11 Fluid Mechanics

JEE-Main

Pressure Variation Inside Fluid

1. If average depth of an ocean is 4000 m and the bulk modulus of water is 2×10^9 Nm^{-2}, then fractional compression $\frac{\Delta V}{V}$ of water at the bottom of ocean is $\alpha \times 10^{-2}$. The value of α is _____
(Given, g = 10 ms^{-2}, ρ = 1000 kg m^{-3}) **[27 Jan, 2024 (Shift-I)]**

2. The depth below the surface of sea to which a rubber ball be taken so as to decrease its volume by 0.02% is _____ m. **[31 Jan, 2024 (Shift-I)]**
(Take density of sea water = 10^3 kgm^{-3}, Bulk modulus of rubber = 9×10^8 Nm^{-2}, and g = 10 ms^{-2}) **[31 Jan, 2024 (Shift-I)]**

3. Mercury is filled in a tube of radius 2 cm up to a height of 30 cm. The force exerted by mercury on the bottom of the tube is ___N.
(Given, atmospheric pressure = 10^5 Nm^{-2}, density of mercury = 1.36×10^4 kg m^{-3}, g = 10 ms^{-2}, $\pi = \frac{22}{7}$) **[4 April, 2024 (Shift-II)]**

4. An air bubble of volume 1cm^3 rises from the bottom of a lake 40 m deep to the surface at a temperature of 12° C. The atmospheric pressure is 1×10^5 Pa, the density of water is 1000 kg/m^3 and g = 10 m/s^2. There is no difference of the temperature of water at the depth of 40 m and on the surface. The volume of air bubble when it reaches the surface will be **[08 April, 2023 (Shift-I)]**
(*a*) 5 cm^3 (*b*) 2 cm^3 (*c*) 4 cm^3 (*d*) 3 cm^3

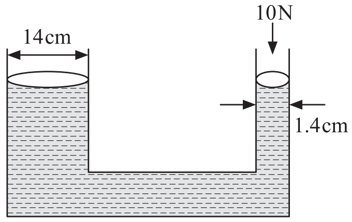
5. A hydraulic automobile lift is designed to lift vehicles of mass 5000 *kg*. The area of cross section of the cylinder carrying the load is 250 cm^2. The maximum pressure the smaller piston would have to bear is:
[Assume g = 100 m/s^2]: **[08 April, 2023 (Shift-II)]**
(*a*) $200 \times 10^{+6}$ Pa (*b*) $20 \times 10^{+6}$ Pa
(*c*) $2 \times 10^{+6}$ Pa (*d*) $2 \times 10^{+5}$ Pa

6. Two cylindrical vessels of equal cross-sectional area 16 cm^2 contain water upto heights 100 cm and 150 cm respectively. The vessels are interconnected so that the water levels in them become equal. The work done by the force of gravity during the process, is [Take density of water = 10^3 kg/m^3 and g = 10 m/s^2] **[27 July, 2022 (Shift-I)]**
(*a*) 0.25 J (*b*) 1 J (*c*) 8 J (*d*) 12 J

7. The pressure acting on a submarine is 3×10^5 Pa at a certain depth. If the depth is doubled, the percentage in the pressure acting on the submarine would be:
(Assume that atmospheric pressure is 1×10^5 Pa density of water is10^3 kgm^{-3}, g = 10 ms^{-2}) **[16 March, 2021 (Shift-I)]**
(*a*) $\frac{3}{200}\%$ (*b*) $\frac{5}{200}\%$
(*c*) $\frac{200}{3}\%$ (*d*) $\frac{200}{5}\%$

Pascal's Law

8. A hydraulic press containing water has two arms with diameters as mentioned in the figure. A force of 10 N is applied on the surface of water in the thinner arm. The force required to be applied on the surface of water in the thicker arm to maintain equilibrium of water is _______ N. **[05 April, 2024 (Shift-II)]**



9. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): When you squeeze one end of a tube to get toothpaste out from the other end, Pascal's principle is observed.
Reason (R): A change in the pressure applied to an enclosed incompressible fluid is transmitted undiminished to every portion of the fluid and to the walls of its container.
In the light of the above statements, choose the most appropriate answer from the options given below: **[6 April, 2023 (Shift-II)]**
(*a*) A is not correct but R is correct
(*b*) A is correct but R is not correct
(*c*) Both A and R are correct and R is the correct explanation of A
(*d*) Both A and R are correct but R is NOT the correct explanation of A

10. Given below are two statements:
Statement-I: Pressure in a reservoir of water is same at all points at the same level of water.
Statement-II: The pressure applied to enclosed water is transmitted in all directions equally.

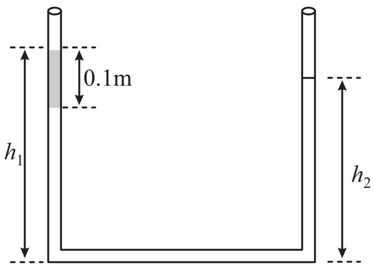
In the light of the above statements, choose the correct answer from the options given below: **[10 April, 2023 (Shift-1)]**

(*a*) Statement-I is false but Statement-II is true
(*b*) Both Statement-I and Statement-II are true
(*c*) Statement-I is true but Statement-II is false
(*d*) Both Statement-I and Statement-II are false

11. A pressure-pump has a horizontal tube of cross sectional area 10cm^2 for the outflow of water at a speed of 20 m/s. The force exerted on the vertical wall just in front of the tube which stops water horizontally flowing out of the tube, is: [given: density of water = 1000 kg/m^3] **[28 July, 2022 (Shift-II)]**

(*a*) 300 N (*b*) 500 N (*c*) 250 N (*d*) 400 N

12. An open-ended *U*-tube of uniform cross-sectional area contains water (density 10^3 kg m^{-3}). Initially the water level stands at 0.29 m from the bottom in each arm. Kerosene oil (a water-immiscible liquid) of density 800 kg m^{-3} is added to the left arm until its length is 0.1 m, as shown in the schematic figure below. The ratio $\left(\frac{h_1}{h_2}\right)$ of the heights of the liquid in the two arms is:

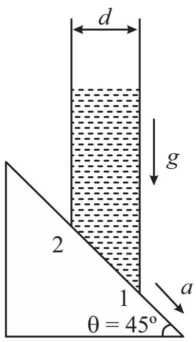


[JEE Adv, 2020]

(*a*) $\frac{15}{14}$ (*b*) $\frac{35}{33}$ (*c*) $\frac{7}{6}$ (*d*) $\frac{5}{4}$

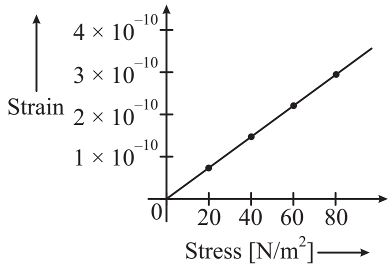
13. A hydraulic press can lift 100 kg when a mass '*m*' is placed on the smaller piston. It can lift_______ kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass '*m*' on the smaller piston. **[24 Feb, 2021 (Shift-I)]**

14. A cylindrical tube, with its base as shown in the figure, is filled with water. It is moving down with a constant acceleration *a* along a fixed inclined plane with angle $\theta = 45°$. P_1 and P_2 are pressures at points 1 and 2, respectively, located at the base of the tube. Let $\beta = (P_1 - P_2)/(\rho g d)$, where ρ is density of water, *d* is the inner diameter of the tube and *g* is the acceleration due to gravity. Which of the following statement(s) is (are) correct? **[JEE Adv, 2021]**



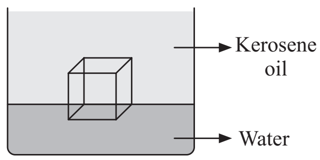
(*a*) $\beta = 0$ when $a = g/\sqrt{2}$
(*b*) $\beta > 0$ when $a = g/\sqrt{2}$
(*c*) $\beta = \frac{\sqrt{2}-1}{\sqrt{2}}$ when $a = g/2$
(*d*) $\beta = \frac{1}{\sqrt{2}}$ when

15. The elastic behaviour of material for linear stress and linear strain, is shown in the figure. The energy density for a linear strain of 5×10^{-4} is __________kJ/m^3. Assume that material is elastic upto the linear strain of 5×10^{-4}. **[26 June, 2022 (Shift-I)]**



T3 Archimedes Principle and Force of Buoyancy

16. A cube of ice floats partly in water and partly in kerosene oil. The ratio of volume of ice immersed in water to that in kerosene oil (specific gravity of Kerosene oil = 0.8, specific gravity of ice = 0.9) **[08 April, 2024 (Shift-II)]**



(*a*) 8 : 9 (*b*) 5 : 4 (*c*) 9 : 10 (*d*) 1 : 1

17. A sphere of relative density σ and diameter *D* has concentric cavity of diameter *d*. The ratio of *D*/*d*, if it just floats on water in a tank is: **[09 April, 2024 (Shift-I)]**

(*a*) $\left(\frac{\sigma}{\sigma-1}\right)^{1/3}$ (*b*) $\left(\frac{\sigma-1}{\sigma-1}\right)^{1/3}$

(*c*) $\left(\frac{\sigma-1}{\sigma}\right)^{1/3}$ (*d*) $\left(\frac{\sigma-2}{\sigma+2}\right)^{1/3}$

18. A tube of length 50 cm is filled completely with an incompressible liquid of mass 250 g closed both ends. The tube is then rotated in horizontal plane about one of its ends with a uniform angular velocity $x\sqrt{F}$ rad s^{-1}. If *F* be the force exerted by the liquid at the other end then the value of *x* will be ______ . **[29 July, 2022 (Shift-II)]**

19. A hot air balloon is carrying some passengers, and a few sandbags of mass 1 kg each so that its total mass is 480 kg. Its effective volume giving the balloon its buoyancy is *V*. The balloon is floating at an equilibrium height of 100 m. When *N* number of sandbags are thrown out, the balloon rises to a new equilibrium height close to 150 m with its volume *V* remaining unchanged. If the variation of the density of air with height h from the ground is $\rho(h) = \rho_0 e^{\frac{h}{h_0}}$, where ρ_0=1.25 kg m^{-3} and h_0= 6000 m, the value of *N* is ________. **[JEE Adv, 2020]**

20. A small spherical droplet of density d is floating exactly half immerse in a liquid ρ and surface tension *T*. The radius of the droplet is (take note that the surface tension applies an upward force on the droplet): **[9 Jan, 2020 (Shift-II)]**

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

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

21. 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. **[5 Sep, 2020 (Shift-I)]**

(a) $\frac{2}{3}R$ (b) $\frac{4}{9}R$ (c) $\frac{1}{3}R$ (d) $\frac{8}{9}R$

22. 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 maximum density of a liquid in which it will float is

(a) $\frac{\rho_0}{5}$ (b) $\frac{2\rho_0}{5}$ (c) $\frac{2\rho_0}{3}$ (d) $\frac{\rho_0}{3}$

23. A leak proof cylinder of length 1m, 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: **[8 Jan, 2020 (Shift-I)]**

(a) 1.0 (b) 1.04 (c) 1.26 (d) 1.01

24. 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: **[9 April, 2019 (Shift-II)]**

(a) 0.5 (b) 0.7 (c) 0.6 (d) 0.8

25. 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) **[10 April, 2019 (Shift-II)]**

(a) 65.4 kg (b) 87.5 kg
(c) 30.1 kg (d) 46.3 kg

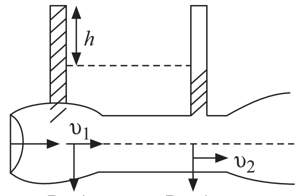
Continuity Equation, Bernoulli Theorem and Their Application

26. The reading of pressure metre attached with a closed pipe is 4.5×10^4 N/m^2. On opening the valve, water starts flowing and the reading of pressure metre falls to 2.0×10^4 N/m^2. The velocity of water is found to be $\sqrt{V}$ m/s. The value of V is ______. **[27 Jan, 2024 (Shift-II)]**

27. In a test experiment on a model aeroplane in wind tunnel, the flow speeds on the upper and lower surfaces of the wings are 70 ms^{-1} and 65 ms^{-1} respectively. If the wing area is 2 m^2 the lift of the wing is _______ N. (Given density of air = 1.2 kg m^{-3}) **[29 Jan, 2024 (Shift-I)]**

28. A plane is in level flight at constant speed and each of its two wings has an area of 40 m^2. If the speed of the air is 180 km/h over the lower wing surface and 252 km/h over the upper wing surface, the mass of the plane is ________kg. (Take air density to be 1 kg m^{-3} and g = 10 ms^{-2}) [1 **Feb, 2024 (Shift-I)]**

29. Given below are two statements:
Statement I: When speed of liquid is zero everywhere, pressure difference at any two points depends on equation $P_1 - P_2 = \rho g(h_2 - h_1)$
Statement II: In ventury tube shown $2gh = \upsilon_1^2 - \upsilon_2^2$



In the light of the above statements, choose the most appropriate answer from the options given below. **[04 April, 2024 (Shift-I)]**
(a) Both Statement I and Statement II are correct.
(b) Statement I is incorrect but Statement II is correct.
(c) Both Statement I and Statement II are incorrect.
(d) Statement I is correct but Statement II is incorrect.

