CBSE Test Paper 01

Chapter 10 Mechanical Properties of Fluids

1. In a hydraulic lift the force applied on the smaller cylinder of area A_1 is F_1. If the area of the larger cylinder is A_2 the maximum weight that can be lifted is **1**
   a. F_1
   b. $\frac{A_1}{A_2}F_1$
   c. F_1A_2
   d. $\frac{A_2}{A_1}F_1$

2. A cylindrical jar of cross-sectional area 0.01 m^2 is filled with water to a height of 50 cm. It carries a tight-fitting piston of negligible mass. What is the pressure at the bottom of the jar when mass of 1 kg is placed on the piston? Take g = 10m s^{-2} **1**
   a. 6000 Pa
   b. 4000 Pa
   c. 2000 Pa
   d. 5000 Pa

3. Pressure p at any point in a fluid at rest is **1**
   a. the normal force at that point per unit volume
   b. the force parallel to area at that point per unit area
   c. the normal force at that point per unit mass
   d. the normal force at that point per unit area

4. At large flow velocities the flow of a fluid becomes **1**
   a. viscous
   b. turbulent
   c. compressible
   d. laminar

5. According to Stokes' law if η is the coefficient of viscosity, 'R' the radius of the sphere

and it is moving with a velocity v the viscous drag force F is given by **1**

a. $F_d = 6\pi\eta Rv$
b. $F_d = 6\pi\eta R$
c. $F_d = 2\pi\eta Rv$
d. $F_d = 6\pi Rv$

6. What happens when a capillary tube of insufficient length is dipped in a liquid? **1**

7. State the law of floatation? **1**

8. If a wet piece of wood burns, then water droplets appear on the other end, why? **1**

9. Find out the dimensions of coefficient of viscosity? **2**

10. The surface tension and vapour pressure of water at 20°C is 7.28×10^{-2} Nm^{-1} and 2.33×10^{3} Pa, respectively. What is the radius of the smallest spherical water droplet which can form without evaporating at 20°C? **2**

11. Atmospheric pressure at a height of about 6 km decreases to nearly half of its value at the sea level, though the height of the atmosphere is more than 100 km. **2**

12. Briefly explain Magnus effect. **3**

13. A liquid drop of diameter 4mm breaks into 1000 droplets of equal size. Calculate the resultant change in the surface energy. Surface tension of the liquid is 0.07 N/m? **3**

14. A freshwater reservoir is 10 m deep. A horizontal pipe 2 cm in diameter passes through the reservoir 8.0 m below the water surface. A plug secures the pipe opening. At a certain time the plug is removed. What volume of water flows out of the pipe in 1 h? Assume cross-section area of the reservoir to be too large. **3**

15. The surface tension of soap solution at 20 °C is 2.50×10^{-2} N m^{-1}. Calculate the excess pressure inside a soap bubble of radius 5 mm of this solution. If an air bubble of the same dimension were formed at depth of 40.0 cm inside a container containing the soap solution of relative density 1.20, what would be the pressure inside the bubble? (1 atm = 1.01×10^{5} pa.). **5**

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Answer

1. d. $\frac{A_2}{A_1}F_1$

   Explanation: According to Pascal's Law,

   Pressure applied to any point inside the liquid is trnasmiteed equally in all direction so,

   Pressure applied on the smaller cylinder is equal to the pressure on the other cylinder,which is given by

   $\frac{F_1}{A_1}=\frac{F_2}{A_2}$

   So,

   Maximum force on the other side is ,

   F2 = $\frac{A_2}{A_1}\times F_1$

2. a. 6000 Pa

   Explanation: The presuure at the bottom of the jar is due to weight of a column of water of height h = 50 cm = 0.5 m and the weight of a load of m = 1 kg.

   Total force acting on the base = $h\rho gA+mg$

   $=0.5\times1000\times10\times0.01+1\times10$

   $=60N$

   $\therefore Pressure=\frac{force}{area}=\frac{60}{0.01}=6000\ Nm^{-2}\ or\ 6000\ Pa$

3. d. the normal force at that point per unit area

   Explanation: It is important to note that it is valid only for a fluid at rest. In the case of a moving fluid, pressures in different directions could be different depending upon fluid accelerations in different directions.

