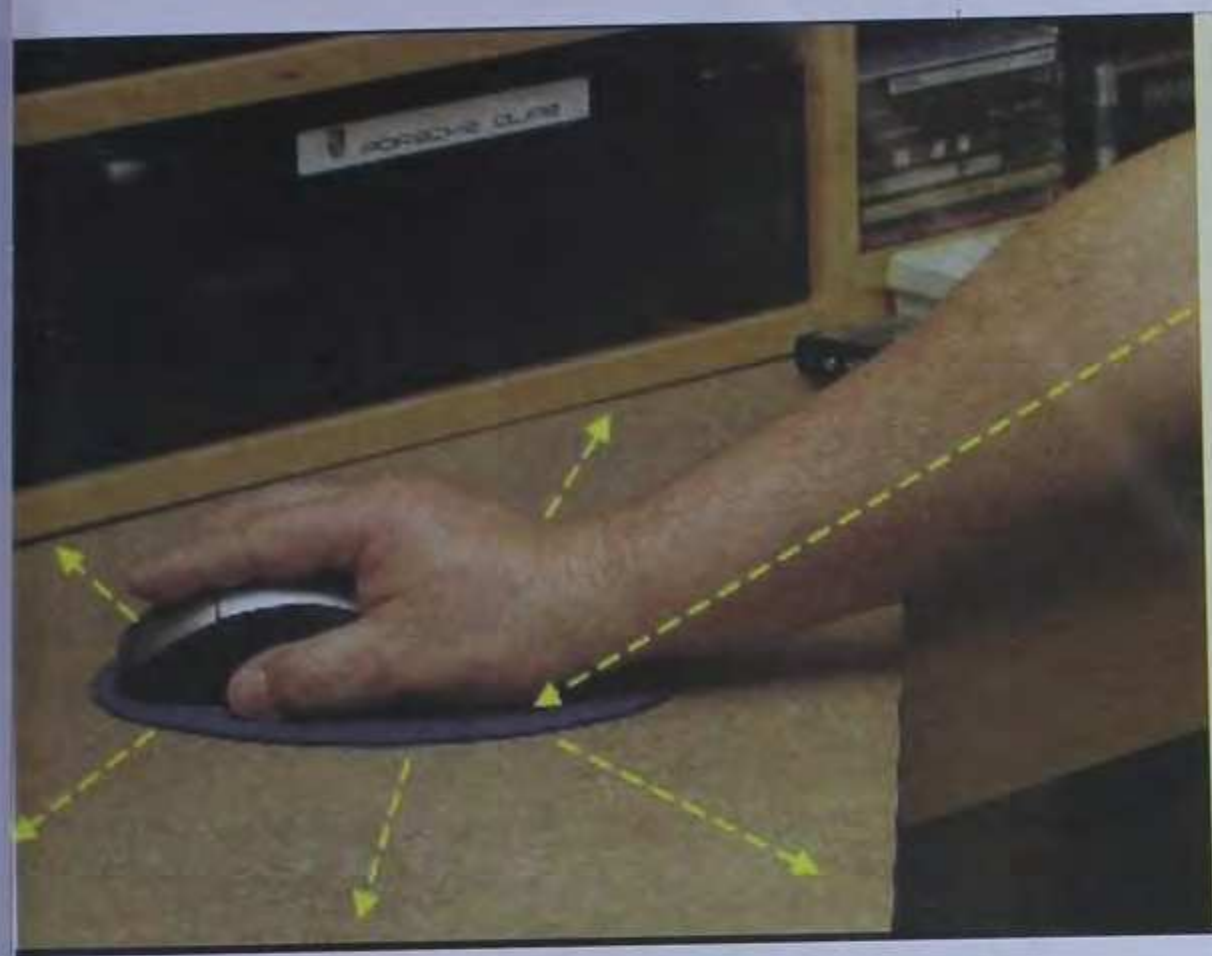


3

Friction

SYLLABUS

Friction : opposes motion - produces heat, wear and tear - can be reduced by using lubricants or wheels – examples from daily life where friction is a help or a hindrance.

FRICTION

When we roll a ball on the ground, it goes up to a certain distance with a decreasing speed and then it finally stops. Similarly, if we stop pedalling our bicycle on a plain road, its speed starts reducing and ultimately it stops. Why does the ball or bicycle stop after moving for sometime ? It happens because the ground renders an opposing force to both, the ball and the bicycle (acting between the two surfaces in contact of the two bodies). This opposing force is known as the **frictional force** and is responsible for stopping the ball or the bicycle.

