arride learning

FLUID MECHANISM

Contents

Syllabus

Pressure in a fluid ; Pascal's law ; Buoyancy ;

Equation of continuity, Bernoulli's theorem and its applications.

Name : ______________________ **Contact No.** ____________________

ARRIDE LEARNING ONLINE E-LEARNING ACADEMY

A-479 indra Vihar, Kota Rajasthan 324005

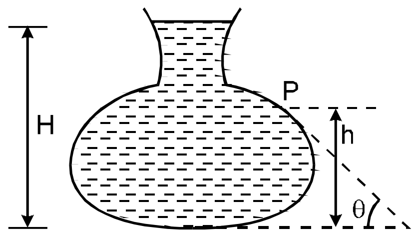
Contact No. 8033545007

EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

Section (A) : Measurement and calculation of pressure

A-1. Figure here shows 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

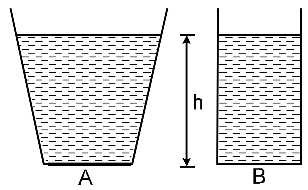


(A) $h\rho g$ (B) $H\rho g$ (C) $(H - h)\rho g$ (D) $(H - h)\rho g \cos\theta$

A-2. A tank with length 10 m, breadth 8 m and depth 6m is filled with water to the top. If g = 10 m s^{-2} and density of water is 1000 kg m^{-3}, then the thrust on the bottom is
(A) 6 × 1000 × 10 × 80 N (B) 3 × 1000 × 10 × 48 N
(C) 3 × 1000 × 10 × 60 N (D) 3 × 1000 × 10 × 80 N

A-3. 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-4. 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

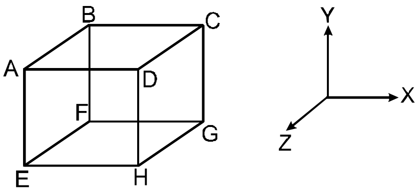


(A) $F_A > F_B$; $W_A > W_B$ (B) $F_A = F_B$; $W_A > W_B$
(C) $F_A = F_B$; $W_A < W_B$ (D) $F_A > F_B$; $W_A = W_B$

A-5. (i) 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 shown in the figure where pressure is maximum, is



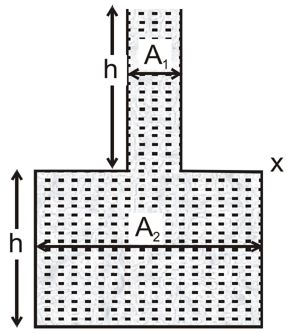
(A) B (B) C (C) E (D) F

(ii) In previous question pressure will be minimum at point –
(A) A (B) B (C) H (D) F

A-6*. Pressure gradient 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*. 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 $2h\rho g$
(B) the weight of the liquid in vessel in equal to $2h\rho g$
(C) the force exerted by the liquid on the base of vessel is $2h\rho g A_2$
(D) the walls of the vessel at the level X exert a force $h\rho g(A_2 - A_1)$ downwards on the liquid.

Section (B) : Archemedies principle and force of buoyancy

B-1. 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-2. 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-3. 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 upto a height h and it is still in liquid. The increase in gravitational potential energy of the system is :

(A) $\sigma_b Vgh$ (B) $(\sigma_b + \sigma_l)Vgh$ (C) $(\sigma_b - \sigma_l)Vgh$ (D) none of these

B-4. A block of steel of size 5 cm × 5 cm × 5 cm is weighed in water. If the relative density of steel is 7. Its apparent weight is :

(A) 6 × 5 × 5 × 5 gf (B) 4 × 4 × 4 × 7 gf (C) 5 × 5 × 5 × 7 gf (D) 4 × 4 × 4 × 6 gf

B-5. 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-6. 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 :

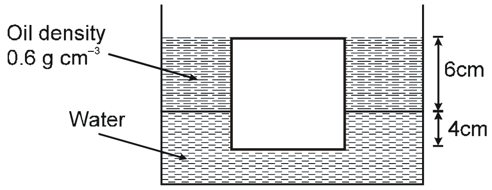
(A) 4/3 (B) 3/2 (C) 3 (D) 5

B-7. 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

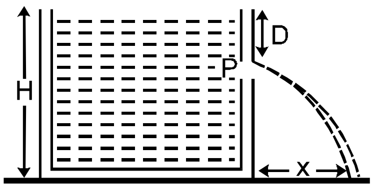
B-8. A cubical block of wood 10 cm on a side, floats at the interface of oil and water as shown in figure. The density of oil is 0.6 g cm^{-3} and density of water is 1 g cm^{-3}. The mass of the block is



(A) 706 g (B) 607 g (C) 760 g (D) 670 g

Section (C) : Continuity equation and Bernoulli theorem & their application

C-1. 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 as shown in the figure. Express the horizontal distance x in terms of H and D :

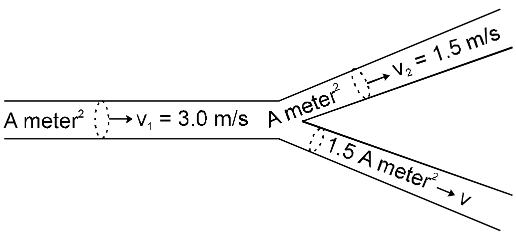


(A) $x = \sqrt{D(H-D)}$ (B) $x = \sqrt{\frac{D(H-D)}{2}}$ (C) $x = 2\sqrt{D(H-D)}$ (D) $x = 4\sqrt{D(H-D)}$

C-2. A fixed 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 horizontal range h is equal to :

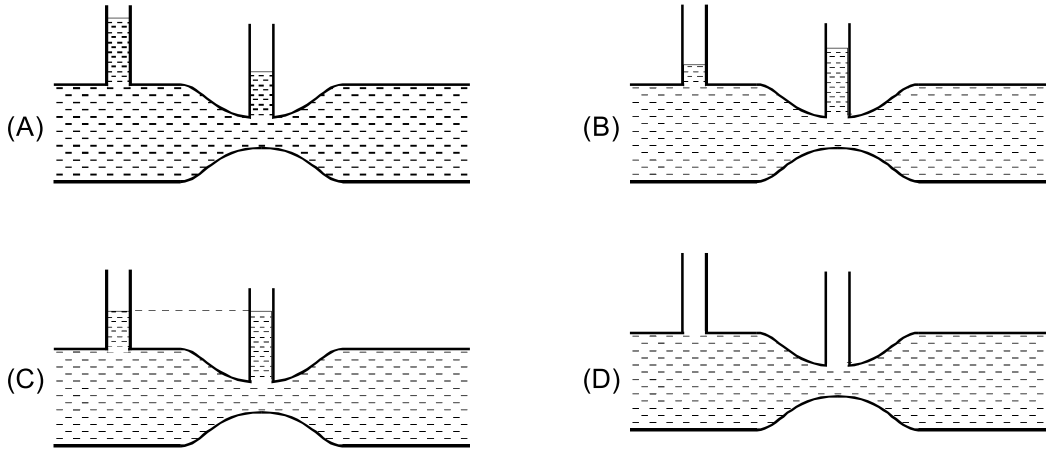
(A) H (B) 3H/4 (C) H/2 (D) H/4

C-3. An incompressible liquid flows through a horizontal tube as shown in the figure. Then the velocity 'v' of the fluid is :

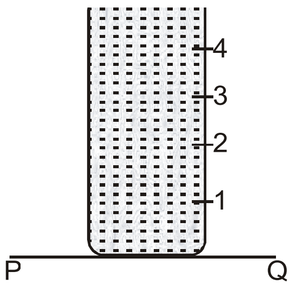


(A) 3.0 m/s (B) 1.5 m/s (C) 1.0 m/s (D) 2.25 m/s

C-4. For a fluid which is flowing steadily in the figure shown, the level in the vertical tubes is best represented by :

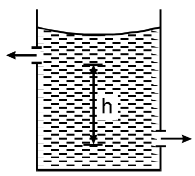


C-5.* A cylindrical vessel of 90 cm height is kept filled upto the brim as shown in the figure. It has four holes 1, 2, 3, 4 which are respectively at heights of 20cm, 30 cm, 40 cm and 50 cm from the horizontal floor PQ. The water falling at the maximum horizontal distance from the vessel comes from



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

C-6. There are two identical small holes on the opposite sides of a tank containing a liquid. The tank is open at the top. The difference in height of the two holes is h as shown in the figure. As the liquid comes out of the two holes, the tank will experience a net horizontal force proportional to:



(A) $h^{1/2}$ (B) h (C) $h^{3/2}$ (D) h^2

C-7. 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 ?

