2 FRICTION

THEORY

2.1 INTRODUCTION

When we press our foot on the floor and try to slide it forward we feel that something is opposing or resisting our action of sliding our foot forward.
This force which opposes our action of sliding our foot on the surface of the floor is called friction.

The force of friction : When one object rubs against something else (which may be in any state such as solid, liquid or gas), a force acts on the surfaces in contact which opposes the relative motion between them. This force is called the force of friction. An important rule of friction is that it always acts in a direction to oppose the relative motion. If we pull a block of wood on a surface to the right, the force of friction on the block will be to the left.

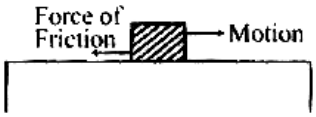


Fig. Force of friction is opposite of the applied force

Similarly, a boat propelled to the east by its motor experience water friction to the west. An object falling downward through the air, experiences air friction, called air resistance, in upward direction. The amount of friction between two surface depends on the kinds of material and how much they are pressed together. The force of friction between two rough surfaces is more than that between two smooth surface. Friction is due to roughness of surfaces. All surface on microscopic view, have tiny bumps as shown in the figure.

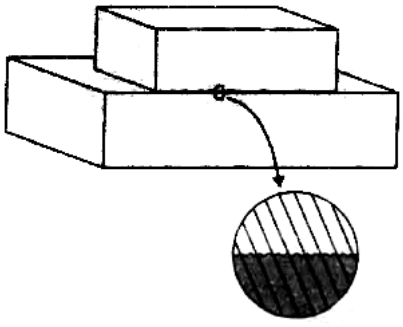
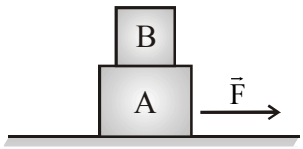


Fig. Friction results from the mutual contact of irregularities in the surfaces of sliding objects. Even surfaces that appear to be smooth have irregular surfaces when viewed at the microscopic level.

Due to these irregularities in the surfaces, friction appears in solid surfaces. Note **that the force of friction doesn't depend on the area of contact of surfaces**.

Remember

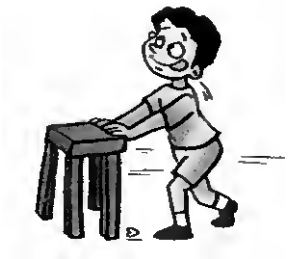
Frictional force does not oppose the motion in all cases, infact in some cases the body moves due to it, In the fig., book B moves to the right due to friction between A & B. If book A is totally smooth (i.e., frictionless) the book B does not move to the right. This is because of no force applied on the book B in the right direction.



2.2 FRICTION

Friction is the opposition to motion experienced when two surfaces are in contact move with respect to each other.

Whenever the surface of one body slides over that of another, each exerts a force on the other which opposes the motion of the body. This is called frictional force shown in given figure.



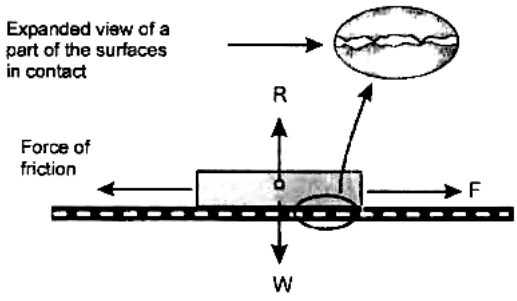
Frictional force comes into play only when two surfaces are in physical contact and is therefore a contact force.

Remember

CAUSES OF FRICTION

The friction between any two surfaces is mainly caused by the following factors:

(i) **Due to the interlocking of surfaces:** No solid surface is perfectly smooth. This means all solid surfaces are rough. The degree of roughness varies from surface to surface. Some are more rough , while some others are less. Even a surface which looks smooth to the naked eyes is actually rough . In the case of highly rough surfaces, the surface roughness can be seen, felt easily.



Roughness of the surfaces in contact can be seen as the presence of hills and valleys in expanded view of a part of the surface is shown in figure.

In the case of surfaces which appear to be smooth, the surface roughness can be seen only with the help of a microscope. A magnified view of the surface roughness is shown alongside.

When a body (say, a wooden block) is pulled over another, these 'hills' and 'valleys' interlock with each other and oppose the relative motion between the two bodies. This gives rise to a frictional force. Thus, friction is due to the roughness of the two surfaces in contact.