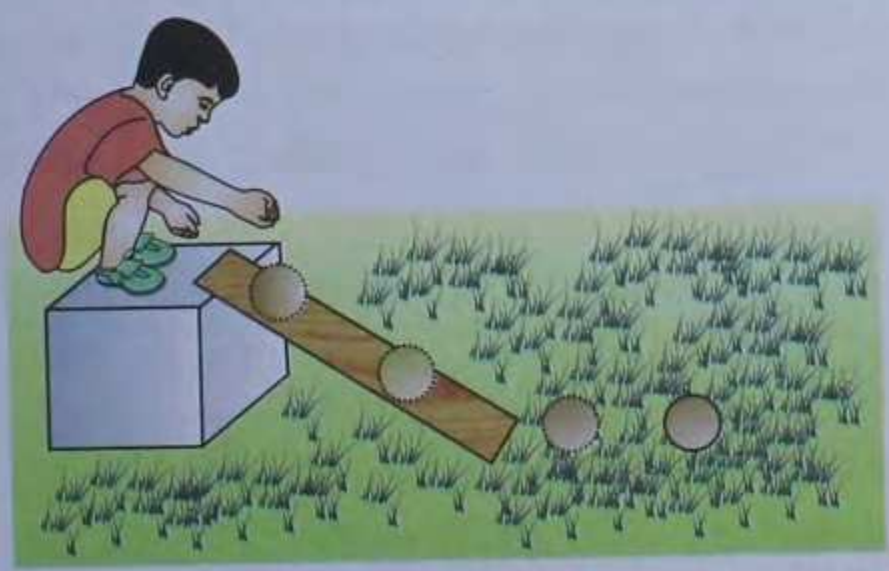


Fig. 3.1 The ball stops after rolling due to friction

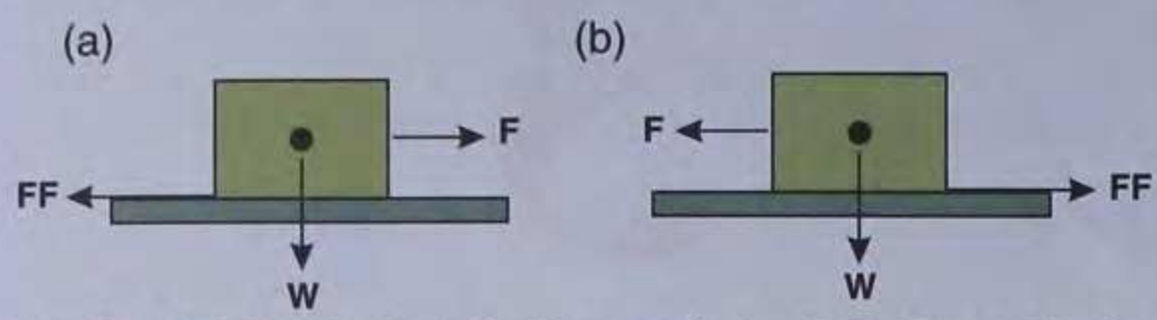
Therefore, *friction is that force which opposes the relative motion between the two surfaces that are in contact with each other.*

The word friction is derived from a Latin word 'fricare' which means 'to rub'.

For example, if we place a box on a table top and then move it towards right, friction will act between the table top and the box towards left and if we move the box towards left, friction will act towards right. It means that the *force of friction opposes the motion* of the box. This resisting force between the two bodies in contact which prevents either body to move smoothly and continuously is called **friction** or **frictional force**. This is the force that slows down the motion of two surfaces in contact when they move across each other. Friction always opposes the relative motion between the two bodies in contact, irrespective of the direction of motion.

For example, when a block is pulled, by force F, towards left the force of friction acts

towards the right [Fig. 3.2 (b)] and when the block is pulled towards the right the force of friction acts towards the left [Fig. 3.2 (a)].



Here, W = Weight of the body, F = Force applied and FF = Force of friction

Fig. 3.2 Showing that friction always opposes the relative motion between the two bodies irrespective of the direction of motion.

