

IMPORTANT QUESTIONS CLASS – 11 PHYSICS

CHAPTER -9 MECHANICAL PROPERTIES OF FLUIDS

Question 1.

Prove Archimedes' Principle mathematically.

Answer:

Let W_1 and W_2 be the weights of the body in the air and when completely immersed in a liquid respectively.

$\therefore$ Loss in weight of body inside the liquid = $W_1 - W_2$.

Proof: Let h = height of a body lying at a depth X below the free surface of a liquid of density p .

Let a = area of the face of the body parallel to the horizontal.

If P_1 and P_2 be the pressures at the upper and lower face of the

$$P_1 = x \rho g \dots (i)$$

$$P_2 = (x + h) \rho g \dots (ii)$$

If F_1 and F_2 be the thrust on the upper and lower face of the body, then

$$F_1 = P_1 a = x \rho g a \dots (iii)$$

and acts vertically downward.

$$\text{and } F_2 = P_2 a = (x + h) \rho g a \dots (iv)$$

and acts vertically upward.

As $F_2 > F_1$, so net thrust acts on the body in the upward direction and is called upthrust (U)

$\therefore$

or

where

$\therefore$

$$U = F_2 - F_1 = a(x + h) \rho g - ax \rho g$$

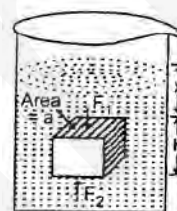
$$U = ah \rho g = V \rho g \dots (v)$$

$$V = ah = \text{volume of the body}$$

$$W_2 = \text{apparent weight of the body}$$

$$= W_1 - U$$

$$= Mg - V \rho g$$



As V = volume of the body = volume of liquid displaced by the body, so $V\rho$ is the mass of the liquid displaced

$\therefore V\rho g = \text{weight of the displaced liquid}$

Thus loss in weight of the body when sunk in the liquid = weight of the liquid displaced.

Question 2.

Derive the condition of floatation of the body.

Answer:

When a body floats in a liquid with a part submerged in the liquid, the weight of the liquid displaced by the submerged part is always equal to the weight of the body.

Let V = volume of the body

σ = density of its material

ρ = density of the liquid in which the body floats such that its volume V' is outside the liquid

Then the volume of the body inside the liquid = $V - V'$

Weight of the displaced liquid = $(V - V') \rho g$

Also weight of the body = $V\sigma g$

$$\begin{aligned} \text{i.e.} \quad (V - V') \rho g &= V\sigma g \\ \text{or} \quad V' &= \frac{(\rho - \sigma)V}{\rho} \end{aligned}$$

For the body to float,

weight of the liquid displaced by the submerged part = weight of the body.

Question 3.

(a) Why the wings of an airplane are rounded outwards (i.e. more curved) while flattened inwards?

What is this shape called?

Answer:

The special design of the wings which is slightly convex upward and concave downward increases velocity at the upper surface and decreases it at the lower surface. So according to Bernoulli's Theorem, the pressure on the upper side is less than the pressure on the lower side.

This difference of pressure provides the additional thrust on the foil called lift. This is called airfoil or aerofoil. It is a solid piece that is so shaped that it an upward vertical. force is produced on it when it moves horizontally through the air.

(b) What is an ideal liquid?

Answer:

A liquid is said to be ideal if:

1. It is incompressible.

2. It is non-viscous.
3. Its flow is steady i.e. stream-line.

Question 4 .

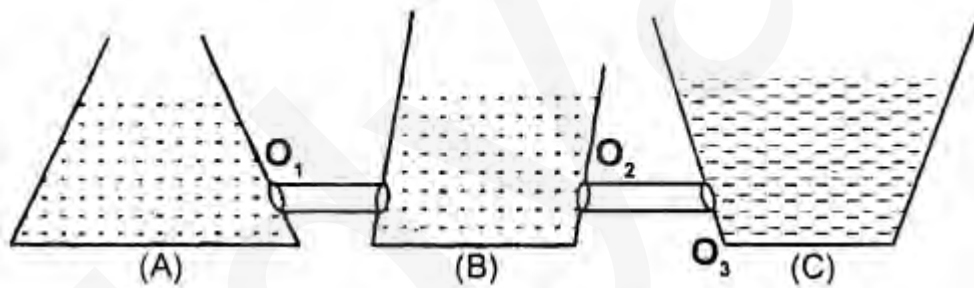
What is a hydrostatic paradox? Explain. Is it really a paradox?

Answer:

It is defined as the inability of a liquid to flow from a vessel having more liquid to a vessel having lesser liquid when the liquid level is the same. Consider three vessels of different shapes but the same base area as shown., The level of water is kept the same in A, B, and C. So the quantity of water is different in the vessels. However, the thrust on the bottom is the same in all of them. It may appear paradoxical

We know that

1. the pressure at a point depends on the height of the liquid column.
2. It does not depend on the quantity of the liquid and
3. thrust is the product of pressure and area of the surface. ,



In the given three cases the pressure at the base is $h\rho g$ and since the area of the base is the same in all the three cases hence the thrust = $h\rho g a$ where a = area of the base

So, we see that the thrust is the same in A, B, and C even though the quantity of liquid is different in them.

