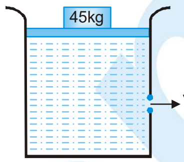
SOLVED EXAMPLES

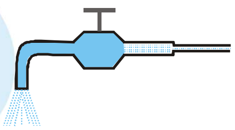
Ex.1 A large cylindrical tank of cross-sectional area $1 m^2$ is filled with water. It has a small hole at a height of 1m from the bottom. A movable piston of mass 5 kg is fitted on the top of the tank such that it can slide in the tank freely. A load of 45 kg is applied on the top of water by piston, as shown in figure. The value of v when piston is 7m above the bottom is ($g = 10\ m/s^2$)



(A) $\sqrt{120}$ m/s **(B)** 10 m/s **(C)** 1 m/s **(D)** 11 m/s

Sol. $\frac{1}{2}\rho v^2 = \rho gh + \frac{Mg}{A} \Rightarrow v = \sqrt{2gh + \frac{2Mg}{\rho A}} = \sqrt{2 \times 10 \times 6 + \frac{2 \times 50 \times 10}{10^3 \times 1}} = \sqrt{120+1} = \sqrt{121} = 11 m/s$

Ex.2 The pressure of water in a water pipe when tap is opened and closed is respectively $3 \times 10^5\ Nm^{-2}$ and $3.5 \times 10^5\ Nm^{-2}$. With open tap, the velocity of water flowing is



(A) 10 m/s (B) 5 m/s (C) 20 m/s (D) 15 m/s

Sol. $P_{open} + \frac{1}{2}\rho v^2 = P_{closed} \Rightarrow v = \sqrt{\frac{2(P_{closed} - P_{open})}{\rho}} = \sqrt{\frac{2 \times (3.5-3) \times 10^5}{10^3}} = 10$ m/s

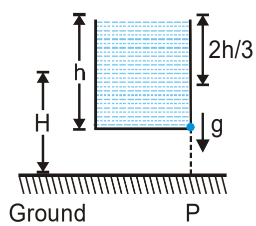
Ex.3 An open vessel full of water is falling freely under gravity. There is a small hole in one face of the vessel, as shown in the figure. The water which comes out from the hole at the instant when hole is at height H above the ground, strikes the ground at a distance of x from P. Which of the following is correct for the situation described?

(A) The value of x is $2\sqrt{\frac{2hH}{3}}$

(B) The value of x is $\sqrt{\frac{4hH}{3}}$

(C) The value of x can't be computed from information provided.

(D) The question is irrevalent as no water comes out from the hole.



Sol. As vessel is falling freely under gravity, the pressure at all points within the liquid remains the same as the atmospheric pressure. If we apply Bernoulli's theorem just inside and outside the hole, then

$$P_{inside} + \frac{\rho v_{inside}^2}{2} + \rho g_{eff} y = p_{outside} + \frac{\rho v_{outside}^2}{2} + \rho g_{eff} y$$

$$v_{inside} = 0,\ p_{inside} = p_{outside} = p_0 \text{ [atmospheric pressure]}$$

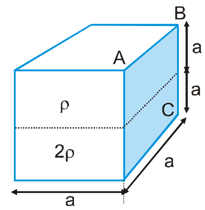
Therefore, $v_{outside} = 0$. i.e., no water comes out.

Ex.4 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 ? [Density of whole blood = $1.06 \times 10^3\ kg\ m^{-3}$].

(A) 0.192 m **(B)** 0.182 m **(C)** 0.172 m **(D)** 0.162 m

Sol. Pressure $P = h\rho g \Rightarrow h = \frac{2000}{1.06 \times 10^3 \times 9.8} = 0.192 m$

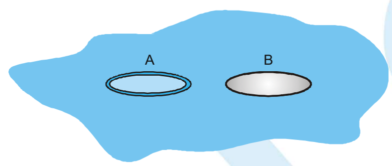
Ex.5 A cuboid ($a \times a \times 2a$) is filled with two immiscible liquids of density 2ρ & ρ as shown in the figure. Neglecting atmospheric pressure, ratio of force on base & side wall of the cuboid is



(A) 2:3 **(B)** 1:3 **(C)** 5:6 **(D)** 6:5

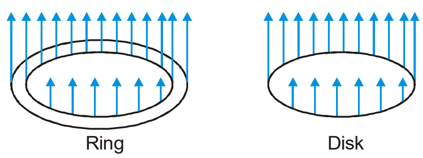
Sol. $F_b = (2\rho gh + \rho gh)a^2 = 3\rho gha^2$; $F_w = \left[\frac{\rho gh}{2}\right]ah + (2\rho gh)ah = \frac{5}{2}\rho gha^2$ [here $h = a$]; $\frac{F_b}{F_w} = \frac{3}{5/2} = \left(\frac{6}{5}\right)$

Ex.6 A rigid ring A and a rigid thin disk B both made of same material, when gently placed on water, just manage to float due to surface tension as shown in the figure. Both the ring and the disk have same radius. What can you conclude about their masses?



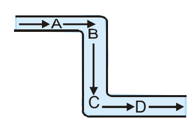
(A) Both have the same mass. **(B)** Mass of the ring is half of that of the disk.
(C) Mass of the ring is double to that of the disk. **(D)** More information is needed to decide.

Sol.



Ring have double surface than that of disk.

Ex.7 The tube shown is of non-uniform cross-section. The cross-section area at A is half of the cross-section area at B,C and D. A liquid is flowing through in steady state.The liquid exerts on the tube-

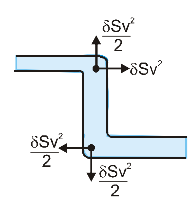


Statement I : A net force towards right. **Statement II :** A net force towards left.
Statement III : A net force in some oblique direction. **Statement IV :** Zero net force
Statement V: A net clockwise torque. **Statement VI:** A net counter-clockwise torque.

Out of these

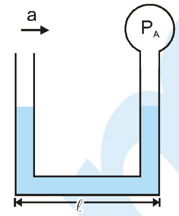
(A) Only statement I and V are correct **(B)** Only statement II and VI are correct
(C) Only statement IV and VI are correct **(D)** Only statement III and VI are correct

Sol. The force has been exerted by liquid on the tube due to change in momentum at the corners i.e., when liquid is taking turn from A to B and from B to C.As corss-section area at A is half of that of B and C, so velocity of liquid flow at B and C is half to that of velocity at A. Let velocity of flow of liquid at A be v and cross section area at A be S, the velocity of flow of liquid at B and C would be $\frac{v}{2}$ [from continuity equation] and corss section area at B and C would be 2S.



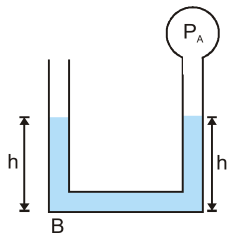
Due to flow of liquid, it is exerting a force per unit time of ρSv^2 on the tube, where ρ is the density of liquid, S is cross section areaand v is velocity of flow of liquid. The force exerted by liquid on tube is shown in the figure. Which clearly shows that a net force is acting on tube due to flowing liquid towards right and a clockwise torque sets in

Ex.8 A liquid of density ρ is filled in a U-tube, whose one end is open & at the other end a bulb is fitted whose pressure is P_A. Now this tube is moved horizontally with acceleration 'a' as shown in the figure. During motion it is found that liquid in both column is at same level at equilibrium. If atmospheric pressure is P_0, then value of P_A is



(A) ρa● **(B)** ρg● **(C)** P_0–ρa● **(D)** P_0 + ρa●

Sol. Consider a point B at the horizontal portion of tube, pressure from both side should be same.

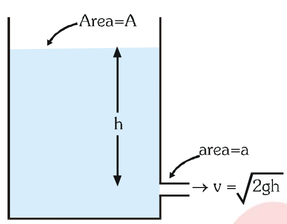


$\therefore$ $P_0 + \rho gh = P_A + \rho gh + \rho a$●, $P_A = P_0 - \rho a$●

Ex.9 A hole is made at the bottom of a large vessel open at the top. If water is filled to a height h, it drains out completely in time t. The time taken by the water column of height 2h to drain completely is

(A) $\sqrt{2}t$ **(B)** 2t **(C)** $2\sqrt{2}t$ **(D)** 4t

Sol.



Here $\left(-A\dfrac{dh}{dt}\right) = (av) = a\sqrt{2gh} \Rightarrow \int_0^h h^{-1/2}dh = \dfrac{a}{A}\sqrt{2g}\int_0^t dt \Rightarrow t = \dfrac{A}{a}\sqrt{\dfrac{2h}{g}} \Rightarrow t \propto \sqrt{h}$

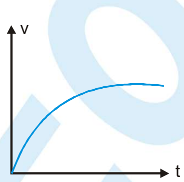
Therefore for height 2h $t' \propto \sqrt{2h} \Rightarrow t' = \sqrt{2}\,t$

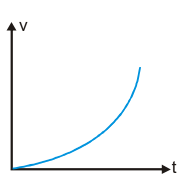
Ex.10 A tank full of water has a small hole at its bottom. Let t_1 be the time taken to empty first one third of the tank and t_2 be the time taken to empty second one third of the tank and t_3 be the time taken to empty rest of the tank then

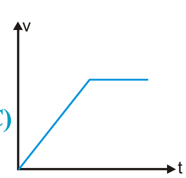
(A) $t_1 = t_2 = t_3$ **(B)** $t_1 > t_2 > t_3$ **(C)** $t_1 < t_2 < t_3$ **(D)** $t_1 > t_2 < t_3$

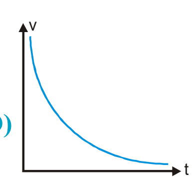
Sol. As the height decreases, the rate of flow with which the water is coming out decreases.

Ex.11 A piece of cork starts from rest at the bottom of a lake and floats up. Its velocity v is plotted against time t. Which of the following best represents the resulting curve?

(A)


(B)


(C)


(D)


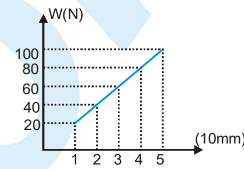
Sol. As the cork moves up, the force due to buoyancy remains constant. As its speed increases, the retarding force due to viscosity increases, being proportional to the speed. Thus the acceleration gradually decreases.

Ex.12 A flat plate moves normally with a speed v_1 towards a horizontal jet of water of uniform area of cross-section. The jet discharges water at the rate of volume V per second at a speed of v_2. The density of water is ρ. Assume that water splashes along the surface of the plate at right angles to the original motion. The magnitude of the force acting on the plate due to jet of water is :–

(A) $\rho V v_1$ **(B)** $\rho\left(\dfrac{V}{v_2}\right)(v_1+v_2)^2$ **(C)** $\dfrac{\rho V}{v_1+v_2}v_1^2$ **(D)** $\rho V(v_1+v_2)$

Sol. $F = \dfrac{\Delta p}{\Delta t} = \dfrac{m(v_1+v_2)}{\Delta t} = V\rho(v_1+v_2)$ where $\dfrac{m}{\Delta t} = V$ = volume/sec

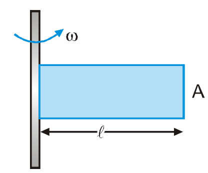
Ex.13 The graph shows the extension of a wire of length 1m suspended from the top of a roof at one end and with a load W connected to the other end. If the cross sectional area of the wire is 1 mm², then the Young's modulus of the material of the wire is



(A) $2\times10^{11}\ Nm^{-2}$ **(B)** $2\times10^{10}\ Nm^{-2}$ **(C)** $\dfrac{1}{2}\times10^{11}\ Nm^{-2}$ **(D)** None of these

Sol. $Y = \dfrac{F/A}{\Delta l/l} = \dfrac{Wl}{A\Delta l} \Rightarrow \dfrac{W}{\Delta l} = \dfrac{YA}{l} = \text{slope} \Rightarrow Y = \dfrac{l}{A}(\text{slope}) = \dfrac{1}{10^{-6}}\left(\dfrac{40-20}{(2-1)\times10^{-3}}\right) = 2\times10^{10}\ Nm^{-2}$

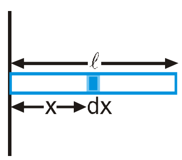
Ex.14 A closed cylinder of length '●' containing a liquid of variable density $\rho(x) = \rho_0(1+\alpha x)$. Find the net force exerted by the liquid on the axis of rotation. (Take the cylinder to be massless and A = cross sectional area of cylinder)



(A) $\rho_0 A\omega^2 l^2\left[\dfrac{1}{2}+\dfrac{1}{3}\alpha l\right]$ **(B)** $\rho_0 A\omega^2 l^2\left[\dfrac{1}{2}+\dfrac{2}{3}\alpha l\right]$

(C) $\rho_0 A\omega^2 l^2\left[\dfrac{1}{2}+\alpha l\right]$ **(D)** $\rho_0 A\omega^2 l^2\left[\dfrac{1}{2}+\dfrac{4}{3}\alpha l\right]$

Sol. **Ans. (A)**



$dm = \rho A dx;\ dF = (dm)\omega^2 x \Rightarrow F = \int_0^l \omega^2 x\rho A dx = \omega^2\rho_0 A\int_0^l (1+\alpha x)x\,dx = \rho_0 A\omega^2 l^2\left(\dfrac{1}{2}+\dfrac{1}{3}\alpha l\right)$

Ex.15 A solid right cylinder of length ● stands upright at rest on the bottom of a large tub filled with water up to height h as shown in the figure-I. Density of material of the cylinder equals to that of water. Now the cylinder is pulled slowly out of water with the help of a thin light inextensible thread as shown in figure-II. Find the work done by the tension force develop in the thread.

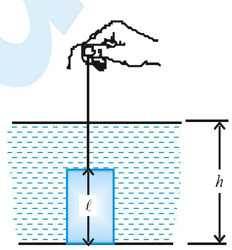


Figure -I

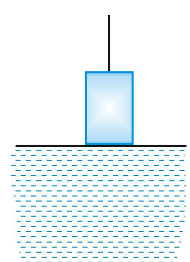


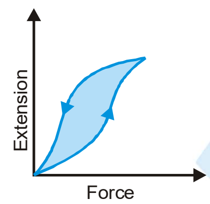
Figure -II

(A) mgh   **(B)** mg●   **(C)** 0.5 mg●   **(D)** mg(0.5●+h)

Sol. Work done by tension force = work done by gravity = 0.5 mg●

Ex.16 The diagram shows a force-extension graph for a rubber band.

Consider the following statements



I. It will be easier to compress this rubber than expand it.

II. Rubber does not return to its original length after it is stretched.

III. The rubber band will get heated if it is stretched and released.

Which of these can deduced from the graph-

(A) III only **(B)** II and III **(C)** I and III **(D)** I only

Sol. Area of hysterisis loop gives the energy loss in the process of stretching and unstretching of rubber band and this loss will appear in the form of heating.

Ex.17 n drops of a liquid, each with surface energy E, joining to form a single drop

(A) some energy will be released in the process

(B) some energy will be absorbed in the process

(C) the energy released or absorbed will be $E(n-n^{2/3})$

(D) the energy released or absorbed will be $nE\,(2^{2/3}-1)$

Sol. $E = T\,4\pi r^2 \Rightarrow \frac{4}{3}\pi R^3 = n \times \frac{4\pi}{3} r^3 \Rightarrow n = \frac{R^3}{r^3} \Rightarrow R = n^{1/3} r$

Surface energy of big drop $E' = T4\pi R^2 = T4\pi n^{2/3} r^2 = En^{2/3}$

Energy released $= nE - E' = nE - n^{2/3}E = E(n-n^{2/3})$

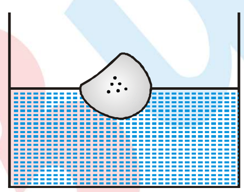
Ex.18 Some pieces of impurity (density $=\rho$) is embedded in ice. This ice is floating in water (density $= \rho_w$). When ice melts, level of water will

(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. 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.

Ex.19 A sphere is dropped into a viscous liquid of viscosity η from some height. If the density of material and liquid are ρ and σ respectively $(\rho > \sigma)$ then which of the following is/are incorrect.

(A) The acceleration of the sphere just after entering the liquid is $g\left(\frac{\rho-\sigma}{\rho}\right)$

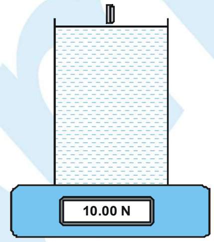
(B) Time taken to attain terminal speed $t \propto \rho^0$

(C) At terminal speed, the viscous force is maximum

(D) At terminal speed, the net force acting on the sphere is zero

Sol. Acceleration will be less than $g\left(\frac{\rho-\sigma}{\rho}\right)$. Time will depend on density ρ. Viscous force may be maximum or minimum both are possible

Ex.20 A glass full of water is placed on a weighing scale, which reads 10 N. A coin with weight 1 N is gently released into the water. At first, the coin accelerates as it falls and about halfway down the glass, the coin reaches terminal velocity. Eventually, the coin rests on the bottom of the glass. Acceleration due to gravity is 10 m/s^2. The scale reads



(A) 10.5 N when the coin accelerates at 5 m/s^2.

(B) 11.5 N, when the coin decelerates at 5 m/s^2.

(C) 11 N, when the coin moves with terminal velocity.

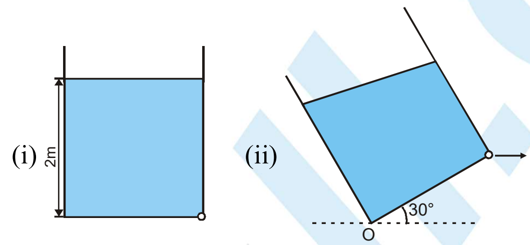
(D) 11 N, when the coin rests on the bottom.

Sol. When coin moves with terminal velocity or rests on the bottom Reading = 10 +1 = 11 N

When coin moves with acceleration of 5 m/s^2 Reading = 10 + 1 (½) = 10.5 N

Ex.21 to 23

Velocity of efflux in Torricelli's theorem is given by $v = \sqrt{2gh}$, here h is the height of hole from the top surface, after that, motion of liquid can be treated as projectile motion.



21. Liquid is filled in a vessel of square base (2m × 2m) upto a height of 2m as shown in figure (i). In figure (ii) the vessel is tilted from horizontal at 30°. What is the velocity of efflux in this case. Liquid does not spills out?

(A) 3.29 m/s **(B)** 4.96 m/s **(C)** 5.67 cm **(D)** 2.68 m/s

22. What is its time of fall of liquid on the ground?

(A) $\frac{1}{\sqrt{2}}$ s **(B)** $\frac{1}{\sqrt{3}}$ s **(C)** $\frac{1}{\sqrt{5}}$ s **(D)** √2s

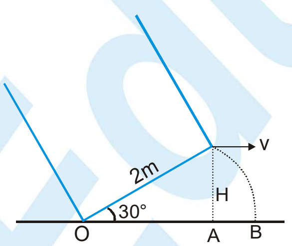
23. At what distance from point O, will be liquid strike on the ground?

(A) 5.24 m **(B)** 6.27 m **(C)** 4.93 m **(D)** 3.95 m

Sol.

21. The volume of liquid should remain unchanged. Hence, $2 \times 2 \times 2 = \frac{1}{2}\left[x + x + \frac{2}{\sqrt{3}}\right] \times 2$ $\quad \therefore \quad x \approx 1.42\,m$

Now $h = x \sin 60° = 1.23$ m $\quad \therefore \; v = \sqrt{2gh} = \sqrt{2 \times 10 \times 1.23} = 4.96\,m/s$

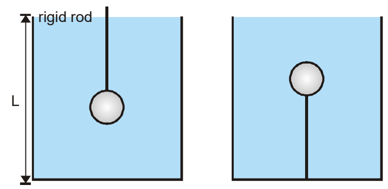
22. 

$H = 2 \sin 30° = 1m \quad \therefore \; t = \sqrt{\frac{2H}{g}} = \frac{1}{\sqrt{5}}\,s$

23. $OA = 2\cos 30° - \sqrt{3}\,m \Rightarrow AB = vt = \frac{(4.96)}{\sqrt{5}}\,s \quad \therefore OB = 3.95\,m$

Ex.24 to 26

A cylindrical container of length L is full to the brim with a liquid which has mass density ρ. It is placed on a weight-scale; the scale reading is w. A light ball which would float on the liquid if allowed to do so, of volume V and mass m is pushed gently down and held beneath the surface of the liquid with a rigid rod of negligible volume as shown on the left.



24. What is the mass M of liquid which overflowed while the ball was being pushed into the liquid?

(A) ρV **(B)** m **(C)** $m - \rho V$ **(D)** none of these

25. What is the reading of the scale when the ball is fully immersed

(A) $w - \rho Vg$ **(B)** w **(C)** $w + mg - \rho Vg$ **(D)** none of these

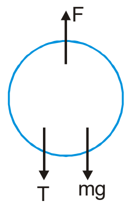
26. If instead of being pushed down by a rod, the ball is held in place by a thin string attached to the bottom of the container as shown on the right. What is the tension T in the string?

(A) $(\rho V – m)g$ **(B)** ρVg **(C)** mg **(D)** none of these

Sol.

24. Ball will displace V volume of liquid, whose mass in ρV.

25. Weight mg is entered while weight ρVg of liquid is overflowed.

26. 