Properties of Friction

1. *Friction is a force that always opposes relative motion, i.e.*, it slows down and ultimately stops a moving object.
2. *Friction always produces heat.* The tyres of vehicles become hot after a long drive due to friction between the tyres and the road. Similarly, the moving parts of a machine become hot due to friction.
3. *Friction causes wear and tear.* Our shoes, tyres of vehicles, parts of machines, *etc.*, wear out due to friction.

ACTIVITY 1

You can test the effects of friction by rubbing your palms together for a minute or two. Make sure they are clean and dry. You will feel that your palms have become warm. This happens because friction creates heat. Now put a small amount of liquid washing soap on your palms and rub them together again. You will observe that this time, it takes a longer time to feel warm. The reason is that liquid washing soap acts as a lubricant due to this the force of friction between the rubbing hands decreases. Similarly, to increase the efficiency of engines, machines, *etc.*, various types of lubricants are used which helps in reducing friction.

Factors which Affect the Force of Friction

1. *Friction depends on the smoothness of the surface* : Friction occurs because most surfaces are not perfectly smooth. Even a table top which may appear smooth to you has little bumps on it. These bumps can be seen with a fine microscope. When two surfaces with little bumps move on each other, the bumps interlock and slow down the motion of the surfaces. That is why, friction occurs. Rougher the surface, more will be the friction.

Fig. 3.3 Friction occurs as most surfaces are not smooth

ACTIVITY 2

Take a flat, long glass plate and place an object on it. As shown in Fig. 3.4(*a*), attach a pulley with a weight of 2 kg fixed at one end of the string and the other end of the string attached to the object, placed on the glass plate. Allow the weight of 2 kg to fall down. As the weight falls downwards, note the distance covered by the object in one minute.

Now take a flat wooden plank, keep it horizontal and attach a pulley and a weight of 2 kg fixed with it. Keep the same object on the wooden plank attached to the other end of the string as shown in Fig. 3.4(*b*). Again allow the weight of 2 kg to fall down. As the weight moves down, note the distance covered by the object in one minute. It will be observed that in the same time, the distance covered by the object is more when placed on glass surface than when placed on wooden surface. This is due to the smooth surface of glass which provides less friction as compared to the wooden

plank which provides greater friction.

Therefore, we conclude that *friction increases with the roughness of the surface in contact.*

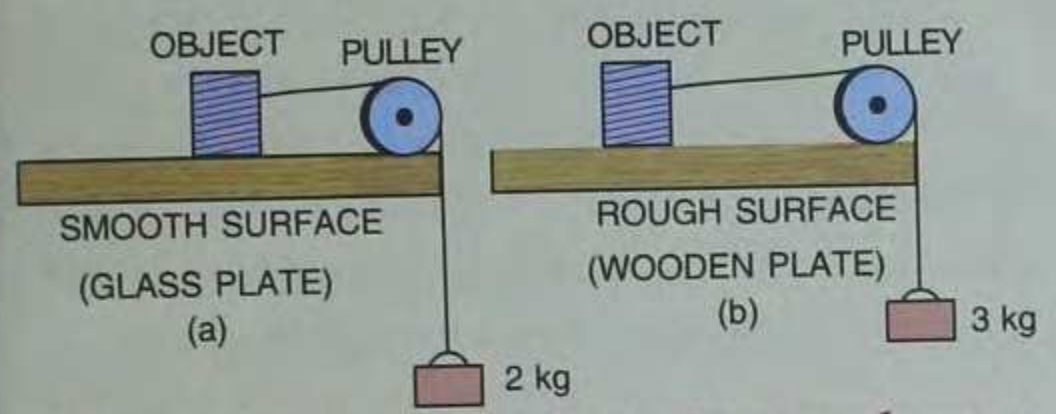


Fig. 3.4 Friction depends on the smoothness or roughness of the surfaces in contact

2. *Solids, liquids and gases all tend to stop things moving in or over them.* They all exert frictional force.

When we play cricket on the ground, grass obstructs the movement of the ball. Moreover, when there is dampness or moisture on the ground, the movement of the ball slows down. This is because the presence of any type of medium solid, liquid or gas exerts frictional force and thus slows down the movement.

