11 Pressure

Learning Objectives

- *To understand the concept of pressure and its dependence upon the surface area.*
- *To know about the pressure exerted by liquids and air.*
- *To learn more about atmospheric pressure and its effects.*
- *To study the instruments used to measure pressure.*

PRESSURE

You have already studied about various types of forces and friction and now you will learn some more effects of force. Pressure is one such effect of force; one of the commonly used word in daily life. Some common experiments and observations suggest that the effect of a force depends on the two main factors:

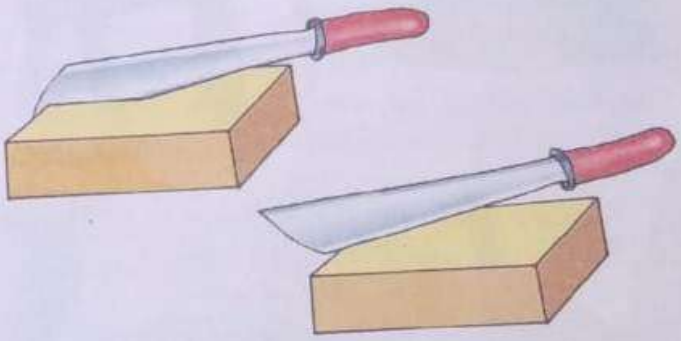
1. **The amount of force applied;** if the force applied is greater, its effect is also greater.
2. **The area on which the force is applied;** if the force is applied on a large area, its effect is lesser and if the same amount of force is applied on a smaller area, its effect is greater.

Hence, to know the effect of a given force, not only in magnitude but also the area over which it should be known. Pressure is the quantity which can be defined as :

The force acting on a unit surface area of any object.

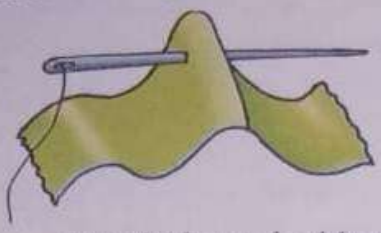
Some examples given below illustrate the fact that the more is the area on which the force is applied, less is its effect :

1. It is always easy to cut an object with the sharp edge of a knife. The blunt edge of the knife has more surface area than the sharp edge, hence sharp edge applies force on lesser area resulting in greater affect.



2. A needle has a pointed tip so that it can easily pierce through the cloth as its pointed tip will have lesser area of

contact and hence there will be more effect of lesser applied force.



3. Buses and trucks have double wheels at their rear which increases the area of contact.
4. High-rise buildings have broad and wide foundation so that the pressure exerted on the ground is less which prevents them from sinking due to high force applied by the tall building.
5. Nature has provided broad feet to heavy animals like elephant. Similarly, desert animals also have broad feet which exert less pressure and they walk easily on the sand.

Bus with double wheels

High-rise building with strong foundation

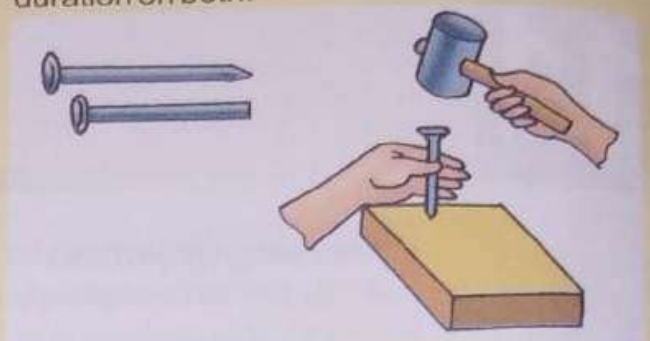
Elephant's broad feet

Fact File

The jacana bird of South America has exceedingly long toes and claws. Therefore its weight is spread over a large area which enables it to walk on the floating lily pads without sinking.

Activity 1

Take two nails of the same size, one having a sharp and pointed tip and the other with a broad blunt tip. Take a wooden board and hammer both the nails into it. Apply some amount of force for some time duration on both.

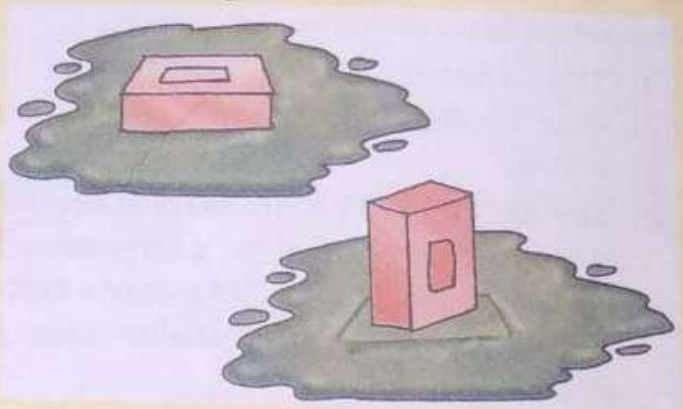


What do you notice?

You will observe that the nail with the pointed tip pierces more easily through the wood than the nail with blunt tip. Why?

Activity 2

Water a piece of muddy land to soften the soil. Then place a plank of wood or a brick flat on this moist land. Remove it and observe the depth of impression made by the plank or brick in the soil. Now place the some plank or brick in upright position as shown in the figure.



Again, remove it and observe the depth of impression made in the soil. What difference do you observe? Why?

This is because the acting force is more effective in the second case as the area of contact has reduced.

