Introduction

Have you ever thought, why a camel can run easily in desert? Or an army tank easily runs upon the continuous chain etc. In all of these cases, an object is exerting force on one another object when coming in contact with each other, making the thing to move on. The force applied by an object on another, depends on the area of contact with each other. Thus, the pressure is defined as the forces exerted by an object per unit area of the surface.

If we stand on the loose sand, the force equivalent to the weight of the body acts perpendicular to the surface, equal to the area occupied by our feet. On the other hand, if we lie down on the sand, the force will act on the surface equal to the area of the body in contact with the sand. We therefore see that the effect of same force of equal magnitude is different over different area. Hence, we can say that the pressure acting on the surface depends on the area of contact with the surface. If we press an iron sheet with the help of our finger, our finger does not dip into the sheet as the force of finger is falling on a large area of the sheet and the force per unit area of the sheet is small. The pressure is given by:

$$Pressure = \frac{Force}{Area}$$

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

The Sl unit of pressure is Newton per meter, which is also called Pascal (Pa).

1 Pascal = 1 Newton per square meter

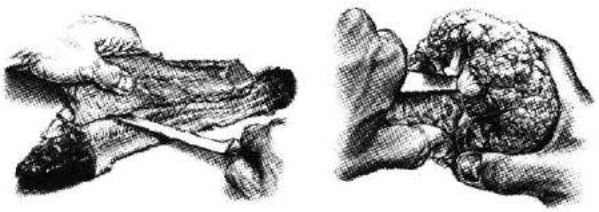
Or, 1 pa = 1 N/m^2

Pascal is a small unit of pressure. The bigger unit of pressure is kilopascal or cap. One kilopascal is equal to the one thousand Pascal.

i.e. 1 kPa = 1000 pa

In real life, there are many such situations where the pressure is the most important parameter. If you are peeling a potato, pressure is the key factor. If the knife is sharp, the area of contact is small and you can peel with less force on the blade. But if the knife is not sharp, you have to apply more pressure to peel it off. Similarly, if a nurse is giving injection to the patient and the needle is sharp, she has to apply less pressure on the syringe. In such case, the patient will feel less pain, as the sharp needle will have lesser area of contacts and less force is required to push the needle through the skin. It is normally seen that the foundation of the building is kept very wide. This is done in order to provide strength to the building.

Thus, we can say that same force acting on the smaller area exerts larger pressure than the force acting on the large area.



Pressure

Commonly Asked QUESTIONS

If an object exerts a force of 45 N over a surface of dimension 15 m x 20 m, what is the pressure exerted by the liquid?

(a) 0.150 Pa (b) 1.25 Pa
(c) 0.58 Pa (d) 2.55 Pa
(e) None of these

Answer: (a)

Explanation

We know that pressure exerted by the liquid at any point within the medium is equal to the force acting per unit area. On calculation it is found to be 0.150 Pa.

The pressure acting on an object depends on many parameters. Smith took a plastic bucket and immersed in water. The pressure acting on bucket is independent of, which one of the following parameters?

(a) Mass (b) Acceleration
(c) Area (d) Shape
(e) None of these

Answer: (d)

Explanation

The pressure acting on an object depends on its mass, accelerations and area.

Atmospheric Pressure

Our atmosphere contains large volume of mixture of gases. These gas exert pressure on the objects form all directions. This pressure is called atmospheric pressure. The atmospheric pressure is maximum at the sea level and minimum on the top of the mountains. This is because the air volume is maximum on the sea level and minimum at the top of the mountain. Thus, as we go up the pressure goes on decreasing. The air pressure on the surface of earth is 101.3 kPa and on the surface of sea-level is 760 mm of Hg.

We can demonstrate the existence of atmospheric pressure with the help of the following activity:

Take a glass jar and fill it with the water up to the brim. Place a sheet of paper on its brim so that no air molecule remains inside. Now keeping the paper in its position, invert the jar in downward direction. You will observe that, the paper does not fall off, though the jar is full of water and exerting pressure in downward direction. This is because of the fact that, the atmospheric pressure acting on the paper in the upward direction, holding the paper sheet in its position. The upward pressure on the sheet is more than the downward pressure, hence it is not falling.