4. b. turbulent

   Explanation: When any liquid is flowing more than the velocity of it's critical velocity then flow becomes turbulent.

5. a. $F_d=6\pi\eta Rv$

   Explanation: The force of viscosity on a small sphere moving through a viscous fluid is given by:

$F_d = 6\pi\eta R v$

Where:

- F_d is the frictional force – known as **Stokes' drag** – acting on the interface between the fluid and the particle
- η is the dynamic viscosity
- R is the radius of the spherical object
- v is the flow velocity relative to the object.

In SI units, F_d is given in Newtons, η in Pa·s, R in meters, and v in m/s.

6. When a capillary tube of insufficient length is dipped in a liquid, the radius of curvature of the mensicus increases so that hr = constant. That is pressure on Concave side becomes equal to pressure exerted by liquid Column so liquid does not overflow.

7. Law of floatation states that a body will float in a liquid, if weight of the liquid displaced by the immersed part of the body is at least equal to or greater than the weight of the body.

8. The wet piece of wood contains quite a bit of moisture. The moisture is converted into steam and travels through the wood piece to the end of the piece. Since the end of the piece is cool the steam or water vapour turns back into water and due to surface tension they appear in form of water drops on the other end.

9. Since

   $\mathrm{f} = \eta \mathrm{A}\frac{dv}{dx}$

   f = visocs force

   A = area

   $\frac{dv}{dx}$ = velocity gradient

   η = co-efficient of viscosity

   $\Rightarrow \eta = \frac{f}{A\frac{dv}{dx}}$

   $dim(\eta) = \frac{dim(f)}{[dim(A)]\left[\frac{dim(dv)}{dim(dx)}\right]}$ .... (1)

   dim(f) = [MLT^{-2}] , dim(A) = [L^2] , dim (dv) = [LT^{-1}] , dim(dx) = [L] dim(dv)/dim(dx) = $[LT^{-1}]/[L] = [T^{-1}]$, putting all the values in equation (1) , we get

$$dim(\eta) = \frac{[MLT^{-2}]}{[L^2][T^{-1}]}$$
$$dim(\eta) = [ML^{-1}T^{-1}]$$

10. The drop will evaporate if the water pressure on liquid, is greater than vapour pressure above the surface of liquid. Let a water droplet of radius R be formed without evaporation then

    Vapour pressure = Excess pressure in a drop

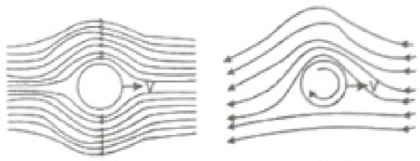
    $\rho = \frac{2\sigma}{R}$ (only one surface in drop)

    $$R = \frac{2\times7.28\times10^{-2}}{\text{Vapour preessure}} = \frac{2\times7.28\times10^{-2}}{2.33\times10^{3}} = \frac{1456\times10}{233\times10^{5}}$$
    $$R = 6.25\times10^{-5}\text{m}.$$

11. Density of air is maximum near the sea level. Density of air decreases with increase in height from the surface. At a height of about 6 km, density decreases to nearly half of its value at the sea level. Atmospheric pressure is proportional to density. Hence, at a height of 6 km from the surface, it decreases to nearly half of its value at the sea level.

12. **Magnus effect**, generation of a sidewise force on a spinning cylindrical or spherical solid immersed in a fluid (liquid or gas) when there is relative motion between the spinning body and the fluid. It is responsible for the “curve” of a served tennis ball or a driven golf ball and affects the trajectory of a spinning artillery shell.

    A spinning object moving through a fluid departs from its straight path because of pressure differences that develop in the fluid as a result of velocity changes induced by the spinning body. The Magnus effect is a particular manifestation of Bernoulli's theroem, fluid pressure decreases at points where the speed of the fluid increases. In the case of a ball spinning through the air, the turning ball drags some of the air around with it. Viewed from the position of the ball, the air is rushing by on all sides. The drag of the side of the ball turning into the air (into the direction the ball is traveling) retards the airflow, whereas on the other side the drag speeds up the airflow. Greater pressure on the side where the airflow is slowed down forces the ball in the direction of the low-pressure region on the opposite side, where a relative increase in airflow occurs.