$F = T + mg \Rightarrow V\rho g = T + mg \quad \therefore T = (V\rho - m)g$

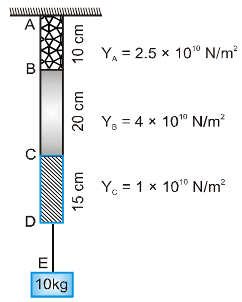
Ex.27 A ideal liquid is flowing in a tube as shown in figure. Area of cross-section at points A, B and C are A_1, A_2 and A_3 respectively ($A1 > A_3 > A_2$). v_1, v_2, $> v_3$ are the velocities at the points A, B and C respectively.

	Column I		Column II
(A)	h_1 is	**(P)**	Less than h_3
(B)	h_2 is	**(Q)**	More than h_3
(C)	v_1 is	**(R)**	Less than v_3
(D)	v_2 is	**(S)**	More than v_3
		(T)	The maximum value amongst the three velocities.

Sol. By using $A_1v_1 = A_2v_2 \rightarrow A_2 < A_3 < A_1 \therefore v_2 > v_3 > v_1$. Now by using $P + ½ \rho v^2 + \rho gh$ = constant

We have $P_2 < P_3 < P_1$ so $h_1 > h_3$ and $h_2 < h_3$

Ex.28 A light rod of uniform cross-section of 10^{-4} m² is shown in figure. The rod consists of three different materials. Assume that the string connecting the block and rod does not elongate.



Column I (Points)		**Column II (Displacements in μm)**	
(A)	B	**(P)**	4
(B)	C	**(Q)**	9
(C)	D	**(R)**	12
(D)	E	**(S)**	15
		(T)	24

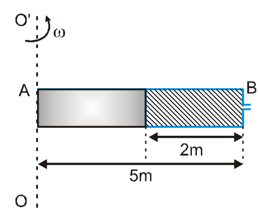
Sol. ✈ $Y = \dfrac{F/A}{\Delta l / l}$ $\quad \therefore \Delta l = \dfrac{Fl}{YA}$ $\qquad \Delta l_B = \dfrac{(100)(0.1)}{2.5 \times 10^{10} \times 10^{-4}} = 4 \times 10^{-6}\,\text{m} = 4\,\mu\text{m}$

$$\Delta l_c - \Delta l_B = \frac{(100)(0.2)}{(4 \times 10^{10})(10^{-4})} = 5 \times 10^{-6}\,\text{m} = 5\,\mu\text{m} \Rightarrow \Delta l_c = 9\,\mu\text{m}$$

$$\Delta l_D - \Delta l_C = \frac{(100)(0.15)}{(1 \times 10^{10})(10^{-4})} = 15 \times 10^{-6}\,\text{m} = 15\,\mu\text{m} \Rightarrow \Delta l_D = 24\,\mu\text{m}$$

Displacement of E = Displacement of D = 24 μm

Ex.29 A horizontal oriented tube AB of length 5 m rotates with a constant angular velocity 0.5 rad/s about a stationary vertical axis OO' passing through the end A. The tube is filled with ideal fluid. The end of the tube is open, the closed end B has a very small orifice. The velocity with which the liquid comes out from the hole (in m/s) is



Sol. Apply Bernoullie theorem between two ends

$$P_0 + \rho\int_3^5 x\omega^2 dx = P_0 + \frac{1}{2}\rho v^2 \Rightarrow \frac{\rho\omega^2}{2}[5^2 - 3^2] = \frac{1}{2}\rho v^2 \Rightarrow (0.5)2 \times 16 = v2 \Rightarrow v = 2\text{m/s}$$

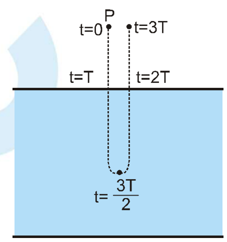
Ex.30 A square plate of 1m side moves parallel to a second plate with velocity 4 m/s. A thin layer of water exist between plates. If the viscous force is 2 N and the coefficient of viscosity is 0.01 poise then find the distance between the plates in mm.

Sol. $F = \dfrac{\eta A v}{d} \Rightarrow d = \dfrac{\eta A v}{F} = \dfrac{0.01 \times 10^{-1} \times 1^2 \times 4}{0.002} = 2\,\text{m}$

Ex.31 A container filled with air under pressure P_0 contains a soap bubble of radius R. The air pressure has been reduced to half isothermally and the new radius of the bubble becomes $\frac{5R}{4}$. If the surface tension of the soap water solution is S, P_0 is found to be $\frac{12nS}{R}$. Find the value of n.

Sol. $$\left(P_0+\frac{4S}{R}\right)\left(\frac{4}{3}\pi R^3\right)=\left(\frac{P_0}{2}+\frac{4S\times 4}{5R}\right)\times\frac{4}{3}\pi\left(\frac{5R}{4}\right)^3 \Rightarrow P_0+\frac{4S}{R}=\left(\frac{P_0}{2}+\frac{16S}{5R}\right)\frac{125}{64} \Rightarrow P_0=\frac{96S}{R}$$

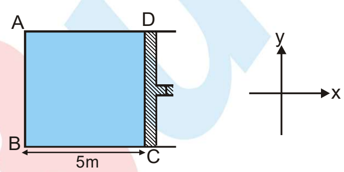
Ex.32 A ball of density ρ_0 falls from rest from a point P onto the surface of a liquid of density ρ in time T. It enters the liquid, stops, moves up, and returns to P in a total time 3T. Neglect viscosity, surface tension and splashing. Find the ratio of $\frac{\rho}{\rho_0}$.



Sol. It strike the surface of liquid with velocity $v_1 = gT$

In water (liquid) its time of flight $T=\frac{2v_1}{\left(\frac{\rho}{\rho_0}-1\right)g}=\frac{2gT}{\left(\frac{\rho}{\rho_0}-1\right)g} \Rightarrow \frac{\rho}{\rho_0}=3$

Ex.33 A cylinder fitted with piston as shown in figure. The cylinder is filled with water and is taken to a place where there is no gravity. Mass of the piston is 50 kg. The system is accelerated with acceleration 0.5 m/sec^2 in positive x–direction. Find the force exerted by fluid on the surface AB of the cylinder in decanewton. Take area of cross–section of cylinder to be 0.01 m^2 and neglect atmospheric pressure (1 decanewton =10N)

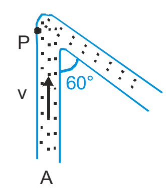


Sol. Force due to piston = 50 × 0.5 = 25 N

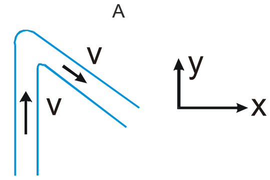
Force due to fluid = (ρah) A = A (1000 × 5 × 0.5) = 2500 Pa × 0.01 m^2 = 25 N

Force on the surface AB = 50N = 5 decanewton

Ex.34 Water (density ρ) is flowing through the uniform tube of cross-sectional area A with a constant speed v as shown in the figure. Find the magnitude of force exerted by the water on the curved corner of the tube is (neglect viscous forces)



Sol. $$|\Delta\vec{P}_x| = mv\sin 60° = \frac{\sqrt{3}}{2}mv$$



$$|\Delta\vec{P}_y| = \frac{mv}{2}+mv=\frac{3}{2}mv \quad\Rightarrow |\Delta\vec{P}_{net}| = \sqrt{\Delta P_x^2+\Delta P_y^2}=\sqrt{\left(\frac{9}{4}+\frac{3}{4}\right)}mv$$

$$|\Delta\vec{P}_{net}| = \sqrt{3}\,mv \Rightarrow |\Delta\vec{F}_{net}| = \sqrt{3}\left(\frac{dm}{dt}\right).v = \sqrt{3}\,\rho A v^2 \quad \left(\text{Since, } dm = A(v\,dt)\rho \Rightarrow \frac{dm}{dt}=A\rho v\right)$$

Exercise # 1

[Single Correct Choice Type Questions]

1. The lower surface of a cube is fixed. On its upper surface, force is applied at an angle of 30° from its surface. The change will be in its :–

(A) Shape **(B)** Size **(C)** Volume **(D)** Both shape and size.

2. Which one of the following substances possesses the highest elasticity :–

(A) Rubber **(B)** Glass **(C)** Steel **(D)** Copper

3. A 2m long rod of radius 1 cm which is fixed from one end is given a twist of 0.8 radians. The shear strain developed will be :–

(A) 0.002 **(B)** 0.004 **(C)** 0.008 **(D)** 0.016

4. If the density of the material increase, the value of Young's modulus :–

(A) increases **(B)** decreases

(C) first increases, then decreases **(D)** first decreases, then increases

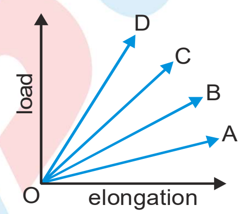
5. A force F is needed to break a copper wire having radius R. The force needed to break a copper wire of radius 2R will be :–

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

6. A fixed volume of iron is drawn into a wire of length ● . The extension produced in this wire by a constant force F is proportional to :–

(A) $\frac{1}{L^2}$ **(B)** $\frac{1}{L}$ **(C)** L^2 **(D)** L

7. The load versus elongation graph for four wires of the same material and same length is shown in the figure. The thinnest wire is represented by the line



(A) OA **(B)** OB **(C)** OC **(D)** OD

8. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied–

(A) Length 50 cm and diameter 0.5 mm **(B)** Length 100 cm and diameter 1 mm

(C) Length 200 cm and diameter 2 mm **(D)** Length 300 cm and diameter 3 mm

9. Two wires of the same material have lengths in the ratio 1 : 2 and their radii are in the ratio $1 : \sqrt{2}$. If they are stretched by applying equal forces, the increase in their lengths will be in the ratio :–

(A) 2 **(B)** $\sqrt{2} : 2$ **(C)** 1 : 1 **(D)** 1 : 2

10. An increases in pressure required to decreases the 200 litres volume of a liquid by 0.004% in container is : (Bulk modulus of the liquid = 2100 MPa) :–
(A) 188 kPa (B) 8.4 kPa (C) 18.8 kPa (D) 84 kPa

11. The area of cross–section of a wire of length 1.1 meter is 1 mm^2. It is loaded with 1 kg. If Young's modulus of copper is 1.1×10^{11} N/m^2, then the increase in length will be (If g = 10 m/s^2) :–
(A) 0.01 mm (B) 0.075 mm (C) 0.1 mm (D) 0.15 mm

12. The Young's modulus of a rubber string 8 cm long and density 1.5 kg/m^3 is 5×10^8 N/m^2, is suspended on the ceiling in a room. The increase in length due to its own weight will be :–
(A) 9.6×10^{-5} m (B) 9.6×10^{-11} m (C) 9.6×10^{-3} m (D) 9.6 m

13. Two wires of same diameter of the same material having the length ● and 2●. If the force F is applied on each, the ratio of the work done in the two wires will be :–
(A) 1 : 2 (B) 1 : 4 (C) 2 : 1 (D) 1 : 1

14. A ball falling in a lake of depth 200 m shows 0.1% decrease in its volume at the bottom. What is the bulk modulus of the material of the ball :–
(A) 19.6×10^8 N/m^2 (B) 19.6×10^{-10} N/m^2 (C) 19.6×10^{10} N/m^2 (D) 19.6×10^{-8} N/m^2

15. A weight is suspended from a long metal wire. If the wire suddenly breaks, its temperature :–
(A) Rises (B) Falls (C) Remains unchanged (D) Attains a value 0 K

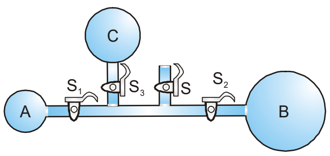
16. A brass rod of cross–sectional area 1 cm^2 and length 0.2 m is compressed lengthwise by a weight of 5 kg. If Young's modulus of elasticity of brass is 1×10^{11} N/m^2 and g = 10 m/sec^2, then increase in the energy of the rod will be :–
(A) 10^{-5} joule (B) 2.5×10^{-5} joule (C) 5×10^{-5} joule (D) 2.5×10^{-4} joule

17. The length of needle floating on the surface of water is 1.5 cm. The force in addition to its weight required to lift the needle from water surface will be (surface tension of water = 7.5 N/cm) :–
(A) 22.5 N (B) 2.25 N (C) 0.25 N (D) 225 N

18. The radius of a soap bubble is r. The surface tension of soap solution is T. Keeping temperature constant, the radius of the soap bubble is doubled, the energy necessary for this will be :–
(A) $24 \pi r^2 T$ (B) $8 \pi r^2 T$ (C) $12 \pi r^2 T$ (D) $16 \pi r^2 T$

19. The ring of radius 1m is lying on the surface of liquid. It is lifted from the liquid surface by a force of 4 Newtons in such a way that the liquid film in it remains intact. The surface tension of liquid will be :–
(A) $\frac{1}{2\pi}$ N/m (B) $\frac{1}{\pi}$ N/m (C) $\frac{1}{3\pi}$ N/m (D) $\frac{1}{4\pi}$ N/m

20. The adjoining diagram shows three soap bubbles A, B and C prepared by blowing the capillary tube fitted with stop cocks S, S_1, S_2 and S_3 with stop cock S closed and stop cocks S_1, S_2 and S_3 opened :–



(A) B will start collapsing with volumes of A and C increasing
(B) C will start collapsing with volumes of A and B increasing
(C) C and A will both start collapsing with the volume of B increasing
(D) Volumes of A, B and C will become equal at equilibrium

21. A liquid drop of diameter D breaks into 27 tiny drops. The resultant change in energy is :–

(A) $2\pi\,TD^2$ **(B)** $4\pi\,TD^2$ **(C)** $\pi\,TD^2$ **(D)** None of these

22. An air bubble is lying just below the surface of water. The surface tension of water is 70×10^{-3} Nm^{-1} and atmospheric pressure is 1.013×10^5 Nm^{-2}. If the radius of bubble is 1 mm, then the pressure inside the bubble will be :–

(A) 1.0270×10^5 Pa **(B)** 1.0160×10^5 Pa **(C)** 1.0144×10^5 Pa **(D)** 1.0131×10^5 Pa

23. Pressures inside two soap bubbles are 1.01 and 1.02 atmospheres. Ratio between their volumes is :–

(A) 102 : 101 **(B)** $(102)^3 : (101)^3$ **(C)** 8 : 1 **(D)** 2 : 1

24. A soap bubble in vacuum has a radius of 3 cm and another soap bubble in vacuum has a radius of 4 cm. If the two bubbles coalesce under isothermal condition, then the radius of the new bubble is :–

(A) 2.3 cm **(B)** 4.5 cm **(C)** 5 cm **(D)** 7 cm

25. Two soap bubbles each of radius r are touching each other. The radius of curvature of the common surface will be:

(A) infinite **(B)** 2r **(C)** r **(D)** r/2

26. Shape of meniscus for a liquid of zero angle of contact is :–

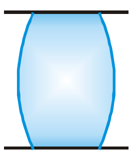
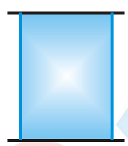
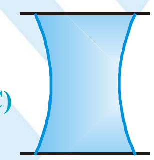
(A) Plane **(B)** Parabolic **(C)** Hemi–spherical **(D)** Cylindrical

27. If a wax coated capillary tube is dipped in water, then water in it will –

(A) Rise up **(B)** Depress

(C) Sometimes rise and sometimes fall **(D)** Rise up and come out as a fountain

28. If a water drop is kept between two glass plates, then its shape is :–

(A)  **(B)**  **(C)**  **(D)** None the these

29. Two capillary tubes of same diameter are put vertically one each in two liquids whose relative densities are 0.8 and 0.6 and surface tensions are 60 dyne/cm and 50 dyne/cm respectively. Ratio of heights of liquids in the two tubes $\frac{h_1}{h_2}$ is :–

(A) $\frac{10}{9}$ **(B)** $\frac{3}{10}$ **(C)** $\frac{10}{3}$ **(D)** $\frac{9}{10}$

30. Water rises to a height h in a capillary at the surface of earth. On the surface of the moon the height of water column in the same capillary will be :–

(A) 6h **(B)** $\frac{1}{6}h$ **(C)** h **(D)** zero

31. The height to which water rises in a capillary will be :–

(A) Maximum at 4° C **(B)** Maximum at 0° C **(C)** Minimum at 0° C **(D)** Minimum at 4° C

32. In a capillary tube experiment, a vertical 30 cm long capillary tube is dipped in water. The water rises up to a height of 10 cm due to capillary action. If this experiment is conducted in a freely falling elevator, the length of the water column becomes :–

(A) 10 cm **(B)** 20 cm **(C)** 30 cm **(D)** Zero

33. Water rises to a height of 16.3 cm in a capillary of height 18 cm above the water level. If the tube is cut at a height of 12 cm :–
(A) Water will come as a fountain from the capillary tube
(B) The height of the water in the capillary will be 12 cm
(C) The height of the water in the capillary will be 16.3 cm
(D) Water will flow down in it's arms

34. If a capillary of radius r is dipped in water, the height of water that rises in it is h and its mass is M. If the radius of the capillary is doubled the mass of water that rises in the capillary will be :–
(A) 4M (B) 2M (C) M (D) $\frac{M}{2}$

35. Water rises in a capillary upto a height h. If now this capillary is tilted by an angle of 45°, then the length of the water column in the capillary becomes :–
(A) 2h (B) $\frac{h}{2}$ (C) $\frac{h}{\sqrt{2}}$ (D) $h\sqrt{2}$

36. A vessel, whose bottom has round holes with diameter of 0.1 mm, is filled with water. The maximum height to which the water can be filled without leakage is :– (S.T. of water = 75 dyne/cm, g = 1000 cm/s^2)
(A) 100 cm (B) 75 cm (C) 50 cm (D) 30 cm

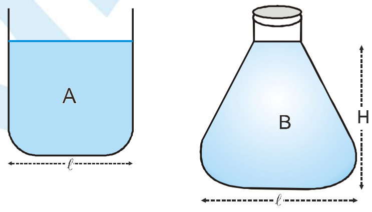
37. Calculate the force required to separate the glass plate of area 10^{-2} m^2 with a film of water 0.05 mm thick [surface tension of water is 70×10^{-3} N/m] :–
(A) 25 N (B) 20 N (C) 14 N (D) 28 N

38. To what height h should a cylindrical vessel of diameter d be filled with a liquid so that the total force on the vertical surface of the vessel be equal to the force on the bottom :–
(A) h = d (B) h = 2d (C) h = 3d (D) h = d/2

39. A crown made of gold and copper weights 210 g in air and 198 g in water. The weight of gold in crown is:–[Given : Density of gold = 19.3 g/cm^3 and Density of copper = 8.5 g/cm^3]
(A) 93 g (B) 100 g (C) 150 g (D) 193 g

40. Water stands upto a height h behind the vertical wall of a dam. What is the net horizontal force pushing the dam down by the stream, if width of the dam is σ ? (ρ = density of water) :–
(A) $2h\sigma g$ (B) $\frac{h^2\sigma\rho g}{2}$ (C) $\frac{h^2\sigma\rho g}{4}$ (D) $\frac{h\sigma\rho g}{4}$

41. Two vessels A and B have the same base area and contain water to the same height, but the mass of water in A is four times that in B. The ratio of the liquid thrust at the base of A to that at the base of B is :–



(A) 4 : 1 (B) 2 : 1 (C) 1 : 1 (D) 16 : 1

42. The side of glass aquarium is 1 m high and 2 m long. When the aquarium is filled to the top with water, what is the total force against the side–
(A) 980×10^3 N (B) 9.8×10^3 N (C) 0.98×10^3 N (D) 0.098×10^3 N

43. A U–tube is partially filled with water. Oil which does not mix with water is next poured into one side, until water rises by 25 cm on the other side. If the density of the oil is 0.8 g/cc, the oil level will stand higher than the water level by :–

(A) 6.25 cm **(B)** 12.50 cm **(C)** 18.75 cm **(D)** 25.00 cm

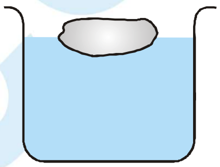
44. The barometric pressure and height on the earth are 10^5 Pa and 760 mm respectively. If it is taken to moon, then barometric height will be :–

(A) 76 mm **(B)** 126.6 mm **(C)** Zero **(D)** 760 mm

45. The gauge pressure of 3×10^5 N/m^2 must be maintained in the main water pipes of a city. How much work must be done to pump 50,000 m^3 of water at a pressure of 1.0×10^5 N/m^2–

(A) 10^{11} J **(B)** 10^{10} J **(C)** 10^9 J **(D)** 10^8 J

46. A body floats in a liquid contained in a beaker. The whole system is shown in figure falling under gravity. The upthrust on the body due to liquid is :–



(A) zero

(B) equal to weight of liquid displaced

(C) equal to weight of the body in air

(D) equal to the weight of the immersed body.

