FLUID MECHANICS
PRESSURE AND PRESSURE ENERGY

POINTS TO REMEMBER

1. **Fluid mechanics** is a branch of physics which deals with the study of nature and properties of flow of fluid.

2. **Fluids:** A substance, such as liquids and gases, which can flow is known as fluid..

3. **Fluid resistance** is the force exerted by a fluid opposing the motion of a body moving through it.

4. **Pressure energy** is the energy possessed by a liquid by virtue of its pressure.

   Pressure energy = PV

   Where P $\rightarrow$ pressure

   V $\rightarrow$ volume of the liquid per unit time

5. **Static pressure:** It is the pressure on a surface due to fluid at rest or due to another surface at rest.

6. **Dynamic** or **Kinetic pressure:** It is the pressure on a surface due to the fluid in motion.

7. **Lateral Pressure:** It is the pressure exerted by the fluid on the sides of the container.

8. **Principle of Buoyancy:** When every body is partly or wholly immersed in a liquid, a force called buoyancy force (or) buoyancy (up thrust) acts on the body in the upward direction.

9. Up thrust acts at the centre of the liquid displaced, called centre of Buoyancy

10. Up thrust does not depend on the mass, shape and size of the body.

11. Up thrust depends on the volume of the solid inside the liquid.

12. Up thrust is proportional to the acceleration due to gravity (g)

13. **Static lift:** The upward force (lift) experienced by a body in a fluid which is at rest is known as static lift.

14. **Dynamic lift:** The upward force experienced by a body in a fluid which is in motion is known as dynamic lift.

15. **Aerodynamic lift:** The up thrust experienced by the body when it is moving in air is known as aerodynamic lift.

16. **Streamline flow:** Every particle of the liquid follows the path of its preceding one. The mass of the liquid entering the tube is equal to the mass of the liquid leaving the tube. The path followed by the particle is called streamline**.**

17. **Turbulent Flow:** The velocity of the particle crossing any particular point of the liquid is not constant in both magnitude and in direction.

18. **Critical velocity (V_c):** The velocity of the liquid above which the flow becomes streamline is called critical velocity

$$\text{Critical velocity } (V_c) = \frac{K\eta}{\rho d}$$

ρ – Density of the liquid and d – Diameter of the pipe

If K < 2000, the flow is streamline or laminar,

If K > 3000 the flow is turbulent.

If K is in between 2000 and 3000 the flow is unsteady.

19. **Poiseulli's Formula:** For less viscous liquids (ex. Water), flowing in a capillary tube of radius r and length l, the volume of the liquid flow per sec (or) volume flux is given by $V = \frac{\pi P r^4}{8\eta l}$

Where η the co-efficient of viscosity of the liquid and P is is the pressure difference between the ends of the capillary tube.

20. Fluid resistance $R = \frac{8\eta l}{\pi r^4}$

21. **Principle of continuity:** It states that when an incompressible and non viscous fluid is flowing through a tube of non-uniform cross section from one point to another, then at any point, the product of area of cross section and velocity of the fluid remains constant.

AV= constant Or $A_1V_1 = A_2V_2$

22. **Bernoulli's Theorem:** It states that when an in compressible and non-viscous fluid is flowing through a tube of non-uniform cross section from one point to another, then at any point the total energy per unit volume is constant.

$$P + \frac{1}{2}\rho V^2 + \rho gh = const$$

Where, P $\rightarrow$ pressure energy per unit volume,

1/2 ρv^2 $\rightarrow$ kinetic energy per unit volume

ρ gh $\rightarrow$ potential energy per unit volume

LONG ANSWER QUESTIONS

1. State Bernoulli's theorem. From conservation of energy in a fluid flow through a tube, derive Bernoulli's theorem. Give an application of Bernoulli's theorem.

A. **Statement:** It states that "when a non-viscous, incompressible fluid flows steadily, the sum of the pressure energy, kinetic energy and potential energy per unit volume of the fluid remains constant at all points in the path of the flow". (March 2010, **March 2008**)

Mathematically Bernoulli's theorem can be stated as $P + \rho gh + \frac{1}{2}\rho v^2 = \text{Constant}$

Proof:

Let a steady, non viscous irrotational and incompressible fluid flows through a tube of area of cross section A_1 at the first end and through area of cross section A_2 at the other end.. Let v_1, P_1 be the velocity and pressure at first end and v_2, P_2 be the velocity and pressure at other end.

