FLUID

1. A hydraulic press can lift 100 kg when a mass 'm' is placed on the smaller piston. It can lift _______kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass 'm' on the smaller piston.

2. A large number of water drops, each of radius r, combine to have a drop of radius R. If the surface tension is T and mechanical equivalent of heat is J, the rise in heat energy per unit volume will be:

(1) $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$ (2) $\frac{2T}{rJ}$

(3) $\frac{3T}{rJ}$ (4) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

3. The pressure acting on a submarine is 3×10^5 Pa at a certain depth. If the depth is doubled, the percentage increase in the pressure acting on the submarine would be : (Assume that atmospheric pressure is 1×10^5 Pa density of water is 10^3 kg m^{-3}, g = 10 ms^{-2})

(1) $\frac{200}{3}\%$ (2) $\frac{200}{5}\%$

(3) $\frac{5}{200}\%$ (4) $\frac{3}{200}\%$

4. What will be the nature of flow of water from a circular tap, when its flow rate increased from 0.18 L/min to 0.48 L/min ? The radius of the tap and viscosity of water are 0.5 cm and 10^{-3} Pa s, respectively.
(Density of water : 10^3 kg/m^3)
(1) Unsteady to steady flow
(2) Remains steady flow
(3) Remains turbulent flow
(4) Steady flow to unsteady flow

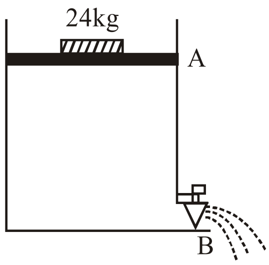
5. When two soap bubbles of radii a and b (b > a) coalesce, the radius of curvature of common surface is :

(1) $\frac{ab}{b-a}$ (2) $\frac{a+b}{ab}$

(3) $\frac{b-a}{ab}$ (4) $\frac{ab}{a+b}$

6. Suppose you have taken a dilute solution of oleic acid in such a way that its concentration becomes 0.01 cm^3 of oleic acid per cm^3 of the solution. Then you make a thin film of this solution (monomolecular thickness) of area 4 cm^2 by considering 100 spherical drops of radius $\left(\frac{3}{40\pi}\right)^{\frac{1}{3}} \times 10^{-3}$ cm. Then the thickness of oleic acid layer will be $x \times 10^{-14}$ m.
Where x is__________.

7. Consider a water tank as shown in the figure. It's cross-sectional area is 0.4 m^2. The tank has an opening B near the bottom whose cross-section area is 1 cm^2. A load of 24 kg is applied on the water at the top when the height of the water level is 40 cm above the bottom, the velocity of water coming out the opening B is v ms^{-1}. The value of v, to the nearest integer, is___. [Take value of g to be 10 ms^{-2}]



8. Two small drops of mercury each of radius R coalesce to form a single large drop. The ratio of total surface energy before and after the change is :

(1) $2^{\frac{1}{3}}:1$ (2) $1:2^{\frac{1}{3}}$

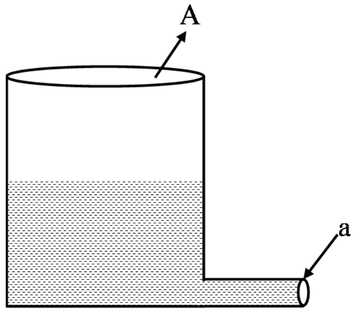
(3) 2 : 1 (4) 1 : 2

9. Two spherical soap bubbles of radii r_1 and r_2 in vacuum combine under isothermal conditions. The resulting bubble has a radius equal to :

(1) $\frac{r_1 r_2}{r_1 + r_2}$ (2) $\sqrt{r_1 r_2}$

(3) $\sqrt{r_1^2 + r_2^2}$ (4) $\frac{r_1 + r_2}{2}$

10. A light cylindrical vessel is kept on a horizontal surface. Area of base is A. A hole of cross-sectional area 'a' is made just at its bottom side. The minimum coefficient of friction necessary to prevent sliding the vessel due to the impact force of the emerging liquid is (a < < A) :