(a) (b)

13. Since the diameter of drop = 4mm

Radius of drop = 2mm = 2×10^{-3}m

S = Surface tension = 0.07N/m

Let r be the radius of each of the small droplets volume of big drop = 1000 $\times$ volume of the small droplets

$\frac{4}{3}\pi r^3 = 1000 \times \frac{4}{3}\pi r^3$

or R = 10r

$\Rightarrow r = \frac{2\times10^{-3}}{10} = 2 \times 10^{-4}\mathrm{m}$

original surface area of the drop $= 4\pi R^2$

Total surface area of $1000 \times 4\pi r^2 - 4\pi R^2$

$= 4\pi\left[1000r^2 - R^2\right]$

Increase in surface $= 4 \times \frac{22}{2}\left(\left[1000 \times \left(2 \times 10^{-4}\right)^2\right] - \left[\left(2 \times 10^{-3}\right)^2\right]\right)$

$= 4 \times \frac{22}{4}\left[1000 \times 4 \times 10^{-8} - 4 \times 10^{-6}\right]$

$= 8 \times \frac{22}{7}\left[10^{-5} - 10^{-6}\right]$

$= \frac{3168}{7} \times 10^{-5} m^2$

Increase in surface energy = Surface tension $\times$ Increase in surface area

$= 0.07 \times \frac{3168}{7} \times 10^{-5}$

$= 3168 \times 10^{-8} J$

14. When the plug is removed

velocity of efflux v $= \sqrt{2gh}$

Here, $h = 8.0m, \therefore v = \sqrt{2 \times 9.8 \times 8} = 12.52\mathrm{ms}^{-1}$

$\therefore$ Rate of volume flow of water = $Av = \frac{\pi d^2}{4} v$

The rate of flow of water may be taken as to be uniform throughout as cross-section area of reservoir is too large,

$\therefore$ amount of water flown in time t $= 1h = 3600s$

$V = Avt = \frac{\pi d^2}{4} vt = \frac{3.140 \times (0.02)^2 \times 12.52 \times 3600}{4}$

$= 14.2 m^3$

15. Calculation of excess pressure inside soap bubble

It is given that the radius of the bubble, r = 5.00 mm = 5×10^{-3} m

and Surface tension of the soap solution,

S = 2.50×10^{-2} N m^{-1}

according to the question the relative density of the soap solution is = 1.20

$\therefore$ Density of the soap solution, $\rho = 1.2 \times 10^3 \text{ kg/m}^3$

depth at which air bubble is formed , h = 40 cm = 0.4 m

Radius of the air bubble, r = 5 mm = $5 \times 10^{-3} m$ The excess pressure inside the soap bubble is given by the relation:

$P = \frac{4S}{r}$, where S is surface tension and r is radius of the bubble

$= \frac{4 \times 2.5 \times 10^{-2}}{5 \times 10^{-3}}$

= 20 Pa

Therefore, the excess pressure inside the soap bubble is 20 Pa.

calculation of execess pressure inside an air bubble

The excess pressure inside the air bubble is given by the relation:

$P' = \frac{2S}{r}$, where S is surface tension and r is radius of the bubble

$= \frac{2 \times 2.5 \times 10^{-2}}{5 \times 10^{-3}}$

= 10 Pa

Therefore, the excess pressure inside the air bubble is 10 Pa.

At a depth of 0.4 m, the total pressure inside the air bubble

$P_{total} = P_{atm} + h\rho g + P'$

$= 1.01 \times 10^5 + 0.4 \times 1.2 \times 10^3 \times 9.8 + 10$

$= 1.057 \times 10^5 \text{ Pa}$

$= 1.06 \times 10^5 \text{ Pa}$

Therefore, the pressure inside the air bubble is $1.06 \times 10^5 \text{ Pa}$