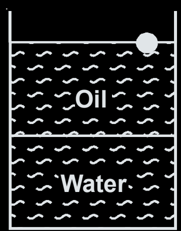
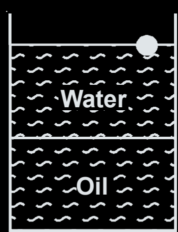
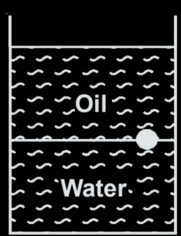
Chapter 8

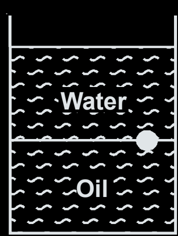
Mechanical Properties of Fluids

1. A ball is made of a material of density ρ where $\rho_{oil} < \rho < \rho_{water}$ with ρ_{oil} and ρ_{water} representing the densities of oil and water, respectively. The oil and water are immiscible. If the above ball is in equilibrium in a mixture of this oil and water, which of the following pictures represents its equilibrium positions? **[AIEEE-2010]**

(1) 

(2) 

(3) 

(4) 

2. Two mercury drops (each of radius r) merge to form a bigger drop. The surface energy of the bigger drop, if T is the surface tension, is **[AIEEE-2011]**

(1) $2^{8/3}\pi r^2 T$ (2) $2^{5/3}\pi r^2 T$

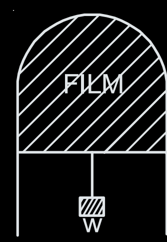
(3) $4\pi r^2 T$ (4) $2\pi r^2 T$

3. If a ball of steel (density ρ = 7.8 g cm^{-3}) attains a terminal velocity of 10 cm s^{-1} when falling in a tank of water (coefficient of viscosity η_{water} = 8.5 × 10^{-4} Pa s), then its terminal velocity in glycerine (ρ = 1.2 g cm^{-3}, η = 13.2 Pa. s) would be, nearly **[AIEEE-2011]**

(1) 1.5 × 10^{-5} cm s^{-1} (2) 1.6 × 10^{-5} cm s^{-1}

(3) 6.25 × 10^{-4} cm s^{-1} (4) 6.45 × 10^{-4} cm s^{-1}

4. A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5 × 10^{-2} N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is **[AIEEE-2012]**



(1) 0.1 Nm^{-1} (2) 0.05 Nm^{-1}

(3) 0.025 Nm^{-1} (4) 0.0125 Nm^{-1}

5. A uniform cylinder of length L and mass M having cross-sectional area A is suspended, with its length vertical, from a fixed point by a massless spring, such that it is half submerged in a liquid of density σ at equilibrium position. The extension x_0 of the spring when it is in equilibrium is

[JEE (Main)-2013]

(1) $\frac{Mg}{k}$ (2) $\frac{Mg}{k}\left(1-\frac{LA\sigma}{M}\right)$

(3) $\frac{Mg}{k}\left(1-\frac{LA\sigma}{2M}\right)$ (4) $\frac{Mg}{k}\left(1+\frac{LA\sigma}{M}\right)$

(Here k is spring constant)

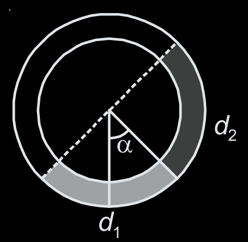
6. Assume that a drop of liquid evaporates by decrease in its surface energy, so that its temperature remains unchanged. What should be the minimum radius of the drop for this to be possible? The surface tension is T, density of liquid is ρ and L is its latent heat of vaporization. **[JEE (Main)-2013]**

(1) $\rho L/T$ (2) $\sqrt{T/\rho L}$

(3) $T/\rho L$ (4) $2\ T/\rho L$

7. 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

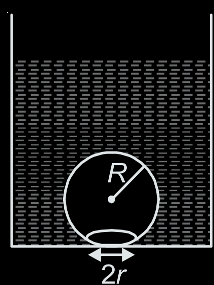
[JEE (Main)-2014]



(1) $\dfrac{1+\sin\alpha}{1-\sin\alpha}$ (2) $\dfrac{1+\cos\alpha}{1-\cos\alpha}$

(3) $\dfrac{1+\tan\alpha}{1-\tan\alpha}$ (4) $\dfrac{1+\sin\alpha}{1-\cos\alpha}$

8. On heating water, bubbles being formed at the bottom of the vessel detatch and rise. Take the bubbles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If $r << R$, and the surface tension of water is T, value of r just before bubbles detatch is (Density of water is ρ_w) **[JEE (Main)-2014]**



(1) $R^2\sqrt{\dfrac{2\rho_w g}{3T}}$ (2) $R^2\sqrt{\dfrac{\rho_w g}{6T}}$

(3) $R^2\sqrt{\dfrac{\rho_w g}{T}}$ (4) $R^2\sqrt{\dfrac{3\rho_w g}{T}}$

9. The top of a water tank is open to air and its water level is maintained. It is giving out 0.74 m^3 water per minute through a circular opening of 2 cm radius in its wall. The depth of the centre of the opening from the level of water in the tank is close to **[JEE (Main)-2019]**

(1) 9.6 m (2) 2.9 m

(3) 4.8 m (4) 6.0 m

10. Water flows into a large tank with flat bottom at the rate of 10^{-4} m^3s^{-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 **[JEE (Main)-2019]**

(1) 5.1 cm (2) 1.7 cm

(3) 2.9 cm (4) 4 cm

11. A liquid of density ρ is coming out of a hose pipe of radius a with horizontal speed v and hits a mesh. 50% of the liquid passes through the mesh unaffected. 25% looses all of its momentum and 25% comes back with the same speed. The resultant pressure on the mesh will be

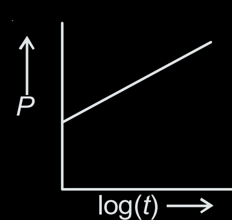
[JEE (Main)-2019]

(1) $\frac{3}{4}\rho v^2$ (2) $\frac{1}{4}\rho v^2$

(3) $\frac{1}{2}\rho v^2$ (4) ρv^2

12. A soap bubble, blown by a mechanical pump at the mouth of a tube, increases in volume, with time, at a constant rate. The graph that correctly depicts the time dependence of pressure inside the bubble is given by **[JEE (Main)-2019]**

(1)



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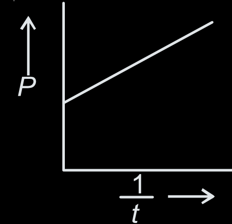

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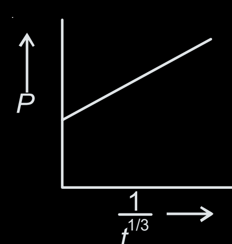

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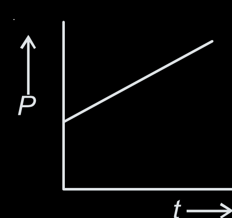


13. A long cylindrical vessel is half filled with a liquid. When the vessel is rotated about its own vertical axis, the liquid rises up near the wall. If the radius of vessel is 5 cm and its rotational speed is 2 rotations per second, then the difference in the heights between the centre and the sides, in cm, will be **[JEE (Main)-2019]**

(1) 1.2 (2) 0.1

(3) 0.4 (4) 2.0

14. Water from a pipe is coming at a rate of 100 liters per minute. If the radius of the pipe is 5 cm, the Reynolds number for the flow is of the order of : (density of water = 1000 kg/m^3, coefficient of viscosity of water = 1 mPa s)

[JEE (Main)-2019]

(1) 10^2 (2) 10^4

(3) 10^3 (4) 10^6

15. If M is the mass of water that rises in a capillary tube of radius r, then mass of water which will rise in a capillary tube of radius $2r$ is

[JEE (Main)-2019]

(1) $2M$
(2) M
(3) $4M$
(4) $\frac{M}{2}$

16. A wooden block floating in a bucket of water has $\frac{4}{5}$ of its volume submerged. When certain amount of an oil is poured into the bucket, it is found that the block is just under the oil surface with half of its volume under water and half in oil. The density of oil relative to that of water is **[JEE (Main)-2019]**

(1) 0.5
(2) 0.8
(3) 0.7
(4) 0.6

17. The ratio of surface tensions of mercury and water is given to be 7.5 while the ratio of their densities is 13.6. Their contact angles, with glass, are close to 135° and 0°, respectively. It is observed that mercury gets depressed by an amount h in a capillary tube of radius r_1, while water rises by the same amount h in a capillary tube of radius r_2. The ratio, (r_1/r_2), is then close to : **[JEE (Main)-2019]**

(1) 4/5
(2) 2/3
(3) 3/5
(4) 2/5

18. A cubical block of side 0.5 m floats on water with 30% of its volume under water. What is the maximum weight that can be put on the block without fully submerging it under water?