(A) 46.26 sec. (B) 4.6 sec. (C) 462.6 sec. (D) 0.46 sec.

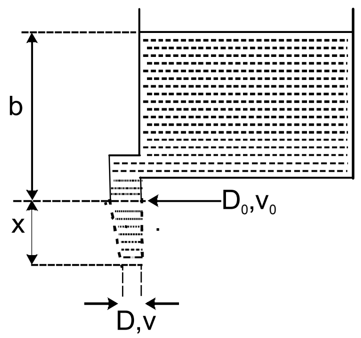
PART - II : MISLLANEOUS QUESTIONS

1. COMPREHENSION

Comprehension # 1

The figure shows the commonly observed decrease in diameter of a water stream as it falls from a tap. The tap has internal diameter D_0 and is connected to a large tank of water. The surface of the water is at a height b above the end of the tap.

By considering the dynamics of a thin "cylinder" of water in the stream answer the following: (Ignore any resistance to the flow and any effects of surface tension, given ρ_w = density of water)



1. Equation for the flow rate, i.e. the mass of water flowing through a given point in the stream per unit time, as function of the water speed v will be

(A) $v\,\rho_w\,\pi D^2/4$
(B) $v\,\rho_w\,(\pi D^2/4 - \pi D_0^2/4)$
(C) $v\,\rho_w\,\pi D^2/2$
(D) $v\,\rho_w\,\pi D_0^2/4$

2. Which of the following equation expresses the fact that the flow rate at the tap is the same as at the stream point with diameter D and velocity v (i.e. D in terms of D_0 , v_0 and v will be) :

(A) $D = \frac{D_0 v_0}{v}$
(B) $D = \frac{D_0 v_0^2}{v^2}$
(C) $D = \frac{D_0 v}{v_0}$
(D) $D = D_0\sqrt{\frac{v_0}{v}}$

3. The equation for the water speed v as a function of the distance x below the tap will be :

(A) $v = \sqrt{2gb}$
(B) $v = [2g\,(b + x)]^{1/2}$
(C) $v = \sqrt{2gx}$
(D) $v = [2g\,(b - x)]^{1/2}$

4. Equation for the stream diameter D in terms of x and D_0 will be :

(A) $D = D_0\left(\frac{b}{b+x}\right)^{1/4}$
(B) $D = D_0\left(\frac{b}{b+x}\right)^{1/2}$
(C) $D = D_0\left(\frac{b}{b+x}\right)$
(D) $D = D_0\left(\frac{b}{b+x}\right)^{2}$

5. A student observes after setting up this experiment that for a tap with D_0 = 1 cm at x = 0.3 m the stream diameter D = 0.9 cm. The heights b of the water above the tap in this case will be :

(A) 5.7 cm
(B) 57 cm
(C) 27 cm
(D) 2.7 cm

Comprehension # 2

One way of measuring a person's body fat content is by "weighing" them under water. This works because fat tends to float on water as it is less dense than water. On the other hand muscle and bone tend to sink as they are more dense. Knowing your "weight" under water as well as your real weight out of water, the percentage of your body's volume that is made up of fat can easily be estimated. This is only an estimate since it assumes that your body is made up of only two substances, fat (low density) and everything else (high density). The "weight" is measured by spring balance both inside and outside the water. Quotes are placed around weight to indicate that the measurement read on the scale is not your true weight, i.e. the force applied to your body by gravity, but a measurement of the net downward force on the scale.

6. Ram and Shyam are having the same weight when measured outside the water. When measured under water, it is found that weight of Ram is more than that of Shyam, then we can say that
(A) Ram is having more fat content than Shyam.
(B) Shyam is having more fat content that Ram.
(C) Ram and Shyam both are having the same fat content.
(D) None of these.

7. Ram is being weighed by the spring balance in two different situations. First when he was fully immersed in water and the second time when he was partially immersed in water, then
(A) Reading will be more in the first case. (B) Reading will be more in the second case.
(C) Reading would be same in both the cases. (D) Reading will depend upon experimental setup.

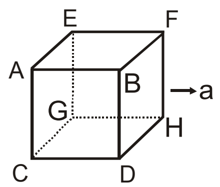
8. Salt water is denser than fresh water. If you were immersed fully first in salt water and then in fresh water and weighed, then
(A) Reading would be less in salt water. (B) Reading would be more in salt water.
(C) Reading would be the same in both the cases. (D) reading could be less or more.

9. A person of mass 165 Kg having one fourth of his volume consisting of fat (relative density 0.4) and rest of the volume consisting of everything else (average relative density $\frac{4}{3}$) is weighed under water by the spring balance. The reading shown by the spring balance is -
(A) 15 N (B) 65 N (C) 150 N (D) 165 N

10. In the above question if the spring is cut, the acceleration of the person just after cutting the spring is
(A) zero (B) 1 m/s^2 (C) 9.8 m/s^2 (D) 0.91 m/s^2

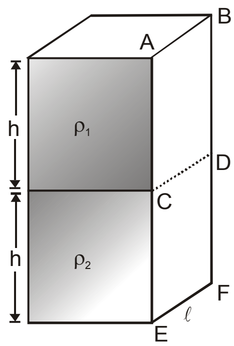
2. MATCH THE COLUMN

11. A cubical box is completely filled with mass m of a liquid and is given horizontal acceleration a as shown in the figure. Match the force due to fluid pressure on the faces of the cube with their appropriate values (assume zero pressure as minimum pressure)



	Column I	Column II
(A)	force on face ABFE	(p) $\frac{ma}{2}$
(B)	force on face BFHD	(q) $\frac{mg}{2}$
(C)	force on face ACGE	(r) $\frac{ma}{2}+\frac{mg}{2}$
(D)	force on face CGHD	(s) $\frac{ma}{2}$ +mg
		(t) $\frac{mg}{2}$ + ma

12. A cuboid is filled with liquid of density ρ_2 upto height h & with liquid of density ρ_1 , also upto height h as shown in the figure

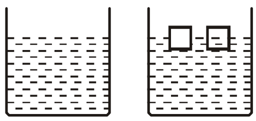


Column I		Column II
(A)	Force on face ABCD due to liquid of density ρ_1	(p) zero
(B)	Force on face ABCD due to liquid of density ρ_2	(q) $\frac{\rho_1 g h^2 \ell}{2}$
(C)	Force on face CDEF transferrred due to liquid of density ρ_1	(r) $\rho_1 g h^2 \ell$
(D)	Force on face CDEF due to liquid of density ρ_2 only	(s) $\frac{\rho_2 g h^2 \ell}{2}$

3. ASSERTION / REASONING

13. **Assertion :** Any pressure increase at one point of a static connected fluid passes to each point undiminished.
Reason : Fluid is assumed to be incompressible.
(A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
(B) If both Assertion and Reason are true, but Reason is not correct explanation of the Assertion.
(C) if Assertion is true, but the Reason is false.
(D) if Assertion is false, but the Reason is true.

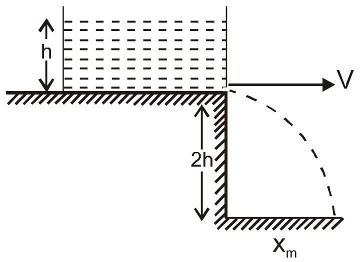
14. **STATEMENT-1 :** One of the two identical container is empty and the other contains two ice cubes as shown in the figure. Now both the containers are filled with water to same level as shown. Then both the containers shall weigh the same.



STATEMENT-2 : The weight of volume of water displaced by ice cube floating in water is equal to the weight of ice cube. Hence both the container in above situation shall weigh the same.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

15. **STATEMENT-1 :** Consider an object that floats in water but sinks in oil. When the object floats in water, half of it is submerged. If we slowly pour oil on top of water till it completely covers the object, the object moves up.
STATEMENT-2 : As the oil is poured in the situation of statement-1, pressure inside the water will increase everywhere resulting in an increase in upward force on the object.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

16. **STATEMENT-1 :** A fixed tank is filled upto a height h with a liquid and is placed on a platform of height 2h from the ground,. To get maximum range x_m, a small hole is punched at a distance h from the free surface of the liquid, for the given condition.



