PHYSICS

BOOKS - CHHAYA PHYSICS (BENGALI ENGLISH)

VISCOSITY AND SURFACE TENSION

Examples Numerical Examples

1. A plate of area 100 cm^2 is floating on oil of depth 2 mm. The coefficient of viscosity of oil is 15.5 poise. What horizontal force is required to move the plate horizontally with a velocity of 3 cm. s^{-1}?

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2. An oil drop of density 950 kg. m^{-3} and radius 10^{-6} m is falling through air. The density of air is $1.3 kg. m^{-3}$ and its coefficient of viscosity is 181×10^{-7} SI unit. Determine the terminal velocity of the oil drop. $\left[g = 9.8 m. S^{-2}\right]$

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3. An air bubble of radius 1 cm is rising from the bottom of a long liquid column. If its terminal velocity is 0.21 cm. s^{-1}, calculate the coefficient of viscosity. Of the liquid. Given that the density of the liquid is 1.47 g. cm^{-3}. Ignore the density of air.

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4. The pressure at an orifice situated at the lower side of a vessel filled with a liquid is greater than the atmospheric pressure by

$9.8 \times 10^3 N.\ m^{-2}$. What is the velocity of efflux if the density of the liquid is 2500 kg. m^{-3} ? $\left[g = 9.8 m.\ s^{-2}\right]$

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5. Water is flowing through a horizontal tube of unequal cross section . At a point where the velocity of water is $0.4 m.\ s^{-1}$, the pressure is 0.1 m Hg. What is the pressure at a point where the velocity of water is 0.8 m.s^{-1} ? The density of mercury $= 13.6 \times 10^3 kg.\ m^{-3}$.

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6. A pitot tube is connected to a main pipeline of diameter 16 cm. The difference in height of the water columns in the two arms of the tube is 10 cm. Determine the rate of flow of water through the main pipe.

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7. A venturimeter has been connected between two points of a pipe. The radii at these two points are 5 cm and 3 cm respectively. The difference in pressure between these points is equal to that of a water column of height 5 cm. Determine the rate of flow of water through the pipe.

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8. Water from a tap falls vertically with a velocity of 3 m.s^{-1}. The area of cross section of the mouth of the tap is 2.5 cm^2. If the flow of water is uniform and steady throughout, then determine the cross section area of the tube of flow of water at a depth of 0.8 m from the mouth of the tap. $\left[g = 10m. s^{-2}\right]$

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9. Water from a tap falls vertically with a velocity of 3 m.s^{-1}. The area of cross section of the mouth of the tap is 2.5 cm^2. If the flow of water is uniform and steady throughout, then determine the cross section area of the tube of flow of water at a depth of 0.8 m from the mouth of the tap. $\left[g = 10m.\, s^{-2}\right]$

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10. A liquid of density $1000kg/m^3$ is flowing in streamline motion through a tube of non-uniform cross section. The tube of Inclined with the ground [Fig. 3.17] The area of cross sections at points P and Q or the tube are $5 \times 10^{-3} m^2$ and $10 \times 10^{-3} m^2$ respectively. The height of the points P and Q from the ground are 3 m and 6 m respectively. The velocity of the liquid at point P is 1 m/s. Calculate the work done per unit volume due to (i) the pressure and (ii) gravitational force for the flow of liquid from point P to point Q .

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11. A big container is kept on a horizontal surface of uniform area of cross section. A [Fig. 3.18]. Two non-viscous liquid of densities d and 2d which are not mixed with each other and not compressed, are kept in the container. The height of both liquid column is $\frac{H}{2}$ and the atmospheric pressure on the open surface of the liquid is p_0. A small orifice is created at a height h from the bottom of the container. (i) Calculate the initial velocity of efflux of the liquid through the orifice. (ii) Calculate the horizontal distance x at which the first liquid drop emerged from the orifice will reach. (iii) What will be the value of h If the value of the horizontal distance x to be maximum x_m ? Also calculate the value of x_m neglecting the air resistance.

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12. The surface tension of water at $20^{\circ} C$ is 72 dyn. cm^{-1}. And for water $\frac{dT}{dth\eta} = -0.146 dyn. Cm^{-1}. K^{-1}$. What is the total surface energy of water?

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13. A drop of water of radius 1 mm is to be divided into 10^{6} point drops of equal size. How much mechanical work should be done ? The surface tension of water = 72 dyn. cm^{-1}.

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14. 1000 water droplets having a radius of 0.01 cm each coalesce to form a single big drop. What will be the decrease in energy ? The surface tension of water = 72 dyn. cm^{-1}.

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15. A rectangular glass slab measures $0.1m \times 0.0154m \times 0.002m$ and its weight in air is $80.36 \times 10^{-3}N$. The slab is immersed half in water keeping its length and thickness horizontal. What will be the apparent weight of the slab ? The surface tension of water is $72 \times 10^{-3}N.\ m^{-1}$.

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16. The radius of a soap-bubble is increased from 1 cm to 3 cm. What amount of work is done for this ? The surface tension of soap-water is 26 dyn. cm^{-1}.

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17. Determine the surface energy of a liquid film formed on a ring of area $0.15m^2$. The surface tension of the liquid $= 5N.\ m^{-1}$.

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18. Determine the surface energy of a soap-water film formed on a frame of area $10^{-3}m^2$. Surface tension of soap-water $= 70 \times 10^{-3} N.\ m^{-1}$.

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19. What will be the work done to form a soap-bubble of radius 5 cm? The surface tension of soap-water = 70 dyn. cm^{-1}

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20. If a large number of water droplets of diameter 2r cm each coalesce to form a large water drop of diameter 2 R cm, then prove that the rise in temperature of water is $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$. Here, T is the surface tension of water and J is the mechanical equivalent of heat.