Atmospheric Pressure

Pressure Inside Our Body

Our body contains liquid in the form of water and blood. These blood flow through the blood vessels and exert pressure on the wall of the vessels. This pressure is called blood pressure. Our body is balanced by the atmospheric pressure and blood pressure and hence we do not get crushed. Our body is so balanced by these pressures that we never feel discomfort. But if we go up high on the mountain where the pressure is very low, we start feeling uncomfortable and uneasy. Many people even start nose bleeding at higher altitude. This is because, due to the difference in the pressure at higher altitude the blood vessel in our body burst and bleeding starts.

Application of Atmospheric Pressure

- While taking cold drinks from the bottles, we use straw. The lower end of the straw is dipped into the bottle and we suck at the upper end with our mouth, the pressure inside the straw decreases. The pressure on the surface of the cold drinks is equal to the atmospheric pressure, which pushes the drinks up into our mouth. Hence, we are able to take the cold drinks.
- The injection syringe works due to the existence of atmospheric pressure. When the nozzle is dipped into the liquid and its piston is pulled, the pressure inside the syringe is lowered. The greater atmospheric pressure on the surface of the liquid pushes the liquid inside the syringe and the syringe gets filled.
- The working of dropper is also due to the existence of atmospheric pressure. We press the rubber bulb keeping its nozzle dipped into the liquid, the air in the glass nozzle and the bulb escapes out of the tube. Due to this, the pressure inside the tube become lesser and the air pressure on the surface of the liquid becomes more. So when we release the bulb, it pushes the liquid inside the tube and the liquid raises in the tube. When we remove the dropper from the liquid and press it again, the liquid comes out of the nozzle in the same way and on the same principle.
- Ink pens are not allowed at higher altitude. Because at higher altitude the atmospheric pressure is less and pressure of ink inside the pen is more, due to which ink oozes out of the pen and spoils the cloth.

Application of Atmospheric Pressure

Commonly Asked QUESTIONS

David tries to float in the air with the help of a glider. After several attempt he remains unsuccessful. He tries to find the reason responsible for it, and comes to conclusion that, it has been the air pressure of the region responsible for his failure. The air pressure of the region has been _____?_____than 101.3kPa.

(a) Less (b) More

(c) Equal (d) Infinite (e) None of these

Answer: (b)

Explanation

The air pressure of the region was more than 101.3 kPa.

Mary went to the restaurant and took a cold drink with the help of straw. She realised that, it was easy for her to drink with the help of straw, rather than directly from the bottle. Which one of the following is the possible reason for this?

(a) Mouth pressure (b) Sucking pressure

(c) Atmospheric pressure (d) All of these

(e) None of these

Answer: (c)

Explanation

We can drink with the help of straw because of difference in the atmospheric pressure.

Archimedes Principle

Archimedes of Syracuse (circa 287 BC - 212 BC), was a Greek mathematician, astronomer, philosopher, physicist and engineer. He was killed by a Roman soldier during the sack of the city, despite orders from the Roman general, Marcellus, that he was not to be harmed. Some historians of Mathematics consider Archimedes as one of the greatest mathematicians in history, along with possibly Newton, Gauss and Euler. Also, St. Lucy was from Syracuse. She died because her eyes was taken out with forks by the violent people.

Archimedes Principle

The concept was put on around 212 B.C., by the Greek scientist Archimedes. According to this principle, an object immersed fully or partially in the liquid is acted upon by the upward force, which is equivalent to the weight of the liquid displaced by the object.

Mathematically, if M is the mass of the liquid, its weight is given by:

$$W = M \times g$$

If V is the volume of the liquid, andp is the density of the liquid, its mass is given by:

$$M = pxV$$

Hence, $W = px\ V\ xg.$

Buoyancy

When an object is immersed in liquid an upward force acts on it, which is called buoyancy. The buoyant force does not depend upon the weight of the object or the shape of the object, it only depends on the weight of the liquid displaced by the object. This principle is applicable to all the object of any density. If the density of the object is more than the density of the liquid, the object will sink. But if the density of the liquid is more

than the object, the object will float on the surface of the liquid. On the other hand, if the density of the liquid and objects are equal, the object will float with half part immersed in the liquid.

Commonly Asked QUESTIONS

Find the weight of an object whose volume 45 m^3 and density 2.4 gm/m^3.

(a) 0.108kg (b) 1.1 kg

(c) 2.4kg (d) 3.2kg

(e) None of these

Answer: (a)

Explanation

Weight of an object is given by,

W = m x g

We can find the value of W by substituting the other parameters and we get the weight to be 0.108 kg.

Thomas throws a silver coin in the sea. The density of the coin is 0.985 gm/m3. Will the coin float on the surface of water or it will sink?

