CHAPTER 8

Force and Pressure

0854CH11

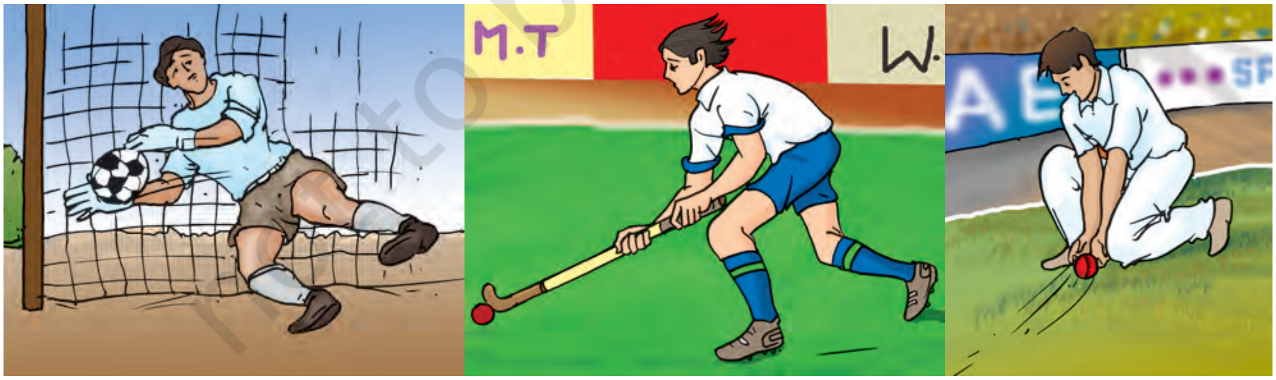
In Class VII, you have learnt how objects move. Do you recall how we can decide whether an object is moving faster than the other? What does the distance moved by an object in unit time indicate? You also know that a moving object like a ball rolling on the ground slows down. Sometimes it may change its direction of motion. It is also possible that the ball may slow down and also change its direction. Have you ever wondered what makes an object slow down or go faster, or change its direction of motion?

Let us recall some of our everyday experiences. What do you do to make a football move? What do you do to make a moving ball move faster? How does a goalkeeper stop a ball? A hockey player changes the direction of the moving ball with a flick of the stick. How do fielders stop a ball hit by a batsman? (Fig. 8.1). In all these situations the ball is either made to move faster or slower or its direction of motion is changed.

We often say that a force has been applied on a ball when it is kicked, pushed, thrown or flicked. What is a force? What can it do to bodies on which it is applied? We shall seek answers to such questions in this chapter.

8.1 Force – A Push or a Pull

Actions like picking, opening, shutting, kicking, hitting, lifting, flicking, pushing, pulling are often used to describe certain tasks. Each of these actions usually results in some kind of change in the state of motion of an object. Can these terms be replaced with one or more terms? Let us find out.



(a) (b) (c)

Fig. 8.1 : ***(a)*** *A goal keeper saving a goal,* ***(b)*** *A hockey player flicking a ball, and* ***(c)*** *A fielder stopping a ball*

Activity 8.1

Table 8.1 gives some examples of familiar situations involving motion of objects. You can add more such situations or replace those given here. Try to identify action involved in each case as a push and/or a pull and record your observations. One example has been given to help you.

Table 8.1 : Identifying Actions as Push or Pull

S. No.	Description of the situation	Action : (pushing/ pulling/picking/ hitting/lifting/ lowering/flying/ kicking/ throwing/shutting/ flicking)				Action can be grouped as a	
						Push	Pull
1.	Moving a book placed on a table	Pushing	Pulling	Lifting	—	Yes	Yes
2.	Opening or shutting a door						
3.	Drawing a bucket of water from a well						
4.	A football player taking a penalty kick						
5.	A cricket ball hit by a batsman						
6.	Moving a loaded cart						
7.	Opening a drawer						

Do you notice that each of the actions can be grouped as a pull or a push or both? Can we infer from this, that to move an object, it has to be pushed or pulled?

In science, a push or a pull on an object is called a **force**. Thus, we can say that the motion imparted to objects was due to the action of a force. When does a force come into play? Let us find out.

I learnt in Class VI that a magnet attracts a piece of iron towards it. Is attraction also a pull? What about repulsion between similar poles of two magnets? Is it a pull or a push?