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21. Water is filled upto a height h in a beaker of radius R as shown in the Fig. 3.24. The density of water is ρ, the surface tension of water is T and the atmospheric pressure is P_0. Consider a vertical section ABCD of the water column through a diameter of the beaker. What is the force on water on one side of this section by water on the other side of this section?

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22. When water in a beaker is gradually heated, a bubble formed at the lower surface of the beaker starts to rise up from the bottom of the beaker. The radius of the spherical bubble is R and the radius of the circular region of the bubble touched with the lower surface of the container is r(r < 

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23. Find the excess pressure inside a rain water drop of diameter 0.02 cm. The surface tension of water = $0.072N. m^{-1}$.

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24. Surface tension of soap solution $= 27 dyn. Cm^{-1}$. Calculate the excess pressure (in N. m^{-2}) inside a soap bubble of radius 3 cm.

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25. Find the pressure inside on air bubble of radius 0.1 mm just inside the surface of water. Surface tension of water = 72 dyn. cm^{-1}.

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26. The excess pressure inside a soap bubble of radius 8mm raises the height of an oil columns by 2mm. Find the surface tension of the soap solution. Density of the oil=0.8g. Cm^{-3}.

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27. In an isothermal process, two soap bubble of radius a and b combine and form a bubble of radius c. If the external pressure is p, then prove that the surface tension of the soap solution is

$$T-\frac{p\left(c^3-a^3-b^3\right)}{4\left(a^2+b^2-c^2\right)}.$$

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28. Two soap bubbles of radii 0.04 m and 0.03 m are combined in such a way that a common surface is formed between the two bubbles. What is the radius of curvature of the common surface ?

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29. A liquid of density $830 kg. m^{-3}$ rises through $0.0893 m$ in a capillary tube of diameter 1.68×10^{-4} m. Determine the surface tension of the liquid. Take the angle of contact as 0°.

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30. A capillary tube with a bore diameter of 0.5 mm is dipped upright in a liquid having surface tension 0.03 N. m^{-1}. The specific gravity of the liquid is 0.8 and the liquid wets the surface of the tube completely. Up to what height will the liquid rise in the tube?

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31. The diameter of a barometer tube is 3 mm. What will be the error in the barometer reading due to surface tension? For mercury in the glass tube, the surface tension $= 0.647 N.m^{-1}$, the angle of contact $= 128^{\circ}$ and the density of mercury $= 13500 kg.m^{-3}$.

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32. The diameters of the two arms of U-tube are 1 mm and 2 mm. The tube is filled partly with water and is kept vertical. If the surface tension of water is 70 dyn. cm^{-1}, then find the difference in the level of water in the two arms of the U-tube . [Angle of contact $= 8^{\circ}$]

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33. There are two parallel glass plates having some water between them [Fig. 3.37]. The surface tension of water is 0.07 N/m. When the two plates are moved apart from each other by 0.2 mm, a water layer is minimum force to applied to separate the plates. Consider, the angle of contact between water and glass plate is zero and area of contact is 4 cm^2.

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34. Water reaches upto a height 2 cm along a capillary tube. Calculate the height upto which water can reach along another capillary tube of radius $\frac{1}{3}$rd of the previous one.

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Exercise Higher Order Thinking Skill Hots Questions

1. What is gradient? What is its dimension ?

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2. How can you detect whether the motion of a liquid is streamline or turbulent ?

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3. Write down the characteristics of streamline motion.

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4. Discuss the difference viscosity and friction.

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5. Why do two streamlines never intersect each other ?

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6. Why does the end of a glass become round on heating?

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7. Why does machine parts get jammed in winter ?

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8. What is an ideal fluid?

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9. Between two lubricating oils A and B, the coefficient of viscosity of A is greater than that of B. For a machine , which one of them is suitable in summer?

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10. During a cyclone, bits of paper, leaves from a tree, etc., enter the twister and move upwards revolving continuously. Explain.

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11. Discuss the importance of the streamlined shape of a fish.

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12. State whether critical velocity and terminal velocity are the same ?

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13. A lead ball is allowed to fall through an elongated column filled with glycerine. What sort of graph would we get on plotting the velocity (v) and the distance traversed (s) by the lead ball?

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14. To make a piece of paper float horizontally in air, we allow air to flow over the upper surface of the paper, but not below its lower surface. Why?

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15. Why flags flutter in a windy day ?

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16. A larger drop of water breaks up into a large number of small droplets. Does the surface energy increase ?

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17. If a large number of water droplets coalesce to form a single large drop, then state whether the total surface energy increases or decreases. Explain.

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18. Why are small drops of water in air spherical in shape?

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19. If a few spherical drops of a liquid coalesce to form a larger drop, will its temperature rise or fall? Explain.

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20. Mention a pair of solid and liquid for each of the following cases where the angle of contact is (i) 90° (ii) less than 90° (iii) more than 90°.

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21. Why does water stick to the fingers, but mercury does not?

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22. Why does water rise through a capillary tube where as mercury goes down through it?

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23. Why does the nib of fountain pen have a sit slit at its centre?

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24. Why do we use a detergent to wash dirty clothes?

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25. In that absence of gravity rise in a capillary tube provided there is no gravity acting on it?

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26. In an experiment on surface tension, water rises up to a height of 0.1 m in a capillary tube. If the same experiment is performed in a satellite moving around the earth, what will be the rise in the capillary tube?