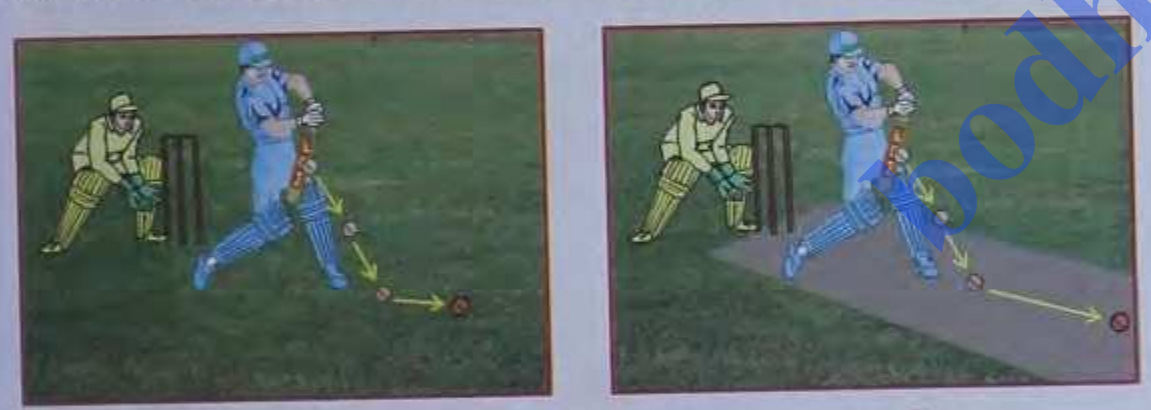


Fig. 3.5 Grass and dampness on the cricket ground increase friction

The force of friction between a solid and a liquid surface is less than that between two solids.

The force of friction between a solid surface and a gas is less than that between a solid and a liquid surface.

3. *Friction depends on normal reaction of the weight of the object. Greater the weight, greater is the normal reaction. For example*, if we apply force on a heavy object, the force of friction is large and if we reduce the weight of the object and apply the same amount of force on it, the force of friction will be less. So, we conclude that more the weight of the object, more the normal reaction and hence more will be the force of friction.

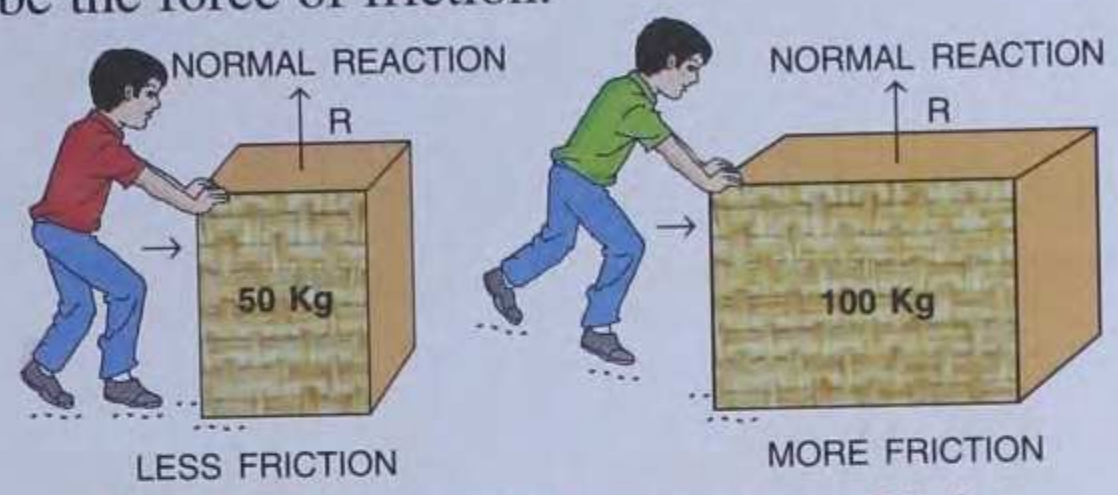


Fig. 3.6 More weight causes more friction

4. *Friction does not depend on the area of the surfaces of contact.* If two objects with similar weights move in a small area or a bigger area, the force of friction will remain the same. Hence, we can say that friction does not vary with size, provided the weight of the object remains the same.

