CHAPTER

9 FRICTION

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You might have seen a driver of a car or a truck slowing down the vehicle at a traffic signal. You, too, slow down your bicycle whenever needed by applying brakes. Have you ever thought why a vehicle slows down when brakes are applied? Not only vehicles, any object, moving over the surface of another object slows down when no external force is applied on it. Finally it stops. Have you not seen a moving ball on the ground stopping after some time? Why do we slip when we step on a banana peel (Fig. 9.1)? Why is it difficult to walk on a smooth and wet floor?

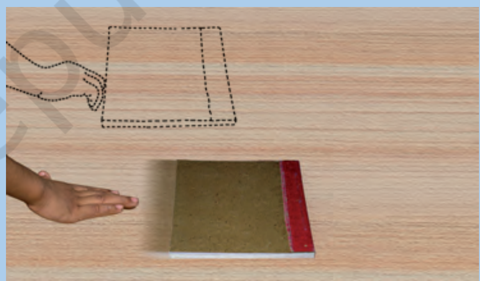
Fig. 9.1 : *A boy falls down when he steps on a banana peel*

You will find the answers to such questions in this chapter.

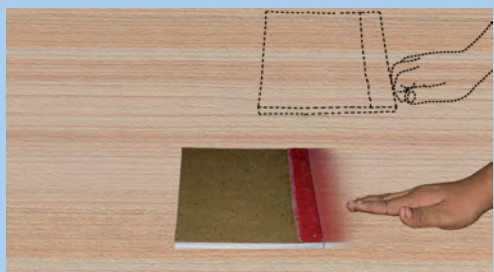
9.1 Force of Friction

Activity 9.1

Gently push a book on a table [Fig. 9.2(a)]. You observe that it stops after moving for some distance. Repeat this activity pushing the book from the opposite direction [Fig. 9.2, (b)]. Does the book stop this time, too? Can you think of an explanation? Can we say that a force must be acting on the book opposing its motion? This force is called the force of friction.



(a)



(b)

Fig. 9.2 (a), (b) : *Friction opposes relative motion between the surfaces of the book and the table*

You saw that if you apply the force along the left, friction acts along the right. If you apply the force along the right, the friction acts along the left direction. In both cases the force opposes the motion of the book. The force of friction always opposes the applied force.

In the above activity, the force of friction acts between the surface of the book and the surface of the table.

Is the friction the same for all the surfaces? Does it depend on the smoothness of the surfaces? Let us find out.

9.2 Factors affecting Friction

Activity 9.2

Tie a string around a brick. Pull the brick by a spring balance (Fig. 9.3). You need to apply some force. Note down the reading on the spring balance when the brick just begins to move. It gives you a measure of the force of friction between the surface of the brick and the floor.

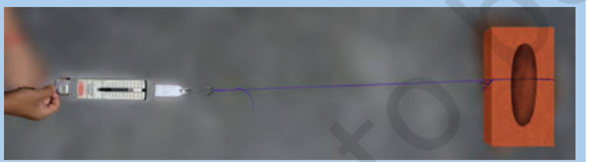


Fig. 9.3 : *A brick is being pulled by spring balance*

Now wrap a piece of polythene around the brick and repeat the activity. Do you observe any difference in the readings of the spring balance in the above two cases? What might be the reason for this difference? Repeat this activity by wrapping a piece of jute bag around the brick. What do you observe?

Spring Balance

Spring balance is a device used for measuring the force acting on an object. It consists of a coiled spring which gets stretched when a force is applied to it. Stretching of the spring is measured by a pointer moving on a graduated scale. The reading on the scale gives the magnitude of the force.

Activity 9.3

Make an inclined plane on a smooth floor, or on a table. You may use a wooden board supported by bricks, or books. [Fig. 9.4 (a)]. Put a mark with a pen at any point A on the inclined plane. Now let a pencil cell move down from this point. How far does it move on the table before coming to rest? Note down the distance. Now spread a piece of cloth over the table. Make sure that there are no wrinkles in the cloth. Try the activity again [Fig. 9.4 (b)].