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Mcqs

1. A spherical steel ball released at the top of a long column of glycerin of length L, falls through a distance $L/2$ with accelerated motion and the remaining distance $L/2$ with a uniform velocity. If t_1 and t_2 denote the time taken to cover the first and second half and W_1 and W_2 the work done against gravity in the two halves, then

A. $t_1 < t_2, W_1 > W_2$

B. $t_1 > t_2, W_1 < W_2$

C. $t_1 = t_2, W_1 = W_2$

D. $t_1 > t_2, W_1 = W_2$

Answer: D

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2. Falling rain drops acquire terminal velocity due to

A. upthrust of air

B. viscous force of air

C. surface tension

D. air current in the atmosphere

Answer: B

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3. An iron ball and an aluminium ball of equal diameters are released from the upper surface of water of a deep lake. The bottom of the lake is reached by

A. the aluminium ball earlier

B. the iron ball earlier

C. both the balls at the same time

D. the iron ball only-the aluminium ball will never reach the bottom.

Answer: B

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4. When a small lead shot is released from the upper surface of a viscous liquid,

A. the lead show will go on descending with an acceleration g

B. the velocity of the lead shot will go on decreasing with time

C. the velocity of the lead shot will go on increasing with time

D. after some time, the lead shot will acquire a uniform velocity

Answer: D

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5. A spherical ball is falling with a uniform velocity v through a viscous medium of coefficient of viscosity η. If the viscous force acting on the spherical ball is F then

A. $F \propto \eta$ and $F \propto \frac{1}{v}$

B. $F \propto \eta$ and $F \propto v$

C. $F \propto \frac{1}{\eta}$ and $F \propto \frac{1}{v}$

D. $F \propto \frac{1}{\eta}$ and $F \propto v$

Answer: B

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6. Velocity of efflux of a liquid through an orific does not depend on

A. acceleration due to gravity

B. height of the liquid in the vessel

C. density of the liquid

D. viscosity of the liquid

Answer: C

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7. The ratio of the terminal velocities of two water drops, when they fall towards the earth's surface , is $4:9$. The ratio of their radii is

A. $4:9$

B. $2:3$

C. $3:2$

D. $9:4$

Answer: B

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8. In case of a falling body of radius r through a viscous medium with a terminal velocity v,

A. $v \propto r$

B. $v \propto r^{-2}$

C. $v \propto r^{-1}$

D. $v \propto r^2$

Answer: D

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9. A small spherical ball of radius r falls freely under gravity through a distance h before entering a tank of water. If, after entering the water, the velocity a of the ball does not change. Then h is proportional to

A. r^2

B. r^3

C. r^4

D. r^5

Answer: C

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10. A small sphere of radius r and density ρ falls from rest in a viscous liquid of density γ and coefficient of viscous η. Due to friction heat is produced. The rate of production of heat when the sphere has acquired the terminal velocity is proportional to

A. r^2

B. r^3

C. r^4

D. r^5

Answer: D

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11. If a fluid flows through the narrower region of a tube of non-uniform cross section, then in that region of the tube

A. both the velocity and the pressure of the fluid will increase

B. both the velocity and the pressure of the fluid will decrease

C. velocity of the fluid will decrease but pressure will increase

D. velocity of the fluid will increase but pressure will decrease

Answer: D

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12. Working principle of a sprayer or atomizer depends on

A. Bernoulli's principle

B. Boyle's law

C. Archimedes' principle

D. Newton's laws of motion.

Answer: A

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13. An incompressible fluid flows through a tube at a uniform rate. Radius of the tube of at a point A is 2r and that at point b is r. If the velocity at the point A is v, then velocity at the point B will be

A. $2v$

B. v

C. $\frac{v}{2}$

D. $4v$

Answer: D

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14. For a uniform flow of an incompressible, non-viscous fluid the Bernoulli's theorem expresses,

A. conservation of angular momentum

B. conservation of density

C. conservation of momentum

D. conservation of energy

Answer: D

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15. For a streamline flow, if the elevation head is h, then velocity head and pressure head will be

A. $\frac{1}{2}v^2$ and $\frac{p}{\rho}$

B. $\frac{1}{2}\frac{v^2}{g}$ and $\frac{p}{\rho g}$

C. $\frac{1}{2}\frac{v^2}{g}$ and $\frac{p}{\rho}$

D. $\frac{1}{2}v^2$ and $\frac{p}{\rho g}$

Answer: B

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16. A cylinder of length 20 m is filled completely with water. Velocity of efflux of water through an orific on the wall of the cylinder near its base is $\left[g = 10 m.\ s^{-2}\right]$

A. $10m. s^{-1}$

B. $20m. s^{-1}$

C. $25.5m. s^{-1}$

D. $5m. s^{-1}$

Answer: B

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17. Excess pressure can be $\left(\frac{2T}{R}\right)$ for

A. spherical drop

B. spherical meniscus

C. cylindrical bubble in air

D. spherical bubble in water

Answer: A::B::D

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18. Viscous force is somewhere like friction at it opposes the motion and is non conservation but not exactly so, because

A. it is velocity dependent while friction not

B. it is velocity independent while friction is not

C. it is temperature dependent while friction is not

D. it is independent of area like surface tension while friction depends on area

Answer: A::C

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19. If the liquid rises to the same height in two capillaries of the same material at the same temperature

A. the weight of liquid in both capillaries must be equal

B. the radius of meniscus must be equal

C. the capillaries must be cyclidrical and vertical

D. the hydrostatic pressure at the base of the capillaries must be same

Answer: A::B::D

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20. n' drops of a liquid, each with surface energy E, join to form a single drop. Then

A. some energy will be released in the process

B. some energy will be absorbed in the process

C. the energy released will be E $\left(n - n^{2/3}\right)$

D. the energy absorbed will be $nE\left(2^{2/3} - 1\right)$

Answer: A::C

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21. The velocity of efflux of an ideal liquid does not depend on

A. the area of orifice

B. the density of liquid

C. the area of cross section of the vessel

D. the depth of the point below the free surface of the liquid

Answer: A::B::C

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22. A syring containing water is held horizontally with its nozzle at a height, h = 1.25 m above the ground as shown in Fig. 3.42. The diameter of the piston is 5 times that of the nozzle. The is pushed with a constant speed of 20 cm. s^{-1}. If $g = 10m. s^{-2}$.