30. Correct Bernoulli's equation is (symbols have their usual meaning): **[08 April, 2024 (Shift-I)]**

(a) $P + mgh + \frac{1}{2}mv^2 = \text{constant}$

(b) $P + \rho gh + \frac{1}{2}\rho v^2 = \text{constant}$

(c) $P + \rho gh + \rho v^2 = \text{constant}$

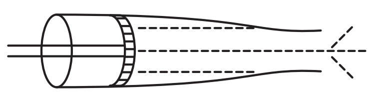
(d) $P + \frac{1}{2}\rho gh + \frac{1}{2}\rho v^2 = \text{constant}$

31. A fully loaded aircraft has a mass of 5.4×10^5 kg. Its total wing area is 500 m^2. It is in level flight with a speed of 1080 km/h. If the density of air is 1.2 kg m^{-3}, the fractional increase in the speed of the air on the upper surface of the wings relative to the lower surface in percentage will be ($g = 10$ m/s^2) **[29 Jan, 2023 (Shift-II)]**

(a) 16 (b) 6 (c) 8 (d) 10

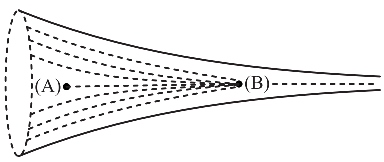
32. The surface of water in a water tank of cross section area 750 cm^2 on the top of a house is h m above the tap level. The speed of water coming out through the tap of cross section area 500 mm^2 is 30 cm/s. At that instant, $\frac{dh}{dt}$ is $x \times 10^{-3}$ m/s. The value of x will be _______. **[01 Feb 2023 (Shift-II)]**

33. Figure below shows a liquid being pushed out of the tube by a piston having area of cross section 2.0 cm^2. The area of cross section at the outlet is 10 mm^2. If the piston is pushed at a speed of 4 cm s^{-1}, the speed of outgoing fluid is ________ cm s^{-1}. **[10 April, 2023 (Shift-II)]**



34. Glycerine of density 1.25×10^3 kg m^{-3} is flowing through the conical section of pipe. The area of cross-section of the pipe at its ends is 10 cm^2 and 5 cm^2 and pressure drop across its length is 3 Nm^{-2}. The rate of flow of glycerine through the pipe is $x \times 10^{-5}$ m^3 s^{-1}. The value of x is ________ . **[12 April, 2023 (Shift-I)]**

35.

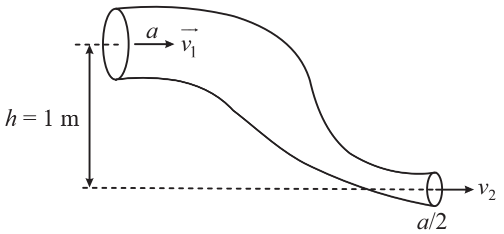


The figure shows a liquid of given density flowing steadily in horizontal tube of varying cross-section. Cross sectional areas at A is 1.5 cm^2 and B is 25 mm^2, if the speed of liquid at B is 60 cm/s then $(P_A - P_B)$ is:
(Given P_A and P_B are liquid pressures at A and B points.
Density $\rho = 1000$ kg m^{-3} $\quad$ A and B are on the axis of tube

[13 April, 2023 (Shift-I)]

(*a*) 175 Pa (*b*) 27 Pa (*c*) 135 Pa (*d*) 36 Pa

36. An ideal fluid of density 800 kgm^{-3}, flows smoothly through a bent pipe (as shown in figure) that tapers in cross-sectional area from a to $a/2$. 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}) **[26 June, 2022 (Shift-I)]**



37. 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}] **[27 June, 2022 (Shift-I)]**

38. When a ball is dropped into a lake from a height 4.9 m above the water level, it hits the water with a velocity v and then sinks to the bottom with the constant velocity v. It reaches the bottom of the lake 4.0 s after it is dropped. The approximate depth of the lake is: **[27 June, 2022 (Shift-II)]**

(*a*) 19.6 m (*b*) 29.4 m (*c*) 39.2 m (*d*) 73.5 m

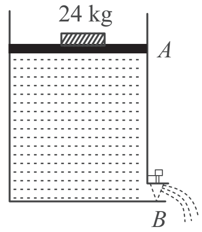
39. Water falls from a 40 m high dam at the rate of 9×10^4 kg per hour. Fifty percentage of gravitational potential energy can be converted into electrical energy. Using this hydro electric energy number of 100 W lamps, that can be lit, is:
(Take g = 10 ms^{-2}) **[28 June, 2022 (Shift-II)]**

(*a*) 25 (*b*) 50 (*c*) 100 (*d*) 18

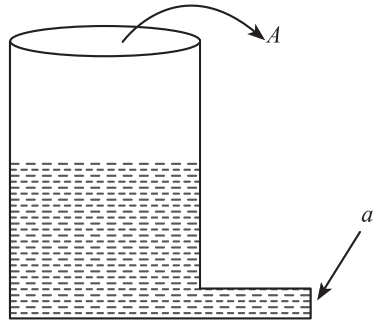
40. A liquid of density 750 kgm^{-3} flows smoothly through a horizontal pipe that tapers in cross-sectional area from $A_1 = 1.2 \times 10^{-2}$ m^2 to $A_2 = \frac{A_1}{2}$. The pressure difference between the wide and narrow sections of the pipe is 4500 Pa. The rate of flow of liquid is _________$\times 10^{-3}$m^{3}s^{-1}. **[28 June, 2022 (Shift-II)]**

41. 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-sectional 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}] **[18 March, 2021 (Shift-II)]**



42. 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 ($a << A$): **[27 July, 2021 (Shift-I)]**



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

(*c*) $\frac{A}{2a}$ (*d*) $\frac{a}{A}$

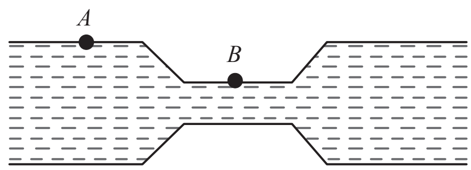
43. The water is filled up to height of 12 m in a tank having vertical sidewalls. A hole is made in one of the walls at a depth 'h' below the water level. The value of 'h' for which the emerging steam of water strikes the ground at the maximum range is _______ m.

[27 July, 2021 (Shift-II)]

44. 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: **[7 Jan, 2020 (Shift-II)]**

(*a*) $\frac{3}{4}$ (*b*) $\frac{81}{256}$ (*c*) $\frac{\sqrt{3}}{2}$ (*d*) $\frac{9}{16}$

45. 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. (density of water = 1000 kg m^{-3}) **[9 Jan, 2020 (Shift-I)]**



(*a*) 1810 cm^3/s (*b*) 2420 cm^3/s
(*c*) 2720 cm^3/s (*d*) 3020 cm^3/s

46. 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: **[4 Sep, 2020 (Shift-II)]**

(*a*) $\frac{3}{4}gdS(x_2-x_1)^2$ (*b*) $gdS(x_2+x_1)^2$

(*c*) $\frac{1}{4}gdS(x_2-x_1)^2$ (*d*) $gdS(x_2^{\,2}+x_1^{\,2})$

47. 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: **[6 Sep, 2020 (Shift-II)]**

(*a*) $\sqrt{\frac{P}{p}+v}$ (*b*) $\sqrt{\frac{2P}{p}+v^2}$

(*c*) $\sqrt{\frac{P}{2p}+v^2}$ (*d*) $\sqrt{\frac{P}{p}+v^2}$

48. A train with cross-sectional area S_t is moving with speed v_t inside a long tunnel of cross-sectional area $S_0(S_0 = 4S_t)$. Assume that almost all the air (density ρ) in front of the train flows back between its sides and the walls of the tunnel. Also, the air flow with respect to the train is steady and laminar. Take the ambient pressure and that inside the train to be p_0. If the pressure in the region between the sides of the train and the tunnel walls is p, then $p_0 - p = \frac{7}{2N}\rho v_t^2$. The value of N is _______. **[JEE Adv, 2020]**

49. 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: **[9 Jan, 2019 (Shift-II)]**

(*a*) 6.0 m (*b*) 4.8 m
(*c*) 9.6 m (*d*) 2.9 m

50. 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: **[10 Jan, 2019 (Shift-I)]**

(*a*) 5.1 cm (*b*) 1.7 cm
(*c*) 4 cm (*d*) 2.9 cm

51. 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 the stream, 0.15 m below the tap would be: (Take $g = 10\ ms^{-2}$) **[10 April, 2019 (Shift-II)]**

(*a*) 1×10^{-5} m^2 (*b*) 5×10^{-5} m^2
(*c*) 2×10^{-5} m^2 (*d*) 5×10^{-4} m^2

52. 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: **[11 Jan, 2019 (Shift-I)]**

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

(*c*) $\frac{1}{2}\rho v^2$ (*d*) ρv^2

Surface Tension, Surface Energy

53. A small liquid drop of radius R is divided into 27 identical liquid drops. If the surface tension is T, then the work done in the process will be: **[29 Jan, 2024 (Shift-II)]**

(*a*) $8\pi R^2T$ (*b*) $3\pi R^2T$

(*c*) $\frac{1}{8}\pi R^2T$ (*d*) $4\pi R^2T$

54. A big drop is formed by coalescing 1000 small identical drops of water. If E_1 be the total surface energy of 1000 small drops of water and E_2 be the surface energy of single big drop of water, the $E_1 : E_2$ is x : 1 where x = ___ _____. **[30 Jan, 2024 (Shift-II)]**

55. A big drop is formed by coalescing 1000 small droplets of water. The surface energy will become: **[1 Feb, 2024 (Shift-II)]**

(*a*) 100 times (*b*) 10 times

(*c*) $\frac{1}{10}th$ (*d*) $\frac{1}{10}th$

56. A soap bubble is blown to a diameter of 7 cm. 36960 erg of work is done in blowing it further. If surface tension of soap solution is 40 dyne/cm then the new radius is ______ cm. Take : $\left(\pi = \frac{22}{7}\right)$.

[04 April, 2024 (Shift-I)]

57. A big drop is formed by coalescing 1000 small droplets of water. The ratio of surface energy of 1000 droplets to that of energy of big drop is $\frac{10}{x}$. The value of x is _________.

[06 April, 2024 (Shift-I)]

58. Pressure inside a soap bubble is greater than the pressure outside by an amount: **[06 April, 2024 (Shift-II)]**

(given : R = Radius of bubble, S = Surface tension of bubble)

(*a*) $\frac{4S}{R}$ (*b*) $\frac{4R}{S}$ (*c*) $\frac{S}{R}$ (*d*) $\frac{2S}{R}$

59. A liquid column of height 0.04 cm balances excess pressure of soap bubble of certain radius. If density of liquid is 8×10^3 kg m^{-3} and surface tension of soap solution is 0.28 Nm^{-1}, then diameter of the soap bubble is________cm.