(a)

(b)

Fig. 9.4 : *The pencil cell covers different distances on different surfaces*

Repeat this activity by spreading a thin layer of sand over the table. Maintain the same slope throughout the activity.

In which case is the distance covered the minimum? Why is the distance covered by the pencil cell different every time. Try to reason why? Discuss the result.

Does the distance covered depend on the nature of the surface on which the cell moves?

Could the smoothness of the surface of the cell also affect the distance travelled by it?

I shall try the activity by wrapping a piece of sandpaper around the cell.

Friction is caused by the irregularities on the two surfaces in contact. Even those surfaces which appear very smooth have a large number of minute irregularities on them (Fig. 9.5). Irregularities on the two surfaces lock into one another. When we attempt to move any surface, we have to apply a force to overcome interlocking. On rough surfaces, there are a larger number of irregularities. So the force of friction is greater if a rough surface is involved.

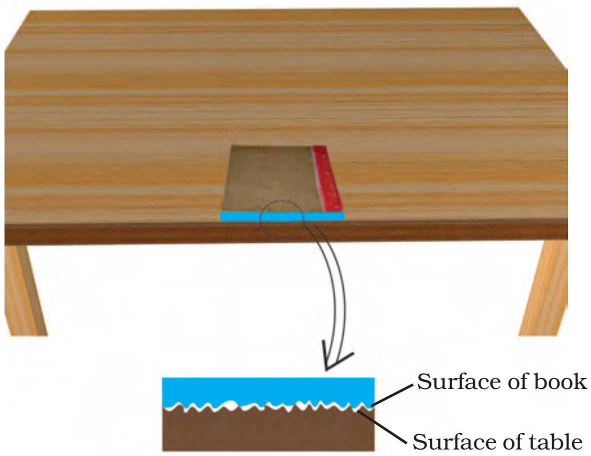


Fig. 9.5 : *Surface irregularities*

We see that the friction is caused by the interlocking of irregularities in the two surfaces. It is obvious that the force of friction will increase if the two surfaces are pressed harder. You can experience it by dragging a mat when nobody is sitting on it, and when a preson is sitting on it.

Fig. 9.6 : *You have to push on the box to keep it moving*

Recall your experience when last time you moved a heavy box from one place to another (Fig. 9.6). If you have no such experience, get that experience now. What is easier — to move the box from rest, or to move it when it is already in motion?

The force required to overcome friction at the instant an object starts moving from rest is a measure of static friction. On the other hand, the force required to keep the object moving with the same speed is a measure of sliding friction.

When the box starts sliding, the contact points on its surface, do not get enough time to lock into the contact points on the floor. So, the sliding friction is slightly smaller than the static friction and you find it somewhat easier to move the box already in motion than to get it started.

9.3 Friction : A Necessary Evil

Recall now some of your experiences. Is it easier to hold a *kulhar* (earthen pot) or a glass tumbler? Suppose the outer surface of the tumbler is greasy, or has a thin layer of cooking oil on it; would it become easier or more difficult to hold it? Just think : would it be possible to hold the glass at all if there is no friction?

Recall also how difficult it is to move on a wet muddy track, or wet marble floor. Can you imagine being able to walk at all if there were no friction?

You could not write with pen or pencil if there were no friction. When your teacher is writing with chalk on the blackboard, its rough surface rubs off some chalk particles which stick to

Fig. 9.7 : *A nail is fixed in the wall due to friction*

the black board. Could it happen if there were no friction between the chalk and the board?

If an object started moving, it would never stop if there were no friction. Had there been no friction between the tyres of the automobiles and the road, they could not be started or stopped or turned to change the direction of motion. You could not fix a nail on the wall (Fig. 9.7) or tie a knot. Without friction no building could be constructed.

Fig. 9.8 : *Soles of shoes wear out due to friction*

On the other hand, friction is an evil, too. It wears out the materials whether they are screws, ball bearings or soles of shoes (Fig. 9.8). You must have seen worn-out steps of foot over-bridges at railway stations.

Friction can also produce heat. Vigorously rub your palms together for a few minutes (Fig. 9.9). How do you feel? When you strike a matchstick against the rough surface, it catches fire (Fig. 9.10).