A. the speed of water emerging from the nozzle is 5m . s^{-1}

B. the time taken by water to hit the ground is 0.5 s

C. the horizontal range, R = 2.5 m

D. the magnitude of the velocity with which the water hits the ground is $5\sqrt{2}m. s^{-1}$

Answer: A::B::C::D

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Exercise Very Short Answer Type Questions

1. What is the nature of a fluid flow when the speed of the fluid exceeds critical velocity?

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2. Write down the dimension of coefficient of viscosity.

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3. What is the dimension of Reynolds number?

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4. State the nature of dependence of the terminal velocity of a body in a viscous medium with the coefficient of viscosity of the medium.

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5. The viscous force is _____ proportional to the velocity gradient.

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6. State whether the viscosity of a gas increases or decrease due to an increase in temperature.

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7. State whether the viscosity of a liquid increases or decreases due to an increases in temperature.

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8. How does the viscosity of a liquid change with an increase in pressure?

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9. How does the viscosity of water change with an increase in pressure?

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10. How does the velocity of flow change with the cross sectional area of a tube of flow?

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11. Liquid : viscosity : : solid : ______ [Fill in the blank]

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12. Which conservation law is expressed by the equation of continuity ?

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13. On which conservation principle is Bernoulli's theorem established ?

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14. To what kind of liquid is Bernoulli's theorem applicable ?

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15. What is the name of the force of attraction between the molecules of two different substances ?

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16. What do you call the tendency of a liquid to contract its surface area?

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17. Write down the dimension of surface tension.

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18. What is the dimension of surface energy?

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19. State whether the surface tension of a liquid increases or decreases due to an increases in temperature.

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20. What is the SI unit of surface tension ?

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21. If a liquid has dissolved organic matter in it, then how does the surface tension of the liquid change?

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22. Name the property due to which a bloatting paper can absorb ink. ?

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23. When a capillary tube is dipped into water, water rises inside the tube. If the tube is made thinner then how will the rise in the water level change ?

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Exercise Short Answer Type Questions I

1. Roof of a house is sometimes blown off during a storm-explain why.

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2. How the surface tension of a liquid changes with temperature ?

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Exercise Problem Set I

1. The relative velocity of two parallel layers of water is 8 cm. s^{-1} and the perpendicular distance between them is 0.1 cm. Determine the velocity gradient.

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2. The ratio of the terminal velocities of two water drops while falling towards the earth's surface is $4:9$. Determine the ratio of the radii.

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3. Determine the volume of water flowing per second through a hole of cross sectional area 0.5 cm^2 situated at a depth of 2.5 m from the surface in a tank of water.

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4. Through a horizontal tube of non-uniform cross section water is flowing a uniform rate. Pressure of water at any point in the tube is $13 \times 10^4 N.\, m^{-2}$ and velocity of water flow is 0.6 m. s^{-1}. If the velocity of water flow at another point in the tube is 9 m. s^{-1}, then what is the pressure there?

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5. An incompressible fluid flows through a tube at a uniform rate. The radius of the tube point A is 2r and that at a point B is r. If the velocity at the point A is v, then what will be the velocity at the point B?

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6. Surface tension of water at $27^{\circ}C$ is 65 dyn. cm^{-1} and in case of water $\frac{dT}{d\theta} = -0.15 dyn. cm^{-1}. K^{-1}$. What is the surface energy of water?

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7. A square frame of side 8 cm is dipped in soap solution and then removed so that a thin film forms on it. What will be the force acting on each side of the frame due to surface tension ?

Surface tension, $T = 26.5 dyn. Cm^{-1}$

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8. Under isothermal condition, a soap bubble of radius R is converted into a large soap bubble of radius 2R . If the surface tension of soap solution is T, then calculate the amount of energy spent.

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9. How much work should be done in constructing a soap bubble of radius 5 cm? Surface tension of soap solution is 30 dyn. cm^{-1}.

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10. The internal radius of a capillary tube is 0.025 mm. Determine the rise in height of water in that tube. Surface tension of water = 70 dyn. cm^{-1}.

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11. Two capillary tubes of radii 0.2 cm and 0.4 cm are dipped inside the same liquid. Determine the ratio of the heights of the liquid in the two tubes.

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12. If the surface tension of water is $7.3 \times 10^{-2} N.m^{-1}$, then what is the pressure inside a spherical drop of water of radius 10^{-3} m?

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13. If the excess pressure inside a spherical soap bubble of radius 0.1 m is balanced by that due to a column of oil of specific gravity

$0.9, 1.36 \times 10^{-3}$ m high, calculate the surface tension.

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Exercise Problem Set Ii

1. A plate of area $30cm^2$ remains separated from another large plate by means of a layer of glycerine 1 mm thick.If the co-efficient of viscosity is 20 poise, then what force is necessary to move that plate with a velocity of 2 cm $.s^{-1}$?

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2. A spherical ball of steel of radius 2 mm is falling down through glycerine. Determine the terminal velocity of the ball. Specific gravities of steel and glycerine are 8 and 1.3 respectively . Coefficient of viscosity of glycerine, $\eta = 8.3$ poise.

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3. Two drops of water of the same size fall through air with a uniform velocity of 0.05m. s^{-1}. If the two drops coalesce to form a single drop, then what will be the terminal velocity of the large drop?

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4. An air bubble of radius 0.4 is rising upwards through a liquid with a uniform velocity of 0.5 cm. s^{-1}. Density of the liquid is 2000 kg. m^{-3}. Determine the coefficient of viscosity of the liquid. Neglect the density of air.

