PHYSICS

Q.1 What is the velocity v of a metallic ball of radius r falling in a tank of liquid at the instant when its acceleration is one half that of a freely falling body ? (The densities of metal and of liquid are ρ and σ respectively and the viscosity coefficient of the liquid is η) -

(A) $\frac{r^2 g}{9\eta}(\rho - 2\sigma)$ (B) $\frac{r^2 g}{9\eta}(2\rho - \sigma)$

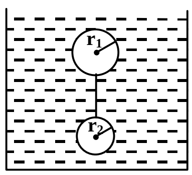
(C) $\frac{r^2 g}{9\eta}(\rho - \sigma)$ (D) $\frac{2r^2 g}{9\eta}(\rho - \sigma)$

[C]

Sol. $\eta = \frac{2r^2}{9}\left(\frac{\rho-\sigma}{V}\left(\frac{g}{2}\right)\right)$

So $V = \frac{r^2 g(\rho-\sigma)}{9\eta}$

Q.2 Two solid spherical balls of radius r_1 & r_2 ($r_2 < r_1$), of density σ are tied up with a string and released in a viscous liquid of lesser density ρ and coefficient of viscosity η, with the string just taut as shown. The terminal velocity of spheres is-

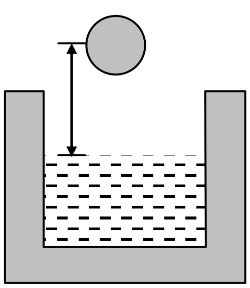


(A) $\frac{2}{9}\frac{r_2^2 g}{\eta}(\sigma-\rho)$ (B) $\frac{2}{9}\frac{r_1^2 g}{\eta}(\sigma-\rho)$

(C) $\frac{2}{9}\frac{(r_1^3+r_2^3)}{r_1+r_2}\frac{(\sigma-\rho)g}{\eta}$ (D) $\frac{2}{9}\frac{(r_1^3-r_2^3)}{r_1-r_2}\frac{(\sigma-\rho)g}{\eta}$

[C]

Q.3 A ball of radius r and density ρ falls freely under gravity through a distance h before entering water. Velocity of ball does not change even on entering water. If viscosity of water is η, the value of h is given by -

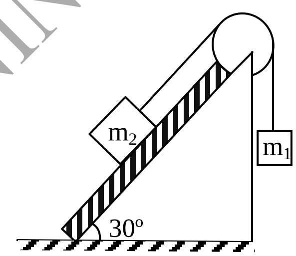


(A) $\frac{2}{9}r^2\left(\frac{1-\rho}{\eta}\right)g$ (B) $\frac{2}{81}r^2\left(\frac{\rho-1}{\eta}\right)g$

(C) $\frac{2}{81}r^4\left(\frac{\rho-1}{\eta}\right)^2 g$ (D) $\frac{2}{9}r^4\left(\frac{\rho-1}{\eta}\right)^2 g$

[C]

Q.4 The mass of block m_1 = 4 kg and m_2 = 20 kg, m_2 slides on the incline on a film of oil 7μm thick. Assume linear velocity profile. Block m_2 is cube of length 10cm. viscosity of oil is 7×10^{-3} Pa-s : Terminal velocity of blocks is –



(A) 2 m/s (B) 3 m/s

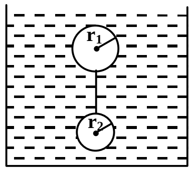
(C) 4 m/s (D) 5 m/s **[B]**

Q.5 The velocity of a small ball of mass M and density d_1, when dropped in a container filled with glycerine becomes constant after some time. If the density of glycerine is d_2, the viscous force acting on the ball will be

(A) $\frac{M d_1 g}{d_2}$ (B) $M g\left(1-\frac{d_2}{d_1}\right)$

(C) $\frac{M(d_1+d_2)}{g}$ (D) M d_1 d_2 **[B]**

Q.6 Two solid spherical balls of radius r_1 & r_2 ($r_2 < r_1$), of density σ are tied up with a string and released in a viscous liquid of lesser density ρ and coefficient of viscosity η, with the string just taut as shown. The terminal velocity of spheres is-



(A) $\frac{2}{9}\frac{r_2^2 g}{\eta}(\sigma-\rho)$

(B) $\frac{2}{9}\frac{r_1^2 g}{\eta}(\sigma-\rho)$

(C) $\frac{2}{9}\frac{(r_1^3+r_2^3)}{r_1+r_2}\frac{(\sigma-\rho)g}{\eta}$

(D) $\frac{2}{9}\frac{(r_1^3-r_2^3)}{r_1-r_2}\frac{(\sigma-\rho)g}{\eta}$

Sol. **[C]** at terminal velocity net force is zero.