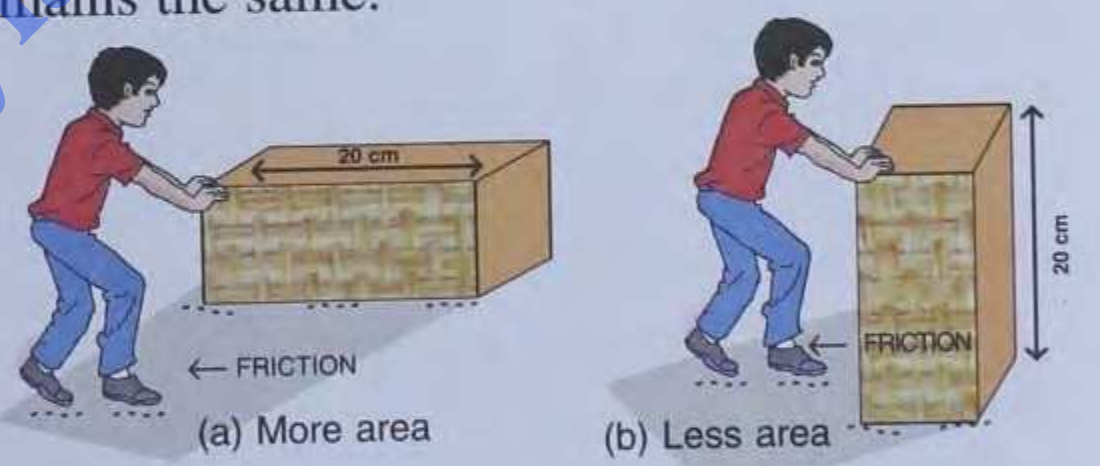


Fig. 3.7 Area does not affect force of friction

Types of Friction

Friction is a self adjusting force up to a maximum limit. When the applied force is gradually increased, the force of friction also increases at the same rate upto its maximum limit and the body remains stationary. This force of friction is called force of static friction or just **static friction**. If the applied force is increased further, a stage comes when the body begins to just move. At this stage, the force of static friction is maximum.

When an object rolls on a smooth surface, like a ball rolling on a cemented surface or a bicycle, bus, car, *etc.*, moving on the wheels, the friction produced between the rolling object and the surface is called the **rolling friction**.

When we slide an object on any surface, the friction produced between the object and the surface is called the **sliding friction**. A glass slab placed on a table top, when moved produces more friction than a rolling object.

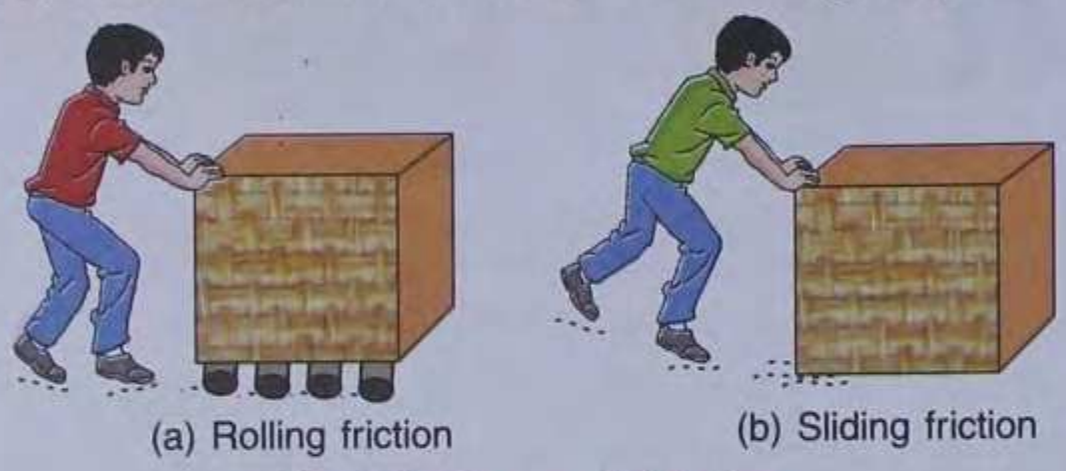


Fig. 3.8 Types of friction

The sliding object as compared to the rolling object is obstructed by more force due to which sliding object faces more friction than the rolling object. The force required to keep a body in motion is less than the force required to start the motion. Therefore,

Static friction > Sliding friction > Rolling friction.

It is our common experience that when heavy objects are to be moved, we use rollers to make the movement easier. This is because the rolling friction is always less than the sliding friction.

It is easier to roll than to slide a body over another. That is the reason it is convenient to pull luggage fitted with rollers.

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 axles of ceiling fans and bicycles.

Vehicles like cars, trucks, bicycles, *etc.*, are provided with wheels to make their movement easier.

Do You Know ?