No. In fact, there is no paradox as such because the pressure depends on the depth of point and not on the quantity of liquid. Here O_1 , O_2 , and O_3 lie in the same horizontal plane, so the pressure is the same.

Question 5.

State Pascal's law. How does it get changed in the presence of gravity?

Answer:

Pascal's law states that for a liquid in equilibrium, the pressure is the same everywhere (provided the effect of gravity can be neglected), It may also be stated as "the pressure

applied anywhere on an enclosed fluid is transmitted equally in all directions throughout the fluid”.

Effect of gravity: Consider a liquid of density ρ contained in a vessel. Let us find the pressure difference between the points x and y . Let us imagine a cylinder of liquid whose faces 1 and 2 are at height h . The cylinder is in equilibrium.

Let P_1 = Pressure at face 1, pressure P_2 at face 2 and the weight of the liquid in cylinder mg . Here m is the mass of the imaginary fluid cylinder. If F_1 and F_2 be the forces on the upper and lower faces of the cylinder, then $F_1 = P_1 A$, $F_2 = P_2 A$. As the cylinder of liquid is in equilibrium, so the net force on it is zero.

$$\text{i.e. } (F_1 + mg) - F_2 = 0$$

$$\text{or } P_1 A + mg - P_2 A = 0$$

$$\text{or } (P_2 - P_1)A = mg$$

where A is the base area of the imaginary cylinder. Since mass of the liquid cylinder $m = V\rho = Ah\rho$ ($\because V = Ah$)

$$\therefore (P_2 - P_1)A = Ah\rho g$$

$$\text{or } (P_2 - P_1) = h\rho g$$

If the point x lies on the surface, then $P_1 = 0$ and Let $P_2 = P$

$$\therefore P = h\rho g$$

Equation (1) gives the expression for the pressure applied by a liquid column of height h .

Question 6.

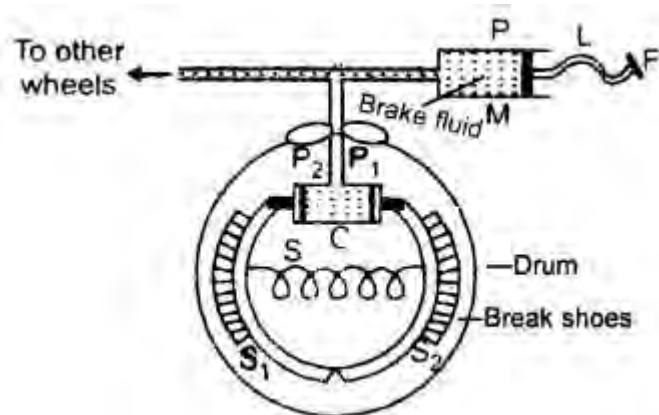
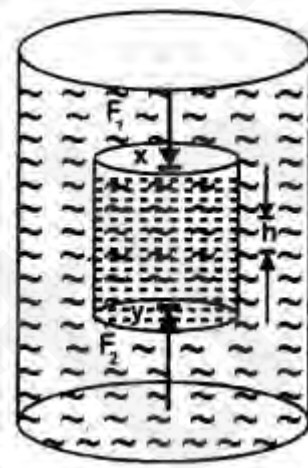
Draw a diagram showing the construction of a hydraulic brake slow does it work?

Answer:

The diagram showing various parts of a hydraulic brake is given here.

On applying foot pressure on the pedal, the brake fluid flows*from the master cylinder transmitting the pressure from P_1 to P_2 equally.

This expands the brake shoe and stops the wheel. When pressure is released at the foot pedals, the spring brings the



brake shoe to its original position and brake fluid is forced back to the master cylinder.

Question 7.

Stake's law deals with spherical bodies moving through a viscous fluid. Give its statement and derive it dimensionally.

Answer:

Stake's law may be stated as "the viscous drag experienced by a spherical body of radius r moving in a fluid of viscosity η with a terminal velocity v is given by

$$F = 6\pi\eta rv$$

Derivation: Let F depends on η , r , and v , we can write

$$F = k\eta^a r^b v^c \dots (1)$$

where k = Proportionality constant.

On writing dimensional formula on both sides, we have

$$\begin{aligned} [MLT^{-2}] &= [ML^{-1}T^{-1}]^a [L]^b [LT^{-1}]^c \\ &= [M^a L^{-a+b+c} T^{-a-c}] \end{aligned}$$

Comparing powers of M , L , T on both sides we have,

$$\begin{aligned} \boxed{a=1}, & \quad -a+b+c = 1 \\ \text{or} & \quad b+c = 2 \\ \text{and} & \quad -2 = -(a+c) \\ \text{or} & \quad c = 2-1 \\ \text{or} & \quad c = 1 \\ \therefore & \quad b = 2-c = 2-1 \\ \text{or} & \quad b = 1 \end{aligned}$$

$$\therefore a = 1, b = 1, c = 1$$

$\therefore$ Putting values of a , b , c in equation (1), we get

$$\begin{aligned} F &= k\eta^1 r^1 v^1 \\ &= k\eta rv. \end{aligned}$$

For spherical bodies Stoke found k to be 6π

$$\therefore F = 6\pi\eta rv$$

Hence, derived.