8.2 Forces are due to an Interaction

Suppose a man is standing behind a stationary car [Fig.8.2(a)]. Will the car move due to his presence? Suppose the man now begins to push the car [Fig.8.2(b)], that is, he applies a force on it. The car may begin to move in the

Fig. 8.2(a) : *A man standing behind a stationary car*

Fig. 8.2 (b) : *A car being pushed by a man*

direction of the applied force. Note that the man has to push the car to make it move.

Fig. 8.3 (a) : *Who is pushing whom?*

Fig. 8.3 shows three situations that may be familiar to you. Can you decide who is pulling and who is pushing in these cases? In Fig. 8.3 (a), both the girls appear to push each other while

Fig. 8.3 (b) : *Who is pulling whom ?*

the pair of girls in Fig. 8.3 (b) are trying to pull each other. Similarly, the cow and the man in Fig. 8.3 (c) appear to

Fig. 8.3 (c) : *Who is pulling whom?*

pull each other. The girls in the two situations shown here are applying force on each other. Is it also true for the man and the cow?

From these examples, we can infer that at least two objects must interact for a force to come into play. Thus, an interaction of one object with another object results in a force between the two objects.

8.3 Exploring Forces

Let us try to learn more about forces.

Activity 8.2

Choose a heavy object like a table or a box, which you can move only by pushing hard. Try to push it all by yourself. Can you move it? Now ask one of your friends to help you in pushing it in the same direction [Fig. 8.4(a)]. Is it easier to move it now? Can you explain why?

Now push the same object, but ask your friend to push it from the opposite side [Fig. 8.4 (b)]. Does the object move? If it does, note the direction in which it moves. Can you guess which one of you is applying a larger force?

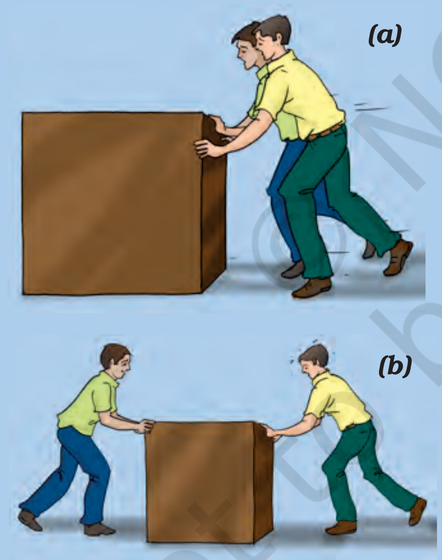


***Fig. 8.4 :** Two friends pushing a heavy load **(a)** in the same direction, **(b)** in opposite direction*

Have you ever seen a game of tug-of war? In this game two teams pull at a rope in opposite directions (Fig. 8.5). Members of both the teams try to pull the rope in their direction. Sometimes the rope simply does not move. Is it not similar to the situation shown in Fig. 8.3 (b)? The team that pulls harder, that is, applies a larger force, finally wins the game.

***Fig. 8.5 :** The rope may not move if the two teams pull at it with equal force*

What do these examples suggest about the nature of force?

Forces applied on an object **in the same direction add** to one another. Now recall what happened when you and your friend pushed the heavy box in the same direction in Activity 8.2.

If the two forces act in the opposite directions on an object, the net force acting on it is the **difference between the two forces**. What did you observe in Activity 8.2 when both of you were pushing the heavy box from opposite directions?

Recall that in the tug-of-war when two teams pull equally hard, the rope does not move in any direction.

So, we learn that a force could be larger or smaller than the other or equal to each other. The strength of a force is usually expressed by its **magnitude**. We have also to specify the direction in which a force acts. Also, if the direction or the magnitude of the applied force changes, its effect also changes.

Does it mean that the net force on an object is zero if the two forces acting on it in opposite directions are equal?

In general, more than one force may be acting on an object. However, the effect on the object is due to the net force acting on it.

8.4 A Force can Change the State of Motion

Let us now find out what happens when a force acts on an object.

Activity 8.3

Take a rubber ball and place it on a level surface such as a table top or a concrete floor. Now, gently push the ball along the level surface (Fig. 8.6). Does the ball begin to move? Push the ball again while it is still moving. Is there any change in its speed? Does it increase or decrease?

Next, place your palm in front of the moving ball. Remove your palm as soon as the moving ball touches it. Does your palm apply a force on the ball? What happens to the speed of the ball now? Does it increase or decrease? What would happen if you let your palm hold the moving ball?