In space, there is no frictional resistance to motion because there is no air. Far from any star or a planet, the force of attraction or the earth's pull is weak. A moving body will keep on moving in space in a straight line. Similarly, a rocket ship in space will also travel in straight line until the engines are fired to feed a force which makes it change its state of motion.

Intext Questions

1. Why does a ball stop after moving for sometime?
2. Why the tyres of a vehicle become hot after a long drive ?
3. Give an example of sliding friction.
4. Friction increases with roughness. Explain.
5. Why is friction necessary between pen and paper when you write?

Advantages of Friction

1. Friction is essential between our feet and the ground for us to walk. Without it, we would slip and fall over the ground.
2. Friction between the wheel and the brakes slows down the motion of a bicycle, car, *etc.*
3. Cars and buses are able to move only because of friction between the road and the tyres.
4. The brakes of all automobiles work because of friction between the brake-lining and the drum of the wheel.
5. Writing with a pencil is possible due to friction. You cannot hold a pencil in your hand without friction. That is why it is very difficult to write on a glazed or waxed paper.
6. It is not possible to cut wood without friction between the saw and the wood.

7. Friction helps in burning a match stick.
8. Friction holds a nail in a wall.
9. Football boots have studs to increase friction.
10. When your teacher is writing with chalk, the rough surface of the blackboard rubs off some chalk particles which stick to the blackboard. This would not happen if there was no friction between the chalk and the blackboard.
11. Without friction no building could be constructed.

Thus, we can say that friction is of great help to us in our day-to-day life.

ACTIVITY 3

Take a ball and roll it on a cemented, smooth floor. Measure the distance covered by the ball. Repeat this exercise on a grass field and measure the distance covered by the ball. Take care that the same ball is rolled and with the same force.

On which floor will the ball cover a longer distance ? Definitely, on the smooth floor because the frictional force between the smooth floor and the ball is less. Thus, we can say, frictional force depends on the smoothness of the two surfaces in contact with each other.

Ways to increase friction —

(1) Soles of the shoes and tyres of automobiles are made corrugated and rough to increase friction and to provide a better grip on the ground or road to prevent skidding.

(2) The brake pads/lining in automobiles are made rough to increase friction between the lining and rim/drum of the wheel.

(3) Wrestlers and kabaddi players rub their hands with soil for better and firm grip due to increased friction between their hands and the opponent's body.

Disadvantages of Friction

Friction opposes motion : We have already observed that the rolling ball stops after sometime. Similarly, friction between water and the moving boat brings the boat to a stop once we stop rowing the boat. Also, it reduces the efficiency of machines. So, we can say that friction always opposes motion.

Fig. 3.9 Due to friction, the soles of shoes wear out

Friction causes wear and tear : Tyres of cars and buses wear out due to friction. The shoes we daily wear also get worn out due to friction.

Friction produces heat: Machine parts get heated due to friction. Due to this heat they get damaged. They have to be occasionally replaced or they undergo mechanical cleaning which means financial loss.

Vigorously rub your palms together for few minutes. How do you feel ? When you strike a matchstick against the rough surface, it catches fire. The jar of a mixer-grinder becomes hot when it is run for a few minutes. These are few more examples which show that friction produces heat.

ACTIVITY 4

Take a paper. Spread some oil over it. Now try to write on the paper with the help of a pen. Will you be able to write ?

No, you will not be able to write because the friction between the pen and paper has decreased due to the presence of oil. Therefore it is difficult to write on oily papers.

Friction during walking : Sometimes, while walking on the road, you step on a banana skin. You might slip because the banana skin reduces the friction between your foot and the road.

Fig. 3.10 A boy slipping on a banana skin

Friction causes wastage of energy : When we are driving a car on a rough or *kuchha* road, we observe that the engine exerts more force in moving the car due to friction between the road and the wheels; the engine soon gets heated up and lot of fuel is wasted in this process. Hence it increases the expenditure on account of fuels.

Thus, we see that friction apart from being useful is also a hindrance in our daily activities.

ACTIVITY 5

Keep a metallic slab on a glass plate and give it a little push. It does not move. Is there any opposing force on the slab ? Yes, there is force of friction between the metallic slab and the glass plate. Increase the force (push) on the slab till the slab is about to start sliding. At this time, the force (push) applied is just equal and opposite to the maximum force of friction that can develop between the slab and the plate.

