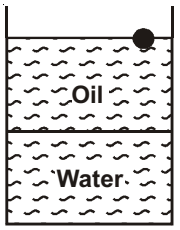
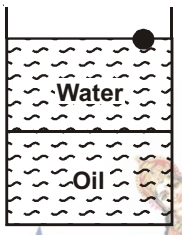
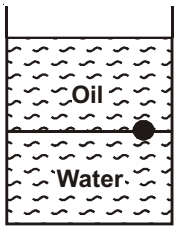
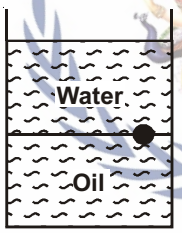
Mechanical Properties of Fluids

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

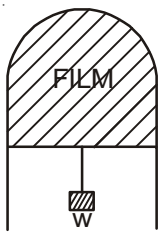
(3) $4\pi r^2 T$ (4) $2\pi r^2 T$

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]**

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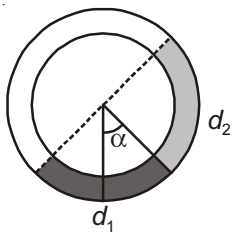
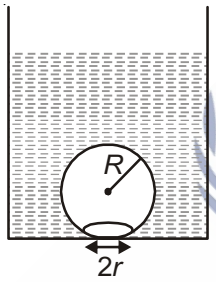


(1) $\frac{1+\sin\alpha}{1-\sin\alpha}$ (2) $\frac{1+\cos\alpha}{1-\cos\alpha}$

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

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

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

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

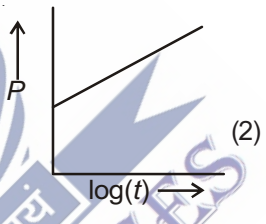
(3) 2.9 cm (4) 4 cm

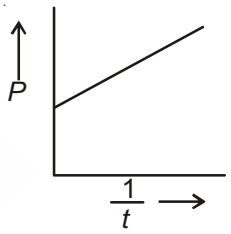
11. A liquid of density ρ is coming out of a hose pipe of radius a with horizontal speed v and hits a mesh. 50% of the liquid passes through the mesh unaffected. 25% looses all of its momentum and 25% comes back with the same speed. The resultant pressure on the mesh will be **[JEE (Main)-2019]**

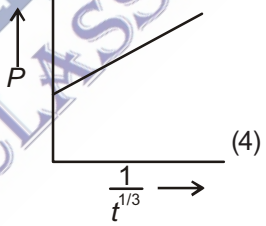
(1) $\frac{3}{4}\rho v^2$ (2) $\frac{1}{4}\rho v^2$

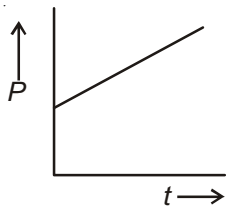
(3) $\frac{1}{2}\rho v^2$ (4) ρv^2

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) 

(2) 

(3) 

(4) 

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

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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 $\rho(r) = \rho_0\left(1 - \frac{r^2}{R^2}\right)$, $0 < r \le R$. 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

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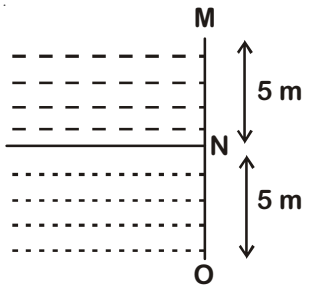
25. 

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)

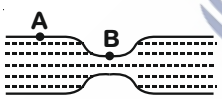
[JEE (Main)-2020]

(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

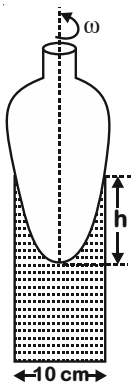
27. A small spherical droplet of density *d* is floating exactly half immersed in a liquid of density ρ and surface tension *T*. The radius of the droplet is (take note that the surface tension applies an upward force on the droplet) **[JEE (Main)-2020]**

(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 v 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) $\sqrt{\frac{P}{\rho} + v^2}$

(2) $\sqrt{\frac{2P}{\rho} + v^2}$

(3) $\sqrt{\frac{P}{\rho} + v}$

(4) $\sqrt{\frac{P}{2\rho} + v^2}$

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]**

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