FLUIDS

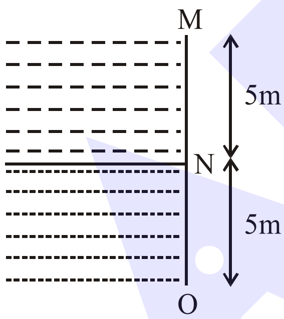
1. An ideal fluid flows (laminar flow) through a pipe of non-uniform diameter. The maximum and minimum diameters of the pipes are 6.4 cm and 4.8 cm, respectively. The ratio of the minimum and the maximum velocities of fluid in this pipe is :

(1) $\frac{\sqrt{3}}{2}$ (2) $\frac{3}{4}$ (3) $\frac{81}{256}$ (4) $\frac{9}{16}$

2. Consider a solid sphere of radius R and mass density $\rho(r)=\rho_0\left(1-\frac{r^2}{R^2}\right)$, $0<r\le R$. The minimum density of a liquid in which it will float is :

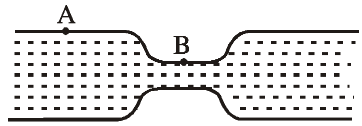
(1) $\frac{\rho_0}{5}$ (2) $\frac{\rho_0}{3}$ (3) $\frac{2\rho_0}{3}$ (4) $\frac{2\rho_0}{5}$

3. Two liquids of densities ρ_1 an ρ_2 ($\rho_2 = 2\rho_1$) are filled up behind a square wall of side 10 m as shown in figure. Each liquid has a height of 5 m. The ratio of the forces due to these liquids exerted on upper part MN to that at the lower part NO is (Assume that the liquids are not mixing)



(1) 1/4 (2) 2/3 (3) 1/3 (4) 1/2

4. Water flows in a horizontal tube (see figure). The pressure of water changes by 700 Nm^{-2} between A and B where the area of cross section are 40 cm^2 and 20 cm^2, respectively. Find the rate of flow of water through the tube. (density of water = 1000 kgm^{-3})



(Fig.)

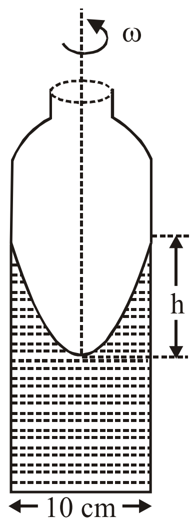
(1) 1810 cm^3/s (2) 3020 cm^3/s
(3) 2720 cm^3/s (4) 2420 cm^3/s

5. A small spherical droplet of density d is floating exactly half immersed in a liquid of density ρ and surface tension T. The radius of the droplet is (take note that the surface tension applies an upward force on the droplet) :

(1) $r=\sqrt{\frac{2T}{3(d+\rho)g}}$ (2) $r=\sqrt{\frac{3T}{(2d-\rho)g}}$

(3) $r=\sqrt{\frac{T}{(d-\rho)g}}$ (4) $r=\sqrt{\frac{T}{(d+\rho)g}}$

6. A cylindrical vessel containing a liquid is rotated about its axis so that the liquid rises at its sides as shown in the figure. The radius of vessel is 5 cm and the angular speed of rotation is ω rad s^{-1}. The difference in the height, h(in cm) of liquid at the centre of vessel and at the side will be:



(1) $\frac{25\omega^2}{2g}$ (2) $\frac{2\omega^2}{5g}$ (3) $\frac{5\omega^2}{2g}$ (4) $\frac{2\omega^2}{25g}$

7. A capillary tube made of glass of radius 0.15 mm is dipped vertically in a beaker filled with methylene iodide (surface tension = 0.05 Nm^{-1}, density = 667 kg m^{-3}) which rises to height h in the tube. It is observed that the two tangents drawn from liquid-glass interfaces (from opp. sides of the capillary) make an angle of 60° with one another. Then h is close to (g = 10 ms^{-2}).

