PHYSICS

The following question given below consist of an "Assertion" (A) and "Reason" (R) Type questions. Use the following Key to choose the appropriate answer.

(A) If both (A) and (R) are true, and (R) is the correct explanation of (A).

(B) If both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) If (A) is true but (R) is false.

(D) If (A) is false but (R) is true.

Q.1 **Assertion :** A block of wood floats in a bucket of water in a lift. The block sink more if the lift starts accelerating in upward direction.

Reason : In the frame of reference of lift, a downward pseudo force acts on the block of wood.

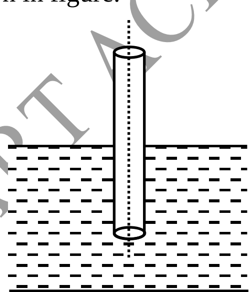
[D]

Q.2 **Assertion :** Two identical spheres one solid and the other hollow are immersed completely in water. The solid sphere will experience greater upthrust.

Reason : The upthrust is directly proportional to the mass of the sphere.

[D]

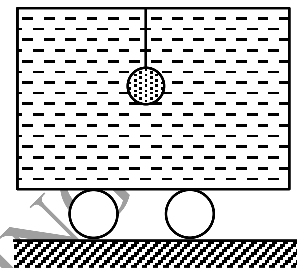
Q. 3 A homogeneous cylinder is floating in a liquid as shown in figure.



Assertion : The cylinder can perform both translational and rotational simple harmonic oscillations, for small displacement.

Reason : Translational equilibrium of cylinder is stable and rotational equilibrium of cylinder is unstable. **[D]**

Q.4 **Assertion :** A bob made of material of density ρ_S is suspended from the ceiling of a cart by means of a massless rigid rod. The cart contains a liquid of density ρ_L. The card suddenly starts accelerating towards right. The bob will move towards right, if $\rho_S > \rho_L$

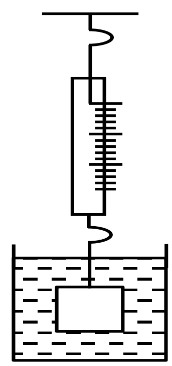


Reason : The torque of buoyant force about the point of suspension will be less than the torque of gravitational force about the point of suspension.

[D]

Q.5 A block is immersed in a liquid and the spring balance reading is recorded.

Assertion : As the temperature of block and liquid system is increased reading of spring balance decreases.



Reason : Increasing temperature cause buoyancy force to decrease.

[D]

Q.6 **Assertion :** In the flow-tube as the cross-section area decreases the flow velocity increases.

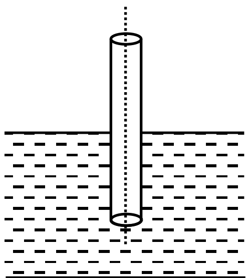
Reason : In ideal fluid flow the total energy per unit mass remains constant. **[B]**

Q.7 **Assertion :** In the flow-tube as the cross-section area decreases the flow velocity increases.

Reason : In ideal fluid flow the total energy per unit mass remains constant.

Sol. **[B]**

Q. 8 A homogeneous cylinder is floating in a liquid as shown in figure.



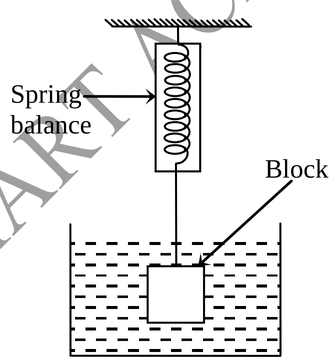
Assertion : The cylinder can perform both translational and rotational simple harmonic oscillations, for small displacement.

Reason : Translational equilibrium of cylinder is stable and rotational equilibrium of cylinder is unstable. **[D]**

Q.9 **Assertion :** In the flow-tube as the cross-section area decreases velocity increases.

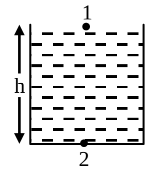
Reason : In ideal fluid flow the total energy per unit mass remains constant. **[B]**

Q.10 **Assertion :** In the given figure as the temperature of block and liquid system increased, reading of spring balance decreases.



Reason : Increasing temperature cause buoyancy force to decrease. **[D]**

Q.11 **Assertion :** A liquid of density 'ρ' is kept in container having a hole as shown in figure, then $P_2 - P_1 = h\rho g$.



Reason : Formula for pressure difference due to liquid column ($P_2 - P_1 = h\rho g$) is valid in fluid statics only. **[D]**

Q.12 **Assertion :** 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.

Reason : In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant. **[A]**

Q.13 **Statement - I :** A ball allowed to spin in a region of uniform wind motion will get an uplift.

Statement - II : Due to spin of the ball in a region of uniform wind motion, the difference in velocity of air flow is present between the lower and upper position of ball leading to varying pressure.

Sol. **[A]**

Q. 14 **Assertion (A) :** In case of motion of an ideal fluid in a horizontal tube, where the area of cross-section is minimum, pressure is maximum.

Reason (R) : Hydrostatic pressure in different ideal liquids at points of different depth can be same.

Sol. **[D]**

Q.15 **Statement I :** When a sphere falls under gravity or moves up due to buoyancy forces in a fluid, its velocity becomes constant after some time.

Statement II : The force of viscosity is proportional to velocity.

Sol. **[A]**

Q.16 **Assertion** : Cross-sectional area of the water pouring out of a tap decreases as the height from the ground decreases.

Reason : Work done by gravity reduces the cross-sectional area.

Sol. **[C]**

Q.17 **Assertion** : A man sitting in a boat which is floating on a pond. If the man drinks some water from the pond, the level of the water in the pond decreases.

Reason : According to Archimedes's principle the weight displaced by body is equal to the weight of the body.

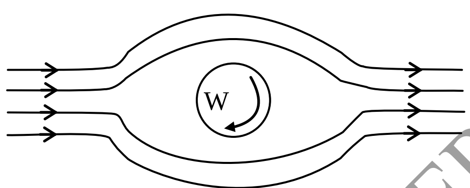
Sol. **[D]**

Q.18 **Assertion** : The velocity of flow of a liquid is smaller when pressure is larger and vice versa.

Reason : According to Bernoulli's theorem, for the stream line flow of an ideal liquid, the total energy per unit mass remains constant.

Sol. **[A]**

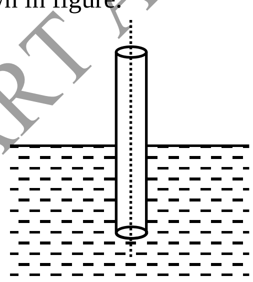
Q.19 **Assertion** : As wind flows left to right and ball is spinned as shown, there will be a lift of the ball.



Reason : Decreased velocity of air below the ball, increases the pressure more than that above the ball.

Sol. **[A]**

Q.20 A homogeneous cylinder is floating in a liquid as shown in figure.

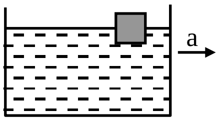
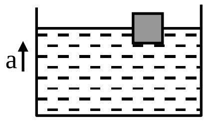
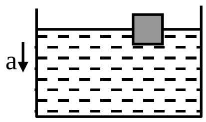
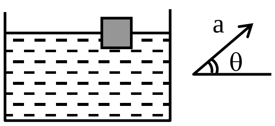


Assertion : The cylinder can perform both translational and rotational simple harmonic oscillations, for small displacement.

Reason : Translational equilibrium of cylinder is stable and rotational equilibrium of cylinder is unstable.

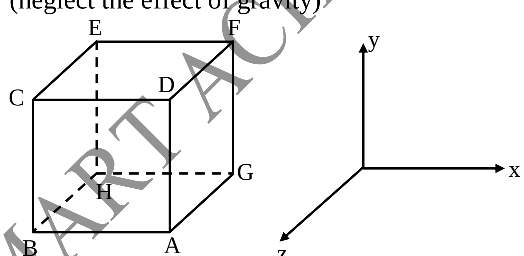
Sol.[D]

Q.1 A block of wood is floating on the surface of water inside a container at rest. Now the container is given some acceleration as shown in column I. Some observation are shown in column II. Match the columns.

Column-I	**Column-II**
(A) 	(P) Buoyant force on the block increases
(B) 	(Q) Buoyant force on the block decreases
(C) 	(R) Pressure at the bottom of the container is non uniform
(D) 	(S) Pressure at the bottom of the container is uniform

(A) → P,R (B) → P,S (C) → Q,S (D) → P,R

Q.2 The cubical container filled with water is given acceleration $\vec{a} = a_0\hat{i} + a_0\hat{j} + a_0\hat{k}$, then : (neglect the effect of gravity)



Column-I	**Column-II**
(A) Pressure at point A is	(P) less than pressure at point G
(B) Pressure at point D is	(Q) less than pressure at point F
(C) Pressure at point E is	(R) Greater than pressure at point C
(D) Pressure at point H is	(S) Greater than pressure at point B

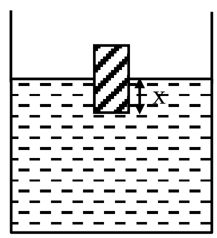
(A) → P,Q (B) → Q (C) → R,S (D) → S

Q.3

Column-I	**Column-II**
(A) Mercury Barometer	(P) Measures atmospheric pressure
(B) Pascal's law	(Q) Measures absolute pressure
(C) Pressure gauge	(R) Measures difference of absolute pressure and atmospheric pressure
(D) Manometer	(S) The change in pressure is transferred to the entire liquid without being diminished in magnitude

(A) → P (B) → S (C) → R (D) → Q

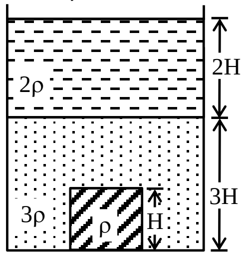
Q.4 A uniform solid cube is floating in a liquid as shown in the figure, with part x inside the liquid. Some changes in parameters are mentioned in Column I. Assuming no other changes, match the following -



Column I	**Column II**
(A) If density of the liquid decreases, x will	(P) Increase
(B) If height of the cube is increased keeping base area and density same, x will	(Q) Decreases
(C) If the whole system is accelerated upward, then x will	(R) Remain same
(D) If the cube is replaced by another cube of same size but lesser density, x will	(S) May increase or decrease

(A) → P (B) → P (C) → R (D) → Q

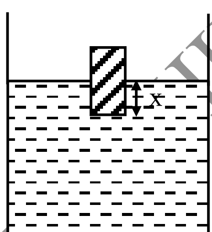
Q.5 A block of area A and density ρ is immersed in a liquid of density 3ρ. Another liquid of density 2ρ is filled above 3ρ. When the block is released then–



Column-I	**Column-II**
(A) Work done by buoyancy when block reaches the surface of lower liquid	(P) $\rho AgH^2/2$
(B) Work done by buoyancy when block moves from lower liquid into the upper liquid	(Q) ρAgH^2
(C) Work done by buoyancy when the block moves from lower surface of upper liquid to the upper surface of same liquid	(R) $6\ \rho AgH^2$
(D) Work done by buoyancy when block comes out from inside upper liquid to the air	(S) $4\ \rho AgH^2$

