Fluid Mechanics

Question1

A horizontal pipe carries water in a streamlined flow. At a point along the pipe, where the cross-sectional area is $10\ \text{cm}^{-2}$, the velocity of water is $1\ \text{ms}^{-1}$ and the pressure is 2000 Pa . What is the pressure of water at another point where the cross-sectional area is $5\ \text{cm}^2$?

[Density of water $= 1000\text{kgm}^{-3}$]

KCET 2025

Options:

A. 300 Pa

B. 400 Pa

C. 500 Pa

D. 200 Pa

Answer: C

Solution:

To solve this problem, we apply the principles of fluid dynamics, specifically the continuity equation and Bernoulli's equation.

Using the Continuity Equation:

The continuity equation for fluid flow states that the product of the cross-sectional area of the pipe and the fluid velocity must remain constant:

$A_1V_1 = A_2V_2$

Given:

$A_1 = 10\,\text{cm}^2 = 10 \times 10^{-4}\,\text{m}^2$

$V_1 = 1\,\text{m/s}$

$A_2 = 5\,\text{cm}^2 = 5 \times 10^{-4}\,\text{m}^2$

Solving for V_2:

$V_2 = \frac{A_1 V_1}{A_2} = \frac{10 \times 10^{-4} \times 1}{5 \times 10^{-4}} = 2\,\text{m/s}$

Applying Bernoulli's Equation:

Bernoulli's equation for steady, incompressible flow along a streamline is:

$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$

Where:

$P_1 = 2000\,\text{Pa}$

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

Rearranging to find P_2:

$P_2 = P_1 + \frac{1}{2}\rho(V_1^2 - V_2^2)$

Substituting the known values:

$P_2 = 2000 + \frac{1}{2} \times 1000 \times (1^2 - 2^2)$

$P_2 = 2000 + \frac{1}{2} \times 1000 \times (1 - 4)$

$P_2 = 2000 + 500 \times (-3) = 2000 - 1500 = 500\,\text{Pa}$

Thus, the pressure of the water at the second point in the pipe is $500\,\text{Pa}$.

Question2

While determining the coefficient of viscosity of the given liquid, a spherical steel ball sinks by a distance $\text{h} = 0.9\text{ m}$. The radius of the ball $\text{r} = \sqrt{3} \times 10^{-3}\text{ m}$. The time taken by the ball to sink in three trails are tabulated as follows.

Trial No.	Time taken by the ball to fall by h (in second)
1.	2.75
2.	2.65
3.	2.70

The difference between the densities of the steel ball and the liquid is 7000 kg m^{-3}. If $g = 10 \text{ ms}^{-2}$, then the coefficient of viscosity of the given liquid at room temperature is

KCET 2025

Options:

A. 0.14 Pa.s

B. 0.14×10^{-3} Pa. s

C. 14 Pa.s

D. 0.28 Pa.s

Answer: A

Solution:

To determine the coefficient of viscosity of a liquid, a spherical steel ball sinks a distance of $h = 0.9\,\text{m}$. The ball's radius is $r = \sqrt{3} \times 10^{-3}\,\text{m}$. The time taken by the ball to sink as measured in three trials is shown in the table below:

Trial No.	Time to sink h (in seconds)
1	2.75
2	2.65
3	2.70

The density difference between the steel ball and the liquid is $7000\,\text{kg/m}^3$, and the gravitational acceleration $g = 10\,\text{m/s}^2$. We aim to calculate the coefficient of viscosity of the liquid at room temperature.

Calculations:

Average Time:

$$t_{avg} = \frac{2.75+2.65+2.70}{3} = 2.7\,\text{seconds}$$

Terminal Velocity:

$$\text{Terminal velocity} = \frac{h}{t_{avg}} = \frac{0.9}{2.7} = \frac{1}{3}\,\text{m/s}$$

Coefficient of Viscosity:

$$\eta = \frac{2}{9} \frac{\pi r^2 g(\rho_{\text{steel}} - \rho_{\text{liquid}})}{v_t}$$

Substituting the values,

$\eta = \frac{2}{9} \times \frac{\pi \times (1.732 \times 10^{-3})^2 \times 10 \times 7000}{\frac{1}{3}}$

Simplifying these terms, we find:

$\eta = 0.14 \, \text{Pa.s}$

The coefficient of viscosity of the liquid is $0.14 \, \text{Pa.s}$.