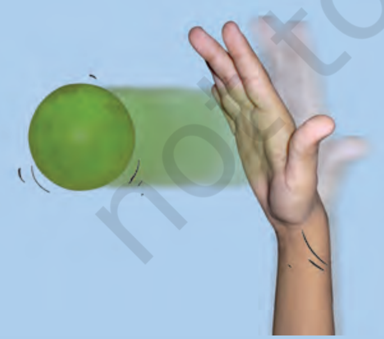


Fig. 8.6 : *A ball at rest begins to move when a force is applied on it*

You might recall similar situations. For example, while taking a penalty kick in football, the player applies a force on the ball. Before being hit, the ball was at rest and so its speed was zero. The applied force makes the ball move towards the goal. Suppose, the goalkeeper dives or jumps up to save the goal. By his action the goalkeeper tries to apply a force on the moving ball. The force applied by him can stop or deflect the ball, saving a goal being scored. If the goalkeeper succeeds in stopping the ball, its speed decreases to zero.

These observations suggest that a force applied on an object may change its speed. If the force applied on the object is in the direction of its motion, the speed of the object increases. If the force is applied in the direction opposite to the direction of motion, then it results in a decrease in the speed of the object.

I have seen children competing with one another in moving a rubber tyre or a ring by pushing it (Fig. 8.7). I now understand why the speed of the tyre increases whenever it is pushed.

Fig. 8.7 : *To move a tyre faster it has to be pushed repeatedly*

Paheli is curious to know whether application of a force can only change the speed of an object. Let us find out.

Activity 8.4

Take a ball and place it on a level surface as you did in Activity 8.3. Make the ball move by giving it a push [Fig. 8.8(a)]. Now place a ruler in its path as shown in Fig. 8.8(b). In doing so, you would apply a force on the moving ball. Does the ball continue to move in the same direction after it strikes the ruler? Repeat the activity and try to obstruct the moving ball by placing the ruler in such a way that it makes different angles to its path. In each case note your observations about the direction of motion of the ball after it strikes the ruler.

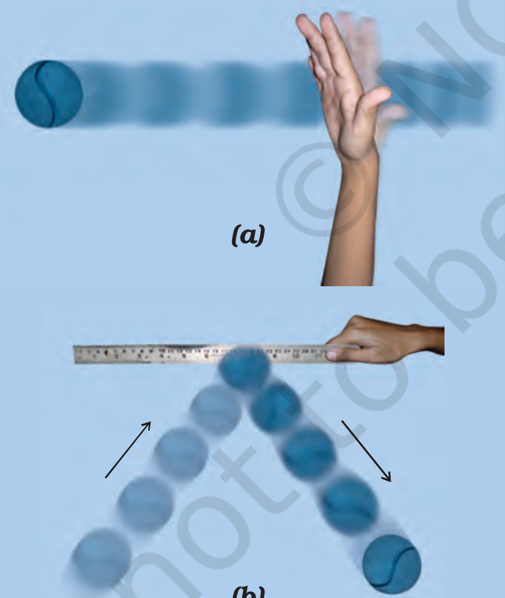


Fig. 8.8 : ***(a)*** *A ball set in motion by pushing it along a level surface and* ***(b)*** *the direction of motion of the ball after it strikes the ruler placed in its path*

Let us consider some more examples. In a game of volleyball, players often push the moving ball to their team mates to make a winning move. Sometimes the ball is returned to the other side of the court by pushing or smashing it. In cricket, a batsman plays his or her shot by applying a force on the ball with the bat. Is there any change in the direction of motion of the ball in these cases? In all these examples the speed and the direction of the moving ball change due to the application of a force. Can you give a few more examples of this kind?

A change in either the speed of an object, or its direction of motion, or both, is described as a **change in its state of motion**. Thus, a force may bring a **change in the state of motion of an object.**

State of Motion

The state of motion of an object is described by its speed and the direction of motion. The state of rest is considered to be the state of zero speed. An object may be at rest or in motion; both are its states of motion.

Does it mean that the application of a force would always result in a change in the state of motion of the object? Let us find out.

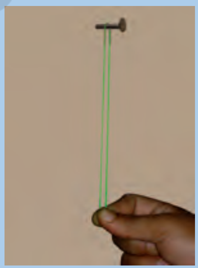
It is common experience that many a time application of force does not result in a change in the state of motion. For example, a heavy box may not move at all even if you apply the maximum force that you can exert. Again, no effect of force is observed when you try to push a wall.