(1) 0.137 m (2) 0.172 m
(3) 0.087 m (4) 0.049 m

8. Pressure inside two soap bubbles are 1.01 and 1.02 atmosphere, respectively. The ratio of their volumes is :

(1) 8 : 1 (2) 0.8 : 1 (3) 2 : 1 (4) 4 : 1

9. When a long glass capillary tube of radius 0.015 cm is dipped in a liquid, the liquid rises to a height of 15 cm within it. If the contact angle between the liquid and glass to close to 0°, the surface tension of the liquid, in milliNewton m^{-1}, is [$\rho_{(liquid)}$ = 900 kgm^{-3}, g = 10 ms^{-2}] (Give answer in closest integer)________.

10. A air bubble of radius 1 cm in water has an upward acceleration 9.8 cm s^{-2}. The density of water is 1 gm cm^{-3} and water offers negligible drag force on the bubble. The mass of the bubble is (g = 980 cm/s^2)

(1) 3.15 gm (2) 4.51 gm
(3) 4.15 gm (4) 1.52 gm

11. Two identical cylindrical vessels are kept on the ground and each contain the same liquid of density d. The area of the base of both vessels is S but the height of liquid in one vessel is x_1 and in the other, x_2. When both cylinders are connected through a pipe of negligible volume very close to the bottom, the liquid flows from one vessel to the other until it comes to equilibrium at a new height. The change in energy of the system in the process is :

(1) $gdS\ (x_2 + x_1)^2$ (2) $\frac{3}{4}gdS(x_2 - x_1)^2$

(3) $\frac{1}{4}gdS(x_2 - x_1)^2$ (4) $gdS(x_2^2 + x_1^2)$

12. A hollow spherical shell at outer radius R floats just submerged under the water surface. The inner radius of the shell is r. If the specific gravity of the shell material is $\frac{27}{8}$ w.r.t. water, the value of r is :

(1) $\frac{4}{9}R$ (2) $\frac{8}{9}R$ (3) $\frac{1}{3}R$ (4) $\frac{2}{3}R$

13. In an experiment to verify Stokes law, a small spherical ball of radius r and density ρ falls under gravity through a distance h in air before entering a tank of water. If the terminal velocity of the ball inside water is same as its velocity just before entering the water surface, then the value of h is proportional to :
(ignore viscosity of air)

(1) r (2) r^4 (3) r^3 (4) r^2

14. A fluid is flowing through a horizontal pipe of varying cross-section, with speed v ms^{-1} at a point where the pressure is P Pascal. P At another point where pressure is $\frac{P}{2}$ Pascal its speed is V ms^{-1}. If the density of the fluid is ρ kg m^{-3} and the flow is streamline, then V is equal to :

(1) $\sqrt{\frac{P}{2\rho}+v^2}$ (2) $\sqrt{\frac{P}{\rho}+v^2}$

(3) $\sqrt{\frac{2P}{\rho}+v^2}$ (4) $\sqrt{\frac{P}{\rho}+v}$

SOLUTION

1. NTA Ans. (4)

Sol. $A_1v_1 = A_2v_2$

$$\frac{v_{min}}{v_{max}} = \frac{A_{min}}{A_{max}} \Rightarrow \frac{v_{min}}{v_{max}} = \left(\frac{4.8}{6.4}\right)^2$$

$$\frac{v_{min}}{v_{max}} = \frac{9}{16}$$

2. NTA Ans. (4)

Sol. In case of minimum density of liqued, sphere will be floating while completely submerged

So mg = B

$$m = \int_0^R \rho(4\pi r^2 dr) = B$$

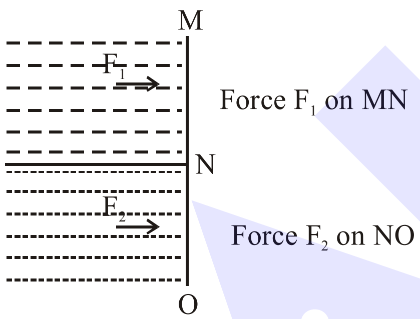
$$= \rho_0 \int_0^R \left(1 - \frac{r^2}{R^2}\right) 4\pi r^2 dr = \frac{4}{3}\pi R^3 \rho_\ell g$$

On Solving

$$\rho_\ell = \frac{2\rho_0}{5}$$

3. NTA Ans. (1)

Sol.



$$F_1 = \frac{\rho g h}{2} \times A$$

$$F_2 = \left(\rho g h + \frac{2\rho g h}{2}\right) A$$

$$\frac{F_1}{F_2} = \frac{1}{4}$$

4. NTA Ans. (3)

Sol. Rate of flow of water = $A_AV_A = A_BV_B$

$(40)V_A = (20)V_B$

$V_B = 2V_A$ .... (1)