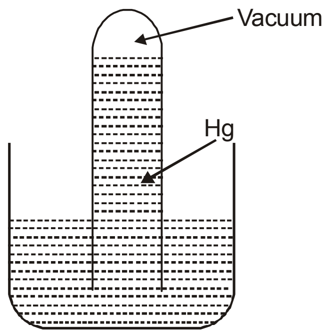
STATEMENT-2 : If a small hole is punched at bottom of container, then speed of liquid coming out from container is maximum.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

4. TRUE / FALSE

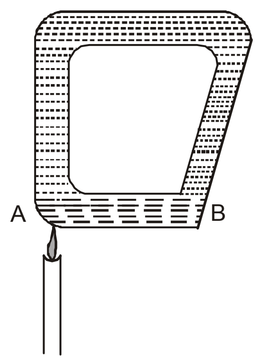
17. **State true / false :**

(i) Hydrostatic pressure is a scalar quantity even though pressure is force divided by area and force is a vector quantity ?

(ii) A barometer made of a very narrow tube (see figure) is placed at normal temperature and pressure. The coefficient of volume expansion of mercury is $0.00018/^0$ C and that of the tube is negligible. The temperature of mercury in the barometer is now raised by 1^0 C but the temperature of the atmosphere does not change. Then, the mercury height in the tube remains unchanged.



(iii) Water in a closed tube (see figure) is heated with one arm vertically placed above a lamp. Water will begin to circulate along the tube in counter–clockwise direction.



(iv) A block of ice with a lead shot embedded in it is floating on water contained in a vessel. The temperature of the system is maintained at $0\,^0$C as the ice melts. When the ice melts completely the level of water in the vessel rises.

5. FILL IN THE BLANKS

18. **Fill in the blanks :**

(i) A solid sphere of radius R made of a material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area A floats on the surface of the liquid. When a mass M is placed on the piston to compress the liquid, the magnitude of fractional change in the radius of the sphere, $\delta R / R$, is.......... .

(ii) A piece of metal floats on mercury. The coefficients of volume expansion of the metal and mercury are γ_1 and γ_2 respectively. If the temperature of both mercury and the metal are increased by an amount ΔT, the fraction of the volume of the metal submerged in mercury changes then the ratio of new fraction to that of the old fraction is.......

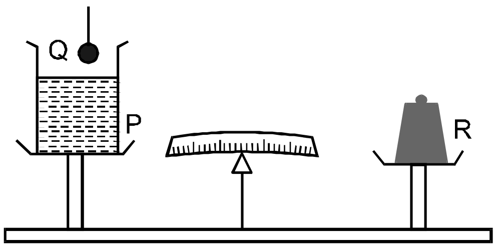
(iii) A horizontal pipe line carries water in a streamline flow. At a point along the pipe where the cross-sectional area is 10 cm², the water velocity is 1 ms^{-1} and the pressure is 2000 Pa. The pressure of water at another point where the cross-sectional area is 5 cm² will be :.
[Density of water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

EXERCISE # 2

PART - I : MIXED OBJECTIVE

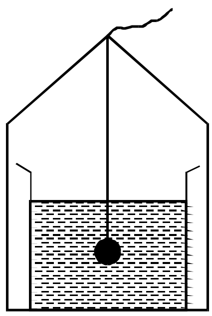
Single choice type

1. Figure shows a weighing-bridge, with a beaker P with water on one pan and a balancing weight R on the other. A solid ball Q is hanging with a thread outside water. It has volume 40 cm^3 and weighs 80 g. If this solid is lowered to sink fully in water, but not touching the beaker anywhere, the balancing weight R' will be



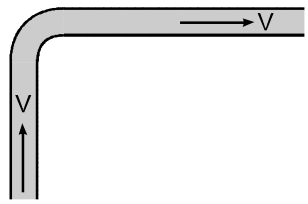
(A) same as R
(B) 40 g less than R
(C) 40 g more than R
(D) 80 g more than R

2. A beaker with a liquid of density 1.4 g cm^{-3} is in balance over one pan of a weighing machine as shown in the figure. 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 mass to be put on the other pan for balance will be:



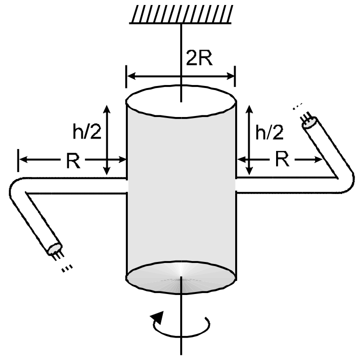
(A) 10.0 g (B) 8.25 g (C) 11.75 g (D) – 1.75 g

3. A fire hydrant (as shown in the figure) 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



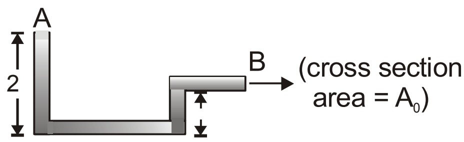
(A) ρVL (B) zero (C) 2ρVL (D) $\sqrt{2}\rho VL$

4. 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:



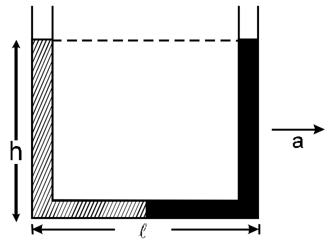
(A) 4 a g h ρR (B) 8 a g h ρR (C) 2 a g h ρR (D) none of these

5. 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]



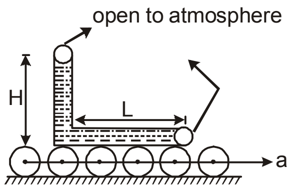
(A) 0 (B) $\rho g\ell A_0$ (C) $2\rho g\ell A_0$ (D) Cannot be determined

6. 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 as shown in the figure. If the height difference between the two surfaces (open to atmosphere) becomes zero, then the height h is given by:



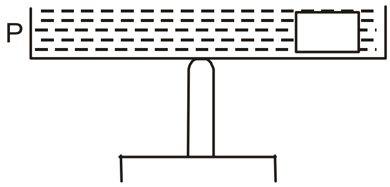
(A) $\frac{a}{2g}\ell$ (B) $\frac{3a}{2g}\ell$ (C) $\frac{a}{g}\ell$ (D) $\frac{2a}{3g}\ell$

7. 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



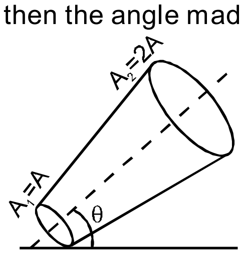
(A) $\frac{gH}{2L}$ (B) $\frac{gH}{L}$ (C) $\frac{2gH}{L}$ (D) $\frac{gH}{\sqrt{2}L}$

8. 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 in the figure. 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) It is not possible to maintained the equilibrium

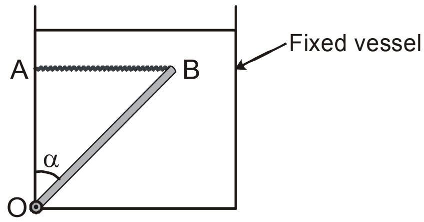
9. A portion of a tube is shown in the figure. Fluid is flowing from cross-section area A_1 to A_2. The two cross-sections are at distance 'ℓ' from each other. The velocity of the fluid at section A_2 is $\sqrt{\frac{g\ell}{2}}$. If the pressures at A_1 & A_2 are same, then the angle made by the tube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



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

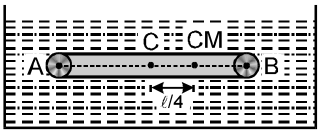
10. There is a small hole in the bottom of a fixed container containing a liquid upto height 'h'. The top of the liquid as well as the hole at the bottom are exposed to atmosphere. As the liquid comes out of the hole. (Area of the hole is 'a' and that of the top surface is 'A') :
(A) the top surface 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 = $\frac{ga^2}{A^2}$