You might have observed that the jar of a mixer becomes hot when it is run

Fig. 9.9 : *Rubbing of your palms makes you feel warm*

for a few minutes. You can cite various other examples in which friction

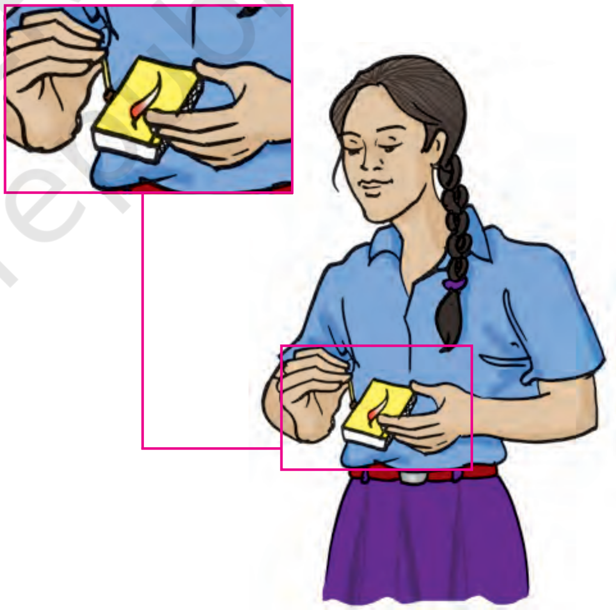


Fig. 9.10 : *Stricking a matchstick produces fire by friction*

produces heat. In fact, when a machine is operated, heat generated causes much wastage of energy. We shall discuss the ways of minimising friction in the following section.

9.4 Increasing and Reducing Friction

As you have seen in the previous section, friction is desirable in some situations.

Have you ever thought why the sole of your shoe is grooved [Fig. 9.11 (a)]? It is done to provide the shoes better grip on the floor, so that you can move safely. Similarly, the treaded tyres of cars,trucks and bulldozers provide better grip with the ground.

(a) (b)

Fig. 9.11 : *(a) Soles of shoes and (b) tyres are treaded to increase friction*

We deliberately increase friction by using brake pads in the brake system of bicycles and automobiles. When you are riding a bicycle, the brake pads do not touch the wheels. But when you press the brake lever, these pads arrest the motion of the rim due to friction. The wheel stops moving. You might have seen that *kabaddi* players rub their hands with soil for a better grip of their opponents. Gymnasts apply some coarse substance on their hands to increase friction for better grip.

In some situations, however, friction is undesirable and we would want to minimise it.

Why do you sprinkle fine powder on the carrom board (Fig. 9.12)? You might have noticed that when a few drops of oil are poured on the hinges of a door, the door moves smoothly. A bicycle and a motor mechanic uses grease between the moving parts of these machines. In all the above cases, we want to reduce

Fig. 9.12 : *Powder is sprinkled on the carrom board to reduce friction*

friction in order to increase efficiency. When oil, grease or graphite is applied between the moving part of a machine, a thin layer is formed there and moving surfaces do not directly rub against each other (Fig. 9.13). Interlocking of irregularities is avoided to a great extent. Movement becomes smooth. The substances which reduce friction are called **lubricants**. In some machines, it may not be advisable to use oil as lubricant. An air cushion between the moving parts is used to reduce friction.

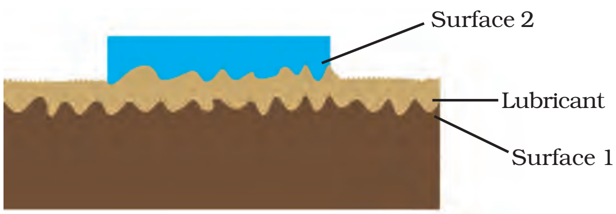


Fig. 9.13 : *Action of lubricant*

Can we reduce friction to zero by polishing surfaces or using large amount of lubricants?

Friction can never be entirely eleminated. No surface is perfectly smooth. Some irregularities are always there.

9.5 Wheels Reduce Friction

You must have seen attaches and other pieces of luggage fitted with rollers. Even a child can pull such pieces of luggage (Fig. 9.14). Why is it so? Let us find out.

