Fluid Mechanics

Question1

A wire of length 20 cm is placed horizontally on the surface of water and is gently pulled up with a force of 1.456×10^{-2} N to keep the wire in equilibrium. The surface tension of water is

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Options:

A.

$0.00364 \mathrm{Nm}^{-1}$

B.

$0.0364 \mathrm{Nm}^{-1}$

C.

$0.00464 \mathrm{Nm}^{-1}$

D.

$0.0864 \mathrm{Nm}^{-1}$

Answer: B

Solution:

Given:

- Length of the wire, $l = 20 \text{ cm} = 0.20 \text{ m}$
- Force required to keep the wire in equilibrium, $F = 1.456 \times 10^{-2}$ N

We are asked to find the **surface tension** T of water.

Concept:

When a wire is in contact with a liquid surface, **two surfaces** are stretched — one on each side of the wire (front and back).

The total upward force due to surface tension is:

$F = 2Tl$

(where the factor 2 accounts for the two surfaces).

Calculation:

$$T = \frac{F}{2l}$$

Substitute the values:

$$T = \frac{1.456 \times 10^{-2}}{2 \times 0.20}$$

$$T = \frac{1.456 \times 10^{-2}}{0.40}$$

$T = 3.64 \times 10^{-2}\ \mathrm{N/m}$

✅ **Final Answer:**

$\boxed{T = 0.0364\ \mathrm{N/m}}$

Correct Option: (B) $0.0364\ \mathrm{Nm}^{-1}$

Question2

When the temperature increases, the viscosity of

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Options:

A.

gases decreases but liquids increases

B.

gases increases but liquids decreases

C.

both gases and liquids increases

D.

both gases and liquids decreases

Answer: B

Solution:

The correct answer is:

✅ **Option B: gases increase but liquids decrease**

Explanation:

- For **liquids**, viscosity is mainly due to intermolecular attraction. As temperature increases, these attractive forces weaken, and molecules move more freely $\longrightarrow$ **viscosity decreases**.
- For **gases**, viscosity arises from molecular momentum transfer. As temperature increases, molecular speed increases, enhancing momentum exchange $\longrightarrow$ **viscosity increases**.

Question3

In a water tank, an air bubble rises from the bottom to the top surface of the water. If the depth of the water in the tank is 7.28 m and atmospheric pressure is 10 m of water, then the ratio of the radii of the bubble at the bottom of the tank and at the top surface of the water is

(Temperature of the water in the tank is constant)

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Options:

A.

2 : 3

B.

5 : 6

C.

3 : 4

D.

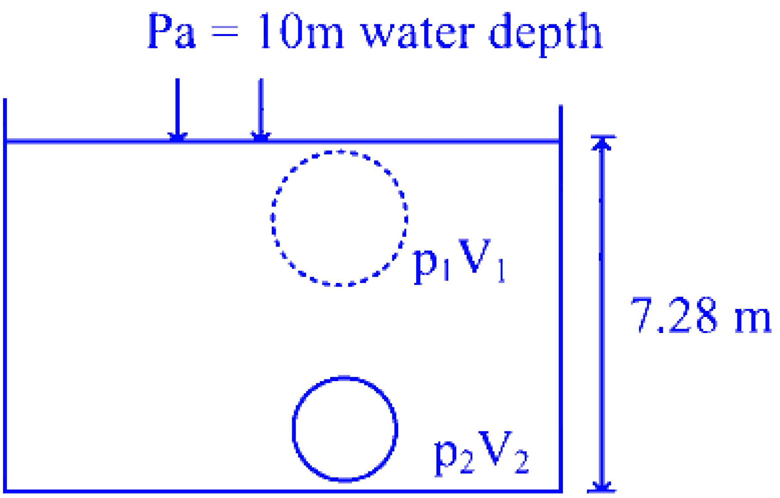
4 : 5

Answer: B

Solution:

As temperature is constant, for air in bubble,

$p_1 V_1 = p_2 V_2$



Given,

$$p_1 = 10 \times \rho_w \times g$$
$$p_2 = (10 + 7.28)\rho_w \times g$$
$$V_1 = \frac{4}{3}\pi r_1^3 \text{ and } V_2 = \frac{4}{3}\pi r_2^3$$

Now by $p_1 V_1 = p_2 V_2$

$$\Rightarrow \quad \frac{V_2}{V_1} = \left(\frac{r_2}{r_1}\right)^3 = \frac{p_1}{p_2}$$
$$\Rightarrow \quad \frac{r_2}{r_1} = \left(\frac{p_1}{p_2}\right)^{\frac{1}{3}} = \left(\frac{10}{17.28}\right)^{\frac{1}{3}}$$
$$= \left(\frac{1000}{1728}\right)^{\frac{1}{3}} = \left(\frac{125}{216}\right)^{\frac{1}{3}} = \frac{5}{6}$$

Question4

Water flowing through a pipe of area of cross-section $2 \times 10^{-3}\ \mathrm{m}^2$ hits a vertical wall horizontally with a velocity of $12\ \mathrm{ms}^{-1}$. If the water does not rebound after hitting the wall, then the force acting on the wall due to water is

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Options:

A.

24 N

B.

144 N

C.

288 N

D.

72 N

Answer: C

Solution:

Step 1: Find the volume of water hitting the wall each second.

The formula for flow rate (volume per second) is:

$\text{Volume per second} = \text{Area} \times \text{Velocity}$

Here, Area = $2 \times 10^{-3}\ \mathrm{m}^2$ and Velocity = $12\ \mathrm{ms}^{-1}$

$\text{Volume per second} = 2 \times 10^{-3} \times 12 = 24 \times 10^{-3}\ \mathrm{m}^3/\mathrm{s}$

Step 2: Find the mass of water hitting the wall each second.