11. 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

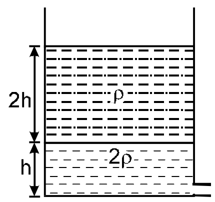
12. A non uniform cylinder of mass m, length ℓ and radius r is having its centre of mass at a distance $\ell/4$ from the centre and lying on the axis of the cylinder as shown in the figure. The cylinder is kept in a liquid of uniform density ρ. The moment of inertia of the rod about the centre of mass 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) $\frac{3\pi\rho g\ell^2 r^2}{4I}$

13. 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

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

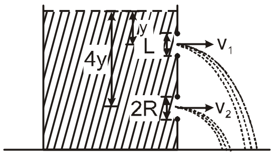


(A) $\sqrt{6gh}$ (B) $2\sqrt{gh}$ (C) $2\sqrt{2gh}$ (D) $\sqrt{gh}$

15. A liquid is kept in a cylindrical vessel which is rotated about 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 ($\pi^2 = 10$) :
(A) 3 cm (B) 2 cm (C) 3/2 cm (D) 2/3 cm

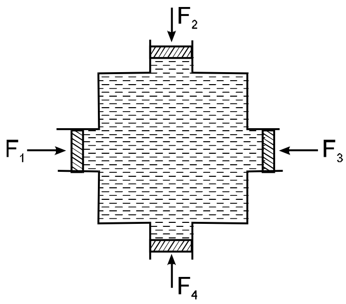
16. Two water pipes P and Q having diameters 2×10^{-2} m and 4×10^{-2} m, respectively, are joined in series with the main supply line of water. The velocity of water flowing in pipe P is
(A) 4 times that of Q (B) 2 times that of Q
(C) 1/2 times that of Q (D) 1/4 rimes that of Q

17. 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 :



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

18. 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

More than one choice type

19*. 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. Thickness of oil is 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.

20. 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.

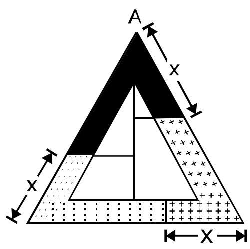
(C) As the bubble rises, its size increases.

(D) As the bubble rises, its size decreases.

PART - II : SUBJECTIVE QUESTIONS

1. An open tank 10 m long and 2m deep is filled upto height 1.5 m of oil of specific gravity 0.80. The tank is accelerated uniformly from rest to a speed of 10 m/sec. What is the shortest time in which this speed may be attained without spilling any oil. [$g = 10 m/s^2$]

2. 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.

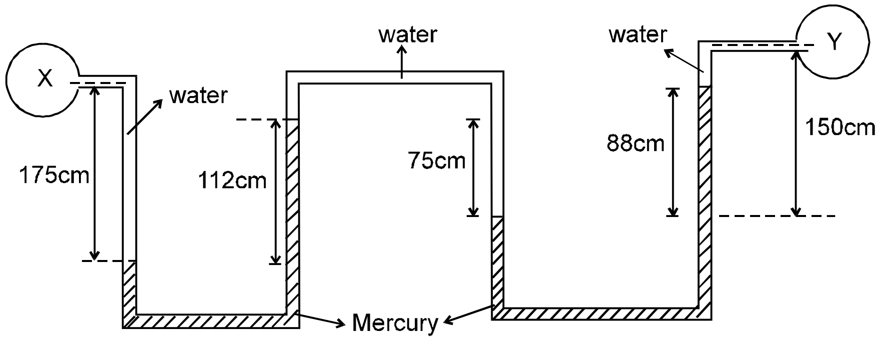


3. We can cut an apple easily with a sharp knife as compared to with a blunt knife. Explain why?

4. Why mercury is used in barometers instead of water ?

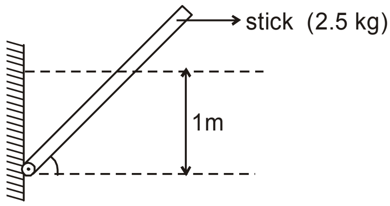
5. Pressure 3 m below the free surface of a liquid is $15 KN/m^2$ in excess of atmosphere pressure. Determine its density and specific gravity. [$g = 10 m/sec^2$]

6. 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. ($g = 10 m/s^2$, $\rho_{Hg} = 13600 kg/m^3$)

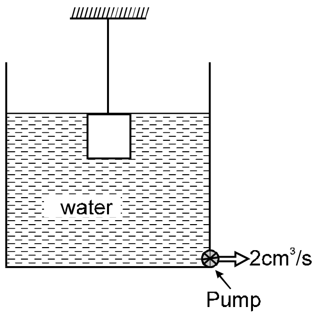


7. A rectangular vessel is filled with water and oil in equal proportion (by volume), the oil being twice lighter than water. Show that the force on each wall of the vessel will be reduced by one fifth if the vessel is filled only with oil. (take into consideration the fact that the oil is found at the top of the vessel). (Assume atmospheric pressure is negligible)

8. A stick of square cross-section (5 cm × 5 cm) and length '4m' weighs 2.5 kg as shown in the figure below. Determine its angle of inclination in equilibrium when the water surface is 1 m above the hinge. Now gradually water level is increased then find the minimum depth of water above hinge required to bring the stick in vertical position.



9. Figure shows a cubical block of side 10 cm and relative density 1.5 suspended by a wire of cross sectional area 10^{-6} m^2. The breaking stress of the wire is 7×10^6 N/m^2. The block is placed in a beaker of base area 200 cm^2 and initially i.e. at t = 0, the top surface of water & the block coincide. There is a pump at the bottom corner which ejects 2 cm^3 of water per sec constantly. Find the time at which the wire will break.



10. A ball of density d is dropped onto 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.

11. Two identical cylindrical vessels with their bases at the same level each contain a liquid of density ρ as shown in figure. The height of the liquid in one vessel is h_2 and other vessels h_1, the area of either base is A. Find the work done by gravity in equalizing the levels when the two vessels are connected.

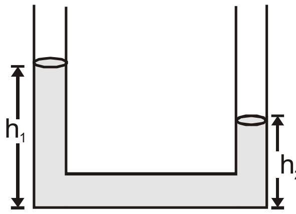


Figure (1)

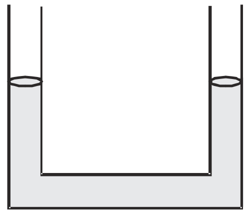
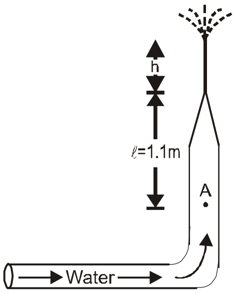


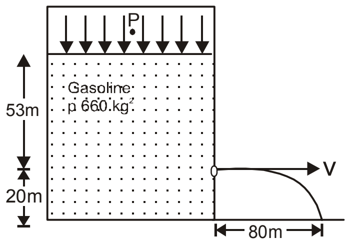
Figure (2)

12. 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).

13. Water shoots out of a pipe and nozzle as shown in the figure. The cross–sectional area for the tube at point A is four times that of the nozzle. The pressure of water at point A is $41 \times 10^3\ Nm^{-2}$ (guage). Find the height 'h' above the nozzle to which water jet will shoot. Neglect all the losses occurred in the above process. [$g = 10\ m/s^2$]

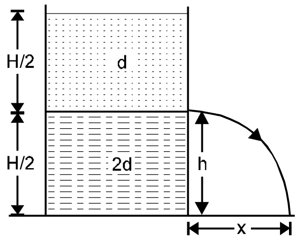


14. A tank containing gasoline is sealed and the gasoline is under pressure P_0 as shown in the figure. The stored gasoline has a density of $660\ kg\ m^{-3}$. A sniper fires a rifle bullet into the gasoline tank, making a small hole 53 m below the surface of gasoline. The total height of gasoline is 73 m from the base. The jet of gasoline shooting out of the hole strikes the ground at a distance of 80 m from the tank initially. Find the pressure P_0 above the gasoline surface. The local atmospheric pressure is $10^5\ Nm^{-2}$.