Repeat this activity by sliding the slab over an oily glass surface. The slab easily moves since the friction between the slab and the plate is now less. **An oily surface develops less force of friction.**

Methods of Reducing Friction

Friction can be reduced by the following ways :

1. **By using lubricants :** When we use lubricants, the unevenness of the two surfaces gets removed due to the formation of a thin smooth layer between the two surfaces and the two surfaces start rolling easily over one another. Some common lubricants used are oils, grease, graphite powder, compressed air, *etc*.

Fig. 3.11 Some methods to reduce friction

Soap solution also acts as a lubricant. That is why we tend to slip on the floor if it is covered with soap solution.

2. **Using ball bearings :** Ball bearings are small steel spheres introduced in between two moving surfaces to reduce friction.
3. **By polishing the surfaces :** Surface roughness can be reduced by polishing the surfaces in contact. Varnish and electroplating are generally done to reduce friction.
4. **Use of wheels or rollers :** A conveyor belt moves on the wheels or rollers to reduce friction. If a suitcase is fitted with wheels, it is easier to move it because the friction between the wheels and the ground is less.
5. **By streamlining :** For objects that move through liquids and air (or gases), a

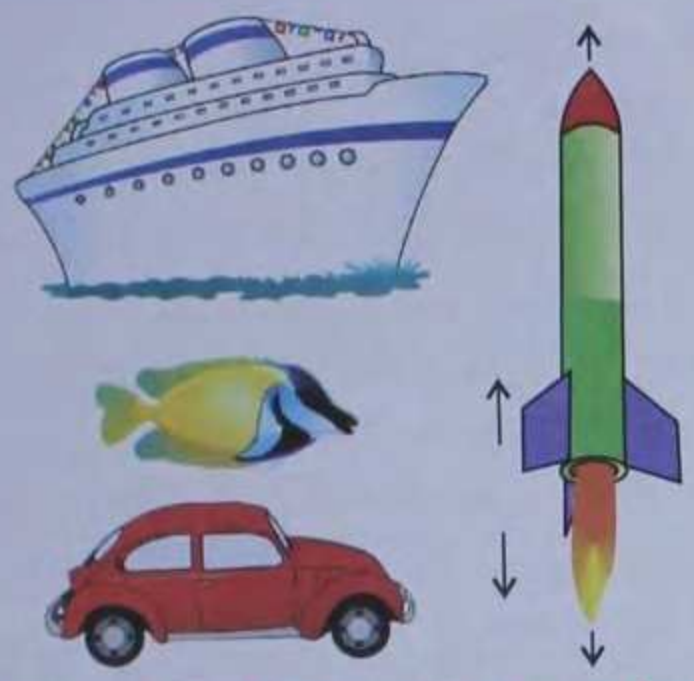


Fig. 3.12 Streamlined shape helps in reducing friction

streamlined shape reduces friction allowing them to move easily. *For example*, boats and fishes have streamlined shapes for moving through water. Birds and aircraft have **streamlined** shape to move through air with minimum friction.

The symmetrical shape of a body/object with a pointed tip which offers least resistance due to fluid friction is called streamlined shape.

6. **By sprinkling a soft, slippery fine powder on the surfaces :** A small quantity of talcum powder on a wooden surface or floor, etc., reduces friction. That is why a small quantity of talcum powder is applied on carrom board. Graphite powder is used in machines to reduce friction.

Do You Know ?

We can reduce friction but cannot make it zero.

ACTIVITY 6

Look at the picture of a satellite orbiting the earth. It does not need to be streamlined. Why ?

Knowledge bank

1. *Why is friction considered a necessary evil ?* Friction is wasteful. It causes loss of energy and wear and tear of machines. But, on the other hand, our daily life would not be possible if there were no friction.
2. *Why are the tyres of automobiles made corrugated and rough ?* Tyres of automobiles are made corrugated and rough to increase friction and to provide a better grip on the road to prevent skidding.
3. *Why is it more difficult to pull a boat on the beach than in the sea ?* When the boat is in the sea, its surface is in contact with water, while when it is on the beach, its surface is in contact with beach sand. There is more friction between the boat and the beach surface than between the boat and the water. As a result, it is more difficult to pull a boat on the beach than on the sea.