(ii) **Due to force of adhesion between the two surfaces: Two** rough surfaces when placed together meet only at certain points. The atoms or molecules present at such points of contact attract each other due to electrostatic attractions. These attractions are called forces of adhesion. When one body is made to move over the other, the force of adhesion opposes the motion. This force which opposes the motion also gives rise to frictional force. So, the force of adhesion between the two surfaces gives rise to friction.

2.2.1 Factors Affecting Friction

1. Friction depends upon the nature of the surfaces in contact. Smoothness of the contacting surfaces does affect the force of friction between two surfaces in contact.
2. The force of friction is directly proportional to the normal force. When a body is moving over a horizontal surface, it presses down against the surface with a force equal to its weight i.e. to the pull of gravity upon it. An increase in the weight of the body causes an increase in the amount of resistance offered to the relative motion of the surface in contact.
3. Friction does not depend on the amount of surface area in contact between the moving bodies. Within limits, friction between two solid surfaces moving with respect to each other does not depend on the relative speed between the two surfaces and the area of contact.

2.2.2 Direction of Frictional Force

When a block is pulled by force F towards the right, the force of friction acts towards the left and when the block is pulled by force F towards the left, the force of friction acts towards the right.
So we can say that force of friction always acts in the direction opposite to that of motion or intended motion.

2.3 TYPES OF FRICTION

You must have noticed that when you have to slide a heavy box, it is easy to slide it once the box has started sliding. You may also have noticed that it is much easier to roll a heavy drum than to slide it.
On the basis of its nature frictional force can be divided into four types. They are :
1. Static Friction 2. Limiting Friction 3. Sliding or Dynamic Friction
4. Rolling Friction

2.3.1 Definition

1. **Static Friction :** The friction that exits between the two surfaces in contact when there is no relative motion between them is called **static friction**.
2. **Limiting Friction :** The maximum force of static friction come into play when one body just slides upon another body is called **limiting friction**.
3. **Sliding or Dynamic Friction :** The force of friction acting between the two bodies, when they are sliding upon one another with a uniform speed is called **dynamic friction** or **sliding friction**.

   or

   The friction that exists between a surface sliding on another surface is called the **sliding friction**.
4. **Rolling Friction :** The friction experienced by a body, when it is made to move over bodies like roller or a wheel is called **rolling friction**.

   or

   When a body rolls on the surface of another, the friction that exists between the surface is known as **rolling friction**.

Experimentally, it has been proved that,

Static friction > Sliding or Dynamic friction > Rolling friction.

It has been demonstrated through the experiment in Activity.

2.3.2 Sliding and Rolling Friction

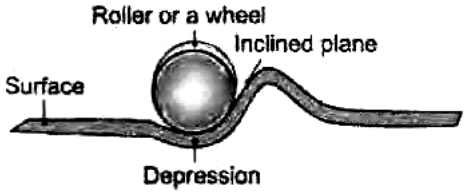
All other factors remaining the same, sliding an object (like a cylinder) is more difficult than rolling as shown in figure. The frictional force offered when sliding an object is called 'sliding friction' and that offered when rolling an object is called rolling friction.

The fact that rolling friction is smaller than sliding is made use of in a device called 'ball bearing'.

Remember

How is rolling friction caused?

1. The roller or the wheel deforms [changes the shape] temporarily the surface on which it is rolling, thereby causing a depression, on account of its weight.
2. In this process the roller or the wheel itself gets deformed temporarily at the point of contact of the surface of the body.
   Because of the above deformations a kind of inclined plane is formed in the direction of motion of the roller or the wheel. Thus, a force is required to overcome this temporary, but continuously forward moving inclined plane. This force applied against the continuously forward moving inclined plane is the equivalent of **rolling friction**.



From the above discussion it is clear **that the smaller the depression formed at the point of contact of wheel or roller with a given surface, the Lesser is the force of rolling friction and vice versa**. Furthermore, rolling friction is far less than the sliding friction. That is why, wherever possible, sliding friction is replaced by rolling friction. This is achieved by using wheels, ball bearing, roller bearings, etc.

2.3.3 Examples of rolling friction

1. When a car or bus or bicycle, moves on the road, a part of its wheels and the surface of the road get continuously deformed. Thus, force has to be applied to overcome this deformation and it is equivalent to the rolling friction.
   It is for the same reason that more force is required, when the tyres do not have sufficient air pressure, because deformation produced is very large. Conversely, if the tyres are heavily inflated, the deformation produced is very small, and hence, the rolling friction decreases. However, the ride becomes very bumpy. Furthermore, it becomes difficult to apply brakes as the vehicle does not stay on its path during the application of brakes.