(A) → P,S ; (B) → R,S ; (C) → P,Q ; (D) → Q

Q.6 A uniform solid cube is floating in a liquid as shown in the figure, with part x inside the liquid. Some changes in parameters are mentioned in Column I. Assuming no other changes, match the following -



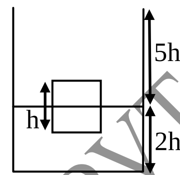
Column I	**Column II**
(A) If density of the liquid decreases, x will	(P) Increase
(B) If height of the cube is increased keeping base area and density same, x will	(Q) Decreases
(C) If the whole system is accelerated upward, then x will	(R) Remain same
(D) If the cube is replaced by another cube of same size but lesser density, x will	(S) May increase or decrease

Sol. **A → P, B → P, C → R, D → Q**

As cube is floating $\rho_s ALg = \rho_L Axg$

$$\therefore \quad x = \left(\frac{\rho_s}{\rho_L}\right)L$$

Q.7 A cubical block is floating in a liquid of density ρ_1 kept in a container. Assume the motion of block with respect to container while it is partially or completely immersed in liquid -



Column I	**Column II**
(A) A immiscible liquid of density $\rho < \rho_1$ is slowly filled so that level of liquid comes over block	(P) Move up first and then move down
(B) A readily miscible liquid of density $\rho < \rho_1$ is slowly filled into container	(Q) Move down
(C) The container is accelerated up	(R) Move up first and then stop
(D) The container is allowed to fall freely	(S) Doesn't move at all

A→ R ; B→ Q; C→ S; D→ S

Q.8

Column I	**Column II**
(A) Coefficient of viscosity	(P) $[M^2L^{-1}T^{-2}]$
(B) Surface tension	(Q) $[ML^0T^{-2}]$
(C) Modulus of elasticity	(R) $[ML^{-1}T^{-2}]$
(D) Energy per unit volume of a fluid	(S) None

Sol. **(A) → (S); (B) → (Q); (C) → (R); (D) → (R)**

Q.9 Match the following (Column-II either an assumption or a definition)

Column-I	**Column-II**
(A) Equation of continuity	(P) Non-viscous flow (ρAv = constant)

(B) Bernoulli's equation	(Q) Steady flow
(C) Velocity at a given point is constant with	(R) Incompressible liquid
(D) Ideal flow	(S) Irrotational flow

Sol. A → Q ; B → P,Q,R,S ;
C → Q; D → P,Q,R,S

Q.10 Some relations and laws related to fluids are given in column I, while the physical reasons behind them are given in column II.

Column I	Column II
(a) Stokes' law	(p) Surface potential energy
(b) Equation of continuity	(q) force of viscosity
(c) Bernoulli's theorem	(r) Conservation of mass
(d) Velocity of efflux	(s) Conservation of energy

(A) a → q, b → r, c → s, d → s
(B) a → r, b → s, c → p, d → s
(C) a → p, b → q, c → r, d → s
(D) a → p, b → s, c → r, d → s

Sol.[A]

Q.11

Column-I	Column-II
(a) Coefficient of viscosity	(p) $M^2L^{-1}T^{-2}$
(b) Surface tension	(q) ML^0T^{-2}
(c) Modulus of rigidity	(r) $ML^{-1}T^{-2}$
(d) Energy per unit volume of fluid	(s) None

(A) a→s; b→q; c→r; d→r
(B) a→r; b→q; c→r; d→s
(C) a→s; b→r; c→q; d→r
(D) a→r; b→r; c→q; d→s

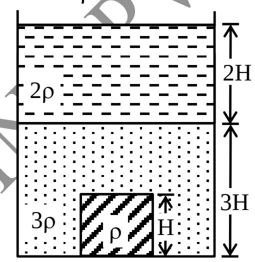
Sol. [A]

Q.12

COLUMN I	**COLUMN II**
(A) Equation of continuity	(P) $P_1 - P_2 = \rho g(h_2 - h_1)$
(B) Bernoulli's equation	(Q) $v = \sqrt{2gh}$
(C) Torricell's theorem	(R) $A_1v_1 = A_2v_2$
(D) Hydrostatics	(S) $P + \rho gh + \frac{1}{2}\rho v^2 = \text{constant}$

Sol. A → R ; B → S ; C → Q ; D → P

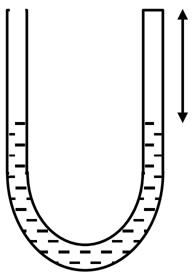
Q.13 A block of area A and density ρ is immersed in a liquid of density 3ρ. Another liquid of density 2ρ is filled above 3ρ. When the block is released then–



Column-I	**Column-II**
(A) Work done by buoyancy when block reaches the surface of lower liquid	(P) $(5/2)\ \rho AgH^2$
(B) Work done by buoyancy when block moves from lower liquid into the upper liquid	(Q) ρAgH^2
(C) Work done by buoyancy when the block moves from lower surface of upper liquid to the upper surface of same liquid	(R) $6\ \rho AgH^2$
(D) Work done by buoyancy when block comes out from inside upper liquid to the air	(S) $2\ \rho AgH^2$

Sol. **A → R; B → P; C → S; D → Q**

Q.1 A long u tube is filled with a liquid of density 'ρ' such that length of tube above liquid is 'a' in both arm. One side of tube (right arm) is sealed the tube is inverted ('P_0' atmospheric pressure)



(A) Liquid will spill out the left tube if $a < \frac{P_0}{4\rho g}$

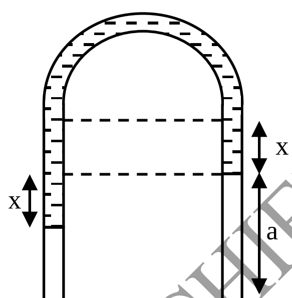
(B) Liquid will not spill out the left tube for any value of 'a'

(C) Liquid surface in left arm will not move if $a = \frac{P_0}{2\rho g}$

(D) Liquid surface in right arm will come down

[A,C]

Sol.



Let pressure of gas in right arm in inverted position be 'P'.

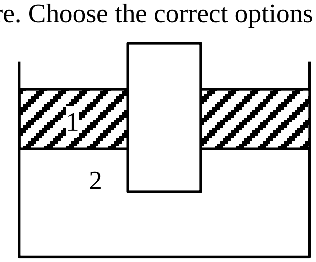
$\therefore\ P(a + x) = P_0.a$ …(i)

$P + 2x\rho g = P_0$ …(ii)

From (i) and (ii)

$x = \left\{\frac{P_0}{2\rho g} - a\right\}$

Q.2 A cylinder is floating in two liquids as shown in figure. Choose the correct options :



(A) net force on cylinder by liquid 1 is zero

(B) net force on cylinder by liquid 1 is non-zero

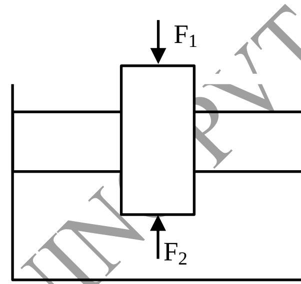
(C) net force on cylinder by liquid 2 is equal to the upthrust

(D) net force on cylinder by liquid 2 is more than the upthrust

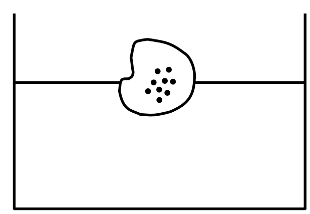
Sol. **(A, D)**

$F_2 - F_1 =$ upthrust

$\therefore\ F_2 >$ upthrust



Q.3 Some pieces of impurity (density = ρ) is embedded in ice. This ice is floating in water. (density = ρ_w). When ice melts, level of water will :



(A) fall if $\rho > \rho_w$

(B) remain unchanged, if $\rho < \rho_w$

(C) fall if $\rho < \rho_w$

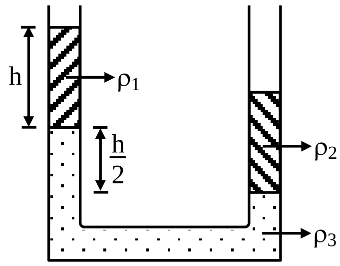
(D) rise if $\rho > \rho_w$

Sol. **(A, B)**

Level will fall if initially the impurity pieces were floating along will ice and later it sinks.

Level will remain unchanged if initially they were floating and later also they keep floating.

Q. 4 Three different liquids are filled in a U-tube as shown in figure. Their densities are ρ_1, ρ_2 and ρ_3 respectively. From the figure we may conclude that :



(A) $\rho_2 > \rho_1$ (B) $\rho_1 > \rho_2$

(C) $\rho_3 = 2(\rho_2 - \rho_1)$ (D) $\rho_3 = \frac{\rho_2 + \rho_1}{2}$

Sol. **(A, C)**

At the level of boundary between ρ_2 and ρ_3, pressures will be equal from both sides. Hence,

$$\rho_1 gh + \rho_3 g \frac{h}{2} = \rho_2 gh$$

$$\therefore \rho_3 = 2(\rho_2 - \rho_1)$$

From this expression itself it is clear that $\rho_2 > \rho_1$.

Q.5 Figure shows a section of tube of varying cross section area. Let A_1, v_1, ρ_1 respectively be cross-sectional area, velocity of fluid (an ideal gas) and density of liquid at 1 and corresponding value at '2' be A_2, v_2 & ρ_2 respectively. Assuming temperature at point 1 and 2 to be same –

(A) $A_1v_1 < A_2v_2$ (B) $A_1v_1 = A_2v_2$

(C) $A_1v_1\rho_1 = A_2v_2\rho_2$ (D) $v_1 = v_2$ **[A,C,D]**

Sol. Bernoulli's equation for compressible and non-viscous fluid

$$\frac{P}{\rho} + gh + \frac{v^2}{2} = \text{constant}$$

Temperature and height is same at 1 and 2

$\Rightarrow v_1 = v_2$

$\Rightarrow A_1v_1 < A_2v_2$

Also, mass conservation $\Rightarrow A_1v_1\rho_1 = A_2v_2\rho_2$

Q.6 In a streamline flow,

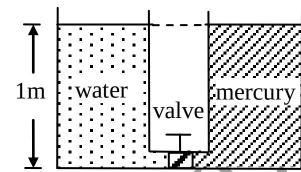
(A) the speed of a particle always remains same

(B) the velocity of a particle always remains same

(C) the kinetic energies of all the particles arriving at a given point are the same

(D) the momenta of all the particles arriving at a given point are the same **[C,D]**

Q.7 Density of water is ρ_w and density of mercury ρ_{Hg}. The valve is opened. Then which of the following is/are true-



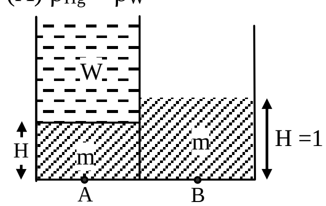
(A) Height of level of mercury in the left container is $\frac{\rho_{Hg} - \rho_W}{2\rho_{Hg}}$

(B) Pressure at the bottom of left container is $\frac{(\rho_{Hg} + \rho_W)g}{2}$

(C) Height of level of mercury in right container is $\frac{(\rho_{Hg} + \rho_W)}{2\rho_{Hg}}$

(D) Pressure at the bottom of right container is $\frac{(\rho_{Hg} - \rho_W)g}{2}$