To get the mass per second, multiply the volume flow by the density of water ($\rho = 1000\ \mathrm{kg}/\mathrm{m}^3$):

$\text{Mass per second} = \text{Density} \times \text{Volume per second}$

$= 1000 \times 24 \times 10^{-3} = 24\ \mathrm{kg}/\mathrm{s}$

Step 3: Calculate the force on the wall.

Force is the change in momentum per second. The water hits the wall at velocity $12 \mathrm{~ms}^{-1}$ and stops instantly.

Force $=$ Mass per second $\times$ Velocity

$= 24 \times 12 = 288 \mathrm{~N}$

Question5

If two soap bubbles A and B of radii r_1 and r_2 respectively are kept in vacuum at constant temperature, then the ratio of masses of air inside the bubbles A and B is

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Options:

A.

$r_2^2 : r_1^2$

B.

$r_1^2 : r_2^2$

C.

$r_1 : r_2$

D.

$r_2 : r_1$

Answer: B

Solution:

Step 1: Find Extra Pressure Inside a Bubble

The extra (excess) pressure inside a soap bubble is $p = \frac{4T}{r}$, where T is surface tension and r is the radius.

So for bubble A: $p_A = \frac{4T}{r_1}$

And for bubble B: $p_B = \frac{4T}{r_2}$

Step 2: Use the Gas Law for Bubbles

The usual gas equation is $pV = nRT$. Here, p is pressure, V is volume, n is the number of moles, R is the gas constant, and T is temperature.

Since the temperature is constant, $pV \propto n$. The number of moles n is related to the mass m of the gas. So, $pV \propto m$.

Step 3: Work Out the Mass for Each Bubble

For bubble A:

The volume of a sphere is $V_A = \frac{4}{3}\pi r_1^3$.

So $p_A V_A \propto m_A$ becomes:

$\frac{4T}{r_1} \times \frac{4}{3}\pi r_1^3 \propto m_A$

This simplifies to $m_A \propto r_1^2$.

For bubble B:

Similarly, $V_B = \frac{4}{3}\pi r_2^3$.

So $\frac{4T}{r_2} \times \frac{4}{3}\pi r_2^3 \propto m_B$

This gives us $m_B \propto r_2^2$.

Step 4: Find the Ratio of the Masses

The ratio is $\frac{m_A}{m_B} = \frac{r_1^2}{r_2^2}$.

Question6

A mercury drop of radius 1 cm is divided into 10^6 droplets of equal size. If surface tension of mercury is $35 \times 10^{-3} \mathrm{Nm}^{-1}$, then the change in surface energy in the process is

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Options:

A. 8712μ J

B.

8712 erg

C.

4356μ J

D.

4356 erg

Answer: C

Solution:

$$\begin{aligned} \frac{4}{3}\pi R^3 &= 10^6 \times \frac{4}{3}\pi r^3 \\ R &= 100r \\ \Rightarrow \quad r &= \frac{R}{100} \end{aligned}$$

$\therefore$ Change in surface energy

$$\begin{aligned} &\Delta E = T \times \Delta A \\ &= 35 \times 10^{-3}\left[10^6 \times 4\pi r^2 - 4\pi R^2\right] \\ &= 35 \times 10^{-3}\left[10^6 \times 4\pi \times \left(\frac{R}{100}\right)^2 - 4\pi R^2\right] \\ &= 35 \times 10^{-3}\left[400\pi R^2 - 4\pi R^2\right] \\ &= 35 \times 10^{-3} \times 396\pi R^2 \\ &= 35 \times 10^{-3} \times 396 \times \frac{22}{7} \times 1 \times 10^{-4} \\ &= 4356 \times 10^{-6}\ \mathrm{J} = 4356\mu\ \mathrm{J} \end{aligned}$$

Question7

An aeroplane of mass 4.5×10^4 kg and total wing area of $600\ \mathrm{m}^2$ is travelling at a constant height. The pressure difference between the upper and lower surfaces of its wings is (Acceleration due to gravity $= 10\ \mathrm{ms}^{-2}$)

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Options:

A.

$500 \mathrm{Nm}^{-2}$

B.

$825 \mathrm{Nm}^{-2}$

C.

$600 \mathrm{Nm}^{-2}$

D.

$750 \mathrm{Nm}^{-2}$

Answer: D

Solution:

Given:

- Mass of the aeroplane, $m = 4.5 \times 10^4 \mathrm{~kg}$
- Total wing area, $A = 600 \mathrm{~m}^2$
- Acceleration due to gravity, $g = 10 \mathrm{~m/s}^2$

The aeroplane is **travelling at a constant height**, meaning **lift = weight**.

Step 1. Lift = Pressure difference × Area

$L = \Delta P \times A$

Step 2. Lift = Weight

$L = mg$

So,

$\Delta P \times A = mg$

Step 3. Solve for pressure difference

$\Delta P = \frac{mg}{A}$

Substitute the known values:

$\Delta P = \frac{4.5 \times 10^4 \times 10}{600}$

$\Delta P = \frac{4.5 \times 10^5}{600}$

$\Delta P = 750 \mathrm{~N/m}^2$

✅ **Answer:** $\boxed{750 \mathrm{~N/m}^2}$

Correct Option: D

Question8

In a hydraulic lift, if the radius of the smaller piston is 5 cm and the radius of the larger piston is 50 cm , then the weight that the larger piston can support when a force of 250 N is applied to the smaller piston is

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Options:

A.

50 kN

B.

100 kN

C.

40 kN

D.

25 kN

Answer: D

Solution:

Since, pressure is same on the both side, thus

$$\frac{F_1}{A_1}=\frac{F_2}{A_2}$$

$$\Rightarrow \quad F_2=\frac{F_1 A_2}{A_1}=\frac{250 \times \pi r_2^2}{\pi r_1^2}$$

$$=250 \times\left(\frac{r_2}{r_1}\right)^2=250 \times\left(\frac{50}{5}\right)^2$$

$$=25000 \mathrm{~N}=25 \mathrm{kN}$$

Question9

A liquid drop of diameter D splits into 3375 small identical drops. If S is the surface tension of the liquid, then the change in the surface energy in the process is

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Options:

A.