47. When a large bubble rises from the bottom of a lake to the surface, its radius doubles. If atmospheric pressure is equal to that of column of water height H, then the depth of lake is :–

(A) H **(B)** 2H **(C)** 7H **(D)** 8H

48. A body of volume 100 c.c. is immersed completely in water contained in a jar. The weight of water and the jar before immersion of the body was 700g wt. After immersion weight of water and jar will be

(A) 700 g wt **(B)** 800 g wt **(C)** 500 g wt **(D)** 100 g wt

49. A boat having a length of 3 metre and breadth 2 metre is floating on a lake. The boat sinks by one cm when a man gets on it. The mass of the man is

(A) 60 kg **(B)** 62 kg **(C)** 72 kg **(D)** 128 kg

50. A sample of metal weights 210 grams in air, 180 grams in water and 120 grams in an unknown liquid. Then:–

(A) the density of metal is 3 g/cm^3

(B) the density of metal is 7 g/cm^3

(C) density of metal is 4 times the density of the unknown liquid

(D) the metal will float in water

51. The total weight of a piece of wood is 6 kg In the floating state in water its 1/3part remains inside the water. On this floating solid, what maximum weight is to be put such that the whole of the piece of wood is to be drowned in the water :–

(A) 12 kg **(B)** 10 kg **(C)** 14 kg **(D)** 15 kg

52. A piece of ice with a stone frozen in it on water is kept in a beaker. The level of water when ice completely melts–

(A) Increase **(B)** Decrease **(C)** Remain the same **(D)** None of these

53. A wooden cube first floats inside water when a 200 g mass is placed on it. When the mass is removed the cube is 2 cm above water level. The side of cube is :–

(A) 5 cm **(B)** 10 cm **(C)** 15 cm **(D)** 20 cm

54. A wooden block of volume 1000 cm^3 is suspended from a spring balance. Its weight is 12 N in air. It is suspended in water such that half of the block is below the surface of water. The reading of spring balance is :–

(A) 10 N **(B)** 9 N **(C)** 8 N **(D)** 7 N

55. A rectangular block is 5 cm × 5cm × 10 cm. The block is floating in water with 5 cm side vertical. If it floats with 10 cm side vertical, what change will occur in the level of water :–
(A) No change (B) It will rise
(C) It will fall (D) It may rise or fall depending on the density of block.

56. Streamline motion is that motion in which there is:–
(A) Only longitudinal velocity gradient (B) Only radial velocity gradient
(C) Longitudinal as well as radial velocity gradient (D) Neither longitudinal nor radial velocity gradient

57. A boat carrying a number of large stones is floating in a water tank. What will happen to the water level if the stones are unloaded into the water :–
(A) Rise (B) Fall
(C) Remain unchanged (D) Rise till half the number of stones are unloaded and then begin to fall

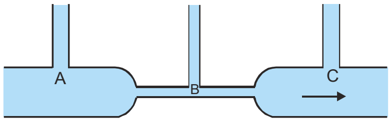
Hydro Dynamics

58. One end of a horizontal pipe is closed with the help of a valve and the reading of a barometer attached to the pipe is 3×10^5 pascal. When the value in the pipe is opened then the reading of barometer falls to 10^5 pascal. The velocity of water flowing through the pipe will be in m/s :–
(A) 0.2 (B) 2 (C) 20 (D) 200

59. An aeroplane of mass 3×10^4 kg and total wing area of 120 m^2 is in a level flight at some height. The difference in pressure between the upper and lower surfaces of its wings in kilo pascal is ($g=10 m/s^2$) :–
(A) 2.5 (B) 5.0 (C) 10.0 (D) 12.5

60. 16 cm^3 of water flows per second through a capillary tube of radius a cm and of length ● cm when connected to a pressure head of h cm of water. If a tube of the same length and radius a/2 cm is connected to the same pressure head, the quantity of water flowing through the tube per second will be:–
(A) 16 cm^3 (B) 4cm^3 (C) 1 cm^3 (D) 8 cm^3

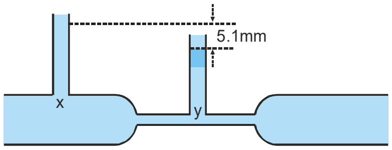
61. In the figure below is shown the flow of liquid through a horizontal pipe. Three tubes A, B and C are connected to the pipe. The radii of the tubes, A, B and C at the junction are respectively 2 cm, 1 cm. and 2 cm. It can be said that the :–
(A) Height of the liquid in the tube A is maximum
(B) Height of the liquid in the tubes A and B is the same
(C) Height of the liquid in all the three tubes is the same
(D) Height of the liquid in the tubes A and C is the same



62. A tank of height 5 m is full of water. There is a hole of cross sectional area 1 cm^2 in its bottom. The initial volume of water that will come out from this hole per second is :–
(A) 10^{-3} m^3/s (B) 10^{-4} m^3/s (C) 10 m^3/s (D) 10^{-2} m^3/s

63. Water contained in a tank flows through an orifice of a diameter 2 cm, under a constant pressure difference of 10 cm of water column. The rate of flow of water through the orifice is:–
(A) 44 cc/s (B) 4.4 cc/s (C) 444 cc/s (D) 4400 cc/s

64. The diagram (figure) shows a venturimeter, through which water is flowing. The speed of water at X is 2 cm/s. The speed of water at Y (taking $g = 1000$ cm/s^2) is :–



(A) 23 cm/s (B) 32 cm/s (C) 101 cm/s (D) 1024 cm/s

65. With increase in temperature, the viscosity of :–
(A) Gases decreases and liquid increases
(B) Gases increases and liquid decreases
(C) Both gases and liquid increases
(D) Both gases and liquid decreases

66. More viscous oil is used in summer than in winter in motors due to :–
(A) Rise in temperature in summer, the viscosity of oil decreases
(B) Rise in temperature in summer, viscosity of oil increases
(C) Surface tension of oil increases
(D) Surface tension of oil decreases

67. Two liquids of densities d_1 and d_2 are flowing in identical capillaries under same pressure difference. If t_1 and t_2 are the time taken for the flow of equal quantities of liquids, then the ratio of coefficients of viscosities of liquids must be :–

(A) $\frac{d_1 d_2}{t_1 t_2}$
(B) $\frac{d_1 t_1}{d_2 t_2}$
(C) $\frac{d_1 t_2}{d_2 t_1}$
(D) $\sqrt{\left(\frac{d_1 t_1}{d_2 t_2}\right)}$

68. A rain drop of radius 0.3 mm has a terminal velocity in air 1m/s. The viscosity of air is 18×10^{-5} poise. The viscous force on it is :–
(A) 101.73×10^{-4} dyne
(B) 101.73×10^{-5} dyne
(C) 16.95×10^{-5} dyne
(D) 16.95×10^{-4} dyne

69. The rate of flow of liquid through a capillary tube, in an experiment to determine the viscosity of the liquid, increases
(A) When the pressure of the tube is increased
(B) When the length of the tube is increased
(C) When the radius of the tube is decreased
(D) None of the above

70. The velocity of falling rain drop attain limited value because of :–
(A) Surface tension
(B) Upthrust due to air
(C) Viscous force exerted by air
(D) Air current

71. Two drops of equal radius are falling through air with a steady velocity of 5cm/sec. If the two drops coalesce, then its terminal velocity will be :–

(A) $4^{\frac{1}{3}} \times 5\ \text{cm/s}$
(B) $4^{\frac{1}{3}}$ cm/s
(C) $5^{\frac{1}{3}} \times 4\ \text{cm/s}$
(D) $4^{\frac{2}{3}} \times 5\ \text{cm/s}$

72. A copper ball of radius 'r' travels with a uniform speed 'v' in a viscous fluid. If the ball is changed with another ball of radius '2r', then new uniform speed will be :–
(A) v
(B) 2v
(C) 4v
(D) 8v

Exercise # 2 — Part # I [Multiple Correct Choice Type Questions]

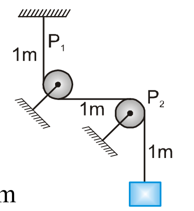
1. A steel wire 1.5 m long and of radius 1 mm is attached with a load 3 kg at one end the other end of the wire is fixed it is whirled in a vertical circle with a frequency 2Hz. Find the elongation of the wire when the weight is at the lowest position– ($Y = 2 \times 10^{11}$ N/m² and g = 10 m/s²)

(A) 1.77×10^{-3} m **(B)** 7.17×10^{-3} m **(C)** 3.17×10^{-7} m **(D)** 1.37×10^{-7} m

2. One end of uniform wire of length L and of weight W is attached rigidly to a point in the roof and a weight W is suspended from its lower end. If s is the area of cross–section of the wire, the stress in the wire at a height $\frac{L}{4}$ from its lower end is :–

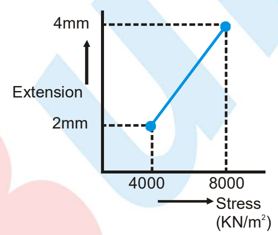
(A) $\frac{W_1}{s}$ **(B)** $\frac{\left[W_1 + \frac{W}{4}\right]}{s}$ **(C)** $\frac{\left[W_1 + \frac{3W}{4}\right]}{s}$ **(D)** $\frac{W_1 + W}{4}$

3. A copper wire of length 3m and area of cross–section 1 mm², passes through an arrangement of two frictionless pulleys, P_1 and P_2. One end of the wire is rigidly clamped and a mass of 1 kg is hanged from the other end. If the Young's modulus for copper is 10×10^{10} N/m², then the elongation in the wire is–



(A) 0.05 mm **(B)** 0.1 mm **(C)** 0.2 mm **(D)** 0.3 mm

4. In determination of young modulus of elasticity of wire, a force is applied and extension is recorded. Initial length of wire is '1m'. The curve between extension and stress is depicted then Young modulus of wire will be:

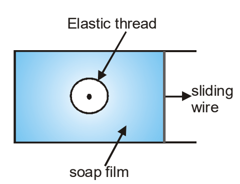


(A) 2×10^9 N/m² **(B)** 1×10^9 N/m² **(C)** 2×10^{10} N/m² **(D)** 1×10^{10} N/m²

5. One end of a long metallic wire of length L area of cross section A and Young's modulus Y is tied to the ceiling. The other end is tied to a massless spring of force constant k. A mass m hangs freely from the free end of the spring. It is slightly pulled down and released. Its time period is given by–

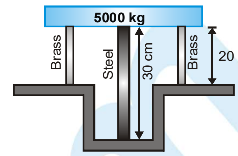
(A) $2\pi\sqrt{\frac{m}{k}}$ **(B)** $2\pi\sqrt{\frac{mYA}{kL}}$ **(C)** $2\pi\sqrt{\frac{mk}{YA}}$ **(D)** $2\pi\sqrt{\frac{m(kL + YA)}{kYA}}$

6. The figure shows a soap film in which a closed elastic thread is lying. The film inside the thread is pricked. Now the sliding wire is moved out so that the surface area increases. The radius of the circle formed by elastic thread will :



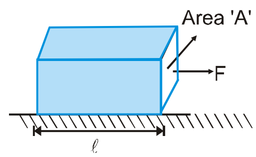
(A) increase **(B)** decreases **(C)** remains same **(D)** data insufficient

7. A steel rod of cross–sectional area 16 cm^2 and two brass rods of cross section area 10 cm^2 together support a load of 5000 kg as shown in figure. The stress in steel rod will be : (Take Y for steel = 2.0×10^6 N/cm^2 and for brass = 1.0×10^6 N/cm^2)



(A) 161.2 N/cm^2 **(B)** 151.4 N/cm^2 **(C)** 131.4 N/cm^2 **(D)** None of these

8. A block of mass 'M' area of cross–section 'A' & length '●' is placed on smooth horizontal floor. A force 'F' is applied on the block as shown. If Y is young modulus of material , then total extension in the block will be:



(A) $\frac{Fl}{AY}$ **(B)** $\frac{Fl}{2AY}$ **(C)** $\frac{Fl}{3AY}$ **(D)** cannot extend

9. Water rise in a capillary upto a extension height such that upward force of surface tension balances the force of 75×10^{-4} N due to weight of water. If surface tension of water is 6×10^{-2} N/m. The internal circumference of the capillary must be :–

(A) 12.5×10^{-2} m **(B)** 6.5×10^{-2} m **(C)** 0.5×10^{-2} m **(D)** 1.25×10^{-2} m

10. There are two thin films, A of liquid and B of polythene, identical in size. They are being pulled with same maximum weight W. If the breadth of the films is increased from b to 2b then the corresponding weights will be respectively.

(A) W, W **(B)** $\frac{W}{2}, \frac{W}{2}$ **(C)** $\frac{W}{2}$, W **(D)** W, $\frac{W}{2}$

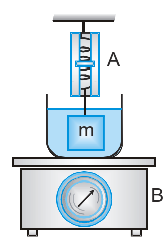
11. In a U–tube diameter of two limbs are 0.5 cm and 1 cm respectively and tube has filled with water (T = 72 dyne/cm) then liquid level difference between two limbs will be :–

(A) 0.5 cm **(B)** 0.25 cm **(C)** 0.293 cm **(D)** none of these

12. On dipping a capillary of radius 'r' in water, water rises upto a height H and potential energy of water is u_1. If a capillary of radius 2r is dipped in water, then the potential energy is u_2. The ratio $\frac{u_1}{u_2}$ is :–

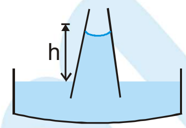
(A) 2 : 1 **(B)** 1 : 2 **(C)** 4 : 1 **(D)** 1 : 1

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



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

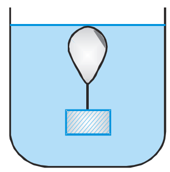
14. A capillary of the shape as shown is dipped in a liquid. Contact angle between the liquid and the capillary is 0° and effect to liquid inside the meniscus is to be neglected. T is surface tension of the liquid, r is radius of the meniscus, g is acceleration due to gravity and ρ is density of the liquid then height h in equilibrium is:



(A) Greater than $\frac{2T}{r\rho g}$ (B) Equal to $\frac{2T}{r\rho g}$

(C) Less than $\frac{2T}{r\rho g}$ (D) Of any value depending upon actual value

15. A balloon filled with air is weighted, so that it barely floats in water as shown in figure. When it is pushed down so that it gets submerged a short distance in water, then the balloon :–



(A) Will come up again to its former position (B) Will remain in the position it is left

(C) Will sink to the bottom (D) Will emerge out of liquid

16. A steel ball is floating in a trough of mercury. If we fill the empty part of the trough with water, what will happen to the steel ball :–

(A) It will continue in its position (B) It will move up

(C) It will move down (D) It will execute vertical oscillations

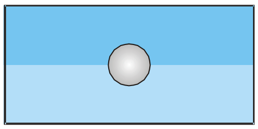
17. A wooden ball of density D is immersed in water of density d to a depth h below the surface of water upto which the ball will jump out of water is :–

(A) $\frac{d}{D}h$ (B) $\left[\frac{d}{D}-1\right]h$ (C) h (D) zero

18. A spherical ball of radius r and relative density 0.5 is floating in equilibrium in water with half of it immersed in water. The work done in pushing the ball down so that whole of it is just immersed in water is [ρ is the density of water] –

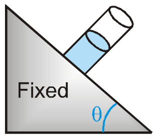
(A) 0.25 ρ rg (B) 0.5 ρ rg (C) $\frac{4}{3}\pi r^3\rho g$ (D) $\frac{5}{12}\pi r^4\rho g$

19. A solid uniform ball having volume V and density ρ floats at the interface of two unmixible liquids as shown in figure. The densities of the upper and the lower liquids are ρ_1 and ρ_2 respectively, such that $\rho_1 < \rho < \rho_2$. What fraction of the volume of the ball will be in the lower liquid :–



(A) $\frac{\rho-\rho_2}{\rho_1-\rho_2}$ (B) $\frac{\rho_1}{\rho_1-\rho_2}$ (C) $\frac{\rho_1-\rho}{\rho_1-\rho_2}$ (D) $\frac{\rho_1-\rho_2}{\rho_2}$

20. A cylindrical vessel filled with water is released on an inclined surface of angle θ as shown in figure. The friction coefficient of surface with vessel is μ(< tanθ). Then the constant angle made by the surface of water with the incline will be–

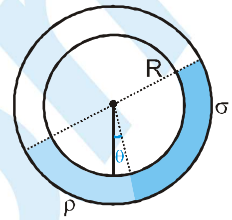


(A) $\tan^{-1}\mu$ (B) $\theta - \tan^{-1}\mu$ (C) $\theta + \tan^{-1}\mu$ (D) $\cot^{-1}\mu$

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

(A) $\frac{v}{n}\left[\frac{R}{r}\right]$ **(B)** $\frac{v}{n}\left[\frac{R}{r}\right]^{\frac{1}{2}}$ **(C)** $\frac{v}{n}\left[\frac{R}{r}\right]^{\frac{3}{2}}$ **(D)** $\frac{v}{n}\left[\frac{R}{r}\right]^{2}$

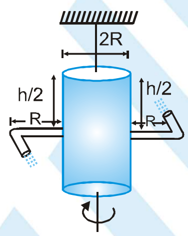
22. A small uniform tube is bent into a circular tube of radius R and kept in the vertical plane. Equal volumes of two liquids of densities ρ and σ (ρ > σ) fill half of the tube as shown. θ is the angle which the radius passing through the interface makes with the vertical. The value of θ is :–



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

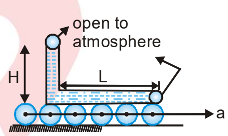
(C) $\theta = \tan^{-1}\left(\frac{\rho}{\rho+\sigma}\right)$ **(D)** $\theta = \tan^{-1}\left(\frac{\rho}{\rho-\sigma}\right)$

23. 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–



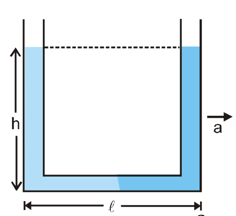
(A) 4 aghρR **(B)** 8 aghρR **(C)** 2 aghρR **(D)** none of these

24. A narrow tube completely filled with a liquid is lying on a series of cylinder 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



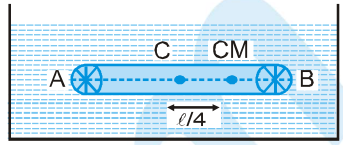
(A) $\frac{gH}{2L}$ **(B)** $\frac{gH}{L}$ **(C)** $\frac{2gH}{L}$ **(D)** $\frac{gH}{\sqrt{2}L}$

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



(A) $\frac{a}{2g}1$ **(B)** $\frac{3a}{2g}1$ **(C)** $\frac{a}{g}1$ **(D)** $\frac{2a}{3g}1$

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

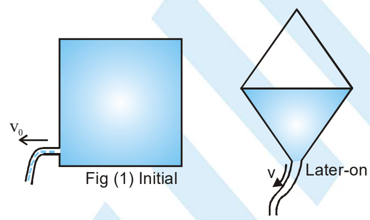


(A) $\frac{\pi\rho g l^2 r^2}{I}$ **(B)** $\frac{\pi\rho g l^2 r^2}{4I}$ **(C)** $\frac{\pi\rho g l^2 r^2}{2I}$ **(D)** $\frac{3\pi\rho g l^2 r^2}{4I}$

27. Water filled in an empty tank of area 10 A through a tap of cross sectional area A. The speed of water flowing out of tap is given by v (m/s) = $10\left(1-\sin\frac{\pi}{30}t\right)$ where 't' is in seconds. The height of water level from the bottom of the tank at t = 15 second will be:

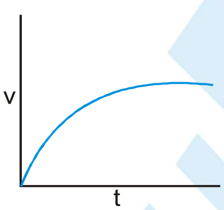
(A) 10m **(B)** $\left[15+\frac{30}{\pi}\right]$m **(C)** $\frac{5}{4}$m **(D)** $\left[15-\frac{30}{\pi}\right]$m

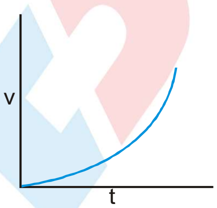
28. A square box of water has a small hole located in one of the bottom corner. When the box is full and sitting on a level surface, complete opening of the hole results in a flow of water with a speed v_0, as shown in figure (1). When the box is tilted by 45° and half filled so that the hole is at the lowest point. Now the water will flow out with a speed of:

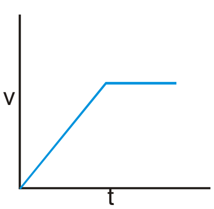


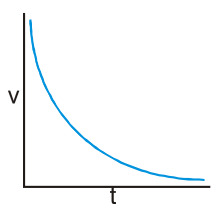
(A) v_0 **(B)** $\frac{v_0}{2}$ **(C)** $\frac{v_0}{\sqrt{2}}$ **(D)** $\frac{v_0}{\sqrt[4]{2}}$

29. A piece of cork starts from rest at the bottom of a lake and floats up. Its velocity v is plotted against time t. Which of the following best represents the resulting curve–

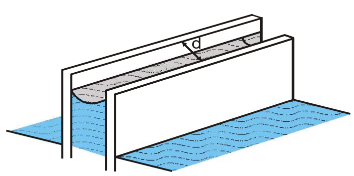
(A) 

(B) 

(C) 

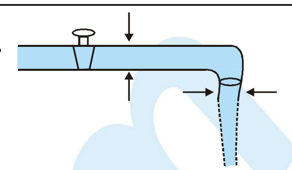
(D) 

30. Two very wide parallel glass plates are held vertically at a small separation d, and dipped in water. Some water climbs up in the gap between the plates. Let S be the surface tension of water, P_0 = atmospheric pressure, P = pressure of water just below the water surface in the region between the plates–



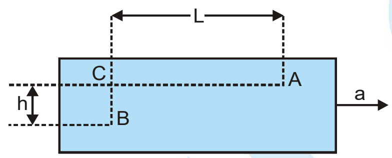
(A) $P = P_0 - \frac{2S}{d}$ **(B)** $P = P_0 + \frac{2S}{d}$ **(C)** $P = P_0 - \frac{4S}{d}$ **(D)** $P = P_0 + \frac{4S}{d}$

31. Water coming out of the mouth of a tap and falling vertically in streamline flow forms a tapering column, i.e., the area of cross–section of the liquid column decreases as it moves down. Which of the following is the most accurate explanation for this :-



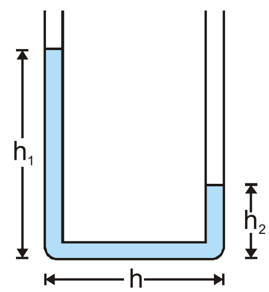
(A) As the water moves down, its speed increases and hence its pressure decreases. It is then compressed by the atmosphere.
(B) Falling water tries to reach a terminal velocity and hence reduces the area of cross–section to balance upward and downward forces.
(C) The mass of water flowing past any cross–section must remain constant. Also, water is almost incompressible. Hence, the rate of volume flow must remain constant. As this is equal to velocity × area, the area decreases as velocity increases.
(D) The surface tension causes the exposed surface area of the liquid to decrease continuously.