15. 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 :

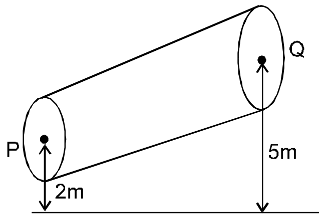
(i) The initial speed of efflux of the liquid at the hole

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

(iii) The height h_m at which the hole should be punched so that the liquid travels the maximum distance x_m initially. Also calculate x_m.
[Neglect air resistance in these calculations]

16. 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.

17. A non-viscous liquid of constant density 1000 kg/m^3 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} m^2 and 8×10^{-3} m^2. The velocity of the liquid at point P is 1 m/s. Find the work done per unit volume by the pressure and by the gravity forces as the liquid flows from point P to Q. (g = 9.8 m/s^2)

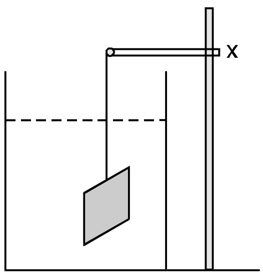


18. A cylindrical vessel filled with water upto a height of 2m stands on horizontal plane. The side wall of the vessel has a plugged circular hole touching the bottom. Find the minimum diameter of the hole so that the vessel begins to move on the floor if the plug is removed. The coefficient of friction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

19. A cube of wood supporting a 200 gm mass just floats in water. When the mass is removed the cube rises by 2 cm at equilibrium. Find side of the cube.

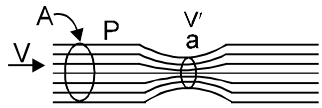
20. A small solid ball of density half that of water falls freely under gravity from a height of 19.6 m and then enter water. Upto what depth will the ball go ? How much time will it take to come again to the water surface? Neglect air resistance, viscosity effects of water and energy loss due to collision at water surface.
(g = 9.8 m/s^2)

21. A metallic square plate 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.

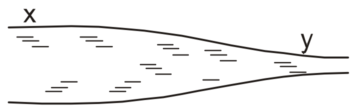


22. Calculate the rate of flow of glycerin of density 1.25 x10^3 kg/m^3 through the conical section of a pipe placed horizontally, if the radii of its ends are 0.1m and 0.04 m and the pressure drop across its length is 10 N/m².

23. Consider the Venturi tube of Figure. Let area A equal 5a. Suppose the pressure at A is 2.0 atm. Compute the values of velocity v at 'A' and velocity v′ at 'a' that would make the pressure p′ at 'a' equal to zero. Compute the corresponding volume flow rate if the diameter at A is 5.0 cm. (The phenomenon at a when p′ falls to nearly zero is known as cavitation. The water vaporizes into small bubbles.) (P_{atm} = 10^5 N/m^2, ρ = 1000 kg/m^3).



24. Water flows through a horizontal tube of variable cross-section (figure). The area of cross-section at x and y are 40 mm^2 and 20 mm^2 respectively. If 10 cc of water enters per second through x, find (i) the speed of water at x, (ii) the speed of water at y and (iii) the pressure difference $P_x - P_y$. (Take g = 10 m/s^2)



25. Suppose the tube in the previous problem is kept vertical with x upward but the other conditions remain the same. The separation between the cross-section at x and y is 15/16 cm. Repeat parts (i), (ii) and (iii) of the previous problem. Take g = 10 m/s^2.

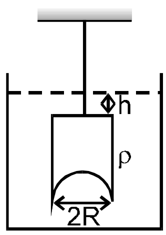
26. Suppose the tube in the previous problem is kept vertical with y upward. Water enters through y at the rate of 10 cm^3/s. Repeat part (i), (ii) and (iii). Note that the speed decreases as the water falls down.

EXERCISE # 3

PART-I IIT-JEE (PREVIOUS YEARS PROBLEMS)

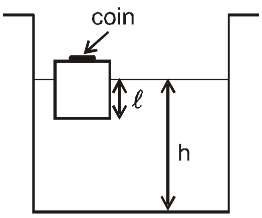
* ***Marked Questions are having more than one correct option.***

1. 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 : **[JEE-2001 (Screening), 3/105]**



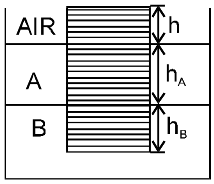
(A) Mg (B) Mg – $V\rho g$ (C) Mg + $\pi R^2 h\rho g$ (D) $\rho g(V + \pi R^2 h)$

2. A wooden block with a coin placed on its top, floats in water as shown in figure. The distance ℓ and h are shown here. After some time the coin falls into the water. Then : **[JEE-2002 (Screening), 3/105]**



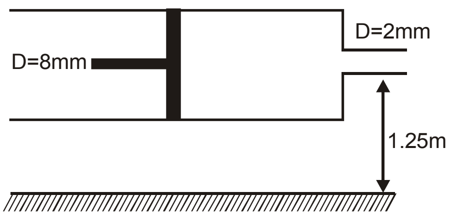
(A) ℓ decreases and h increase
(B) ℓ increases and h decreases
(C) both ℓ and h increases
(D) both ℓ and h decrease

3. A uniform solid cylinder of density 0.8 g/cm^3 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/cm^3 and 1.2 g/cm^3 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. **[JEE-2002 (Mains), 5/90]**



(i) Find the total force exerted by liquid A on the cylinder.
(ii) Find h, the length of the part of the cylinder in air.
(iii) The cylinder is depressed in 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.

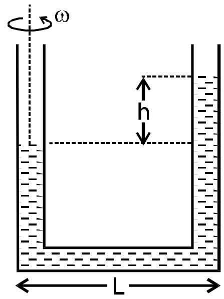
4. Consider a horizontally oriented syringe containing water located at a height of 1.25 m above the ground. The diameter of the plunger is 8 mm and diameter of nozel is 2mm. The plunger is pushed with a constant speed of 0.25 m/s. Find the horizontal range of water stream on the ground. (Take g = 10 m/s^2). **[JEE-2004 (Mains), 2/60]**



5. 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 v^2 is : (where v is the velocity of water coming out of the hole) (g = 10 m/s^2) **[IIT-JEE 2005 (Screening), 2/60]**

(A) 50
(B) 51
(C) 48
(D) 51.5

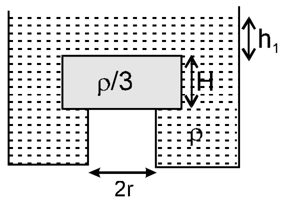
6. A U tube is rotated about one of it's limbs with an angular velocity ω. Find difference in height h of the liquid (density ρ) levels, where diameter of the tube d << L. **[IIT-JEE 2005 (Mains), 2/60]**



Comprehension

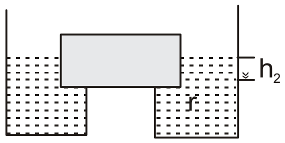
A wooden cylinder of diameter 4r, height H and density $\rho/3$ is kept on a hole of diamete 2r of a tank, filled with liquid of density ρ as shown in the figure.

7. 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 : **[IIT-JEE 2006, 5/184]**



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

8. 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 **[IIT-JEE 2006 , 5/184]**

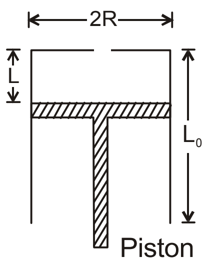


(A) $\frac{4H}{9}$ (B) $\frac{5H}{9}$ (C) Remains same (D) $\frac{2H}{3}$

9. If height h_2 of water level is further decreased, then **[IIT-JEE 2006 , 5/184]**
(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

Comprehension **[IIT-JEE 2007, 4×3/184]**

A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0.