$44D^2S$

B.

$44\pi D^2S$

C.

$56D^2S$

D.

$56\pi D^2S$

Answer: D

Solution:

Let the **original drop radius** = D (this is what the options imply; if D were truly the diameter, the answer would come out different and none of the options would match).

Number of drops $n = 3375 = 15^3$.

Volume conservation:

$$\frac{4}{3}\pi D^3 = n \cdot \frac{4}{3}\pi r^3 \Rightarrow r = \frac{D}{15}$$

Surface areas:

$$A_i = 4\pi D^2$$

$$A_f = n \cdot 4\pi r^2 = 3375 \cdot 4\pi \left(\frac{D}{15}\right)^2 = 3375 \cdot 4\pi \frac{D^2}{225} = 15 \cdot 4\pi D^2 = 60\pi D^2$$

Increase in area:

$$\Delta A = 60\pi D^2 - 4\pi D^2 = 56\pi D^2$$

Change in surface energy:

$$\Delta E = S\,\Delta A = 56\pi D^2 S$$

✅ **Answer:** $56\pi D^2 S$ **(Option D)**

Question10

If water flows with a velocity of $20 \mathrm{cms}^{-1}$ in a pipe of radius 2 cm , then the flow is (The coefficient of viscosity of water is 10^{-3} kg m^{-1} s^{-1} and density of water is 10^3 kg m^{-3})

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Options:

A.

turbulant

B.

steady flow

C.

non-viscous

D.

unsteady

Answer: A

Solution:

Reynolds number

$$R_e=\frac{\rho v d}{\eta}$$
$$=\frac{10^3\times0.2\times0.04}{10^{-3}}=8000$$

Since, $R_z>2000$

Thus, flow of water is turbulent.

Question11

Water flows from a tap of diameter 1.5 cm with $75\times10^{-5}\ \mathrm{m}^3\ \mathrm{s}^{-1}$. Coefficient of viscosity of water is 10^{-3} Pa. The flow is

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Options:

A. turbulent with Reynold number less than 6000

B. steady flow with Reynolds number less than 2000

C. turbulent with Reynolds number greater than 6000

D. steady flow with Reynolds number more than 6000

Answer: C

Solution:

Given:

Flow rate, $Q = 7.5 \times 10^{-5}\,\text{m}^3/\text{s}$

Diameter of the tap, $d = 1.5\,\text{cm} = 0.015\,\text{m}$

Coefficient of viscosity, $\mu = 10^{-3}\,\text{Pa}\cdot\text{s}$

Reynolds Number Calculation

To determine the type of flow, we calculate the Reynolds number (R_e) using the formula:

$R_e = \frac{\rho v d}{\mu}$

where:

$\rho = 1000\,\text{kg/m}^3$ (density of water),

v is the velocity of the fluid,

d is the diameter of the tap,

μ is the dynamic viscosity of the fluid.

Velocity of the Fluid

The velocity (v) of the fluid can be calculated using the flow rate equation:

$Q = Av$

where $A = \pi\left(\frac{d}{2}\right)^2$ is the cross-sectional area of the pipe.

$v = \frac{Q}{A} = \frac{Q}{\pi\left(\frac{d}{2}\right)^2}$

Substituting the given values:

$v = \frac{7.5\times10^{-5}}{\pi\times\left(\frac{0.015}{2}\right)^2} \approx 0.42\,\text{m/s}$

Calculate Reynolds Number

Now, substitute the values into the Reynolds number formula:

$R_e = \frac{1000\times0.42\times0.015}{10^{-3}}$

$R_e = 6300$

Interpretation of Reynolds Number

A Reynolds number less than 2000 indicates laminar flow.

A Reynolds number greater than 4000 indicates turbulent flow.

Since the calculated $R_e = 6300$, the flow is turbulent.

Question12

Two cylindrical vessels A and B of different areas of cross-section kept on same horizontal plane are filled with water to the same height. If the volume of water in vessel A is 3 times the volume of water in vessel B, then the ratio of the pressures at the bottom of the vessels A and B is

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Options:

A. $1 : 1$

B. $1 : 3$

C. $1 : 9$

D. $1 : 6$

Answer: A

Solution:

The pressure at the bottom of a vessel due to a liquid column is calculated using the formula:

$p = \rho g h$

where:

ρ is the density of the liquid,

g is the acceleration due to gravity,

h is the height of the liquid column.

In this scenario, both vessels A and B have the same height h of water, and since the density of water and the acceleration due to gravity are constants, we can determine the pressure ratio at the bottom of the two vessels.

The ratio of pressures at the bottom of the vessels is:

$\frac{p_A}{p_B} = \frac{\rho g h_A}{\rho g h_B} = \frac{\rho g h}{\rho g h} = 1$

Thus, the ratio of pressures is:

$p_A : p_B = 1 : 1$

Question13

Water is flowing in streamline manner in a horizontal pipe. If the pressure at a point where cross-sectional area is $10 \mathrm{~cm}^2$ and velocity $1 \mathrm{~ms}^{-1}$ is 2000 Pa , then the pressure of water at another point where the cross-sectional area $5 \mathrm{~cm}^2$ is

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Options:

A. 2500 Pa

B. 2000 Pa

C. 1000 Pa

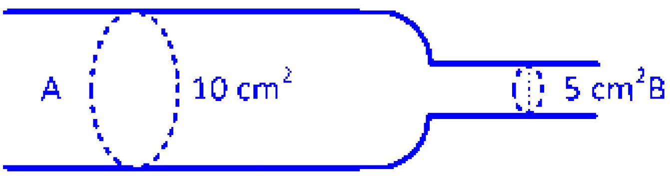
D. 500 Pa

Answer: D

Solution:

Given, pressure $= 2000 \mathrm{~Pa}$

Let the pressure be p at the second point and let velocity $v_2 = v$



Applying equation of continuity,

$$\begin{aligned} A_1 v_1 &= A_2 v_2 \\ 10 \times 1 &= 5 \times v \\ v &= 2 \mathrm{~m/s} \end{aligned}$$

Applying Bernoull's theorem at both point A and B

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h$$

$$2000 + \frac{1}{2} \times 1000 \times 1^2$$
$$=$$
$$p_2 + \frac{1}{2} \times 1000 \times 4$$
$$p_2 =$$

Question14

A spherical ball of radius 1×10^{-4} m and of density $10^4 \mathrm{kgm}^{-3}$ falls freely under gravity through a distance h before entering a tank of water. After entering water if the velocity of the ball does not change, then h is(The coefficient of viscosity of water $9.8 \times 10^{-6} \mathrm{Nsm}^{-2}$)

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Options:

A. 20.4 cm

B. 20.4 mm

C. 20.4 m

D. 10.2 m

Answer: C

Solution:

Given:

Radius of ball, r: 1×10^{-4} m

Density of the ball, ρ: 10^4 kg/m^3

Density of water, σ: 10^3 kg/m^3

Coefficient of viscosity of water, η: 9.8×10^{-6} N s/m^2

The terminal velocity v of a spherical object moving through a fluid can be calculated using the equation:

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

Substitute the given values into the equation:

$v=\frac{2}{9} \times\left(1 \times 10^{-4}\right)^2 \times \frac{\left(10^4-10^3\right)}{9.8 \times 10^{-6}} \times 9.8$

Simplifying the expression gives:

$v=\frac{2}{9} \times 10^{-8} \times \frac{9000}{9.8 \times 10^{-6}} \times 9.8$

$\Rightarrow v=20 \mathrm{~m} / \mathrm{s}$

The distance h required to reach this terminal velocity when falling in air is given by:

$h=\frac{v^2}{2 g}$

Substitute $v=20 \mathrm{~m} / \mathrm{s}$ and $g=9.8 \mathrm{~m} / \mathrm{s}^2$:

$h=\frac{(20)^2}{2 \times 9.8}$

$\Rightarrow h=20.4 \mathrm{~m}$

Question15

A large tank filled water to a height h is to be emptied through a small hole at the bottom. The ratio of the time taken for the level to fall from h to $\frac{h}{2}$ and that taken for the level to fall from $\frac{h}{2}$ to 0 is

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Options:

A. $\sqrt{2}-1$

B. $\frac{1}{\sqrt{2}}$

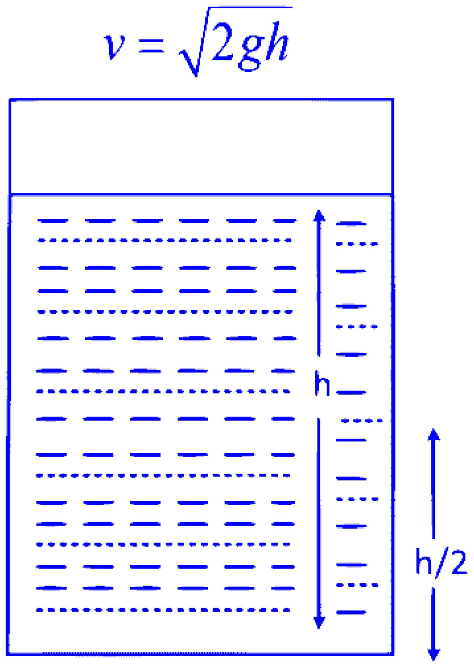
C. $\sqrt{2}$

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

Answer: A

Solution:

According to Torricelli's theorem,



Case (i), Initial height, $h_1 = h$

Final height, $h_2 = \frac{h}{2}$

Case (ii), Initial height, $h_1{}' = \frac{h}{2}$

Final height, $h_2{}' = 0$

From Eq. (i),

$$v = \sqrt{2gh}$$
$$\frac{dh}{dt} = \sqrt{2gh} \Rightarrow dt = \frac{dh}{\sqrt{2gh}}$$

Integrating both side,

$$\int dt = \int_0^h \frac{dh}{\sqrt{2gh}}$$
$$t = \sqrt{\frac{2h}{g}}$$

For $t_1, t_1 = \sqrt{\frac{2}{g}}\left(\sqrt{h} - \sqrt{\frac{h}{2}}\right)$

For $t_2, t_2 = \sqrt{\frac{2}{g}}\left(\sqrt{\frac{h}{2}} - 0\right)$

$$\text{Ratio, } \frac{t_1}{t_2} = \frac{\sqrt{h} - \sqrt{\frac{h}{2}}}{\sqrt{\frac{h}{2}}}$$

$$\Rightarrow \quad \frac{t_1}{t_2} = \frac{\sqrt{h}}{\sqrt{\frac{h}{2}}} - 1$$

$$\frac{t_1}{t_2} = \sqrt{2} - 1$$

Question16

Depth of a river is 100 m magnitude of compressibility of the water is $05 \times 10^{-9}\ \mathrm{N}^{-1}\ \mathrm{m}^2$. The fractional compression in water at the bottom of the river is (acceleration due to gravity $= 10\ \mathrm{m/s}^2$)

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Options:

A. 0.9×10^3

B. 0.5×10^{-3}

C. 2×10^{-3}

D. 1.3×10^{-2}

Answer: B

Solution:

To find the fractional compression of water at the bottom of the river, let's work through the given data:

Given Information:

Depth of the river, $h = 100\,\mathrm{m}$

Compressibility magnitude, $\alpha = 0.5 \times 10^{-9}\,\mathrm{N}^{-1}\mathrm{m}^2$