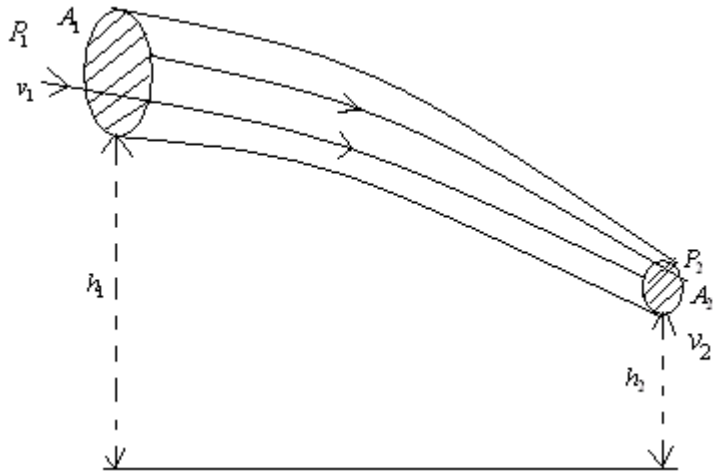
Due to the pressure, the amount of work done is W = F × ds $= PA(ds) = PA(v\ dt)$

$$\left[\because P = \frac{F}{A}\ and\ \ v = \frac{ds}{dt} \Rightarrow ds = v(dt)\right]$$

Work done by the fluid on the tube at first end $W_1 = P_1 A_1 v_1 (dt)$ which is positive.

Work done on the fluid by the tube at second end $W_2 = P_2 A_2 v_2 (dt)$ which is negative.

The net work done (or) pressure energy is $= W_1 - W_2 . = P_1 A_1 v_1 (dt) - P_2 A_2 v_2 (dt)$



The work done by the gravitational force will be stored as potential energy.

Potential energy at first end $= mgh_1$

Potential energy at second end = mgh_2

Net potential energy of the system = $mgh_1 - mgh_2$

Total work done due to pressure difference and height difference is

W = Pressure energy + P.E

Or $W = P_1 A_1 v_1 (dt) - P_1 A_2 v_2 (dt) + mgh_1 - mgh_2 \rightarrow$ (1)

From work- energy theorem, the total work done on the system is equal to change in K.E of the system

$$\therefore W = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2 \rightarrow (2)$$

From (1) & (2)

$$P_1 A_1 v_1 (dt) - P_2 A_2 v_2 (dt) + mgh_1 - mgh_2 = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$$

$$P_1 A_1 v_1 (dt) + mgh_1 + \frac{1}{2} m v_1^2 = P_2 A_2 v_2 (dt) + mgh_2 + \frac{1}{2} m v_2^2$$

Dividing through out with m and substituting $m=\rho V=\rho A(ds)=\rho A\, v(dt)$

$$\frac{P_1A_1v_1(dt)}{m}+gh_1+\frac{1}{2}v_1^2=\frac{P_2A_2v_2(dt)}{m}+gh_2+\frac{1}{2}v_2^2$$

Or $$\frac{P_1A_1v_1(dt)}{\rho_1A_1v_1(dt)}+gh_1+\frac{1}{2}v_1^2=\frac{P_2A_2v_2(dt)}{\rho_2A_2v_2(dt)}+gh_2+\frac{1}{2}v_2^2$$

$$\frac{P_1}{\rho}+gh_1+\frac{1}{2}v_1^2=\frac{P_2}{\rho}+gh_2+\frac{1}{2}v_2^2\left[\because \rho_1=\rho_2=\rho\right]$$

$$\frac{P}{\rho}+gh+\frac{1}{2}v^2=cons\tan t \text{ or } P+\rho gh+\frac{1}{2}\rho v^2=cons\tan t$$

This equation is known as Bernoulli's equation and this is in accordance with law of conservation of energy.