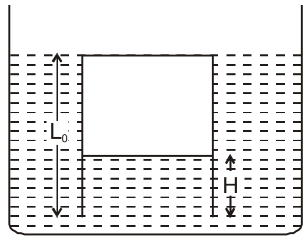
10. The piston is now pulled out slowly and held at a distance 2L from the top. The pressure in the cylinder between its top and the piston will then be

(A) P_0 (B) $\frac{P_0}{2}$ (C) $\frac{P_0}{2}+\frac{Mg}{\pi R^2}$ (D) $\frac{P_0}{2}-\frac{Mg}{\pi R^2}$

11. While the piston is at a distance 2L from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is

(A) $\left(\frac{2P_0\pi R^2}{\pi R^2 P_0 + Mg}\right)(2L)$ (B) $\left(\frac{P_0\pi R^2 - Mg}{\pi R^2 P_0}\right)(2L)$ (C) $\left(\frac{P_0\pi R^2 + Mg}{\pi R^2 P_0}\right)(2L)$ (D) $\left(\frac{P_0\pi R^2}{\pi R^2 P_0 - Mg}\right)(2L)$

12. The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ. In equilibrium, the height H of the water column in the cylinder satisfies



(A) $\rho g (L_0 - H)^2 + P_0 (L_0 - H) + L_0P_0 = 0$ (B) $\rho g (L_0 - H)^2 - P_0 (L_0 - H) - L_0P_0 = 0$

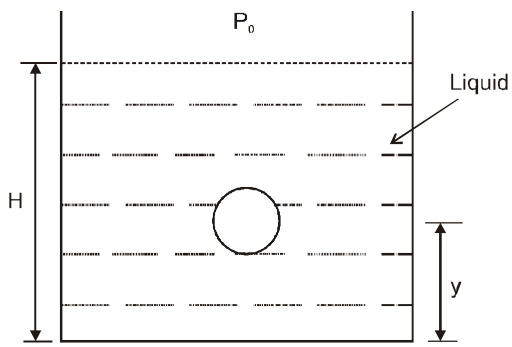
(C) $\rho g (L_0 - H)^2 + P_0 (L_0 - H) - L_0P_0 = 0$ (D) $\rho g (L_0 - H)^2 - P_0 (L_0 - H) + L_0P_0 = 0$

13. **STATEMENT -1** **[IIT-JEE 2008, 3/162]**
The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down.
and
STATEMENT -2
In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.
(A) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 is a correct explanation for STATEMENT -1
(B) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 is NOT a correct explanation for STATEMENT -1
(C) STATEMENT -1 is True, STATEMENT -2 is False
(D) STATEMENT -1 is False, STATEMENT -2 is True.

Comprehension

A small spherical monoatomic ideal gas bubble $\left(\gamma = \frac{5}{3}\right)$ is trapped inside a liquid of density ρ_ℓ (see figure).

Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure is P_0 (Neglect surface tension). **[IIT-JEE 2008, 12/162]**
Figure :



14. As the bubble moves upwards, besides the buoyancy force the following forces are acting on it.
(A) Only the force of gravity
(B) The force due to gravity and the force due to the pressure of the liquid
(C) The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid
(D) The force due to gravity and the force due to viscosity of the liquid

15. When the gas bubble is at a height y from the bottom, its temperature is

(A) $T_0\left(\dfrac{P_0+\rho_\ell gH}{P_0+\rho_\ell gy}\right)^{2/5}$ (B) $T_0\left(\dfrac{P_0+\rho_\ell g(H-y)}{P_0+\rho_\ell gH}\right)^{2/5}$

(C) $T_0\left(\dfrac{P_0+\rho_\ell gH}{P_0+\rho_\ell gy}\right)^{3/5}$ (D) $T_0\left(\dfrac{P_0+\rho_\ell g(H-y)}{P_0+\rho_\ell gH}\right)^{3/5}$

16. The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant)

(A) $\rho_\ell nRgT_0\dfrac{(P_0+\rho_\ell gH)^{2/5}}{(P_0+\rho_\ell gy)^{7/5}}$ (B) $\dfrac{\rho_\ell nRgT_0}{(P_0+\rho_\ell gH)^{2/5}[P_0+\rho_\ell g(H-y)]^{3/5}}$

(C) $\rho_\ell nRgT_0\dfrac{(P_0+\rho_\ell gH)^{3/5}}{(P_0+\rho_\ell gy)^{8/5}}$ (D) $\dfrac{\rho_\ell nRgT_0}{(P_0+\rho_\ell gH)^{3/5}[P_0+\rho_\ell g(H-y)]^{2/5}}$

17. **Column II** shows five systems in which two objects are labelled as X and Y. Also in each case a point P is shown. **Column I** gives some statements about X and/or Y. Match these statements to the appropriate system(s) from **Column II.** **[IIT-JEE 2009, 8/160]**

Column I

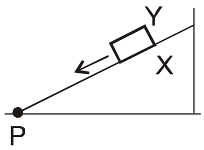
(A) The force exerted by X on Y has a magnitude Mg.

(B) The gravitational potential energy of X is continuously increasing,

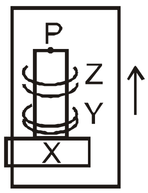
(C) Mechanical energy of the system X + Y is continuously decreasing.

(D) The torque of the weight of Y about point P is zero.

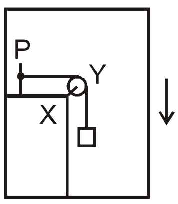
Column II

(p) 

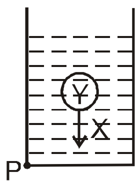
Block Y of mass M left on a fixed inclined plane X, slides on it with a constant velocity.

(q) 

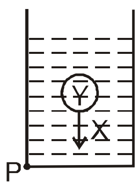
Two ring magnets Y and Z, each of mass M, are kept in frictionless vertical plastic stand so that they repel each other. Y rests on the base X and Z hangs in air in equilibrium. P is the topmost point of the stand on the common axis of the two rings. The whole system is in a lift that is going up with a constant velocity.

(r) 

A pulley Y of mass m_0 is fixed to a table through a clamp X. A block of mass M hangs from a string that goes over the pulley and is fixed at point P of the table. The whole system is kept in a lift that is going down with a constant velocity.

(s) 

A sphere Y of mass M is put in a nonviscous liquid X kept in a container at rest. The sphere is released and it moves down in the liquid.

(t) 

A sphere Y of mass M is falling with its terminal velocity in a viscous liquid X kept in a container.

18._ A cylindrical vessel of height 500 mm has an orifice (small hole) at its bottom. The orifice is initially closed and water is filled in it up to height H. Now the top is completely sealed with a cap and the orifice at the bottom is opened. Some water comes out from the orifice and the water level in the vessel becomes steady with height of water column being 200 mm. Find the fall in height (**in mm**) of water level due to opening of the orifice.

[Take atmospheric pressure = 1.0×10^5 N/m^2 , density of water = 1000 kg/m^3 and g = 10 m/s^2. Neglect any effect of surface tension] **[IIT-JEE 2009, 4/160, –1]**

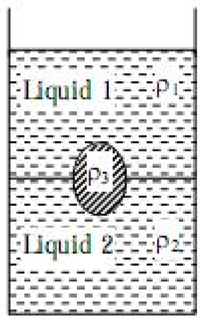
PART-II AIEEE (PREVIOUS YEARS PROBLEMS)

* ***Marked Questions are having more than one correct option.***

1. A cylinder of height 20m is completely filled with water. The velocity of efflux of water (in ms^{-1}) through a small hole on the side wall of the cylinder near its bottom, is : **[AIEEE 2002, 4/300]**

(1) 10 (2) 20 (3) 25.5 (4) 5

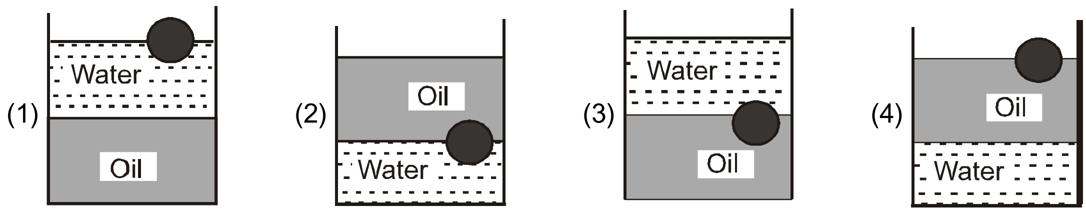
2. A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 and ρ_2, respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure. **[AIEEE 2008, 4/300]**



Which of the following is true for ρ_1, ρ_2 and ρ_3 ?