[Take, density of water = 10^3 kg/m^3]

[JEE (Main)-2019]

(1) 30.1 kg
(2) 46.3 kg
(3) 87.5 kg
(4) 65.4 kg

19. Water from a tap emerges vertically downwards with an initial speed of 1.0 ms^{-1}. The cross-sectional area of the tap is 10^{-4} m^2. Assume that the pressure is constant throughout the stream of water and that the flow is streamlined. The cross-sectional area of stream, 0.15 m below the tap would be:

(Take g = 10 ms^{-2}) **[JEE (Main)-2019]**

(1) 1×10^{-5} m^2
(2) 5×10^{-5} m^2
(3) 5×10^{-4} m^2
(4) 2×10^{-5} m^2

20. A submarine experiences a pressure of 5.05×10^6 Pa at a depth of d_1 in a sea. When it goes further to a depth of d_2, it experiences a pressure of 8.08×10^6 Pa. Then $d_2 - d_1$ is approximately (density of water = 10^3 kg/m^3 and acceleration due to gravity = 10 ms^{-2}) :

[JEE (Main)-2019]

(1) 600 m
(2) 500 m
(3) 300 m
(4) 400 m

21. A solid sphere, of radius R acquires a terminal velocity v_1 when falling (due to gravity) through a viscous fluid having a coefficient of viscosity η. The sphere is broken into 27 identical solid spheres. If each of these spheres acquires a terminal velocity, v_2, when falling through the same fluid, the ratio $\left(\frac{v_1}{v_2}\right)$ equals **[JEE (Main)-2019]**

(1) $\frac{1}{27}$
(2) 9
(3) $\frac{1}{9}$
(4) 27

22. An ideal fluid flows (laminar flow) through a pipe of non-uniform diameter. The maximum and minimum diameters of the pipes are 6.4 cm and 4.8 cm, respectively. The ratio of the minimum and the maximum velocities of fluid in this pipe is

[JEE (Main)-2020]

(1) $\frac{81}{256}$
(2) $\frac{9}{16}$
(3) $\frac{3}{4}$
(4) $\frac{\sqrt{3}}{2}$

23. Consider a solid sphere of radius R and mass density $\rho(r) = \rho_0\left(1 - \frac{r^2}{R^2}\right)$, $0 < r \leq R$. The minimum density of a liquid in which it will float is

[JEE (Main)-2020]

(1) $\frac{2\rho_0}{5}$
(2) $\frac{\rho_0}{3}$
(3) $\frac{\rho_0}{5}$
(4) $\frac{2\rho_0}{3}$

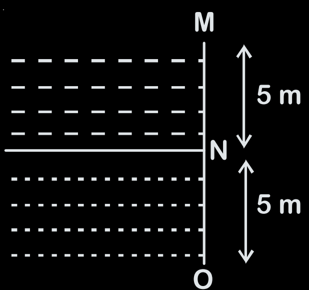
24. A leak proof cylinder of length 1 m, made of a metal which has very low coefficient of expansion is floating vertically in water at 0°C such that its height above the water surface is 20 cm. When the temperature of water is increased to 4°C, the height of the cylinder above the water surface becomes 21 cm. The density of water at T = 4°C, relative to the density at T = 0°C is close to **[JEE (Main)-2020]**

(1) 1.04

(2) 1.03

(3) 1.26

(4) 1.01

25. 

Two liquids of densities ρ_1 and ρ_2 ($\rho_2 = 2\rho_1$) are filled up behind a square wall of side 10 m as shown in figure. Each liquid has a height of 5 m. The ratio of the forces due to these liquids exerted on upper part MN to that at the lower part NO is (Assume that the liquids are not mixing)

[JEE (Main)-2020]

(1) 1/4

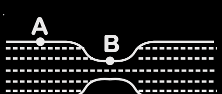
(2) 1/2

(3) 2/3

(4) 1/3

26. Water flows in a horizontal tube (see figure). The pressure of water changes by 700 Nm^{-2} between A and B where the area of cross section are 40 cm^2 and 20 cm^2, respectively. Find the rate of flow of water through the tube. **[JEE (Main)-2020]**

(density of water = 1000 kgm^{-3})



(Fig.)

(1) 3020 cm^3/s (2) 1810 cm^3/s

(3) 2720 cm^3/s (4) 2420 cm^3/s

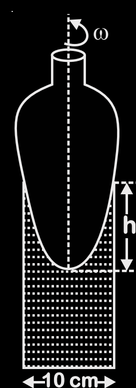
27. A small spherical droplet of density d is floating exactly half immersed in a liquid of density ρ and surface tension T. The radius of the droplet is (take note that the surface tension applies an upward force on the droplet) **[JEE (Main)-2020]**

(1) $r = \sqrt{\frac{3T}{(2d-\rho)g}}$ (2) $r = \sqrt{\frac{T}{(d+\rho)g}}$

(3) $r = \sqrt{\frac{T}{(d-\rho)g}}$ (4) $r = \sqrt{\frac{2T}{3(d+\rho)g}}$

28. A cylindrical vessel containing a liquid is rotated about its axis so that the liquid rises at its sides as shown in the figure. The radius of vessel is 5 cm and the angular speed of rotation is ω rad s^{-1}. The difference in the height, h (in cm) of liquid at the centre of vessel and at the side will be

[JEE (Main)-2020]



(1) $\frac{2\omega^2}{25g}$ (2) $\frac{5\omega^2}{2g}$

(3) $\frac{2\omega^2}{5g}$ (4) $\frac{25\omega^2}{2g}$

29. A capillary tube made of glass of radius 0.15 mm is dipped vertically in a beaker filled with methylene iodide (surface tension = 0.05 Nm^{-1}, density = 667 kg m^{-3}) which rises to height h in the tube. It is observed that the two tangents drawn from liquid-glass interfaces (from opp. sides of the capillary) make an angle of 60° with one another. Then h is close to (g = 10 ms^{-2}) **[JEE (Main)-2020]**

(1) 0.049 m

(2) 0.087 m

(3) 0.137 m

(4) 0.172 m

30. Pressure inside two soap bubbles are 1.01 and 1.02 atmosphere, respectively. The ratio of their volumes is **[JEE (Main)-2020]**

(1) 2 : 1
(2) 0.8 : 1
(3) 4 : 1
(4) 8 : 1

31. A air bubble of radius 1 cm in water has an upward acceleration 9.8 cm s^{-2}. The density of water is 1 gm cm^{-3} and water offers negligible drag force on the bubble. The mass of the bubble is (g = 980 cm/s^2) **[JEE (Main)-2020]**