Fig. 9.14 : Rolling reduces friction

Activity 9.4

Take a few pencils which are cylindrical in shape. Place them parallel to each other on a table. Place a thick book over it (Fig. 9.15). Now push the book. You observe the pencils rolling as the book moves. Do you feel it easier to move the book in this way than to slide it? Do you think that resistance to the motion of the book has been reduced? Have you seen heavy machinary being moved by placing logs under it?

Fig. 9.15 : *Motion of the book on rollers*

When one body rolls over the surface of another body, the resistance to its motion is called **rolling friction**. Rolling reduces friction. It is always easier to roll than to slide a body over another. That is the reason it is convenient to pull luggage fitted with rollers. Can you now understand why the wheel is said to be one of the greatest inventions of mankind?

Since the rolling friction is smaller than the **sliding friction**, sliding is replaced in most machines by rolling by the use of ball bearings. Common examples are the use of ball bearings between hubs and the axles of ceiling fans and bicycles (Fig. 9.16).

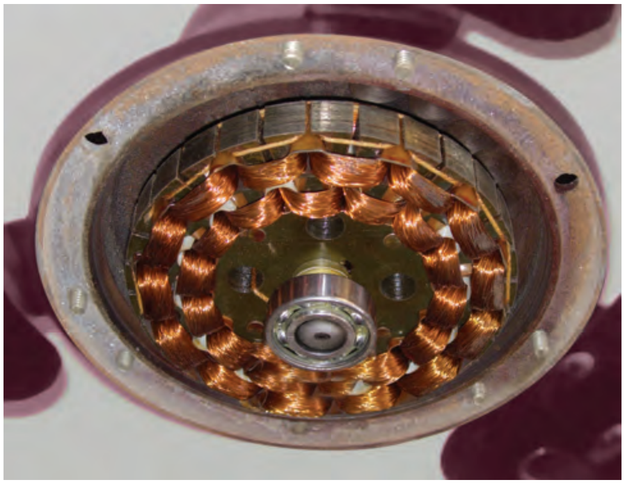


Fig. 9.16 : Ball bearings reduce friction

9.6 Fluid Friction

You know that air is very light and thin. Yet it exerts frictional force on objects moving through it. Similarly, water and other liquids exert force of friction when objects move through them. In science, the common name of gases and liquids is **fluids**. So we can say that fluids exert force of friction on objects in motion through them.

The frictional force exerted by fluids is also called **drag**.

The frictional force on an object in a fluid depends on its speed with respect to the fluid. The frictional force also depends on the shape of the object and the nature of the fluid.

It is obvious that when objects move through fluids, they have to overcome friction acting on them. In this process they lose energy. Efforts are, therefore, made to minimise friction. So, objects are given special shapes. Where do you think scientists get hints for these special shapes? From nature, of course. Birds and fishes have to move about in fluids all the time. Their bodies must have evolved to shapes which would make them lose less energy in overcoming friction. Look carefully at the shape of an aeroplane (Fig. 9.17). Do you find any similarity in its shape and that of a bird? In fact, all vehicles are designed to have shapes which reduce fluid friction.

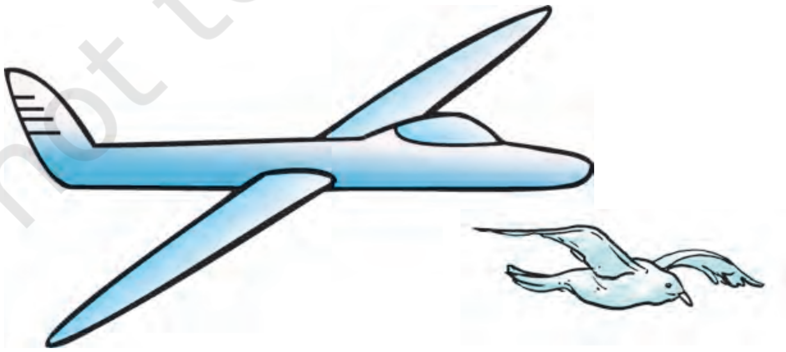


Fig. 9.17 : Similarity in shapes of an aeroplane and a bird