(1) $\rho_1 > \rho_3 > \rho_2$ (2) $\rho_1 < \rho_2 < \rho_3$ (3) $\rho_1 < \rho_3 < \rho_2$ (4) $\rho_3 < \rho_1 < \rho_2$

3. A ball is made of a material of density ρ where $\rho_{oil} < \rho < \rho_{water}$ with ρ_{oil} and ρ_{water} representing the densities of oil and water, respectively. The oil and water are immiscible. If the above ball is in equilibrium in a mixture of this oil and water, which of the following pictures represents its equilibrium position? **[AIEEE 2010, 4/144]]**



EXERCISE # 4

NCERT QUESTIONS

1. Fill in the blanks using the word(s) form the list appended with each statement ;
(a) Surface tension of liquid generally.................. With temperature (increases/ decreases)
(b) Viscosity of gases............... with temperature, whereas viscosity of liquids................. with temperature (increases / decreases)
(c) For solid with elastic modulus of rigidity, the shearing force is proportional to............ while for fluids it is proportional to ....(shear strain / rate of shear strain)
(d) For a fluid in steady flow, the increase in flow speed at a constriction follows from............ while the decrease of pressure there follows from............(conservation of mass / Bernoulli's principle)
(e) For the model of a plane in a wind tunnel, turbulence occurs at a.......... speed than the critical speed for turbulence for an actual plane (greater / smaller)

2. A 50 kg girl wearing high heel shoes balances on a single heel. The is circular with a diameter 1.0 cm. What is the pressure exerted by the heel on the horizontal floor ?

3. Toricelli's barometer used mercury. Pascal duplicated it using French wine of density 984 kg m^{-3}. Determine the height of the wine column for normal atmospheric pressure.

4. A vertical off-shore structure is built to withstand a maximum stress of 10^9 Pa. Is the structure suitable for putting up on top of an oil well in the ocean ? Take the depth of the ocean to be roughly 3 km, and ignore ocean currents.

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

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

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

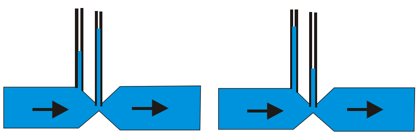
8. Can Bernoulli's equation be used to describe the flow of water through a rapid in a river ? Explain.

9. Does it mater if one uses gauge instead of absolute pressures in applying Bernoulli's equation? Explain.

10. Glycerine flows steadily through a horizontal tube of length 1.5 m and radius 1.0 cm. If the amount of glycerine collected per second at one end is 4.0×10^{-3} kg s^{-1}, what is the pressure difference between the two ends of the tube ? (Density of glycerine = 1.3×10^3 kg m^{-3} and viscosity of glycerine = 0.83 Pa s.) [You may also like to check if the assumption of laminar flow in the tube is correct].

11. In a test experiment on a model aeroplane in a wind tunnel, the flow speed on the upper and lower surfaces of the wing are 70 m s^{-1} and 63 m s^{-1} respectively. What is the lift on the wing if its area is 2.5 m^2 ? Take the density of air to be 1.3 kg m^{-3}.

12. Figures (a) and (b) refer to the steady flow of a (non-viscous) liquid. Which of the two figures is incorrect ? Why ?

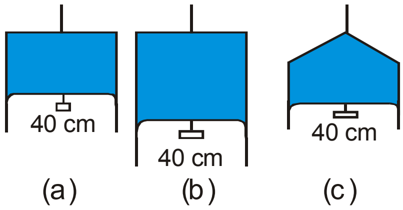


(a) (b)

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

14. A U-shaped wire is dipped in a soap solution, and removed. The thin soap film formed between the wire and the light slider supports a weight of 1.5 x 10^{-2} N (Which includes the small weight of the slider). The length of the slider is 30 cm. What is the surface tension of the film ?

15. Figure (a) shows a thin liquid film supporting a small weight = 4.5 x 10^{-2} N. What is the weight supported by a film of the same liquid at the same temperature in fig. (b) and (c) ? Explain your answer physically.

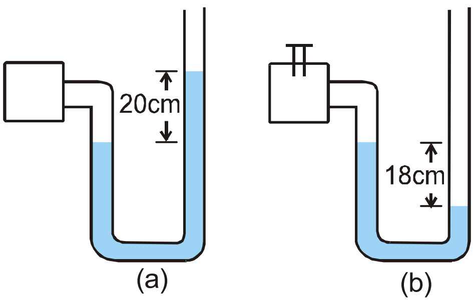


16. What is the pressure inside the drop of mercury of radius 3.00 mm at room temperature ? Surface tension of soap solution at the temperature (20 °C) is 4.65 x10^{-1} N m^{-1}. The atmospheric pressure is 1.01 x 10^5 Pa. Also give the excess pressure inside the drop.

17. What is the excess pressure inside a bubble of soap solution of radius 5.00 mm, given that the surface tension of soap solution at the temperature (20 °C) is 2.50 x 10^{-2} N m^{-1} ? If an air bubble of the same dimension were formed at depth of 40.0 cm inside a container containing the soap solution (of relative density 1.20), what would be the pressure inside the bubble ? (1 atmospheric pressure is 1.01 x 10^5 Pa).

18. A tank with a square base of area 1.0 m^2 is divided by a vertical, partition in the middle. The bottom of the partition has a small-hinged door of area 20 cm^2. The tank is filled with water in one compartment, and an acid (of relative density 1.7) in the other, both to a height of 4.0 m. compute the force necessary to keep the door close.

19. A manometer reads the pressure of a gas in an enclosure as shown in Fig. (a). When a pump removes some of the gas, the manometer reads as in Fig. (b). The liquid used in the manometers is mercury and the atmospheric pressure is 76 cm of mercury.
(a) Give the absolute and gauge pressure of the gas in the enclosure for cases (a) and (b), in units of cm of mercury.
(b) How should the levels change incase (b) if 13.6 cm of water (immiscible with mercury) are poured into the right limb of the manometer ? (Ignore the small change in the volume of the gas).



20. Two vessels have the same base area but different shapes. The first vessel takes twice the volume of water that the second vessel requires to fill upto a particular common height. Is the force exerted by the water on the base of the vessel the same in the two cases ? If so, why do the vessels filled with water to that same height give different readings on a weighing scale ?

21. During blood transfusion the needle is inserted in a vein where the gauge pressure is 2000 Pa. At what height must the blood container be placed so that blood may just enter the vein ? [Use density of whole blood from Table 10.1].

22. In deriving Bernoulli's equation, we equated the work done on the fluid in the tube to its change inthe potential and kinetic energy. (a) How does the pressure change as the fluid moves along the tube if dissipative forces are present ? (b) Do the dissipative forces become more important as the fluid velocity increases ? Discuss qualitatively.

23. (a) What is the largest average velocity of blood flow in an artery of radius 2×10^{-3} m if the flow must remain laminar ? (b) What is the corresponding flow rate ? (Take viscosity of blood to be 2.084 x 10-3 Pa s).

24. A plane is in level flight at constant speed and each of its two wings has an area of 25 m^2. If the speed of the air is 180 km/h over the lower wing and 234 km/h over the upper wing surface, determine the plane's mass. (Take air density to be 1 km m^{-3}).

25. In Millikan's oil drop experiment, what is the terminal speed of an uncharged drop of radius 2.0×10^{-5} m and density 1.2×10^{-3} kg m^{-3}. Take the viscosity of air at the temperature of the experiment to be 1.8×10^{-5} Pa s. How much is the viscous force on the drop at that speed ? Neglect buoyancy of the drop to air.

26. Mercury has an angle of contact equal to 140° with soda lime glass. A narrow tube of radius 1.00 mm made of this glass is dipped in a trough containing mercury. By what amount does the mercury dip down in the tube relative to the liquid surface outside ? Surface tension of mercury at the temperature of the experiment is 0.465 N m^{-1}. Density of mercury = 13-6 x 10^3 kg m^{-3}.

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

28. (a) It is know that density ρ of air decreases with height y (in meters) as

$$\rho = \rho_0 e^{-y/y_o}$$

where ρ_0 =1.25 kg m^{-3} is the density at sea level, and y_o is a constant. This density variations called the law of atmospheres. Obtain this law assuming that the temperature of atmosphere remains a constant (isothermal conditions). Also assume that the value of g remains constant.

(b) A large he balloon of volume 1425 m^3 is used to lift a payload of 400 kg. Assume that the balloon maintains constat radius as it rises. How high does it rise ?

[Take y_o =*8000* m and ρ_{He} = 0/18 kg m^{-3}].