Application:

Dynamic lift on aeroplane wing (or) airfoil:- The aeroplane wing is designed in such that it is more curved at the top due to which more streamlines gather and velocity is more at the top. There by pressure becomes less at the top. At bottom less number of stream lines gather and velocity is less. Hence pressure is more at bottom. Due to this pressure difference aeroplane experiences a dynamic lift.As $P_B > P_T$, the aeroplane experiences a dynamic lift which is required for its take off.

SHORT ANSWER TYPE QUESTIONS

1. What is force of Buoyancy? Obtain the expression for the buoyant force acting on a body submerged in a fluid.

A. Force of Buoyancy: When a body is submerged in a fluid, the net upward thrust acting on it due to the pressure difference between top and bottom surfaces is known as buoyant force.

Explanation: Consider a cylindrical body of height h and area of cross-section A, which is completely submerged in a fluid of density ρ .

Let the pressure exerted by the fluid on top surface is P_1. Then the downward force acting on the top surface F_1 is given by

$$F_1=P_1A=(h_1\rho g)(A) \qquad \left[\because P=\frac{F}{A} \text{ and } P=h\rho g\right]$$

Similarly the upward force F_2 on the bottom surface is given by,

$$F_2=P_2A=(h_2\rho g)A$$

The resultant force or buoyant force is

$$F_{net}=F_2-F_1=(h_2\rho g)A-(h_1\rho g)A=\rho gA[h_2-h_1]=\rho gA[h]=\rho gV \qquad (\because V=Ah)$$

$$F_{net}=F_B$$

$F_B=\rho gV$ Where V is the volume of cylinder we know that $\rho=\frac{m}{V}\Rightarrow m=\rho V$

$\therefore F_B = mg$ i.e., the buoyant force is equal to the weight of the fluid displaced for which volume is exactly equal to the volume of the submerged body.

2. **Distinguish between stream line and turbulent flow of liquids?**

A . **Streamline flow:**

a) Every particle of the liquid follows the path of its preceding one.
b) The mass of the liquid entering the tube is equal to the mass of the liquid leaving the tube.
c) The path followed by the particle is called streamline.
d) Streamlines may be curves or straight lines.
e) The tangent drawn to the streamline gives the direction of flow of liquid
f) No two streamlines intersect each other
g) No radial flow
h) Pressure at any cross-section is same.
i) A bundle of streamlines having same velocity is called tube of flow.

Turbulent Flow:

a) The velocity of the particle crossing any particular point of the liquid is not constant in both magnitude and in direction.
b) Velocity varies with time.
c) Turbulent flow is featured by eddy currents (or) eddies
d) In turbulent flow. Internal friction is much greater than in stream line flow
e) The velocity of the liquid at which streamline flow converts into turbulent flow is called critical velocity (V_c)

3. When a tap is open so that water comes out in a stream, one would observe the cross section of water decreases as water descends. Why? (March2011)

A : According to equation of continuity,

AV = constant where V is the velocity of water A is area of section of water

As water descends the velocity of the water increases due to gravity and hence the value of A decreases according to equation of continuity .Hence the cross section of water decreases as water descends when a tap is open

4. Liquids of different densities in tanks, having an orifice, at exactly same depth below the liquid surface have same efflux velocity of liquid coming out of orifice. Why?

A. 1) The speed of a liquid coming out of an orifice at a depth 'h' below the surface of a liquid is same as that of a particle fallen through the height 'h' under gravity. This is called Torricelli Theorem.

2) The velocity of the liquid with which it flows out of the orifice at a depth h from the liquid surface is known as velocity of efflux.

3) If a liquid is flowing from an orifice at a depth h is below the free surface of the liquid, then Velocity of efflux (v) = $\sqrt{2gh}$

4) Efflux velocity depends on acceleration due to gravity g and depth h.

5) Efflux velocity doesn't depend on density of liquid. Hence, the liquids of different densities in tanks, having an orifice at exactly same depth below the liquid surface have same efflux velocity through an orifice.