Sol.[A,B,C] (A) $\rho_{Hg} > \rho_W$



$P_A = P_B$

$\Rightarrow \rho_w\, g\, h_w + \rho_{Hg}\, g\, H = \rho_{Hg}\, g(1 - H)$

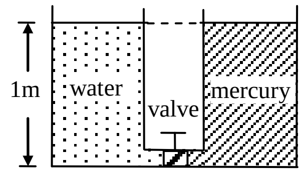
$\Rightarrow H = \frac{\rho_{Hg} - \rho_w}{2\rho_{Hg}}$

(B) $P_A = P_B = \rho_{Hg}g\,(1 - H)$

$$= \rho_{Hg}\, g\left[1 - \frac{\rho_{Hg} - \rho_w}{2\rho_{Hg}}\right] = g\,\frac{(\rho_{Hg} + \rho_w)}{2}$$

(C) $1 - H = 1 - \frac{\rho_{Hg} - \rho_w}{2\rho_{Hg}} = \frac{\rho_{Hg} + \rho_w}{2\rho_{Hg}}$

Q. 8 Density of water is ρ_w and density of mercury ρ_{Hg}. The valve is opened. Then which of the following is/are true-



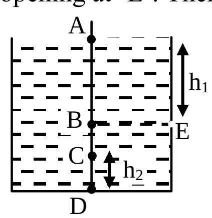
(A) Height of level of mercury in the left container is $\frac{\rho_{Hg} - \rho_W}{2\rho_{Hg}}$

(B) Pressure at the bottom of left container is $\frac{(\rho_{Hg} + \rho_W)g}{2}$

(C) Height of level of mercury in right container is $\frac{(\rho_{Hg} + \rho_W)}{2\rho_{Hg}}$

(D) Pressure at the bottom of right container is $\frac{(\rho_{Hg} - \rho_W)g}{2}$ **[A,B,C]**

Q. 9 An incompressible and non–viscous liquid of density 'ρ' is kept in a cylindrical container having a opening at 'E'. Then -



(A) $P_B - P_A = h_1\rho g$ (B) $P_D - P_C = h_2\rho g$
(C) $P_B > P_E$ (D) $P_A = P_E$

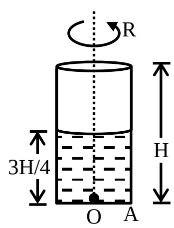
Sol.[B,C,D] Pressure due to liquid column is equal to hρg only if fluid is at rest

Hence (A) is not correct and (B) is correct.

At same horizontal level pressure decreases with velocity hence (C) is correct

$P_A = P_E$ = Atmospheric pressure

Q. 10 A liquid of density ρ filled in the vessel as shown is rotated with constant angular velocity 'ω' about the axis passing through the middle. The radius of cylinder is R. Then –



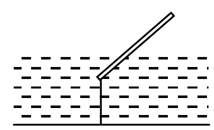
(A) The minimum value of 'ω' for which the liquid comes out is $\sqrt{\frac{gH}{R^2}}$

(B) The value of 'ω' for which the base of container is just exposed is $\sqrt{\frac{2gH}{R^2}}$

(C) Volume of liquid remaining in the container in case (B) is $\frac{\pi R^2 H}{2}$

(D) Gauge pressure at point A in the container in case (B) is ρgH **[A,B,C,D]**

Q. 11 A stick is tied to the floor of the water tank with a string as shown. The length of stick is 2 m and its area of cross-section is 10^{-3} m^2. If specific gravity of stick is 0.25 and g = 10 m/s^2 , then –



(A) tension in the string is 5 N
(B) buoyancy force acting on stick is 10 N
(C) length of stick immersed in water is 1 m
(D) tension in the string is zero **[A,B,C]**

Sol.

If A is area of cross-section then,

$\rho_W A\ell g = T + mg$ ....(1)

where ℓ is the length of stick immersed in water.

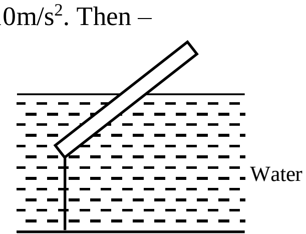
Now, taking torque

$$\rho_W \ell A g \times \frac{\ell}{2}\cos\theta = mg \times \frac{L}{2}\cos\theta$$

or $\rho_W \ell^2 = \rho_S L^2$ ....(2)

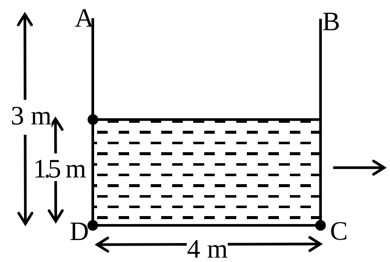
Solve equation (1) and equation (2)

Q. 12 A stick is tied to the floor of the water tank with a string as shown in the figure. The length of stick is 2m. Area of cross-section of stick is 10^{-3} m^2. Specific gravity of stick is 0.25. Take g = $10 m/s^2$. Then –



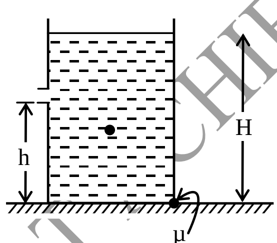
(A) Tension in the string is 5N
(B) Buoyancy force acting on stick is 10 N
(C) Length of stick immersed in water is 1m
(D) When string is cut initial acceleration of stick is $1 m/s^2$ **[A,B,C,D]**

Q. 13 A container having dimensions 5m × 4m × 3m is accelerated along its breadth in horizontal. Container is filled with water up to the height of 1.5 m. Container is accelerated with $7.5\ m/s^2$. Take
$g = 10 m/s^2$, density of water is $10^3\ kg/m^3$ -



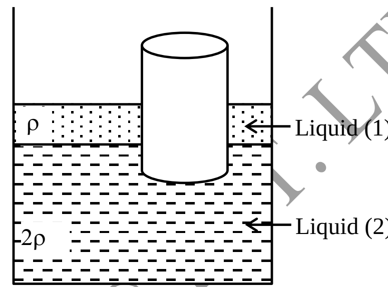
(A) Gauge pressure at point C is 10^4 Pascal
(B) Gauge pressure at point D is 3×10^4 Pascal
(C) Gauge pressure at the middle of the base is 1.5×10^4 Pascal
(D) Remaining volume of liquid inside the container is $20 m^3$ **[B,C]**

Q. 14 A vessel filled with liquid is resting on the rough horizontal surface. A hole is made in the vessel as shown. Then –



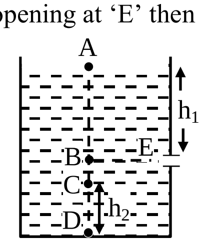
(A) The torque due to friction about the centre of gravity is of into the plane of the paper
(B) The torque due to normal reaction force between container and ground about center of gravity is out of the plane of paper
(C) Torque due to friction about center of gravity is zero
(D) Torque due to normal reaction force between container and ground about center of gravity is zero **[A,B]**

Q.15 A cylinder block of length L = 1m is in two immiscible liquids. Part of block inside liquid(1) is $\frac{1}{4}$ m and in liquid (2) is $\frac{1}{4}$ m. Area of cross-section of block is A. Densities of liquid (1) & (2) are ρ and 2ρ respectively –



(A) Density of block is 3ρ/4
(B) Force exerted by liquid (1) on block is ρAg/4
(C) Block is depressed so that it is just completely immersed in liquid (1) and released. A initial acceleration of block is 4/3 g
(D) In case (C) force exerted by liquid (2) on block is 3/2 ρAg **[A,C]**

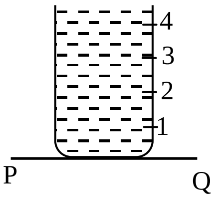
Q.16 A incompressible and non viscous liquid of density ρ is kept in a cylindrical container having a opening at 'E' then



(A) $P_B - P_A = h_1 \rho g$ (B) $P_D - P_C = h_2 \rho g$
(C) $P_B > P_E$ (D) $P_A = P_E$

Sol. **[B,C,D]**
Pressure due to liquid column is equal to hρg only if fluid is at rest. Hence 'A' is not correct and 'B' is correct.
At same horizontal line pressure decreases with velocity. Hence 'C' is correct
$P_A = P_E$ = Atmospheric pressure.

Q.17 A cylindrical vessel of 90cm height is kept filled upto the brim. It has four holes 1, 2 , 3, 4 which are respectively at heights of 20cm, 30cm, 40cm and 50cm from the horizontal floor P, Q. 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

Sol. **[A,B]**

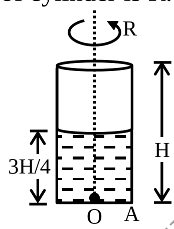
The maximum horizontal distance from the vessel comes from hole number 3 and 4

v = $\sqrt{2gh}$ $\rightarrow$ h is height of hole from top

horizontal distance x = vt = $\sqrt{2gh}\ \sqrt{\dfrac{2(H-h)}{g}}$

x = 2 $\sqrt{h(H-h)}$

Q. 18 A liquid of density ρ filled in the vessel as shown is rotated with constant angular velocity 'ω' about the axis passing through the middle. The radius of cylinder is R. Then –



(A) The minimum value of 'ω' for which the liquid comes out is $\sqrt{\dfrac{gH}{R^2}}$

(B) The value of 'ω' for which the base of container is just exposed is $\sqrt{\dfrac{2gH}{R^2}}$

(C) Volume of liquid remaining in the container in case (B) is $\dfrac{\pi R^2 H}{2}$

(D) Gauge pressure at point A in the container in case (B) is ρgH

Sol. [A,B,C,D]

(A) as $H_{max.} = H_0 + \dfrac{\omega^2 R^2}{4g}$

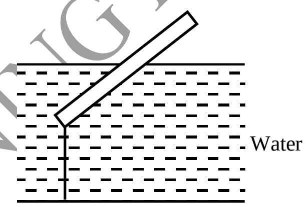
$\therefore \quad H_{max.} = H,\ H_0 = \dfrac{3H}{4}$

(B) as $H = H_{min.} + \dfrac{\omega^2 r^2}{2g}$

$\therefore\ H_{min.} = 0,\ H = H,\ r = R$

(C) volume remaining = $\left(\dfrac{0+H}{2}\right)\pi R^2$

Q. 19 A stick is tied to the floor of the water tank with a string as shown in the figure. The length of stick is 2m. Area of cross-section of stick is 10^{-3} m^2. Specific gravity of stick is 0.25. Take g = 10m/s^2. Then –



(A) Tension in the string is 5N

(B) Buoyancy force acting on stick is 10 N

(C) Length of stick immersed in water is 1m

(D) When string is cut initial acceleration of stick is 10m/s^2

Sol. **[A,B,C,D]**

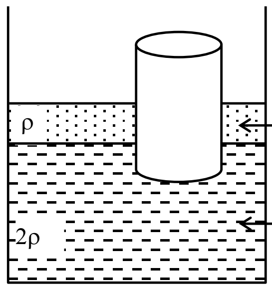
As $T + mg = F_B$ ...(1)

Taking torque $F_B \times \dfrac{x}{2}\cos\theta = mg\ \dfrac{\ell}{2}\cos\theta$

