9 MECHANICAL PROPERTIES OF FLUIDS

MCQs with One Correct Answer

1. The total weight of a piece of wood is 6 kg. In the floating state in water its $\frac{1}{3}$ part remains inside the water. On this floating piece of wood what maximum weight is to be put such that the whole of the piece of wood is to be drowned in the water?

(a) 15 kg (b) 14 kg
(c) 10 kg (d) 12 kg

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

(a) 15.82×10^5 Pa (b) 6.92×10^5 Pa
(c) 2.63×10^5 Pa (d) 1.12×10^5 Pa

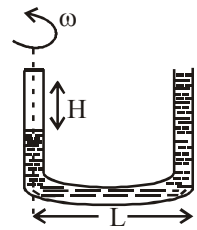
3. A U-shaped tube contains a liquid of density ρ and it is rotated about the left dotted line as shown in the figure. Find the difference in the levels of liquid column.

(a) $\frac{\omega^2 L^2}{2g}$

(b) $\frac{\omega^2 L^2}{2\sqrt{2}g}$

(c) $\frac{2\omega^2 L^2}{g}$

(d) $\frac{2\sqrt{2}\omega^2 L^2}{g}$



4. Air of density 1.2 kg m^{-3} is blowing across the horizontal wings of an aeroplane in such a way that its speeds above and below the wings are 150 ms^{-1} and 100 ms^{-1}, respectively. The pressure difference between the two sides of the wings, is :

(a) 60 Nm^{-2} (b) 180 Nm^{-2}
(c) 7500 Nm^{-2} (d) 12500 Nm^{-2}

5. If it takes 5 minutes to fill a 15 litre bucket from a water tap of diameter $\frac{2}{\sqrt{\pi}}$ cm then the Reynolds number for the flow is (density of water = 10^3 kg/m^3) and viscosity of water = 10^{-3} Pa s) close to :

(a) 1100 (b) 11000
(c) 550 (d) 5500

6. Water flows into a large tank with flat bottom at the rate of 10^{-4} m^3 $s^{-(}1)$ Water is also leaking out of a hole of area 1 cm^2 at its bottom. If the height of the water in the tank remains steady, then this height is:

(a) 5.1 cm (b) 7 cm
(c) 4 cm (d) 9 cm

7. A spherical drop of radius R is divided into eight equal droplets. If surface tension is T, then the work done in this process is

(a) $2\pi R^2 T$ (b) $3\pi R^2 T$
(c) $4\pi R^2 T$ (d) $2\pi R T^2$

8. A U-shaped wire is dipped in a soap solution and removed. The thin soap film formed between the wire and the light slider supports a weight of

1.5×10^{-2} N (which includes the small weight of the slider). The length of the slider is 30 cm. What is the surface tension of the film?

(a) 2.5×10^{-2} Nm^{-1} (b) 5.5×10^{-2} Nm^{-1}

(c) 9.5×10^{-2} Nm^{-1} (d) 11.5×10^{-2} Nm^{-1}

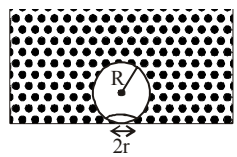
9. Water rises in a capillary tube to a certain height such that the upward force due to surface tension is balanced by 7.5×10^{-4}N force due to the weight of the liquid. If the surface tension of water is 6×10^{-2}Nm^{-1}, the inner circumference of the capillary must be

(a) 1.25×10^{-2}m (b) 0.50×10^{-2}m

(c) 6.5×10^{-2}m (d) 12.5×10^{-2}m

10. On heating water, bubbles being formed at the bottom of the vessel detach and rise. Take the bubbles to be sphere of radius R and making a circular contact of radius r with the bottom of the vessel. If r $\ll$ R and the surface tension of water is T, value of r just before bubbles detach is:

(density of water is ρ_w)



(a) $R^2\sqrt{\frac{\rho_w g}{3T}}$ (b) $R^2\sqrt{\frac{2\rho_w g}{3T}}$

(c) $R^2\sqrt{\frac{\rho_w g}{T}}$ (d) $R^2\sqrt{\frac{3\rho_w g}{T}}$

11. A U tube contains water and methylated spirit separated by mercury. The mercury columns in the two arms are in level with 10.0 cm of water in one arm and 12.5 cm of spirit in the other, the relative density of spirit is

(a) 0.8 (b) 1.32

(c) 2.38 (d) 3.52

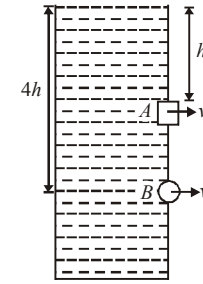
12. A square hole of side length ℓ is made at a depth of h and a circular hole of radius r is made at a depth of 4h from the surface of water in a water tank kept on a horizontal surface (See figure). If $\ell << h, r << h$ and the rate of water flow from the two holes is the same, then r is equal to

(a) $\frac{\ell}{\sqrt{2\pi}}$

(b) $\frac{\ell}{\sqrt{3\pi}}$

(c) $\frac{\ell}{3\pi}$

(d) $\frac{\ell}{2\pi}$



13. 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

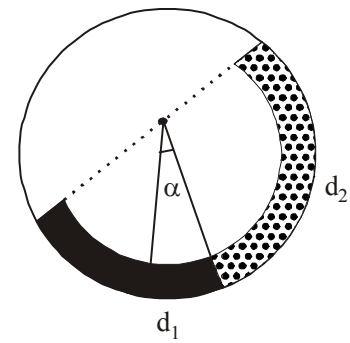
(c) 0.1 m/s (d) 0.2 m/s

14. Two tubes of radii r_1 and r_2, and lengths l_1 and l_2, respectively, are connected in series and a liquid flows through each of them in streamline conditions. P_1 and P_2 are pressure differences across the two tubes. If P_2 is $4P_1$ and l_2 is $\frac{l_1}{4}$, then the radius r_2 will be equal to :