ANSWERS

Exercise # 1

PART-I

A-1.	(C)	**A-2.**	(A)	**A-3.**	(A)	**A-4.**	(B)	**A-5.**	**(i)** (A)	**(ii)** (C)		**A-6*.**	(AC)
A-7*.	(ACD)	**B-1.**	(D)	**B-2.**	(A)	**B-3.**	(C)	**B-4.**	(A)	**B-5.**	(C)	**B-6.**	(C)
B-7.	(A)	**B-8.**	(C)	**C-1.**	(C)	**C-2.**	(C)	**C-3.**	(C)	**C-4.**	(A)	**C-5.***	(AB)
C-6.	(B)	**C-7.**	(A)										

PART-II

1.	(A)	**2.**	(D)	**3.**	(B)	**4.**	(A)	**5.**	(B)	**6.**	(B)	**7.**	(B)
8.	(A)	**9.**	(C)	**10.**	(D)	**11.**	(A) - p ; (B) - q ; (C) - t ; (D) - s						
12.	(A) – q ; (B) - p ; (C) - r ; (D) - s					**13.**	(A)	**14.**	(A)	**15.**	(A)	**16.**	(B)

17. **(i)** True **(ii)** False **(iii)** False **(iv)** False

18. **(i)** $\frac{Mg}{3AK}$ **(ii)** $\frac{x'}{x} = 1 + (\gamma_2 - \gamma_1)\,\Delta T$ **(iii)** 500 Pa

Exercise # 2

PART-I

1.	(C)	**2.**	(A)	**3.**	(D)	**4.**	(A)	**5.**	(B)	**6.**	(B)	**7.**	(A)
8.	(B)	**9.**	(B)	**10.**	(D)	**11.**	(B)	**12.**	(B)	**13.**	(A)	**14.**	(B)
15.	(B)	**16.**	(A)	**17.**	(A)	**18.**	(A)	**19*.**	(CD)	**20.**	(BC)		

PART-II

1. 10 second. **2.** $x = \frac{\ell}{3}$

3. Sharp kinife applies more pressure as compare to blunt knife because of lesser area of contact.

4. It is having high specific gravity. **5.** 500 kg/m^3 , 0.5

6. If g = 10m/s^2 , 253200 N/m^2

7. Initially $\left[\frac{0+\rho ga}{2}\right](a)^2 + \left[\frac{\rho ga + 3\rho ga}{2}\right](a^2) = 2.5\ \rho ga^3$

Finally $\left[\frac{0+\rho ga}{2}\right](2a^2) = 2\rho ga^3$

Difference = 0.5 ρga^3 [Which is one fifth of initial]

8. $\theta = 30^\circ$, depth of water ≥ 2 m

9. 100 sec.

10. (a) $\frac{t_1 d_L}{d_L - d}$ (b) No (c) $v = g\frac{t_1}{2}$ = constant

11. $\frac{gA\rho}{4}(h_1 - h_2)^2$

12. $m \geq \pi r^2 L\ (\sqrt{\rho\sigma} - \rho)$

13. 3.2 m

14. 2.78 x 10^5 Nm^{-2}

15. (a) (i) Density = $\frac{5}{4}d$ (ii) Pressure = $P_0 + \frac{1}{4}(6H + L)dg$

(b) (i) $v = \sqrt{\frac{g}{2}(3H - 4h)}$ (ii) $x = \sqrt{h(3H - 4h)}$ (iii) $x_{max} = \frac{3}{4}H$, $h_{max} = \frac{3H}{8}$

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

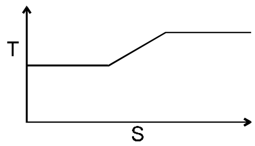
17. 2.94 × 10^4 J/m^3, 29025 J/m^3

18. $\frac{0.2}{\sqrt{\pi}} = 0.113$ m

19. 10 cm

20. 19.6 m, 4 sec

21.



22. 6.43 x 10^{-4} m^3/s

23. v = 4.1 m/s ; v′ = 21 m/s ; Av = 8.1 x 10^{-3} m^3 /sec

24. (i) 25 cm/s, (ii) 50 cm/s (iii) 93.75 N/m^2

25. (i) 25 cm/s, (ii) 50 cm/s (iii) zero

26. (i) 25 cm/s, (ii) 50 cm/s (iii) 187.5 N/m^2

Exercise # 3

PART-I

1. (D) **2.** (D) **3.** (i) zero ; (ii) 0.25 cm ; (iii) g/6 (upwards). **4.** 2m

5. (A) **6.** $H = \frac{\omega^2 L^2}{2g}$ **7.** (C) **8.** (A) **9.** (A) **10.** (A)

11. (D) **12.** (C) **13.** (A) **14.** (D) **15.** (B) **16.** (B)

17. (A) → (p), (t); (B) → (q), (s), (t); (C) → (p), (r), (t); (D) → (q) **18.** 6

PART-II

1. (2) **2.** (3) **3.** (2)

Exercise # 4

1. (a) decreases (b) η of gases increases, η of liquid decreases with temperature (c) shear strain, rate of shear strain (d) conservation of mass, Bernoulli's equation (e) greater.

2. 6.2×10^6 Pa. **3.** 10.5 m

4. Pressure at that depth in the sea is about 3×10^7 Pa. The structure is suitable since it can withstand far greater pressure or strain .

5. 6.92×10^5 Pa **6.** 0.800

7. Mercury will rise in the arm containing spirit ; the difference in levels of mercury will be 0.221 cm.

8. No, Bernoulli's principle applies to streamline flow only.

9. No, unless the atmospheric pressures at the two points where Bernoulli's equations applied are significantly different.

10. 9.8×10^2 Pa **11.** $1.5 \text{ X } 10^3$ N

12. Fig (a) is incorrect [Reason: at a constriction (i.e. where the area of cross-section of the tube is smaller), flow speed is larger due to mass conservation. Consequently pressure there is smaller according to Bernoulli's equation. We assume the fluid to be incompressible].

13. 0.64 m s^{-1} **14.** 2.5×10^{-2} N m^{-1}

15. 4.5×10^{-2} N for (b) and (c), the same as in (a).

16. Excess pressure = 310 Pa, total pressure = 1.0131×10^{-5} Pa. However, since data are correct to three significant figures, we should write total pressure inside the drop as 1.01×10^5 Pa.

17. Excess pressure inside the soap bubble -= 20.0 Pa; excess pressure inside the air bubble in soap solution = 10.0 Pa. Outside pressure for air bubble = $1.01 \times 10^5 + 0.4 \times 10^3 \times 9.8 \times 1.2 = 1.06 \times 10^5$ Pa. The excess pressure is so small that up to three significant figures, total pressure inside the air bubble is 1.06×10^5 Pa.

18. 55 N (Note, the base area does not affect the answer)

19. (a) absolute pressure = 96 cm of Hg; gauge pressure = 20 of Hg for (a), absolute pressure = 58 cm of Hg, gauge pressure = –18cm of Hg for (b); (b) mercury would rise in the left limb such that the difference in its levels in the two limbs becomes 19 cm.

20. Pressure (and therefore force) on the two equal base areas are identical. But force is exerted by water on the sides of the vessels also, which has a nonzero vertical component when the sides of the vessel are not perfectly normal to the base. This net vertical component of force by water on sides of the vessel is greater for the first vessel than the second. Hence the vessels weigh different even when the force on the base is the same in the two cases.

21. 0.2 m

22. (a) The pressure drop is greater (b) More important with increasing flow velocity.

23. (a) 0.98 m s^{-1}; (b) 1.24×10^{-5} m^3 s^{-1}

24. 4393 kg **25.** 5.8 cm s^{-1}, 3.9×10^{-10} N **26.** 5.34 mm

27. For the first bore, pressure difference (between the concave and convex side) = $2 \times 7.3 \times 10^{-2} / 3 \times 10^{-3} = 48.7$ Pa. Similarly for the second bore, pressure difference = 97.3 Pa. Consequently, the level difference in the two bores is $[48.7 / (10^3 \times 9.8)]$ m = 5.0 mm. The level in the narrower bore is higher. (Note, for zero angle of contact, the radius of the meniscus equals radius of the bore. The concave side of the surface in each bore os at 1 atm).

28. 8 km. If we consider the variation of *g* with altitude the height is somewhat more, about 8.2 km.