(1) $\frac{A}{2a}$ (2) None of these

(3) $\frac{2a}{A}$ (4) $\frac{a}{A}$

11. A raindrop with radius R = 0.2 mm falls from a cloud at a height h = 2000 m above the ground. Assume that the drop is spherical throughout its fall and the force of buoyance may be neglected, then the terminal speed attained by the raindrop is :
[Density of water f_w = 1000 kg m^{-3} and Density of air f_a = 1.2 kg m^{-3}, g = 10 m/s^2
Coefficient of viscosity of air = 1.8×10^{-5} Nsm^{-2}]

(1) 250.6 ms^{-1} (2) 43.56 ms^{-1}
(3) 4.94 ms^{-1} (4) 14.4 ms^{-1}

12. The water is filled upto height of 12 m in a tank having vertical sidewalls. A hole is made in one of the walls at a depth 'h' below the water level. The value of 'h' for which the emerging stream of water strikes the ground at the maximum range is ___ m.

13. Two narrow bores of diameter 5.0 mm and 8.0 mm are joined together to form a U-shaped tube open at both ends. If this U-tube contains water, what is the difference in the level of two limbs of the tube.
[Take surface tension of water T = 7.3×10^{-2} Nm^{-1}, angle of contact = 0, g = 10 ms^{-2} and density of water = 1.0×10^3 kg m^{-3}]

(1) 3.62 mm (2) 2.19 mm
(3) 5.34 mm (4) 4.97 mm

14. A soap bubble of radius 3 cm is formed inside the another soap bubble of radius 6 cm. The radius of an equivalent soap bubble which has the same excess pressure as inside the smaller bubble with respect to the atmospheric pressure is .... cm.

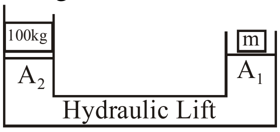
15. In Millikan's oil drop experiment, what is viscous force acting on an uncharged drop of radius 2.0×10^{-5} m and density 1.2×10^3 kgm^{-3} ? Take viscosity of liquid = 1.8×10^{-5} Nsm^{-2}. (Neglect buoyancy due to air).

(1) 3.8×10^{-11} N (2) 3.9×10^{-10} N
(3) 1.8×10^{-10} N (4) 5.8×10^{-10} N

SOLUTION

1. Official Ans. by NTA (25600)

Sol. Using Pascals law



$$\frac{100\times g}{A_2}=\frac{mg}{A_1} \quad ....(1)$$

Let m mass can lift M_0 in second case then

$$\frac{M_0 g}{16A_2} = \frac{mg}{A_1/16} \quad ....(2)$$

$\{\text{Since } A = \frac{\pi d^2}{4}\}$

From equation (1) and (2) we get

$$\frac{M_0}{16.100} = 16$$

$\Rightarrow M_0 = 25600$ kg

2. Official Ans. by NTA (4)

Sol. $n\times\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$\therefore n^{1/3} r = R$

$\therefore$ Total change in surface energy

$= (n(4\pi r^2) - 4\pi R^2)T$

$\Rightarrow 4\pi T\,(nr^2 - R^2)$

$\therefore$ Heat energy

$$= \frac{4\pi T\left(nr^2 - R^2\right)}{J\times\frac{4}{3}\pi R^3} = \frac{3T}{J}\left(\frac{nr^2}{R^3}-\frac{1}{R}\right)$$

Put $nr^3 = R^3$

$$\therefore \frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$$

3. Official Ans. by NTA (1)

Sol. $P_1 = \rho gd + P_0 = 3\times10^5$ Pa

$\therefore \rho gd = 2\times10^5$ Pa

$P_2 = 2\rho gd + P_0$

$= 4\times10^5 + 10^5 = 5\times10^5$ Pa

$$\%\text{increase} = \frac{P_2 - P_1}{P_1}\times100$$

$$= \frac{5\times10^5 - 3\times10^5}{3\times10^5}\times100 = \frac{200}{3}\%$$

4. Official Ans. by NTA (4)

Sol. The nature of flow is determined by Reynolds Number.

$$R_e = \frac{\rho v D}{\eta}$$

[$\rho \rightarrow$ density of fluid ; $\eta \rightarrow$ coefficient of viscosity
v $\rightarrow$ velocity of flow
D $\rightarrow$ Diameter of pipe]