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5. A large tank is filled with water up to a height h. Water emerges through a hole near the bottom of the tank. Find the ratio of the time intervals in which water falls down from height h to $\frac{h}{2}$ and from $\frac{h}{2}$ to zero.

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6. In Millikan's oil drop experiment what is the terminal speed of an unchanged drop of radius 20×10^{-5}m and density 1.2×10^{3} kg. m^{-3}. Take the viscosity of air at the temperature of the experiment to be 1.8×10^{-5}Pa. s. How much is the viscous force on the drop at that speed ? Neglect buoyancy of the drop due to air.

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7. In a test experiment on a model aeroplane in a wind tunnel, the flow speeds on the upper and lower surfaces of the wing are 70 m.s^{-1} and $63 m. s^{-1}$ respectively. What is the lift on the wing if its area is 2.5 m^2 ? Take the density of air to be $1.3 kg. m^{-3}$.

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8. The cylindrical tube of a spray pump has a cross section of 8.0 cm^2 one end of which has 40 find holes each of diameter 1.0 mm. If the liquid flow inside the tube is 1.5 m. $\min^{-1}$. What is the speed of ejection of the liquid through the holes?

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9. A mercury drop of diameter 1×10^{-2} m breaks into 8 mercury droplets of equal size. Determine the work done in this process. Surface tension of mercury $= 0.435N. M^{-1}$.'

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10. At the same temperature a drop of water of diameter 1 mm is broken into 10^6 equal water droplets of spherical shape. How much mechanical work should be done in forming the new surface area ? Surface tension of water $= 0.074N. m^{-1}$.

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11. Two drops of mercury, each having a radius R, coalesce to from a large drop. Determine the ratio of their surface energies before and after the change. Surface tension of mercury = T.

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12. The dimensions of a soap film is 10 cm $\times$ 6 cm. If it is increased to 10 cm $\times$ 11 cm, then work done is 3×10^{-4}J. What is the surface tension of the soap solution?

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13. 216 water droplets (radius of each is r) coalesce to form a large drop of water. If the energy released in this process increases the temperature of the water drop then what will be the rise in temperature? [s = specific heat, J = mechanical equivalent of heat, T = surface tension, ρ = density of water,]

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14. How much will a liquid level be depressed inside a capillary tub of radius 0.02 cm, if the angle of contact of the liquid with the tube is 135°? Surface tension of the liquid = 0.547N. m^{-1}, density of the liquid $= 13.5 \times 10^3 kg. m^{-3}$ and acceleration due to gravity $= 9.8 m. s^{-2}$.

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15. When a capillary tube is dipped in water, water rises up to a height of 0.1 m inside the tube. If that capillary tube is dipped in mercury, then the mercury level falls down through 0.342 m. If the specific gravity of mercury is 13.6, angle of contact of water is 0° and that of mercury is 135°, then compare the surface tension of water and mercury.

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16. A U-tube is made up of two capillary tubes of bores 1 mm and 2 mm. The tube is held vertically and some part of it is filled with a liquid of surface tension 0.049N $.m^{-1}$ and of zero angle of contact. If the level difference of the liquid in the two arms is 1.25 cm, then determine the density of the liquid.

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17. In a capillary tube water rises up to a certain height and the upward force due to surface tension balances the force of $7.5 \times 10^{-4} N$ due to weight of water. If the surface tension of water is $6 \times 10^{-2} N.m^{-1}$ then what will be the internal circumference of the capillary tube?

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18. What is the pressure inside a drop of mercury of radius 3.00 mm at room temperature? Surface tension of mercury at that temperature $(20^\circ C)$ is $4.65 \times 10^{-1} N. m^{-1}$. The atmospheric pressure is $1.01 \times 10^5 Pa$. Also give the excess pressure inside the drop.

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19. What is the excess pressure inside a bubble of soap solution of radius 5.00 mm, given that the surface tension of soap solution at the temperature $(20^\circ C)$ is $2.50 \times 10^{-2} N. m^{-1}$? If an air bubble of the same dimension were formed at a 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 standard atmosphere pressure is $1.01 \times 10^5 Pa$.).

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Exercise Hots Numerical Problems

1. Water flows through a horizontal tube as shown in Fig. 3.41. If the difference in heights of water column in the verticle tubes is 0.02 m, and the areas of cross section at A and B are $4 \times 10^{-4} m^2$ and 2×10^{-4} respectively, then find the rate of flow water across any section,

Exercise Entrance Corner Assertion Reason Type

1. Statement I: The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down.

Statement II: In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: A

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2. Statement I: The viscosity of liquid increases with rise in temperature.

Statement II: Viscosity of a liquid is the property of the liquid by virtue of which it oppose the relative motion amongst its different layers.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: D

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3. Statement I: All the rain drops hit the surface of the earth with the same constant velocity.

Statement II: An object falling through a viscous medium eventually attains a terminal velocity.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: A

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4. Statement I: Air flows from a small bubbles to a large bubble when they are connected to each other by a capillary tube.

Statement II: The excess pressure because of surface tension inside a spherical bubble decreases as its radius increases.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: A

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5. Statement I: When height of the tube is less than the rise in liquid in a capillary tube, the liquid does not overflow.

Statement II: Product of radius of meniscus and height of liquid in the capillary tube always remains constant.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: A

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6. Statement I: It is easier to spray water in which some soap is dissolved.

Statement II: Soap is easier to spread.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: C

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7. Statement I: A needle placed carefully on the surface of water may float, whereas a ball of the same material will always sink.

Statement II: The buoyancy of an object depends both on the material and shape of the object.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: C

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8. Statement I: A large force is required to draw apart normally two glass plates enclosing a thin water film.