8.5 Force can Change the Shape of an Object

Activity 8.5

Some situations have been given in Column 1 of Table 8.2 in which objects are not free to move. Column 2 of the Table suggests the manner in which a force can be applied on each object while Column 3 shows a diagram of the action. Try to observe the effect of force in as many situations as possible. You can also add similar situations using available material from your environment. Note your observations in Columns 4 and 5 of the Table.

Table 8.2 : Studying the Effect of Force on Objects

Description of Situation	How to Apply Force	Diagram	Action of Force			
			Change in State of Motion		Change in Shape	
			Yes	No	Yes	No
A lump of dough on a plate.	Pressing it down with your hands.					
Spring fixed to the seat of a bicycle.	By sitting on the seat.					
A rubber band suspended from a hook/nail fixed on a wall.	By hanging a weight or by pulling its free end.					
A plastic or metal scale placed between two bricks.	By putting a weight at the centre of the scale.					

What do you conclude from the observations noted in Table 8.2? What happens when you apply a force on an inflated balloon by pressing it between your palms? What happens to the shape of a ball of dough when it is rolled to make a *chapati*? What happens when you press a rubber ball placed on a table? In all these examples you saw that the application of **force on an object may change its shape**.

Having performed all the above activities, you would have realised that a force

- may make an object move from rest.
- may change the speed of an object if it is moving.
- may change the direction of motion of an object.
- may bring about a change in the shape of an object.
- may cause some or all of these effects.

While a force may cause one or more of these effects, it is important to remember that none of these actions can take place without the action of a force. Thus, an object cannot move by itself, it cannot change speed by itself, it cannot change direction by itself and its shape cannot change by itself.

8.6 Contact Forces

Muscular Force

Can you push or lift a book lying on a table without touching it? Can you lift a bucket of water without holding it? Generally, to apply a force on an object, your body has to be in contact with the object. The contact may also be with the help of a stick or a piece of rope. When we push an object like a school bag or lift a bucket of water, where does the force come from? This force is caused by the action of muscles in our body. The force resulting due to the action of muscles is known as the **muscular force**.

It is the muscular force that enables us to perform all activities involving movement or bending of our body. In Class VII you have learnt that in the process of digestion the food gets pushed through the alimentary canal. Could it be a muscular force that does it? You also know that lungs expand and contract while we inhale and exhale air during breathing. Where are these muscles located which make breathing possible? Can you list a few more examples of the force exerted by the muscles in our body?

Animals also make use of muscular force to carry out their physical activities and other tasks. Animals like bullocks, horses, donkeys and camels are used to perform various tasks for us. In performing these tasks they use muscular force (Fig. 8.9).

Fig. 8.9 : *Muscular force of animals is used to carry out many difficult tasks*

2024-25

Since muscular force can be applied only when it is in contact with an object, it is also called a **contact force**. Are there other types of contact forces? Let us find out.

Friction

Recall some of your experiences. A ball rolling along the ground gradually slows down and finally comes to rest. When we stop pedalling a bicycle, it gradually slows down and finally comes to a stop. A car or a scooter also comes to rest once its engine is switched off. Similarly, a boat comes to rest if we stop rowing it. Can you add some more such experiences?

In all these situations no force appears to be acting on the objects, yet their speed gradually decreases and they come to rest after some time. What causes a change in their state of motion? Could some force be acting on them! Can you guess the direction in which the force must be acting in each case?

The force responsible for changing the state of motion of objects in all these examples is the force of **friction**. It is the force of friction between the surface of the ball and the ground that brings the moving ball to rest. Similarly, friction between water and the boat brings it to a stop once you stop rowing.

The force of friction always acts on all the moving objects and its direction is always opposite to the direction of motion. Since the force of friction arises due to contact between surfaces, it is also an example of a contact force. You will learn more about this force in Chapter 9.

You may be wondering whether it is essential for the agent applying a force on an object to be always in contact with it. Let us find out.

8.7 Non-contact Forces

Magnetic Force

Activity 8.6

Take a pair of bar magnets. Place the longer side of one of the magnets over three round shaped pencils or wooden rollers as shown in Fig. 8.10. Now bring one end of the other magnet near the end of the magnet placed on the rollers. Make sure that the two magnets do not touch each other. Observe what happens. Next, bring the other end of the magnet near the same end of the magnet placed on the rollers (Fig.8.10). Note what happens to the magnet placed on the rollers every time another magnet is brought near it.