(if $g = 10\ ms^{-2}$) **[08 April, 2024 (Shift-I)]**

60. The excess pressure inside a soap bubble is thrice the excess pressure inside a second soap bubble. The ratio between the volume of the first and the second bubble is: **[09 April, 2024 (Shift-II)]**

(*a*) 1 : 9 (*b*) 1 : 3
(*c*) 1 : 81 (*d*) 1 : 27

61. A spherical drop of liquid splits into 1000 identical spherical drops. If μ_i is the surface εenergy of the original drop and μ_f is the total surface energy of the resulting drops, then (ignoring evaporation) $\frac{u_f}{u_i} = \left(\frac{10}{x}\right)$. Then value of x is_______ .**[25 Jan, 2023 (Shift-II)]**

62. Surface tension of a soap bubble is 2.0×10^{-2} Nm^{-1}. Work done to increase the radius of soap bubble from 3.5 *cm* to 7 *cm* will be :

[Use $\pi = \frac{22}{7}$] **[29 Jan, 2023 (Shift-I)]**

(*a*) 0.72×10^{-4} *J* (*b*) 5.76×10^{-4} *J*
(*c*) 18.48×10^{-4} *J* (*d*) 9.24×10^{-4} *J*

63. If 1000 droplets of water of surface tension 0.07 N/m having same radius 1 mm each, combine to form a single drop. In the process the released surface energy is:

$\left(\text{Take } \pi = \frac{22}{7}\right)$ **[31 Jan, 2023 (Shift-I)]**

(*a*) 7.92×10^{-6} J (*b*) 7.92×10^{-4} J
(*c*) 9.68×10^{-4} J (*d*) 8.8×10^{-5} J

64. A mercury drop of radius 10^{-3} *m* is broken into 125 equal size droplets. Surface tension of mercury is 0.45 Nm^{-1}. The gain in surface energy is: **[01 Feb 2023 (Shift-I)]**

(*a*) 2.26×10^{-5} J (*b*) 28×10^{-5} J
(*c*) 17.5×10^{-5} J (*d*) 5×10^{-5} J

65. The surface tension of soap solution is 3.5×10^{-2} Nm^{-1}. The amount of work done required to increase the radius of soap bubble from 10 cm to 20 cm is ____ $\times 10^{-4}$J. **[11 April, 2023 (Shift-II)]**

66. There is an air bubble of radius 1.0 mm in a liquid of surface tension 0.075 Nm^{-1} and density 1000 kg m^{-3} at a depth of 10 cm below the free surface. The amount by which the pressure inside the bubble is greater than the atmospheric pressure is __________ Pa ($g = 10$ ms^{-2}) **[15 April, 2023 (Shift-I)]**

67. 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: **[28 June, 2022 (Shift-I)]**

(*a*) 2.8×10^{-4} J (*b*) 1.5×10^{-3} J
(*c*) 1.9×10^{-4} J (*d*) 9.4×10^{-5} J

68. A drop of liquid of density ρ is floating half immersed in a liquid of density σ and surface tension 7.5×10^{-4} Ncm^{-1}. The radius of drop in cm will be: (g = 10 ms^{-2}) **[25 July, 2022 (Shift-II)]**

(*a*) $\frac{15}{\sqrt{2\rho-\sigma}}$ (*b*) $\frac{15}{\sqrt{\rho-\sigma}}$
(*c*) $\frac{3}{2\sqrt{\rho-\sigma}}$ (*d*) $\frac{3}{20\sqrt{2\rho-\sigma}}$

69. 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:
(Given π = 3.14) **[26 July, 2022 (Shift-I)]**

(*a*) 8.5×10^{-4} J (*b*) 8.2×10^{-4} J
(*c*) 7.5×10^{-4} J (*d*) 5.3×10^{-4} J

70. 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: **[26 Feb, 2021 (Shift-I)]**

(*a*) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$ (*b*) $\frac{2T}{rJ}$
(*c*) $\frac{3T}{rJ}$ (*d*) $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

71. Two small drops of mercury each of radius *R* coalesce to from a single large drop. The ratio of total surface energy before and after the change is: **[20 July, 2021 (Shift-II)]**

(*a*) $2^{\frac{1}{3}}:1$ (*b*) $1:2^{\frac{1}{3}}$
(*c*) 2 : 1 (*d*) 1 : 2

72. 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 $T = 7.3 \times 10^{-2}$ Nm^{-1}, angle of contact = 0, $g = 10$ ms^{-2} and density of water = 1.0×10^3 kgm^{-3}]
[26 Aug, 2021 (Shift-I)]

(*a*) 2.19 mm (*b*) 4.97 mm (*c*) 5.34 mm (*d*) 3.62 mm

73. When water is filled carefully in a glass, one can fill it to a height h above the rim of the glass due to the surface tension of water. To calculate *h* just before water starts flowing, model the shape of the water above the rim as a disc of thickness *h* having semicircular edges, as shown schematically in the figure. When the pressure of water at the bottom of this disc exceeds what can be withstood due to the surface tension, the water surface breaks near the rim and water starts flowing from there. If the density of water, its surface tension and the acceleration due to gravity are 10^3 kg m^{-3}, 0.07 Nm^{-1} and 10 ms^{-2}, respectively, the value of *h* (in mm) is ____________.
[JEE Adv, 2020]

Capillary Rise

74. Given below are two statements: **[29 Jan, 2024 (Shift-I)]**

Statement-I: If a capillary tube is immersed first in cold water and then in hot water, the height of capillary rise will be smaller in hot water.

Statement-II: If a capillary tube is immersed first in cold water and then in hot water, the height of capillary rise will be smaller in cold water.

In the light of the above statements, choose the most appropriate from the options given below

(*a*) Both Statement-I and Statement-II are true
(*b*) Both Statement-I and Statement-II are false
(*c*) Statement-I is true but Statement-II is false
(*d*) Statement-I is false but Statement-II is true

75. Given below are two statements:
Statement I: The contact angle between a solid and a liquid is a property of the material of the solid and liquid as well.
Statement II: The rise of a liquid in a capillary tube does not depend on the inner radius of the tube.
In the light of the above statements, choose the correct answer from the options given below: **[04 April, 2024 (Shift-II)]**
(*a*) Both Statement I and Statement II are false
(*b*) Statement I is false but Statement II is true.
(*c*) Statement I is true but Statement II is false.
(*d*) Both Statement I and Statement II are true.

76. Given below are two statements :

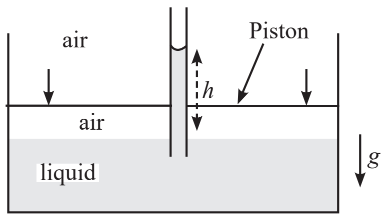
Statement-I: When a capillary tube is dipped into a liquid, the liquid neither rises nor falls in the capillary. The contact angle may be 0°.

Statement-II: The contact angle between a solid and a liquid is a property of the material of the solid and liquid as well:

In the light of above statement, choose the correct answer from the options given below. **[05 April, 2024 (Shift-I)]**
(*a*) **Statement-I** is false but **Statement-II** is true.
(*b*) Both **Statement-I** and **Statement-II** are true.
(*c*) Both **Statement-I** and **Statement-II** are false.
(*d*) **Statement-I** is true and **Statement-II** is false.

77. An incompressible liquid is kept in a container having a weightless piston with a hole. A capillary tube of inner radius 0.1 mm is dipped vertically into the liquid through the airtight piston hole, as shown in the figure. The air in the container is isothermally compressed from its original volume $\frac{100}{101}V_0$ with the movable piston. Considering ah' as an ideal gas, the height (h) of the liquid column in the capillary above the liquid level in cm is_______.

[Given: Surface tension of the liquid is 0.075 Nm^{-1}, atmospheric pressure is 10^5 Nm^{-2}, acceleration due to gravity (g) is 10 ms^{-2}, density of the liquid is 10^3 kg m^{-3} and contact angle of capillary surface with the liquid is zero] **[JEE Adv, 2023]**

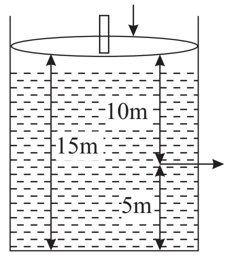


78. The height of liquid column raised in a capillary tube of certain radius when dipped in liquid A vertically is, 5 cm. If the tube is dipped in a similar manner in another liquid B of surface tension and density double the values of liquid A, the height of liquid column raised in liquid B would be_____ m.

[30 Jan, 2023 (Shift-I)]

(a) 0.20 (b) 0.5 (5) 0.05 (d) 0.10

79. Consider a cylindrical tank of radius 1m 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 5×10^5N is applied on the top surface of water using a piston. The speed of efflux from the hole will be:
(given atmospheric pressure $P_A = 1.01 \times 10^5$ Pa, density of water ρ_w = 1000kg /m^3 and gravitational acceleration g = 10m/ s^2)
[28 July, 2022 (Shift-II)]

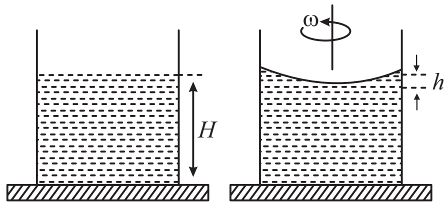


(a) 11.6 m/s (b) 10.8 m/s (c) 17.8 m/s (d) 14.4 m/s

80. 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}) **[2 Sep, 2020 (Shift-II)]**

(a) 0.049 m (b) 0.087 m (c) 0.137 m (d) 0.172 m

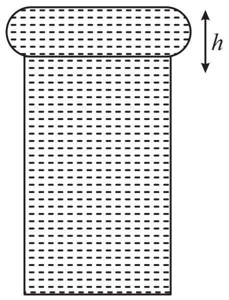
81. A beaker of radius r is filled with water (refractive index $\frac{4}{3}$) up to a height H as shown in the figure on the left. The beaker is kept on a horizontal table rotating with angular speed ω. This makes the water surface curved so that the difference in the height of water level at the center and at the circumference of the beaker is $h(h << H$, $h << r)$, as shown in the figure on the right. Take this surface to be approximately spherical with a radius of curvature R. Which of the following is/are correct?
(g is the acceleration due to gravity)
[JEE Adv, 2020]



(a) $R = \frac{h^2 + r^2}{2h}$ (b) $R = \frac{3r^2}{2h}$

(c) Apparent depth of the bottom of the beaker is close to $\frac{3H}{2}\left(1+\frac{\omega^2 H}{2g}\right)^{-1}$

(d) Apparent depth of the bottom of the beaker is close to $\frac{3H}{4}\left(1+\frac{\omega^2 H}{4g}\right)^{-1}$



82. 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 (ignore viscosity of air)
[5 Sep, 2020 (Shift-II)]

(a) r^4 (b) r^3 (c) r (d) r^2

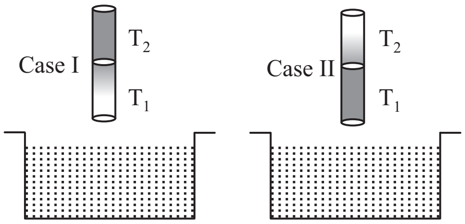
83. If 'M' is the mass of water that rises in a capillary tube of radius 'r', then mass of water which will rise in a capillary tube of radius '$2r$' is: **[9 April, 2019 (Shift-I)]**

(a) 4 M (b) $\frac{M}{2}$ (c) M (d) 2 M

84. 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:
[10 April, 2019 (Shift-I)]

(a) 3/5 (b) 4/5 (c) 2/3 (d) 2/5

85. A cylindrical capillary tube of 0.2 mm radius is made by joining two capillaries T_1 and T_2 of different materials having water contact angles of 0° and 60°, respectively. The capillary tube is dipped vertically in water in two different configurations, case I and II as shown in figure. Which of the following option(s) is(are) correct? (Surface tension of water = 0.075 N/m, density of water = 1000 kg/m^3, take g = 10m/s^2) **[JEE Adv, 2019]**



(*a*) The correction in the height of water column raised in the tube, due to weight of water contained in the meniscus, will be different for both cases.