(1) 1.52 gm
(2) 4.51 gm
(3) 3.15 gm
(4) 4.15 gm

32. Two identical cylindrical vessels are kept on the ground and each contain the same liquid of density d. The area of the base of both vessels is S but the height of liquid in one vessel is x_1 and in the other, x_2. When both cylinders are connected through a pipe of negligible volume very close to the bottom, the liquid flows from one vessel to the other until it comes to equilibrium at a new height. The change in energy of the system in the process is **[JEE (Main)-2020]**

(1) $gdS(x_2 + x_1)^2$
(2) $\frac{1}{4}gdS(x_2 - x_1)^2$
(3) $\frac{3}{4}gdS(x_2 - x_1)^2$
(4) $gdS\left(x_2^2 + x_1^2\right)$

33. A hollow spherical shell at outer radius R floats just submerged under the water surface. The inner radius of the shell is r. If the specific gravity of the shell material is $\frac{27}{8}$ w.r.t water, the value of r is **[JEE (Main)-2020]**

(1) $\frac{2}{3}R$
(2) $\frac{4}{9}R$
(3) $\frac{1}{3}R$
(4) $\frac{8}{9}R$

34. In an experiment to verify Stokes law, a small spherical ball of radius r and density ρ falls under gravity through a distance h in air before entering a tank of water. If the terminal velocity of the ball inside water is same as its velocity just before entering the water surface, then the value of h is proportional to **[JEE (Main)-2020]**

(ignore viscosity of air)

(1) r^4
(2) r^3
(3) r
(4) r^2

35. A fluid is flowing through a horizontal pipe of varying cross-section, with speed ν ms^{-1} at a point where the pressure is P pascal.

At another point where pressure is $\frac{P}{2}$ pascal its speed is V ms^{-1}. If the density of the fluid is ρ kg m^{-3} and the flow is streamline, then V is equal to **[JEE (Main)-2020]**

(1) $\sqrt{\frac{P}{\rho}+\nu^2}$
(2) $\sqrt{\frac{2P}{\rho}+\nu^2}$
(3) $\sqrt{\frac{P}{\rho}+\nu}$
(4) $\sqrt{\frac{P}{2\rho}+\nu^2}$

36. 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) _____. **[JEE (Main)-2020]**

37. A hydraulic press can lift 100 kg when a mass 'm' is placed on the smaller piston. It can lift _______ kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass 'm' on the smaller piston.

[JEE (Main)-2021]

38. A large number of water drops, each of radius r, combine to have a drop of radius R. If the surface tension is T and mechanical equivalent of heat is J, the rise in heat energy per unit volume will be

[JEE (Main)-2021]

(1) $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$
(2) $\frac{3T}{rJ}$
(3) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$
(4) $\frac{2T}{rJ}$

39. The pressure acting on a submarine is 3 × 10^5 Pa at a certain depth. If the depth is doubled, the percentage increase in the pressure acting on the submarine would be: **[JEE (Main)-2021]**

(Assume that atmospheric pressure is 1 × 10^5 Pa, density of water is 10^3 kg m^{-3}, g = 10 ms^{-2})

(1) $\frac{200}{5}\%$
(2) $\frac{3}{200}\%$
(3) $\frac{200}{3}\%$
(4) $\frac{5}{200}\%$

40. What will be the nature of flow of water from a circular tap, when its flow rate increased from 0.18 L/min to 0.48 L/ min? The radius of the tap and viscosity of water are 0.5 cm and 10^{-3} Pa s, respectively. **[JEE (Main)-2021]**

(Density of water : 10^3 kg/m^3)

(1) Steady flow to unsteady flow

(2) Remains turbulent flow

(3) Unsteady to steady flow

(4) Remains steady flow

41. When two soap bubbles of radii *a* and *b* (*b* > *a*) coalesce, the radius of curvature of common surface is **[JEE (Main)-2021]**

(1) $\frac{ab}{b-a}$ (2) $\frac{ab}{a+b}$

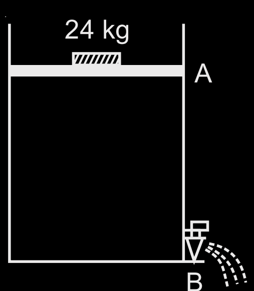
(3) $\frac{b-a}{ab}$ (4) $\frac{a+b}{ab}$

42. Consider a water tank as shown in the figure. It's cross-sectional area is 0.4 m^2. The tank has an opening B near the bottom whose cross-section area is 1 cm^2. A load of 24 kg is applied on the water at the top when the height of the water level is 40 cm above the bottom, the velocity of water coming out the opening B is v ms^{-1}.

The value of v, to the nearest integer, is ______.

[Take value of g to be 10 ms^{-2}]

[JEE (Main)-2021]



43. Two small drops of mercury each of radius R coalesce to form a single large drop. The ratio of total surface energy before and after the change is

[JEE (Main)-2021]

(1) 2 : 1 (2) 1 : 2

(3) $2^{\frac{1}{3}}:1$ (4) $1:2^{\frac{1}{3}}$

44. Two spherical soap bubbles of radii r_1 and r_2 in vacuum combine under isothermal conditions. The resulting bubble has a radius equal to

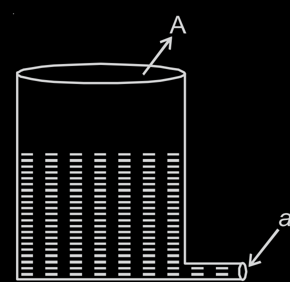
[JEE (Main)-2021]

(1) $\frac{r_1+r_2}{2}$ (2) $\sqrt{r_1r_2}$

(3) $\frac{r_1r_2}{r_1+r_2}$ (4) $\sqrt{r_1^2+r_2^2}$

45. A light cylindrical vessel is kept on a horizontal surface. Area of base is A. A hole of cross-sectional area '*a*' is made just at its bottom side. The minimum coefficient of friction necessary to prevent sliding the vessel due to the impact force of the emerging liquid is (*a* < < A)

[JEE (Main)-2021]



(1) $\frac{A}{2a}$ (2) None of these

(3) $\frac{2a}{A}$ (4) $\frac{a}{A}$

46. A raindrop with radius R = 0.2 mm falls from a cloud at a height *h* = 2000 m above the ground. Assume that the drop is spherical throughout its fall and the force of buoyance may be neglected, then the terminal speed attained by the raindrop is

[Density of water f_w = 1000 kg m^{-3} and

Density of air f_a = 1.2 kg m^{-3}, g = 10 m/s^2

Coefficient of viscosity of air = 1.8 × 10^{-5} Nsm^{-2}]

[JEE (Main)-2021]

(1) 250.6 ms^{-1}

(2) 14.4 ms^{-1}

(3) 43.56 ms^{-1}

(4) 4.94 ms^{-1}

47. The water is filled upto height of 12 m in a tank having vertical sidewalls. A hole is made in one of the walls at a depth 'h' below the water level. The value of 'h' for which the emerging stream of water strikes the ground at the maximum range is ______m. **[JEE (Main)-2021]**

48. Two narrow bores of diameter 5.0 mm and 8.0 mm are joined together to form a U-shaped tube open at both ends. If this U-tube contains water, what is the difference in the level of two limbs of the tube?

[Take surface tension of water T = 7.3×10^{-2} Nm^{-1}, angle of contact = 0, g = 10 ms^{-2} and density of water = 1.0×10^3 kg m^{-3}] **[JEE (Main)-2021]**

(1) 2.19 mm
(2) 3.62 mm
(3) 5.34 mm
(4) 4.97 mm

49. A soap bubble of radius 3 cm is formed inside the another soap bubble of radius 6 cm. The radius of an equivalent soap bubble which has the same excess pressure as inside the smaller bubble with respect to the atmospheric pressure is _____ cm.