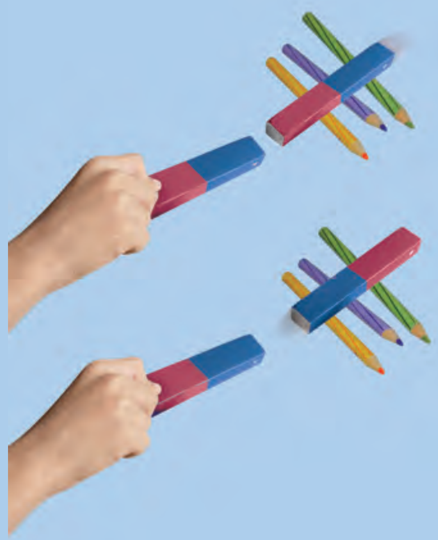


Fig. 8.10 : *Observing attraction and repulsion between two magnets*

Does the magnet on the rollers begin to move when the other magnet is brought near it? Does it always move in the direction of the approaching magnet? What do these observations suggest? Does it mean that some force must be acting between the two magnets?

You have learnt in Class VI that like poles of two magnets repel each other and unlike poles attract each other. Attraction or repulsion between objects can also be seen as another form of pull or push. Do you have to bring the magnets in contact for observing the force between them? A magnet can exert a force on another magnet without being in contact with it. The force exerted by a magnet is an example of a **non-contact force**.

Similarly, the force exerted by a magnet on a piece of iron is also a non-contact force.

Electrostatic Force

Activity 8.7

Take a plastic straw and cut it into nearly two equal pieces. Suspend one of the pieces from the edge of a table with the help of a piece of thread (Fig. 8.11). Now hold the other piece of straw in your hand and rub its free end with a sheet of paper. Bring the rubbed end of the straw near the suspended straw. Make sure that the two pieces do not touch each other. What do you observe?

Next, rub the free end of the suspended piece of straw with a sheet of paper. Again, bring the piece of straw that was rubbed earlier with paper near the free end of the suspended straw. What do you observe now?

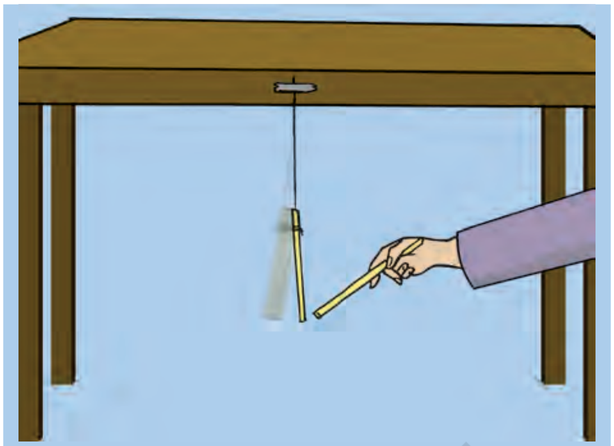


Fig. 8.11 : *A straw rubbed with paper attracts another straw but repels it if it has also been rubbed with a sheet of paper*

A straw is said to have acquired electrostatic charge after it has been rubbed with a sheet of paper. Such a straw is an example of a charged body.

The force exerted by a charged body on another charged or uncharged body is known as **electrostatic force**. This force comes into play even when the bodies are not in contact. The electrostatic force, therefore, is another example of a non-contact force. You will learn more about electric charges in Chapter 12.

Gravitational Force

You know that a coin or a pen falls to the ground when it slips off your hand. Leaves and fruits also fall to the ground when they get detached from the plant. Have you ever wondered why it is so?

When the coin is held in your hand it is at rest. As soon as it is released, it begins to move downwards. It is clear that the state of motion of the coin undergoes a change. Can this happen without a force acting on it? Which is this force?

Objects or things fall towards the earth because it pulls them. This force is called the **force of gravity**, or just **gravity**. This is an attractive force. The force of gravity acts on all objects. The force of gravity acts on all of us all the time without our being aware of it. Water begins to flow towards the ground as soon as we open a tap. Water in rivers flows downward due to the force of gravity.

> Gravity is not a property of the earth alone. In fact, every object in the universe, whether small or large, exerts a force on every other object. This force is known as the **gravitational force**.

8.8 Pressure

Is there any relation between pressure and force? Let us find out.