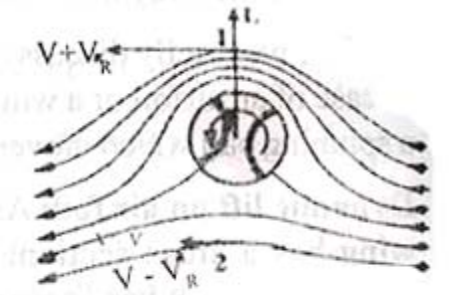
5. A spinning ball through air takes a curved path than a ball that does not have spin. What force comes into play for a spinning ball? (June2006, March 2001)

A. If the ball moves with a certain velocity V and spins in air with a velocity V_R , then

(i) the resultant velocity at the top of the ball becomes $V+V_R$

(ii) At the bottom of the ball, the resultant velocity becomes $V-V_R$

(iii) As $V+V_R$ at the top is greater than $V-V_R$ at the bottom, from Bernoulli's principle, pressure at the top is less than the pressure at the bottom.



Dynamic lift on a spinning ball

Due to the pressure difference, ball experiences an upward force which is known as dynamic lift. Hence spinning ball through air takes a curved path than a ball which doesn't have spin.

6. State and explain the characteristic of a fluid.

A. Character of a fluid flow: Fluid flow is of two types.

1) Streamlines (or) laminar flow 2) Turbulent flow.

In **stream line** flow every particle of the liquid follows the path of its preceding one. The mass of the liquid entering the tube is equal to the mass of the liquid leaving the tube.

In **turbulent flow** eddy currents (or) eddies are formed which absorb more amount of energy in turbulent flow internal friction is much greater than in streamline flow.

1) Fluid flow may be steady (or) non steady : The velocity of the fluid at a point changes with time, the flow is called unsteady flow.

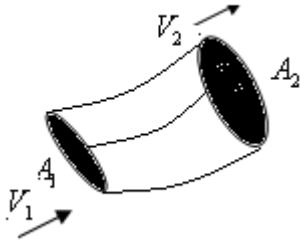
2) Fluid flow may be rotational (or) irrotational : Flow is irrotational. If there is no net angular momentum of the fluid at each point.

3) Fluid flow may be compressible (or) incompressible: If there is no change in the density along the flow of the fluid , then it is called incompressible.

4) Fluid flow may be viscous or non-viscous: Fluid flow may be viscous (or) non – viscous. While a liquid in flowing the internal friction between the adjacent layers of the fluid known as viscosity exists. This hinders the motion of the fluid.

7. Derive an expression for the equation of continuity.

A. Consider a fluid under a steady flow in a pipe whose cross-sectional areas are A_1 and A_2 as shown. Let V_1 and V_2 are velocities and ρ_1 and ρ_2 are the densities of the liquid at these points.



The mass of the liquid flowing through a cross-section of the pipe in unit time is called mass flux. If Δm is the mass of liquid passing the cross section in a small interval of time Δt , then the mass flux is given by

$$\mu = \frac{\Delta m}{\Delta t} = \frac{Al\rho}{\Delta t} = AV\rho$$

According to the law of conservation of mass, mass flux is same for any cross-section of the pipe.

$\therefore \mu_1 = \mu_2$

(or) $A_1V_1\rho_1 = A_2V_2\rho_2$ (or) $AV\rho$ = constant

If the liquid is incompressible, the density of the liquid is same at every point.

$\therefore A_1V_1 = A_2V_2$ (or) AV = constant. This is known as equation of continuity.

VERY SHORT ANSWER QUESTIONS

1. Explain the terms Pressure, pressure energy.

A. **Pressure:** The force per unit surface area is called pressure. If F is the force acting perpendicular to a surface of area A, then

Pressure (P)$= \frac{\text{Force (F)}}{\text{Area (A)}}$ It is a scalar quantity. Its unit is N/m^2 (or) Pascal.

Pressure energy: The work done by a fluid by virtue of difference in pressure at different depths is known as pressure energy. The pressure energy per unit volume is equal to the pressure exerted by the liquid.

Pressure energy = Pressure x volume

2. State the expression for the pressure energy per unit mass and pressure energy per unit volume of a liquid.

A. Pressure energy per unit mass $= \frac{\text{Pressure} \times \text{Volume}}{\text{Mass}} = \frac{P}{\rho}$

Pressure energy per unit volume $= \frac{\text{Pressure} \times \text{Volume}}{\text{Volume}} =$ Pressure

3. When an object floats on a fluid what is the fraction of the volume of the object submerged in the fluid? b) For a floating body what is the relation between the weight of the floating body and the weight of the fluid displaced?