(a) r_1 (b) $2r_1$

(c) $4r_1$ (d) $\frac{r_1}{2}$

15. 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 $\frac{d_1}{d_2}$ is:



(a) $\frac{1+\sin\alpha}{1-\sin\alpha}$ (b) $\frac{1+\cos\alpha}{1-\cos\alpha}$

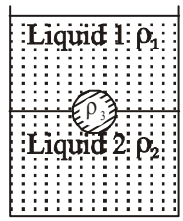
(c) $\frac{1+\tan\alpha}{1-\tan\alpha}$ (d) $\frac{1+\sin\alpha}{1-\cos\alpha}$

16. 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_1 ($\rho_2 < \rho_1$). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed v, i.e., $F_{viscous} = -kv^2$ ($k > 0$). The terminal speed of the ball is

(a) $\sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$ (b) $\frac{Vg\rho_1}{k}$

(c) $\sqrt{\frac{Vg\rho_1}{k}}$ (d) $\frac{Vg(\rho_1 - \rho_2)}{k}$

17. A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 and, ρ_2 respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure.Which of the following is true for ρ_1, $\rho_2$and ρ_3?



(a) $\rho_3 < \rho_1 < \rho_2$ (b) $\rho_1 > \rho_3 > \rho_2$

(c) $\rho_1 < \rho_2 < \rho_3$ (d) $\rho_1 < \rho_3 < \rho_2$

18. A thin uniform tube is bent into a circle of radius r in the vertical plane. Equal volumes of two immiscible liquids, whose densities are ρ_1 and ρ_1 ($\rho_1 > \rho_2$) fill half the circle. The angle θ between the radius vector passing through the common interface and the vertical is

(a) $\theta = \tan^{-1}\left[\frac{\pi}{2}\left(\frac{\rho_1 - \rho_2}{\rho_1 + \rho_2}\right)\right]$

(b) $\theta = \tan^{-1}\frac{\pi}{2}\left(\frac{\rho_1 - \rho_2}{\rho_1 + \rho_2}\right)$

(c) $\theta = \tan^{-1}\pi\left(\frac{\rho_1}{\rho_2}\right)$

(d) None of above

19. A body of density ρ' is dropped from rest at a height h into a lake of density ρ where $\rho > \rho'$ neglecting all dissipative forces, calculate the maximum depth to which the body sinks.

(a) $\frac{h}{\rho - \rho'}$ (b) $\frac{h\rho'}{\rho}$

(c) $\frac{h\rho'}{\rho - \rho'}$ (d) $\frac{h\rho}{\rho - \rho'}$

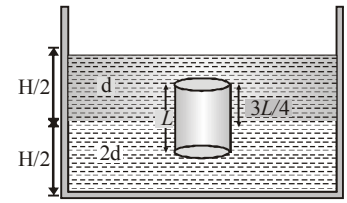
20. A homogeneous solid cylinder of length L (L < H/2) cross-sectional area A/5 is immersed such that it floats with its axis vertical at the liquid-liquid interface with length L/4 in the denser liquid as shown in the fig. The lower density liquid is open to atmosphere having pressure P_0. Then density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

(a) $\frac{5}{4}d$

(b) $\frac{4}{5}d$

(c) d

(d) $\frac{d}{5}$



Numeric Value Answer

21. 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.]

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

23. 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 $X\pi r\sqrt{2rT\varepsilon_0}$ find the value of X.

24. A 20 cm long capillary tube is dipped in water. The water rises up to 8 cm. If the entire arrangement is put in a freely falling elevator the length (in m) of water column in the capillary tube will be

25. 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

26. Two identical charged spheres are suspended by strings of equal lengths. The strings make an angle of 30° with each other. When suspended in a liquid of density 0.8g cm^{-3}, the angle remains the same. If density of the material of the sphere is 1.6 g cm^{-3}, the dielectric constant of the liquid is

27. 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) _____.

28. An air bubble of radius 0.1 cm is in a liquid having surface tension 0.06 N/m and density 10^3 kg/m^3. The pressure inside the bubble is 1100 Nm^{-2} greater than the atmospheric pressure. At what depth (in m) is the bubble below the surface of the liquid? ($g = 9.8\ ms^{-2}$)

29. 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 (in cm) of the air column above mercury in the tube now?
(Atmospheric pressure = 76 cm of Hg)

30. The velocity of water in a river is 18 km/h near the surface. If the river is 5 m deep, find the shearing stress (in N/m^2) between the horizontal layers of water. The co-efficient of viscosity of water = 10^{-2} poise.

ANSWER KEY

1	(d)	**4**	(c)	**7**	(c)	**10**	(b)	**13**	(c)	**16**	(a)	**19**	(c)	**22**	(3)	**25**	(20)	**28**	(0.1)
2	(b)	**5**	(d)	**8**	(a)	**11**	(a)	**14**	(d)	**17**	(d)	**20**	(a)	**23**	(8)	**26**	(2)	**29**	(16)
3	(a)	**6**	(a)	**9**	(a)	**12**	(a)	**15**	(c)	**18**	(d)	**21**	(6)	**24**	(20)	**27**	(101)	**30**	(10^{-2})