From NCERT

If $R_e < 1000$ $\rightarrow$ flow is steady

$1000 < R_e < 2000 \rightarrow$ flow becomes unsteady

$R_e > 2000 \rightarrow$ flow is turbulent

$$R_{e\,initial} = 10^3\times\frac{0.18\times10^{-3}}{\pi\times(0.5\times10^{-2})^2\times60}\times\frac{1\times10^{-2}}{10^{-3}}$$

$= 382.16$

$$R_{e\,final} = 10^3\times\frac{0.48\times10^{-3}}{\pi\times(0.5\times10^{-2})^2\times60}\times\frac{1\times10^{-2}}{10^{-3}}$$

$= 1019.09$

5. Official Ans. by NTA (1)

Sol. Excess pressure at common surface is given by

$$P_{ex} = 4T\left(\frac{1}{a}-\frac{1}{b}\right) = \frac{4T}{r}$$

$$\therefore \frac{1}{r}=\frac{1}{a}-\frac{1}{b}\ ; \quad r = \frac{ab}{b-a}$$

6. Official Ans. by NTA (25)

Sol. $4t_T = 100\times\frac{4}{3}\pi r^3$

$= 100\times\frac{4\pi}{3}\times\frac{3}{40\pi}\times10^{-9} = 10^{-8}\ \text{cm}^3$

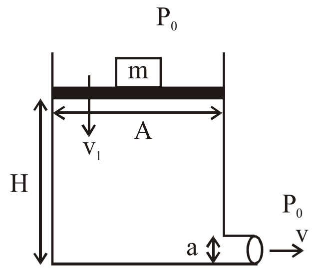
$t_T = 25\times10^{-10}$ cm

$= 25\times10^{-12}$ m

$t_0 = 0.01\,t_T = 25\times10^{-14}$ m $= 25$

7. Official Ans. by NTA (3)

Sol.



m = 24 kg

A = 0.4 m²

a = 1 cm²

H = 40cm

Using Bernoulli's equation

$$\Rightarrow\left(P_0+\frac{mg}{A}\right)+\rho gH+\frac{1}{2}\rho v_1^2 \ (\rightarrow 0)$$

$$=P_0+0+\frac{1}{2}\rho v^2 \qquad \text{... (1)}$$

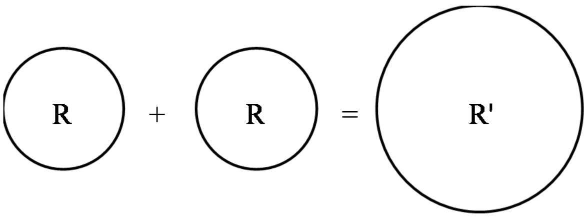
$\Rightarrow$ Neglecting v_1

$$\Rightarrow v=\sqrt{2gH+\frac{2mg}{A\rho}} \qquad \Rightarrow v=\sqrt{8+1.2}$$

$$\Rightarrow v = 3.033 \text{ m/s} \qquad \Rightarrow v\simeq 3\text{m/s}$$

8. Official Ans. by NTA (1)

Sol.



$$\frac{4}{3}\pi R^3+\frac{4}{3}\pi R^3=\frac{4}{3}\pi R'^3$$

$$R'=2^{\frac{1}{3}}R \qquad \text{....(i)}$$

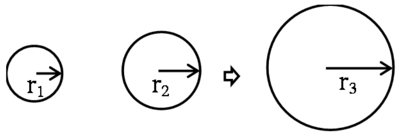
$$A_i=2[4\pi R^2]$$

$$A_f=4\pi R'^2$$

$$\frac{U_i}{U_f}=\frac{A_i}{A_f}=\frac{2R^2}{2^{2/3}R^2}=2^{1/3}$$

9. Official Ans. by NTA (3)

Sol.



no. of moles is conserved

$n_1 + n_2 = n_3$

$P_1V_1 + P_2V_2 = P_3V$

$$\frac{4S}{r_1}\left(\frac{4}{3}\pi r_1^3\right)+\frac{4S}{r_2}\left(\frac{4}{3}\pi r_2^3\right)=\frac{4S}{r_3}\left(\frac{4}{3}\pi r_3^3\right)$$

$$r_1^2+r_2^2=r_3^2$$

$$r_3=\sqrt{r_1^2+r_2^2}$$

10. Official Ans. by NTA (3)

Sol. For no sliding

$f \geq \rho a v^2$

$\mu mg \geq \rho a v^2$

$\mu\rho Ahg \geq \rho a 2gh$

$$\boxed{\mu \geq \frac{2a}{A}}$$

Option (3)

