Test Paper 6

1. What is terminal velocity? What is the terminal velocity of a body in a freely falling system 1

Ans. It is the maximum constant velocity acquired by the body while falling freely in a viscous medium. In a freely falling system, g = 0. Therefore, the terminal velocity of the body will also be zero.

2. The diameter of ball A is half that of ball B. What will be their ratio of their terminal velocities in water? 1

Ans. The terminal velocity is directly proportional to the square of radius of the ball, therefore the ratio of terminal velocities will be 1:4.

3. Find out the dimensions of co-efficient of viscosity? 1

Ans. $[ML^{-1}T^{-1}]$

4. What is the cause of viscosity in a fluid? How does the flow of fluid depend on viscosity? What is the cause of viscosity in a fluid? How does the flow of fluid depend on viscosity? 2

Ans. Internal friction is the cause of viscosity of fluid. The flow of fluid decreases when viscosity increases, because viscosity is a frictional force and greater the friction, lesser is the flow of liquid.

5. If eight rain drops each of radius 1 mm are falling through air at a terminal velocity of 5 cms^{-1}. If they coalesce to form a bigger drop, what is the terminal velocity of bigger drop? If eight rain drops each of radius 1 mm are falling through air at a terminal velocity of 5 cms^{-1}. If they coalesce to form a bigger drop, what is the terminal velocity of bigger drop? 3

Ans. $Given: \quad V_{SD} = 5cms^{-1}$

$$R = 10^{-3}m$$

$To\ find: V_{BD} = ?$

$Sol^n: \quad Let\ \ r - radius\ of\ small\ drop$

$R - radius\ of\ big\ drop$

$$Now,\ \frac{4}{3}\pi R^3 = 8\times\frac{4}{3}\pi r^3$$

$$R = 2r$$

$$r = 2\times10^{-3}m$$

$$\text{Terminal}\ velocity\ of\ each\ small\ drop\ V_{SD} = \frac{2}{9}\times\frac{r^2}{\eta}(P-\sigma)g \quad \to (1)$$

$$\text{Terminal}\ velocity\ of\ each\ bigger\ drop\ V_{BD} = \frac{2}{9}\times\frac{R^2}{\eta}(P-\sigma)g \quad \to (2)$$

$(2)\div(1)$

$$\frac{V_{BD}}{V_{SD}} = \frac{R^2}{r^2}$$

$$\frac{V_{BD}}{5} = \frac{(0.2)^2}{(0.1)^2}$$

$$V_{BD} = 20cms^{-1}$$

6. Why does the cloud seem floating in the sky? 1

Ans. The terminal velocity of a raindrop is directly proportional to the square of radius of drop. When falling, large drops have high terminal velocities while small drops have small terminal velocities hence the small drops falls so slowly that cloud seems floating.

7. A metal plate 5 cm × 5 cm rests on a layer of castor oil 1 mm thick whose coefficient of viscosity is 1.55 Nsm^{-2}. What is the horizontal force required to more the plate with a speed of 2 cms^{-1}? 2

Ans. *Given*:

$\eta = 1.55 Nsm^{-2}$

$dx = 10^{-3} m$

$dv = 2\times10^{-2} ms^{-1}$

$l = 5cm$

$b = 5cm$

To find: ?

Solution:

$A = l \times b = 5\times5 = 25cm^2 = 25\times10^{-4} m^2$

$$\frac{dv}{dx} = \frac{2\times10^{-2}}{10^{-3}} = 20m$$

$$F = \eta A \frac{dv}{dx} = 1.55\times25\times10^{-4}\times20 = 0.0775N$$

8. A small ball of mass 'm' and density 'd' dropped in a viscous liquid of density 'd'. After some time, the ball falls with a constant velocity. What is the viscous force on the ball? A small ball of mass 'm' and density 'd' dropped in a viscous liquid of density 'd'. After some time, the ball falls with a constant velocity. What is the viscous force on the ball? 2

Ans. Volume of ball, $V = \frac{m}{d}$

Density of viscous liquid $= d_1$

Mass of liquid displaced by the ball, $m_1 = \frac{m}{d}\times d_1 \rightarrow (1)$

When the ball falls with a constant velocity (terminal velocity), we have

Viscous force F = weight of ball in water $\rightarrow$ (2)

Weight of ball in water = Weight of ball − Weight of liquid displaced by the ball

$$= mg - m_1 g$$

$$= mg - \frac{mgd_1}{d}$$

$$= mg\left(1 - \frac{d_1}{d}\right)$$

Hence from equation (2)

Viscous force, $F = mg\left(1 - \frac{d_1}{d}\right)$

9. Two capillary tubes of length 15 cm and 5 cm and radii 0.06 cm and 0.02 cm respectively are connected in series. If the pressure difference a cross the end faces is equal to the pressure of 15 cm high water column, then find the pressure difference across the : → 1) first tube 2) Second tube. 3

Ans. $P_1 = \rho g (15 - h)$

$P_2 = \rho g h$

$$\text{Volume of liquid through first tube}, V_1 = \frac{\pi}{8}\frac{P_1 r_1^4}{\eta l_1}$$

$$\text{Volume of liquid through second tube}, V_2 = \frac{\pi}{8}\frac{P_2 r_2^4}{\eta l_2}$$

For tubes connected in series

$V_1 = V_2$

$$\frac{\pi}{8}\frac{P_1 r_1^4}{\eta l_1} = \frac{\pi}{8}\frac{P_2 r_2^4}{\eta l_2}$$

$$\frac{P_1 r_1^4}{l_1} = \frac{P_2 r_2^4}{l_2}$$

$$\frac{\rho g (15 - h)(0.06)^4}{15} = \frac{\rho g h (0.02)^4}{5}$$

$(15 - h)1296 = 3 \times h \times 16$

$(15 - h)27 = h$

$15 \times 27 - 27h = h$

$$h = \frac{15 \times 27}{28} = 14.46$$

$\therefore P_1 = 15 - h = 15 - 14.46 = 0.536\,cm\ of\ water\ column$

$P_2 = 14.46\,cm\ of\ water\ column$

10. A metallic sphere of radius 1×10^{-3} m and density 1×10^4 kgm^{-3} enters a tank of water after a free fall through a high 'h' in earth's gravitational field. If its velocity remains unchanged after entering water, determine the value of h. Given: co-efficient of viscosity of water = 1×10^{-3} Nsm^{-2}; g = 10 ms^{-2}; density of water = 1×10^3 kgm^{-3}? 2

Ans. The velocity acquired by the sphere in falling freely through a height h is $v = \sqrt{2gh}$

As per the conditions of the problem, this is the terminal velocity of sphere in water, so

Terminal Velocity of sphere in water, $v = \sqrt{2gh}$

Also, Terminal velocity of sphere in water, $v = \dfrac{2r^2 g(P-\sigma)}{9\eta}$ $[Stoke's\ law]$

$$So,\ \sqrt{2gh} = \frac{2r^2 g(P-\sigma)}{9\eta}$$

$$2gh = \frac{4r^4 g^2 (P-\sigma)^2}{81\eta^2}$$

$$h = \frac{2r^4 g(P-\sigma)^2}{81\eta^2}$$

$$= \frac{2\times\left(10^{-3}\right)^4 \times 10\left(10^4 - 10^3\right)^2}{81\times\left(10^{-3}\right)^2}$$

$$= 20m$$