Try to push a nail into a wooden plank by its head. Did you succeed? Try now to push the nail by the pointed end (Fig. 8.12). Could you do it this time?

Fig. 8.12 : *Pushing a nail into a wooden plank*

Try cutting vegetables with a blunt knife and then with a sharp knife. Which is easier?

Do you get the feeling that the area over which the force is applied (for example, the pointed end of the nail) plays a role in making these tasks easier?

The force acting on a unit area of a surface is called **pressure**.

pressure = force / area on which it acts

> At this stage we consider only those forces which act perpendicular to the surface on which the pressure is to be computed.

I now understand why porters place a round piece of cloth on their heads, when they have to carry heavy loads (Fig. 8.13). By doing this they increase the area of contact of the load with their head. So, the pressure on their head is reduced and they find it easier to carry the load.

Fig. 8.13 : *A porter carrying a heavy load*

Note that the area is in the denominator in the above expression. So, the smaller the area, larger the pressure on a surface for the same force. The area of the pointed end of the nail is much smaller than that of its head. The same force, therefore, produces a pressure sufficient to push the pointed end of the nail into the wooden plank.

Can you explain now why shoulder bags are provided with broad straps and not thin strap? And, why the tools meant for cutting and piercing always have sharp edges?

Do liquids and gases also exert pressure? Does it also depend on the area on which the force acts? Let us find out.

8.9 Pressure Exerted by Liquids and Gases

Activity 8.8

Take a transparent glass tube or a plastic pipe. The length of the pipe/tube should be about 25 cm and its diameter should be 5-7.5 cm. Also take a piece of thin sheet of a good quality rubber, say, a rubber balloon. Stretch the rubber sheet tightly over one end of the pipe. Hold the pipe at the middle, keeping it in a vertical position (Fig. 8.14). Ask one of your friends to pour some water in the pipe. Does the rubber sheet bulge out? Note also the height of the water column in the pipe. Pour some more water. Observe again the bulge in the rubber sheet and the height of the water column in the pipe. Repeat this process a few more times. Can you see any relation between the amount of the bulge in the rubber sheet and the height of the water column in the pipe?

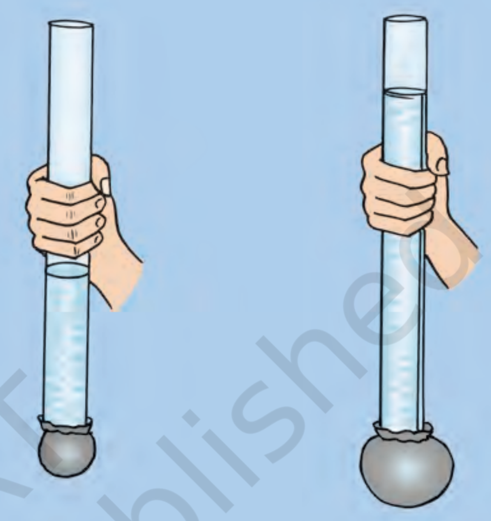


Fig. 8.14 : *Pressure exerted by water at the bottom of the container depends on the height of its column*

Activity 8.9

Take a plastic bottle. You can take a discarded water or soft drink bottle. Fix a cylindrical glass tube, a few cm long near its bottom as shown in Fig. 8.15. You can do so by slightly heating one end of the glass tube and then quickly inserting it near the bottom of the bottle. Make sure that the water does not leak from the joint. If there is any leakage, seal it with molten wax. Cover the mouth of the glass tube with a thin rubber sheet as you did in Activity 8.8. Now fill the bottle upto half with water. What do you observe? Why does the rubber sheet fixed to the glass tube bulge this time? Pour some more water in the bottle. Is there any change in the bulge of the rubber sheet?

Fig. 8.15 : *A liquid exerts pressure on the walls of the container*

Note that the rubber sheet has been fixed on the side of the container and not at the bottom. Does the bulging of the rubber sheet in this case indicate that water exerts pressure on the sides of the container as well? Let us investigate further.

Activity 8.10

Take an empty plastic bottle or a cylindrical container. You can take a used tin can or a used plastic bottle. Drill four holes all around near the bottom of the bottle. Make sure that the holes are at the same height from the bottom (Fig. 8.16). Now fill the bottle with water. What do you observe?

Do the different streams of water coming out of the holes fall at the same distance from the bottle? What does this indicate?