32. A sealed tank containing a liquid of density ρ moves with a horizontal acceleration a, as shown in the figure. The difference in pressure between the points A and B is–



(A) hρg **(B)** ●ρa **(C)** hρg – ●ρa **(D)** hρg + ●ρa

33. The U–tube shown has a uniform cross–section. A liquid is filled in the two arms up to heights h_1 and h_2, and then the liquid is allowed to move. Neglect viscosity and surface tension. When the levels equalize in the two arms, the liquid will–



(A) be at rest

(B) be moving with an acceleration of $g\left(\dfrac{h_1 - h_2}{h_1 + h_2 + h}\right)$

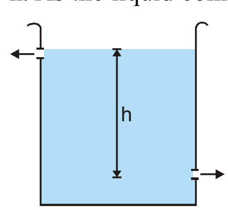
(C) be moving with a velocity of $(h_1 - h_2)\sqrt{\dfrac{g}{2(h_1 + h_2 + h)}}$

(D) exert a net force to the right on the tube

34. A U–tube of uniform cross–section is partially filled with a liquid I. Another liquid II which does not mix with liquid I is poured into one side. It is found that the liquid levels of the two sides of the tube are the same, while the level of liquid I has risen by 2 cm. If the specific gravity of liquid I is 1.1, the specific gravity of liquid II must be :–

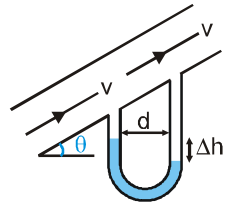
(A) 1.12 **(B)** 1.1 **(C)** 1.05 **(D)** 1.0

35. 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 between the two holes is h. As the liquid comes out of the two holes, the tank will experience a net horizontal force proportional to–



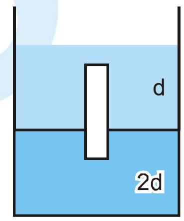
(A) $\sqrt{h}$ **(B)** h **(C)** $h^{3/2}$ **(D)** h^2

36. A mercury manometer is connected as shown in the figure. The difference in height Δh is : (symbols have usual meaning).



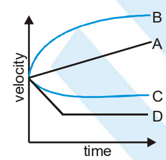
(A) $\dfrac{\rho d \cot\theta}{\rho_{Hg}}$ **(B)** $\dfrac{\rho d \tan\theta}{\rho_{Hg}}$ **(C)** $\dfrac{\rho d \sin\theta}{\rho_{Hg}}$ **(D)** None of these

37. A homogeneous solid cylinder of length L (L < H/2), cross–sectional area A/5 is immersed such that it floats with its axis vertical at the liquid–liquid interface with length L/4 in the denser liquid as shown in the figure. The lower density liquid is open to atmosphere having pressure P_0. Then, density D of solid is given by :–



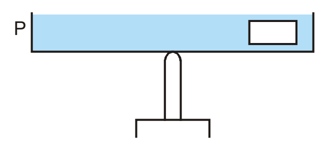
(A) $\frac{5}{4}d$ **(B)** $\frac{4}{5}d$ **(C)** 4d **(D)** $\frac{d}{5}$

38. A small ball is left in a viscous liquid form very much height. Correct graph of its velocity with time is :–



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

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



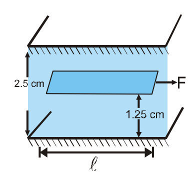
(A) Equilibrium will be maintained only if $\rho < \rho_w$

(B) Equilibrium will be maintained only $\rho \le \rho_w$

(C) Equilibrium will be maintained for all relations between ρ and ρ_w

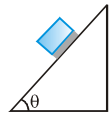
(D) Equilibrium will not be maintained in all cases.

40. A space 2.5 cm wide between two large plane surfaces is filled with oil. Force required to drag a very thin plate of area 0.5 m^2 just midway the surfaces at a speed of 0.5 m/s is 1N. The coefficient of viscosity in kg–sec/m^2 is:



(A) 5×10^{-2} **(B)** 2.5×10^{-2} **(C)** 1×10^{-2} **(D)** 7.5×10^{-2}

41. A cubical block of side 'a' and density 'ρ' slides over a fixed inclined plane with constant velocity 'v'. There is a thin film of viscous fluid of thickness 't' between the plane and the block. Then the coefficient of viscosity of the thin film will be:



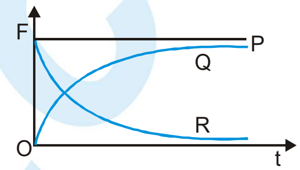
(A) $\dfrac{\rho a g t \sin\theta}{v}$ **(B)** $\dfrac{\rho a g t \cos\theta}{v}$ **(C)** $\dfrac{v}{\rho a g t \sin\theta}$ **(D)** None of these

42. If the terminal speed of a sphere of gold (density = 19.5 kg/m^3) is 0.2 m/s in a viscous liquid (density = 1.5 kg/m^3), find the terminal speed of a sphere of silver (density = 10.5 kg/m^3) of the same size in the same liquid.
(A) 0.4 m/s **(B)** 0.133 m/s **(C)** 0.1 m/s **(D)** 0.2 m/s

43. A large drop of oil, whose density is less than that of water, floats up through a column of water. Assume that the oil and the water do not mix. The coefficient of viscosity of the oil is η_o and that of water is η_W. The velocity of the drop will depend on–
(A) both η_o and η_W **(B)** η_o only **(C)** η_W only **(D)** neither η_o nor η_W

44. A small sphere of mass m is dropped from a height. After it has fallen 100 m, it has attained its terminal velocity and continues to fall at that speed. The work done by air friction against the sphere during the first 100 m of fall is :–
(A) Greater than the work done by air friction in the second 100 m
(B) Less tan the work done by air friction in the second 100 m
(C) Equal to 100 mg
(D) Greater than 100 mg

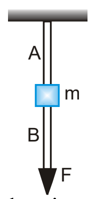
45. A spherical ball is dropped in a long column of viscous liquid. Which of the following graphs represent the variation of :–
(i) Gravitational force with time
(ii) Viscous force with time
(iii) Net force acting on the ball with time



(A) Q, R, P **(B)** R, Q, P **(C)** P, Q, R **(D)** R, P, Q

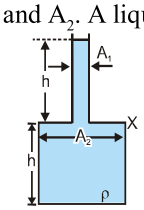
46. When a capillary tube is dipped in a liquid, the liquid rises to a height h in the tube. The free liquid surface inside the tube is hemispherical in shape. The tube is now pushed down so that the height of the tube outside the liquid is less than h:-
(A) The liquid will come out of the tube like in a small fountain.
(B) The liquid will ooze out of the tube slowly.
(C) The liquid will fill the tube but not come out of its upper end.
(D) The free liquid surface inside the tube will not be hemispherical.

47. The wires A and B shown in the figure are made of the same material, and have radii r_A and r_B respectively. The block between them has a mass m. When the force F is mg/3, one of the wires breaks–



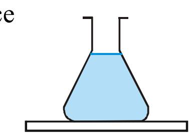
(A) A will break before B if $r_A = r_B$
(B) A will break before B if $r_A < 2r_B$
(C) Either A or B may break if $r_A = 2r_B$
(D) The lengths of A and B must be known to predict which wire will break

48. The vessel shown in the figure has two sections of areas of cross–section A_1 and A_2. A liquid of density ρ fills both the sections, up to a height h in each. Neglect atmospheric pressure:-



(A) The pressure at the base of the vessel is 2hρg.
(B) The force exerted by the liquid on the base of the vessel is $2h\rho gA_2$.
(C) The weight of the liquid is $< 2h\rho gA_2$.
(D) The walls of the vessel at the level X exert a downward force $h\rho g\,(A_2 - A_1)$ on the liquid.

49. A massless conical flask filled with a liquid is kept on a table in a vacuum. The force exerted by the liquid on the base of the flask is W_1. The force exerted by the flask on the table is W_2.



(A) $W_1 = W_2$ **(B)** $W_1 > W_2$ **(C)** $W_1 < W_2$
(D) The force exerted by the liquid on the walls of the flask is $(W_1 - W_2)$.

50. A vertical U–tube contains a liquid. The total length of the liquid column inside the tube is ●. When the liquid is in equilibrium, the liquid surface in one of the arms of the U–tube is pushed down slightly and released. The entire liquid column will undergo a periodic motion :–

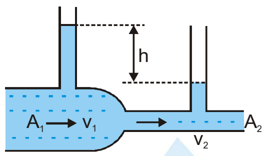
(A) The motion is not simple harmonic motion.

(B) The motion is simple harmonic motion.

(C) If it undergoes simple harmonic motion, the time period will be $2\pi\sqrt{\frac{l}{g}}$

(D) It is undergoes simple harmonic motion, the time period will be $2\pi\sqrt{\frac{l}{2g}}$

51. A liquid flows through a horizontal tube. The velocities of the liquid in the two sections, which have areas of cross–section A_1 and A_2, are v_1 and v_2 respectively. The difference in the levels of the liquid in the two vertical tubes is h–



(A) The volume of the liquid flowing through the tube in unit time is A_1v_1

(B) $v_2 - v_1 = \sqrt{2gh}$

(C) $v_2^2 - v_1^2 = 2gh$

(D) The energy per unit mass of the liquid is the same in both sections of the tube.

Part # II [Assertion & Reason Type Questions]

These questions contains, Statement 1 (assertion) and Statement II (reason).

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for Statement–I

(C) Statement–I is true, Statement–II is false

(D) Statement–I is false, Statement–II is true

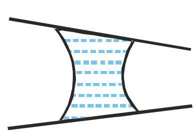
1. **Statement–I :** Upthrust on a solid block of iron when immersed in a lake will be less on the surface than on the bed of the lake.

Statement–II : On the surface of the lake density of water will be less than that at the bed and upthrust depends on the density of liquid.

2. **Statement–I :** A solid sphere and a hollow sphere of same material are floating in a liquid. Radius of both the spheres are same. Percentage of volume immersed of both the spheres will be same.

Statement–II : Upthrust acts on volume of liquid displaced. It has nothing to do whether the body is solid or hollow.

3. **Statement–I :** Two identical conical pipes shown in figure have a drop of water. The water drop tends to move towards tapered end.



Statement–II : Excess pressure is directed towards centre of curvature and inversely proportional to radius of curvature. Net excess pressure is therefore, directed towards tapered end. So the water drop tends to move towards tapered end.

4. **Statement–I :** Elasticity restoring forces may be conservative.
Statement–II : The value of strain for same stress are different while increasing the load and while decreasing the load.

5. **Statement–I :** A ball allowed to swing in a region of uniform wind motion, will get an uplift.
Statement–II : Due to swing of the ball in a region of uniform wind motion, the difference in a velocity of air flow is present between the lower and upper position of ball, leading to varying pressure.

6. **Statement–I :** Identical springs of steel and copper are equally stretched. More work will be done on the steel spring.
Statement–II : Steel is more elastic than copper

7. **Statement–I :** Young's modulus for a perfectly plastic body is zero.
Statement–II : For a perfectly plastic body, restoring force is zero.

8. **Statement–I :** The bridges are declared unsafe after a long use.
Statement–II : Elastic strength of bridges losses with time.

9. **Statement–I :** The velocity of horizontal flow of a ideal liquid is smaller where pressure is large and vice versa.
Statement–II : According to Barnoullis theorem for the stream line flow of an ideal liquid, the total energy per unit mass remains constant.

10. **Statement–I :** The angle of contact of a liquid decrease with increase in temperature.
Statement–II : With increase in temperature the surface tension of liquid increase.

11. **Statement–I :** The shape of an automobile is so designed that its front resembles the stream line pattern of the fluid through which it moves.
Statement–II : The shape of the automobile is made stream lined in order to reduce resistance offered by the fluid.

12. **Statement–I :** Machine parts are jammed in winter.
Statement–II : The viscosity of lubricant used in machine part decrease at low temperature.

13. **Statement–I :** It is better to wash the clothes in cold soap solution.
Statement–II : The surface tension of cold solution is more than the surface tension of hot solution.:

14. **Statement–I :** In gravity free space, the liquid in a capillary tube will rise to infinite height.
Statement–II : In the absence of gravity , there will be no force to prevent the rise of liquid due to surface tension.

15. **Statement–I :** A parachute descends slowly whereas a stone dropped from same height falls rapidly.
Statement–II : The viscous force of air on parachute is larger than that of on a falling stone.

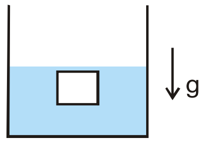
16. **Statement–I :** A gas filled balloon stops rising after it has attained a certain height in the sky.
Statement–II : At the highest point, the density of air is such that the buoyant force on the balloon just equals its weight.

17. **Statement–I :** Hot soup tastes better than the cold soup.
Statement–II : Hot soup spread properly on our tongue due to lower surface tension.

18. **Statement–I :** The stream of water emerging from a water tap "necks down" as it falls.
Statement–II : The volume flow rate at different levels is same.

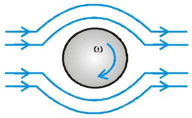
19. **Statement–I :** Roofs of buildings are blown off during a strong storm.
Statement–II : Roofs of buildings becomes lighter during storm.

20. **Statement–I :** A block is immersed in a liquid inside a beaker, which is falling freely. Buoyant force acting on block is zero.



Statement–II : In case of freely falling liquid there is no pressure difference between any two points.

21. **Statement–I :** As wind flows left to right and a ball is spined as shown, there will be a lift of the ball.



Statement–II : Decrease in velocity of air below the ball, increases the pressure more than that above the ball.

22. **Statement–I :** Leaves and small insects float on the surface of water buoyed up by Archimedes's principle.
Statement–II : They are not partially submerged. The objects are kept afloat by surface tension.

23. **Statement–I :** An ice cube is floating in water in a vessel at 0^0C. When ice cube melts, level of water in the vessel remain same.
Statement–II : Volume of melted ice is same as volume of water displaced by ice.

24. **Statement–I :** The stretching of a coil is determined by its shear modulus.
Statement–II : Shear modulus change only shape of a body keeping its dimensions unchanged

25. **Statement–I :** Weight of a empty balloon measured in air is w_1. If air at atmospheric pressure is filled inside balloon and again weight of balloon is measured. Weight of balloon is w_2 in second case. Then w_2 is equal to w_1.
Statement–II : Upthrust is equal to weight of the fluid displaced by the body.

26. **Statement–I :** At critical temperature, surface tension of liquid becomes zero.
Statement–II : At this temperature, intermolecular forces for liquids and gases become equal. Liquid can expand without any restriction.

27. **Statement–I :** The size of a hydrogen balloon increases as it rises in air.
Statement–II : The material of the balloon can be easily stretched.

28. **Statement–I :** When a large soap bubble and a small soap bubble are connected by a capillary tube, the large bubble expands and while the small bubble shrinks.
Statement–II : The excess pressure inside a bubble is inversely proportional to radius.

29. **Statement–I :** Specific gravity of a fluid is a dimensionless quantity.
Statement–II : It is the ratio of density of fluid to the density of water.

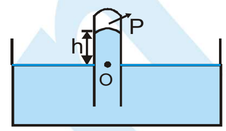
30. **Statement–I :** Smaller drops of liquid resist deforming forces better than the larger drops.
Statement–II : Excess pressure inside a drop is directly proportional to its surface area.

31. **Statement–I :** A thin stainless steel needle can lay floating on a still water surface.
Statement–II : Any object floats when the buoyancy force balances the weight of the object.

32. **Statement–I :** For Reynold number $R_e > 2000$, the flow of fluid is turbulent.
Statement–II : Inertial forces are dominant compared to the viscous forces at such high Reynold numbers.

Exercise # 3 Part # I [Matrix Match Type Questions]

1. A tube is inverted in a mercury vessel as shown in figure. If pressure P is increased, then :



	Column I		Column II
(A)	Height h	**(P)**	will increase
(B)	Pressure at O	**(Q)**	will decrease
(C)	Pressure at 1 cm above O	**(R)**	will remain same

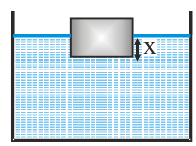
2. Two soap bubbles coalesce to form a single large bubble.:

	Column I		Column II
(A)	Surface energy in the process will	**(P)**	increase
(B)	Temperature of the bubble will	**(Q)**	decrease
(C)	Pressure inside the soap bubble will	**(R)**	remains same

3. A solid is immersed completely in a liquid. The coefficients of volume expansion of solid and the liquid are γ_1 and γ_2 ($<\gamma_1$). If temperatures of both are increased, then

	Column I		Column II
(A)	Upthrust on the solid will	**(P)**	increase
(B)	apparent weight of the solid will	**(Q)**	decrease
(C)	Fraction of volume immersed in the liquid if allowed to float	**(R)**	remains same

4. A cube is floating in a liquid as shown in figure.

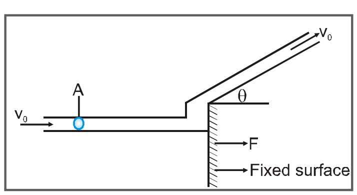


	Column I		Column II
(A)	If density of liquid decreases then x will	**(P)**	increase
(B)	If size of cube is increased then x will	**(Q)**	decrease
(C)	If the whole system is accelerated upwards then x will	**(R)**	remains same

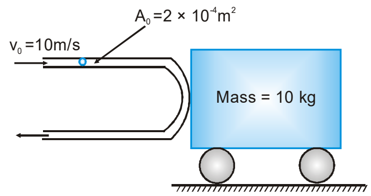
Part # II [Comprehension Type Questions]

Comprehension # 1

When jet of liquid strikes a fixed or moving surface, it exerts thrust on it due to rate of change of momentum.
$F = (\rho A v_0)v_0 - (\rho A v_0)v_0\cos\theta = \rho A v_0^2\ [1-\cos\theta]$



If surface is free and starts moving due to thrust of liquid, then at any instant, the above equation gets modified based on relative change of momentum with respect to surface. Let any instant the velocity of surface is u, then above equation becomes – $F = \rho A(v_0 - u)^2\ [1-\cos\theta]$



Based on above concept, in the below given figure, if the cart is frictionless and free to move in horizontal direction, then answer the following :Given cross–section area of jet = 2×10^{-4} m^2 velocity of jet v_0 = 10 m/s, density of liquid = 1000 kg/m^3, Mass of cart M = 10 kg:

1. Initially (t = 0) the force on the cart is equal to :

(A) 20 N **(B)** 40 N **(C)** 80 N **(D)** zero

2. Velocity of cart at t = 10 s. is equal to:

(A) 4 m/s **(B)** 6 m/s **(C)** 8 m/s **(D)** 5 m/s

3. In the above problem, what is the acceleration of cart at this instant –

(A) 1.6 m/s^2 **(B)** 1 m/s^2 **(C)** 0.64 m/s^2 **(D)** 0.16 m/s^2

4. The time at which velocity of cart becomes 2m/s, is equal to:

(A) 1.6 s **(B)** 2 s **(C)** 3.2 s **(D)** 4s

5. The power supplied to the cart, when its velocity becomes 5 m/s, is equal to :

(A) 100 W **(B)** 25 W **(C)** 50 W **(D)** 200 W

Comprehension # 2

If the container filled with liquid gets accelerated horizontally or vertically, pressure in liquid gets changed. In case of horizontally accelerated liquid (a_x), the free surface has the slope $\frac{a_x}{g}$. In case of vertically accelerated liquid (a_y) for calculation of pressure, effective g is used. A closed box with horizontal base 6m × 6m and a height 2m is filled with liquid. It is given a constant horizontal acceleration g/2 and vertical downward acceleration $\frac{g}{2}$.

1. The angle of the free surface with the horizontal is equal to :

(A) 30° **(B)** $\tan^{-1}\frac{2}{3}$ **(C)** $\tan^{-1}\frac{1}{3}$ **(D)** 45°

2. Length of exposed portion of top of box is equal to:

(A) 2 m **(B)** 3 m **(C)** 4 m **(D)** 2.5 m

3. Water pressure at the bottom of centre of box is equal to:
(atmospheric pressure = 10^5 N/m^2, density of water = 1000 kg/m^3, g = 10 m/s^2)

(A) 1.1 MPa **(B)** 0.11 MPa **(C)** 0.101 MPa **(D)** 0.011 MPa

4. Maximum value of water pressure in the box is equal to :

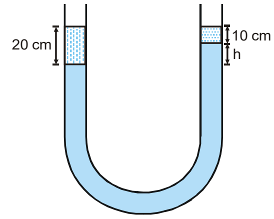
(A) 1.4 MPa **(B)** 0.14 MPa **(C)** 0.104 MPa **(D)** 0.014 MPa

5. What is the value of vertical acceleration of box for given horizontal acceleration (g/2). so that no part of bottom of box is exposed:

(A) $\frac{g}{2}$ upward **(B)** $\frac{g}{4}$ downward **(C)** $\frac{g}{4}$ upward **(D)** Not possible

Comprehension # 3

In a U–tube, if different liquids are filled then we can say that pressure at same level of same liquid is same.