$\therefore\ F_B\, x = mg\ell$

Now, $F_B = (Ax)\rho_w g$ and $mg = (A\ell)\rho_s g$

Q.20 A cylinder block of length L = 1m is in two immiscible liquids. Part of block inside liquid(1) is $\dfrac{1}{4}$ m and in liquid (2) is $\dfrac{1}{4}$ m. Area of cross-section of block is A. Densities of liquid (1) & (2) are ρ and 2ρ respectively –



(A) Density of block is 3ρ/4

(B) Force exerted by liquid (1) on block is ρAg/4

(C) Block is depressed so that it is just completely immersed in liquid (1) and released. A initial acceleration of block is 4/3 g

(D) In case (C) force exerted by liquid (2) on block is 3/2 ρAg

Sol. **[A,C]**

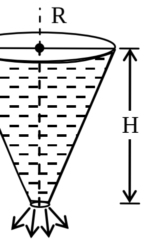
(A) $\rho_B LAg = \rho \times \frac{L}{4} Ag + 2\rho \times \frac{L}{4} Ag$

(B) $F_B = \rho \times \frac{L}{4} Ag + 2\rho \times \frac{3L}{4} Ag$

$F_B = \frac{7}{4} \rho LAg$

$a = \frac{F_B - mg}{m}$

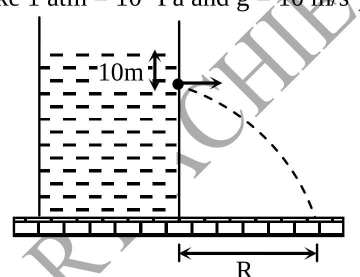
Q.1 A conical container of radius R = 1m and height H = 5m is filled completely with liquid. There is a hole at the bottom of container of area $\pi \times 10^{-3}$ m^2 (see figure). Time taken to empty the conical container (in sec) is ……………….. Take g = 10 m/s^2 –



[0200]

Q.2 A horizontal pipeline carries water in a streamline flow. At a point along the pipe, where the cross-sectional area is 10 cm^2, the water velocity is 1 m/s and the pressure is 4000 Pa. The pressure of water at another point where the cross-sectional area is 5 cm^2, is..... Pa. (Density of water = 10^3 kg. m^{-3}).
[2500]

Q.3 A large tank is filled with water (density = $10^3 kg/m^3$). A small hole is made at a depth 10 m below water surface. The range of water issuing out of the hole is R on ground. What extra pressure (in atm) must be applied on the water surface so that the range becomes 2R :
(take 1 atm = 10^5 Pa and g = 10 m/s^2)



Sol. **[3 atm]**
Range will become twice of velocity of efflux becomes twice. Now as,

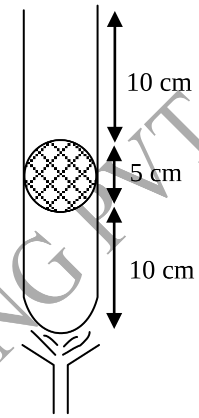
$v = \sqrt{2gh}$

Therefore, h should become 4 times or 40 m
Thus, an extra pressure equivalent to 30 m of water should be applied.
1 atm = 0.76 × 13.6 m of water

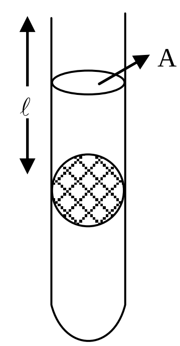
= 10.336 m of water

30 m of water $\approx$ 3.0 atm

Q.4 A mercury pallet is trapped in a tube as shown in figure. The tube is slowly heated to expel all mercury inside it (Isothermal condition). Heat given to the tube in 10^{-3} J is : (ρ_{Hg} = 13.6 gm/cc, Atmospheric pressure = 10^5 Pa, cross–section area of tube = 2 cm^2)



Sol.



$W_{gas} = -\{W_{gravity} + W_{external pressure}\}$
$= mg\ell + P_0\ell A$ [m = mass of Hg pallet]
= 2.136 J
$\therefore \Delta Q = \Delta W$
= 2.136 J

Q.5 A ball is immersed in water kept in container and released. At the same time container is accelerated in horizontal direction with acceleration, $\sqrt{44}\ m/s^2$. Acceleration of ball w.r.t. container (in m/s^2) is (specific gravity of ball = 12/17, g = 10m/s^2) -

Sol. **[5]**
$a = \left(\frac{1}{\rho} - 1\right) g_{eff}$

$= \left(\frac{17}{12} - 1\right).12 = 5 m/s^2$

Q.6 **Assertion :** When a soda-water bottle falls freely from a height 'h', the gas bubble rise in bottle from bottom.

Reason : Air is lighter than water.

Sol. **[D]**

A : False, R: True

Upthurst will be zero.

Q.7 A solid uniform ball of volume V floats on the interface of two immiscible liquids. The specific gravity of the upper liquid is ρ_U and of the lower one ρ_ℓ whilst the specific gravity of the ball is

$\rho_b = \rho_\ell$

The fraction of the volume of the ball will be in the lower liquid is n. What is value of n ?

Sol. **[0001]**

$(V_u + V_\ell)\rho_b = V_u \rho_u + V_\ell \rho_\ell$ ....(1)

$V = V_u + V_\ell$ ....(2)

from (1) and (2)

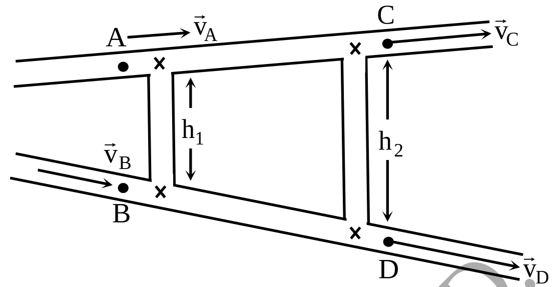
$V_1 = V \frac{\rho_\ell - \rho_b}{\rho_\ell - \rho_u}$

$V_2 = V\left(\frac{\rho_b - \rho_u}{\rho_\ell - \rho_u}\right)$

If $\rho_b = \rho_\ell$ then

$V_1 = 0, V_2 = V$

Q.8 An ideal fluid is flowing in two pipes of same cross-sectional pipes area. Both the pipes are connected with two vertical tubes, of length h_1 and h_2 as shown in figure. The flow is stream line in both pipes. If velocity of fluid at A, B, and C are 2 m/s, 4 m/s and 4m/s respectively, the velocity of fluid at D (in m/s) is -

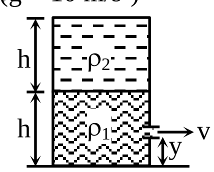


Sol. **[2]**

Equation of continuity $\Rightarrow v_A + v_B = v_C + v_D$

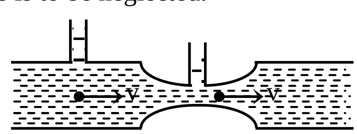
$\Rightarrow v_D = 2 m/s$

Q.9 A cylindrical tank having area of cross section $A = 0.5\ m^2$ is filled with two liquids of density ρ_1 900 kgm^{-3} and $\rho_2 = 600\ kg\ m^{-3}$, to a height h = 60 cm each as shown. A small hole is made in right vertical wall at a height y = 20 cm from the bottom then the velocity of efflux from hole in m/s is (g = 10 m/s^2)



Sol. **[4]**

Q.10 To measure the flow rate in a gas pipeline a narrowing is made in it and the pressure difference between the wide and the narrow parts of the pipe is measured. Find the gas flow rate, if its density is 1.4 kg/m^3, the diameter of the pipe is 50 mm, the diameter of the narrowing is 30 mm and the pressure difference is 18 cm of water. The compressibility of the gas is to be neglected.



Sol.[0001] $\Delta P = \frac{\rho V^2}{2}\left(\frac{D^4}{d^4} - 1\right) = \rho_0 g h$

where D and d are the diameters of the pipeline and of the narrowing.

Flow rate $= \rho S V = \frac{1}{4}\pi\rho V D^2$

Q.1 A uniform cylinder of length L and mass M having cross-sectional area A is suspended, with its length vertical, from a fixed point by a massless spring, such that it is half-submerged in a liquid of density ρ at equilibrium position. When the cylinder is given a small downward push and released it starts oscillating vertically with a small amplitude. If the force constant of the spring is k, the frequency of oscillation of the cylinder is -

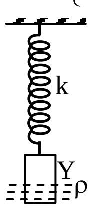
(A) $\frac{1}{2\pi}\left(\frac{k-A\rho g}{M}\right)^{1/2}$ (B) $\frac{1}{2\pi}\left(\frac{k+A\rho g}{M}\right)^{1/2}$

(C) $\frac{1}{2\pi}\left(\frac{k+\rho g L^2}{M}\right)^{1/2}$ (D) $\frac{1}{2\pi}\left(\frac{k+A\rho g}{A\rho g}\right)^{1/2}$

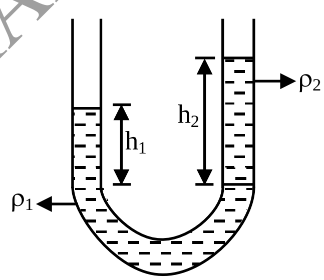
[B]

Sol. $F = -\{kY + AY\rho g\} \Rightarrow Ma = -\{k + A\rho g\}\, Y$

$a = -\left\{\frac{k+A\rho g}{M}\right\}Y \;\Rightarrow f = \frac{1}{2\pi}\sqrt{(K+A\rho g)/M}$



Q.2 Two liquids which do not react chemically are placed in a bent tube a shown in figure. The heights of the liquids above their surface of separation are –



(A) directly proportional to their densities

(B) inversely proportional to their densities

(C) directly proportional to square of their densities

(D) equal **[B]**

Sol. The pressure at the interface must be same, calculated via either tube. Since, both tube are open to the atmosphere, we must have

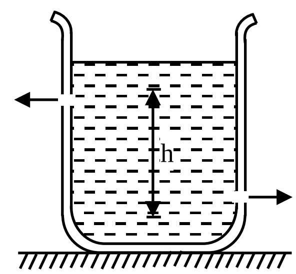
$h_1\rho_1 g = h_2\rho_2 g$

or $h_1\rho_1 = h_2\rho_2$

or $h\rho$ = constant

or $h \propto \frac{1}{\rho}$

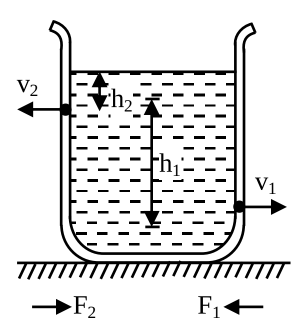
Q.3 There are two identical small holes of area of cross-section a on the opposite sides of a tank containing a liquid of density ρ. The difference in height between the holes is h. Tank is resting on a smooth horizontal surface. Horizontal force which will have to be applied on the tank to keep it in equilibrium is –



(A) ghρa (B) $\frac{2gh}{\rho a}$

(C) 2ρagh (D) $\frac{\rho gh}{a}$ **[C]**

Sol. Thrust force



$F = F_1 - F_2 = \rho a v_1^2 - \rho a v_2^2$
$= \rho a\,(2gh_1) - \rho a\,(2gh_2)$
$= 2\rho ag\,(h_1 - h_2)$
$= 2\,\rho agh$

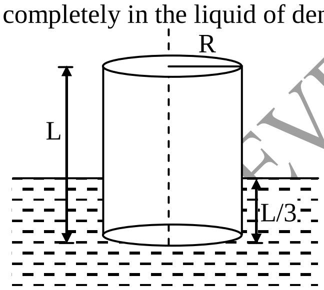
Q.4 A block of iron is kept at the bottom of a bucket full of water at 2°C. The water exerts bouyant force on the block. If the temperature of water is increased by 1°C the temperature of iron block also increased by 1°C. The buoyant force on the block by water.