2. The wheels of the train are made of steel and so are the railway tracks. Thus, the deformation produced in them is very small, and hence, they have a very small rolling friction. It is because of this small rolling friction that the trains run very fast.

A steel wheel on railway

3. These days luggage, such as suitcase is provided with tiny wheels. These wheels offer very small amount of rolling friction and are easy to move.

A suitcase with wheels

A girl on roller skates

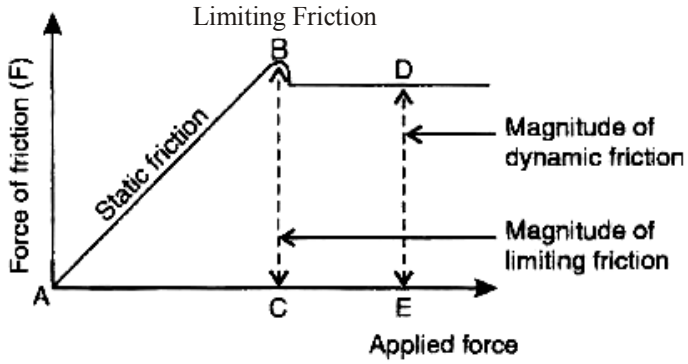
4. Roller skates have tiny wheels. These wheels have very small rolling friction and help fast motion of the skater.

Remember

Why is dynamic friction slightly less than the limiting friction?

You know that friction is caused due to the interlocking of the irregularities on the surfaces of two bodies in contact with each other. Now, more force is required to unlock the irregularities between the surfaces of two stationary bodies as compared to the force required to keep the irregularities unlocked between the surfaces of two sliding bodies . Thus, the liming friction is always slightly more than the dynamic friction or dynamic friction is slightly less than the limiting friction.

Figure shows a graph between the applied force on the spring balance and the force of friction. The region **AB** in the graph shows static friction, which is self adjusting. **BC** shows the magnitude of limiting friction. **DE** shows the magnitude of dynamic friction or sliding friction.



2.3.4 Factors affecting limiting friction

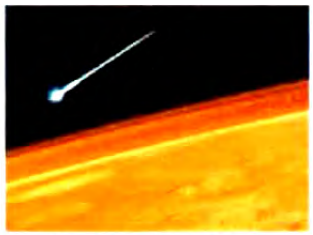
1. Limiting friction always opposes the motion of a body and acts in the direction opposite to the direction of applied force.
2. Limiting friction depends upon the nature of surfaces in contact with each other.
3. Limiting friction increases with the increase in the weight of the body and vice versa.
4. Limiting friction is independent of areas of contact between two surfaces, provided the weight of the body and the nature of surfaces do not change.

2.4 EFFECT OF FRICTION

When an object moves in contact with another object, the force of friction can produce following effects.

(a) **Friction opposes motion :** The force of friction always acts in the direction opposite to the direction of the applied force. It opposes the motion of the body and tries to stop it. Take the example of a moving car at a constant speed of 60 km/h. If we lift our foot from the accelerator. The car slows down and finally stops. It is because of the force of friction. As a matter of fact, when a vehicle is moving at a constant speed, the energy spent in keeping the vehicle to move at same speed is utilised in overcoming friction of the road.

(b) **Friction produces heat :** Take a one rupee coin and hold it from its edge. Rub the coin against the wooden table top. Touch the rubbed side of coin with your hand. What do you observe? The coin feels very hot. It is because the force of friction between the table top and the coin changes into heat energy.


Burning of meteor

It is for the same reason that our palms get warm when rubbed against each other. Similarly, the cave man produced fire by rubbing a dry wooden stick in a hole of dry wooden block.

It is for the same reason that the jar of a mixer grinder get hot at their moving parts.

The meteors (shooting stars) enter the atmosphere of earth at a very-very high speed. At such speeds, the friction between a meteor and the air is extremely high. Due to this high friction the temperature of the meteor rises to such a high degree that it catches fire and completely burns before reaching the earth. In fact, force of friction of air saves us from the impact of meteors coming from the space.

The spaceships are provided with heat shield at their nose. It is because when spaceships enter the atmosphere, due to friction of air they can catch fire much like meteors. However, the heat shield prevents such a fire due to friction.

(c) **Friction causes wear and tear :** Try to compare the soles of your new shoes with old shoes. You will notice that the soles of old shoes are worn out. It is because when we walk, material of the soles wears out due to friction.