Using Bernoulli's theorem

$$P_A + \frac{1}{2}\rho V_A^2 = P_B + \frac{1}{2}\rho V_B^2$$

$$P_A - P_B = \frac{1}{2}\rho(V_B^2 - V_A^2)$$

$$700 = \frac{1}{2} \times 1000(4V_A^2 - V_A^2)$$

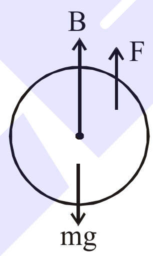
V_A = 0.68 m/s = 68 cm/s

Rate of flow = A_AV_A

= (40) (68) = 2720 cm^3/s

5. NTA Ans. (2)

Sol. FBD of droplet



B + F = mg

$$B = \left(\frac{2}{3}\pi R^3\right)\rho g$$

F = T(2πR)

$$m = d\left(\frac{4}{3}\pi R^3\right)$$

$$\left(\frac{2}{3}\pi R^3\right)\rho g + T(2\pi R) = d\left(\frac{4}{3}\pi R^3\right)g$$

$$T(2\pi R) = \left(\frac{2}{3}\pi R^3\right)g[2d - \rho]$$

$$R = \sqrt{\frac{3T}{(2d-\rho)g}}$$

∴ Correct answer (2)

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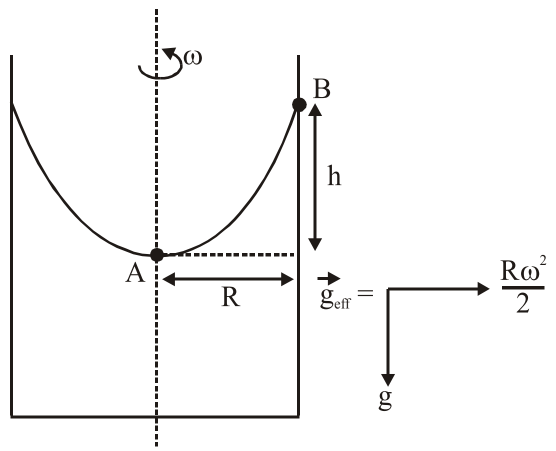
6. Official Ans. by NTA (1)

Sol.



Applying pressure equation from A to B

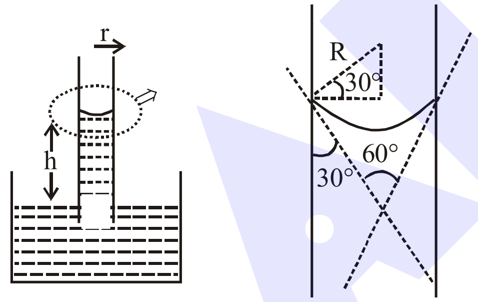
$$P_0 + \rho.\frac{R\omega^2}{2}.R - \rho gh = P_0$$

$$\frac{\rho R^2\omega^2}{2} = \rho gh$$

$$h = \frac{R^2\omega^2}{2g} = (5)^2\frac{\omega^2}{2g} = \frac{25}{2}\frac{\omega^2}{g}$$

7. Official Ans. by NTA (3)

Sol.



r → radius of capillary
R → Radius of meniscus.

From figure, $\frac{r}{R} = \cos 30°$

$$R = \frac{2r}{\sqrt{3}} = \frac{2\times 0.15\times 10^{-3}}{\sqrt{3}}$$

$$= \frac{0.3}{\sqrt{3}}\times 10^{-3}\,m$$

Height of capillary

$$h = \frac{2T}{\rho gR} = 2\sqrt{3}\,T$$

$$h = \frac{2\times 0.05}{667\times 10\times\left(\frac{0.3\times 10^{-3}}{\sqrt{3}}\right)}$$

h = 0.087 m

8. Official Ans. by NTA (1)

Sol. $\Delta P_1 = 0.01 = 4T/R_1$ .....(1)

$\Delta P_2 = 0.02 = 4T/R_2$ .....(2)