11. Official Ans. by NTA (3)

Sol. At terminal speed

$a = 0$

$F_{net} = 0$

$mg = F_v = 6\pi\eta Rv$

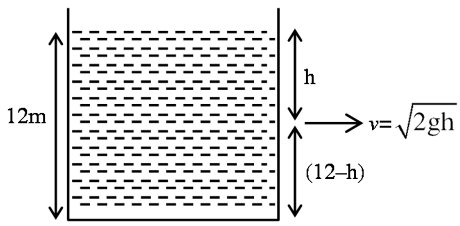
$$v=\frac{mg}{6\pi\eta Rv}$$

$$v=\frac{\rho_w\frac{4\pi}{3}R^3g}{6\pi\eta R}=\frac{2\rho_w R^2 g}{9\eta}$$

$$=\frac{400}{81}\text{ m/s}=4.94\text{ m/s}$$

12. Official Ans. by NTA (6)

Sol.



$$R=\sqrt{2gh}\times\sqrt{\frac{(12-h)\times 2}{g}}$$

$$\sqrt{4h(12-h)}=R$$

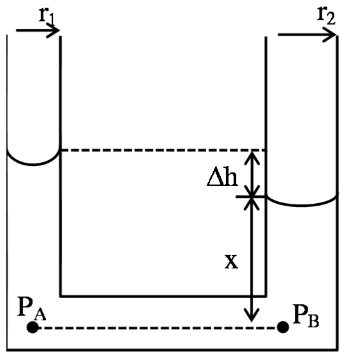
For maximum R

$$\frac{dR}{dh}=0$$

$\Rightarrow h = 6\text{m}$

13. Official Ans. by NTA (2)

Sol.



We have $P_A = P_B$. [Points A & B at same horizontal level]

$$\therefore P_{atm} - \frac{2T}{r_1} + \rho g\left(x + \Delta h\right) = P_{atm} - \frac{2T}{r_2} + \rho g x$$

$$\therefore \rho g \Delta h = 2T\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

$$= 2 \times 7.3 \times 10^{-2}\left[\frac{1}{2.5 \times 10^{-3}} - \frac{1}{4 \times 10^{-3}}\right]$$

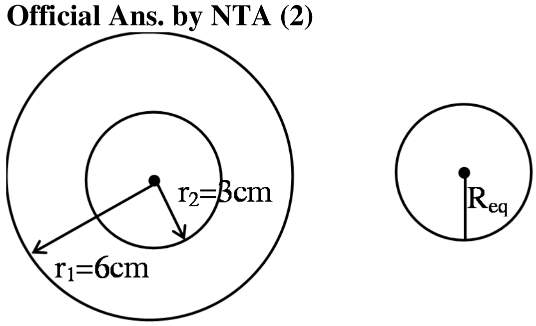
$$\therefore \Delta h = \frac{2 \times 7.3 \times 10^{-2} \times 10^{3}}{10^{3} \times 10}\left[\frac{1}{2.5} - \frac{1}{4}\right]$$

$= 2.19 \times 10^{-3}$m = 2.19 mm

Hence option (2)

14. Official Ans. by NTA (2)

Sol.



Excess pressure inside the smaller soap bubble

$$\Delta P = \frac{4S}{r_1} + \frac{4S}{r_2} \quad \text{.... (i)}$$

The excess pressure inside the equivalent soap bubble

$$\Delta P = \frac{4S}{R_{eq}} \quad \text{... (ii)}$$

From (i) & (ii)

$$\frac{4S}{R_{eq}} = \frac{4S}{r_1} + \frac{4S}{r_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} = \frac{1}{6} + \frac{1}{3}$$

$R_{eq} = 2$ cm

Ans. 2.00

15. Official Ans. by NTA (2)

Sol. Viscous force = Weight

$$= \rho \times \left(\frac{4}{3}\pi r^3\right)g = 3.9 \times 10^{-10}$$