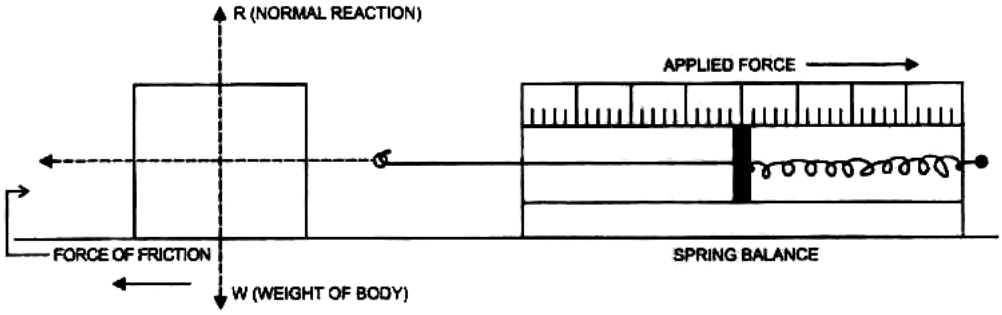
Similarly, the tyres of all kinds of vehicles wear out due to friction. In fact, all movable parts of all kinds of machines were out. This in turn makes the machines inefficient or useless.

ACTIVITY

Take a heavy wooden block provided with a hook. Place the wooden block on a table top. Attach a spring balance to its hook and pull it slowly towards the right side. You will note that initially the wooden block does not move but the spring balance records the force applied on the wooden block. The force recorded by the spring balance is equal and opposite to the force of friction between the wooden block and the table top.

Next, Increase the force on the spring balance. What do you observe? The wooden block does not move but the spring balance indicates higher value of applied force. Thus, as the wooden block remains static, the applied force is equal and opposite to the force of friction. This suggests that the force of friction in stationary or static state of the body is self-adjusting. This force of friction is known as **static friction**.

Go on increasing the pull on the wooden block, till it starts sliding. Note the reading shown by the spring balance. It will record maximum applied force which is equal and opposite to the force of friction. This maximum force required to make one body just slide over another body is called limiting friction.



Types of friction

Apply the pull on the wooden block in such a way that it gently slides over the table top. What do you observe? The spring balance registers lesser force than the limiting friction. This lesser force that enables the wooden block just slide on the table top is known as **sliding** or **dynamic friction**. This activity explains the meaning of static friction, limiting friction and dynamic friction.

2.5 FRICTION DUE TO LIQUIDS AND GASES

When a solid move in a liquid or a gas, the surface of the solid experiences friction. The frictional force exerted by fluids (liquid or gas) is called drag. It is established that liquids exert less force of friction as compared to the solids. Also, the gases exert the least force of friction as compared to the solids and liquids. The shape of a body around which a fluid (liquid or gas) can easily flow, offering minimum friction, is called streamlined shape. In nature, the body of fishes is streamlined such that they encounter least friction in water. Even a swimmer tries to streamline his body as far as possible so that he faces least friction due to water.

The body of boats and ship is also streamlined so that they encounter minimum friction while moving through water. The body of automobiles and aeroplanes is streamlined so that they encounter least resistance through air)

Remember

Fluid friction : The force of friction due to air and water (and other fluids) is called fluid friction. It also called 'Drag'

When cars and aeroplanes move at very high speeds, their motion is opposed by friction offered by the air molecules surrounding them. Drag, opposes the motion of the vehicle. The same applies to ships and boats.

2.6 ADVANTAGES OF FRICTION

There are numerous advantages of friction. Without friction, life would be impossible! You have learnt about the advantages of friction in earlier classes.

(i) It is because of friction that we can walk, drive, open doors, turn taps, and write.

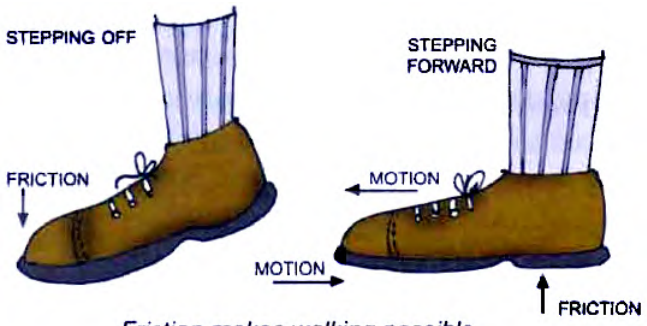
(ii) We use screws and nails to keep pieces of furniture together. The screws and nails to do not slip off because of the friction between the wood and the metal surface of the screw.