(a) Sink (b) Float

(c) Float half immersed (d) can't say

(e) None of these

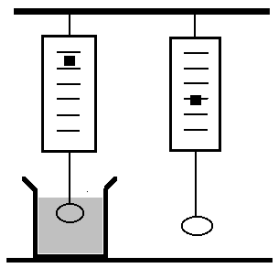
Answer: (b)

Explanation

Since the density of the coin is less than the density of water, hence it will float on water.

Amount of Buoyancy

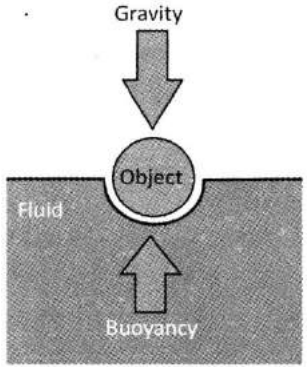
The amount of buoyancy of a body is determined by the body's specific gravity. Specific gravity is the ratio of the weight of a body to the weight of the water it displaces. Pure water has a specific gravity 1. The specific gravity of other objects is determined by finding the ratio of the density of the object to the density of the water. Objects with the gravity of less than 1 will float and the object with a specific gravity greater than 1 will sink.



Archimedes' Principle

From the above figure, we can observe that when a weight is hanged with the help of a spring balance, the weight is more in air and less when it is dipped into the liquid. This is because, when the weight is immersed

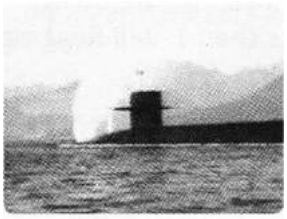
into the liquid, the buoyant force acts on it in upward direction, which reduces its weight. The decrease in the weight is equivalent to the weight of the liquid displaced by the object immersed in it.



State of the Buoyancy

Positive Buoyancy

If an object floats, it means the object displaces an amount of water that weighs more than the weight of the object. In other words, the object is less dense than the water.



Positive Buoyancy

Negative, Buoyancy

If an object displaces the amount of water whose weight is less than the object, it will sink. This means that the object is denser than the water and the water does not provide sufficient buoyancy to make it float.

Neutral Buoyancy

If an object is neutral, that is, it floats half immersed in the liquid, this means the object displaces the amount of water that weighs the same as the weight of the object.

Neutral Buoyancy

Commonly Asked QUESTIONS

The pressure of the liquid is not same at each point in the sea. If a diver dives into the sea, at which point the diver will feel the maximum pressure?

(a) At the top
(b) At the bottom
(c) In the middle
(d) Same at all points
(e) None of these

Answer: (b)

Explanation

We know that pressure increases with the depth of the sea, so diver will feel maximum pressure at the bottom of the sea.

A small boat carrying loads does not sink in the river, at the same time an iron pillar of same weight sinks into the river. The reason for this is_____.

(a) Positive buoyancy
(b) Negative buoyancy
(c) Neutral buoyancy
(d) All of these
(e) None of these

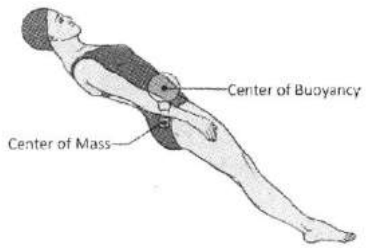
Answer: (a)

Explanation

The reason for this is the total downward weight in case of boat is less than that in the case of iron pillar. Therefore, it sinks.

Center of Buoyancy

The center of buoyancy is a point on the object, around which the buoyant force is balanced. For example, in human body the lungs provide a large buoyant volume of air, the center of buoyancy is usually located in the chest. The center of mass is below the center of buoyancy. When a person of average build tries to float horizontally on the back with arms along the sides of the body, the center of mass is nearly level with the center of buoyancy. Many people have more body weight than their legs and hips, because of the high proportion of muscle tissue at that point their center of mass is near the hips. When they try to float in a horizontal position, gravity pulls their hips and legs downward, while the buoyant force of the water pushes the chest area (center of buoyancy). Thus, the centre of the buoyancy of any individual lies in and around waist and chest of the individual, depending upon his/her weight.



Commonly Asked QUESTIONS

A box floats in water with 60 % of its volume below water surface. What is the density of the box? Take the density of water to be 1000 kg/m^3.