(*b*) For case I, if the capillary joint is 5 cm above the water surface, the height of water column raised in the tube will be more than 8.75 cm. (Neglect the weight of the water in the meniscus)

(*c*) For case I, if the joint is kept at 8 cm above the water surface, the height of water column in the tube will be 7.5 cm. (Neglect the weight of the water in the meniscus)

(*d*) For case II, if the capillary joint is 5 cm above the water surface, the height of water column raised in the tube will be 3.75 cm. (Neglect the weight of the water in the meniscus)

Excess Pressure in Drop and Bubble

86. 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 ___________. **[27 July, 2022 (Shift-II)]**

87. Given below arc two statements: One is labelled as Assertion (A) and the other is labelled as Reason (R).

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. **[29 July, 2022 (Shift-I)]**

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

(*b*) Both (A) and (R) arc true but (R) is not the correct explanation of (A)

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

(*d*) (A) is true but (R) is true

88. When two soap bubbles of radii a and b ($b > a$) coalesce, the radius of curvature of common surface is: **[17 March, 2021 (Shift-I)]**

(*a*) $\dfrac{ab}{a+b}$ (*b*) $\dfrac{ab}{b-a}$

(*c*) $\dfrac{b-a}{ab}$ (*d*) $\dfrac{a+b}{ab}$

89. Suppose you have taken a dilute solution of oleic acid in such a way that its concentration becomes 0.01 cm^3 of oleic acid per cm^3 of the solution. Then you make a thin film of this solution (monomolecular thickness) of area 4 cm^2 by considering 100 spherical drops of radius $\left(\dfrac{3}{40\pi}\right)^{\frac{1}{3}} \times 10^{-3}$ cm. Then the thickness of oleic acid Layer will be $x \times 10^{-14}$ m. Where x is ________. **[17 March, 2021 (Shift-II)]**

90. 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. **[26 Aug, 2021 (Shift-I)]**

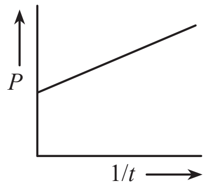
91. Pressure inside two soap bubbles are 1.01 atm and 1.02 atm, respectively. The ratio of their volumes is: **[3 Sep, 2020 (Shift-I)]**

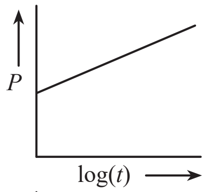
(*a*) 2 : 1 (*b*) 0.8 : 1 (*c*) 4 : 1 (*d*) 8 : 1

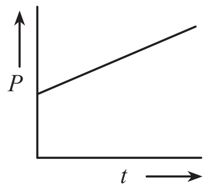
92. A air bubble of radius 1 cm in water has an upward acceleration 9.8 cm s^{-2}. The density of water is 1 gm cm^{-3} and water offers negligible drag force on the bubble. The mass of the bubble is (g = 980 cm/s^2) **[4 Sep, 2020 (Shift-I)]**

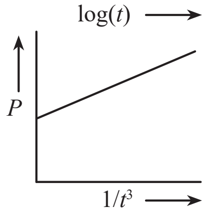
(*a*) 1.52 gm (*b*) 4.51 gm (*c*) 3.15 gm (*d*) 4.15 gm

93. 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: **[12 Jan, 2019 (Shift-II)]**

(*a*)


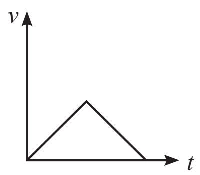
(*b*)


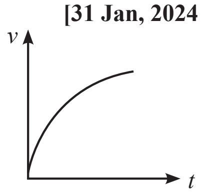
(*c*)


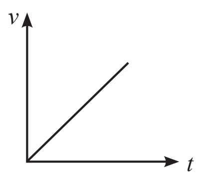
(*d*)


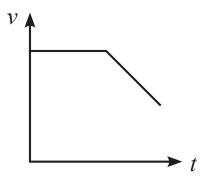
Viscosity and Viscous Force

94. A small steel ball is dropped into a long cylinder containing glycerine. Which one of the following is the correct representation of the velocity time graph for the transit of the ball? **[31 Jan, 2024 (Shift-I)]**

(*a*)


(*b*)


(*c*)


(*d*)


95. Given below are two statements: **[27 Jan, 2024 (Shift-I)]**

Statement-I: Viscosity of gases is greater than that of liquids.

Statement-II: Surface tension of a liquid decreases due to the presence of insoluble impurities.

In the light of the above statements, choose the most appropriate answer from the options given below:

(*a*) Statement-I is correct but statement-II is incorrect
(*b*) Statement-I is incorrect but Statement-II is correct
(*c*) Both Statement-I and Statement-II are incorrect
(*d*) Both Statement-I and Statement-II are correct

96. A small spherical ball of radius r, falling through a viscous medium of negligible density has terminal velocity 'v'. Another ball of the same mass but of radius 2r, falling through the same viscous medium will have terminal velocity: **[31 Jan, 2024 (Shift-II)]**

(*a*) $\frac{v}{2}$ (*b*) $\frac{v}{4}$ (*c*) 4v (*d*) 2v

97. A small ball of mass m and density ρ is dropped in a viscous liquid of density ρ_0. After sometime, the ball falls with constant velocity. The viscous force on the ball is: **[06 April, 2024 (Shift-I)]**

(*a*) $mg\left(\frac{\rho_0}{\rho}-1\right)$ (*b*) $mg\left(1+\frac{\rho}{\rho_0}\right)$

(*c*) $mg(1-\rho\rho_0)$ (*d*) $mg\left(1-\frac{\rho_0}{\rho}\right)$

98. Small water droplets of radius 0.01 mm are formed in the upper atmosphere and falling with a terminal velocity of 10 cm/s. Due to condensation, if 8 such droplets are coalesced and formed a larger drop, the new terminal velocity will be ………..cm/s.

[08 April, 2024 (Shift-II)]

99. A spherical ball of radius 1×10^{-4} m and density 10^5 kg/m³ falls freely under gravity through a distance *h* before entering a tank of water, If after entering in water the velocity of the ball does not change, then the value of h is approximately :

(The coefficient of viscosity of water is 9.8×10^{-6} N s/m²)

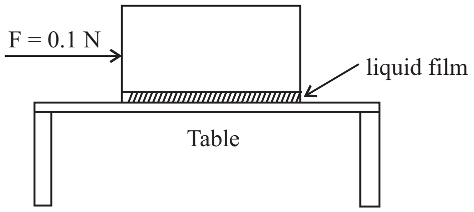
[09 April, 2024 (Shift-II)]

(*a*) 2296 m (*b*) 2249 m
(*c*) 2518 m (*d*) 2396 m

100. A spherical ball of radius 1 *mm* and density 10.5 *g*/*cc* is dropped in glycerine of coefficient of viscosity 9.8 poise and density 1.5 *g*/*cc*. Viscous force on the ball when it attains constant velocity is 3696 $\times 10^{-x}N$. The value of *x* is_______. **[24 Jan, 2023 (Shift-II)]**

(Given, $g=9.8\,m/s^2$ and $\pi=\frac{22}{7}$)

101. A metal block of base area 0.20 m² is placed on a table, as shown in the figure. A liquid film of thickness 0.25 mm is inserted between the block and the table. The block is pushed by a horizontal force of 0.1 N and moves with a constant speed. If the viscosity of the liquid is 5.0×10^{-3} *Pl*, the speed of the block is ______ $\times 10^{-3}$ *m/s*. **[29 Jan, 2023 (Shift-II)]**



102. A small ball of mass *M* and density ρ is dropped in a viscous liquid of density ρ_0. After some time, the ball falls with a constant velocity. What is the viscous force on the ball ? **[6 April, 2023 (Shift-I)]**

(*a*) $F=\text{Mg}\left(1-\frac{\rho_0}{\rho}\right)$ (*b*) $F=Mg\left(1+\frac{\rho}{\rho_0}\right)$

(*c*) $\text{F}=\text{Mg}\left(1+\frac{\rho_0}{\rho}\right)$ (*d*) $F=\text{Mg}\left(1\pm\rho\rho_0\right)$

103. An air bubble of diameter 6 mm rises steadily through a solution of density 1750 kg/m³ at the rate of 0.35 cm/s. The co-efficient of viscosity of the solution (neglect density of air) is ___ Pas (given, *g* = 10 ms^{-2}) **[8 April, 2023 (Shift-I)]**

104. Match List-I with List-II **[8 April, 2023 (Shift-II)]**

LIST-I	LIST-I
A. Torque	I. $ML^{-2}T^{-2}$
B. Stress	II. ML^2T^{-2}
C. Pressure gradient	III. $ML^{-1}T^{-1}$
D. Coefficient of viscosity	IV. $ML^{-1}T^{-2}$

Choose the correct answer from the options given below:

(*a*) A-III, B-IV, C-I, D-II (*b*) A-IV, B-II, C-III, D-I
(*c*) A-II, B-IV, C-I, D-III (*d*) A-II, B-I, C-IV, D-III

105. Eight equal drops of water are falling through air with a steady speed of 10 cm/s. If the drops coalesce, the new velocity is:

[11 April, 2023 (Shift-II)]

(*a*) 10 cm/s (*b*) 40 cm/s (*c*) 16 cm/s (*d*) 5 cm/s

106. The terminal velocity (v_t) of the spherical rain drop depends on the radius (*r*) of the spherical rain drop as:

[25 June, 2022 (Shift-I)]

(*a*) $r^{1/2}$ (*b*) r (*c*) r^2 (*d*) r^3

107. 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) **[25 June, 2022 (Shift-I)]**

108. 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: **[27 June, 2022 (Shift-I)]**

(*a*) $mg\left(1-\frac{d_1}{d_2}\right)$ (*b*) $mg\left(1-\frac{d_2}{d_1}\right)$

(*c*) $mg\left(\frac{d_1}{d_2}-1\right)$ (*d*) $mg\left(\frac{d_2}{d_1}-1\right)$

109. Given below are two statements: One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A: Product of Pressure (P) and time (t) has the same dimension as that of coefficient of viscosity.

Reason R: Coefficient of viscosity = $\frac{\text{Force}}{\text{Velocity gradient}}$

Choose the correct answer from the options given below:

[28 June, 2022 (Shift-I)]

(*a*) Both A and R true, and R is correct explanation of A.
(*b*) Both A and R are true but R is NOT the correct explanation of A.
(*c*) A is true but R is false.
(*d*) A is false but R is true.

110. A water drop of radius 1 μm falls in a situation where the effect of buoyant force is negligible. Co-efficient of viscosity of air is 1.8 $\times 10^{-5}$ Nsm^{-2} and its density is negligible as compared to that of water 10^6 gm^{-3}. Terminal velocity of the water drop is:

[28 June, 2022 (Shift-II)]

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

(*a*) 145.4×10^{-6} ms^{-1} (*b*) 118.0×10^{-6} ms^{-1}
(*c*) 132.6×10^{-6} ms^{-1} (*d*) 123.4×10^{-6} ms^{-1}

111. A small spherical ball of radius 0.1 mm and density 10^4 kgm^{-3} falls freely under gravity through a distance h before entering a tank of water. If, after entering the water the velocity inside water, then the value of h will be ________m. **[29 June, 2022 (Shift-II)]** (Given g = 10 ms^{-2}, viscosity of water = 1.0×10^{-5} N-sm^{-2}).

112. The diameter of an air bubble which was initially 2mm, rises steadily through a solution of density 1750 kgm^{-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).