A. a) Fraction of the volume of the body submerged in a fluid is given by

Fraction submerge $= \frac{\text{Density of the object}}{\text{Density of the fluid}}$

b) When ever a body is floating on a liquid then the weight of the body is equal to the weight of the liquid displaced.

Weight of the body = weight of the liquid displaced.

4. For an incompressible, steady flow of a fluid what is the relation between area of cross section of a tube flow and the velocity of the fluid flowing through it ? Give an example of equation of continuity.

A. If A is the area of cross-section of the tube and V is the velocity of the fluid ,then according to equation of continuity $A_1V_1 = A_2V_2$

(or) A V = constant

Ex : when water is falling from a tap, its stream becomes narrow as water comes down. As the water column is falling down velocity increases and cross-section decreases.

5. State any two examples of Bernoulli's theorem. (March2010, March-2000)

A. 1) During storms, in heavy winds roofs of huts are blown off. When the velocity of wind is greater on the roof top than inside the house pressure energy decreases

at the top than inside the house. Due to this pressure difference, the roofs are blown off.

2) A person standing on railway platform feels a pushing force towards a fast moving train because of the drag velocity of the air in contact with the person increases, there by the pressure of air between the train the man decreases.

6. **What is Turbulent flow? How is it identified? (May2009, March 2003)**

A It is a type of flow of fluid in which the motion of fluid particles at a point varies rapidly in magnitude and direction. It is identified by its zigzag path.

7. For which type of fluids Bernoulli's theorem is applicable. ((March 2006, March 2005)

A. Bernoulli's theorem is applicable to non-viscous, incompressible fluids under streamline flow.

8. Show that Reynolds number $R = \frac{\rho v_0 d}{\eta}$ is dimensionless. (March 2009)

Sol: $R = \frac{\left(kg/m^3\right)\left(m/s\right)\left(m\right)}{\left(N/m^2\right)s} = \text{dim}\,ensionless$

SOLVED PROBLEMS

1. The pressure at the bottom of lake due to water, is 4.9×10^6 N/m^2. What is the depth of the lake?

Sol: $P = h\rho g = 4.9\text{x}10^6\ \text{N/m}^2$; $\rho = 1000\ \text{kg/m}^3$; $g = 9.8 m/s^2$

$$P = h\rho g \Rightarrow h = \frac{P}{\rho g} = 500m$$

2. when a polar bear jumps on an iceberg, he notices that his 240 kg weight is just sufficient to sink the iceberg. What is the weight of the iceberg? Given that specific gravity of ice is 0.9 and that of sea water 1.02.

Sol: If M is the mass of the iceberg in kg, its volume $V = \frac{M}{0.9x10^3} m^3$

Weight of Volume V of sea Water= $Vx1.02x10^3 xg.N$

Mg+240g = $\left(\frac{M}{0.9x10^3}\right) x \left(1.02x10^3\right) xg$

$M = 1800kg$

3. Four-fifths of cylindrical block of wood, floats in a liquid. Assuming the relative density of wood is 0.8, find the density of liquid

Sol: Let V be the volume of wooden block, the volume of liquid displaced $= \frac{4}{5}V$.

If d be the density of liquid, the weight of liquid displaced $= \frac{4}{5}Vdg$.

Weight of the block $= V\times0.8\times10^3\times g$

As block floats $V\times0.8\times10^3\times g = \frac{4}{5}Vdg \Rightarrow \quad d = 10^3 kg/m^3$

4. Two bodies are in equilibrium when suspended in water from the arms of a balance. The mass of one body is 28g and its density is 5.6g/c.c. If the mass of the other body is 36g, find its density.