Intext Questions

1. Give *two* examples of friction in your daily life.
2. Can we reduce friction upto zero ?
3. Name some lubricants to reduce friction.
4. How do the wheels of vehicles help in faster movement ? Explain.
5. Why do we have slipping tendency over slushy wet surface ?

TEST YOURSELF

A. Short Answer Questions

1. State whether the following statements are *true* or *false* :
   (a) Friction depends on the normal reaction of weight of the object.
   (b) Streamlined body increases friction.
   (c) Friction increases with area.
   (d) Friction causes wear and tear.
   (e) Friction helps in our movement.
2. Fill in the blanks :
   (a) Friction is the force that ..... the motion of two surfaces in contact.
   (b) Friction increases with ..... .
   (c) We use ball bearings to ..... friction.
   (d) The heat produced by friction is used for ..... a match stick.
3. Tick the correct answer :
   (a) Friction occurs because most surfaces are not
      (i) smooth (ii) rough
      (iii) plain (iv) hard
   (b) Friction produces
      (i) energy (ii) heat
      (iii) movement (iv) nuisance
   (c) Friction can be reduced by using
      (i) lubricants (ii) ball bearings
      (iii) wheels (iv) all of them
   (d) Friction can be increased by
      (i) spreading oil
      (ii) moisture on the surface
      (iii) rough surface
      (iv) all of them
   (e) Force of friction is directly proportional to
      (i) size (ii) area (iii) weight
      (iv) all these factors of the moving body
   (f) The flying machine offering the least frictional force should be
      (i) irregular
      (ii) tree-like
      (iii) symmetrical with many arms
      (iv) streamlined
4. Answer the following questions :
   (a) Why is it easy to push a car on a smooth road than on a rough road ?
   (b) Why is it difficult to walk on a smooth floor ?
   (c) What happens to the speed of your bicycle when you
      (i) pedal faster ? (ii) apply brakes to it ?
5. Rahul has to push a lighter box and Seema has to push a similar heavier box on the same floor. Who will have to apply a larger force and why ?
6. Preeti runs her toy car on dry marble floor, wet marble floor, newspaper and towel spread on the floor. The force of friction acting on the car on different surfaces in increasing order will be
   (a) wet marble floor, dry marble floor, newspaper and towel.
   (b) newspaper, towel, dry marble floor, wet marble floor.
   (c) towel, newspaper, dry marble floor, wet marble floor.
   (d) wet marble floor, dry marble floor, towel, newspaper.

B. Long Answer Questions :

1. What is friction ? Give its *two* important properties.
2. Why do vehicles skips when there is water on the road ?
3. Mention *three* ways of reducing friction.
4. Is friction desirable ? If so, why ?
5. What form of energy does friction always produce ?
6. Give *two* advantages and *two* disadvantages of friction.
7. Friction is a necessity evil. Comment.
8. Can you walk on a frictionless floor ? Give reason.
9. Why is machine oil poured on the moving parts of a machine ?

RECAPITULATION

- Frictional force opposes the motion of moving objects.
- Friction produces heat. A simple example to illustrate this fact is that when we rub our palms together, they become warm due to the heat produced by rubbing them.
- Friction causes wear and tear in machines. The moving parts slowly wear out when they are regularly used. The wheels of a car and other vehicles wear out when they move on rough roads. Due to friction, the moving parts of the machines produce noise and thus reduce the efficiency of the machines.
- The force of friction depends on the smoothness or roughness of the two surfaces in contact with each other.
- The force of friction is dependent on the normal reaction of weight of the body. More the weight of the object greater the normal reaction and greater is the force of friction.
- The force of friction does not depend on the area of the surfaces in contact.
- The rolling friction is less than the sliding friction which is less than static friction.
- Friction can be reduced by (i) making the surface smooth (ii) lubrication (iii) using ball bearings (iv) streamlined body (v) use of wheels or rollers and (vi) by sprinkling a soft, slippery fine powder on the surface.
- Friction is a boon as well as an evil.
- The frictional force exerted by fluids is called drag.
- Static friction comes into play when we try to move an object at rest.
- Sliding friction comes into play when an object is sliding over another.

Project Work

1. Take a sheet of paper, tracing paper and a sheet of paper with oil spread on it. Now with the help of your pen try to write on each of them. In which case it is easier to write ? Why ?
2. Take a bowl with cold water and a bowl with hot water. Let the water become still. Now with a dropper put one drop of ink in both and see in which case it spreads faster ? Why? Make a report of your analysis.