(A) will increase
(B) will decrease
(C) will not change
(D) may decrease or increase depending on the values of their coefficient of expansion

[A]

Sol. Increasing the temperature of water from 2°C to 3°C increases it's density while decreases the density of iorn.
Hence the bouyant force increases.

Q.5 A cylinder of radius R is floating in a liquid as shown. The work done in submerging the cylinder completely in the liquid of density ρ is



(A) $\frac{2}{9}\rho\pi R^2L^2g$ (B) $\frac{8}{18}\rho\pi R^2L^2g$
(C) $\frac{1}{3}\rho\pi R^2L^2g$ (D) $\frac{2}{9}\rho R^2L^2g$ **[A]**

Sol. At any submerged length x

$F_B = \rho\pi R^2xg$ ... (1)

If density of cylinder is ρ_C then,

$$\frac{\rho_C}{\rho} = \frac{\frac{L}{3}}{L} = \frac{1}{3} \Rightarrow \rho_C = \frac{\rho}{3}$$

then,

$$W = \int_{L/3}^{L}\left(\rho\pi R^2xg - \frac{\rho}{3}\pi R^2Lg\right)dx$$

Q.6 A large tank is filled with water to height H and there is a small hole at the bottom of tank. If in time T_1 the height of water level decreases to height $\frac{H}{n}$ (n > 1) and in the same time T_1 rest of water flows out, then the value of n is -

(A) 2 (B) 3
(C) 4 (D) $2\sqrt{2}$ **[C]**

Sol. $\frac{dV}{dt} = A\sqrt{2gh}$

$\therefore \frac{dh}{\sqrt{h}} = \sqrt{2g}\,dt$

$\therefore \sqrt{H} - \sqrt{h} = Kt$

Q.7 A 20 cm long capillary tube is dipped in water. The water rises up to 15cm. If the entire arrangement is put in a freely falling elevator the length of water column in the capillary tube will be -

(A) 20 cm (B) 4 cm
(C) 10 cm (D) 18 cm

Sol.[A] In condition of weightless, water rises to the whole of the available length.

Q.8 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. The, R is equal to :

(A) $L/\sqrt{2\pi}$ (B) $2\pi L$
(C) L (D) $L/2\pi$ **[A]**

Sol. Velocity of efflux at a depth h is given by v $= \sqrt{2gh}$. Volume of water flowing out per second from both the holes are qual.

$\therefore a_1v_1 = a_2v_2$

or $(L^2)\sqrt{2g(y)} = \pi R^2\sqrt{2g(4y)}$

or $R = \frac{L}{\sqrt{2\pi}}$

Q.9 A block of wood floats in fresh water with two third of its volume submerged. In oil the block floats with one fourth of is volume submerged. The density of oil is -

(A) 2666.7 kg/m^3 (B) 5333.3 kg/m^3

(C) 1333.3 kg/m^3 (D) 3333.3 kg/m^3 **[A]**

Sol. $\rho_w \frac{2}{3} V = \rho_b V$

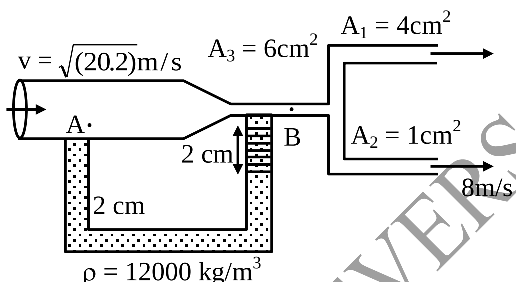
$\rho_{oil} \frac{1}{4} V = \rho_b V$

$\therefore \frac{2}{3} \rho_w = \frac{1}{4} \rho_{oil}$

$\rho_{oil} = \frac{8}{3} \rho_w$

$= \frac{8000}{3} = 2666.7$

Q.10 Calculate the velocity with which the liquid gushes out of the 4 cm^2 outlet, if the liquid flowing in the tube is water and liquid in U tube has a specific gravity 12. Velocity of liquid at point A is $\sqrt{20.2}$ m/s -



(A) 2.5 m/s (B) 5.5 m/s (C) 8 m/s (D) 10 m/s

Sol.[B] $P_A + \frac{1}{2}\rho v_A^2 = P_B + \frac{1}{2}\rho v_B^2$

$P_A - P_B = \frac{1}{2}\rho(v_B^2 - v_A^2)$

$0.02 \times 12000 \times 10 = \frac{1}{2} \times 1000\ (v_B^2 - 20.2)$

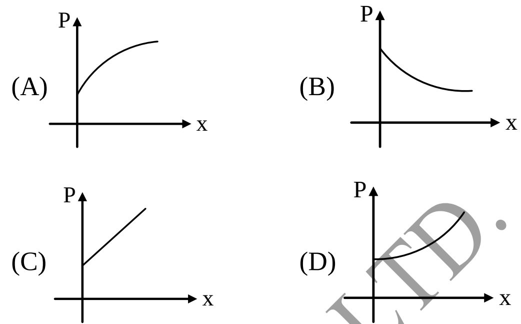
$4.8 = v_B^2 - 20.2 \Rightarrow v_B = 5$m/s

$\Rightarrow A_3.v_B = A_1v_1 + A_2v_2$

$\Rightarrow 30 = 4v_1 + 8$

$\Rightarrow 4v_1 = 22 \Rightarrow v_1 = \frac{22}{4} = 5.5$ m/s

Q.11 The cross sectional area of a horizontal tube increases along its length linearly as moved in the direction of flow. The variation of pressure, as we move along its length in the direction of flow (x-direction), can be best represented by the following graph -



[A]

Sol. As $Av = k_1$(constant)

also $P + \frac{1}{2}\rho v^2 + \rho gh = k_2$ (constant)

$\therefore \quad P = k_2 - \frac{1}{2}\rho \frac{k_1^2}{A^2}$

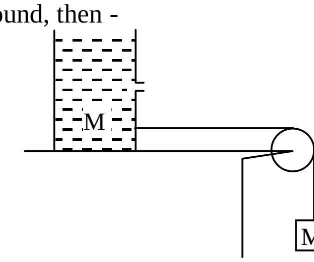
Q.12 A small block of wood of specific gravity 0.5 is submerged at a depth of 1.2 m in a vessel filled with water. The vessel accelerated upward with an acceleration of a = g/2. Time taken by block to reach the surface is (g = 10 m/s^2) -

(A) 0.6 sec (B) 0.4 sec

(C) 1.2 sec (D) 1 sec

Sol.[C] Acceleration w.r.t vessel is $a = \left(\frac{1-S}{S}\right)(g + a)$.

Q.13 The container is massless. Mass of liquid initially at t = 0 filled in the container is M. There is a hole in the container as shown. If there is no friction between container and ground, then -



(A) initial acceleration of system is less then g/2

(B) initial acceleration of system is equal to g/2

(C) initial acceleration of system is greater than g/2

(D) system remain at rest **[A]**

Sol. Due to water flowing out from hole a force will acts on container towards left

Q.14 A spherical air bubble of radius 2cm is released 30 m below the surface of a pond at 280 K. Its volume when it reaches the surface, which is at 300 K assuming it is in thermal equilibrium the whole time, is V. Ignore the size of the bubble compared to other dimensions like 30 m. Then V is equal to -

(A) 1.4×10^{-4} m^3 (B) 2.8×10^{-4} m^3
(C) 0.7×10^{-4} m^3 (D) 4.2×10^{-4} m^3

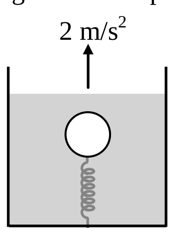
Sol. **[A]** $\frac{P_i V_i}{T_i} = \frac{P_f V_f}{T_f}$

$V_f = \left(\frac{P_i V_i}{P_f} \frac{T_f}{T_i}\right)$

$P_f = P_{atm}$

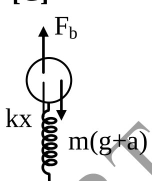
$P_i = P_{atm} + \rho gh$

Q.15 A ball of mass 10 kg and density 1 gm/cm^3 is attached to the base of a container having a liquid of density 1.1 gm/cm^3, with the help of a spring as shown in the figure. The container is going up with an acceleration 2 m/s^2. If the spring constant of the spring is 200 N/m, the elongation in the spring is –



(A) 2 cm (B) 4 cm (C) 6 cm (D) 8 cm

Sol. **[C]**



$\rho_\ell V(g + a) - m(g + a) = kx$
$(1.1)V(g + a) - 1 \times V(g + a) = 200x$
$x = 6$ cm

Q.16 A cubical vessel open from top of side L is filled with a liquid of density ρ then the torque of hydrostatic force on a side wall about an axis passing through one of bottom edges is-

(A) $\frac{\rho g L^4}{4}$ (B) $\frac{\rho g L^4}{6}$

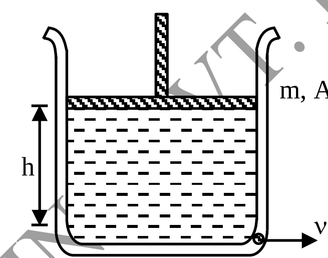
(C) $\frac{2\rho g L^4}{3}$ (D) $\frac{\rho g L^4}{3}$ **[B]**

Sol. Force by hydrostatic pressure

$= P_{av} \times \text{Area} = \frac{1}{2}\rho g L \times L^2 = \frac{1}{2}\rho g L^3$

and centre of pressure is at height $\frac{L}{3}$.

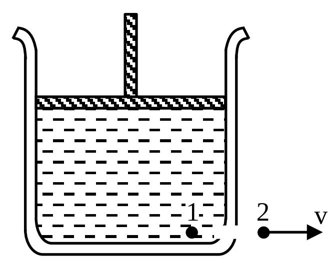
Q.17 A cylindrical vessel contains a liquid of density ρ upto a height h. The liquid is closed by a piston of mass m and area of cross-section A. There is a small hole at the bottom of the vessel. The speed v with which the liquid comes out of the hole is –



(A) $\sqrt{2gh}$ (B) $\sqrt{2\left(gh + \frac{mg}{\rho A}\right)}$

(C) $\sqrt{2\left(gh + \frac{mg}{A}\right)}$ (D) $\sqrt{2gh + \frac{mg}{A}}$ **[B]**

Sol. Applying Bernoulli's theorem at 1 and 2 : difference in pressure energy between 1 and 2 = difference in kinetic energy between 1 and 2



or $\rho gh + \frac{mg}{A} = \frac{1}{2}\rho v^2$

or $v = \sqrt{2gh + \frac{2mg}{\rho A}} = \sqrt{2\left(gh + \frac{mg}{\rho A}\right)}$

Q.18 A wooden cube just floats inside water when a 200 g mass is placed on it. When the mass is removed, the cube is 2 cm above the water level. What is the size of each sides of the cube?