[28 July, 2022 (Shift-I)]

113. The velocity of a small ball of mass 0.3g 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*, value of x is _________ [use g = 10 m/s^2] **[29 July, 2022 (Shift-II)]**

114. 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 through its fall and the force of buoyance may be neglected, then the terminal speed attained by the raindrop is:

[27 July, 2021 (Shift-II)]

[Density of water ρ_w = 1000 kgm^{-3} and Density of air ρ_a = 1.2 kg^{-3}, g = 10 m/s^2

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

(*a*) 4.94 ms^{-1} (*b*) 14.4 ms^{-1}
(*c*) 43.56 ms^{-1} (*d*) 250.6 ms^{-1}

115. In Millikan's oil drop experiment, what is viscous force acting on an uncharged drop of radius 2.0×10^{-5} and density 1.2×10^3 kgm^{-3}? Take viscosity of liquid = 1.8×10^{-5} Nsm^{-2}. (Neglect buoyancy due to air). **[27 Aug, 2021 (Shift-I)]**

(*a*) 5.8×10^{-10} *N* (*b*) 1.8×10^{-10} *N*
(*c*) 3.8×10^{-10} *N* (*d*) 3.9×10^{-10} *N*

116. As shown schematically in the figure, two vessels contain water solutions (at temperature *T*) of potassium permanganate ($KMnO_4$) of different concentrations n_1 and n_2 ($n_1 > n_2$) molecules per unit volume with $\Delta n = (n_1 - n_2) << n_1$. When they are connected by a tube of small length ℓ and cross-sectional area *S*, $KMnO_4$ starts to diffuse from the left to the right vessel through the tube. Consider the collection of molecules to behave as dilute ideal gases and the difference in their partial pressure in the two vessels causing the diffusion. The speed v of the molecules is limited by the viscous force $-\beta v$ on each molecule, where β is a constant. Neglecting all terms of the order $(\Delta n)^2$, which of the following is/are correct? (k_B is the Boltzmann constant): **[JEE Adv, 2020]**

(*a*) The force causing the molecules to move across the tube is $\Delta n k_B TS$

(*b*) Force balance implies $n_1 \beta v \ell = \Delta n k_B T$

(*c*) Total number of molecules going across the tube per sec is $\left(\frac{\Delta n}{\ell}\right)\left(\frac{k_B T}{\beta}\right) S$

(*d*) Rate of molecules getting transferred through the tube does not change with time

117. 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 (v_1/v_2) equals : **[12 April, 2019 (Shift-II)]**

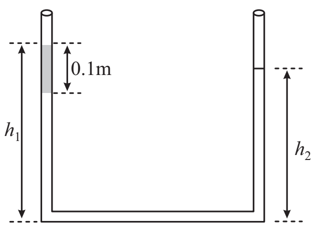
(*a*) 27 (*b*) 1/27
(*c*) 9 (*d*) 1/9

JEE-Advanced

Calculation of Pressure, Pascal's Law

Single Correct

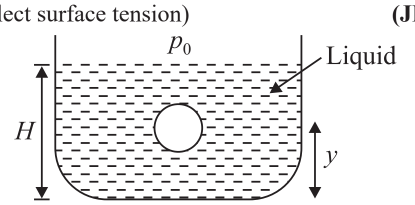
1. An open-ended *U*-tube of uniform cross-sectional area contains water (density 10^3 kg m^{-3}). Initially the water level stands at 0.29 m from the bottom in each arm. Kerosene oil (a water-immiscible liquid) of density 800 kg m^{-3} is added to the left arm until its length is 0.1 m, as shown in the schematic figure below. The ratio $\left(\frac{h_1}{h_2}\right)$ of the heights of the liquid in the two arms is:



C-32.48 W-27.38 UA-40.14 PC-0 (JEE Adv. 2020)

(*a*) $\frac{15}{14}$ (*b*) $\frac{35}{33}$
(*c*) $\frac{7}{6}$ (*d*) $\frac{5}{4}$

2. A small spherical monatomic ideal gas bubble (γ = 5/3) is trapped inside a liquid of density ρ_l (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains *n* moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is *H* and the atmospheric pressure is p_0 (Neglect surface tension) **(JEE Adv. 2008)**



When the gas bubble is at a height *y* from the bottom, its temperature is

(a) $T_0\left(\dfrac{p_0+\rho_l gH}{p_0+\rho_l gy}\right)^{2/5}$ (b) $T_0\left(\dfrac{p_0+\rho_l g(H-y)}{p_0+\rho_l gH}\right)^{2/5}$

(c) $T_0\left(\dfrac{p_0+\rho_l gH}{p_0+\rho_l gy}\right)^{3/5}$ (d) $T_0\left(\dfrac{p_0+\rho_l g(H-y)}{p_0+\rho_l gH}\right)^{3/5}$

3. A closed compartment containing gas is moving with some acceleration in horizontal direction. Neglect effect of gravity. Then, the pressure in the compartment is **(IIT-JEE 1999)**

(a) Same everywhere (b) Lower in the front side

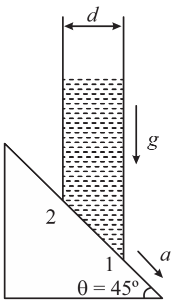
(c) Lower in rear side (d) Lower in upper side

4. A U-tube of uniform cross-section is partially filled with a liquid I. Another liquid II which does not mix with liquid I is poured into one side. It is found that the liquid levels of the two sides of the tube are the same, while the level of liquid I has risen by 2cm. If the specific gravity of liquid I is 1.1, the specific gravity of liquid II must be **(IIT-JEE 1983)**

(a) 1.12 (b) 1.1 (c) 1.05 (d) 1.0

Multiple Correct

5. A cylindrical tube, with its base as shown in the figure, is filled with water. It is moving down with a constant acceleration a along a fixed inclined plane with angle $\theta = 45°$. P_1 and P_2 are pressures at points 1 and 2, respectively, located at the base of the tube. Let $\beta = (P_1 - P_2)/(\rho g d)$, where ρ is density of water, d is the inner diameter of the tube and g is the acceleration due to gravity. Which of the following statement(s) is (are) correct?



C-6.31 W-24.09 UA-61.58 PC-8.02 (JEE Adv. 2021)

(a) $\beta = 0$ when $a = g/\sqrt{2}$ (b) $\beta > 0$ when $a = g/\sqrt{2}$

(c) $\beta = \dfrac{\sqrt{2}-1}{\sqrt{2}}$ when $a = g/2$ (d) $\beta = \dfrac{1}{\sqrt{2}}$ when

Numerical Types/Integer Types

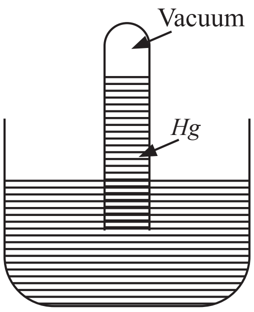
6. A cylindrical vessel of height 500 mm has an orifice (small hole) at its bottom. The orifice is initially closed and water is filled in it upto height H. Now, the top is completely sealed with a cap and the orifice at the bottom is opened. Some water comes out from the orifice and the water level in the vessel becomes steady with the height of the water column being 200mm. Find the fall in height (in mm) of water level due to opening of the orifice.

[Take atmospheric pressure = 10×10^5 Nm^{-2}, density of water = 1000 kg.m^{-3} and g = 10 ms^{-2}. Neglect any effect of surface tension.] **(JEE Adv. 2009)**

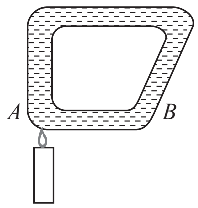
7. A column of mercury of length 10 cm is contained in the middle of a horizontal tube of length 1m which is closed at both the ends. The two equal lengths contain air at standard atmospheric pressure of 0.76 m of mercury. The tube is now turned to a vertical position. By what distance will the column of mercury be displaced? Assume temperature to be constant. **(IIT JEE 1978)**

True/False

8. A barometer made of a very narrow tube (see figure) is placed at normal temperature and pressure. The coefficient of volume expansion of mercury is 0.00018/°C and that of the tube is negligible. The temperature of mercury in the barometer is now raised by 1°C but the temperature of the atmosphere does not change. Then, the mercury height in the tube remains unchanged **(IIT-JEE 1983)**

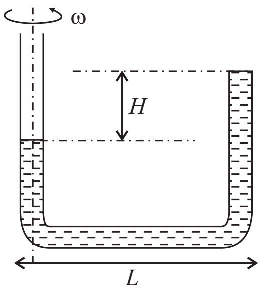


9. Water in a closed tube (see figure) is heated with one arm vertically placed above a lamp. Water will begin to circulate along the tube in counter-clockwise direction. **(IIT-JEE 1983)**



Subjective

10. A U-shaped tube contains a liquid of density ρ and it is rotated about the line as shown in the figure. Find the difference in the levels of the liquid column. **(JEE Adv. 2005)**



11. Two identical cylindrical vessels with their bases at the same level each contain a liquid of density ρ. The height of the liquid in one vessel is h_1 and in the other is h_2. The area of either base is A. What is the work done by gravity in equalizing the levels when the two vessels are connected? **(IIT JEE 1981)**

"Archimedes Principle and Force of Buoyancy"

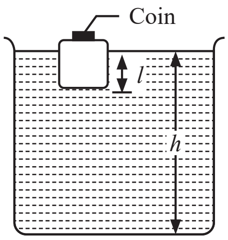
Single Correct

12. A thin uniform cylindrical shell, closed at both ends, is partially filled with water. It is floating vertically in water in a half-submerged state. If ρ_c is the relative density of the material of the shell with respect to water, then the correct statement is that the shell is

C-15.83 W-40.69 UA-43.48 (JEE Adv. 2012)

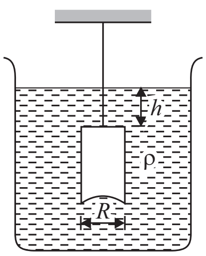
(*a*) More than half-filled if ρ_c is less than 0.5
(*b*) More than half-filled if ρ_c is more than 1.0
(*c*) Half-filled if ρ_c is more than 0.5
(*d*) Less than half-filled if ρ_c is less than 0.5

13. A wooden block, with a coin placed on its top, floats in water as shown in figure. The distance *l* and *h* are shown there. After some time the coin falls into the water. Then **(IIT-JEE 2002)**



(*a*) *l* decreases and *h* increases (*b*) *l* increases and *h* decreases
(*c*) Both *l* and *h* increase (*d*) Both *l* and *h* decrease

14. A hemispherical portion of radius *R* is removed from the bottom of a cylinder of radius *R*. The volume of the remaining cylinder is *V* and mass *M*. It is suspended by a string in a liquid of density ρ, where it stays vertical. The upper surface of the cylinder is at a depth *h* below the liquid surface. The force on the bottom of the cylinder by the liquid is **(IIT-JEE 2001)**

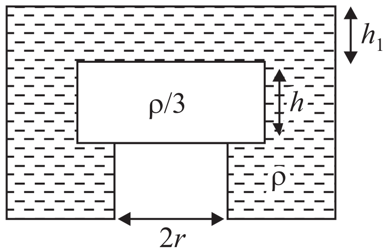


(*a*) Mg (*b*) Mg – Vρ*g*
(*c*) Mg + $\pi R^2 h\rho g$ (*d*) $\rho g(V + \pi R^2 h)$

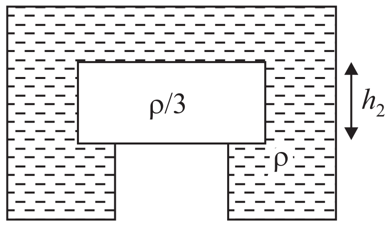
15. A vessel contains oil (density = 0.8 g/cm^3) over mercury (density =13.6 g/cm^3). A homogeneous sphere floats with half its volume immersed in mercury and the other half in oil. The density of the material of the sphere in g/cm^3 is **(IIT JEE 1988)**

(*a*) 3.3 (*b*) 6.4
(*c*) 7.2 (*d*) 12.8

16. A wooden cylinder of diameter 4*r*, height *h* and density ρ/3 is kept on a hole of diameter 2*r* of the tank, filled with liquid of density ρ as shown in the figure.