50. In Millikan's oil drop experiment, what is viscous force acting on an uncharged drop of radius 2.0×10^{-5} m and density 1.2×10^3 kgm^{-3} ? Take viscosity of liquid = 1.8×10^{-5} Nsm^{-2}. (Neglect buoyancy due to air). **[JEE (Main)-2021]**

(1) 5.8×10^{-10} N
(2) 1.8×10^{-10} N
(3) 3.8×10^{-11} N
(4) 3.9×10^{-10} N

51. When a rubber ball is taken to a depth of _____ m in deep sea, its volume decreases by 0.5%.

(The bulk modulus of rubber = 9.8×10^8 Nm^{-2},

Density of sea water = 10^3 kgm^{-3}, g = 9.8 m/s^2)

[JEE (Main)-2021]

52. The terminal velocity (v_t) of the spherical rain drop depends on the radius (r) of the spherical rain drop as **[JEE (Main)-2022]**

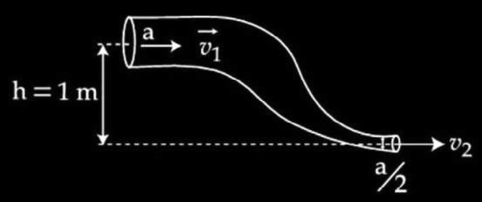
(1) $r^{1/2}$
(2) r
(3) r^2
(4) r^3

53. The velocity of upper layer of water in a river is 36 kmh^{-1}. Shearing stress between horizontal layers of water is 10^{-3} Nm^{-2}. Depth of the river is ____ m. (Co-efficient of viscosity of water is 10^{-2} Pa.s)

[JEE (Main)-2022]

54. An ideal fluid of density 800 k gm^{-3}, flows smoothly through a bent pipe (as shown in figure) that tapers in cross-sectional area from a to $\frac{a}{2}$. The pressure difference between the wide and narrow sections of pipe is 4100 Pa. At wider section, the velocity of fluid is $\frac{\sqrt{x}}{6}$ ms^{-1} for x =_______. (Given g =10 ms^{-2})

[JEE (Main)-2022]



55. 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, then the viscous force acting on the ball, will be **[JEE (Main)-2022]**

(1) $mg\left(1-\frac{d_1}{d_2}\right)$
(2) $mg\left(1-\frac{d_2}{d_1}\right)$
(3) $mg\left(\frac{d_1}{d_2}-1\right)$
(4) $mg\left(\frac{d_2}{d_1}-1\right)$

56. The area of cross-section of a large tank is 0.5 m^2. It has a narrow opening near the bottom having area of cross-section 1 cm^2. A load of 25 kg is applied on the water at the top in the tank. Neglecting the speed of water in the tank, the velocity of the water, coming out of the opening at the time when the height of water level in the tank is 40 cm above the bottom, will be ______ cms^{-1}.

[Take g = 10 ms^{-2}] **[JEE (Main)-2022]**

57. A water drop of diameter 2 cm is broken into 64 equal droplets. The surface tension of water is 0.075 N/m. In this process the gain in surface energy will be

[JEE (Main)-2022]

(1) 2.8×10^{-4} J (2) 1.5×10^{-3} J

(3) 1.9×10^{-4} J (4) 9.4×10^{-5} J

58. A water drop of radius 1 mm falls in a situation where the effect of buoyant force is negligible. Co-efficient of viscosity of air is 1.8×10^{-5} Nsm^{-2} and its density is negligible as compared to that of water (10^6 gm^{-3}). Terminal velocity of the water drop is

(Take acceleration due to gravity = 10 ms^{-2})

[JEE (Main)-2022]

(1) 145.4×10^{-6} ms^{-1}

(2) 118.0×10^{-6} ms^{-1}

(3) 132.6×10^{-6} ms^{-1}

(4) 123.4×10^{-6} ms^{-1}

59. A liquid of density 750 kgm^{-3} flows smoothly through a horizontal pipe that tapers in cross-sectional area from $A_1 = 1.2 \times 10^{-2}$ m^2 to $A_2 = \frac{A_1}{2}$. The pressure difference between the wide and narrow sections of the pipe is 4500 Pa. The rate of flow of liquid is _____ $\times 10^{-3}$ m^{3}s^{-1}.

[JEE (Main)-2022]

60. A small spherical ball of radius 0.1 mm and density 10^4 kg m^{-3} falls freely under gravity through a distance h before entering a tank of water. If, after entering the water the velocity of ball does not change and it continue to fall with same constant velocity inside water, then the value of h will be ______ m.

(Given g = 10 ms^{-2}, viscosity of water = 1.0×10^{-5} N-sm^{-2}). **[JEE (Main)-2022]**

61. A drop of liquid of density ρ is floating half immersed in a liquid of density σ and surface tension 7.5×10^{-4} N cm^{-1}. The radius of drop in cm will be (g = 10 ms^{-2}) **[JEE (Main)-2022]**

(1) $\frac{15}{\sqrt{(2\rho-\sigma)}}$ (2) $\frac{15}{\sqrt{(\rho-\sigma)}}$

(3) $\frac{3}{2\sqrt{(\rho-\sigma)}}$ (4) $\frac{3}{20\sqrt{(2\rho-\sigma)}}$

62. A water drop of radius 1 cm is broken into 729 equal droplets. If surface tension of water is 75 dyne/cm, then the gain in surface energy upto first decimal place will be : **[JEE (Main)-2022]**

(Given π = 3.14)

(1) 8.5×10^{-4} J (2) 8.2×10^{-4} J

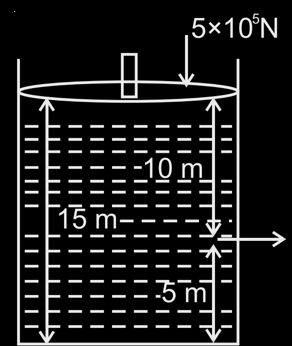
(3) 7.5×10^{-4} J (4) 5.3×10^{-4} J

63. A spherical soap bubble of radius 3 cm is formed inside another spherical soap bubble of radius 6 cm. If the internal pressure of the smaller bubble of radius 3 cm in the above system is equal to the internal pressure of the another single soap bubble of radius r cm. The value of r is ___ **[JEE (Main)-2022]**

64. The diameter of an air bubble which was initially 2 mm, rises steadily through a solution of density 1750 kg m^{-3} at the rate of 0.35 cms^{-1}. The coefficient of viscosity of the solution is _______ poise (in nearest integer). (The density of air is negligible).

[JEE (Main)-2022]

65. Consider a cylindrical tank of radius 1 m is filled with water. The top surface of water is at 15 m from the bottom of the cylinder. There is a hole on the wall of cylinder at a height of 5 m from the bottom. A force of 5×10^5 N is applied on the top surface of water using a piston. The speed of efflux from the hole will be: (given atmosphere pressure $P_A = 1.01 \times 10^5$ Pa, density of water ρ_w = 1000 kg/m^3 and gravitational acceleration g = 10 m/s^2) **[JEE (Main)-2022]**



(1) 11.6 m/s (2) 10.8 m/s

(3) 17.8 m/s (4) 14.4 m/s

66. Given below are two statements: One is labelled as **Assertion (A)** and the other· is labelled as **Reason (R)**. **[JEE (Main)-2022]**

Assertion (A) : Clothes containing oil or grease stains cannot be cleaned by water wash.

Reason (R) : Because the angle of contact between the oil/ grease and water is obtuse.

In the light of the above statements, choose the correct answer from the option given below.