$6\pi\eta(r_1+r_2)\,V_T + \frac{4}{3}\pi(r_1^3+r_2^3)\rho g = \frac{4}{3}\pi(r_1^3+r_2^3)\,\sigma g$

Q. 7 A wide jar is filled with glycerin having specific gravity 1.26, in this jar a steel ball of radius 0.25 cm has been dropped. After some time it has observed that ball is taking equal interval of time 1.8 sec to cover equal successive distances of 20 cm. The viscosity of glycerin in N-s/m^2 would be [$\rho_{steal} = 7.8 \times 10^3$ kg/m^3, g = 9.8 m/s^2]-

(A) 0.802 (B) 1.67

(C) 0.76 (D) 0.963 **[A]**

Q.8 A solid ball of density ρ_1 and radius r falls vertically through a liquid of density ρ_2. Assume that the viscous force acting on the ball is F = krv, where k is a constant and v its velocity. What is the terminal velocity of the ball ?

(A) $\frac{4\pi r^2(\rho_1-\rho_2)}{3k}$ (B) $\frac{2\pi r(\rho_1-\rho_2)}{3gk}$

(C) $\frac{2\pi g(\rho_1+\rho_2)}{3gr^2k}$ (D) none of these

[A]

Sol. Net force on the ball = 0
(when terminal velocity is attained).
Hence,
Weight = upthrust + viscous force

$\therefore \frac{4}{3}\pi r^3\rho_1 g = \frac{4}{3}\pi r^3\rho_2 g + krv_T$

$\therefore v_T = \frac{4\pi g r^2}{3k}(\rho_1-\rho_2)$

Q.9 A newtonion fluid fills the clearance between a shaft and a sleeve. When a force of 800 N is applied to the shaft, parallel to the sleeve, the shaft attains a speed of 2 cm/s. If a force of 2.4 kN is applied instead, the shaft would move with a speed of -

(A) 2 cm/s (B) 15 cm/s

(C) 6 cm/s (D) None of these **[C]**

Sol. $F = \eta A\frac{v}{d}$

$\frac{F_1}{F_2} = \frac{v_1}{v_2}$

$\frac{800}{2400} = \frac{2}{v_2}$

$v_2 = 6$ cm/s

Q.10 A small drop of steel falls from rest through a long height h in coaltar, the final velocity will be proportional to h^n, then n is -

(A) 1/2 (B) 1

(C) – 1 (D) 0 **[D]**

Sol. $v \propto h^0$ so n is equal to zero.

Q.11 The velocity of a small ball of mass M and density d_1, when dropped in a container filled with glycerine becomes constant after some time. If the density of glycerine is d_2, the viscous force acting on the ball will be –

(A) $\frac{Md_1 g}{d_2}$ (B) $\frac{M(d_1+d_2)}{g}$

(C) $Mg\left(1-\frac{d_2}{d_1}\right)$ (D) $M\,d_1\,d_2$ **[C]**

Q.12 A small lead ball is falling freely in a viscous liquid. The velocity of the ball –

(A) goes on increasing

(B) goes on decreasing

(C) remains constant

(D) first increases and then becomes constant

[D]

Q.13 The terminal velocity of a spherical ball of radius r falling through a viscous liquid is proportional to –

(A) r (B) r^2

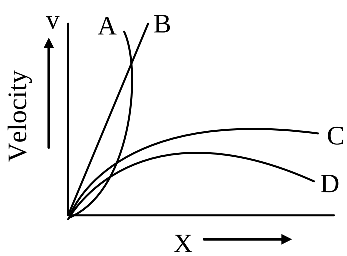
(C) r^3 (D) r^{-1} **[B]**

Q.14 The viscous force acting on a solid ball moving in air with terminal velocity ν is directly proportional to -

(A) $\sqrt{\nu}$ (B) ν

(C) $\frac{1}{\sqrt{\nu}}$ (D) ν^2 **[B]**

Q.15 A small spherical solid ball is dropped in a viscous liquid. Its journey in the liquid is best described in the figure by –



Distance travelled

(A) Curve A (B) Curve B

(C) Curve C (D) Curve D **[C]**

Q.16 The relative velocity between two parallel layers of water is 8 cm/s and the perpendicular distance between them is 0.1 cm. Calculate the velocity- gradient -

(A) 90/s (B) 80.5 /s

(C) 80 /s D) None of these

[C]