(iii) Bed sheets remain on the bed because of friction.

(iv) You can sit on a chair without sliding off because of friction.

From what has been discussed above, it may appear that if there were no friction, our life would have been much easier and we would not have to spend energy in overcoming the frictional resistance.

This is not true. As a matter of fact, it is only because of friction that we are able to move around. Try to run on a very smooth surface and see what happens. As we step forward, friction opposes the forward force, so that the foot does not slip forward (Figure). When we raise our heel again to take another forward pace, the friction prevents the front part of the shoe from moving back.



Friction makes walking possible

On account of the friction between the ground and the rubber tyre of a bicycle, the latter can move forward. In the absence of friction between the wheels and ground, the wheel are unable to roll. That is why the wheels of a bicycle and other vehicles are treads to increase friction. To stop the bicycle, we use the opposing frictional force between the brake blocks and the wheel rim. So if an object started moving, it would never stop if there were no friction. It would be impossible to write with a pen or pencil without friction between pen and the writing pad. Friction holds a screw in wood. It also enables us to use nails to fix boards together. If friction were eliminated, dishes would slide off the table unless the table were perfectly in level. Thus with out friction, our life would have been in reality very inconvenient. Imagine, what would happen if there were no friction?

Looking at advantages and disadvantages of friction in our life, it can be rightly said that **friction is a necessary evil**.

Illustration 1

Give two examples to show that friction can also produce heat?

Solution

(i) When we vigorously rub our palms together for a few minutes we feel warm.

(ii) When we strike a matchstick against the rough surface, it catches fire due to friction.

2.7 DISADVANTAGES OF FRICTION

(i) In machinery and automobiles, where there are moving parts, friction causes them to heat up. Heating up of the parts results in a waste of energy and fuel.

(ii) Friction also causes wear and tear of the moving parts.

(iii) Wear and tear due to friction depends on two factors. The roughness of the two surfaces in contact and the amount of time the two surfaces rub against each other. Wear and tear of an object is not desirable because it reduces its life.

Whenever there is a relative motion of two surfaces in contact, there is frictional resistance. When a body moves over another, it has to overcome friction. This needs energy. Hence, some energy is always wasted in overcoming friction. When two parts of a machine rub against each other, heat is produced, and the efficiency of the machine decreases. There will be greater wear and tear in different parts of a machine due to friction. Thus friction reduces the efficiency of machines.

FRICTION PLAYS AN IMPORTANT ROLE IN OUR DAILY LIFE

(i) Without friction we would slip and fall every time we attempt to walk or run. There is very little friction on a wet polished floor. That is why it is easy to slip on such a floor.

(ii) Friction causes nails and screws to hold on to walls.

(iii) It would not be possible to light a matchstick without friction between its head and the side of the match box.

(iv) Cars and buses are able to run on roads because of friction between the tyres and the road.

(v) Without friction writing on paper would be impossible as the tip of the pen will slip on paper.

(vi) It is because of friction between the brake 'shoes' and wheels that bicycles and auto mobiles stop when brakes are applied.

FRICTION IS A DEMERIT TOO IN SOME CIRCUMSTANCES:

(i) The heat produce in the moving parts of machinery due to friction results in wear and tear of the parts.

(ii) Forest fires are caused due to friction between branches of trees rubbing against each other.

(iii) Tyres of vehicles and soles of footwear wear out because of friction (figure).

Worn out sole of a shoe

(iv) Energy is wasted in overcoming the force of friction.

2.8 METHODS TO REDUCE FRICTION

(i) Friction between moving parts is usually reduced by introducing a substance between the moving surfaces. This process is called lubrication. The substance introduced is called a lubricant. Common lubricants are oil and grease.

(ii) Ball bearings are also used to reduce friction.

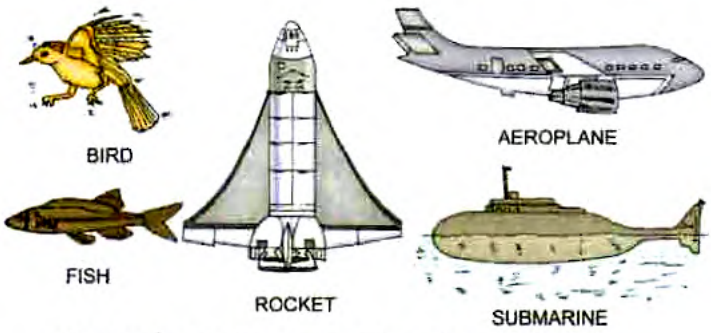
(iii) By Polishing.