(1) Both **(A)** and **(R)** are true and **(R)** is the correct explanation of **(A)**

(2) Both **(A)** and **(R)** are true but **(R)** is not the correct explanation of **(A)**

(3) **(A)** is true but **(R)** is false

(4) **(A)** is false but **(R)** is true

67. The velocity of a small ball of mass 0.3 g and density 8 g/cc when dropped in a container filled with glycerine becomes constant after some time. If the density of glycerine is 1.3 g/cc, then the value of viscous force acting on the ball will be $x \times 10^{-4}$ N. The value of x is _______. [use $g = 10\ m/s^2$]

[JEE (Main)-2022]

68. A tube of length 50 cm is filled completely with an incompressible liquid of mass 250 g and closed at both ends. The tube is then rotated in horizontal plane about one of its ends with a uniform angular velocity $x\sqrt{F}$ rads^{-1}. If F be the force exerted by the liquid at the other end then the value of x will be______

[JEE (Main)-2022]

69. If ρ is the density and η is coefficient of viscosity of fluid which flows with a speed v in the pipe of diameter d, the correct formula for Reynolds number R_e is:

[JEE (Main)-2022]

(1) $R_e = \dfrac{\eta d}{\rho v}$

(2) $R_e = \dfrac{\rho v}{\eta d}$

(3) $R_e = \dfrac{\rho v d}{\eta}$

(4) $R_e = \dfrac{\eta}{\rho v d}$

❑ ❑ ❑

Chapter 8

Mechanical Properties of Fluids

1. Answer (3)

$\rho > \rho_{oil}$, ball must sink in oil alone.

As $\rho < \rho_{water}$, ball must float in water.

2. Answer (1)

$SE = T \times SA$

$= T \times 4\pi R^2$

Now, $R^3 = 2r^3$

$R = 2^{1/3}r$

$\Rightarrow \quad SE = T \times 4\pi 2^{2/3} r^2$

3. Answer (3)

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

$$\Rightarrow \quad \frac{v'}{v} = \frac{\rho - \sigma'}{\eta'} \times \frac{\eta}{\rho - \sigma}$$

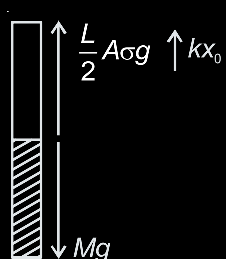
$$= \frac{7.8 - 1.2}{13.2} \times \frac{8.5 \times 10^{-4}}{7.8 - 1}$$

$v' = 6.25 \times 10^{-4}$ cm s^{-1}

4. Answer (3)

5. Answer (3)

For equilibrium,



$$Mg = \frac{L}{2}A\sigma g + kx_0$$

$$\Rightarrow \quad x_0 = \frac{Mg}{k}\left(1 - \frac{LA\sigma}{2M}\right)$$

6. Answer (4)

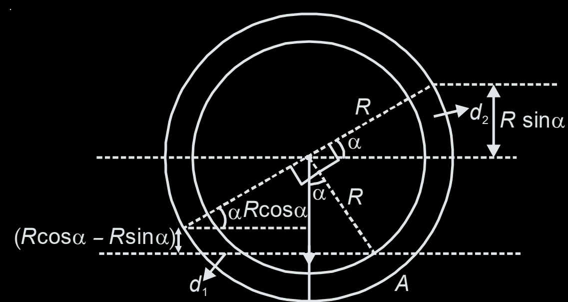
This could happen if $dm \times L = dA \times T$

$4\pi R^2 dR \times \rho \times L = 8\,\pi R dR \times T$

$$R = \frac{2T}{\rho L}$$

7. Answer (3)

Equating pressure at A



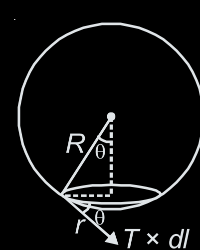
$(R\cos\alpha + R\sin\alpha)d_2 g = (R\cos\alpha - R\sin\alpha)d_1 g$

$$\Rightarrow \quad \frac{d_1}{d_2} = \frac{\cos\alpha + \sin\alpha}{\cos\alpha - \sin\alpha} = \frac{1 + \tan\alpha}{1 - \tan\alpha}$$

8. Answer (1)

When the bubble gets detached,

Buoyant force = force due to surface tension



$$\int T \times dl \sin\theta = \frac{4}{3}\pi R^3 \rho_w g$$

$$\Rightarrow \quad T \times 2\pi r \times \frac{r}{R} = \frac{4}{3}\pi R^3 \rho_w g$$

$$\Rightarrow \quad r^2 = \frac{2R^4 \rho_w g}{3}$$

$$\Rightarrow \quad r = R^2\sqrt{\frac{2\rho_w g}{3T}}$$

9. Answer (3)

Volume flow Rate = $\frac{0.74}{60}\ \text{m}^3/\text{s}$

Speed of efflux = $\frac{0.74 \times 10^4}{60 \times \pi \times 4}$ m/s = $\sqrt{2gh}$

$\Rightarrow \quad 9.82 = \sqrt{2 \times 10 \times h}$

$\Rightarrow \quad h = 4.8$ m

10. Answer (1)

$$-\frac{dh}{dt} = \sqrt{2gh}$$

$$a\sqrt{2gh} = Q$$

$$10^{-4}\sqrt{2gh} = 10^{-4}$$

$$h = \frac{1}{2g}$$

$$h = 5.1\ \text{cm}$$

11. Answer (1)

Let area be A.

$$F = \frac{\rho A}{4} \times v^2 + \frac{\rho A}{4} \times 2v^2$$

Pressure = $\frac{3\rho A v^2}{4A} = \frac{3\rho}{4} v^2$

12. Answer (3)

$$P - P_0 = \frac{4S}{R}$$

$$\therefore \quad P = \frac{4S}{R} + P_0$$

$$\therefore \quad P = 4S\left[\frac{4\pi}{3v}\right]^{1/3} + P_0$$

$$P = 4S\left[\frac{4\pi}{3kt}\right]^{1/3} + P_0$$

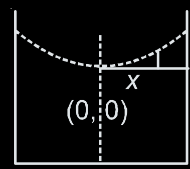
Also $v = \frac{4}{3}\pi R^3$

$$\Rightarrow \quad \left[\frac{3v}{4\pi}\right]^{1/3} = R$$

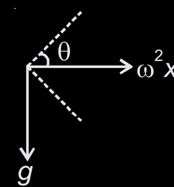
Given $v = kt$

Correct form: $P = m\left(\frac{1}{t^{1/3}}\right) + c$

13. Answer (4)



$\omega = 4\pi$ rad/s



$$\tan\theta = \frac{dy}{dx} = \frac{\omega^2 x}{g}$$

$$\Rightarrow \quad \int_0^h dy = \int_0^x \frac{\omega^2 x}{g} \cdot dx$$

$$\therefore \quad y = \left.\frac{\omega^2 x^2}{2g}\right|_0^{5\times10^{-2}}$$

$$\therefore \quad y = \frac{16\pi^2 \times 25 \times 10^{-4}}{2 \times 10} = 1.9\ \text{cm} \approx 2.0\ \text{cm}$$

14. Answer (2)

Flow rate of water (Q) = 100 lit/min

$$= \frac{100 \times 10^{-3}}{60} = \frac{5}{3} \times 10^{-3}\ \text{m}^3$$

$\therefore$ Velocity of flow (v) $= \frac{Q}{A} = \frac{5 \times 10^{-3}}{3 \times \pi \times (5 \times 10^{-2})^2}$

$$= \frac{10}{15\pi} = \frac{2}{3\pi}\ \text{m/s}$$

$= 0.2$ m/s

$\therefore$ Reynold number (R_e) $= \frac{Dv\rho}{\eta}$

$$= \frac{(10 \times 10^{-2}) \times \frac{2}{3\pi} \times 1000}{1} \simeq 2 \times 10^4$$