1. In a U–tube 20 cm of a liquid of density ρ is on left hand side and 10 cm of another liquid of density 1.5 ρ is on right hand side. In between them there is a third liquid of density 2ρ. What is the value of h.

(A) 5 cm **(B)** 2.5 cm **(C)** 2 cm **(D)** 7.5 cm

2. If small but equal lengths of liquid –1 and liquid –2 are increased in their corresponding sides then h will.

(A) remain same **(B)** increase **(C)** decrease **(D)** may increase or decrease

Comprehension # 4

The human circulatory system can be thought of as a closed system of interconnecting pipes through which fluid is continuously circulated by two pumps. The two pumps, the right and left ventricles of the heart, work as simple two–stroke force pumps. The muscles of the heart regulate the force by contracting and relaxing. The contraction (systole) lasts about 0.2s, and a complete systole/diastole (contraction/relaxation) cycle lasts about 0.8 s.

For blood pressures and speeds in the normal range, the volume flow rate of blood through a blood vessel is directly proportional to the pressure difference over a length of the vessel and to the fourth power of the radius of the vessel. The total mechanical energy per unit volume of blood just as it leaves the heart is : $E/V = \rho gh + P + \rho v^2$

1. Why is diastolic blood pressure much lower than systolic pressure ?

(**Note :** A typical systole/diastole reading in mm Hg is 120/80)

(A) Because the heart exerts more force on the blood during diastole

(B) Because the heart exerts no force on the blood during diastole

(C) Because the radii of the blood vessels increase during diastole, while the force exerted by the heart on the blood remains the same.

(D) Because the radii of the blood vessels decrease during diastole, while the force exerted by the heart on the blood remains the same

2. Which of the following is a way to achieve approximately a 45% increase in the volume flow rate of blood through a blood vessel ?

(A) Increase the radius by 10%

(B) Increase the cross–sectional area of the vessel by 10%

(C) Decrease the change in pressure by 10%

(D) Decrease the speed of flow by 10%

3. What is the gravitational potential energy of 8 cm^3 of blood in a 1.8 m tall man, in a blood vessel 0.3 m above his heart ? (**Note :** The man's blood pressure is 1.3×10^4 N/m^2.)

(A) 1×10^{-4} J **(B)** 2.5×10^{-2} J **(C)** 301×10^3 J **(D)** 4×10^4 J

4. The blood pressure in a capillary bed is essentially zero, allowing blood to flow extremely slowly through the tissues in order to maximize exchange of gases nutrients, and waste products. What is the work on 200 cm^3 of blood against gravity to bring it to the capillaries to the brain, 50 cm above the heart ?

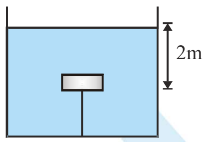
(A) 5145 J **(B)** 105 J **(C)** 10 J **(D)** 1 J

5. During intense exercise, the volume of blood pumped per second by an athlete's heart increases by a factor of 7, and his blood pressure increases by 20%/ By what factor does the power output of the heart increase during exercise ?

(A) 1.2 **(B)** 3.5 **(C)** 7 **(D)** 8.4

Comprehension # 5

Newton's laws of motion can be applied to a block in liquid also. Force due to liquid (e.g., upthrust) are also considered in addition to other forces. A small block of weight W is kept inside. The block is attached with a string connected to the bottom of the vessel. Tension in the string is W/2.



1. The string is cut. Find the time when it reaches the surface of the liquid

(A) $\frac{1}{\sqrt{5}}$ s **(B)** $\sqrt{5}$ s **(C)** $\sqrt{3}$ s **(D)** $\frac{2}{\sqrt{5}}$ s

2. If weight of the block is doubled, then tension in the string becomes x times and the time calculated above becomes y times. Then

(A) x=2 **(B)** y= $\sqrt{2}$

(C) both **(A)** and **(B)** are correct **(D)** both **(A)** and **(B)** are wrong

Comprehension # 6

When an object moves through a fluid, as when a ball falls through air or a glass sphere falls through water, the fluid exerts a viscous force F on the object. This force tends to slow the object. For a small sphere of radius r, moving is given by Stoke's law, $F_v = 6\pi\eta r v$. In this formula, η is the coefficient of viscosity of the fluid, which is the proportionality constant that determines how much tangential force is required to move a fluid layer at a constant speed v, when the layer has an area A and is located a perpendicular distance z from and immobile surface. The magnitude of the force is given by $F = \eta A v/z$. For a viscous fluid to move from location 2 to location 1 along 2 must exceed that at location 1. Poiseuille's law gives the volume flow rate Q that results from such a pressure difference $P_2 – P_1$. The flow rate is expressed by the formula : $Q = \frac{\pi R^4 (P_2 - P_1)}{8\eta L}$ Poiseuille's law remains valid as long as the fluid flow is laminar.

For a sufficiently high speed, however, the flow becomes turbulent. Flow is laminar as long as the Reynolds number is less than approximately 2000. This number is given by the formula : $R_e = \frac{2\bar{v}\rho R}{\eta}$. In which $\bar{v}$ is the average speed, ρ is the density, η is the coefficient of viscosity of the fluid, and R is the radius of the pipe.

Take the density of water to be $\rho = 1000$ kg/m^3.

1. Which of the following may be concluded from the information in the passage ?

(A) The volume flow rate and the mass flow rate are the more for more viscous fluids

(B) The volume flow rate is smaller for more viscous fluids, whereas the mass flow rate is greater for more viscous fluids

(C) The volume flow rate is greater for more viscous fluids, whereas the mass flow rate is smaller for more viscous fluids

(D) The volume flow rate and the mass flow rate are greater for less viscous fluids

2. Blood vessel is 0.10 m in length and has a radius of 1.5×10^{-3} m. Blood flows at rate of 10^{-7} m^3/s through this vessel. The pressure difference that must be maintained in this flow, between the two ends of the vessel, is 20 Pa. What is the viscosity sufficient of blood ?

(A) 2×10^{-3} Pa–s (B) 1×10^{-3} Pa–s (C) 4×10^{-3} Pa–s (D) 5×10^{-4} Pa–s

3. Calculate the highest average speed that blood ($\rho \approx 1000 kg/m^3$) could have and still remain in laminar flow when it flows through the arorta ($R = 8 \times 10^{-3} m$). Take the coefficient of viscosity of blood to be 4×10^{-3} Pa.s.

(A) 0.5 m/s (B) 1.0 m/s (C) 1.5 m/s (D) 2.0 m/s

4. What is the viscous force on a glass sphere of radius r = 1mm falling through water ($\eta = 1 \times 10^{-3}$ Pa–s) when the sphere has speed of 3m/s ?

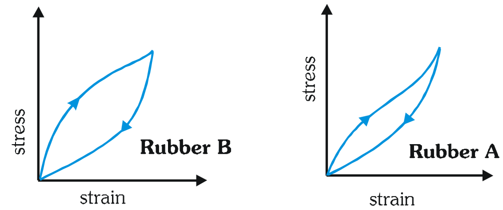
(A) 2.7×10^{-2} N (B) 2.5×10^{-5} N (C) 3.7×10^{-3} N (D) 5.6×10^{-5} N

5. If the sphere in previous question has mass of 1×10^{-5} kg, what is its terminal velocity when falling through water ? ($\eta = 1 \times 10^{-3}$ Pa–s)

(A) 1.3 m/s (B) 3.4 m/s (C) 5.2 m/s (D) 6.5 m/s

Exercise # 4 [Subjective Type Questions]

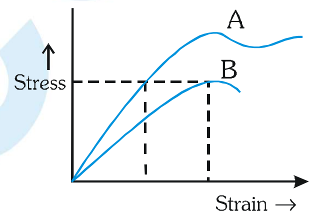
1. Two different types of rubber are found to have the stress–strain curves as shown in figure.



(i) A heavy machine is to be installed in a factory. To absorb vibrations of the machine, a block of rubber is placed between the machinery and the floor. Which of the two rubbers A and B would you prefer to use for this purpose? Why ?

(ii) Which of the two rubber materials would you choose for a car tyre ?

2. The stress versus strain graphs for two materials A and B are shown. Explain



(i) Which material has greater Young's modulus ?

(ii) Which material is more ductile ?

(iii) Which material is more brittle ?

(iv) Which of the two is the stronger material ?

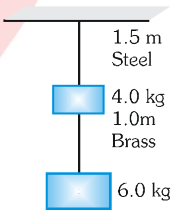
3. The maximum stress that can be applied to the material of a wire used to suspend an elevator is $\frac{3}{\pi} \times 10^8$ N/m^2. If the mass of elevator is 900 kg and it move up with an acceleration 2.2 m/s^2 than calculate the minimum radius of the wire.

4. A steel rope has length L, area of cross–section A, Young's modulus Y. [Density =d]

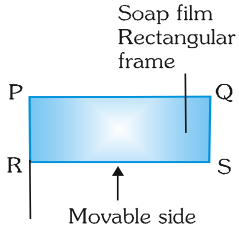
(i) It is pulled on a horizontal frictionless floor with a constant horizontal force F = [dALg]/2 applied at one end. Find the strain at the midpoint.

(ii) If the steel rope is vertical and moving with the force acting vertically up at the upper end. Find the strain at distance L/3 from lower end.

5. Two wires of diameter 0.25 cm, one made of steel and other made of brass are loaded as shown in figure. The unloaded length of steel wire is 1.5 m and that of brass wire is 1.0 m. Young's modulus of steel is 2.0×10^{11} Pa and that of brass is 0.91×10^{11} Pa. Calculate the elongation of steel and brass wires. (1 Pa = 1 Nm^{-2})



6. PQRS is a rectangular frame of copper wire shown in figure the side RS of the frame is movable. If a soap film is formed on it then what is the diameter of the wire to maintain equilibrium (Given surface tension of soap solution = 0.045 N/m and density of copper = 8.96×10^3 kg/m^3)



7. A light rod of length 2m is suspended from the ceiling horizontally by means of two vertical wires of equal length tied to its ends. One of the wires is made of steel and is of cross–sectional area 0.1sq. cm and the other is of brass of cross–sectional area 0.2 sq. cm. Find out the position along the rod at which a weight may be hung to produce equal stresses in both wires. : Y for steel = 20×10^{11} dyne cm^{-2} and Y for brass = 10×10^{11} dyne m^{-2}.

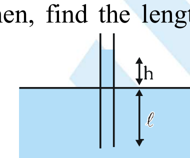
8. If a compressive force of 3.0×10^4 N is exerted on the end of a 20 cm long bone of cross–sectional area 3.6 cm^2. **(i)** Will the bone break and **(ii)** if not, by how much length does it shorten ? Given compressive strength of bone = 7.7×10^8 N/m^2 and young's modulus of bone = 1.5×10^{10} N/m^2.

9. The pressure of air in a soap bubble of 0.7 cm diameter is 8 mm of water above the atmospheric pressure. Calculate the surface tension of soap solution. (Take g = 980 cm/sec^2)

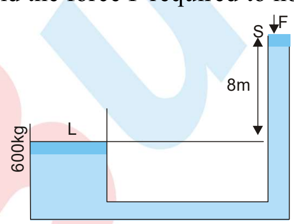
10. There is soap bubble of radius 2.4×10^{-4} m in air cylinder which is originally at the pressure of 10^5 N/m^2. The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate now the pressure of air in the cylinder. The surface tension of the soap film is 0.08 Nm^{-1}.

11. Two soap bubbles whose radii are R_1 and R_2 coalesce to form a new bubble (Isothermally). Whose radius is R. If change in volume of air inside bubble is V and change in area of whole surface is S, then show that 3PV + 4ST = 0 where P is the atmospheric pressure and T is the surface tension of the soap solution.

12. The capillary tube is dipped in water vertically. It is sufficiently long so that water rises to maximum height h in the tube. The length of the portion immersed in water is ● > h. The lower end of the tube is closed, the tube is taken out and opened again. Then, find the length of the water column remaining in the tube.



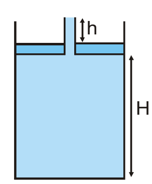
13. For the system shown in the figure, the cylinder on the left at L has a mass of 600 kg and a cross sectional area of 800 cm^2. The piston on the right, at S, has cross sectional area 25 cm^2 and negligible weight. If the apparatus is filled with oil (ρ =0.75 gm/cm^3) Find the force F required to hold the system in equilibrium.



14. 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 piston have to bear? (taking g = 10 m/s^2)

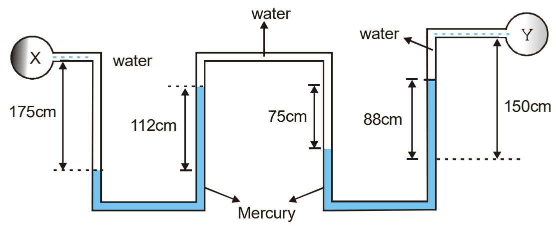
15. An air bubble doubles its volume as it rises from the bottom of a tank to its surface. If the atmospheric pressure be 76 cm of Hg, what is the depth of the tank ?

16. A piston of mass M=3kg and radius R=4cm has a hole into which a thin pipe of radius r = 1cm is inserted. The piston can enter a cylinder tightly and without friction, and initially it is at the bottom of the cylinder. 750 gm of water is now poured into the pipe so that the piston & pipe are lifted up as shown. Find the height H of water in the cylinder and height h of water in the pipe.

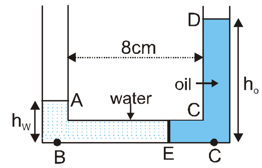


17. Two identical cylindrical vessels with their bases at the same level each contain a liquid of density ρ. The height of the liquid in one vessel is h_1 and in the other is h_2. The area of either base is A. What is the work done by gravity in equalising the levels when the two vessels are connected ?

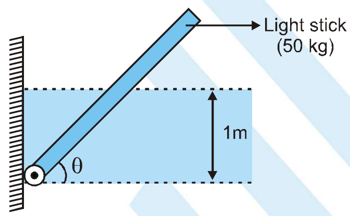
18. Two U–tube manometers are connected in series as shown in figure. Determine difference of pressure between X and Y. Take specific gravity of mercury as 13.6



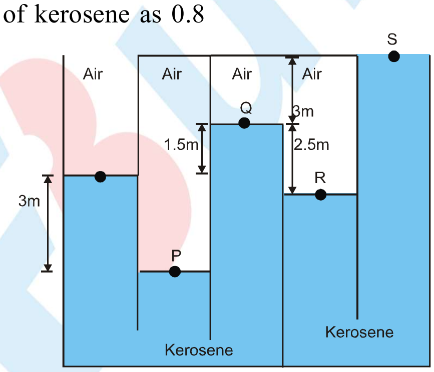
19. A tube of uniform cross–section has two vertical portions connected with a horizontal thin tube 8 cm long at their lower ends. Enough water to occupy 22 cm of the tube is poured into one branch and enough oil of specific gravity 0.8 to occupy 22 cm is poured into the other. Find the position of the common surface E of the two liquids.



20. A light metal stick of square cross–section (5 cm × 5cm) and length '4m' mass 2.5 kg and is shown in the figure below. Determine its angle of inclination when the water surface is 1m above the hinge. What minimum depth of water above high will be required to bring the metal stick in vertical position.

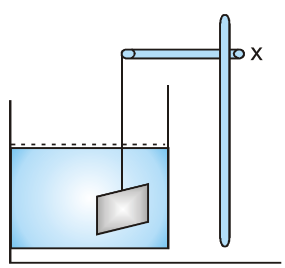


21. The container shown below holds kerosene and air as indicated. Compute the pressure at P, Q, R and S in KN/m^2. Take specific gravity of kerosene as 0.8



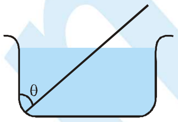
22. A block weight 15 N in air and 12 N when immersed in water. Find the specific gravity of block.

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

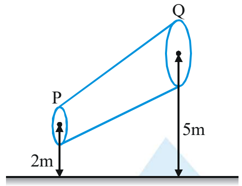


24. A glass beaker is placed partially filled with water in a sink. It has a mass of 390 gm and an interior volume of 500 cm^3. When water starts filling the sink, it is found that if beaker is less than half full it will float. But if it is more than half full, it remains on the bottom of the sink,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

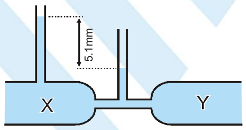
25. A wooden plank of length 1m and uniform cross–section is hinged at one end to the bottom of a tank as shown in figure. The tank is filled with water upto a height 0.5 m. The specific gravity of the plank is 0.5. Find the angle θ that the plank makes with the vertical in the equilibrium position. (exclude the cosθ = 0°).



26. A non–viscous liquid of constant density 1000 kg/m^3 flows in 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 height of 2 m and 5m metres 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 the gravity forces as the fluid flows from point P to Q.



27. The diagram shows venturimeter through which water is flowing. The speed of water at X is 2 cm/sec. Find the speed of water at Y (taking g = 1000 cm/sec^2).

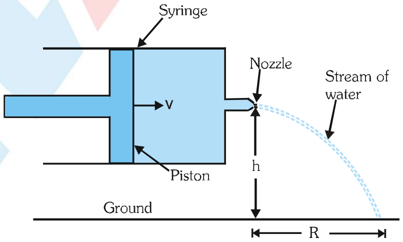


28. A large open top container of negligible mass and uniform cross–sectional area A has a small holes of cross–sectional area $\frac{A}{100}$ in its side wall near the bottom. The container contains a liquid of density ρ and mass m_0. Assuming that the liquid starts flowing out horizontally through the hole at t = 0. Calculate :

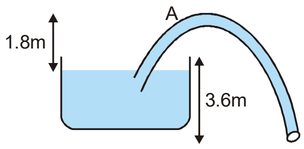
(i) the acceleration of the container and

(ii) its velocity when 75% of the liquid has drained out.

29. A syringe containing water is held horizontally with its nozzle at a height h above the ground as shown in fig. The cross–sectional areas of the piston and the nozzle are A and a respectively. The piston is pushed with a constant speed v. Find the horizontal range R of the stream of water on the ground.

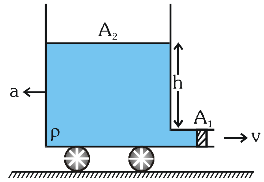


30. A siphon has a uniform circular base of diameter $\frac{8}{\sqrt{\pi}}$ cm with its crest A 1.8 m above water level as in figure. Find **(i)** velocity of flow **(ii)** discharge rate of the flow in m^3/sec **(iii)** absolute pressure at the crest level A. [Use $P_0 = 10^5$ N/m^2 & g = 10 m/s^2]



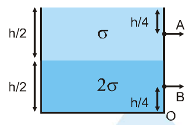
31. A flask contains glycerine and the other contains water. Both are stirred vigorously and placed on the table. In which flask will the liquid come to rest earlier and why ?

32. In a movable container shown in figure a liquid of density ρ is filled up to a height h. The upper & lower tube cross sectional areas are A_2 & A_1 respectively ($A_2 >> A_1$). If the liquid leaves out the container through the tube of cross–sectional area A_1 then find –



(i) Velocity of liquid coming out. **(ii)** Backward acceleration of the container.

33. A large tank is filled with two liquids of specific gravities 2σ and σ. Two holes are made on the wall of the tank as shown. Find the ratio of the distance from O of the points on the ground where the jets from holes A & B strike.



34. A spherical ball of radius 3×10^{-4} m and density 10^4 kg/m^3 falls freely under gravity through a distance h before entering a tank of water. If after entering the water the velocity of the ball does not change, find h. The viscosity of water is 9.8×10^{-6} N–s/m^2.

35. There is a 1mm thick layer of glycerine between a flat plate of area 100 cm^2 and a big plate. If the coefficient of viscosity of glycerine is 1.0 kg/m–sec, then how much force is required to move the plate with a velocity of 7 cm/sec.

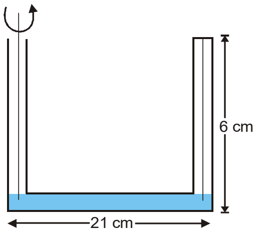
36. A ball of density d is dropped on to a horizontal solid surface. It bounces elastically from the surface and returns to its original position in a time t_1. Next, the ball is released and it falls through the same height before striking the surface of a liquid of density d_L.

(i) 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.

(ii) is the motion of the ball simple harmonic ?

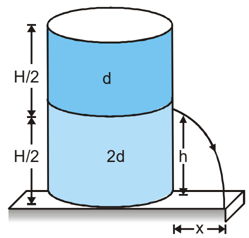
(iii) If $d = d_L$, how does the speed of the ball depend on its depth inside the liquid ? Neglect all frictional and other dissipative forces. Assume the depth of the liquid to be large.

37. Length of horizontal arm of a uniform cross–section U–tube is ●=21 cm and ends of both of the vertical arms are open to surrounding of pressure 10500 N/m^2. A liquid of density $\rho = 10^3$ kg/m^3 is poured into the tube such that liquid just fills the horizontal part of the tube. Now one of the open ends is sealed and the tube is then rotated about a vertical axis passing through the other vertical arm with angular velocity ω_0 = 10 rad/s. If length of each vertical arm be a = 6 cm. Calculate the length of air column in the sealed arm : [g=10m/s^2]



38. A solid block of volume $V = 10^{-3}$ m^3 and density d = 800 kg/m^3 is tied to one end of a string, the other end of which is tied to the bottom of the vessel. The vessel contains 2 immiscible liquids of densities $\rho_1 = 1000$ kg/m^3 and $\rho_2 = 1500$ kg/m^3. The solid block is immersed with 2/5th of its volume in the liquid of higher density & 3/5th in the liquid of lower density. The vessel is placed in an elevator which is moving up with an acceleration of a =g/2. Find the tension in the string. [g = 10 m/s^2]

39. 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.