(a) 0.6 kg/m^3 (b) 60 kg/m^3
(c) 100 kg/m^3 (d) 600 kg/m^3
(e) None of these

Answer: (d)

Archimedes principle has wide application. It can be used to find the volume of the solid, which is immersed in the liquid or the relative density of the liquid. Can Archimedes principle be used for the measurement of density of solid objects?

(a) Yes (b) No
(c) Few selected solid (d) Can't say (e) None of these

Answer: (a)

You Must KNOW

- The water pressure 10,000 m below the surface is equivalent to seven elephants standing on a dinner plate.
- The pressure at the centre of the earth is about 400 billion Pa.
- The pressure of a shark bite is about 30 million Pa.
- The vacuum in the best laboratory is 1 trillionth Pa.
- The pressure of sunlight is about 3 millionths Pa.

SUMMARY

- Pressure is defined as the force per unit area of the surface.
- Liquid and gas exert pressure on the wall of the container.
- The atmospheric pressure is the pressure exerted by the air molecule on us.
- The force acting normal to the surface is called thrust.
- Buoyancy is the upward force acting on the object, which is fully or partially immersed in water.
- Archemedes principle states that force acting on an object is equivalent to the weight of the liquid displaced by the object.
- Relative density of the liquid is the density of one liquid with respect to the liquid.
- Sharp knives require less force to cut vegetables than a blunt knife.
- Pressure of the liquid increases with the depth.
- Pressure decreases with the height.

Self Evaluation TEST

Duration 10 Minutes

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1. Hary says water exerts pressure on the bottom of the bucket, but Robert says water exerts pressure on the wall of the bucket. Whose statement is correct?

(a) Hary
(b) Robert
(c) Both
(d) The statement is irrelevant
(e) None of these

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2. We have observed that water from the leaking pipe forms fountains. What conclusion can you draw from this observation?

(a) Water exert pressure on the wall
(b) Water is flowing
(c) Water does not exert pressure
(d) Water is at rest
(e) None of these

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3. When we inflate the balloons with air, we find that its size increases. The large number of gas molecule collides with each other and creates large:

(a) Force
(b) Pressure
(c) Increase in size
(d) Increase in mass
(e) None of these

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4. Which one of the following figures given below represents the fountain of water?

(a) 

(b) 

(c) 

(d) 

(e) None of these

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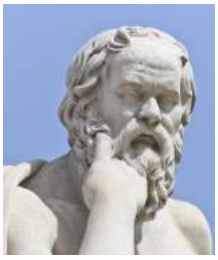
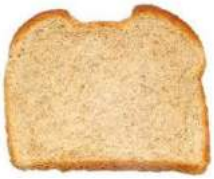
5. In which one of the following case, the pressure exerted will be maximum?

(a) 
Baloon

(b) 
Water in Bucket

(c) 
Statue

(d) 
Bread

(e) None of these

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6. When we press the bulb of a dropper with its nozzle kept in water, air in the dropper is seen to escape in the form of bubbles. Once we release the pressure on the bulb, water gets filled in the dropper.
The raise of water in the dropper is due to:

(a) Pressure of water
(b) Gravity of earth
(c) Shape of bulb
(d) Atmospheric pressure
(e) None of these

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7. Match the following in the table given below:

Terms	Unit of measurement
(1) Pressure	(A) Coulombs
(2) Force	(B) Metersquare
(3) Area	(C) Newton
(4) Electric charge	(D) Pascal

(a) 1-C, 2-A, 3-B, 4-D
(b) 1-B, 1-0, 3-A, 4-C
(c) 1-D, 2-C, 3-B, 4-A
(d) 1-A, 2-B, 3-C, 4-D
(e) None of these

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8. Statement I: Pressure is the force acting per unit area of the surface.
Statement II: Force acting perpendicular to the surface is called thrust.

(a) Statement I is correct
(b) Statement II is correct
(c) Both the statement are correct
(d) Both the statement are incorrect
(e) None of these

9. **It is seen that vegetables are cut easily with the sharp knife. In such case, less force are required to cut the vegetables. This is due to the fact that sharp knife has very:**

(a) Thin edge (b) Thick edge
(c) Use of large force (d) Smaller size
(e) None of these

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10. **The air pressure at the sea level is found to be:**

(a) 960mmHg (b) 860 mm Hg
(c) 760mmHg (d) 650mmHg
(e) None of these

Answers – Self Evaluation Test																			
1.	C	**2.**	A	**3.**	B	**4.**	A	**5.**	A	**6.**	D	**7.**	C	**8.**	C	**9.**	A	**10.**	C