Order of $R_e = 10^4$

15. Answer (1)

$h \propto 1/r$

$M \propto \pi r^2 h$

$M \propto r$

16. Answer (4)

$$V\sigma g = \frac{4}{5}v\rho_\omega g \qquad \ldots(1)$$

$$V\sigma g = \frac{v}{2}\rho_\omega g + \frac{v}{2}\rho_0 g$$

$$\Rightarrow \left(\frac{\rho_\omega}{2} + \frac{\rho_{oil}}{2}\right) = \frac{4}{5}\rho_\omega$$

$$\Rightarrow \frac{\rho_{oil}}{2} = \rho_\omega\left(\frac{4}{5} - \frac{1}{2}\right) = \frac{3}{10}\rho_\omega$$

$$\Rightarrow \rho_{oil} = \frac{3}{5}\rho_\omega = 0.6\rho_\omega$$

17. Answer (4)

Ratio of surface tension

$$\frac{S_{Hg}}{S_{Water}} = 7.5$$

$$\frac{\rho_{Hg}}{\rho_W} = 13.6 \ \& \ \frac{\cos\theta_{Hg}}{\cos\theta_W} = \frac{\cos 135^\circ}{\cos 0^\circ} = \frac{1}{\sqrt{2}}$$

$$\frac{R_{Hg}}{R_{Water}} = \left(\frac{S_{Hg}}{S_W}\right)\left(\frac{\rho_W}{\rho_{Hg}}\right)\left(\frac{\cos\theta_{Hg}}{\cos\theta_W}\right)$$

$$= 7.5 \times \frac{1}{13.6} \times \frac{1}{\sqrt{2}} = 0.4 = \frac{2}{5}$$

18. Answer (3)

Given $(50)^3 \times \frac{30}{100} \times (1) \times g = M_{cube}g$ $\qquad \ldots$(i)

Let m mass should be placed

Hence $(50)^3 \times (1) \times g = (M_{cube} + m)g$ $\qquad \ldots$(ii)

equation (ii) – equation (i)

$\Rightarrow$ $mg = (50)^3 \times g(1 - 0.3) = 125 \times 0.7 \times 10^3$ g

$\Rightarrow$ $m = 87.5$ kg

19. Answer (2)

Using Bernoullie's equation $v_2 = \sqrt{v_1^2 + 2gh}$

Equation of continuity

$A_1V_1 = A_2V_2$

$$(1\,\text{cm}^2)(1\,\text{m/s}) = (A_2)\left(\sqrt{(1)^2 + 2 \times 10 \times \frac{15}{100}}\right)$$

$$\Rightarrow A_2\left(\text{In cm}^2\right) = \frac{1}{2}$$

$\Rightarrow$ $A_2 = 5 \times 10^{-5}\ \text{m}^2$

20. Answer (3)

$\Delta P = P_2 - P_1 = \rho g \Delta H$

$3.03 \times 10^6 = 10^3 \times 10 \times \Delta H$

$\Rightarrow$ $\Delta H \simeq 300$ m

21. Answer (2)

$R^3 = 27r^3$

$\Rightarrow$ $R = 3r$

$$\frac{V_1}{V_2} = \left(\frac{R}{r}\right)^2 = 9$$

22. Answer (2)

$A_1v_1 = A_2v_2$ (Equation of continuity)

$$\frac{v_{min}}{v_{max}} = \frac{v_1}{v_2} = \frac{A_2}{A_1} = \frac{(4.8)^2}{(6.4)^2} = \frac{9}{16}$$

23. Answer (1)

For minimum density of liquid, solid sphere has to float (completely immersed) in the liquid.

$\therefore$ mg = F_B (Also $V_{immersed} = V_{total}$)

or $\int \rho dV = \frac{4}{3}\pi R^3 \rho_\ell$

$$\Rightarrow \int_0^R \rho_0 4\pi\left(1 - \frac{r^2}{R^2}\right) \cdot r^2 dr = \frac{4}{3}\pi R^3 \rho_\ell$$

$$\Rightarrow 4\pi\rho_0\left[\frac{r^3}{3} - \frac{r^5}{5R^2}\right]_0^R = \frac{4}{3}\pi R^3\rho_\ell$$

$$\Rightarrow \frac{4\pi\rho_0 R^3}{3} \times \frac{2}{5} = \frac{4}{3}\pi R^3 \rho_\ell$$

$$\therefore \rho_\ell = \frac{2\rho_0}{5}$$

24. Answer (4)

Law of floatation

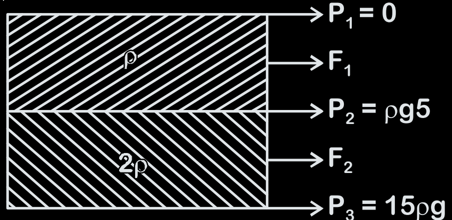
$$\frac{V_i}{V} = \frac{\rho_{body}}{\rho_{liquid}}$$

In given case

$$\therefore \quad \frac{h_1}{h_2} = \frac{(\rho_{4°C})_{water}}{(\rho_{0°C})_{water}} \quad \left[\rho_{body} = \text{constant}\right]$$

$$\frac{\rho_{4°C}}{\rho_{0°C}}\left(\frac{100-20}{100-21}\right) = \frac{80}{79} = 1.01$$

25. Answer (1)



$$F_1 = \frac{(P_1 + P_2)}{2}A$$

$$F_2 = \frac{(P_2 + P_3)}{2}A$$

$$\therefore \quad \frac{F_1}{F_2} = \frac{5\rho g}{20\rho g} = \frac{5}{20} = \frac{1}{4}$$

26. Answer (3)

$$(P_A - P_B) = \frac{1}{2}\rho(V_B^2 - V_A^2)$$

$$\Rightarrow \quad \Delta P = \frac{1}{2}\rho\left(V_B^2 - \frac{V_B^2}{4}\right)$$

$$\Rightarrow \quad \Delta P = \frac{3}{8}\rho V_B^2$$

$$V_B = \sqrt{\frac{(\Delta P)8}{3\rho}} = \sqrt{\frac{(\Delta P)4}{1500}} = \sqrt{\frac{700 \times 4}{1500}}\ m/s$$

$$Q = A_B V_B = (20)\left(\sqrt{\frac{28}{15}}\right) \times 100\ \frac{\text{cm}^3}{s}$$

$$Q \approx 2720\ \text{cm}^3/\text{s}$$

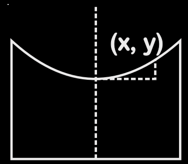
27. Answer (1)

$$T.2\pi r + \frac{2}{3}\pi r^3 \rho g = \frac{4}{3}\pi r^3 dg$$

$$T = \frac{r^2}{3}(2d - \rho)g$$

$$r = \sqrt{\frac{3T}{(2d-\rho)g}}$$

28. Answer (4)



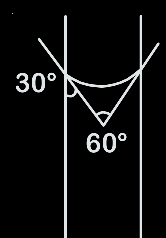
$$y = \frac{\omega^2 x^2}{2g}$$

$x = R$

$$\Rightarrow \quad y = \frac{25\omega^2}{2g}$$

29. Answer (2)

Angle of contact = 30°



$$h = \frac{2T\cos\theta}{r\rho g} = \frac{2 \times 0.05 \times \left(\frac{\sqrt{3}}{2}\right)}{0.15 \times 10^{-3} \times 667 \times 10} = 0.087\ \text{m}$$

30. Answer (4)

$$P_1 = P_0 + \frac{4T}{r_1}$$

$$P_2 = P_0 + \frac{4T}{r_2}$$

$$\frac{r_1}{r_2} = 2$$

$$\Rightarrow \quad \frac{V_1}{V_2} = 8$$

31. Answer (4)

$$\frac{4}{3}\pi r^3 \rho_w g - mg = ma$$

$$\Rightarrow\ m = \frac{\frac{4}{3}\pi r^3 \rho_w g}{g+a}$$

$= 4.15$ gm

32. Answer (2)

|Change in energy| = $U_i - U_f$

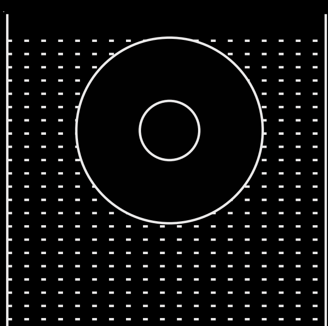
$$= (dsx_1)g\frac{x_1}{2} + (dsx_2)g\frac{x_2}{2}$$

$$-2\times\left\{ds\left(\frac{x_1+x_2}{2}\right)\right\}g\left(\frac{x_1+x_2}{4}\right)$$

$$= \frac{1}{4}gds(x_2-x_1)^2$$

33. Answer (4)

$$\frac{4}{3}\pi R^3 \times \rho_w \times g = \frac{4}{3}\pi\left(R^3 - r^3\right)\rho_m \times g$$



$$\Rightarrow\ R^3 = \left(R^3 - r^3\right)\times\frac{27}{8}$$

$$\Rightarrow\ r = \left(\frac{19}{27}\right)^{\frac{1}{3}} R \approx \frac{8}{9}R$$