(A) 6 cm (B) 8 cm
(C) 10 cm (D) 12 cm

Sol. **[C]**

Let a be the size of each side of the cube. Then,

$200 \times g = (2) \times (a^2) \times 1 \times g$

$\therefore \quad a = 10$ cm

Q.19 A vessel contain oil (d = 0.8 g/cc) over mercury (d = 13.6 g/cc). 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 g/cc is -

(A) 3.3 (B) 6.4

(C) 7.2 (D) 12.8 **[C]**

Sol. For equilibrium, the total upward pull will be equal to the gravitational force

$$\frac{V}{2} \times 13.6 \times g + \frac{V}{2} \times (0.8)g = V\rho g$$

$\rho = 7.2$ g/cc

Q.20 Water is flowing through a tube of non uniform cross section. If the radii of the tube at the entrance and exit are in the ratio 3 : 2, then the ratio of velocity of liquid entering and leaving the tube is-

(A) 1 : 1 (B) 4 : 9 (C) 9 : 4 (D) 8 : 27

Sol.[B] By equation of continuity

$A_1v_1 = A_2v_2 \Rightarrow \pi r_1^2 v_1 = \pi r_2^2 v_2$

$$\Rightarrow \frac{v_1}{v_2} = \frac{r_2^2}{r_1^2} = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$$

Q.21 A tank is filled with water to a height H. A hole is punched in one of the walls at a depth h below the water surface. Then the distance x from the foot of the wall at which the stream strikes the floor is –

(A) $2\sqrt{Hh}$ (B) $\sqrt{2(H-h)H}$

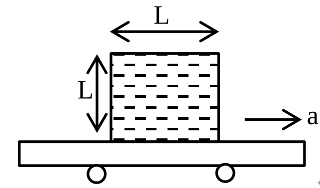
(C) $2\sqrt{(H-h)h}$ (D) $2h\left(\frac{H-h}{H}\right)$ **[C]**

Sol. Using Bernoulli's equation, $h\rho g = 1/2\rho v^2$

$v = \sqrt{2gh}$ = horizontal speed of water jet from the hole.

Time of fall = $\sqrt{\frac{2(H-h)}{g}}$, x = vt

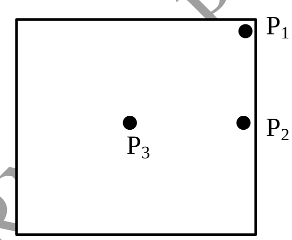
Q.22 A cubical sealed vessel with edge L is placed on a cart, which is moving horizontally with an acceleration 'a' as shown in figure. The cube is filled with an ideal fluid having density d. The gauge pressure at the centre of the cubical vessel is –



(A) $\frac{Ldg}{2}$ (B) $\frac{Ld}{2}$ (g + a)

(C) $\frac{Lda}{2}$ (D) $\frac{Ld}{2}$ (g – a) **[B]**

Sol.



$P_1 = P_{atm}$

$P_2 = P_{atm} + \frac{Ldg}{2}$

$P_3 = P_2 + \frac{Lda}{2}$

$\therefore\ P_3 - P_{atm} = \frac{Ld}{2}$ (g + a)

Q.23 When a loaded boat enters into the sea from a river, it rises because -

(A) there is more water in the sea than in river

(B) sea water is denser than river

(C) there is difference of temperature

(D) sea is deeper than river **[B]**

Sol. Since the density of sea-water is more than that of river therefore lesser volume of sea water is required to be displaced to balance the weight of the boat.

Q.24 A beaker containing water is placed on the platform of a spring balance. The balance reads 1.5 kg. A stone of mass 0.5 kg and density 500 kg/m^3 is completely immersed in water without touching the walls of beaker. Now the balance reading will be -

(A) 2 kg (B) 1 kg

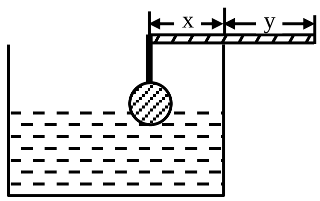
(C) 2.5 kg (D) 3 kg **[C]**

Sol. R = 1.5 g + B

$= 1.5\text{ g} + \left(\frac{0.5}{500}\right) 1000\text{ g}$

$= 2.5\text{ g}$

Q. 25 A homogenous aluminium ball of volume V is suspended on a weightless theread from one end of a homogeneous rod of mass M. Rod is placed on the edge of a tumbler so that half of the ball is submerged in water when system is in equilibrium. The densities of aluminium and water are ρ_A and ρ_W respectively then -



(A) $\frac{y}{x} = \frac{2Mg + 2[\rho_A gV - \rho_W g\frac{V}{2}]}{Mg}$

(B) $\frac{y}{x} = 1 + \frac{2\left[\rho_A - \frac{\rho_W}{2}\right]V}{M}$

(C) $\frac{y}{x} = 1$

(D) $\frac{y}{x} = 2$ **[B]**

Q.26 Liquids A and B are at 30°C and 20°C respectively. When mixed in equal masses, the temperature of the mixture is found to be 26°C, The specific heats of A and B are in the ratio of-

(A) 3 : 2 (B) 1 : 1

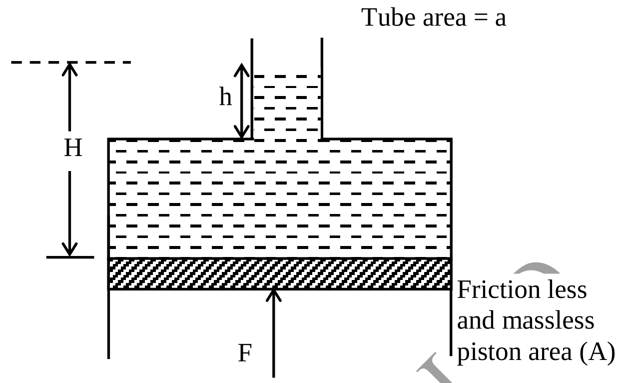
(C) 2 : 3 (D) 4 :3

Sol.[A] $ms_A (30–26) = ms_B (26–20)$

$\Rightarrow 4s_A = 6s_B$

$\therefore \frac{s_A}{s_B} = \frac{6}{4} = \frac{3}{2}$

Q.27 The force F needed to support the liquid of density ρ is –



(A) ρa [ha – (H – h)A] (B) ρ gHA

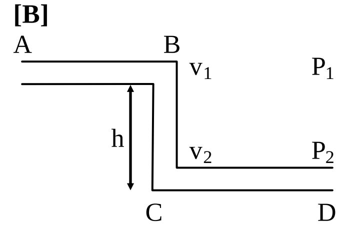
(C) ρgHa (D) ρ g(H – h) A **[B]**

Q.28 A pipe ABCD of uniform cross-section is bent into three sections, viz., a horizontal section AB, a vertical section BC with C below B, and a horizontal section CD. Liquid flowing through the pipe has speed v_1 and pressure p_1 in section AB, and speed v_2 and pressure p_2 in section CD -

(A) $v_1 = v_2, p_1 = p_2$ (B) $v_1 = v_2, p_2 > p_1$

(C) $v_2 > v_1, p_2 > p_1$ (D) $v_2 > v_1, p_1 = p_2$

Sol. **[B]**

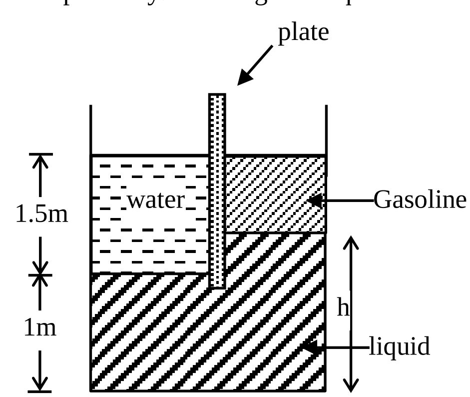


$v_1 = v_2$ (equation of continuity)

Also; $\frac{v_1^2}{2} + gh + \frac{P_1}{\rho} = \frac{v_2^2}{2} + 0 + \frac{p_2}{\rho}$

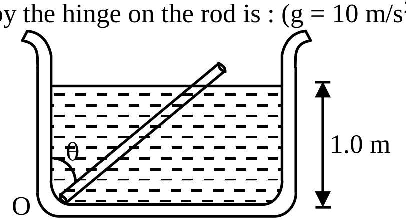
$P_2 – P_1 = h\rho g \therefore P_2 > P_1$

Q.29 Water and gasoline surfaces are open to atmosphere and at the same elevation. Specific gravity of gasoline and liquid are 0.6 and 1.6 respectively. The height of liquid is –



(A) 1m (B) 0.6
(C) 1.6 m (D) 1.5 m **[C]**

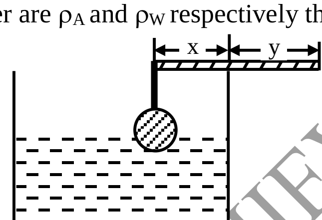
Q.30 A uniform rod of length 2.0 m specific gravity 0.5 and mass 2 kg is hinged atone end to the bottom of a tank of water (specific gravity = 1.0) filled upto a height of 1.0 m as shown in figure. Taking the case $\theta \neq 0^o$ the force exerted by the hinge on the rod is : ($g = 10\ m/s^2$) –



(A) 10.2 N upwards
(B) 4.2 N downwards
(C) 8.3 N downwards
(D) 6.2 N upwards **[C]**

Sol. Length of rod inside the water = 1.0 secθ = secθ

Q.31 A homogenous aluminium ball of volume V is suspended on a weightless thread from one end of a homogeneous rod of mass M. Rod is placed on the edge of a tumbler so that half of the ball is submerged in water when system is in equilibrium. The densities of aluminium and water are ρ_A and ρ_W respectively then -



(A) $\frac{y}{x} = \frac{2Mg + 2[\rho_A gV - \rho_W g \frac{V}{2}]}{Mg}$

(B) $\frac{y}{x} = 1 + \frac{2\left[\rho_A - \frac{\rho_W}{2}\right]V}{M}$

(C) $\frac{y}{x} = 1$

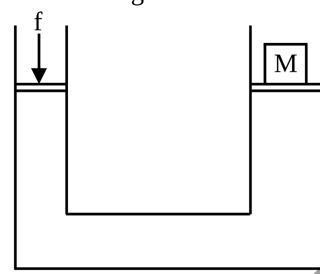
(D) $\frac{y}{x} = 2$

Sol. **[B]**

Taking torque,

$$\left(V\rho_A g - \frac{V}{2}\rho_\omega g\right)x = Mg \times \left[y - \left(\frac{x+y}{2}\right)\right]$$

Q. 32 In hydraulic press radii of connecting pipes r_1 and r_2 are in ratio 1 : 2. In order to lift a heavy mass M on larger piston, the small piston must be pressed through a minimum force f equal to –



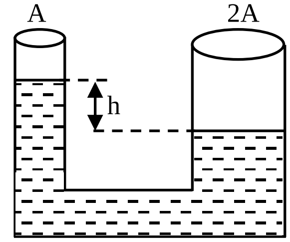
(A) Mg (B) Mg/2
(C) Mg/4 (D) Mg/8 **[C]**