Statement II: Water works as glue and sticks two glass plates.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: B

View Text Solution

9. Statement I: Tiny drops of liquid resist deforming forces better than bigger drop.

Statement II: Excess pressure inside a drop is directly proportional to surface tension.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: B

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10. Statement I: The uplift of the wing of an aircraft moving horizontally is caused by a pressure difference between the upper and lower faces of the wing.

Statement II: The velocity of air moving along the upper surface is higher than that along the lower surface.

A. Statement I is true, statement II is true , statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true , statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false.

D. Statement I is false, statement II is true.

Answer: A

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Exercise Comprehension Type

1. When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening. We first assume that the drop formed at the opening is spherical because that requires in its surface energy . To determine the size, we calculate the net verticle force due to the surface tension T when the radius of the drop is R. when the force becomes smaller than weight of the drop, the drop gets detached from the dropper.

i. If the radius of the opening of the dropper is r, the verticle force due to the surface tension of the drop of radius R (assuming $r < < R$) is

A. $2\pi rT$

B. $2\pi RT$

C. $\frac{2\pi r^2 T}{R}$

D. $\dfrac{2\pi R^2 T}{R}$

Answer: C

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2. When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening. We first assume that the drop formed at the opening is spherical because that requires in its surface energy . To determine the size, we calculate the net verticle force due to the surface tension T when the radius of the drop is R. when the force becomes smaller than weight of the drop, the drop gets detached from the dropper.

ii. If

$r = 5 \times 10^{-4} m, \rho = 10^3 kg. m^{-3}, g = 10 m. s^{-2}, T = 0.11 N. m^{-1}$

the radius of the drop when it detaches from the dropper is approximately

A. $.14 \times 10^{-3}$ m

B. 3.3×10^{-3} m

C. $2.0 \times 10^{-3} m$

D. 4.1×10^{-3} m

Answer: A

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3. When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening. We first assume that the drop formed at the opening is spherical because that requires in its surface energy . To determine the size, we calculate the net verticle force due to the surface tension T when the radius of the drop is R. when the force becomes smaller than weight of the drop, the drop gets detached from the dropper.

iii. After the drop detaches, its surface energy is

A. $1.4 \times 10^{-6} J$

B. $2.7 \times 10^{-6} J$

C. $5.4 \times 10^{-6} J$

D. $8.1 \times 10^{-6} J$

Answer: B

View Text Solution

4. Let n number of little droplets of water of surface tension S $dyn. Cm^{-1}$, all of the same radius r cm, combine to form a single drop of radius R cm. J is joule's mechanical equivalent of heat.

While using CGS system of units answer the following questions.

i. The energy released is

A. $S \times 4\pi nr^2$

B. $S \times 4\pi R^2$

C. $S \times 4\pi r^2 n\left[1 - n^{-1/3}\right]$

D. $S \times 4\pi R^2\left[n^{2/3} - 1\right]$

Answer: C

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5. Let n number of little droplets of water of surface tension S $dyn.\,Cm^{-1}$, all of the same radius r cm, combine to form a single drop of radius R cm. J is joule's mechanical equivalent of heat. While using CGS system of units answer the following questions.

ii. If the whole energy released is taken by the water drop formed, then rise in temperature in $\hat{} \circ C$ is

A. $\frac{S}{j}\left[\frac{1}{r}-\frac{1}{R}\right]$

B. $\frac{4S}{J}\left[\frac{n}{r}-\frac{1}{R}\right]$

C. $\frac{3S}{J}\left[\frac{1}{r}-\frac{1}{R}\right]$

D. $\frac{S}{J}\left[\frac{n}{r}-\frac{1}{R}\right]$

Answer: C

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6. Let n number of little droplets of water of surface tension S $dyn. Cm^{-1}$, all of the same radius r cm, combine to form a single drop of radius R cm. J is joule's mechanical equivalent of heat. While using CGS system of units answer the following questions.

iii. What is the change in excess of pressure inside the big drop formed and a small drop if the change in temperature is ignored

?

A. $2S\left[\frac{1}{r}-\frac{1}{R}\right]$

B. $S\left[\frac{1}{r}-\frac{1}{R}\right]$

C. $S\left[\frac{n}{r}-\frac{1}{R}\right]$

D. $2S\left[\frac{n}{r}-\frac{1}{R}\right]$

Answer: A

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7. A cyclinderical tank is open at the top and has cross sectional area a_1. Water is filled in it up to a height h. There is a hole of cross sectional area a_2 at its bottom. Given $a_1 = 3a_2$.

i. The initially velocity with which the water falls in the tank is

A. $\sqrt{2gh}$

B. $\sqrt{gh}$

C. $\sqrt{\frac{gh}{2}}$

D. $\frac{1}{2}\sqrt{gh}$

Answer: D

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8. A cyclinderical tank is open at the top and has cross sectional area a_1. Water is filled in it up to a height h. There is a hole of cross sectional area a_2 at its bottom. Given $a_1 = 3a_2$.

ii. The initially velocity with which the water emerges from the hole is

A. $\frac{1}{2}\sqrt{gh}$

B. $\sqrt{2gh}$

C. $\frac{3}{2}\sqrt{gh}$

D. $2\sqrt{2gh}$

Answer: C

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9. A cyclinderical tank is open at the top and has cross sectional area a_1. Water is filled in it up to a height h. There is a hole of cross sectional area a_2 at its bottom. Given $a_1 = 3a_2$.

iii. The time taken to empty the tank is

A. $\sqrt{\frac{2h}{g}}$

B. $4\sqrt{\frac{h}{g}}$

C. $6\sqrt{\frac{2h}{g}}$

D. $8\sqrt{\frac{2h}{g}}$

Answer: B

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Exercise Integer Answer Type

1. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure of $8N.m^{-2}$. The radii of bubbles A and B are 2 cm and 4 cm respectively. Surface tension of the soap water. Used to make bubbles is $0.04N.m^{-1}$. Find the ratio n_B/n_A, where n_A and n_B are the number of moles of air in bubbles A and B respectively. (Neglect the effect of gravity),

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2. A vessel show bottom has a round hole with diameter of 1 mm is filled with water. Only surface tension acts at the hole. Surface tension of water is $75 \times 10^{-3} N.\,m^{-1}$ and $g = 10 m.\,S^{-2}$. What is the maximum height (in cm) to which water can be filled in the vessel without leakage?

