.**	A
C 5.	B	**C 6.**	B	**C 7.**	B	**C 8.**	C
C 9.	C	**C 10.**	C	**C 11.**	A	**C 12.**	B
C 13.	B	**C 14.**	A	**C 15.**	C	**C 16.**	A
C 17.	A	**C 18.**	AB				

EXERCISE - 3

1.	B	**2.**	C	**3.**	C	**4.**	A
5.	A	**6.**	D	**7.**	B	**8.**	A
9.	B	**10.**	A	**11.**	B	**12.**	A
13.	A	**14.**	B	**15.**	B	**16.**	D
17.	D	**18.**	C	**19.**	A	**20.**	C
21.	B	**22.**	C	**23.**	A	**24.**	A
25.	C	**26.**	C	**27.**	B	**28.**	B
29.	D	**30.**	B	**31.**	B		

EXERCISE - 4

1. 0.1 m **2.** $\frac{d^2 H^2 S}{2\rho g} = 320$ J,

3. $h = \frac{3\ell - \ell\sqrt{5}}{2}$ **4.** 1.02 N

5. (a) 10 m/s (b) 35 kN/m^2 (c) 64 kN/m^2
(d) same (e) yes (f) yes

6. $x = \frac{1}{3}$ **7.** $\frac{\pi\rho_w R^4}{4} = 1018$ J

9. 0.5 sec. **9.** (a) $\frac{t_1 d_L}{d_L - d}$ (b) No

EXERCISE - 5

1.	C	**2.**	A	**3.**	A	**4.**	B	
5.	D	**6.**	BC	**7.**	A	**8.**	D	
9.	B	**10.**	(I)	A	(II)	A		
11.	C	**12.**	A	**13.**	(I)	B	(II)	A
14.	B	**15.**	B	**16.**	500 Pa			

17. (a) (i) Density = $\frac{5}{4}d$

(ii) Pressure = $P_0 + \frac{1}{4}$ (6 H + L) dg

(b) (i) $v = \sqrt{\frac{g}{2}(3H - 4h)}$ (ii) $x = \sqrt{h\,(3H - 4h)}$

(iii) $x_{max} = \frac{3}{4}H$, $h_{max} = \frac{3H}{8}$

18. (a) 10 m/s (b) 14.1 m/s (c) 2.5 hr

19. **(C)** **20.** $\omega = \sqrt{\frac{3g}{2L}\left(\frac{d_2 - d_1}{d_1}\right)}$

21. (a) 0.2 m/s^2 (b) $\sqrt{2g\frac{m_0}{A\rho}}$

22. 2.94×10^4 J/m^3, 29025 J/m^3

23. 3.6×10^{-3} m **24.** C, D

25. C **26.** A **27.** m ³ pr^{2}l ($\sqrt{\rho\sigma}$ – r)

28. A **29.** BC **30.** 0.113 m

31. D **32.** D

33. (a) zero (b) 0.25 cm (c) g/6 (upwards).

34. 2 m **35.** A **36.** $H = \frac{\omega^2 L^2}{2g}$

37. C **38.** A **39.** A