Acceleration due to gravity, $g = 10\,\mathrm{m/s}^2$

Formula for Fractional Compression:

The fractional compression is given by the formula:

$\left|\frac{\Delta V}{V}\right| = \frac{\Delta p}{B}$

where B is the bulk modulus of the water, and it's the reciprocal of compressibility:

$B = \frac{1}{\alpha}$

Calculation Steps:

Fractional Compression Formula:

$\left|\frac{\Delta V}{V}\right| = \Delta p \cdot \alpha$

Pressure Change (Δp):

The change in pressure due to the weight of the water column is:

$\Delta p = \rho g h$

where:

ρ (density of water) = 10^3 kg/m^3

$g = 10\,\mathrm{m/s^2}$

$h = 100\,\mathrm{m}$

Calculate:

$\Delta p = 10^3 \times 10 \times 100 = 10^6\,\mathrm{N/m^2}$

Substitute into the Fractional Compression Formula:

$\left|\frac{\Delta V}{V}\right| = 10^6 \times 0.5 \times 10^{-9} = 0.5 \times 10^{-3}$

Thus, the fractional compression of water at the bottom of the river is 0.5×10^{-3}.

Question17

Two mercury drops, each with same radius r merged to form a bigger drop. T is the surface tension of single drop, then the surface energy of bigger drop is given by

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Options:

A. $2\pi r^2 T$

B. $2^{\frac{5}{3}} \pi r^2 T$

C. $2\pi r^2 T^2$

D. $2^{\frac{8}{3}} \pi r^2 T$

Answer: D

Solution:

To understand how the surface energy changes when two mercury drops merge, we start by considering the radii of the drops:

Let the radius of each smaller drop be r.

When the two drops merge, the radius of the resulting bigger drop is R.

The volume of a single spherical drop is given by $\frac{4}{3} \pi r^3$. Since the volumes combine when two droplets merge, we have:

$2 \times \frac{4}{3} \pi r^3=\frac{4}{3} \pi R^3$

Simplifying this equation, we find:

$2 \times r^3=R^3$

Taking the cube root of both sides, the radius of the larger drop becomes:

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

Next, we compute the surface energy of the bigger drop. Surface energy (E) is given by the product of the surface tension (T) and the surface area (A) of the drop:

$E=T \cdot A$

The surface area of a sphere is $4 \pi R^2$, hence for the larger drop:

$A=4 \pi R^2=4 \pi\left(2^{1/3} \cdot r\right)^2=4 \pi\left(2^{2/3} \cdot r^2\right)$

Solving further for E:

$E=T \cdot 4 \pi\left(2^{2/3} \cdot r^2\right)=2^{8/3} \pi r^2 T$

Thus, the surface energy of the bigger drop is $2^{8/3} \pi r^2 T$.

Question18

The radius of cross-section of the cylindrical tube of a spray pump is 2 cm . One end of the pump has 50 fine holes each of radius 0.4 mm . If the speed of flow of the liquid inside the tube is $0.04 \mathrm{~ms}^{-2}$. The speed of ejection of the liquid from the holes is

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Options:

A. 6 ms^{-1}

B. 2 ms^{-1}

C. 4 ms^{-1}

D. 3 ms^{-1}

Answer: B

Solution:

To find the speed of ejection of the liquid from the holes, we begin with the given information:

Radius of the cylindrical tube, $R = 2\,\text{cm} = 0.02\,\text{m}$

Number of fine holes, $n = 50$

Radius of each hole, $r = 0.4\,\text{mm} = 0.0004\,\text{m}$

Speed of flow of liquid inside the tube, $v_1 = 0.04\,\text{m/s}$

First, calculate the cross-sectional area of the cylindrical tube:

$$A_1 = \pi R^2 = \pi(0.02)^2 = \pi(0.0004) \approx 0.00125\,\text{m}^2$$

Next, calculate the total cross-sectional area of the 50 holes:

$$\begin{aligned} A_2 &= 50 \times \pi r^2 = 50 \times \pi(0.0004)^2 \\ &= 50 \times \pi(0.00000016) \\ &= 50 \times 0.000000502 \approx 0.0000251\,\text{m}^2 \end{aligned}$$

By using the conservation of mass (continuity equation) which states that the mass flow rate through the tube equals the mass flow rate through the holes, we have:

$$A_1 v_1 = A_2 v_2$$

Therefore, solve for v_2:

$$\begin{aligned} v_2 &= \frac{A_1 v_1}{A_2} \\ &= \frac{0.00125 \times 0.04}{0.0000251} \\ &= \frac{0.00005}{0.0000251} \approx 1.99 \approx 2\,\text{m/s} \end{aligned}$$

Thus, the speed of ejection of the liquid from the holes is approximately $2\,\text{m/s}$.

Question19

If S_1, S_2 and S_3 are the tensions at liquid-air, solid-air and solid-liquid interfaces respectively and θ is the angle of contact at the solid-liquid interface, then

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Options:

A. $S_1 \cos \theta+S_2 \sin \theta=S_3$

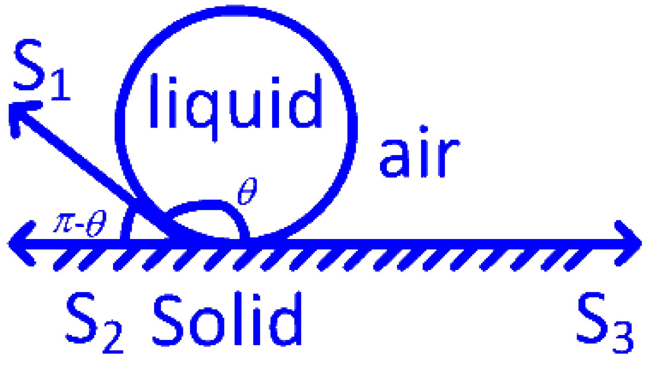
B. $S_1 \cos \theta+S_3=S_2$

C. $S_2 \cos \theta+S_3=S_1$

D. $S_3 \cos \theta+S_1=S_2$

Answer: B

Solution:



$$S_1 \cos (\pi-\theta) l+S_2 l=S_3 l$$
$$\Rightarrow \quad -S_1 \cos \theta+S_2=S_3$$
$$\Rightarrow \quad S_1 \cos \theta+S_3=S_2$$