Sol. According to Pascal's principle

$$\frac{f_1}{f_2} = \frac{A_1}{A_2} = \frac{r_1^2}{r_2^2} = \frac{1}{4}$$

$$f_1 = \frac{1}{4} Mg$$

Q. 33 A U-tube of cross section A and 2A as shown contains liquid of density d. Initially, the liquid in the two arms are held with a level difference h. After being released the levels equalize after some time. The work done by gravity forces on the liquid in the process is –



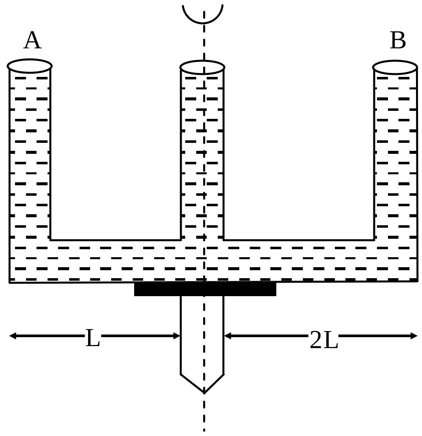
(A) $\frac{Adgh^2}{3}$ (B) $\frac{Adgh^2}{2}$

(C) $\frac{Adgh^2}{6}$ (D) $\frac{Adgh^2}{8}$ **[A]**

Sol. $\Delta U = mg\left(\frac{h}{2} - \frac{h}{6}\right) = mg\ \frac{h}{3}$

$= Adhg.\ \frac{h}{3} = \frac{Adh^2g}{3}$

Q. 34 A given shaped glass tube having uniform area of cross-section is filled with water and is mounted on a rotatable shaft as shown in Fig. If the tube is rotated with a constant angular velocity ω, then -



(A) Water level in A will rise and fall in B

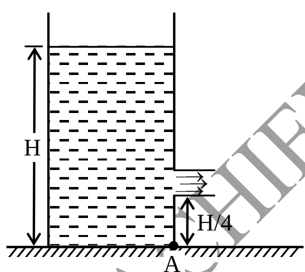
(B) Water level in both A and B will rise

(C) Water level in B will rise and will fall in A

(D) Water level remains same in both A and B

Sol. **[B]** Extra force F = $\frac{m\omega^2 r}{2}$ & extra pressure

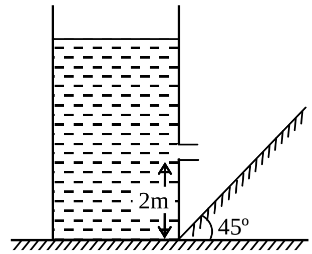
Q. 35 A container has a liquid filled upto the height H. There is a hole at height H/4. The area of hole is 'a'. Density of liquid is ρ. Torque due to the efflux coming out about an axis passing through 'A' and perpendicular to the plane of figure is –



(A) $\frac{\rho a g H^2}{4}$ (B) $\frac{3\rho a g H^2}{4}$

(C) $\frac{3}{8}\rho a g H^2$ (D) $\rho a g H^2$ **[B]**

Q. 36 A container has a hole at a height of 2m. If the time taken by the efflux to strike the inclined plane perpendicularly is 1 sec. Then the height of liquid level initially is (Take g = 10 m/s^2) –



(A) 2 m (B) 5 m

(C) 7 m (D) 3 m **[C]**

Q.37 Water from a tap emerges vertically downwards with an initial speed of 1.0 m/s. The cross-sectional area of tap is 10^{-4} m^2. Assume that the pressure is constant throughout and that the flow is steady, the cross-sectional area of stream 0.15 m below the tap is :

(A) 5.0×10^{-4} m^2 (B) 1.0×10^{-4} m^2

(C) 5.0×10^{-5} m^2 (D) 2.0×10^{-5} m^2

[C]

Sol. From conservation of energy

$v_2^2 = v_1^2 + 2gh$ … (1)

[can also be found by applying Bernouilli's theorem between 1 and 2]

From continuity equation

$A_1 v_1 = A_2 v_2$

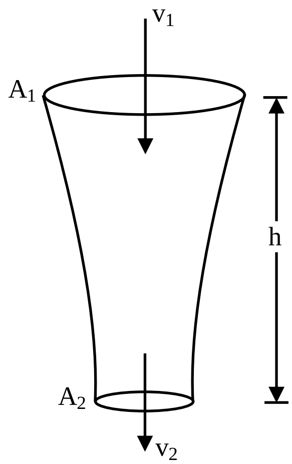
$v_2 = \left(\frac{A_1}{A_2}\right) v_1$ … (2)

Substituting value of v_2 from Eq. (2) in Eq. (1)

$\frac{A_1^2}{A_2^2} . v_1^2 = v_1^2 + 2gh$

or $A_2^2 = \frac{A_1^2 v_1^2}{v_1^2 + 2gh}$

$\therefore A_2 = \frac{A_1 v_1}{\sqrt{v_1^2 + 2gh}}$

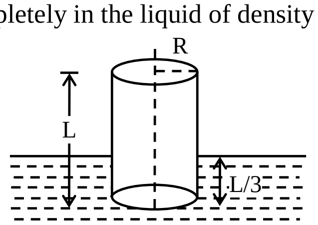


Substituting the given values

$$A_2 = \frac{(10^{-4}\,m^2)(1.0\,m/s)}{\sqrt{(1.0\,m/s)^2 + 2(10)(0.15)}}$$

$A_2 = 5.0 \times 10^{-5}\ m^2$

Q. 38 A cylinder of radius R is floating in a liquid as shown. The work done in submerging the cylinder completely in the liquid of density 'ρ' is –



(A) $\frac{2}{9}\rho\pi R^2L^2g$ (B) $\frac{8}{18}\rho\pi R^2L^2g$

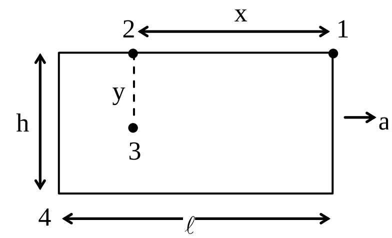
(C) $\frac{1}{3}\rho\pi R^2L^2g$ (D) $\frac{2}{9}\rho R^2L^2g$ **[A]**

Q.39 A sealed tank of length ℓ and height h, completely filled with liquid of density ρ, moves with horizontal acceleration a. The maximum difference in pressure between any two points in the liquid is -

(A) ρgh
(B) $\rho g\ell$
(C) $\rho(gh + a\ell)$
(D) all points in the liquid are at the same pressure

Sol. **[C]** $P_2 - P_1 = x\rho a$; $P_3 - P_2 = y\rho g$

$P_3 - P_1 = x\rho a + y\rho g \therefore P_4 - P_1 = \rho(gh + a\ell)$



Q.40 A tank is filled with water to a height H. A hole is punched in one of the walls at a depth h below the water surface. Then the distance x from the foot of the wall at which the stream strikes the floor is –

(A) $2\sqrt{Hh}$ (B) $\sqrt{2(H-h)H}$

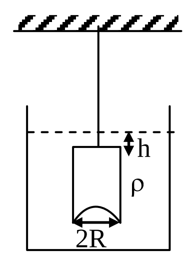
(C) $2\sqrt{(H-h)h}$ (D) $2h\left(\frac{H-h}{H}\right)$ **[C]**

Sol. Using Bernoulli's equation, $h\rho g = 1/2\rho v^2$

$v = \sqrt{2gh}$ = horizontal speed of water just from the hole.

Time of fall = $\sqrt{\frac{2(H-h)}{g}}$, $x = vt$

Q.41 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 –



(A) Mg (B) $Mg - V\rho g$
(C) $Mg + \pi R^2h\rho g$ (D) $\rho g(V + \pi R^2h)$ **[D]**

Q.42 A liquid having area of free surface 'A' has an orifice at a depth 'h' with an area 'a' below liquid surface, then the velocity V of flow through the orifice is -

(A) $\sqrt{2gh}$ (B) $\sqrt{2gh}\sqrt{\frac{A^2}{A^2 - a^2}}$

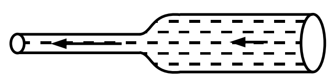
(C) $\sqrt{2gh}\sqrt{\frac{A}{A-a}}$ (D) None of these

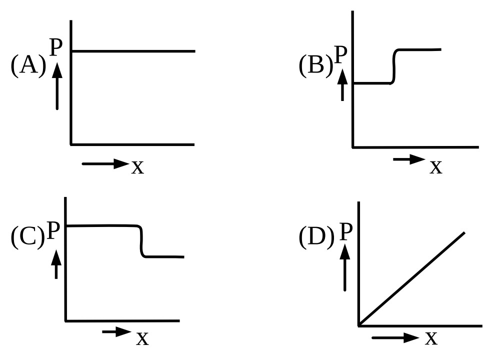
Sol. **[B]**

$P + \frac{1}{2}\rho V^2 + \rho gh = P + \frac{1}{2}\rho v^2 + 0$ ……….(i)

also AV = av ………(ii)

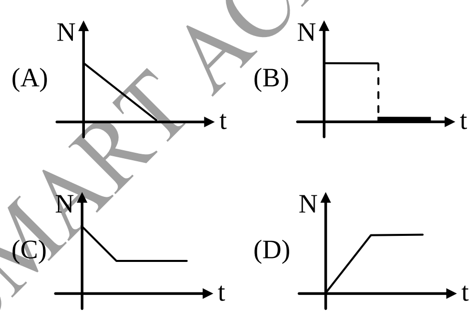
Q.43 Water is flowing in streamline motion through a tube of varying cross-section, as shown. The pressure p at points along the axis of the tube is represented by.





[C]

Q.44 A cube of density 0.5 g/cm^3 is placed in vessel and a liquid of density 1 g/cm^3 is gradually filled in the vessel at a constant rate then the graph representing variation of normal reaction of vessel on cube and time is -



[B]

Sol. Here force of buoyancy will act on cube when the liquid level rises above it and it will rise up.

Q.45 A tank is filled with water to a height H. A hole is made in one of the walls at a depth D below the water surface. The distance x from the foot of the wall at which the stream of water coming out of the tank strikes the ground is given by

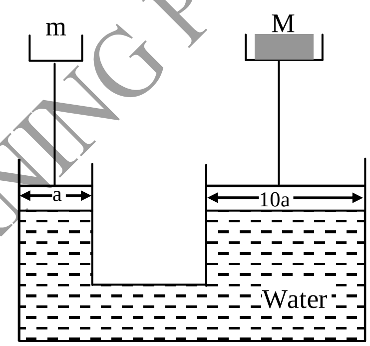
(A) x = 2 [D (H – D)]$^{1/2}$

(B) x = 2 (gD)$^{1/2}$

(C) x = 2 [D (H + D)]$^{1/2}$

(D) None of these **[A]**

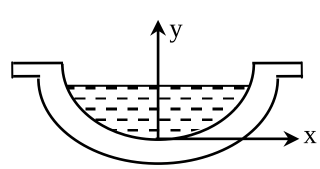
Q.46 When the system shown in the following figure is in equilibrium and if the areas of cross-section of the smaller piston and bigger piston are 'a' and '10a' then



(A) m = M (B) M = 10 m

(C) m = 10M (D) M = 100 m **[B]**

Q.47 A small hole is made at the bottom of a symmetrical jar as shown in figure. A liquid is filled into the jar upto a certain height. The rate of descension of liquid is independent of the level of the liquid in the jar. Then the surface of the jar is a surface of revolution of the curve –



(A) $y = kx^4$ (B) $y = kx^2$

(C) $y = kx^3$ (D) $y = kx^5$

Sol. **[A]**

Let y be the height of liquid at some instant.