Q.17 There is a 1 mm thick layer of oil between a flat plate of area 10^{-2} m^2 and a big plate. How much force is required to move the plate with a velocity of 1.5 cm/s^2 ? The coefficient of viscosity of oil is 1 poise -

(A) 1.5×10^{-3} N (B) 1.3×10^{-5} N

(C) 1.5×10^{-2} N (D) 1.5×10^{2} N **[C]**

Q.18 A steel shot of diameter 2 mm is dropped in a viscous liquid filled in a drum. Find the terminal speed of the shot. Density of the material of the shot = 8.0×10^3 kg/m^3, density of liquid = 1.0×10^3 kg/ m^3. Coefficient of viscosity of liquid = 1.0 kg/(m-s), g = 10 m/s^2

(A) 1.55 cm/s (B) 1.455 cm/s

(C) 5.1 cm/s (D) None of these

[A]

Q.19 An air bubble (radius 0.4 mm) rises up in water. If the coefficient of viscosity of water be 1×10^{-3} kg/(m–s), then determine the terminal speed of the bubble density of air is negligible-

(A) 0.843 m/s (B) 3.048 m/s

(C) 0.483 m/s (D) 0.348 m/s **[D]**

Q.20 If an oil drop of density 0.95×10^3 kg/ m^3 and radius 10^{-4} cm is falling in air whose density is 1.3 km/m^3 and coefficient of viscosity is 18×10^{-6} kg/(m–s). Calculate the terminal speed of the drop.

(A) 0.00015 cm/s (B) 0.0005 cm/s

(C) 0.0115 cm/s (D) None of these

[C]

Q.21 The terminal velocity of a ball in air is v, where acceleration due to gravity is g. Now the same ball is taken in a gravity free space where all other conditions are same. The ball is now pushed at a speed v, then –

(A) The terminal velocity of the ball will be v/2

(B) The ball will move with a constant velocity

(C) The initial acceleration of the ball is 2g in opposite direction of the ball's velocity

(D) The ball will finally stop (Given that density of the ball ρ = 2 times the density of air σ)

[D]

Q.22 A tank is filled up to a height 2H with a liquid and is placed on a platform of height H from the ground. The distance x from the ground where a small hole is punched to get the maximum range R is -

(A) H (B) 1.25 H

(C) 1.5 H (D) 2H **[A]**

Q.23 Which one of the following represents the correct dimensions of the coefficient of viscosity ? **[AIEEE-2004]**

(A) $ML^{-1}T^{-1}$ (B) MLT^{-1}

(C) $ML^{-1}T^{-2}$ (D) $ML^{-2}T^{-2}$ **[A]**

Q.24 Spherical balls of radius 'R' are falling in a viscous fluid of viscosity 'η' with a velocity 'v'. The retarding viscous force acting on the spherical ball is – **[AIEEE-2004]**

(A) inversely proportional to both radius 'R' and velocity 'v'

(B) directly proportional to both radius 'R' and velocity 'v'

(C) directly proportional to 'R' but inversely proportional to 'v'

(D) inversely proportional to 'R' but directly proportional to velocity 'v' **[B]**

Q.25 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– **[AIEEE-2006]**

(A) 0.1 m/s (B) 0.2 m/s

(C) 0.4 m/s (D) 0.133 m/s **[A]**

Q.26 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_2 ($\rho_2 < \rho_1$). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed υ, i.e., $F_{viscous} = -k\upsilon^2$ (k > 0). The terminal speed of the ball is - **[AIEEE-2008]**

(A) $\frac{Vg\rho_1}{k}$ (B) $\frac{Vg\rho_1}{k}$

(C) $\frac{Vg(\rho_1-\rho_2)}{k}$ (D) $\sqrt{\frac{Vg(\rho_1-\rho_2)}{k}}$

[D]

Q.27 Two rain drops reach the earth with their terminal velocities in the ratio 4 : 9. The ratio of their radii is -

(A) 4 : 9 (B) 2 : 3 (C) 3 : 2 (D) 9 : 4

[B]

Sol. $v \propto r^2$; $\frac{r_1}{r_2} = \sqrt{\frac{v_1}{v_2}}$

Q.28 Blood is flowing at the rate of 100 cm^3/s in a capillary of cross-sectional area 0.25 m^2. The velocity of flow is -

(A) .1 mm/s (B) 0.2 mm/s

(C) 0.3 mm/s (D) 0.4 mm/s **[D]**

Sol. $Q = Av \Rightarrow v = \frac{Q}{A} = \frac{100\times10^{-6}}{0.25}$

$v = 400 \times 10^{-3}$ mm/s = 0.4 mm/s

Q.29 The mass of a lead ball is M. It falls down in a viscous liquid with terminal velocity V. The terminal velocity of another lead ball of mass 8M in the same liquid will be -

(A) 64 V (B) 4 V (C) 8 V (D) V

Sol. **[B]**

mass = $\frac{4}{3}\pi r^3 \times \rho$. so when mass become 8M so radius will become 2r & terminal velocity $V_t \propto r^2$ so it becomes 4 times of its previous value.