Equation (1) ÷ (2)

$$\frac{1}{2} = \frac{R_2}{R_1}$$

$R_1 = 2R_2$

$$\frac{V_1}{V_2} = \frac{R_1^3}{R_2^3} = \frac{8R_2^3}{R_2^3} = 8$$

9. Official Ans. by NTA (101)

Sol. Capillary rise

$$h = \frac{2S\cos\theta}{\rho gr} \qquad \Rightarrow S = \frac{\rho grh}{2\cos\theta}$$

$$= \frac{(900)(10)(15\times 10^{-5})(15\times 10^{-2})}{2}$$

$S = 1012.5 \times 10^{-4}$

$S = 101.25 \times 10^{-3} = 101.25$ mN/m

In question closest integer is asked

so closest integer = 101.00 Ans.

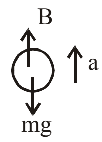
10. Official Ans. by NTA (3)

Sol. Volume $V = \frac{4\pi}{3}r^3 = \frac{4\pi}{3}\times(1)^3 = 4.19\text{cm}^3$

$a = 9.8$ cm/s²

B – mg = ma

$$m = \frac{B}{g+a}$$



$$\Rightarrow m = \frac{(V\rho_\omega g)}{g+a} = \frac{V\rho_\omega}{1+\frac{a}{g}}$$

$$= \frac{(4.19)\times 1}{1+\frac{9.8}{980}} = \frac{4.19}{1.01} = 4.15\text{gm}$$

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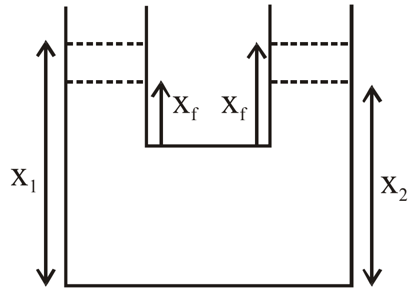
11. Official Ans. by NTA (3)

Sol.



$U_i = (\rho S x_1)g \cdot \frac{x_1}{2} + (\rho S x_2)g \cdot \frac{x_2}{2}$

$U_f = (\rho S x_f)g \cdot \frac{x_f}{2} \times 2$

By volume conservation

$Sx_1 + Sx_2 = S(2x_f)$

$x_f = \frac{x_1 + x_2}{2}$

$$\Delta U = \rho S g\left[\left(\frac{x_1^2}{2} + \frac{x_2^2}{2}\right) - x_f^2\right]$$

$$= \rho S g\left[\frac{x_1^2}{2} + \frac{x_2^2}{2} - \left(\frac{x_1 + x_2}{2}\right)^2\right]$$

$$= \frac{\rho S g}{2}\left[\frac{x_1^2}{2} + \frac{x_2^2}{2} - x_1 x_2\right]$$

$$= \frac{\rho S g}{4}(x_1 - x_2)^2$$

12. Official Ans. by NTA (2)

Sol. $\frac{4}{3}\pi\left(R^3 - r^3\right)\rho_m g = \frac{4}{3}\pi R^3 \rho_w g$

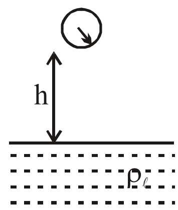
$$1 - \left(\frac{r}{R}\right)^3 = \frac{8}{27}$$

$$\Rightarrow \frac{r}{R} = \left(\frac{19}{27}\right)^{1/3} = \frac{19^{1/3}}{3}$$

$$= 0.88 \simeq \frac{8}{9}$$

13. Official Ans. by NTA (2)

Sol.



After falling through h, the velocity be equal to terminal velocity

$$\sqrt{2gh} = \frac{2}{9}\frac{r^2 g}{\eta}(\rho_\ell - \rho)$$

$$\Rightarrow h = \frac{2}{81}\frac{r^4 g (\rho_\ell - \rho)^2}{\eta^2}$$

$\Rightarrow h \propto r^4$

14. Official Ans. by NTA (2)

Sol. Applying Bernoulli's Equation

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$P + \frac{1}{2}\rho v^2 = \frac{P}{2} + \frac{1}{2}\rho V^2$$

$$\frac{2P}{2\rho} + \frac{1}{2}\frac{\rho v^2}{\rho} \times 2 = V^2$$

$$\sqrt{\frac{P}{\rho} + v^2} = V$$

Ans. (2)