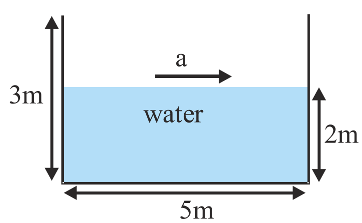
(i) A homogeneous solid cylinder of length $L\left(L < \frac{H}{2}\right)$, cross–sectional area $\frac{A}{5}$ is immersed such that if floats with its axis vertical at the liquid–liquid interface with length $\frac{L}{4}$ in the denser liquid. Determine:
(A) the density D of the solid, **(B)** the total pressure at the bottom of the container.

(ii) 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 $\left(h < \frac{H}{2}\right)$. Determine :

(A) the initial speed of efflux of the liquid at the hole
(B) the horizontal distance x travelled by the liquid initially, and
(C) 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 the air resistance in these calculations)

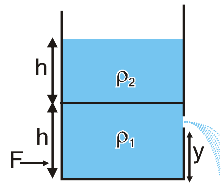
40. A ship sailing from sea into a river sinks X mm and on discharging the cargo rises Y mm. On proceeding again into sea the ship rises the Z mm. Find the specific gravity of sea–water assuming the faces of ship are vertically along the line of sea–water.

41. An open rectangular tank 5 m x 4m x 3m high containing water upto a height of 2m is accelerated horizontally along the longer side.



(i) Determine the maximum acceleration that can be given without spilling the water.
(ii) Calculate the percentage of water split over, if this acceleration is increased by 20%.
(iii) If initially, the tank is closed at the top and is accelerated horizontally by 9m/s^2, find the gauge pressure at the bottom of the front and rear walls of the tank.

42. A cylindrical tank having cross–sectional area A = 0.5 m^2 is filled with two liquids of densities ρ_1 = 900 kgm^{-3} & ρ_2 =600 kgm^{-3}, to a height h = 60 cm as shown in the figure. A small hole having area a = 5 cm^2 is made in right vertical wall at a height y = 20 cm from the bottom. Calculate



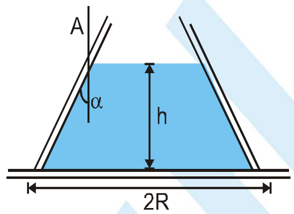
(i) velocity of efflux.

(ii) horizontal force F to keep the cylinder in static equilibrium, if it is placed on a smooth horizontal plane

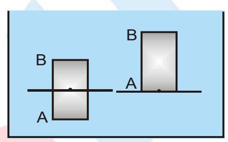
(iii) Minimum and maximum value of F to keep the cylinder at rest. The coefficient of friction between cylinder and the plane is μ = 0.1

(iv) velocity of the top most layer of the liquid column and also the velocity of the boundary separating the two liquids.

43. A conical vessel without a bottom stands on a table. A liquid is poured with the vessel & as the level reaches h, the pressure of the liquid raises the vessel. The radius of the base of the vessel is R and half angle of the cone is α and the weight of the vessel is W. What is the density of the liquid?



44. A cylindrical rod of length ● = 2m & density $\frac{\rho}{2}$ floats vertically in a liquid of density ρ as shown in figure.



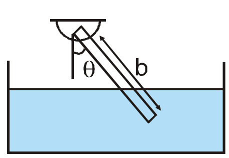
(i) Show that it performs SHM when pulled slightly up & released & find its time period. Neglect change in liquid level.

(ii) Find the time taken by the rod to completely immerse when released from position shown in **(B)**. Assume that it remains vertical throughout its motion. (take $g=\pi^2$ m/s^2)

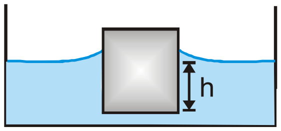
45. A cylindrical wooden float whose base area S = 4000 cm^2 & the altitude H = 50 cm drifts on the water surface. Specific weight of wood d = 0.8 gf/cm^3.
(i) What work must be performed to take the float out of the water?
(ii) Compute the work to be performed to submerged completely the float into the water.

46. On the opposite sides of a wide vertical vessel filled with water two identical holes are opened, each having the cross–sectional area S = 0.50 cm^2. The height difference between them is equal to Dh = 51 cm. Find the resultant force of reaction of the water flowing out of the vessel.

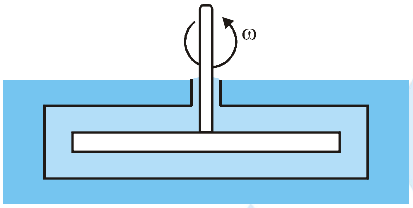
47. A uniform rod of length b capable of turning about its end which is out of water, rests inclined to the vertical. If its specific gravity is 5/9, find the length immersed in water.



48. A cube with a mass 'm' completely wettable by water floats on the surface of water. Each side of the cube is 'a'. What is the distance h between the lower face of cube and the surface of the water if surface tension is S. Take density of water as ρ_w. Take angle of contact is zero.



49. A thin horizontal disc of radius R = 10 cm is located with in a cylindrical cavity filled with oil whose viscosity η = 0.08 P (figure). The distance between the disc and the horizontal planes of the cavity is equal to h = 1.0 mm. Find the power developed by the viscous forces acting on the disc when it rotates with the angular velocity ω=60 rad/s. The end effects are to be neglected.



50. When a vertical capillary of length ● with the sealed upper end was brought in contact with the surface of a liquid, the level of this liquid rise to the height h. The liquid density is ρ, the inside diameter of the capillary is d, the contact angle is θ, the atmospheric pressure is P_0. Find the surface tension of the liquid.

Exercise # 5

Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. A wire suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower ends. The weight stretches the wire by 1mm. Then the elastic energy stored in the wire is- **[AIEEE - 2003]**

(1) 0.2 J **(2)** 10 J **(3)** 20 J **(4)** 0.1 J

2. A wire fixed at the upper end stretches by length ● by applying a force F. The work done in stretching is- **[AIEEE - 2004]**

(1) $\frac{F}{21}$ **(2)** F● **(3)** 2F● **(4)** $\frac{Fl}{2}$

3. If S is stress and Y is Young's modulus of material of a wire, the energy stored in the wire per unit volume is- **[AIEEE - 2004]**

(1) $2S^2Y$ **(2)** $\frac{S^2}{2Y}$ **(3)** $\frac{2Y}{S^2}$ **(4)** $\frac{S}{2Y}$

4. A wire elongates by ● mm when a load W is hanged from it. If the wire goes over a pulley and two weights W each are hung at the two ends, the elongation of the wire will be (in mm)- **[AIEEE - 2006]**

(1) ● **(2)** 2● **(3)** zero **(4)** ●/2

5. A cylinder of height 20 m 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]**

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

6. Spherical balls of radius R are falling in a viscous fluid of viscosity η with a velocity v. the retarding viscous force acting on the spherical ball is- **[AIEEE - 2004]**

(1) directly proportional to R but inversely proportional to v
(2) directly proportional to both radius R and velocity v
(3) inversely proportional to both radius R and velocity v
(4) inversely proportional to R but directly proportional to velocity v

7. If two soap bubbles of different radii are connected by a tube- **[AIEEE - 2004]**

(1) air flows from the bigger bubble to the smaller bubble till the sizes become equal
(2) air flows from bigger bubble to the smaller bubble till the sizes are interchanged
(3) air flows from the smaller bubble to the bigger bubble
(4) there is no flow of air

8. A 20 cm long capillary tube is dipped in water. The water rises upto 8 cm. If the entire arrangement is put in a freely falling elevator, the length of water column in the capillary tube will be- **[AIEEE - 2005]**

(1) 8 cm **(2)** 10 cm **(3)** 4 cm **(4)** 20 cm

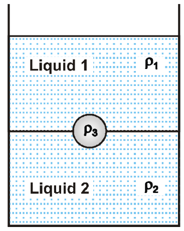
9. If the terminal speed of a sphere of gold (density = 19.5 kg/m^3) is 0.2 m/s in a viscous liquid (density = 1.5 kg/m^3), find the terminal speed of a sphere of silver (density=10.5 kg/m^3) of the same size in the same liquid. **[AIEEE - 2006]**

(1) 0.4 m/s **(2)** 0.133 m/s **(3)** 0.1 m/s **(4)** 0.2 m/s

10. A spherical solid ball of volume V is made of a material of density ρ_1. It is falling through a liquid of density $\rho_2\left(\rho_2 < \rho_1\right)$. Assume that the liquid applies a viscous force on the ball that is propoertional to the square of its speed v, i.e., $F_{viscous} = -kv^2$ (k > 0). Then terminal speed of the ball is **[AIEEE - 2008]**

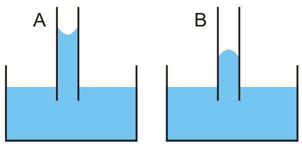
(1) $\sqrt{\frac{Vg\left(\rho_1-\rho_2\right)}{k}}$ **(2)** $\frac{Vg\rho_1}{k}$ **(3)** $\sqrt{\frac{Vg\rho_1}{k}}$ **(4)** $\frac{Vg\left(\rho_1-\rho_2\right)}{k}$

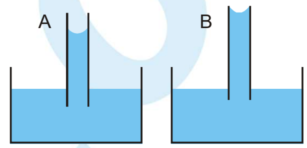
11. A jar is filled with two non-mixing liqudis 1 and 2 having densities ρ_1 and ρ_2, respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure. Which of the following is true for ρ_1, ρ_2 and ρ_3 **[AIEEE - 2008]**

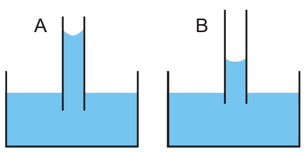


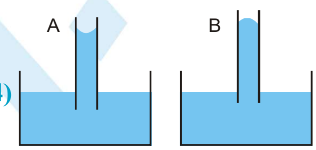
(1) $\rho_3 < \rho_1 < \rho_2$ **(2)** $\rho_1 > \rho_3 > \rho_2$ **(3)** $\rho_1 < \rho_2 < \rho_3$ **(4)** $\rho_1 < \rho_3 < \rho_2$

12. A capillary tube (1) is dipped in water. Another identical tube (2) is dipped in a soap -water solution. Which of the following shows the relative nature of the liquid columns in the two tubes? **[AIEEE - 2008]**

(1) 

(2) 

(3) 

(4) 

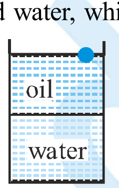
13. A spherical solid ball of volume V is made of a material of density ρ_1. It is falling through a liquid of density ρ_2 ($\rho_2 < \rho_1$). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed v. i.e., $F_{viscous} = -kr^2$, $k > 0$. The terminal speed of the ball is - **[AIEEE - 2008]**

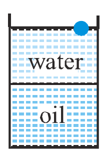
(1) $\sqrt{\dfrac{Vg(\rho_1 - \rho_2)}{k}}$ **(2)** $\dfrac{Vg\rho_1}{k}$ **(3)** $\sqrt{\dfrac{Vg\rho_1}{k}}$ **(4)** $\dfrac{V(\rho_1 - \rho_2)}{k}$

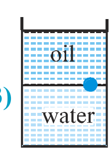
14. Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area A and wire 2 has cross-sectional area 3A. If the length of wire 1 increases by Δx on applying force F, how much force is needed to stretch wire 2 by the same amount ? **[AIEEE - 2009]**

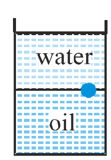
(1) 6F **(2)** 9F **(3)** F **(4)** 4F

15. 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]**

(1) 

(2) 

(3) 

(4) 

16. Water is flowing continuously from a tap having an internal diameter 8×10^{-3} m. The water velocity as it leaves the tap is 0.4 ms^{-1}. The diameter of the water stream at a distance 2×10^{-1} m below the tap is close to :- **[AIEEE - 2011]**

(1) 9.6×10^{-3} m **(2)** 3.6×10^{-3} m **(3)** 5.0×10^{-3} m **(4)** 7.5×10^{-3} m

17. Work done in increasing the size of a soap bubble from a radius of 3 cm to 5cm is nearly (Surface tension of soap solution = 0.03 Nm^{-1}) :- **[AIEEE - 2011]**

(1) 2π mJ **(2)** $0.4\ \pi$ mJ **(3)** 4π mJ **(4)** $0.2\ \pi$ mJ

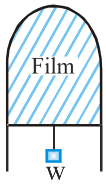
18. Two merucry drops (each of radius 'r') merge to form a bigger drop. The surface energy of the bigger drop, ifs T is the surface tension, is : **[AIEEE - 2011]**

(1) $2^{5/3}\pi r^2T$ **(2)** $4\pi r^2T$ **(3)** $2\pi r^2T$ **(4)** $2^{8/3}\pi r^2T$

19. If a ball of steel (density ρ = 7.8 g cm^{-3}) attains a terminal velocity of 10 cm s^{-1} when falling in a tank of water (coefficient of viscosity η_{water} = 8.5 × 10^{-4} Pa.s) then its terminal velocity in glycerine (ρ = 12 g cm^{-3}, η = 13.2 Pa.s) would be nearly :- **[AIEEE - 2011]**

(1) 1.6×10^{-5} cm s^{-1} **(2)** 6.25×10^{-4} cm s^{-1} **(3)** 6.45×10^{-4} cm s^{-1} **(4)** 1.5×10^{-5} cm s^{-1}

20. A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5×10^{-2} N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is :- **[AIEEE - 2012]**

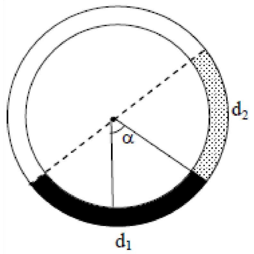


(1) 0.025 Nm^{-1} **(2)** 0.0125 Nm^{-1} **(3)** 0.1 Nm^{-1} **(4)** 0.05 Nm^{-1}

21. An open glass tube is immersed in mercury in such a way that a length of 8 cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46 cm. What will be length of the air column above mercury in the tube now? (Atmospheric pressure = 76 cm of Hg) **[JEE (Main) - 2014]**

(1) 38 cm **(2)** 6 cm **(3)** 16 cm **(4)** 22 cm

22. There is a circular tube in a vertical plane. Two liquids which do not mix and of densities d_1 and d_2 are filled in the tube. Each liquid subtends 90° angle at centre. Radius joining their interface makes an angle α with vertical. ratio d_1/d_2 is **[JEE (Main) - 2014]**



(1) $\dfrac{1+\tan\alpha}{1-\tan\alpha}$ **(2)** $\dfrac{1+\sin\alpha}{1-\cos\alpha}$ **(3)** $\dfrac{1+\sin\alpha}{1-\sin\alpha}$ **(4)** $\dfrac{1+\cos\alpha}{1-\cos\alpha}$

23. When a rubber-band is stretched by a distance x, it exerts a restoring force of magnitude $F = ax + bx^2$ where a and b are constants. The work done in stretching the unstretched rubber band by L is : **[JEE (Main) - 2014]**

(1) $\dfrac{aL^2}{2}+\dfrac{bL^3}{3}$ **(2)** $\dfrac{1}{2}\left[\dfrac{aL^2}{2}+\dfrac{bL^3}{3}\right]$ **(3)** aL^2+bL^2 **(4)** $\dfrac{1}{2}\left(aL^2+bL^3\right)$

24. A pendulum made of a uniform wire of cross-sectional area A has time period T. When an additional mass M is added to its bob, the time period changes to T_M. If the Young's modulus of the material of the wire is Y then 1/Y is equal to : (g = gravitational acceleration) **[JEE (Main) - 2015]**

(1) $\left[1-\left(\dfrac{T_M}{T}\right)^2\right]\dfrac{A}{Mg}$ **(2)** $\left[1-\left(\dfrac{T}{T_M}\right)^2\right]\dfrac{A}{Mg}$

(3) $\left[\left(\dfrac{T_M}{T}\right)^2-1\right]\dfrac{A}{Mg}$ **(4)** $\left[\left(\dfrac{T_M}{T}\right)^2-1\right]\dfrac{Mg}{A}$

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

MCQ's (only one correct answers)

1. 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 the stream of water and that the flow is steady, the cross–sectional area of stream 0.15 m below the tap is :– **[IIT-JEE 1998]**

(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

2. A given quantity of an ideal gas is at pressure P and absolute temperature T. The isothermal bulk modulus of the gas is :– **[IIT-JEE 1998]**

(A) 2/3 P **(B)** P **(C)** 3/2 P **(D)** 2P

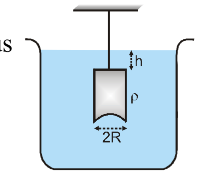
3. A closed compartment containing gas is moving with some acceleration in horizontal direction. Neglect effect of gravity. Then, the pressure in the compartment is :– **[IIT-JEE 1999]**

(A) same every where **(B)** lower in front side **(C)** lower in rear side **(D)** lower in upper side

4. 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 the holes are both same. Then, R is equal to :– **[IIT-JEE 2000]**

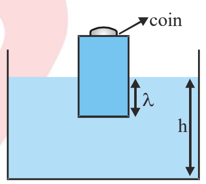
(A) $\frac{L}{\sqrt{2\pi}}$ **(B)** $2\pi L$ **(C)** L **(D)** $\frac{L}{2\pi}$

5. 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 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 :– **[IIT-JEE 2001]**



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

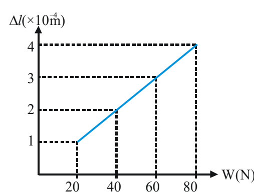
6. A wooden block, with a coin placed on its top, floats in water as shown in figure. The distance ● and h are shown there. After sometime the coin falls into the water. Then :– **[IIT-JEE 2002]**



(A) ● decreases and h increases **(B)** ● increases and h decreases

(C) both ● and h increase **(D)** both ● and h decrease

7. The adjacent graph shows the extension (Δ●) of a wire of length 1m suspended from the top of a roof at one end and with a load W connected to the other end. If the cross–sectional area of the wire is 10^{-6} m^2, calculate the Young's modulus of the material of the wire :– **[IIT-JEE 2003]**

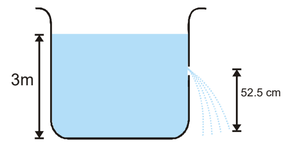


(A) 2×10^{11} N/m^2 **(B)** 2×10^{-11} N/m^2 **(C)** 3×10^{12} N/m^2 **(D)** 2×10^{13} N/m^2

8. The pressure of a medium is changed from 1.01×10^5 Pa to 1.165×10^5 Pa and change in volume is 10% keeping temperature constant. The bulk modulus of the medium is :– **[IIT-JEE 2005]**

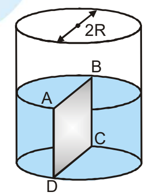
(A) 204.8×10^5 Pa **(B)** 102.4×10^5 Pa **(C)** 51.2×10^5 Pa **(D)** 1.55×10^5 Pa

9. Water is filled in a cylindrical container to a height of 3 m. The ratio of the cross–sectional area of the orifice and the beaker is 0.1. The square of the speed of the liquid coming out from the orifice is ($g = 10\ m/s^2$) **[IIT-JEE 2005]**



(A) $50\ m^2s^2$ **(B)** $50.5\ m^2s^2$ **(C)** $51\ m^2s^2$ **(D)** $52\ m^2s^2$

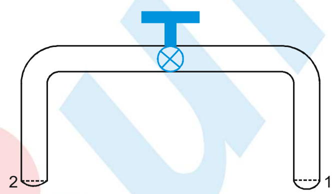
10. Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water is ρ, the surface tension of water is T and the atmospheric pressure is P_0. Consider a vertical section ABCD of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude :– **[IIT-JEE 2007]**



(A) $[2P_0Rh + \pi R^2\rho gh - 2RT]$ **(B)** $[2P_0Rh + R\rho gh^2 - 2RT]$

(C) $[P_0\pi R^2 + R\rho gh^2 - 2RT]$ **(D)** $[P_0\pi R^2 + R\rho gh^2 + 2RT]$

11. A glass tube of uniform internal radius (R) has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherical soap bubble of radius r. End 2 has sub–hemispherical soap bubble as shown in figure. Just after opening the valve, **[IIT-JEE 2008]**



(A) Air from end 1 flows towards end 2. No change in the volume of the soap bubbles.
(B) Air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases.
(C) No change occurs
(D) Air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases.

12. One end of a horizontal thick copper wire of length 2L and radius 2R is welded to an end of another horizontal thin copper wire of length L and radius R. When the arrangement is stretched by applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is :-

(A) 0.25 **(B)** 0.50 **(C)** 2.00 **(D)** 4.00

MCQ's (Multiple Correct answers)

1. A solid sphere of radius R and density ρ is attached to one end of a mass-less spring of force constant k. The other end of the spring is connected to another solid sphere of radius R and density 3ρ. The complete arrangement is placed in a liquid of density 2ρ and is allowed to reach equilibrium. The correct statement(S) is (are)

(A) the net elongation of the spring is $\frac{4\pi R^3\rho g}{3k}$ **(B)** the net elongation of the spring is $\frac{8\pi R^3\rho g}{3k}$

(C) the light sphere is partially submerged. **(D)** the light sphere is completely submerged.