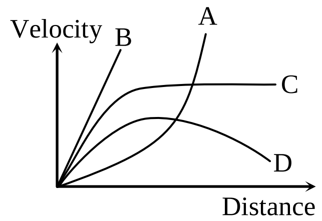
Q.30 When body falls in liquid with terminal velocity, the ratio of resistive force of liquid to its weight is-

(A) $\frac{2r^2\rho_s g}{9\eta^2}$ (B) $\frac{2r^2(\rho_s-\rho_m)g}{9\eta}$

(C) $\frac{2r^2\rho_m g}{9\eta}$ (D) 1

Sol. **[D]** $F_v + F_u = Mg$; so $\frac{F_v + F_u}{Mg} = 1$

Q.31 A small spherical solid ball is dropped in a viscous liquid. Its journey in the liquid is best described in figure drawn by -



(A) curve A (B) curve B
(C) curve C (D) curve D

Sol. **[C]**

Q.32 A liquid whose coefficient of viscosity is η flows on a horizontal surface. Let dx represent the vertical distance between two layers of liquid and dv represent the difference in the velocities of the two layers. Then the quantity $\eta(dv/dx)$ has the same dimensions as -
(A) acceleration (B) force
(C) momentum (D) pressure

Sol. **[D]** $F = \eta A \frac{dv}{dx} \Rightarrow \frac{F}{A} = \eta \frac{dv}{dx}$ = Dimension of pressure

Q.33 Viscosity is closely related to -
(A) friction
(B) adhesive molecular force
(C) cohesive molecular force
(D) Barnoulli's theorem

Sol. [A] Viscous force is a opposing force.

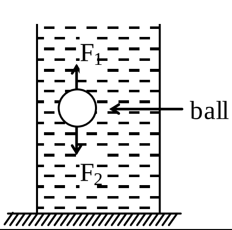
Q.34 Water sticks to glass because of -
(A) force of cohesion
(B) force of adhesion
(C) vander wall force
(D) None

Sol. [B] Adhesive force of attraction act between molecules of different substances.

Q.35 With the increase in temperature viscosity of a liquid -
(A) increases (B) decreases
(C) remain same (D) None

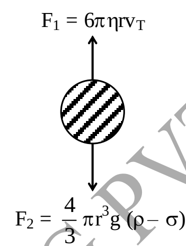
Sol.[B] With increase of temperature, free flow of liquid increase, hence viscosity decrease.

Q.36 A sphere falls from top and travels through some distance in liquid when it attains terminal velocity. Then -



(A) F_2 is total weight of the sphere
(B) if F_2 is total weight of sphere then F_1 is upward force of viscosity
(C) If F_2 is net weight of body then F_1 is upward thrust
(D) None

Sol.[B]



Q.37 Two solid spheres of radii r_1 and r_2 have surfaces of same nature and are of same material. Both spheres are at same high temperature 'T'. They are allowed to cool under same conditions. Initial rate of heat loss is -

(A) $\left(\frac{r_2}{r_1}\right)^2$ (B) $\left(\frac{r_1}{r_2}\right)^2$ (C) $\sqrt{\frac{r_1}{r_2}}$ (D) $\sqrt{\frac{r_2}{r_1}}$

Sol.[B] Since ratio of rate of loss of heat is equal to ratio between rate of emission, we have

$$\frac{Q_1}{Q_2} = \frac{\varepsilon_1}{\varepsilon_2} = \frac{eA_1\sigma\theta^4}{eA_2\sigma\theta^4} = \frac{4\pi r_1^2}{4\pi r_2^2} = \left(\frac{r_1}{r_2}\right)^2$$

Q.38 Two spheres A and B fall through the same viscous fluid. A and B have the same density and B has the larger radius -
(A) A has the larger terminal velocity
(B) A and B have the same terminal velocity
(C) B has the larger terminal velocity
(D) Insufficient information is given to reach a conclusion.

Sol. **[C]**