Fig. 8.16 : *Liquids exert equal pressure at the same depth*

Can you now say that **liquids exert pressure on the walls of the container**?

Do gases also exert pressure? Do they also exert pressure on the walls of their containers? Let us find out.

I have seen fountains of water coming out of the leaking joints or holes in pipes supplying water. Is it not due to the pressure exerted by water on the walls of the pipes?

When you inflate a balloon, why do you have to close its mouth? What happens when you open the mouth of an inflated balloon? Suppose you have a balloon which has holes. Would you be able to inflate it? If not, why? Can we say that air exerts pressure in all directions?

Do you recall what happens to the air in the bicycle tube when it has a puncture? Do these observations suggest that air exerts pressure on the inner walls of an inflated balloon or a tube? So, we find that **gases, too, exert pressure on the walls of their container.**

8.10 Atmospheric Pressure

You know that there is air all around us. This envelop of air is known as the **atmosphere**. The atmospheric air extends up to many kilometres above the surface of the earth. The pressure exerted by this air is known as **atmospheric pressure**. We know that pressure is force per unit area. If we imagine a unit area and a very long cylinder standing on it filled with air, then the force of gravity on the air in this cylinder is the atmospheric pressure (Fig. 8.17).

Fig. 8.17 : *Atmospheric pressure is the force of gravity on air in a column of unit area*

But, how large or small is the atmospheric pressure? Let us get an idea about its magnitude.

Activity 8.11

Take a good quality rubber sucker. It looks like a small rubber cup (Fig. 8.18). Press it hard on a smooth plane surface. Does it stick to the surface? Now try to pull it off the surface. Can you do it?

Fig. 8.18 : *A rubber sucker pressed on a surface*

When you press the sucker, most of the air between its cup and the surface escapes out. The sucker sticks to the surface because the pressure of atmosphere acts on it. To pull the sucker off the surface, the applied force should be large enough to overcome the atmospheric pressure. This activity might give you an idea about the magnitude of atmospheric pressure. In fact, it would not be possible for any human being to pull the sucker off the surface if there were no air at all between the sucker and the surface. Does it give you an idea how large the atmospheric pressure is?

If the area of my head were 15 cm × 15 cm, how much force air will exert on my head?

The force due to air in a column of the height of the atmosphere and area 15 cm × 15 cm (Fig. 8.19) is nearly equal to the force of gravity on an object of mass 225 kg (2250N). The reason we are not crushed under this force of gravity is that the pressure inside our bodies is also equal to the atmospheric pressure and balances the pressure from outside.

Fig. 8.19 : *Pressure of atmosphere on your head*

Did you know?

Otto von Guericke, a German scientist of the 17th century, invented a pump to extract air out of a vessel. With the help of this pump, he demonstrated dramatically the force of the air pressure. He joined two hollow metallic hemispheres of 51 cm diameter each and pumped air out of them. Then he employed eight horses on each hemisphere to pull them apart (Fig. 8.20). So great is the force of air pressure that the hemispheres could not be pulled apart.

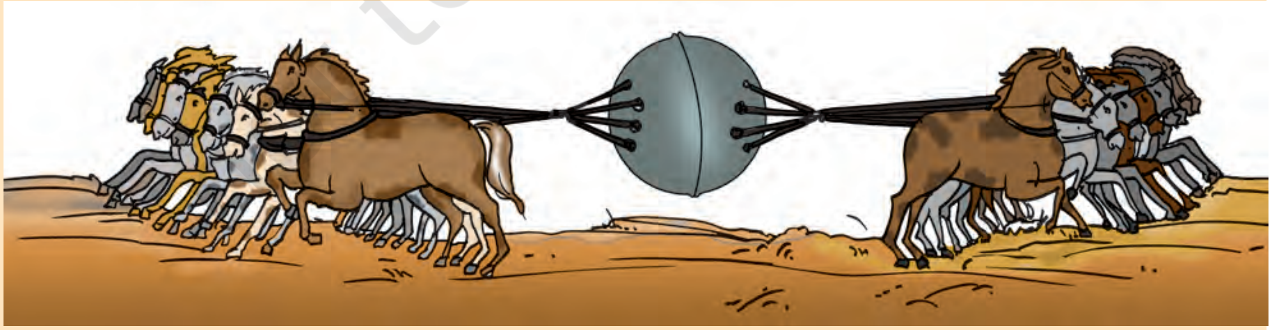


Fig. 8.20 : *Horses pulling the hemispheres*