Match the Column Type

1. **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 appropriates system (S) from **Column II**. **[IIT-JEE 2009]**

Column I

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

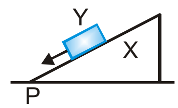
(B) The gravitational potential kept energy of X is continuously increasing.

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

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

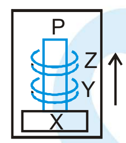
Column II

(P)



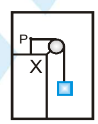
Block Y of mass M left on a fixed inclined plane X, Slides on it with a constant velocity.

(Q)



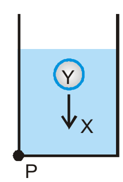
Two ring magnets Y and Z, each of mass M are in frictionless vertical plastic stand so that they repel each other. Y rests on the base X and Z hangs in air in equilibrium. P is the topmost point of the stand on the common axis of the two rings. The whole system is in a lift that is going up with a constant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

(R)



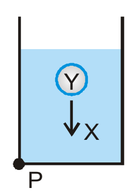
A pulley Y of mass m_0 is fixed to a table through a clamp X. A block of mass M hangs from a string that goes over the pulley and is fixed at point P of the table. The whole system is kept in a lift that is going down with a constant velocity.

(S)



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

(T)



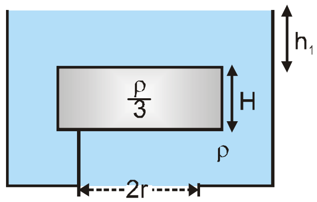
A sphere Y of mass M is falling with its terminal velocity in a viscous liquid X kept in a container

Comprehension Based Question

Comprehension#1

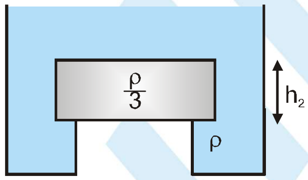
A wooden cylinder of diameter 4r, height H and density $\rho/3$ is kept on a hole of diameter 2r of a tank, filled with liquid of density ρ as shown in the figure.

1. Now 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]**



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

2. 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]**



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

3. If height h_2 of water level is further decreased, then :– **[IIT-JEE 2006]**

(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

Assertion–Reason

1. **Statement–1 :** 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. **[IIT-JEE 2008]**

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

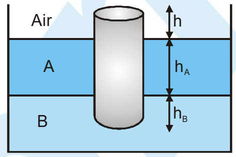
(C) Statement–1 is True, Statement–2 is False

(D) Statement–1 is False, Statement–2 is True

Subjective Type Questions

1. A wooden stick of length L, 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). **[IIT-JEE 1999]**

2. 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 0.7 g/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. **[IIT-JEE 2002]**

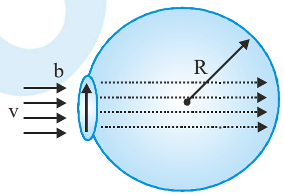


(i) Find the total force exerted by liquid A on the cylinder.

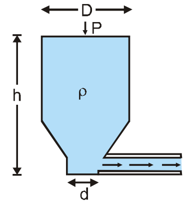
(ii) Find h, the length of the part of the cylinder in air.

(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.

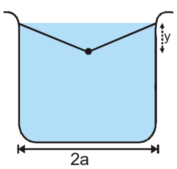
3. A bubble having surface tension T and radius R is formed on a ring of radius b (b<<R). Air is blown inside the tube with velocity v as shown. The air molecule collides perpendicularly with the wall of the bubble and stops. Calculate the radius at which the bubble separates from the ring. **[IIT-JEE 2003]**



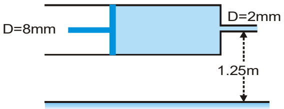
4. Shown in the figure is a container whose top and bottom diameters are D and d respectively. At the bottom of the container, thee is a capillary tube of outer radius b and inner radius a. The volume flow rate in the capillary is Q. If the capillary is removed the liquid comes out with a velocity of v_0. The density of the liquid is given as calculate the coefficient of viscosity η. (Given : $\pi a^2 = 10^{-6}$ m^2 and $\frac{a^2}{l} = 2 \times 10^{-6}$ m) **[IIT-JEE 2003]**



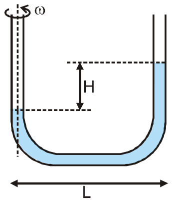
5. A container of width 2a is filled with a liquid. A thin wire of weight per unit length λ is gently placed over the liquid surface in the middle of the surface as shown in the figure. As a result, the liquid surface is depressed by a distance y (y << a). Determine the surface tension of the liquid. **[IIT-JEE 2004]**



6. 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 the diameter of the nozzle is 2 mm. The plunger is pushed with a constant speed of 0.25 m/s. Find the horizontal range of water stream on the ground. (Assume liquid is compressible and non–viscous) (Take g = 10 m/s^2). **[IIT-JEE 2004]**



7. A U–shaped tube contains a liquid of density ρ and it is rotated about the line as shown in the figure. Find the difference in the levels of liquid column. **[IIT-JEE 2005]**



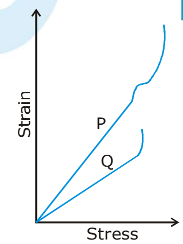
Integer Type Questions

1. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure 8 N/m^2. The radii of bubbles A and B are 2 cm and 4 cm, respectively. Surface tension of the soap–water used to make bubbles is 0.04 N/m. Find the ratio n_B/n_A, where n_A and n_B are the number of moles of air in bubbles A and B, respectively. [Neglect the effect of gravity] **[IIT-JEE 2009]**

2. 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]**

MCQ's (Multiple Correct answers)

1. In plotting stress versus strain curves for two materials P and Q, a student by mistake puts strain on the y-axis and stress on the x-axis as shown in the figure. Then the correct statemetn**(s)** is (are) **[IIT-JEE 2015]**



(A) P has more tensile strength than Q
(B) P is more ductile than Q
(C) P is more brittle than Q
(D) The Young's modulus of P is more than that of Q

2. A spherical body of radius R consists of a fluid of constant density and is in equilibrium under its own gravity. If P(r) is the pressure at r (r < R), then the corect option(s) is (are) **[IIT-JEE 2015]**

(A) $P(r=0)=0$

(B) $\frac{P(r = 3R/4)}{P(r = 2R/3)} = \frac{63}{80}$

(C) $\frac{P(r = 3R/5)}{P(r = 2R/5)} = \frac{16}{21}$

(D) $\frac{P(r = R/2)}{P(r = R/3)} = \frac{20}{27}$

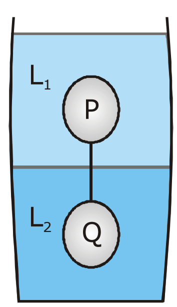
3. Two spheres P and Q of equal radii have densities ρ_1 and ρ_2, respectively. The spheres are connected by a massless string and placed in liquids L_1 and L_2 of densities σ_1 and σ_2 and viscosities η_1 and η_2, respectively. They float in equilibrium with the sphere P in L_1 and sphere Q in L_2 and the string being taut (see figure). If sphere P along in L_2 has terminal velocity $\vec{V}_P$ and Q in L_1 has terminal velocity $\vec{V}_Q$, then **[IIT-JEE 2015]**

(A) $\frac{|\vec{V}_P|}{|\vec{V}_Q|} = \frac{\eta_1}{\eta_2}$

(B) $\frac{|\vec{V}_P|}{|\vec{V}_Q|} = \frac{\eta_2}{\eta_1}$

(C) $\vec{V}_P \cdot \vec{V}_Q > 0$

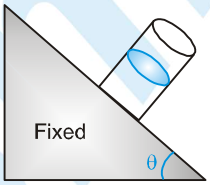
(D) $\vec{V}_P \cdot \vec{V}_Q < 0$



MOCK TEST

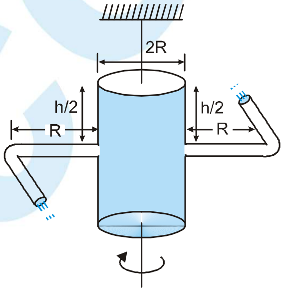
SECTION - I : STRAIGHT OBJECTIVE TYPE

1. A cylindrical vessel filled with water is released on an inclined surface of angle θ as shown in figure. The friction coefficient of surface with vessel is μ ($< \tan\theta$). Then the constant angle made by the surface of water with the incline will be:



(A) $\tan^{-1}\mu$ **(B)** $\theta - \tan^{-1}\mu$ **(C)** $\theta + \tan^{-1}\mu$ **(D)** $\cot^{-1}\mu$

2. 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) $4\,a\,g\,h\,\rho\,R$ **(B)** $8\,a\,g\,h\,\rho\,R$
(C) $2\,a\,g\,h\,\rho\,R$ **(D)** none of these

3. A block of silver of mass 4 kg hanging from a string is immersed in a liquid of relative density 0.72. If relative density of silver is 10, then tension in the string will be:[take $g = 10\ m/s^2$]

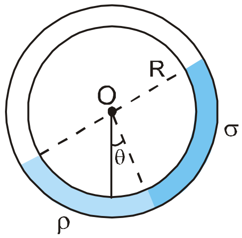
(A) 37.12 N **(B)** 42 N **(C)** 73 N **(D)** 21 N

4. A vessel contains oil (density = 0.8 gm/cm^3) over mercury (density = 13.6 gm/cm^3). A uniform sphere floats with half its volume immersed in mercury and the other half in oil. The density of the material of sphere in gm/cm^3 is:

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

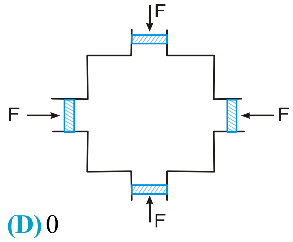
5. A small uniform tube is bent into a circular tube of radius R and kept in the vertical plane. Equal volumes of two liquids of densities ρ and σ ($\rho > \sigma$) fill half of the tube as shown in the figure. θ is the angle which the radius passing through the interface makes with the vertical.

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



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

6. 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) $\dfrac{F}{A}$ **(B)** $\dfrac{2F}{A}$ **(C)** $\dfrac{4F}{A}$ **(D)** 0

7. 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 increases by 1°C. The bouyant force on the block by water

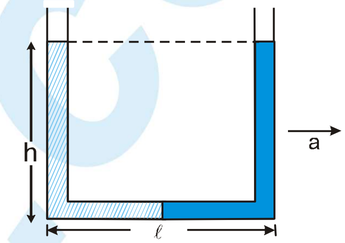
(A) will increase **(B)** will decrease **(C)** will not change

(D) may decrease or increase depending on the values of their coefficient of expansion

8. An open tank 10m long and 2m deep is filled up to 1.5 m height with oil of specific gravity 0.82. The tank is uniformly accelerated along its length from rest to a speed of 20 m/sec horizontally. The shortest time in which the speed may be attained without spilling any oil is : [g = 10 m/sec^2]

(A) 20 sec. **(B)** 18 sec. **(C)** 10 sec. **(D)** 5 sec.

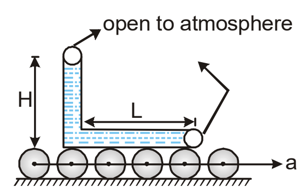
9. A U-tube of base length "●" filled with same volume of two liquids of densities ρ and 2ρ is moving with an acceleration "a" on the horizontal plane. If the height difference between the two surfaces (open to atmosphere) becomes zero, then the height h is given by:



(A) $\frac{a}{2g}\lambda$ **(B)** $\frac{3a}{2g}\lambda$

(C) $\frac{a}{g}\lambda$ **(D)** $\frac{2a}{3g}\lambda$

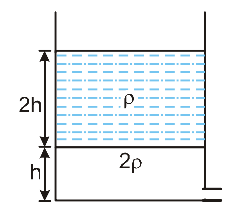
10. A narrow tube completely filled with a liquid is lying on a series of cylinders as shown in figure. Assuming no sliding between any surfaces, the value of acceleration of the cylinders for which liquid will not come out of the tube from anywhere is given by



(A) $\frac{gH}{2L}$ **(B)** $\frac{gH}{L}$

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

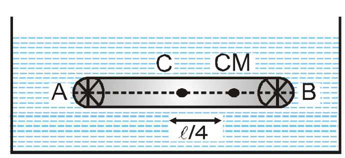
11. The velocity of the liquid coming out of a small hole of a vessel containing two different liquids of densities 2ρ and ρ as shown in figure is



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

(C) $2\sqrt{2gh}$ **(D)** $\sqrt{gh}$

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

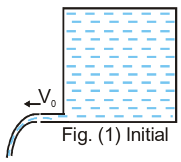


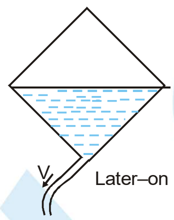
(A) $\frac{\pi\rho g\lambda^2 r^2}{I}$ **(B)** $\frac{\pi\rho g\lambda^2 r^2}{4I}$ **(C)** $\frac{\pi\rho g\lambda^2 r^2}{2I}$ **(D)** $\frac{3\pi\rho g\lambda^2 r^2}{4I}$

13. The coefficient of viscosity η of a liquid is defined as the tangential force on a layer in that liquid per unit area per unit velocity gradient across it. Then a sphere of radius 'a', moving through it under a constant force F attains a constant velocity 'V' given by :
(where K is a numerical constant)

(A) $K\,Fa\,\eta$ **(B)** $K\,\frac{F}{a}\,\eta$ **(C)** $K\,\frac{F}{a\eta}$ **(D)** $K\eta\,\frac{a}{F}$

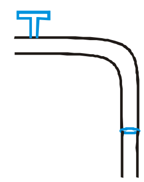
14. A square box of water has a small hole located in one of the bottom corner. When the box is full and placed on a level surface, complete opening of the hole results in a flow of water with a speed v_0, as shown in figure (1). When the box is still half empty, it is tilted by 45° so that the hole is at the lowest point. Now the water will flow out with a speed of





(A) V_0 **(B)** $V_0/2$ **(C)** $V_0/\sqrt{2}$ **(D)** $V_0/\sqrt[4]{2}$

15. A steady stream of water falls straight down from a pipe as shown. Assume the flow is incompressible, then



(A) the pressure in the water is higher at lower points in the stream.
(B) the pressure in the water is lower at lower points in the stream.
(C) the pressure in the water is the same at all points in the stream.
(D) pressure variation will depend upon density and exit speed of the water.

16. Water filled in an empty tank of area 10 A through a tap of cross sectional area A. The speed of water flowing out of tap is given by $v\,(m/s) = 10\left(1 - \sin\frac{\pi}{30}t\right)$ where 't' is in seconds. The height of water level from the bottom of the tank at t = 15 sec will be

(A) 10 m **(B)** $15 + \frac{30}{\pi}$ m **(C)** $\frac{5}{4}$ m **(D)** $15 - \frac{30}{\pi}$ m

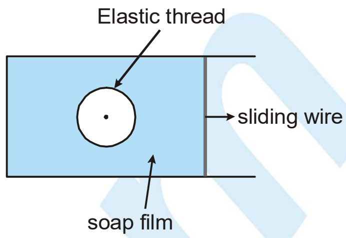
17. A mosquito with 8 legs stands on water surface and each leg makes depression of radius 'a'. If the surface tension and angle of contact are 'T' and zero respectively, then the weight of mosquito is :

(A) $8\,T\,.\,a$ **(B)** $16\,\pi\,T\,a$ **(C)** $\frac{T\,a}{8}$ **(D)** $\frac{T\,a}{16\,\pi}$

18. An isolated and charged spherical soap bubble has a radius 'r' and the pressure inside is atmospheric. If 'T' is the surface tension of soap solution, then charge on drop is:

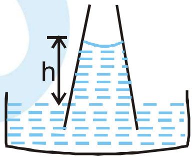
(A) $2\sqrt{\frac{2\,r\,T}{\varepsilon_0}}$ **(B)** $8\,\pi\,r\sqrt{2\,r\,T\,\varepsilon_0}$ **(C)** $8\,\pi\,r\sqrt{r\,T\,\varepsilon_0}$ **(D)** $8\,\pi\,r\sqrt{\frac{2\,r\,T}{\varepsilon_0}}$

19. The figure shows a soap film in which a closed elastic thread is lying. The film inside the thread is pricked. Now the sliding wire is moved out so that the surface area increases. The radius of the circle formed by elastic thread will



(A) increase
(B) decrease
(C) remains same
(D) data insufficient

20. A capillary of the shape as shown is dipped in a liquid. Contact angle between the liquid and the capillary is 0^0 and effect of liquid inside the meniscus is to be neglected.
T is surface tension of the liquid, r is radius of the meniscus, g is acceleration due to gravity and ρ is density of the liquid then height h in equilibrium is



(A) greater than $\frac{2T}{r\rho g}$
(B) equal to $\frac{2T}{r\rho g}$
(C) less than $\frac{2T}{r\rho g}$
(D) of any value depending upon actual values

21. Shape of the meniscus formed by two liquids when capillaries are dipped in them are shown. In I it is hemispherical where as in II it is flat. Pick correct statement regarding contact angles formed by the liquids in both situations

(A) It is 180º in I and 90º in II.
(B) It is 0º in I and 90º in II
(C) It is 90º in I and 0º in II
(D) It is greater than 90º in I and equal to 90º in II.

22. A uniform rod of density ρ, and length 'l' is having square cross-section of side 'a'. It is placed in a liquid of equal density ρ vertically along length in a tank having sufficient height of liquid. The surface tension of liquid is 'T' and angle of contact is 120º. Then :
(A) rod will float completely immersed inside the liquid
(B) rod will sink to bottom of tank
(C) rod will float partially submerged with height $\frac{4T}{a\rho g}$ above liquid
(D) rod will float partially submerged with height $\frac{2T}{a\rho g}$ above liquid.

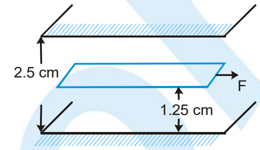
23. A cubical block of side 'a' and density 'ρ' slides over a fixed inclined plane with constant velocity 'v'. There is a thin film of viscous fluid of thickness 't' between the plane and the block. Then the coefficient of viscosity of the thin film will be :

(A) $\eta = \frac{\rho\, a g t \sin\theta}{v}$
(B) $\frac{\rho\, a g t \tan^2\theta}{v}$
(C) $\frac{v}{\rho\, a g t \sin\theta}$
(D) none of these

24. When a ball is released from rest in a very long column of viscous liquid, its downward acceleration is 'a'(just after release). Find its acceleration when it has acquired two third of the maximum velocity :

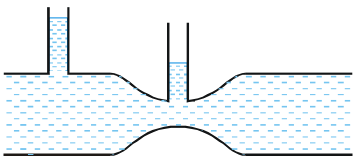
(A) $\frac{a}{3}$ (B) $\frac{2a}{3}$ (C) $\frac{a}{6}$ (D) none of these

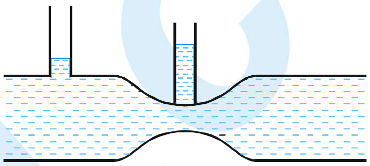
25. A space 2.5 cm wide between two large plane surfaces is filled with oil. Force required to drag a very thin plate of area 0.5 m^2 just midway the surfaces at a speed of 0.5 m/sec is 1N. The coefficient of viscosity in kg–sec/m^2 is :

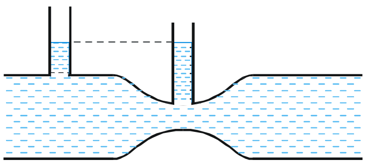


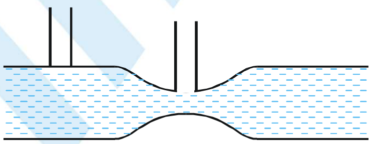
(A) 5×10^{-2} (B) 2.5×10^{-2}
(C) 1×10^{-2} (D) 7.5×10^{-2}

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

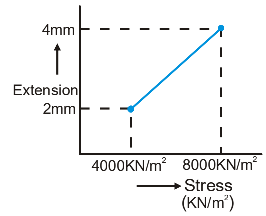
(A) 

(B) 

(C) 

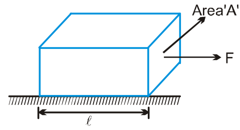
(D) 

27. In determination of young modulus of elasticity of wire, a force is applied and extension is recorded. Initial length of wire is '1 m'. The curve between extension and stress is depicted then young modulus of wire will be:



(A) 2×10^9 N/m^2 (B) 1×10^9 N/m^2
(C) 2×10^{10} N/m^2 (D) 1×10^{10} N/m^2

28. A block of mass 'M' area of cross-section 'A' & length 'λ' is placed on smooth horizontal floor. A force 'F' is applied on the block as shown. If 'y' is young modulus of material, then total extension in the block will be:



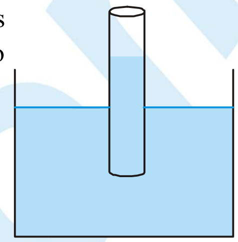
(A) $\frac{F\lambda}{AY}$ (B) $\frac{F\lambda}{2AY}$ (C) $\frac{F\lambda}{3AY}$ (D) cannot extend

29. A uniform rod of mass m and length ● is rotating with constant angular velocity ω about an axis which passes through its one end and perpendicular to the length of rod. The area of cross section of the rod is A and its young's modulus is Y. Neglect gravity. The strain at the mid point of the rod is :

(A) $\frac{m\omega^2\lambda}{8AY}$ (B) $\frac{3m\omega^2\lambda}{8AY}$ (C) $\frac{3m\omega^2\lambda}{4AY}$ (D) $\frac{m\omega^2\lambda}{4AY}$

30. Assuming the xylem tissues through which water rises from root to the branches in a tree to be of uniform cross-section find the maximum radius of xylum tube in a 10 m high coconut tree so that water can rise to the top.
(surface tension of water = 0.1N/m, Angle of contact of water with xylem tube = 60°)
(A) 1 cm **(B)** 1 mm **(C)** 10 μm **(D)** 1 μm

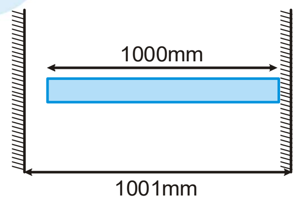
31. A long capillary tube of mass 'π' gm, radius 2mm and negligible thickness, is partially immersed in a liquid of surface tension 0.1 N/m. Take angle of contact zero and neglect buoyant force of liquid. The force required to hold the tube vertically, will be - ($g = 10\ m/s^2$)



(A) $10.4\ \pi$ mN **(B)** $10.8\ \pi$ mN
(C) $0.8\ \pi$ mN **(D)** $4.8\ \pi$ mN

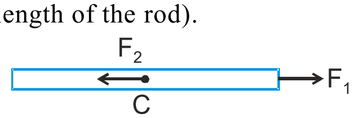
32. The elongation in a metallic rod hinged at one end and rotating in a horizontal plane becomes four times of the initial value. The angular velocity of rotation becomes :
(A) two times the initial value **(B)** half of initial value
(C) one third of initial value **(D)** four times the initial value.