Question3

Water flows through a horizontal pipe of varying cross-section at a rate of $0.314 \text{ m}^3 \text{ s}^{-1}$. The velocity of water at a point where the radius of the pipe is 10 cm is

KCET 2024

Options:

A. 0.1 ms^{-1}

B. 1 ms^{-1}

C. 10 ms^{-1}

D. 100 ms^{-1}

Answer: C

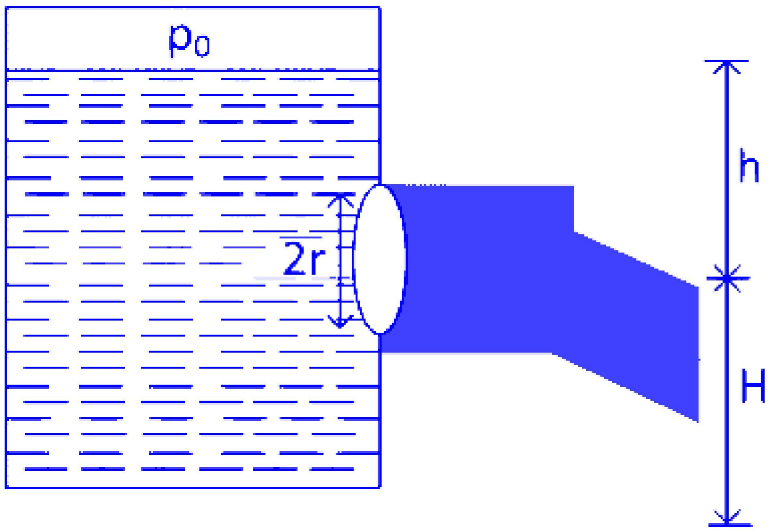
Solution:

$$\begin{aligned} \text{Given, flow rate, } Q &= 0.314 \text{ m}^3 \text{ s}^{-1} \\ r &= 10 \text{ cm} = 0.1 \text{ m} \\ &= 10^{-1} \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Since,} \quad Q &= Av \\ 0.314 &= \pi r^2 v \\ 0.314 &= 314 \times 10^{-2} v \\ \Rightarrow \quad v &= 10 \text{ m/s} \end{aligned}$$

Question4

A closed water tank has cross-sectional area A. It has a small hole at a depth of h from the free surface of water. The radius of the hole is r so that $r \ll \sqrt{\frac{A}{\pi}}$. If p_o is the pressure inside the tank above water level and p_a is the atmospheric pressure, the rate of flow of the water coming out of the hole is (ρ is density of water)



KCET 2023

Options:

A. $\pi r^2 \sqrt{2gh}$

B. $\pi r^2 \sqrt{2gh + \frac{2(p_0 - p_a)}{\rho}}$

C. $\pi r^2 \sqrt{2gH}$

D. $\pi r^2 \sqrt{gh + \frac{2(p_0 - p_a)}{\rho}}$

Answer: B

Solution:

From Bernoulli's principle we have

$$\frac{1}{2}\rho v^2 + p_0 + \rho g h = \frac{1}{2}\rho v_A^2 + p_A + \rho g(0)$$

$$p_0 - p_A + \rho g h = \frac{1}{2}\rho v_A^2 - \frac{1}{2}\rho v^2$$

$$\Rightarrow v^2 = \frac{2\left(p_0 - p_A\right)}{\rho} + \frac{2\rho g h}{P} \quad (\because v = 0 \text{ at top})$$

$$\Rightarrow v = \sqrt{\frac{2\left(p_0 - p_A\right)}{\rho} + 2gh}$$

Water coming out of hole $=$ area $\times$ velocity

$= \pi r^2 \sqrt{2gh + \frac{2(p_0 - p_A)}{\rho}}$

Question5

Two capillary tubes P and Q are dipped vertically in water. The height of water level in capillary tube P is $\frac{2}{3}$ of the height in capillary tube Q. The ratio of their diameter is