34. Answer (1)

$v_T \propto r^2$

$\sqrt{2gh} \propto r^2$

$\Rightarrow\ h \propto r^4$

35. Answer (1)

$$P + \frac{1}{2}\rho v^2 = \frac{P}{2} + \frac{1}{2}\rho V^2$$

$$\Rightarrow\ V = \sqrt{\frac{P}{\rho} + v^2}$$

36. Answer (101)

$$h = \frac{2T\cos\theta}{\rho g r}$$

$$\Rightarrow\ T = \frac{\rho g r \times h}{2\cos\theta} = \frac{900\times10\times15\times15}{100\times1000\times100\times2}$$

$\Rightarrow$ T = 0.10125 Nm^{-1}

$\Rightarrow$ T = 101.25 $\approx$ 101 milliNewton m^{-1}

37. Answer (25600)

Initially $\dfrac{100g}{A_1} = \dfrac{mg}{A_2}(A_2 < A_1)$

Later $\dfrac{Mg}{16A_1} = \dfrac{mg}{A_2/16}$

$\Rightarrow$ M = 25600

38. Answer (3)

$nr^3 = R^3$

$H = T[4\pi nr^2 - 4\pi R^2]$

Rise in Heat energy/volume (Q)

$$Q = \frac{4\pi T}{Jn.\frac{4}{3}\pi r^3}\left[nr^2 - R^2\right]$$

Solving we get

$$Q = \frac{3T}{J}\left(\frac{1}{r} - \frac{1}{R}\right)$$

39. Answer (3)

$P_1 = P_0 + \rho g h_1$

$$h_1 = \frac{2P_0}{\rho g}$$

$P_2 = P_0 + 4P_0 = 5P_0$

% increase $= \dfrac{P_2 - P_1}{P_1}\times100 = \dfrac{200}{3}\%$

40. Answer (1)

$$R = \frac{\rho VD}{\eta}$$

$$R = \frac{4\rho Q}{\pi D\eta}$$

$$R_1 = \frac{4\times10^3\times0.18\times10^{-3}}{60\times\pi\times10^{-2}\times10^{-3}} = \frac{4\times10^5\times0.18}{60\pi}$$

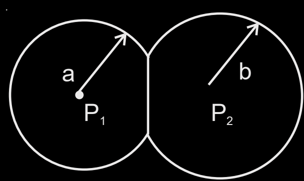
$$= 0.0038 \times 10^5 = 380$$

$$R_2 = \frac{0.48}{0.18}\times380 = 1018$$

41. Answer (1)

$$P_1 = P_0 + \frac{4T}{a}$$

$$P_2 = P_0 + \frac{4T}{b}$$



$$\therefore \quad P_1 - P_2 = \frac{4T}{r_c}$$

$$\Rightarrow \quad \frac{1}{a} - \frac{1}{b} = \frac{1}{r_c}$$

$$\Rightarrow \quad r_c = \frac{ab}{(b-a)}$$

42. Answer (3)

$$\frac{mg}{A} + \rho gH = \frac{1}{2}\rho\nu^2$$

$$\Rightarrow \frac{240}{0.4} + 1000\times10\times0.4 = \frac{1}{2}\times1000\times\nu^2$$

$\Rightarrow \nu = 3$ m/s

43. Answer (3)

$$\frac{4}{3}\pi R^3\times2 = \frac{4}{3}\pi R_2^3$$

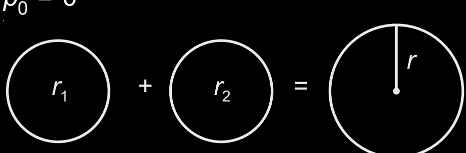
$$\Rightarrow R_2 = R\times2^{\frac{1}{3}}$$

$$\therefore \quad \frac{E_1}{E_2} = \frac{T\times4\pi R^2\times2}{T\times4\pi R^2\times2^{\frac{2}{3}}}$$

$$= \frac{2}{2^{2/3}} = 2^{\frac{1}{3}}$$

44. Answer (4)

$p_0 = 0$



$$P_1 = P_0 + \frac{4T}{r_1},\ P_2 = P_0 + \frac{4T}{r_2},\ P = P_0 + \frac{4T}{r}$$

and $n_1 + n_2 = n$

$$\Rightarrow \frac{P_1V_1}{RT} + \frac{P_2V_2}{RT} = \frac{P\times V}{RT}$$

$$\Rightarrow r_1^2 + r_2^2 = r^2$$

$$\Rightarrow r = \sqrt{r_1^2 + r_2^2}$$

45. Answer (3)

$$V_e = \sqrt{2gh}$$

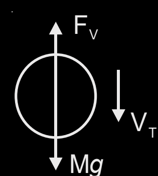
Thrust force = friction

$\rho av^2 = \mu(\rho Ah)g$

$a(2gh) = \mu Agh$

$$\mu = \frac{2a}{A}$$

46. Answer (4)



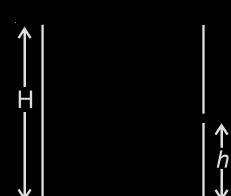
$$F_V = Mg$$

$$6\pi\eta RV_T = \left(\frac{4}{3}\pi R^3\right)\rho_w\times g$$

$$V_T = \frac{2R^2\rho_w g}{9\times\eta} = \frac{2\times(2\times10^{-4})^2\times1000\times10}{9\times1.8\times10^{-5}}$$

$\simeq 4.94$ m/s

47. Answer (6)



For maximum range

$h = H - h$

$$h = \frac{H}{2}$$

$$= \frac{12}{2}\text{m} = 6\text{ m}$$

48. Answer (1)

$\rho g \Delta H = \Delta P$

$$\Rightarrow \Delta H = \frac{\Delta P}{\rho g}$$

$$\Delta P = 2T\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \Delta H = \frac{2T}{\rho g}\left(\frac{R_2 - R_1}{R_1 R_2}\right)$$

$$= \frac{2\times 7.3\times 10^{-2}}{100\times 10}\left(\frac{4-2.5}{4\times 2.5\times 10^{-3}}\right)$$

= 2.19 mm

49. Answer (2)

P_{inside} smaller bubble

$$= P_{atm} + \frac{4T}{R_{out}} + \frac{4T}{R_{in}}$$

P_{inside} equivalent bubble

$$= P_{atm} + \frac{4T}{R_{eq}}$$

$$\Rightarrow \frac{1}{R_{eq}} = \frac{1}{R_{out}} + \frac{1}{R_{in}}$$

$\Rightarrow R_{eq} = 2$ cm

50. Answer (4)

At steady state,

Viscous force = Gravity force

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

$$= \frac{4}{3}\times 3.14\times 8\times 10^{-15}\times 1.2\times 10^3\times 9.8$$