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3. A layer of glycerine of thickness 1 mm is present between a large surface area and surface area of $0.1 m^2$. With what force (in N) the small surface is to be pulled. So that it can move with a velocity of $1 m.\,S^{-1}$? (Given the coefficient of viscosity $= 0.07 kg.\,m^{-1}.\,s^{-1}.$)

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4. A glass rod of diameter $d_1 = 1.5$ mm is inserted symmetrically into a glass capillary with inside diameter $d_2 = 2.0$ mm. Then the whole arrangement is vertically oriented and brought in contact with the surface of water. To what height (in cm) will the liquid rise in the capillary ? Surface tension of water $= 73 \times 10^{-3} N.\ m^{-1}$.

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5. A metal ball of radius 2 mm and density $10.5 g.\ Cm^{-3}$ is dropped in glycerine of coefficient of viscosity $9.8 dyn.\ Cm^{-2}.\ s$ and density $1.5 g.\ cm^{-3}$. Find the terminal velocity (in cm. s^{-1}.) of the ball.

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1. A small spherical body of radius r made of material of density ρ is dropped into a long column of viscous liquid of density σd and coefficient of viscosity η.The graph of the terminal velocity (v) vs radius (r) of the body will be

A. straight line

B. parabola

C. ellipse

D. none of these

Answer: B

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2. A spherical air bubble of radius r is formed in water. If T be the surface tension of water, the excess pressure inside the bubble is

A. $\frac{4T}{r}$

B. $\frac{2T}{r}$

C. $\frac{T}{r}$

D. none of these

Answer: B

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3. During fall of water gently from a water-tap the stream gets thinner at the bottom. Why?

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4. According to Jurin's law, the graph of the diameter (d) vs height of the water column (h) of the capillary tube will be

A. Circular

B. Parabola

C. Hyperbola

D. Straight line

Answer: C

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5. The work down in blowing a soap bubble of volume V is W. The work is to be done in blowing it of volume 2V equals to

A. 2W

B. $\sqrt[3]{4}W$

C. $\sqrt[3]{2}W$

D. $\sqrt{2}W$

Answer: B

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6. Two solids spheres of same metal having masses M and 8M respectively fall simultaneously on a same viscous liquid and their terminal velocities are v and nv, then the value of 'n' is

A. 16

B. 8

C. 4

D. 2

Answer: C

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7. Two water drops of equal size are falling through air with constant velocity of $2\frac{m}{s}$. If the two drops are allowed to coalesce to form a single drop, what would be its terminal velocity?

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8. The dimension of coefficient of viscosity is

A. MLT^{-2}

B. $M^{-1}L^{-1}T^{-1}$

C. $ML^{-1}T^{-1}$

D. $ML^{-1}T^{-2}$

Answer: C

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9. What is the gain in potential energy of the water column in case of rise of water in glass capillary tube? What is the work done by surface tension ? Assume that the angle of contact between glass and water is 0°.

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10. Water rises up to a height h in a certain capillary tube of a particular diameter. Another capillary tube is taken whose diameter is half that of the previous tube. The height up to which water will rise in the second tube is

A. $3h$

B. $2h$

C. $4h$

D. h

Answer: B

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11. When two soap bubbles of radii r_1 and $r_2 (r_2 < r_1)$ adjoin, the radius of curvature of the common surface is

A. $r_2 - r_1$

B. $r_2 + r_1$

C. $\frac{(r_2 - r_1)}{r_1 r_2}$

D. $\frac{r_1 r_2}{r_2 - r_1}$

Answer: D

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12. (iii) 27 number of droplets having same size are falling through air with the same terminal velocity of $1m. S^{-1}$. If the small droplets merge to produce a new drop, what will be the terminal velocity of the new drop?

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13. The dimension of surface tension is

A. MLT^{-2}

B. MLT^{-1}

C. MT^{-2}

D. ML^2T^{-2}

Answer: C

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14. The speed of a ball of radius 2 cm in viscous liquid medium is 20 cm. s^{-1}. The speed of a ball of radius 1 cm in the same liquid will be

A. $5cm. s^{-1}$

B. $10cm. s^{-1}$

C. $40cm. s^{-1}$

D. $80cm. s^{-1}$

Answer:

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Exercise Examination Archive With Solutions Wbjee

1. A small metal sphere of radius a is falling with a velocity through a verticle column of a viscous liquid. If the coefficient of viscosity of the liquid is η, then the sphere encounters an opposing force of

A. $6\pi\eta a^2 v$

B. $\frac{6\eta v}{\pi a}$

C. $6\pi\eta a v$

D. $\frac{\pi\eta v}{6a^3}$

Answer: C

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2. A drop of some liquid of volume 0.04 cm^3 is placed on the surface of a glass slide. Then another glass slide is placed on it in such a way that the liquid forms a thin layer of area 20cm^2 between the surface of the two slides. To separate the slides , force of 16×10^5 dyne has to be applied normal to the surfaces. The surface tension of the liquid is (in dyn.cm^{-1})

A. 60

B. 70

C. 80

D. 90

Answer: C

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3. A 20 cm long capillary tube is dipped vertically in water and the liquid rises upto 10 cm. If the entire system is kept in a freely falling platform, the length of water column in the tube will be