33. A rod of length 1000 mm and co-efficient of linear expansion $\alpha = 10^{-4}$ per degree is placed symmetrically between fixed walls separated by 1001 mm. The Young's modulus of the rod is $10^{11}\ N/m^2$. If the temperature is increased by 20 °C, then the stress developed in the rod is (in N/m^2):



(A) 10 **(B)** 10^8
(C) 2×10^8 **(D)** cannot be calculated

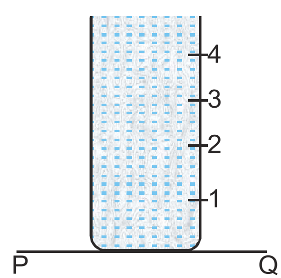
34. Two forces F_1 and F_2 act on a thin uniform elastic rod placed in space. Force F_1 acts at right end of the rod and F_2 acts exactly at centre of the rod as shown (both forces act parallel to length of the rod).
(i) F_1 causes extension of rod while F_2 causes compression of rod.
(ii) F_1 causes extension of rod and F_2 also causes extension of rod.
(iii) F_1 causes extension of rod while F_2 does not change length of rod.



The correct order of True / False in above statements is
(A) T F F **(B)** F T F **(C)** F F T **(D)** F F F

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

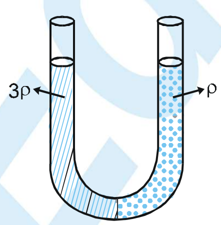
35. A cylindrical vessel of 90 cm height is kept filled upto the brim. It has four holes 1, 2, 3, 4 which are respectively at heights of 20cm, 30 cm, 40 cm and 50 cm from the horizontal floor PQ. The water falling at the maximum horizontal distance from the vessel comes from



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

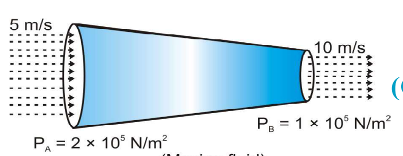
36. Which of the following is not possible ?

(A)



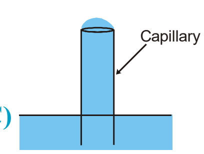
(Stationary fluid)

(B)



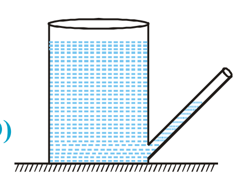
(Moving fluid)

(C)



(Stationary fluid)

(D)



(Stationary fluid)

SECTION - III : ASSERTION AND REASON TYPE

37. **Statement-1 :** Imagine holding two identical bricks under water. Brick A is completely submerged just below the surface of water, while brick B is at a greater depth. The magnitude of force exerted by the person (on the brick) to hold brick B in place is the same as magnitude of force exerted by the person (on the brick) to hold brick A in place.

Statement-2 : The magnitude of buoyant force on a brick completely submerged in water is equal to magnitude of weight of water it displaces and does not depend on depth of brick in water .

(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

38. **Statement-1 :** A uniform elastic rod lying on smooth horizontal surface is pulled by constant horizontal force of magnitude F as shown in figure (i). Another identical elastic rod is pulled vertically upwards by a constant vertical force of magnitude F (see figure ii). The extension in both rods will be same.

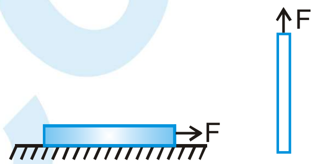


Fig.-i Fig.-ii

Statement-2 : In a uniform elastic rod, the extension depends only on forces acting at the ends of rod.

(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.

SECTION - IV : COMPREHENSION TYPE

Comprehension : 1

If the container filled with liquid gets accelerated horizontally or vertically, pressure in liquid gets changed. In case of horizontally accelerated liquid (a_x), the free surface has the slope $\frac{a_x}{g}$. In case of vertically accelerated liquid (a_y) for calculation of pressure, effective g is used. A closed box with horizontal base 6m by 6m and a height 2m is half filled with liquid. It is given a constant horizontal acceleration g/2 and vertical downward acceleration g/2.

39. The angle of the free surface with the horizontal is equal to -

(A) 30º **(B)** $\tan^{-1}\frac{2}{3}$ **(C)** $\tan^{-1}\frac{1}{3}$ **(D)** 45º

40. Length of exposed portion of top of box is equal to-

(A) 2m **(B)** 3m **(C)** 4m **(D)** 2.5 m

41. Water pressure at the bottom of centre of box is equal to – (atmospheric pressure = 10^5 N/m^2, density of water = 1000 kg/m^3, g = 10 m/sec^2)

(A) 1.1 MPa **(B)** 0.11 MPa **(C)** 0.101 MPa **(D)** 0.011 MPa

42. Maximum value of water pressure in the box is equal to

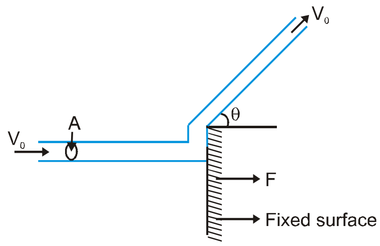
(A) 1.4 MPa **(B)** 0.12 MPa **(C)** 0.104 MPa **(D)** 0.014 MPa

43. What is the value of vertical acceleration of box for given horizontal acceleration (g/2), so that no part of bottom of box is exposed :

(A) g/2 upward **(B)** g/4 downward **(C)** g/4 upward **(D)** not possible

Comprehension # 2

When jet of liquid strikes a fixed or moving surfaces, it exerts thrust on it due to rate of change of momentum.

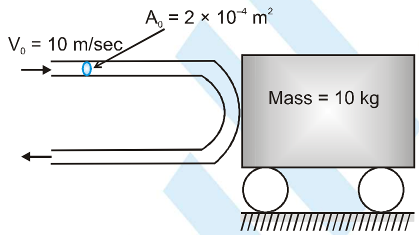


$F = (\rho AV_0).V_0 - (\rho AV_0).V_0 \cos\theta = \rho AV_0^2\,[1 - \cos\theta]$

If surface is free and starts moving due to thrust of liquid, then at any instant, the above equation gets modified based on relative change of momentum with respect to surface. Let any instant the velocity of surface is u, then above equation becomes –

$$F = \rho A(V_0 - u)^2\,[1 - \cos\theta\,]$$

Based on above concept, in the below given figure, if the cart is frictionless and free to move in horizontal direction, then answer the following :



Given cross–section area of jet = $2 \times 10^{-4}\ m^2$ velocity of jet $V_0 = 10$ m/sec., density of liquid = 1000 kg/m^3 , Mass of cart = M = 10 kg.

44. Initially (t = 0) the force on the cart is equal to :

(A) 20 N **(B)** 40 N **(C)** 80 N **(D)** zero

45. Velocity of cart at t = 10 sec. is equal to :

(A) 4 m/sec. **(B)** 6 m/sec. **(C)** 8 m/sec. **(D)** 5 m/sec.

46. In the above problem, what is the acceleration of cart at this instant –

(A) 1.6 m/sec^2 **(B)** 1 m/sec^2 **(C)** 0.64 m/sec^2 **(D)** 0.16 m/sec^2

47. The time at which velocity of cart becomes 2 m/sec, is equal to

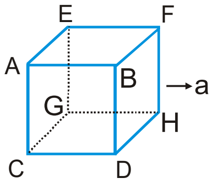
(A) 10/16 sec. **(B)** 2 sec. **(C)** 3.2 sec. **(D)** 4 sec.

48. The power supplied to the cart, when its velocity becomes 5 m/sec., is equal to :

(A) 100 W **(B)** 25 W **(C)** 50 W **(D)** 200 W

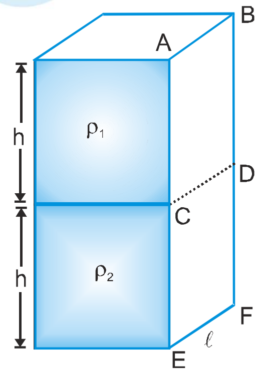
SECTION - V : MATRIX - MATCH TYPE

49. A cubical box is completely filled with mass m of a liquid and is given horizantal acceleration a as shown match the force due to fluid pressure on the faces of the cube with their appropriate values (assume zero pressure at 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)	$\frac{mg}{2}+ma$

50. A cuboid is filled with liquid of density ρ_2 upto height h and with liquid of density ρ_1 , also upto height h as shown



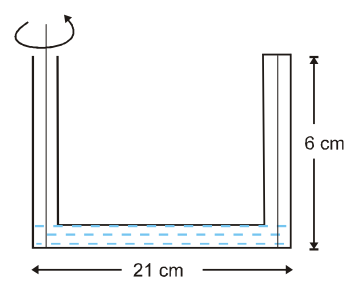
	Column I	Column II
(A)	Force on face ABCD due to liquid of density ρ_1	(P) zero
(B)	Force on face ABCD due to liquid of density ρ_2	(Q) $\frac{\rho_1 gh^2\lambda}{2}$
(C)	Force on face CDEF due to liquid of density ρ_1	(R) $\rho_1 gh^2$●
(D)	Force on face CDEF due to liquid of density ρ_2	(S) $\left[\rho_1 gh+\frac{\rho_2 gh}{2}\right]h\lambda$
		(T) $10\rho_1 gh^2$ ●^{2}

SECTION - VI : INTEGER TYPE

51. A cube with a mass m = 20 g wettable by water floats on the surface of water. Each face of the cube a is 30 cm long. What is the distance between the lower face of the cube and the surface of the water (in mm.)?
[S.T of water = 70 dyn/cm, g = 10 m/sec^2, assume angle of contact with water is zero]

52. A piston of 20 cm diameter and 20 cm long moves down in a cylinder of diameter 20.0628 cm. The oil filling the annular space has a viscosity of 10 poise and the weight of the piston is 1 kg. If the speed is x/10 cm s^{-1} with which the piston slides down.then x is [g = 1000 cm/sec^2]

53. Length of horizontal arm of a uniform cross–section U–tube is l = 21 cm and ends of both of the vertical arms are open to surrounding of pressure 10500 N/m^2. A liquid of density $\rho = 10^3$ kg/m^3 is poured into the tube such that liquid just fills the horizontal part of the tube. Now one of the open ends is sealed and the tube is then rotated about a vertical axis passing through the other vertical arm with angular velocity ω_0 = 10 rad/sec. If length of each vertical arm be a = 6 cm. Calculate the length of air column in the sealed arm in cm. [g=10 m/sec^2]



54. A rod 1 m long is 10 cm^2 in area for a portion of its length and 5 cm^2 in area for the remainder . The strain energy of this stepped bar is 40 % of that a bar 10 cm^2 in area 1 m long under the same stress in 10cm^2 part . What is the length of the portion 10 cm^2 in area.

ANSWER KEY

EXERCISE - 1

1. D	**2.** C	**3.** B	**4.** A	**5.** C	**6.** C	**7.** A	**8.** A	**9.** C	**10.** D	**11.** C	**12.** B	**13.** A
14. A	**15.** A	**16.** B	**17.** A	**18.** A	**19.** B	**20.** C	**21.** A	**22.** C	**23.** C	**24.** C	**25.** A	**26.** C
27. B	**28.** C	**29.** D	**30.** A	**31.** D	**32.** C	**33.** B	**34.** B	**35.** D	**36.** D	**37.** D	**38.** D	**39.** D
40. B	**41.** C	**42.** B	**43.** A	**44.** C	**45.** B	**46.** A	**47.** C	**48.** B	**49.** A	**50.** B	**51.** A	**52.** B
53. B	**54.** B	**55.** A	**56.** A	**57.** B	**58.** C	**59.** A	**60.** C	**61.** D	**62.** A	**63.** C	**64.** B	**65.** B
66. A	**67.** B	**68.** A	**69.** A	**70.** C	**71.** A	**72.** C						

EXERCISE - 2 : PART # I

1. A	**2.** B	**3.** D	**4.** A	**5.** D	**6.** C	**7.** A	**8.** B	**9.** A	**10.** D	**11.** C	**12.** D	**13.** C
14. C	**15.** C	**16.** B	**17.** B	**18.** D	**19.** C	**20.** A	**21.** D	**22.** A	**23.** A	**24.** A	**25.** B	**26.** B
27. D	**28.** D	**29.** A	**30.** A	**31.** C	**32.** D	**33.** C	**34.** B	**35.** B	**36.** B	**37.** A	**38.** C	**39.** B
40. B	**41.** A	**42.** C	**43.** C	**44.** A	**45.** C	**46.** CD	**47.** A,B,C	**48.** A,B,C,D	**49.** B	**50.** B,D	**51.** A,C,D	

PART # II

1. A	**2.** D	**3.** A	**4.** B	**5.** A	**6.** A	**7.** A	**8.** A	**9.** A	**10.** C	**11.** A	**12.** C	**13.** D
14. A	**15.** A	**16.** A	**17.** A	**18.** A	**19.** C	**20.** A	**21.** A	**22.** D	**23.** A	**24.** A	**25.** A	**26.** A
27. B	**28.** A	**29.** A	**30.** C	**31.** C	**32.** A							

EXERCISE - 3 : PART # I

1. A → Q ; B → R ; C → R

2. A → Q ; B → P ; C → Q

3. A → P ; B → Q ; C → Q

4. A → P ; B → P, C → R

PART # II

Comprehension #1 : **1.** B **2.** C **3.** D **4.** A **5.** C

Comprehension #2 : **1.** D **2.** C **3.** B **4.** B **5.** A

Comprehension #3: **1.** B **2.** C

Comprehension #4 : **1.** B **2.** A **3.** B **4.** D **5.** D

Comprehension #5 : **1.** D. **2.** A

Comprehension #6 : **1.** D **2.** C **3.** A **4.** D **5.** C

EXERCISE - 4

1. **(i)** B **(ii)** A **2.** **(i)** A **(ii)** A **(iii)** B **(iv)** A **3.** 6 mm **4.** **(i)** $\frac{dgL}{4Y}$ **(ii)** $\frac{dgL}{6Y}$

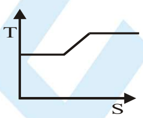
5. Steel wire : 1.49×10^{-4}m, Brass wire : 1.31×10^{-4} m **6.** 1.14 mm **7.** $\frac{4}{3}$ m from steel wire **8.** **(i)** No **(ii)** 1.11 mm

9. 68.6 dyne/cm **10.** 8.08×10^5 N/m^2 **12.** 2h **13.** 37.5 N **14.** 7.06×10^5 Pa **15.** 10.34m

16. $H = \frac{11}{32\pi}$ m , $h = \frac{2}{\pi}$ m **17.** $-A\rho g\left[\frac{h_1 - h_2}{2}\right]^2$ **18.** 248 kN/m^2 **19.** BE = 6 cm **20.** $\theta = 30^0$ depth of water $\geq$ 2m

21. P_P = 124.9 kN/m^2, P_Q = 89.5 kN/m^2, P_R = 89.5 kN/m^2, P_S = 46.4 kN/m^2 **22.** 5

23.



24. 2.78 **25.** 45^0 **26.** + 29625 J/m^3, – 30000 J/m^3 **27.** 32 cm/s

28. **(i)** 0.2 m/s^2 **(ii)** $\sqrt{2g\frac{m_0}{A\rho}}$ **29.** $R = \frac{Av}{a}\sqrt{\frac{2h}{g}}$

30. **(i)** $6\sqrt{2}$ m/s **(ii)** $9.6\sqrt{2}\times10^{-3}$ m^3/s **(iii)** 4.6×10^4 N/m^2 **31.** Glycerine Flask

32. **(i)** $v=\left(\sqrt{2gh}\right)$ **(ii)** $a=\frac{2gA_1}{A_2}$ **33.** $\sqrt{3}:\sqrt{2}$ **34.** 1.65×10^3 m **35.** 0.7 N

36. **(i)** $t_2=t_1\left[\frac{d_L}{dL-d}\right]$ **(ii)** No **(iii)** does not depend **37.** 5 cm **38.** 6N

39. **(i) (A)** $D=\frac{5}{4}d$ **(B)** $P=P_0+\frac{1}{4}(6H+L)\,dg$ **(ii) (A)** $v=\sqrt{\frac{g}{2}(3H-4h)}$ **(B)** $x=\sqrt{h(3H-4h)}$ **(C)** $x_{max}=\frac{3}{4}H$

40. $\frac{Y}{Y-X+Z}$ **41.** **(i)** $4m/s^2$ **(ii)** 10% **(iii)** 0, 45 kPa

42. **(i)** 4 m/s **(ii)** F = 7.2 N **(iii)** $F_{min}=0, F_{max}=52.2$ N **(iv)** both 4×10^{-3} m/s **43.** $\rho=\frac{w}{\pi h^2 g\tan\alpha\left(R-\frac{1}{3}h\tan\alpha\right)}$

44. **(i)** 2 sec **(ii)** 1 sec **45.** **(i)** $\frac{d^2H^2S}{2\rho g}=32$ kgf–m **(ii)** $\frac{1}{2}SH^2(1-d^2)=2$Kgf–m **46.** 0.50 N **47.** $\frac{b}{3}$

48. $h=\frac{mg+4Sa}{\rho_w a^2 g}$ **49.** 9W **50.** $\left[\rho gh+\frac{P_0h}{1-h}\right]\frac{d}{4\cos\theta}$

EXERCISE - 5 : PART # I

1. 4 **2.** 4 **3.** 2 **4.** 1 **5.** 2 **6.** 2 **7.** 3 **8.** 4 **9.** 3 **10.** 1 **11.** 4 **12.** 3 **13.** 1
14. 2 **15.** 3 **16.** 2 **17.** 2 **18.** 4 **19.** 2 **20.** 1 **21.** 1 **22.** 1 **23.** 1 **24.** 3

PART # II

MCQ's (Single Correct answers)

1. C **2.** B **3.** B **4.** A **5.** D **6.** D **7.** A **8.** D **9.** A **10.** B **11.** B **12.** C

MCQ's (Multiple Correct answers) **1.** A, D

Match the Column Type **1.** $A\to P,T$; $B\to Q,S,T\to C\to P,R,T$; $D\to Q$

Comprehension Based Questions **1.** C **2.** A **3.** A

Assertion–Reason **1.** A

Subjective Questions

1. $\pi R^2L\left(\sqrt{\rho\sigma}-\rho\right)$ **2.** **(i)** zero **(ii)** 0.25 m **(iii)** $\frac{g}{6}$ **3.** $R=\frac{4T}{\rho v^2}$

4. $\eta=\frac{\pi}{8Ql}\times\frac{1}{2}\rho v_0^2\left[1-\left(\frac{A_2}{A_1}\right)^2\right]\times a^4$ where $\frac{A_2}{A_1}=\frac{b^2}{D^2}$ **5.** $\frac{\lambda a}{2y}$ **6.** 2m **7.** $H=\frac{\omega^2L^2}{2g}$

Integer Type Questions **1.** 6 **2.** 206

MCQ's (Multiple Correct answers) **1.** A,B **2.** B,C **3.** A,D

MOCK TEST

1. A **2.** A **3.** A **4.** C **5** A **6.** A **7.** A **8.** A **9.** B **10.** A **11.** B **12.** B **13.** C
14. D **15.** C **16.** D **17.** B **18.** B **19.** C **20.** C **21.** B **22.** D **23.** A **24.** A **25.** B **26.** A
27. A **28.** B **29.** B **30.** D **31.** B **32.** A **33.** B **34.** C **35.** A,B **36.** A,C,D **37.** A **38.** C **39.** D
40. C **41.** B **42.** B **43.** A **44.** B **45.** C **46.** D **47.** A **48.** C **49.** $A\to P$; $B\to Q$; $C\to T$; $D\to S$
50 $A\to Q$; $B\to P$; $C\to R$; $D\to S$ **51.** 23 **52.** 25 **53.** 5 **54.** 40