$= 3.9 \times 10^{-10}$ N

51. Answer (500)

$$B = -\frac{VdP}{dV} = -\frac{V}{dV}(\rho g h)$$

$$h = \frac{9.8\times 10^8\times 0.005}{10^3\times 9.8}$$

= 500 m

52. Answer (3)

$$6\pi\eta v_t r = \frac{4}{3}\pi r^3(\rho - \sigma)g$$

$\Rightarrow$ $v_t = Cr^2$ where C is a constant

or $v_t \propto r^2$

53. Answer (100)

$$F = -\eta A\frac{du}{dx}$$

$$\Rightarrow \quad 10^{-3} = 10^{-2}\times\frac{10}{h}$$

$$\Rightarrow \quad h = \frac{10^{-1}}{10^{-3}}\,\text{m} = 100\text{ m}$$

$\Rightarrow$ (100)

54. Answer (363)

Applying Bernoulli's theorem:

$$P_1 + \rho g h + \frac{1}{2}\rho v^2 = P_2 + 0 + \frac{1}{2}\rho(2v)^2$$

Putting the values,

$$4100 = 800\left\{\frac{3}{2}v^2 - 10\right\}$$

$$\Rightarrow \quad v = \frac{\sqrt{363}}{6}\text{ m/s}$$

55. Answer (2)

Viscous force acting on the ball will be equal and opposite to net of weight and buoyant force

$$\Rightarrow \quad F_0 = \frac{4}{3}\pi r^3 d_1 g - \frac{4}{3}\pi r^3 d_2 g$$

$$= \frac{4}{3}\pi r^3 d_1 g\left(1 - \frac{d_2}{d_1}\right)$$

$$= mg\left(1 - \frac{d_2}{d_1}\right)$$

$\Rightarrow$ Option (2) is correct

56. Answer (300)

By Bernoulli's theorem:

$$\frac{250}{0.5} + \rho g h = \frac{1}{2}\rho v^2$$

$\Rightarrow v = 3$ m/s

$v = 300$ cm/s

57. Answer (1)

$$r' = \frac{r}{4}$$

$\Rightarrow \quad \Delta E = T(\Delta S)$

$= T \times 4\pi(nr'^2 - r^2),\ n = 64$

$= T \times 4\pi \times (4 - 1)r^2$

$\Rightarrow \quad \Delta E = 0.075 \times 4 \times 3.142\ (3) \times 10^{-4}$ J

$= 2.8 \times 10^{-4}$ J

58. Answer (4)

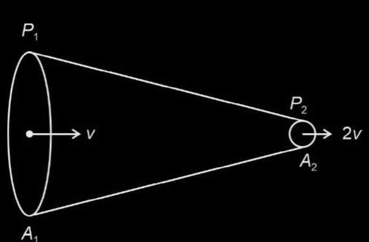
$$6\pi\eta r v = mg$$

$$6\pi\eta r v = \frac{4}{3}\pi r^3 \rho g$$

or $\quad v = \dfrac{2}{9}\dfrac{\rho r^2 g}{\eta} = \dfrac{2}{9} \times \dfrac{10^3 \times (10^{-6})^2 \times 10}{1.8 \times 10^{-5}}$

$= 123.4 \times 10^{-6}$ m/s

59. Answer (24)



Using Bernoulli's equation

$$P_1 + \frac{1}{2}\rho v^2 = P_2 + \frac{1}{2}\rho 4v^2$$

$$\frac{3}{2}\rho v^2 = P_1 - P_2$$

$$\Rightarrow v = \sqrt{\frac{2(P_1 - P_2)}{3\rho}}$$

$$= \sqrt{\frac{2 \times 4500}{3 \times 750}} = 2 \text{ m/sec}$$

So $Q = A_1 v = 24 \times 10^{-3}$ m^3/sec

60. Answer (20)

$\sqrt{2gh}$ = terminal speed

$$\Rightarrow \quad \sqrt{2gh} = \frac{2}{9}\frac{r^2 g(\rho - \rho')}{\eta}$$

$$= \frac{2}{9} \times \frac{10^{-8} \times 10 \times 9000}{10^{-5}}$$

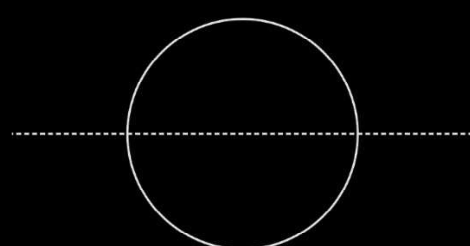
$$\Rightarrow h = \frac{400}{2g}$$

$\Rightarrow h = 20$ m

61. Answer (1)

Balancing the forces on drop

$$2\pi RT + \frac{4}{3}\pi R^3 \rho g = \frac{2}{3}\pi R^3 \sigma g$$



$$\Rightarrow \quad 2T = \frac{2R^2}{3}(\sigma - 2\rho) \times 10$$

$$\Rightarrow \quad \frac{15 \times 10^{-2} \times 3}{10(\sigma - 2\rho)2} = R^2$$

$$R = \frac{3}{2 \times 10}\sqrt{\frac{1}{(\sigma - 2\rho)}}$$

$$= \frac{3}{20}\sqrt{\frac{1}{\sigma - 2\rho}} \text{ (in m)}$$

$$(R)\text{ in cm} = \frac{3\times100}{20}\sqrt{\frac{1}{\sigma-2\rho}} = 15\times\frac{1}{\sqrt{\sigma-2\rho}}$$

Now if $2\rho > \sigma (R_{\text{in cm}}) = \dfrac{15}{\sqrt{2\rho-\sigma}}$

62. Answer (3)

$$729\times\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$$

$\Rightarrow$ $R = 9r$ ...(1)

$\Delta U = S \times \Delta A$ ...(2)

$\Rightarrow$ $\Delta U = S \times \{-4\pi R^2 + 729 \times 4\pi r^2\}$

$= S \times 4\pi\{729r^2 - 81r^2\}$

$= 7.5 \times 10^{-4}$ J

63. Answer (2)

$$\frac{4T}{R_1}+\frac{4T}{R_2}=\frac{4T}{r}$$

$$\Rightarrow \frac{1}{r}=\frac{1}{3}+\frac{1}{6}\Rightarrow r = 2\text{ cm}$$

64. Answer (11)

$F = 6\pi\eta rv$

$$\frac{4}{3}\pi r^3\rho_l g = 6\pi\eta rv$$

$$\eta = \frac{2r^2\rho_l g}{v}$$

$$= \frac{2\times\left(2\times10^{-3}\right)^2\times1750\times10}{9\times3.5\times10^{-3}\times4}$$

= 11 poise

65. Answer (3)

By Bernoulli's theorem,

$$\frac{5\times10^5}{\pi(1)^2}+\rho g(10) = 1.01\times10^5+\frac{1}{2}\rho(v)^2$$

$$\Rightarrow v^2 = 200+\frac{10^6}{1000\pi}-202$$

$\Rightarrow v \simeq 17.8$ m/s

66. Answer (1)

Due to obtuse angle of contact the water doesn't wet the oiled surface properly and cannot wash it also.

$\Rightarrow$ Assertion is correct and Reason given is a correct explanation.

67. Answer (25)

$F_v = 6\pi\eta rv_T$

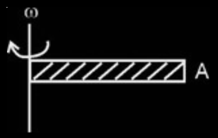
$F_v + F_B = mg$

$\Rightarrow F_v = mg - F_B$

$$= 10\times(8-1.3)\times\frac{0.3}{8}\times10^{-3}$$

$= 2.5125 \times 10^{-3}$ N $\simeq 25\times10^{-4}$ N

68. Answer (4)



Applying $F_c = \dfrac{m\omega^2 l}{2}$

$$\frac{m\omega^2 l}{2} = F$$

$$\omega = \sqrt{\frac{2F}{\frac{1}{2}\times\frac{1}{4}}} = \sqrt{16\,F} = 4\sqrt{F}$$

69. Answer (3)

$$R_e = \frac{\rho vd}{\eta}$$

Direct formula based.

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