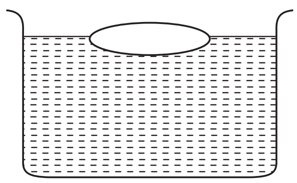


The block in the above question is maintained at the position by external means and the level of liquid is lowered. The height h_2 when this external force reduces to zero is **(JEE Adv. 2006)**



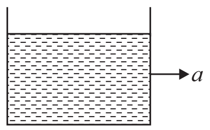
(*a*) 4*h*/9 (*b*) 5*h*/9
(*c*) Remains same (*d*) 2*h*/3

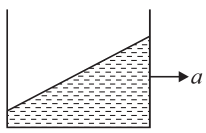
17. A body floats in a liquid contained in a beaker. The whole system as shown in figure falls freely under gravity. The upthrust on the body is **(IIT-JEE 1982)**

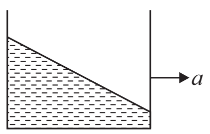


(*a*) Zero
(*b*) Equal to the weight of liquid displaced
(*c*) Equal to the weight of the body in air
(*d*) Equal to the weight of the immersed portion of the body

18. A vessel containing water is given a constant acceleration towards the right along a straight horizontal path. Which of the following diagrams represents the surface of the liquid? **(IIT-JEE 1981)**

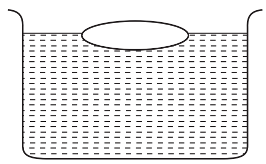
(*a*) 

(*b*) 

(*c*) 

(*d*) None of these

19. A metal ball immersed in alcohol weighs w_1 at 0°C and w_2 at 50°C. The coefficient of cubical expansion of the metal is less than that of the alcohol. Assuming that the density of the metal is large compared to that of alcohol, it can be shown that **(IIT-JEE 1980)**



(*a*) $w_1 > w_2$ (*b*) $w_1 = w_2$
(*c*) $w_1 < w_2$ (*d*) All of these

20. The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant) **(IIT-JEE 2008)**

(a) $\rho_l nRgT_0 \dfrac{(p_0+\rho_l gH)^{2/5}}{(p_0+\rho_l gy)^{2/5}}$

(b) $\dfrac{\rho_l nRgT_0}{(p_0+\rho_l gH)^{2/5}\left[p_0+\rho_l g(H-y)\right]^{3/5}}$

(c) $\rho_l n\mathrm{Rg}T_0 \dfrac{(p_0+\rho_l gH)^{3/5}}{(p_0+\rho_l gy)^{8/5}}$

(d) $\dfrac{\rho_l nRgT_0}{(p_0+\rho_l gH)^{3/5}\left[p_0+\rho_l g(H-y)\right]^{2/5}}$

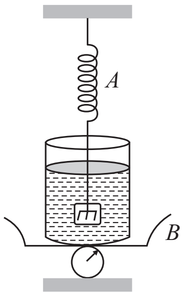
Multiple Correct

21. A solid sphere of radius R and density ρ is attached to one end of a massless spring of force constant k. The other end of the spring is connected to another solid sphere of radius R and density 3ρ. The complete arrangement is placed in a liquid of density 2ρ and is allowed to reach equilibrium. The correct statement(s) is (are)

C-15.5 W-41.64 UA-42.85 (JEE Adv. 2013)

(a) The net elongation of the spring is $(4\pi R^3\rho g)/3k$
(b) The net elongation of the spring is $(8\pi R^3\rho g)/3k$
(c) The light sphere is partially submerged
(d) The light sphere is completely submerged

22. The spring balance A reads 2 kg with a block m suspended from it. A balance B reads 5 kg when a beaker with liquid is put on the pan of the balance. The two balances are now so arranged that the hanging mass is inside the liquid in the beaker as shown in the figure. In this situation. **(IIT-JEE 1985)**



(a) The balance A will read more than 2 kg
(b) The balance B will read more than 5 kg
(c) The balance A will read less than 2 kg and B will read more than 5 kg
(d) The balances A and B will read 2 kg and 5 kg respectively

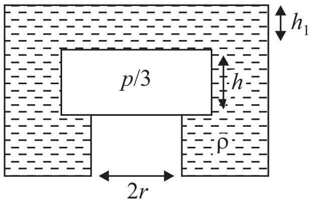
Numerical Types/Integer Types

23. A hot air balloon is carrying some passengers, and a few sandbags of mass 1 kg each so that its total mass is 480 kg. Its effective volume giving the balloon its buoyancy is V. The balloon is floating at an equilibrium height of 100 m. When N number of sandbags are thrown out, the balloon rises to a new equilibrium height close to 150 m with its volume V remaining unchanged. If the variation of the density of air with height h from the ground is $\rho(h)=\rho_0 e^{\frac{h}{h_0}}$, where ρ_0=1.25 kg m^{-3} and h_0= 6000 m, the value of N is ________.

C-5.02 W-16.05 UA-78.93 (JEE Adv. 2020)

Comprehension Based/Passage Based

Direction (Q. 38-39): A wooden cylinder of diameter 4r, height h and density ρ/3 is kept on a hole of diameter 2r of the tank, filled with liquid of density ρ as shown in the figure. **(JEE Adv. 2006)**

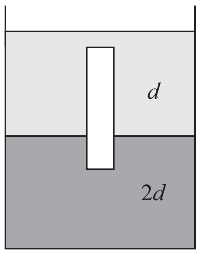


24. Now the level of the liquid starts decreasing slowly. When the level of liquid is at a height h_1 above the cylinder the block starts moving up. At what value of h_1, will the block rise?

(a) $4h/9$ (b) $5h/9$
(c) $5h/3$ (d) Remains same

25. If height h_2 of water level is further decreased, then
(a) Cylinder will not move up and remains at its original position
(b) For $h_2 = h/3$, cylinder again starts moving up
(c) For $h_2 = h/4$, cylinder again starts moving up
(d) For $h_2 = h/5$, cylinder again starts moving up

26. A homogeneous solid cylinder of length L and cross-sectional area A/5 is immersed such that it floats with its axis vertical at the liquid-liquid interface with length L/4 in the denser liquid as shown in the figure. The lower density liquid is open to atmosphere having pressure P_0 **(IIT-JEE 1995)**



Then, density D of solid is given by
(a) $5/4d$ (b) $4/5d$ (c) $4d$ (d) $d/5$

Fill in the Blanks

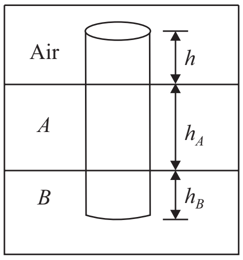
27. A piece of metal floats on mercury. The coefficients of volume expansion of the metal and mercury are γ_1 and γ_2 respectively. If the temperatures of both mercury and the metal are increased by an amount ΔT, the fraction of the volume of the metal submerged in mercury changes by the factor ___________. **(IIT-JEE 1991)**

True/False

28. A block of ice with a lead shot embedded in it is floating on water contained in a vessel. The temperature of the system is maintained at 0°C as the ice melts. When the ice melts completely the level of water in the vessel rises. **(IIT-JEE 1986)**

Subjective

29. A uniform solid cylinder of density 0.8 g/cm^3 floats in equilibrium in a combination of two non-mixing liquids A and B with its axis vertical. The densities of the liquids A and B are 0.7 g/cm^3 and 1.2 g/cm^3, respectively. The height of liquid A is h_A = 1.2 cm. The length of the part of the cylinder immersed in liquid B is h_B = 0.8 cm. **(IIT-JEE 2002)**



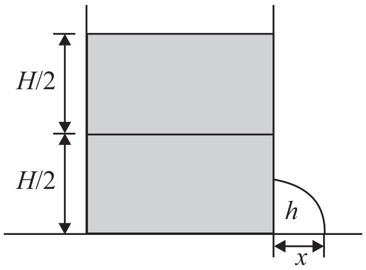
(*a*) Find the total force exerted by liquid A on the cylinder.

(*b*) Find h, the length of the part of the cylinder in air.

(*c*) The cylinder is depressed in such a way that its top surface is just below the upper surface of liquid A and is then released. Find the acceleration of the cylinder immediately after it is released.

30. A wooden stick of length L, radius R and density ρ has a small metal piece of mass m (of negligible volume) attached to its one end. Find the minimum value for the mass m (in terms of given parameters) that would make the stick float vertically in equilibrium in a liquid of density $\sigma(> \rho)$ **(IIT-JEE 1999)**

31. A container of large uniform cross-sectional area A resting on a horizontal surface, holds two immiscible, non-viscous and incompressible liquids of densities d and 2d, each of height H/2 as shown in figure. The lower density liquid is open to the atmosphere having pressure p_0 **(IIT-JEE 1995)**



A homogeneous solid cylinder of length $L(L < H/2)$, cross-sectional area $A/5$ is immersed such that it floats with its axis vertical at the liquid-liquid interface with length $L/4$ in the denser liquid. Determine

(*a*) the density D of the solid,

(*b*) the total pressure at the bottom of the container.

32. A ball of density d is dropped onto a horizontal solid surface. It bounces elastically from the surface and returns to its original position in a time t_1. Next, the ball is released and it falls through the same height before striking the surface of a liquid of density d_L **(IIT-JEE 1992)**

(*a*) If $d < d_L$, obtain an expression (in terms of d, t_1 and d_L) for the time t_2 the ball takes to come back to the position from which it was released.

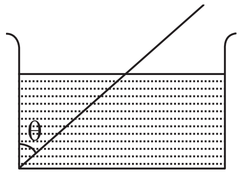
(*b*) Is the motion of the ball simple harmonic?

(*c*) If $d = d_L$, how does the speed of the ball depend on its depth inside the liquid?

Neglect all frictional and other dissipative forces. Assume the depth of the liquid to be large.

33. A boat floating in a water tank is carrying a number of large stones. If the stones are unloaded into water, what will happen to the water level? **(IIT-JEE 1979)**

34. A wooden plank of length 1 m and uniform cross-section is hinged at one end to the bottom of a tank as shown in figure. The tank is filled with water upto a height 0.5 m. The specific gravity of the plank is 0.5. Find the angle *q* that the plank makes with the vertical in the equilibrium position (exclude the case $\theta = 0°$).

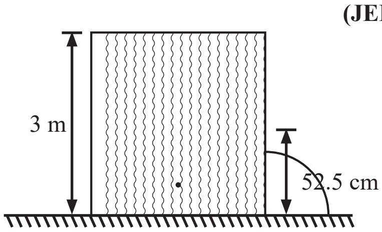


(IIT-JEE 1984)

"Continuity Equation, Bernoulli Theorem and Their Application"

Single Correct

35. Water is filled in a cylindrical container to a height of 3 m. The ratio of the cross-sectional area of the orifice and the beaker is 0.1. The square of the speed of the liquid coming out from the orifice is (g = 10 m/s^2) **(JEE Adv. 2005)**



(*a*) 50 m^2/s^2 (*b*) 50.5 m^2/s^2 (*c*) 51 m^2/s^2 (*d*) 52 m^2/s^2

36. A large open tank has two holes in the wall. One is a square hole of side L at a depth y from the top and the other is a circular hole of radius R at a depth $4y$ from the top. When the tank is completely filled with water, the quantities of water flowing out per second from both holes are the same. Then, R is equal to **(IIT-JEE 2000)**

(*a*) $\frac{L}{\sqrt{2\pi}}$ (*b*) $2\pi L$ (*c*) L (*d*) $\frac{L}{2\pi}$

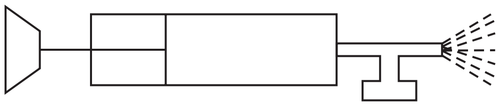
37. Water from a tap emerges vertically downwards with an initial speed of 1.0m/s. The cross-sectional area of the tap is 10^{-4} m^2. Assume that the pressure is constant throughout the steam of water and that the flow is steady, the cross-sectional area of stream 0.15m below the tap is **(IIT-JEE 1998)**

(*a*) 5.0×10^{-4} m^2 (*b*) 1.0×10^{-4} m^2

(*c*) 5.0×10^{-5} m^2 (*d*) 2.0×10^{-5} m^2

Comprehension Based/Passage Based

A spray gun is shown in the figure where a piston pushes air out of nozzle. A thin tube of uniform cross-section is connected to the nozzle. The other end of the tube is in a small liquid container. As the piston pushes air through the nozzle, the liquid from the container rises into the nozzle and is sprayed out. For the spray gun shown, the radii of the piston and the nozzle are 20 mm and 1 mm respectively. The upper end of the container is open to the atmosphere.