Question 8.

A ring is cut from a platinum tube having 8.5 cm internal and 8.7 cm external diameter. It is supported horizontally from a pan of balance so that it comes in contact with water in a glass vessel. What is the surface tension of water if an extra 3.97 g weight is required to pull it away from water ($g = 980 \text{ ms}^{-2}$)?

Answer:

Here, $m = 3.97 \text{ gm}$

$r_1 = 8.5 \text{ cm}$

$r_2 = 8.7 \text{ cm}$

$T = ?$

The water is in contact with the inner and outer circumference of the ring. To pull it out, work has to be done against forces due to surface tension.

$$\begin{aligned} \text{i.e.} \quad F &= T \times 2\pi r_1 + T \times 2\pi r_2 \\ &= T [2\pi (r_1 + r_2)] \\ &= 2\pi \times T (r_1 + r_2) \\ \text{Also} \quad F &= mg \\ \therefore T \times 2\pi (r_1 + r_2) &= mg \\ \text{or} \quad T &= \frac{mg}{2\pi(r_1 + r_2)} \\ &= \frac{3.97 \times 980}{2 \times 3.142 \times (8.5 + 8.7)} \\ &= 72.07 \text{ dyne cm}^{-1}. \end{aligned}$$

Question 9.

A stone of density 2.5 g cm^{-3} completely immersed in seawater is allowed to sink from rest. Calculate the depth to which the stone would sink in 2s. The specific gravity of seawater is 1.025 and acceleration due to gravity is 980 cm s^{-2} . Neglect the effect of friction.

Answer:

Here, $g = 980 \text{ cm s}^{-2}$.

$\rho_1 = \text{density of stone} = 2.5 \text{ g cm}^{-3}$.

Specific gravity of sea water = 1.025

$\therefore \rho_2 = \text{density of sea water} = 1.025 \text{ g cm}^{-3}$.

Now let $m = \text{mass of stone}$.

$\therefore V = \text{volume of stone} = \frac{\text{mass}}{\rho_1} = \frac{m}{2.5} \text{ cm}^3$.

and this is equal to the volume of the displaced seawater.

$\therefore M = \text{mass of seawater displaced}$.

$= \rho_2 \times V$

$= 1.025 \times \frac{m}{2.5} \text{ gram}$

∴ Weight of sea water displaced = $\frac{1.025}{2.5} \times g$
 If W_1 be the weight of the stone in seawater, then
 W_1 = weight of stone – the weight of seawater displaced.

∴ Downward acceleration 'a' of stone in seawater is given by

Now let S = depth to which stone sinks. $t = 2s$, $u = 0$

∴ Using the relation,

Question 10.

Krishna went sightseeing to a nearby river along with his physics teacher. He noticed that the wind was blowing from the side and the sailboat still continue to move forward. He was surprised. He asked his physics teacher an explanation of this situation. The teacher has noticed his “interest explained the concept through a small example.

The physics of sailing is very interesting in that sailboats do not need the wind to push from behind in order to move. The wind can blow from the side and the sailboat can still move forward.

The answer lies in the well-known principle of aerodynamic lift. Imagine you are a passenger in a car as it's moving along, and you place your right hand out the window, if you tilt your hand in the clockwise sense your hand will be pushed backward and up. This is due to the force of the air which has a sideways component and upwards component (therefore your hand is pushed backward and up).

(a) What values could you find- in Krishna?

Answer:

Krishna is very interested in learning the subject; also he is interested in knowing how science helps in understanding the day-to-day experiences, observant, has the courage to ask questions.

(b) Also explain what the Magnus effect is.

Answer:

The difference in velocities of air above the ball is relatively larger than below. Hence, there is a pressure difference between the lower and upper faces and there is a net upward force on the ball. This dynamic lift due to spinning is called the Magnus effect.

$$\begin{aligned}
 &= mg - mg = mg - \frac{1.025}{2.5} mg \\
 &= \left(1 - \frac{1.025}{2.5}\right) mg \\
 &= \frac{2.5 - 1.025}{2.5} mg \\
 &= \frac{1.475}{2.5} \times mg
 \end{aligned}$$

$$\begin{aligned}
 a &= \frac{W_1}{m} = \frac{1.475}{2.5} \times 980 \\
 &= 578.2 \text{ cm s}^{-2}
 \end{aligned}$$

$$\begin{aligned}
 S &= ut + \frac{1}{2} at^2, \text{ we get} \\
 S &= 0 + \frac{1}{2} \times 578.2 \times 2^2 \\
 &= 1156.4 \text{ cm} \\
 &= 11.56 \text{ m.}
 \end{aligned}$$