Question20

216 small identical liquid drops each of surface area A coalesce to form a bigger drop. If the surface tension of the liquid is T. The energy released in the process is

AP EAPCET 2024 - 18th May Morning Shift

Options:

A. 3604 T

B. 180AT

C. 90AT

D. 12041

Answer: B

Solution:

To determine the energy released when 216 small liquid drops coalesce into a larger drop, follow these steps:

Given:

Number of small drops = 216

Surface area of each small drop = $A = 4\pi r^2$

Surface tension of the liquid = T

Calculations:

Volumes:

Volume of one small drop: $\frac{4}{3}\pi r^3$

Total volume for 216 small drops: $216 \times \frac{4}{3}\pi r^3$

Volume of the large drop:

Since volume is conserved, the volume of the large drop is:

$\frac{4}{3}\pi R^3 = 216 \times \frac{4}{3}\pi r^3$

$R^3 = 6r^3 \quad \Rightarrow \quad R = 6r$

Surface Areas:

Total surface area of 216 small drops:

$216 \times 4\pi r^2 = 864\pi r^2$

Surface area of the large drop:

$4\pi(6r)^2 = 144\pi r^2$

Decrease in Surface Area:

$\Delta A = 864\pi r^2 - 144\pi r^2 = 720\pi r^2$

Energy Released:

Using the formula $E = T \cdot \Delta A$:

$E = T \cdot 720\pi r^2$

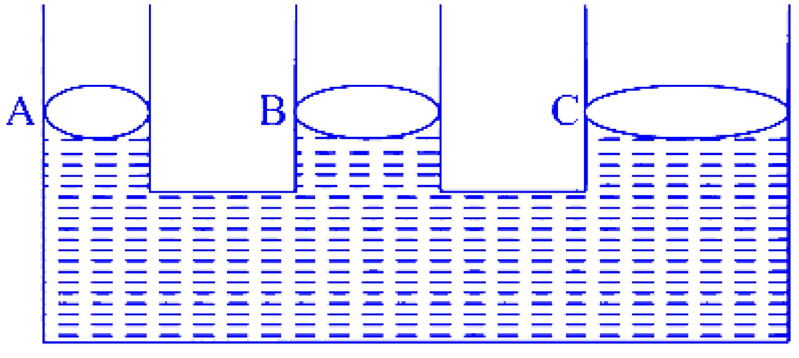
$E = 180 \cdot T \cdot 4\pi r^2$

$E = 180AT$

Thus, the energy released during the coalescence process is $180AT$.

Question21

A hydraulic lift is shown in the figure. The movable pistons A, B and C are of radius 10 cm, 100 m and 5 cm respectively. If a body of mass 2 kg is placed on piston A, the maximum masses that can be lifted by piston B and C are respectively.



AP EAPCET 2022 - 5th July Morning Shift

Options:

A. 200 kg and 500 kg

B. 20 kg and 50 kg

C. 200 kg and 5000 kg

D. 2000 kg and 5000 kg

Answer: A

Solution:

Given,

$r_A = 10 \text{ cm} = 0.1 \text{ m}$
$r_B = 100 \text{ m}$
$r_C = 5 \text{ cm} = 0.05 \text{ m}$

weight placed on piston $A = m \times g$

$= 2 \text{ g}$

Using Pascal's law;

$$\frac{F_A}{A_A} = \frac{F_B}{A_B} = \frac{F_C}{A_C}$$

$$\Rightarrow \quad \frac{2g}{\pi(0.1)^2} = \frac{F_B}{\pi(100)^2} = \frac{F_C}{\pi(0.05)^2} \quad \ldots \text{(i)}$$

From Eq. (i) we have

$$F_B = \frac{2g}{\pi(0.1)^2} \times \frac{\pi(100)^2}{1} = \frac{2 \times 10000 \times g}{0.01}$$
$$= 2 \times 10^6 \text{ g}$$

Similarly, $F_c = \frac{\pi(0.05)^2}{1} \times \frac{2 \text{ g}}{\pi(0.1)^2}$

$= \frac{0.0025}{0.01} \times 2 \text{ g} = 0.50 \text{ g}$

Hence, B can lift mass of 2×10^6 kg and C can lift mass of 0.50 kg.

Therefore, no option is correct.

Question22

In a hydraulic lift, compressed air exerts a force F on a small piston of radius 3 cm . Due to this pressure the second piston of radius 5 cm lifts a load of 1875 kg . The value of F is (Acceleration due to gravity $= 10 \text{ ms}^{-2}$)

AP EAPCET 2022 - 4th July Evening Shift

Options:

A. 1250 N

B. 125 N

C. 6750 N

D. 675 N

Answer: C

Solution:

In a hydraulic lift, compressed air applies a force F on a small piston with a radius of 3 cm. This pressure causes a second piston, which has a radius of 5 cm, to lift a load weighing 1875 kg. We want to determine the value of F, considering the acceleration due to gravity is $10 \mathrm{~ms}^{-2}$.