38. If the piston is pushed at a speed of 5 mm/s, the air comes out of the nozzle with a speed of

C-45.62 W-28.4 UA-25.97 (JEE Adv. 2014)

(*a*) 0.1 ms^{-1} (*b*) 1 ms^{-1} (*c*) 2 ms^{-1} (*d*) 8 ms^{-1}

39. If the density of air is ρ_a and that of the liquid ρ_l, then for a given piston speed the rate (volume per unit time) at which the liquid is sprayed will be proportional to

C-23.3 W-31.22 UA-45.48 (JEE Adv. 2014)

(*a*) $\sqrt{\frac{\rho_a}{\rho_l}}$ (*b*) $\sqrt{\rho_a \rho_l}$ (*c*) $\sqrt{\frac{\rho_l}{\rho_a}}$ (*d*) ρ_l

Match the Column

40. A person in a lift is holding a water jar, which has a small hole at the lower end of its side. When the lift is at rest, the water jet coming out of the hole hits the floor of the lift at a distance d of 1.2m from the person. In the following, the state of the lift's motion is given in List-I and the distance where the water jet hits the floor of the lift is given in List-II. Match the statements from List-I with those in List-II and select the correct answer using the code given below the lists. **C-16.16 W-73.98 UA-9.85 (JEE Adv. 2014)**

List-I		List-II	
A.	Lift is accelerating vertically up.	(*p*)	$d = 1.2$ m
B.	Lift is accelerating vertically down with an acceleration less than gravitational acceleration.	(*q*)	$d > 1.2$ m
C.	Lift is moving vertically up with constant speed.	(*r*)	$d < 1.2$ m
D.	Lift is falling freely.	(*s*)	No water leaks out of the jar

(*a*) A-*q*, B-*r*, C-*q*, D-*s*
(*b*) A-*q*, B-*r*, C-*p*, D-*s*
(*c*) A-*p*, B-*p*, C-*p*, D-*s*
(*d*) A-*q*, B-*r*, C-*p*, D-*p*

Numerical Types/Integer Types

41. A train with cross-sectional area S_t is moving with speed v_t inside a long tunnel of cross-sectional area $S_0(S_0 = 4S_t)$. Assume that almost all the air (density ρ) in front of the train flows back between its sides and the walls of the tunnel. Also, the air flow with respect to the train is steady and laminar. Take the ambient pressure and that inside the train to be p_0. If the pressure in the region between the sides of the train and the tunnel walls is p, then $p_0 - p = \frac{7}{2N}\rho v_t^2$. The value of N is ______. **C-1.47 W-20.13 UA-78.4 (JEE Adv. 2020)**

42. A horizontal pipeline carries water in a streamline flow. At a point along the pipe, where the cross-sectional area is 10 cm^2, the water velocity is 1 ms^{-1} and the pressure is 2000 P_a. The pressure of water at another point where the cross-sectional area is 5 cm^2, is ...,. P_a. (Density of water = 10^3 kg-m^3) **(IIT-JEE 1994)**

Assertion and Reason/Statement Based

43. **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.

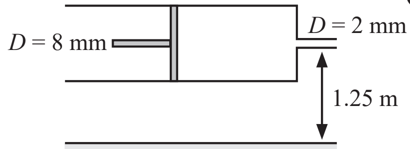
Statement-II: In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

Mark your answer as **(2008 IIT-JEE)**

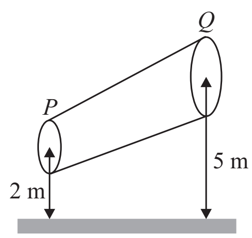
(*a*) If Statement-I is true, Statement-II is true; Statement-II is the correct explanation for Statement-I.
(*b*) If Statement-I is true, Statement-II is true; Statement-II is not a correct explanation for Statement-I.
(*c*) If Statement-I is true; Statement-II is false.
(*d*) If Statement-I is false; Statement-II is true.

Subjective

44. Consider a horizontally oriented syringe containing water located at a height of 1.25 m above the ground. The diameter of the plunger is 8mm and the diameter of the nozzle is 2mm. The plunger is pushed with a constant speed of 0.25 m/s. Find the horizontal range of the water stream on the ground. (Take $g = 10$ m/s^2) **(IIT-JEE 2004)**



45. A non-viscous liquid of constant density 1000 kg/m^3 flows in streamline motion along a tube of variable cross-section. The tube is kept inclined in the vertical plane as shown in the figure. The area of cross-section of the tube at two points P and Q at heights of 2 m and 5 m are respectively 4×10^{-3} m^2 and 8×10^{-3} m^2. The velocity of the liquid at point P is 1 m/s. Find the work done per unit volume by the pressure and the gravity forces as the fluid flows from point P to Q. **(IIT-JEE 1997)**



46. A large open top container of negligible mass and uniform cross-sectional area A has a small hole of cross-sectional area A/100 in its side wall near the bottom. The container is kept on a smooth horizontal floor and contains a liquid of density ρ and mass m_0. Assuming that the liquid starts flowing out horizontally through the hole at $t = 0$. Calculate **(IIT-JEE 1997)**

(*a*) The acceleration of the container and
(*b*) Velocity of efflux when 75% of the liquid has drained out

Viscosity and Viscous Force

Multiple Correct

47. Consider a thin square plate floating on a viscous liquid in a large tank. The height h of the liquid in the tank is much less than the width of the tank. The floating plate is pulled horizontally with a constant velocity u_0. Which of the following statements is (are) true?

C-9.64 W-16.36 UA-36.76 PC-37.24 (JEE Adv. 2018)

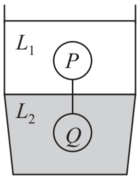
(*a*) The resistive force of liquid on the plate is inversely proportional to h

(*b*) The resistive force of liquid on the plate is independent of the area of the plate

(*c*) The tangential (shear) stress on the floor of the tank increases with u_0

(*d*) The tangential (shear) stress on the plate varies linearly with the viscosity η of the liquid

48. Two spheres P and Q for equal radii have densities ρ_1 and ρ_2, respectively. The spheres are connected by a massless string and placed in liquids L_1 and L_2 of densities σ_1 and σ_2 and viscosities η_1 and η_2, respectively. They float in equilibrium with the sphere P in L_1 and sphere Q in L_2 and the string being taut (see figure). If sphere P alone in L_2 has terminal velocity v_P and Q alone in L_1 has terminal velocity v_Q, then **(JEE Adv. 2015)**



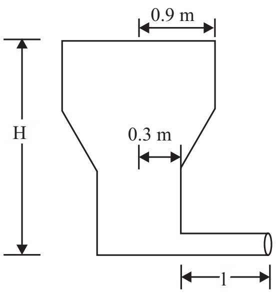
(*a*) $|v_P|/|v_Q| = \eta_1/\eta_2$ (*b*) $|v_P|/|v_Q| = \eta_2/\eta_1$

(*c*) $v_P.v_Q > 0$ (*d*) $v_P.v_Q < 0$

Numerical Types/Integer Types

49. Consider two solid spheres P and Q each of density 8g cm^{-3} and diameters 1 cm and 0.5 cm, respectively. Sphere P is dropped into a liquid of density 0.8 gm/cm^3 and viscosity η = 3 Poiseuille's. Sphere Q is dropped into a liquid of density 1.6 gm/cm^3 and viscosity η = 2 Poiseuille's. The ratio of the terminal velocities of P and Q is **C-42.06 W-53.93 UA-4 (JEE Adv. 2016)**

50. A liquid of density 900 kg/m^3 is filled in a cylindrical tank of upper radius 0.9 m and lower radius 0.3 m. A capillary tube of length l is attached at the bottom of the tank as shown in the figure. The capillary has outer radius 0.002 m and inner radius a. When pressure p is applied at the top of the tank, the volume flow rate of the liquid is 8×10^{-6} m^3/s and if the capillary tube is detached, the liquid comes out from the tank with a velocity 10 m/s. **(JEE Adv. 2003)**
Determine the coefficient of viscosity of the liquid.
[Given, $\pi a^2 = 10^{-6}$ m^2 and $a^2/l = 2 \times 10^{-6}$ m]



Subjective

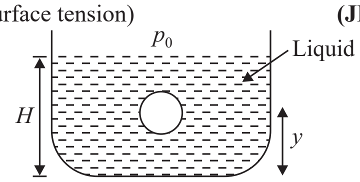
51. A small sphere falls from rest in a viscous liquid. Due to friction, heat is produced. Find the relation between the rate of production of heat and the radius of the sphere at terminal velocity.

(JEE Adv. 2004)

Surface Tension, Surface Energy, Excess Pressure, Capillary Rise, Viscosity and Viscous Force

Single Correct

52. A small spherical monatomic ideal gas bubble (γ = 5/3) is trapped inside a liquid of density ρ_l (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure is p_0 (Neglect surface tension) **(JEE Adv. 2008)**



As the bubble moves upwards, besides the buoyancy force the following forces are acting on it.

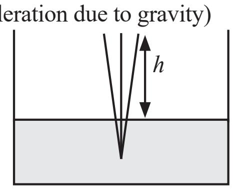
(*a*) Only the force of gravity

(*b*) The force due to gravity and the force due to the pressure of the liquid

(*c*) The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid

(*d*) The force due to gravity and the force due to viscosity of the liquid

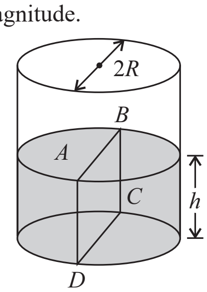
53. A glass capillary tube is of the shape of a truncated cone with an apex angle α so that its two ends have cross-sections of different radii. When dipped in water vertically, water rises in it to a height h, where the radius of its cross-section is b. If the surface tension of water is S, its density is ρ, and its contact angle with glass is θ, the value of h will be (g is the acceleration due to gravity) **(JEE Adv. 2014)**



(*a*) $2S/b\rho g \cos(\theta - \alpha)$ (*b*) $2S/b\rho g \cos(\theta + \alpha)$

(*c*) $2S/b\rho g \cos(\theta - \alpha/2)$ (*d*) $2S/b\rho g \cos(\theta + \alpha/2)$

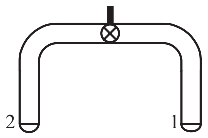
54. Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water is ρ, the surface tension of water is T and the atmospheric pressure is p_0. Consider a vertical section $ABCD$ of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude. **(JEE Adv. 2007)**



(*a*) $|2p_0Rh + \pi R^2\rho gh - 2RT|$ (*b*) $|2p_0Rh + R\rho gh^2 - 2RT|$

(*c*) $|p_0\pi R_2 + R\rho gh^2 - 2RT|$ (*d*) $|p_0\pi R_2 + R\rho gh^2 + 2RT|$

55. A glass tube of uniform internal radius (r) has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherial soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in figure. Just after opening the valve. **(IIT-JEE 2008)**



(*a*) air from end 1 flows towards end 2. No change in the volume of the soap bubbles

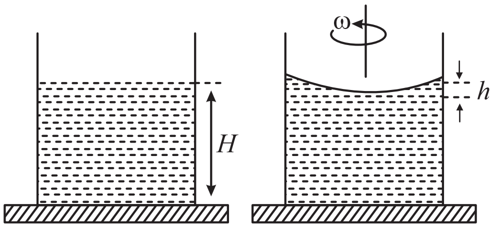
(*b*) air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases

(*c*) no change occurs

(*d*) air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases

Multiple Correct

56. A beaker of radius r is filled with water (refractive index $\frac{4}{3}$) up to a height H as shown in the figure on the left. The beaker is kept on a horizontal table rotating with angular speed ω. This makes the water surface curved so that the difference in the height of water level at the center and at the circumference of the beaker is h($h << H$, $h << r$), as shown in the figure on the right. Take this surface to be approximately spherical with a radius of curvature R. Which of the following is/are correct?
(g is the acceleration due to gravity)
C-7.99 W-23.73 UA-56.53 PC-11.75 (JEE Adv. 2020)



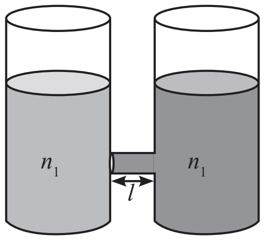
(*a*) $R = \dfrac{h^2 + r^2}{2h}$

(*b*) $R = \dfrac{3r^2}{2h}$

(*c*) Apparent depth of the bottom of the beaker is close to $\dfrac{3H}{2}\left(1 + \dfrac{\omega^2 H}{2g}\right)^{-1}$

(*d*) Apparent depth of the bottom of the beaker is close to $\dfrac{3H}{4}\left(1 + \dfrac{\omega^2 H}{4g}\right)^{-1}$