Then $-\frac{dy}{dt}$ = constant (given)

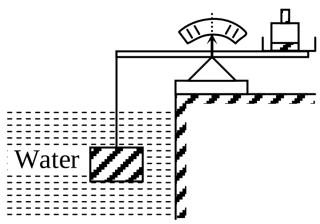
From equation of continuity,

$$(\pi x^2)\left(-\frac{dy}{dt}\right) = a\sqrt{2gy} \qquad \text{(a = area of hole)}$$

Here, $\pi\left(\frac{-dy}{dt}\right)$, a and g are constants

Hence, squaring the equation, we get $y = kx^4$.

Q.48

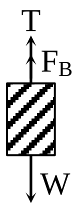


The volume of brick is 2.197 litres. The submerged brick is balanced by a 2.54 kg mass on the beam scale. The weight of the brick is –

(A) 46 N (B) 50 N

(C) 56 N (D) 72 N

Sol. **[A]**

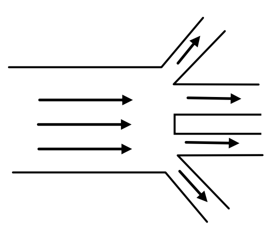


$T + F_B - W = 0$

$W = T + F_B = 2.54 \times 9.8 + 10^3 \times 2.197 \times 10^{-3} \times 10$

$W = 46.43$ N

Q.49 Water is flowing through a channel that is 12 m wide with a speed of 0.75 m/s. The water then flows into four identical channels that have a width of 4.0m. The depth of the water does not change as it flows into the four channels. What is speed of the water in one of the smaller channels ?



(A) 0.56 m/s (B) 2.3 m/s

(C) 0.25 m/s (D) 0.75 m/s

Sol. **[A]**

$Av = A_1v_1 + A_2v_2 + A_3v_3 + A_4v_4$

$Av = 4(A_1v_1)$

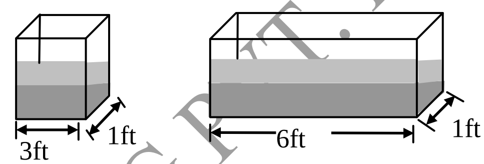
$12 \times 0.75 = 4\,[4 \times v]$

$v = \frac{3}{4} \times 0.75$

$= 0.75 \times 0.75$

$v = 0.56$ m/s

Q.50 The figure shows two fish tank, each having ends of width 1 foot. Tank A is 3 feet long while tank B is 6 feet long. Both tanks are filled with 1 foot of water.



S_A = the magnitude of the force of the water on the end of tank A

S_B = the magnitude of the force of the water on the end of tank B

B_A = the magnitude of the force of the water on the bottom of tank A

B_B = the magnitude of the force of the water on the bottom of tank B Using the notation given above, Which one of the following sets of equations below is correct for this situation ?

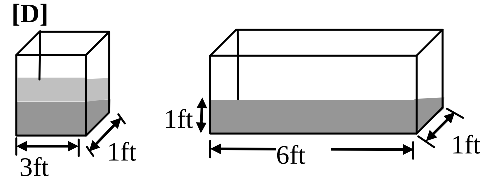
(A) $S_A = S_B$ and $B_A = B_B$

(B) $S_A = 2S_B$ and $B_A = B_B$

(C) $2S_A = S_B$ and $2B_A = B_B$

(D) $S_A = S_B$ and $2B_A = B_B$

Sol. **[D]**



$S_A = (\rho gh)\ A$ $\qquad S_B = (\rho gh)\ (1ft^2)$

$S_A = (\rho gh)\ (1ft^2)$ $\qquad B_B = (\rho gh)\ (6ft^2)$

$B_A = \rho gh\ (3ft^2)$

$S_A = S_B$; $B_B = 2B_A$

PHYSICS

Q.1 An air bubble starts rising from the bottom of a lake. Its diameter is 3.6 mm at the bottom and 4 mm at the surface. The depth of the lake is 250 cm and the temperature at the surface is 40ºC. What is the temperature at the bottom of the lake? Given atmospheric pressure = 76 cm of Hg and g = 980 cm/s^2.

Sol. T_1 = 283.37 K or 10.37ºC

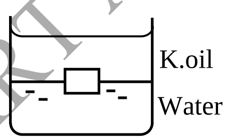
Q.2 A U-tube containing a liquid is accelerated horizontally with a constant acceleration a_0. If the separation between the vertical limbs is l, find the difference in the heights of the liquid in the two arms.

[$\frac{a_0 l}{g}$]

Q.3 A hollow spherical body of inner and outer radii 6 cm and 8 cm respectively floats half submerged in water. Find the density of the material of the sphere. **[**865 kg/m^3**]**

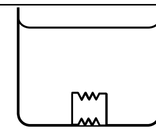
Q.4 A cubical block of ice floating in water has to support a metal piece weighing 0.5 kg. What can be the minimum edge of the block so that it does not sink in water ? Specific gravity of ice = 0.9. **[**17 cm**]**

Q.5 A cube of ice floats partly in water and partly in K.oil (figure). Find the ratio of the volume of ice immersed in water to that in K oil. Specific gravity of K.oil is 0.8 and that of ice is 0.9.



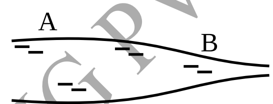
[1 : 1**]**

Q.6 A metal piece of mass 160 g lies in equilibrium inside a glass of water (figure). The piece touches the bottom of the glass at a small number of points. If the density of the metal is 8000 kg/m^3, find the normal force exerted by the bottom of the glass on the metal piece.



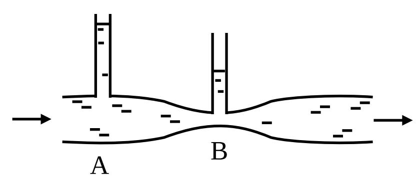
[1.4 N**]**

Q.7 Water flows through a horizontal tube of variable cross-section (in figure). The area of cross-section at A and B are 4mm^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 $P_A - P_B$.



[(a) 25 cm/sec, (b) 50 cm/ sec, (c) 94 N/m^2]

Q.8 Water flows through a horizontal tube as shown in figure. If the difference of heights of water column in the vertical tubes is 2 cm, and the areas of cross-section at A and B are 4 cm^2 and 2cm^2 respectively, find the rate of flow of water across any section.



[146 cc/sec]

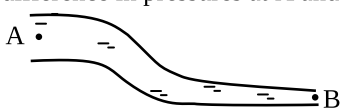
Q.9 A cube of ice of edge 4 cm is placed in an empty cylindrical glass of inner diameter 6 cm. Assume that the ice melts uniformly from each side so that it always retains its cubical shape. Remembering that ice is lighter than water, find the length of the edge of the ice cube at the instant it just leaves contact with the bottom of the glass.

[2.26 cm]

Q.10 A wooden block of mass 0.5 kg and density 80 kg/m^3 is fastened to the free end of a vertical spring of spring constant 50 N/m fixed at the bottom. If the entire system is completely immersed in water, find (a) the elongation (or compression) of the spring in equilibrium and (b) the time-period of vertical oscillations of the block when it is slightly depressed and released.

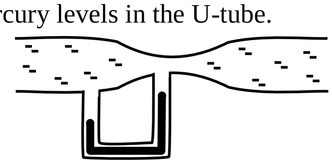
[(a) 2.5 cm (b) π/5 s]

Q.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.



[(a) 20 cm/s (b) 485 N/m²]

Q.12 Water flows through the tube shown in figure. The areas of cross-section of the wide and the narrow portions 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.



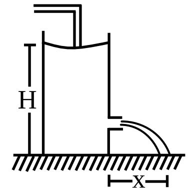
[1.97 cm]

Q.13 Water leaks out from an open tank through a hole of area 2mm^2 in the bottom. Suppose water is filled up to a height of 80cm and area of cross-section of the tank is 0.4 m^2. The pressure at the open surface and at the hole are equal to the atmospheric pressure. Neglect the small velocity of the water near the open surface in the tank. (a) Find the initial speed of water coming out of the hole. (b) Find the speed of water coming out when half of water has leaked out. (c) Find the volume of water leaked out during a time interval dt after the height remained is h. Thus find the decrease in height dh in terms of h and dt. (d) From the result of part (c) find the time required for half of the water to leak out.

[(a) 4m/s (b) $\sqrt{8}$ m/s (c) (2mm²) $\sqrt{2gh}$ dt,

$\sqrt{2gh}$ × 5 × 10^{-6} dt (d) 6.5 hours]

Q.14 Water level is maintained in a cylindrical vessel upto a fixed height H. The vessel is kept on a horizontal plane. At what height above the bottom should a hole be made in the vessel so that the water stream coming out of the hole strikes the horizontal plane at the greatest distance from the vessel



[$\frac{H}{2}$]

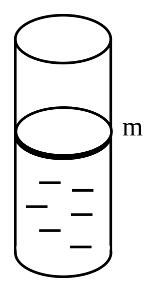
Q.15 An ornament weighing 36 g in air, weighs only 34 g in water. Assuming that some copper is mixed with gold to prepare the ornament, find the amount of copper in it. Specific gravity of gold is 19.3 and that of copper is 8.9.

[2.2g]

Q.16 A beaker of circular cross-section of radius 4 cm is filled with mercury upto a height of 10 cm. Find the force exerted by the mercury on the bottom of the beaker. The atmospheric pressure = 10^5 N/m^2. Density of mercury = 13600 kg/m^3. Take g = 10 m/s^2

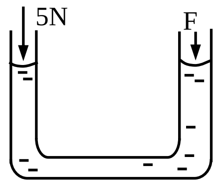
[571N]

Q.17 A cylindrical vessel containing a liquid is closed by a smooth piston of mass m as shown in the figure. The area of cross-section of the piston is A. If the atmospheric pressure is P_0, find the pressure of the liquid just below the piston -



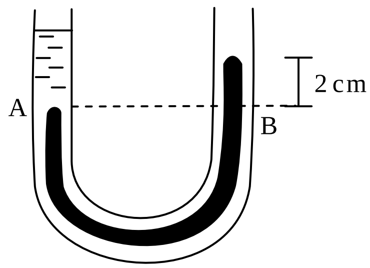
[$P = P_0 + \frac{mg}{A}$]

Q.18 The area of cross-section of the two arms of a hydraulic press are 1 cm^2 and 10 cm^2 respectively. A force of 5 N is applied on the water in the thinner arm. What force should be applied on the water in the thicker arm so that the water may ramain in equilibrium ?



[F = 50 N]

Q.19 The liquids shown is figure in the two arms are mercury (specific gravity = 13.6) and water. If the difference of heights of the mercury columns is 2 cm, find the height h of the water column –



[27 cm]

Q.20 The density of air near earth's surface is 1.3 kg/m^3 and the atmospheric pressure is 1.0×10^5 N/m^2. If the atmosphere had uniform density, same as that observed at the surface of the earth, what would be the height of the atmosphere to exert the same pressure ?

[7850 m]