KCET 2021

Options:

A. 2 : 3

B. 3 : 2

C. 3 : 4

D. 4 : 3

Answer: B

Solution:

As we know, height of capillary rise or fall of a liquid in a capillary tube is given as

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

$$\Rightarrow \quad h \propto \frac{1}{r} \quad \text{..... (i)}$$

where, r is the radius of the capillary tube. Given, height of water level in capillary tube $P = \frac{2}{3}$ height of water in capillary tube Q.

$$\Rightarrow \quad h_P = \frac{2}{3} h_Q$$
$$\text{or} \quad \frac{h_P}{h_Q} = \frac{2}{3}$$

From Eq. (i), we can write

$$\frac{h_P}{h_Q} = \frac{r_Q}{r_P}$$
$$\Rightarrow \quad \frac{2}{3} = \frac{r_Q}{r_P}$$
$$\text{or} \quad r_P : r_Q = 3 : 2$$

As diameter of the tube is equals to twice the radius.

So, $\frac{(\text{diameter} \quad)_P}{(\text{diameter} \quad)_Q} = \frac{3}{2}$

Question6

Iceberg floats in water with part of it submerged. What is the fraction of the volume of iceberg submerged, if the density of ice is $\rho_i = 0.917 \text{ g cm}^{-3}$?

KCET 2020

Options:

A. 0.917

B. 1

C. 0.458

D. 0

Answer: A

Solution:

Density of ice, $\rho_i = 0.917 \text{ g cm}^{-3}$

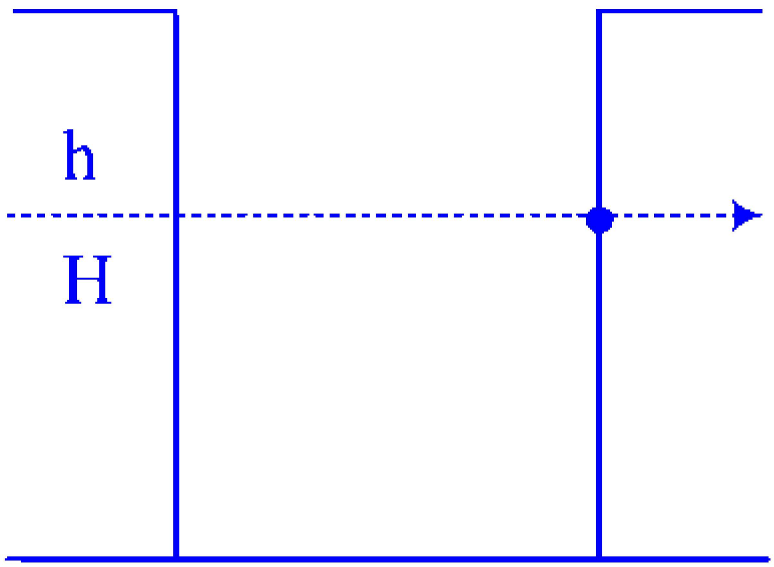
Fraction of the volume of iceberg submerged in water is given as

$$\frac{\text{Volume of iceberg submerged in water}}{\text{Volume of iceberg}}$$

$$= \frac{\text{density of ice}}{\text{density of water}} = \frac{0.917 \text{ g cm}^{-3}}{1 \text{ g cm}^{-3}} = 0.917$$

Question7

A cylindrical container containing water has a small hole at height of $H = 8$ cm from the bottom and at a depth of 2 cm from the top surface of the liquid. The maximum horizontal distance travelled by the water before it hits the ground x is



KCET 2019

Options:

A. 8 cm

B. $4\sqrt{2}$ cm

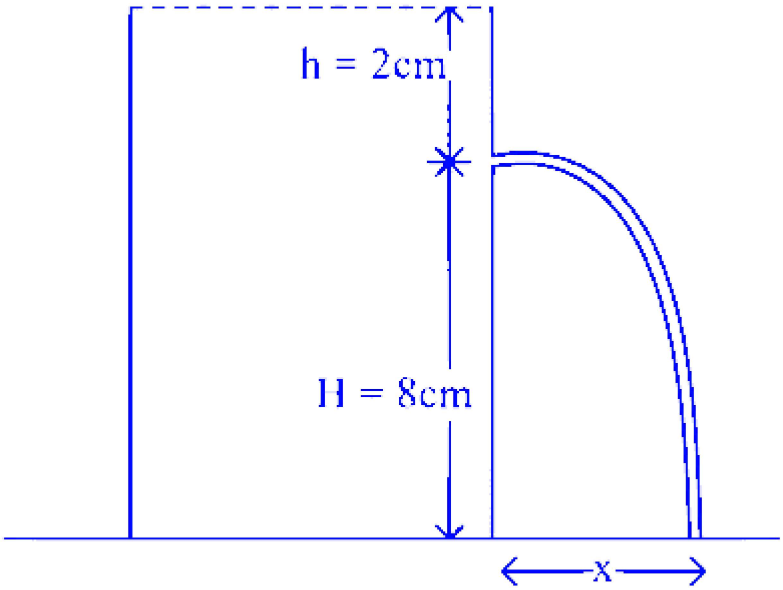
C. 4 cm

D. 6 cm

Answer: A

Solution:

Situation of cylindrical container is shown in the figure



Horizontal range x is given by, $x = v\sqrt{\frac{2H}{g}}$ .... (i)

where, v is velocity of efflux.

$\therefore \quad v = \sqrt{2gh} = \sqrt{2 \times 10 \times 2 \times 10^{-2}} = 2\sqrt{10^{-1}}\ \mathrm{m/s}$

$\therefore$ From Eq (i)

$$x = 2\sqrt{(10^{-1})} \times \sqrt{\frac{2 \times 8 \times 10^{-2}}{10}} = 2\sqrt{10^{-1} \times 16 \times 10^{-3}}$$
$$= 8 \times 10^{-2}\ \mathrm{m} = 8\ \mathrm{cm}$$

Question8

An aluminium sphere is dipped into water. Which of the following is true?

KCET 2019

Options:

A. Buoyancy will be less in water at 0°C than that is water at 4°C

B. Buoyancy will be more in water at 0°C than that in water at 4°C

C. Buoyancy in water at 0°C will be same as that in water at 4°C

D. Buoyancy may be more or less in water 4°C depending on the radius of the sphere

Answer: A

Solution:

Buoyancy depends on the fluid in which the body is immersed. More the density, more is the buoyancy, since density of water at $4^{\circ}C$ is maximum, so the buoyancy at $4^{\circ}C$ will be maximum. So, (a) is correct.

Question9

The pressure at the bottom of a liquid tank is not proportional to the

KCET 2018

Options:

A. acceleration due to gravity

B. density of the liquid

C. height of the liquid

D. area of the liquid surface

Answer: D

Solution:

The pressure at the bottom of a liquid tank is determined using the hydrostatic pressure formula:

$P = \rho g h$

where:

ρ is the density of the liquid,

g is the acceleration due to gravity, and

h is the height of the liquid column.

Notice that the formula does not include any term for the area of the liquid surface. Therefore, the pressure is not proportional to the:

• Area of the liquid surface

So, the correct answer is:

Option D

Area of the liquid surface

Question10

'Hydraulic lift' works on the basis of

KCET 2017

Options:

A. Stoke's law

B. Bernoulli's law

C. Pascal's law

D. Toricelli's law

Answer: C

Solution:

The hydraulic lift operates based on Pascal's law.

Here's a brief explanation:

Pascal's Law: States that when pressure is applied to a confined fluid, the pressure change is transmitted equally throughout the fluid. The mathematical expression is:

$P = \frac{F}{A}$

where:

P is the pressure,

F is the force applied,

A is the area over which the force is applied.

Application in Hydraulic Lifts: In a hydraulic lift, a small force applied on a small piston creates a pressure that is transmitted through the fluid to a larger piston. This results in a larger force being exerted by the larger piston, allowing it to lift heavy objects.

Therefore, the correct answer is:

Option C: Pascal's law.