57. As shown schematically in the figure, two vessels contain water solutions (at temperature T) of potassium permaganate ($KMnO_4$) of different concentrations n_1 and n_2 ($n_1 > n_2$) molecules per unit volume with $\Delta n = (n_1 - n_2) << n_1$. When they are connected by a tube of small length ℓ and cross-sectional area S, $KMnO_4$ starts to diffuse from the left to the right vessel through the tube. Consider the collection of molecules to behave as dilute ideal gases and the difference in their partial pressure in the two vessels causing the diffusion. The speed v of the molecules is limited by the viscous force$-\beta v$ on each molecule, where β is a constant. Neglecting all terms of the order $(\Delta n)^2$, which of the following is/are correct? (k_B is the Boltzmann constant):



C-4.69 W-11.5 UA-64.47 PC-19.34 (JEE Adv. 2020)

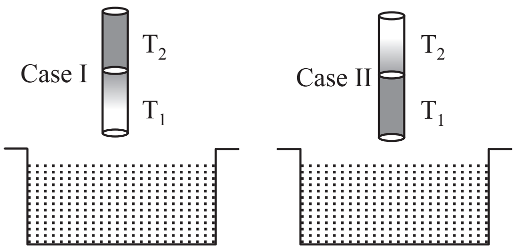
(*a*) The force causing the molecules to move across the tube is $\Delta n k_B T S$

(*b*) Force balance implies $n_1 \beta v \ell = \Delta n k_B T$

(*c*) Total number of molecules going across the tube per sec is $\left(\dfrac{\Delta n}{\ell}\right)\left(\dfrac{k_B T}{\beta}\right)S$

(*d*) Rate of molecules getting transferred through the tube does not change with time

58. A cylindrical capillary tube of 0.2 mm radius is made by joining two capillaries T_1 and T_2 of different materials having water contact angles of 0° and 60°, respectively. The capillary tube is dipped vertically in water in two different configurations, case I and II as shown in figure. Which of the following option(s) is(are) correct? (Surface tension of water = 0.075 N/m, density of water = 1000 kg/m³, take g = 10m/s²)
C-4 W-14 UA-55 PC-27 (JEE Adv, 2019)



(*a*) The correction in the height of water column raised in the tube, due to weight of water contained in the meniscus, will be different for both cases.

(*b*) For case I, if the capillary joint is 5 cm above the water surface, the height of water column raised in the tube will be more than 8.75 cm. (Neglect the weight of the water in the meniscus)

(*c*) For case I, if the joint is kept at 8 cm above the water surface, the height of water column in the tube will be 7.5 cm. (Neglect the weight of the water in the meniscus)

(*d*) For case II, if the capillary joint is 5 cm above the water surface, the height of water column raised in the tube will be 3.75 cm. (Neglect the weight of the water in the meniscus)

59. A uniform capillary tube of inner radius r is dipped vertically into a beaker filled with water. The water rises to a height h in the capillary tube above the water surface in the beaker. The surface tension of water is σ. The angle of contact between water and the wall of the capillary tube is θ. Ignore the mass of water in the meniscus. Which of the following statements is (are) true? **(JEE Adv. 2018)**

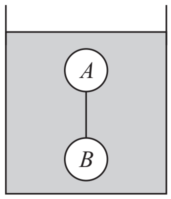
(*a*) For a given material of the capillary tube, h decreases with increase in r

(*b*) For a given material of the capillary tube, h is independent of σ

(*c*) If this experiment is performed in a lift going up with a constant acceleration, then h decreases

(*d*) h is proportional to contact angle θ

60. Two solid spheres A and B of equal volumes but of different densities d_A and d_B are connected by a string. They are fully immersed in a fluid of density d_F. They get arranged into an equilibrium state as shown in the figure with a tension in the string. The arrangement is possible only if **(IIT-JEE 2011)**



(*a*) $d_A < d_F$ (*b*) $d_B > d_F$ (*c*) $d_A > d_F$ (*d*) $d_A + d_B = 2d$

Comprehension Based/Passage Based

Direction (Q. 75 to 77): 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 of the dropper. We wish to estimate the size of the drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper. **(JEE Adv. 2010)**

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

(*a*) $2\pi rT$ (*b*) $2\pi RT$ (*c*) $(2\pi r^2T)/R$ (*d*) $(2\pi R^2T)/r$

62. If $r = 5 \times 10^{-4}$ m, $\rho = 10^3$ kg.m^{-3}, $g = 10$ ms^{-2}, $T = 0.11$ Nm^{-1}, the radius of the drop when it detaches from the dropper is approximately

(*a*) 1.4×10^{-3} m (*b*) 3.3×10^{-3} m

(*c*) 2.0×10^{-3} m (*d*) 4.1×10^{-3} m

63. After the drop detaches, its surface energy is

(*a*) 1.4×10^{-6} J (*b*) 2.7×10^{-6} J

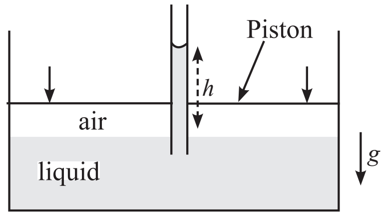
(*c*) 5.4×10^{-6} J (*d*) 8.1×10^{-6} J

Numerical Types/Integer Types

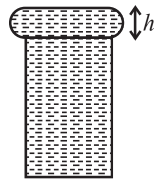
64. An incompressible liquid is kept in a container having a weightless piston with a hole. A capillary tube of inner radius 0.1 mm is dipped vertically into the liquid through the airtight piston hole, as shown in the figure. The air in the container is isothermally compressed from its original volume $\frac{100}{101}V_0$ with the movable piston. Considering ah' as an ideal gas, the height (h) of the liquid column in the capillary above the liquid level in cm is_______.

[Given: Surface tension of the liquid is 0.075 Nm^{-1}, atmospheric pressure is 10^5 Nm^{-2}, acceleration due to gravity (g) is 10 ms^{-2}, density of the liquid is 10^3 kg m^{-3} and contact angle of capillary surface with the liquid is zero]

C-4.03 W-62.65 UA-33.33 (JEE Adv. 2023)



65. When water is filled carefully in a glass, one can fill it to a height h above the rim of the glass due to the surface tension of water. To calculate h just before water starts flowing, model the shape of the water above the rim as a disc of thickness h having semicircular edges, as shown schematically in the figure. When the pressure of water at the bottom of this disc exceeds what can be withstood due to the surface tension, the water surface breaks near the rim and water starts flowing from there. If the density of water, its surface tension and the acceleration due to gravity are 10^3 kg m^{-3}, 0.07 Nm^{-1} and 10 ms^{-2}, respectively, the value of h (in mm) is ____________.



C-1.25 W-65.74 UA-33.02 (JEE Adv. 2020)

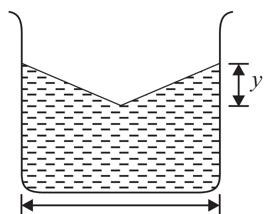
66. A drop of liquid of radius $R = 10^{-2}$ m having surface tension $S = 0.1/4\pi$ Nm^{-1} divides itself into K identical drops. In this process the total change in the surface energy $\Delta U = 10^{-3}$ J. If $K = 10^{\alpha}$, then the value of α is **C-22.62 W-72.36 UA-5.01 (JEE Adv. 2017)**

67. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure 8 Nm^{-2}. The radii of bubbles A and B are 2 cm, respectively. Surface tension of the soap-water used to make bubbles is 0.04 Nm^{-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] **(JEE Adv. 2009)**

Subjective

68. A container of width $2a$ is filled with a liquid. A thin wire of weight per unit length λ is gently placed over the liquid surface in the middle of the surface as shown in the figure.

As a result, the liquid surface is depressed by a distance $y(y << a)$. Determine the surface tension of the liquid. **(JEE Adv. 2004)**



69. A soap bubble is being blown at the end of a very narrow tube of radius b. Air (density ρ) moves with a velocity v inside the tube and comes to rest inside the bubble. The surface tension of the soap solution is T. After sometime the bubble, having grown to radius r separates from the tube. Find the value of r. Assume that $r >> b$ so that you can consider the air to be falling normally on the bubble's surface. **(JEE Adv. 2003)**

ANSWER KEY

JEE-Main

1. [2]	**2.** [18]	**3.** [177]	**4.** (*a*)	**5.** (*c*)	**6.** (*b*)	**7.** (*c*)	**8.** [1000 N]	**9.** (*c*)	**10.** (*b*)
11. (*d*)	**12.** (*b*)	**13.** [25600]	**14.** (*a*, *c*)	**15.** [25]	**16.** (*d*)	**17.** (*a*)	**18.** [4]	**19.** [4]	**20.** (*b*)
21. (*d*)	**22.** (*b*)	**23.** (*d*)	**24.** (*c*)	**25.** (*b*)	**26.** [50]	**27.** [810]	**28.** [9600]	**29.** [4]	**30.** (*b*)
31. (*d*)	**32.** [2]	**33.** [80]	**34.** [4]	**35.** (*a*)	**36.** [363]	**37.** [300]	**38.** (*d*)	**39.** (*b*)	**40.** [24]
41. [3]	**42.** (*b*)	**43.** [6]	**44.** (*d*)	**45.** (*c*)	**46.** (*c*)	**47.** (*d*)	**48.** [9]	**49.** (*b*)	**50.** (*a*)
51. (*b*)	**52.** (*b*)	**53.** (*a*)	**54.** [10]	**55.** (*d*)	**56.** (7)	**57.** (1)	**58.** (1)	**59.** [7]	**60.** (*d*)
61. [1]	**62.** (*c*)	**63.** (*b*)	**64.** (*a*)	**65.** [264]	**66.** [1150]	**67.** (*a*)	**68.** (*a*)	**69.** (*c*)	**70.** (*a*)
71. (*a*)	**72.** (*a*)	**73.** [3.74]	**74.** (*c*)	**75.** (3)	**76.** (*a*)	**77.** [25]	**78.** (*c*)	**79.** (*c*)	**80.** (*b*)
81. (a,d)	**82.** (*a*)	**83.** (*d*)	**84.** (*d*)	**85.** (*a,c,d*)	**86.** [2]	**87.** (*a*)	**88.** (*b*)	**89.** [25]	**90.** [2]
91. (*d*)	**92.** (*d*)	**93.** (*)	**94.** (*b*)	**95.** (*b*)	**96.** (*a*)	**97.** (4)	**98.** [40]	**99.** (*c*)	**100.** [7]
101. [25]	**102.** (*a*)	**103.** [10]	**104.** (*c*)	**105.** (*b*)	**106.** (*c*)	**107.** [100]	**108.** (*b*)	**109.** (*c*)	**110.** (*d*)
111. [20]	**112.** [11]	**113.** [25]	**114.** (*a*)	**115.** (*d*)	**116.** (a,b,c)	**117.** (*c*)			

JEE-Advanced

1. (*b*)	**2.** (*b*)	**3.** (*a*)	**4.** (*b*)	**5.** (*a*,*c*)	**6.** [6]	**7.** [2.95]	**8.** [False]	**9.** [False]	**12.** (*a*)
13. (*d*)	**14.** (*d*)	**15.** (*c*)	**16.** (*a*)	**17.** (*a*)	**18.** (*c*)	**19.** (*c*)	**20.** (*b*)	**21.** (*a*,*d*)	**22.** (*b*,*c*)
23. [4]	**24.** (*c*)	**25.** (*a*)	**26.** (*a*)	**28.** [False]	**35.** (*a*)	**36.** (*a*)	**37.** (*c*)	**38.** (*c*)	**39.** (*a*)
40. (*c*)	**41.** [9]	**42.** [500]	**43.** (*a*)	**44.** [2]	**47.** (*a*, *c*, *d*)	**48.** (*a*,*d*)	**49.** [3]	**50.** [1/720]	**52.** (*d*)
53. (*d*)	**54.** (*b*)	**55.** (*b*)	**56.** (*a*,*d*)	**57.** (*a*,*b*,*c*)	**58.** (*a*,*c*,*d*)	**59.** (*a*,*c*)	**60.** (*a*,*b*,*d*)	**61.** (*c*)	**62.** (*a*)
63. (*b*)	**64.** [25]	**65.** [3.74]	**66.** [6]	**67.** [6]					