Limits of Pressure

Pressure is defined as : The force acting on a unit surface area

or, $$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

In SI system of measurement, force is measured in **Newton (N)** and area is measured in **metre square (m^2)**.

Replacing these units of measurement in the given expression,

$$\text{Pressure} = \frac{\text{Newton}}{\text{Metre}^2} = \frac{\text{N}}{\text{m}^2}$$

Hence, in SI system, the unit of pressure is N/m^2 which is also known as **Pascal (Pa)**.

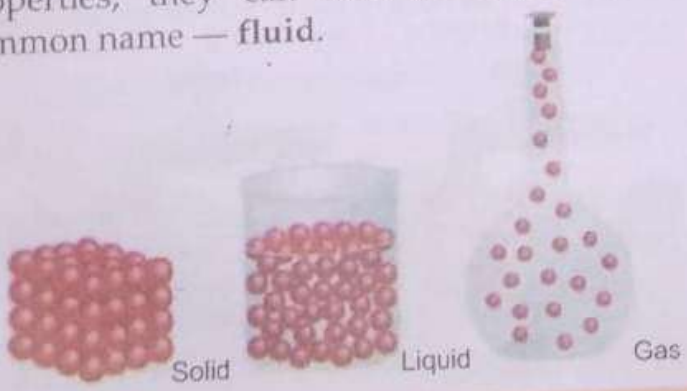
In CGS system, the unit of pressure is $dyne/cm^2$.

Test Yourself

1. Define pressure.
2. What is the SI unit of pressure? What is its unit in CGS system?
3. Give reason, why the walls of a dam are thicker from the bottom.
4. Why is it easier to cut an apple from the sharper side than the blunt side of a knife?
5. How is pressure related to the force?

FLUIDS

Matter exists in three forms in nature : Solid, liquid and gas. You have studied their molecular arrangements in your previous class and you know that liquids and gases do not have a fixed shape and size. In addition to that, both of them can easily flow. Hence, it can be concluded that they possess similar properties and based on these similar properties, they can also be called by a common name — **fluid**.



Like solids, all liquids and gases (or fluids) have weight and they exert a pressure on the area in their contact.

PRESSURE EXERTED BY AIR

What happens when you fill air in a balloon? It inflates; because air molecules exert pressure on the inside walls of the balloon. What happens if you keep on filling air into it? It bursts if too much air is blown into it because air increases inside it and more gas in a limited space applies more pressure on its walls.

All gases exert pressure on the walls, bottom and top of the container in which they are stored or on the surface of the object in which they are filled. The most common gas known and necessary for all is the air present in the atmosphere.

Atmospheric Pressure

You know that the earth is surrounded by a layer of air known as the **atmosphere** which extends up to 500 km above the surface. This atmospheric air, comprising of various gases, has weight and thus exerts pressure on various objects on the earth. This weight of air, acting per unit area, is known as the pressure of the atmosphere and is called **atmospheric pressure**.

This atmospheric pressure is about 100 kilo Pascal (100 kpa) at sea level and is called **normal pressure** or **standard pressure**.

The human body generally does not experience this high atmospheric pressure, as it is counterbalanced by the pressure of the blood running in the blood vessels. Atmospheric pressure reduces on high altitudes. That is why on high altitudes when blood pressure is more than the atmospheric pressure, bleeding starts from nose or ears as their blood vessels rapture.

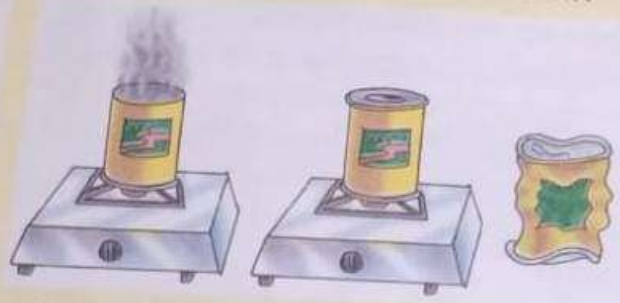
Nevertheless, the human body is capable of adjusting to such changes.

Similarly, a fountain pen leaks on high altitudes, because the air within the ink tube remains higher than the atmospheric pressure.

The existence of atmospheric pressure can be demonstrated with the help of some simple activities.

Activity 3

Take a small canister with a tight fitting lid. Pure some water in it and boil it with its lid open and you will observe steam coming out of the open mouth of the tin. Now, close the lid tightly to close the tin. Remove it from fire and pour some cold water to cool it. What do you observe? Does the canister deform?



You will notice that the canister will crush. It crushes due to the atmospheric pressure outside the tin which is different from the pressure inside the hot container.

The instrument which is used to measure the atmospheric pressure is called a **barometer**. A standard mercury barometer has a glass column of about 30 inches in length and it is closed at one end with a reservoir filled with mercury. Air pressure is usually measured in millibars or in inches of mercury.

A mercury barometer

Test Yourself

1. What do you understand by fluids?
2. Why does a balloon burst on filling excess of air?
3. What is the atmospheric pressure and what is its value at sea level?
4. Why do fountain pens tend to leak on high mountains?

PRESSURE EXERTED BY LIQUIDS

What happens when you fill water in a water-balloon? It starts bulging out in all directions; because water molecules exert pressure on the inner walls of the balloon. What happens if you keep on filling water into it? It bursts because more liquid (water) gets accumulated in limited space. More liquid exerts more pressure on balloon's wall and subsequently it bursts.