Using the principle of hydraulic lifts, we have:

$\frac{F_1}{A_1}=\frac{F_2}{A_2}$

This can be rewritten based on the areas of the pistons:

$$
\begin{aligned}
& \Rightarrow \quad \frac{F}{\pi r_1^2}=\frac{m g}{\pi r_2^2} \\
& \Rightarrow \quad \frac{F}{r_1^2}=\frac{m g}{r_2^2} \\
& \Rightarrow \quad \frac{F}{\left(3 \times 10^{-2}\right)^2}=\frac{1875 \times 10}{\left(5 \times 10^{-2}\right)^2} \\
& \Rightarrow \quad F=18750 \times \frac{9 \times 10^{-4}}{25 \times 10^{-4}} \\
& \Rightarrow \quad F=6750 \mathrm{~N}
\end{aligned}
$$

Question23

In a U-shaped tube the radius of one limb is 2 mm and that of other limb is 4 mm . A liquid of surface tension $0.03 \mathrm{~Nm}^{-1}$, density $1500 \mathrm{~kg} \mathrm{~m}^{-3}$ and angle of contact zero is taken in the tube. The difference in the heights of the levels of the liquid in the two limbs is(Acceleration due to gravity $=10 \mathrm{~ms}^{-2}$)

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Options:

A. 3 mm

B. 2.5 mm

C. 1 mm

D. 1.5 mm

Answer: C

Solution:

For the first limb of the tube, height ascent by liquid

$h_1 = \frac{2T\cos\theta}{r_1\rho g}$

$$\begin{aligned} \text{where, } T &= \text{ surface tension ,} \\ \theta &= \text{ angle of contact} \\ r_1 &= \text{ radius of tube,} \\ \rho &= \text{ density of liquid and} \\ g &= \text{ gravitational acceleration.} \end{aligned}$$

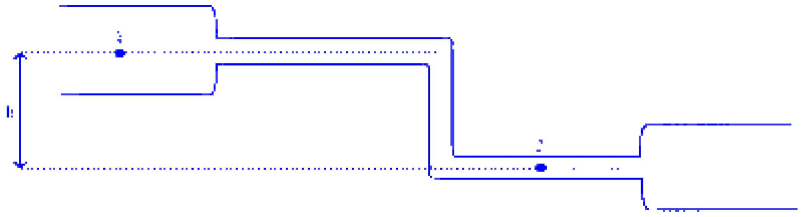
For the second limb of the tube, height ascent by liquid,

$$\begin{aligned} h_2 &= \frac{2T\cos\theta}{r_2\rho g} \\ \therefore h_1 - h_2 &= \frac{2T\cos\theta}{\rho g}\left[\frac{1}{r_1} - \frac{1}{r_2}\right] \end{aligned}$$

$$\begin{aligned} \text{Given, } T &= 0.03\text{Nm}^{-1} \\ r_1 &= 2\text{ mm} = 2\times10^{-3}\text{ m,} \\ r_2 &= 4\text{ mm} = 4\times10^{-3}\text{ m,} \\ \theta &= 0^\circ, \rho = 150\text{ kg m}^{-3}\text{ and } g = 10\text{ ms}^{-2} \\ h_1 - h_2 &= \frac{2\times0.03\times\cos0^\circ}{1500\times10}\left[\frac{1}{2\times10^{-3}} - \frac{1}{4\times10^{-3}}\right] \\ &= 0.001\text{ m} = 1\text{ mm} \end{aligned}$$

Question24

A steady flow of a liquid of density ρ is shown in figure. At point 1, the area of cross-section is $2A$ and the speed of flow of liquid is $\sqrt{2}\text{ ms}^{-1}$. At point 2 , the area of cross-section is A. Between the points 1 and 2, the pressure difference is 100 Nm^{-2} and the height difference is 10 cm . The value of ρ is (Acceleration due to gravity $= 10\text{ ms}^{-2}$)



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Options:

A. $25 \mathrm{~kg} \mathrm{~m}^{-3}$

B. $30 \mathrm{~kg} \mathrm{~m}^{-3}$

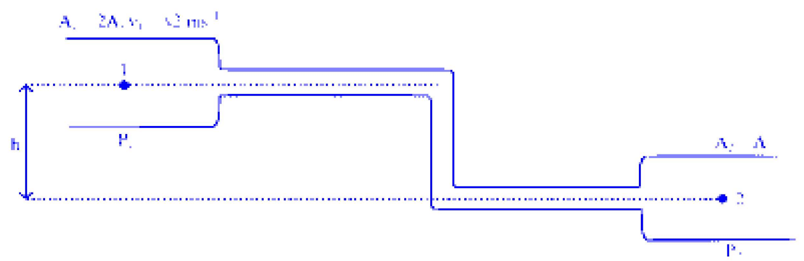
C. $50 \mathrm{~kg} \mathrm{~m}^{-3}$

D. $70 \mathrm{~kg} \mathrm{~m}^{-3}$

Answer: C

Solution:

The given situation is shown below



$h=h_1-h_2=10 \mathrm{~cm}=0.1 \mathrm{~m}$

By the principle of continuity,

$$\begin{aligned} & A_1 v_1=A_2 v_2 \\ \Rightarrow \quad & 2 A \times \sqrt{2}=A \times v_2 \\ \Rightarrow \quad & v_2=2 \sqrt{2} \mathrm{~m} / \mathrm{s} \end{aligned}$$

According to Bernoulli's theorem,

$$p_1+\frac{1}{2}\rho v_1^2+\rho g h_1=p_2+\frac{1}{2}\rho v_2^2+\rho g h_2$$

$$\Rightarrow (p_1-p_2)+\rho g\left(h_1-h_2\right)=\frac{1}{2}\rho\left(v_2^2-v_1^2\right)$$

$$\Rightarrow \quad 100+\rho g(0.1)=\frac{1}{2}\rho\left[(2\sqrt{2})^2-(\sqrt{2})^2\right]$$

$$\Rightarrow \quad 100+\rho\times 10\times 0.1=\frac{1}{2}\rho(8-2)$$

$$\Rightarrow \quad 100+\rho=3\rho$$

$$\Rightarrow \quad 100=2\rho$$

$$\Rightarrow \quad \rho=50 \text{ kg m}^{-3}$$

Question25

Statement (A) When the temperature increases the viscosity of gases increases and the viscosity of liquids decreases.