Sol: Volume of first body $= \frac{28}{5.6}$ and Volume of second body $= \frac{36}{d}$

Weight of water displaced by first body $= \frac{28}{5.6} g$

Weight of water displaced by second body $= \frac{36}{d} g$

Apparent weight of first body = $\left(28 - \frac{28}{5.6}\right) g$

Apparent weight of second body $= \left(36 - \frac{36}{d}\right) g.$

Since bodies are in equilibrium $\left(28 - \frac{28}{5.6}\right) g = \left(36 - \frac{36}{d}\right) g \Rightarrow d \quad 2.8\, g/cc$

5. What is kinetic energy of each cubic meter of water in a stream that is moving with a speed of 20 m/s?

Sol: Kinetic energy per unit volume $= \frac{1}{2}\rho v^2 = \frac{1}{2}\left(10^3\right) \times \left(20^2\right) = 10^5 J$

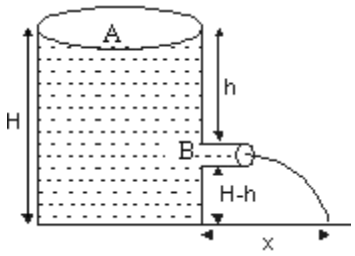
6. A horizontal pipe of cross-section 20 sq. cm has a constriction of cross-section 5 sq. cm Gasoline (density $\rho = 600 kg/cm^3$) flows with a speed of 2 m/s in a large pipe where the pressure is $6 \times 10^5 N/m^2$. What is the pressure in the constriction?

Sol: $P_1 - P_2 = \frac{\rho V_1^2}{2}\left(\frac{A_1^2}{A_2^2} - 1\right) = \frac{600 \times 2^2}{2}\left[\left(\frac{20}{5}\right)^2 - 1\right] = 0.18 \times 10^5 N/m^2$

$\therefore P_2 = P_1 - 0.18 \times 10^5 = 6 \times 10^5 - 0.18 \times 10^5 N/m^2 = 5.82 \times 10^5$

7. An open water tank has a small side hole. Initially water is filled to a height 'h' above the centre of the side hole which is plugged. If water is allowed to flow by unplugging the hole find the velocity of the water through it.

Sol: **C**onsider a liquid of density ρ contained in a tank up to a height H. A narrow hole is made to the wall of the tank at a depth h below the surface of the liquid. Let the velocity of the liquid coming out of the hole is v and P be the atmospheric pressure.



Applying Bernoulli's theorem at A and B ,

$$P + \rho g H + 0 = P + \rho g\left(H - h\right) + \frac{1}{2}\rho \mathrm{v}^2$$

Or $\mathrm{v} = \sqrt{2gh}$

This velocity is known as velocity of efflux. The velocity of efflux of a liquid through an orifice of a vessel is equal to the velocity acquired by a freely falling body from a height which is equal to that of liquid level from the orifice. This is known as Torricelli's theorem.

8. With what speed does water flow from an opening that is 10 m below the free surface?

Sol: $V = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 10} = 14 m/s$

9. Find the aerodynamic lift on the wings of an aero plane.

Sol: Pressure difference = $P_1 - P_2 = \frac{1}{2}\rho\left(v_2^2 - v_1^2\right)$

Aerodynamic lift = Pressure difference × Area of the wings = $\frac{1}{2}\rho A\left(v_2^2 - v_1^2\right)$

10. What is the viscosity of the oil which flows at the rate of 420 cc/min through a tube of length 100 cm and internal diameter 2 mm under a pressure difference of 30 N/cm^2.

Sol: $Q = \frac{\pi \Pr^4}{8\eta l}$ *or* $\eta = \frac{\pi \Pr^4}{8Ql} = \frac{3.14\times\left(3\times10^6\right)\times\left(0.1\right)^4}{8\times7\times100} = 0.17 Poise$

EXERCISE 1

1. A body of density is let free in a liquid of density d (where $d' > d$), what is the downward acceleration of the body while sinking in the liquid?

A. Weight of the body = mg = vd$'g$ (down words)

Force of buoyancy = vdg (up words)

Net force $F = vd'g - vdg$

$$ma = vg(d' - d) \quad \Rightarrow vd'a = vg(d' - d) \quad \Rightarrow \quad a = g\left(1 - \frac{d}{d'}\right)$$

2. What mass of lead will weigh as much as 8gm of iron, when both are immersed in water? (Given specific gravities of iron and lead are 8 and 11 respectively).