A. 5 cm

B. 10 cm

C. 15 cm

D. 20 cm

Answer: D

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4. A gas bubble of 2 cm diameters rises through a liquid of density 1.75 g. cm^{-3} with a fixed speed of 0.35cm. s^{-1}. Neglect the density of the gas. The coefficient of viscosity of the liquid is

A. 870 poise

B. 1120 poise

C. 982 poise

D. 1089 poise

Answer: D

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5. 1000 droplets of water having 2 mm diameter each coalesce to form a single drop. Given the surface tension of water is $0.072 N.m^{-1}$. The energy loss in the process is

A. $8.146 \times 10^{-4} J$

B. $4.4 \times 10^{-4} J$

C. $2.108 \times 10^{-5} J$

D. $4.7 \times 10^{-1} J.$

Answer: A

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6. A drop of water detaches itself from the exit of a tap when $[\sigma =$ surface tension of water, $\rho =$ density of water, R = radius of the tap exit, r = radius of the drop]

A. $r > \left(\frac{2}{3}\frac{R\sigma}{\rho g}\right)^{\frac{1}{3}}$

B. $r > \left(\frac{2}{3}\frac{R\sigma}{\rho g}\right)$

C. $\frac{2\sigma}{r} > \text{atmospheric pressure}$

D. $r > \left(\frac{2}{3}\frac{R\sigma}{(\rho g)^{\frac{2}{3}}}\right)$

Answer:

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7. A uniform capillary tube of length l and inner radius r with its end sealed is submerged vertically into water. The outside pressure is p_0 and surface tension of water is γ. When a length x of the capillary is submerged into water . It is found that water levels inside and outside the capillary coincide. The Value of x is

A. $\dfrac{l}{\left(1+\frac{p_0 r}{4\gamma}\right)}$

B. $\dfrac{l}{\left(1-\frac{p_0 r}{4\gamma}\right)}$

C. $\dfrac{l}{\left(1-\frac{p_0 r}{2\gamma}\right)}$

D. $\dfrac{l}{\left(1+\frac{p_0 r}{2\gamma}\right)}$

Answer: D

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8. What will be the approximate terminal velocity of a rain drop of diameter $1.8 \times 10^{-3} m$, when density of rain water $\approx 10^3 kg. m^{-3}$ and the coefficient of viscosity of air $\approx 1.8 \times 10^{-5} N. s. m^{-2}$?(Neglect buoyancy of air)

A. $49 m. s^{-1}$

B. $98 m. S^{-1}$

C. $392 m. S^{-1}$.

D. $980 m. S^{-1}$.

Answer: B

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Exercise Examination Archive With Solutions Aipmt

1. A certain number of spherical drops of a liquid of a liquid of radius r coalesce to form a single drop of radius R and volume V. if T is the surface tension of the liquid, then

A. energy $= 4VT\left(\frac{1}{r} - \frac{1}{R}\right)$ is released

B. energy $= 3VT\left(\frac{1}{r} + \frac{1}{R}\right)$ is absorbed

C. energy $= 3VT\left(\frac{1}{r} - \frac{1}{R}\right)$ is released

D. energy is neither released nor absorbed.

Answer: C

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2. A wind with speed 40m /s blows parallel to the roof of a house. The area of the roof is $250m^2$. Assuming that the pressure inside the house is atmospheric pressure, the force exerted by the wind on the roof and the direction of the force will be

$\left[p_{\text{air}} = 1.2 kg / m^3\right]$

A. $4.8 \times 10^5 N$, downwards

B. $4.8 \times 10^5 N$, upwards

C. $2.4 \times 10^5 N$, upwards

D. $2.4 \times 10^5 N$, downwards

Answer: C

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Exercise Examination Archive With Solutions Neet

1. A metal block of base area 0.2 m^2 is connected to a 0.02 kg mass via a string that passes over an ideal pulley as shown in figure. A liquid film of thickness 0.6 mm is placed the block and the table. When released the block moves to the right with a constant speed of $0.17 m/s$. The co-efficient of viscosity of the liquid is

A. $3.45 \times 10^{3} Pa. s$

B. $3.45 \times 10^{-2} Pa. s$

C. $3.45 \times 10^{-3} Pa. s$

D. $3.45 \times 10^{2} Pa. s$

Answer: C

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2. A small sphere of radius r falls from rest in a viscous liquid. As a result, heat is produced due to viscous force. The rate of production of heat when the sphere attains its terminal velocity, is proportional to

A. r^5

B. r^2

C. r^3

D. r^4

Answer: A

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Exercise Cbse Scanner

1. State and prove Bernoulli's theorem.

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2. Write two factors affecting viscosity. Which one is more viscous: pure water or saline water?

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3. Give two similarities and dissimilarities between friction and viscosity.

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4. State Stokes' law.

The terminal velocity of copper ball of radius 2.0 mm falling through a tank of oil at $20^\circ C$ is 6.5 cm. s^{-1}.

Compute the coefficient of viscosity of the oil at $20^\circ C$. (Density of oil is $1.5 \times 10^3 kg. m^{-3}$, density of copper is $8.9 \times 10^3 kg. m^{-3}$)

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5. When we try to close a water tap with our fingers fast jets of water through the openings between our fingers. Explain why.

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6. What do you mean by terminal velocity of a drop falling through a viscous medium? Write its expression.

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7. What is the surface energy ? Find the relation between surface tension and surface energy. Explain why.

(i) surface tension of a liquid is independent of the area of the surface.

(ii) detergents should have small angle of contact.

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8. State and prove Bernoulli's theorem. Write any two limitations of Bernoulli's theorem.

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9. (ii) A liquid of density ρ and surface tension S rises to a height h in a capillary tube of diameter D. What is the weight of the liquid in the capillary tube? Angel of contact is 0°.

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