Statement (B) Water does not wet an oily glass because cohesive force of oil is less than that of water.

Statement (C) A liquid will wet a surface of a solid, if the angle of contact is greater than 90°.

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Options:

A. A, B and C are false.

B. A and B false, C is true.

C. B and C false, A is true.

D. A and C false, B is true.

Answer: C

Solution:

With the increase of temperature, the viscosity of gases increases due to increase of their thermal velocity whereas, viscosity of liquids decreases with the increse of temperature. Water does not wet an oily glass because cohesive force between water molecules is less than adhesive force. between the molecules of oil and glass.

A liquid will wet a surface of a solid if the angle of contact is acute (i.e less than 90°).

Hence, statement (A) is true and statement (B) and (C) are false.

Question26

What causes the free surface of a liquid tohave minimum area?

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Options:

A. Viscosity

B. Surface tension

C. Diffusion

D. Pressure

Answer: B

Solution:

As we know that,

Surface tension is that property of any fluid due towhich it resist any external force due to cohesivenature of fluid that cause liquid to have minimumarea.

Question27

Assertion (A) The upper surface of the wing of an aeroplane is made convex and the lower surface is made concave.

Reason (R) The air currents at the top have smaller velocity and thus less pressure at the bottom than at the top.

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Options:

A. Both A and R are true and R is a correct explanation for A.

B. Both A and R are true but R is not a correct explanation for A.

C. A is true, R is false.

D. A is false, R is true.

Answer: C

Solution:

Since, aeroplane works on Bernoulli's principlein which fast moving air above wing exert lesspressure than air below it which pushes the wingin upward direction, so wings are made convexfrom upper side and concave from lower side.Hence, Assertion is true but Reason is false.

Question28

A glass flask weighting 390 g, having internalvolume 500 cc just floats when half of it isfilled with water. Specific gravity of the glassis

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Options:

A. 2.8

B. 1.8

C. 1.0

D. 2.5

Answer: A

Solution:

Given,

Weight of glass, $W = 390$ g

internal volume, $V_i = 500$ cc

Let specific gravity of glass $= \rho$

Density of water $= 1\ \text{gcc}^{-1}$

As we know that,

$$\text{Density } (d) = \frac{\text{Mass } (m)}{\text{Volume } (V)}$$
$$\Rightarrow \quad m = dV \Rightarrow \left(390 + \frac{500}{2}\right) = 1 \times V$$
$$\Rightarrow \quad (390 + 250) = V \Rightarrow V = 640 \text{ cc}$$
$$\therefore \text{ Volume of glass, } V_g = V - V_{\text{in}}$$
$$= 640 - 500 = 140 \text{ cc}$$
$$\therefore \rho = \frac{390}{140} = 2.78 \text{ gcc}^{-1} = 2.8 \text{ gcc}^{-1}$$

Question29

Water does not wet an oily glass because

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Options:

A. cohesive force of oil is greater than adhesive force between oil and glass

B. cohesive force of oil is greater than cohesive force of water

C. oil repels water

D. cohesive force of water is greater than adhesive force between water and oil molecules

Answer: D

Solution:

Cohesive force is defined as the force ofattraction between intermolecular particles. Since,cohesive force between the molecules of water isgreater than adhesive force between water and oilmolecules.

$\therefore$ Water does not wet glass.

Question30

Identify the incorrect statement regarding Reynold's number (R_e).

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Options:

A. For $R_e < 1000$, flow is laminar.

B. For $1000 < R_e < 2000$, flow is steady.

C. For $R_e > 2000$, flow is turbulent.

D. R_e is a dimensionless number.

Answer: C

Solution:

As we know that,

Reynold's number (R_e) is used to determine the nature of flow of water.

If R_e lies between 0 to 2000, then flow is laminar and steady.

For $200 \leq R_e < 300$. flow is unstable.

And for $R_e > 3000$, flow is turbulent.

$\therefore$ Option (c) is incorrect.

Question31

The lower end of a capillary tube is dippedinto water and it is observed that the waterin capillary tube rises by 7.5 cm. Find theradius of the capillary tube used, if surfacetension of water is 7.5

$\times 10^{-2}$ Nm^{-1}. Angle of contact between water and glass is 0ϒ and acceleration due to gravity is 10 ms^{-2}.

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Options:

A. 0.2 cm

B. 0.1 cm

C. 0.4 mm

D. 0.2 mm

Answer: D

Solution:

Given, capillary rise, $H = 7.5 \text{ cm} = 7.5 \times 10^{-2} \text{ m}$

Surface tension, $T = 7.5 \times 10^{-2} \text{Nm}^{-1}$

Angle of contact, $\theta = 0^\circ$

Acceleration due to gravity $= 10 \text{ ms}^{-2}$

Let radius of capillary tube be R.

Density of water, $\rho = 1000 \text{ kg/m}^3$

Since, $H = \frac{2T\cos\theta}{\rho g R}$

$\Rightarrow \quad R = \frac{2T\cos\theta}{\rho g H} = \frac{2\times7.5\times10^{-2}\times\cos0^\circ}{1000\times10\times7.5\times10^{-2}}$

$= 2 \times 10^{-4} \text{ m} = 0.2 \text{ mm}$

Question32

An ideal liquid flows through a horizontaltube of variable diameter. The pressure islowest where the

Options:

A. velocity is highest

B. velocity is lowest

C. diameter is largest

D. velocity is intermediate

Answer: A

Solution:

Given, horizontal tube of variable diameter By using equation of continuity

$Av=$ constant .... (i)

where, A is area of cross-section and v is velocity of fluid through that cross-section.

As, $p=F/A \Rightarrow A=F/p$

Substituting in Eq. (i), we get

$F/p \cdot v=$ constant

If force is same.

$\therefore \quad \frac{v}{p}=$ constant

If pressure is least, then velocity is highest.