A. Weight of lead in water = weight of iron in water

$mg\left(1 - \frac{d_w}{d_{lead}}\right) = m'g\left(1 - \frac{d_w}{d_{iron}}\right)$ Where m = mass of lead, m' = mass of iron

$m\left(1 - \frac{1}{11}\right) = 8\left(1 - \frac{1}{8}\right) \quad \Rightarrow \quad m = \left(\frac{77}{10}\right) = 7.7 gram$

3. A piece of copper (density 8.8gcm^{-3}) having an internal cavity weighs 264g in air and 221g in water. Find the volume of the cavity.

A. Weight in air $mg = \left(v - v_{cavity}\right)d_c\, g$

$\Rightarrow \quad m = \left(v - v_c\right)d_c$

$\Rightarrow \; v - v_c = \frac{264}{8.8} \Rightarrow \quad v = \frac{264}{8.8} + v_c$

$\therefore$ Weight in water = weight in air - buoyancy force

$\left(221\right)g = \left(264\right)g - vd_w g \Rightarrow 221 = 264 - \left(\frac{264}{8.8} + v_c\right)\times1 \Rightarrow v_c = 13 cm^3$

4. The base area of a boat is 2m^{-2}. A man weight 76kg weight steps into the boat. Calculate depth into which the boat sinks further into water.

A. mg = Force of buoyancy

$$76\times g = h(A)\,d_w g$$

$$76 = h(2)\times 1000$$

$$h = \frac{38}{1000} = 0.038m = 3.8cm$$

5. If the atmospheric pressure is 76cm of Hg , at what depth of water the pressure will become 4 atmospheres?

A. $P_{bottam} = P_{atoms} + h\,d_w g$

$$4\times 10^5 = 1\times 10^5 + h\times 10^3 \times 9.8$$

$$3\times 10^5 = h\times 10^3 \times 9.8$$

$$h = 31m$$

6. How much work is done by agent in forcing $3m^3$ of water through a pipe of radius 2cm, if the difference in pressure at two ends of the pipe is 10^6 N/m^2?

A. Pressure difference = 10^6 N/m^2 ; Volume = $3m^3$
Work done = pressure x volume
$W = 3 \times 10^6$ J

7. Water flows through a horizontal tube of diameter 8cm and length 1km at the rate of 40 lit./s. Find the pressure difference required if η = 0.01 poise for water.

A. d =8cm, l = 1km = 10^5 cm, r = 4cm,
Rate of flow Q = 40 lit/s = 40 x 10^3 cc/s

$$Q = \frac{\pi Pr^4}{8\eta l} \Rightarrow P = \frac{8Q\eta l}{\pi r^4} = \frac{8\times 40\times 10^3\times 0.01\times 10^5}{3.14\times (4)^4} = 3.98\times 10^5\ dynes$$

8. How should the pressure difference be altered so that the rate of flow of liquid be doubled when radius and length are both doubled.

A. $Rate\ of\ \ flow\ Q = \frac{\pi Pr^4}{8\eta l}$ *and* $Q_2 = 2Q_1$

$$P \propto \frac{Ql}{r^4} \quad \text{and} \quad l_2 = 2l_1, r_2 = 2r_1$$

$$\frac{P_1}{P_2} = \frac{Q_1 l_1}{Q_2 l_2}\times\frac{r_2^4}{r_1^4} = \frac{\theta_1 l_1}{2\theta_1 2l_1}\times\frac{(2r_1)^4}{r_1^4} \Rightarrow p_2 = \frac{p_1}{4}$$

Hence *pressure is* $\frac{1}{4}$ *of its previous value.*

ASSESS YOURSELF

1. Do objects weigh less in air than in Vacuum?

A. Yes. The objects weigh less in air due to buoyancy of air. $F = Mg\left(1-\frac{d_l}{d_b}\right)$

2. What is the buoyant force on an object immersed in a fluid when the container of the fluid falls freely?

A. Zero

3. On which principle, equation of continuity is based on.

A. Law of conservation of mass. The mass of fluid flowing through a cross section of pipe in unit time remains constant.

4. On which principle scent sprayer is based on.

A. Bernoulli's theorem.