(iv) By Streamlining.

(v) By Powdering.

2.8.1 Ways to Reduce Friction

(i) **Streamlined Bodies :** Air and water offer the maximum friction. Objects moving in air or water have streamlined bodies to reduce friction. Birds, cars, aeroplanes and rockets have special streamlined bodies to reduce air resistance. Ship, fishes, boats and submarines are broad in the middle and narrow in front and at the back. So they faces least friction produced due to water current.



Streamlined shapes help to reduce friction

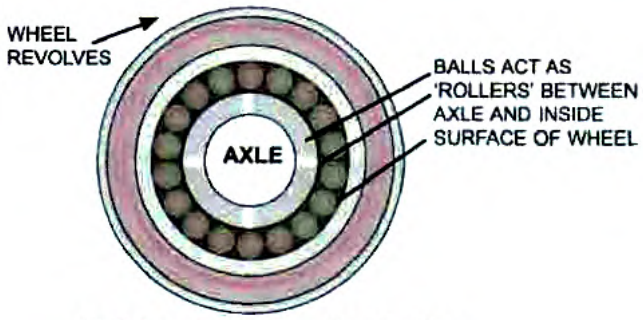
(ii) **Polishing :** Polishing of rough surfaces also reduce friction If the surfaces that are in contact are rough, there is more friction. Hence to reduce friction, the surfaces in contact are kept smooth and polished. It is worth noting that if the two surfaces in contact are of the same metal, the friction increases on polishing the two surfaces. This is why the bearings and the axle are made of different metals.

(iii) **Wheels :** If a suitcase is fitted with wheels, it is easier to move it because the friction between the wheels and the ground is less. Thus, wheels reduce friction.

Wheels reduce friction

(iv) **Lubricants :** Use of lubricants make the surface smooth. In machines, friction is reduced by using lubricants such as oil, grease or graphite powder. The lubricant fills the minute unevenness of the two surfaces and separates them by forming a very thin layer in-between. This layer offers very little resistance and as a result, the friction gets reduced.

(v) **Ball Bearings or Roller Bearings :** They are made in various designs to reduce friction. They reduce friction because rolling friction is smaller than sliding friction. These bearings are also lubricated to further improve their function.

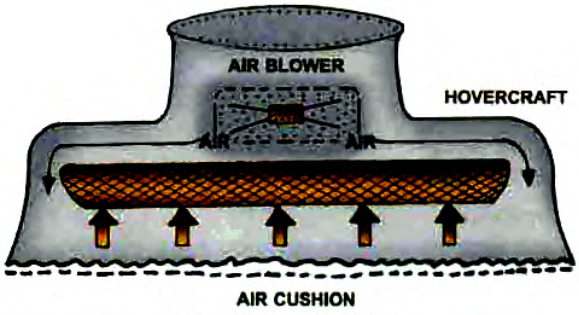


Ball bearing and rolling friction

Ball bearings change sliding friction to rolling friction.
Ball bearings are used in most mechanical structures which have moving parts.
Small metal balls made of stainless steel, brass, ceramic, etc. are placed between moving surfaces (the surfaces can be flat or cylindrical) to reduce friction shown in figure.

(vi) **Anti-friction Metals :** When steel slides over an alloy of lead, the friction is less than when steel slides on steel. Bearing are sometimes packed with such an alloy.

(vii) **Air Cushion :** By separating the surfaces by an air cushion, a hovercraft can travel over rough land, swamp or sea. Here, as the moving object does not come in contact with the other solid surface, the frictional forces are reduced to a very great extent.



Hovercraft principle

Illustrations

Illustration 2

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

Solution

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

2.8.2 Methods to increase friction

(i) Making the surfaces rough. For example, the tyres of vehicles have treads (there are the designs that you can see on the tyre surface which increase the friction between the tyre and the road).

(ii) Increasing the mass of the object that is moving.

Figure: Tyres have treads

2.9 FRICTION : A NECESSARY EVIL

It may appear that since the force of friction always opposes motion, it is always a curse. This is not so, because very often the force of friction is also a boon or, as we often say, a necessary evil. In fact, life would have been almost impossible if there were no friction. Friction helps us to walk and to drive our vehicles. It also helps us to produce heat.

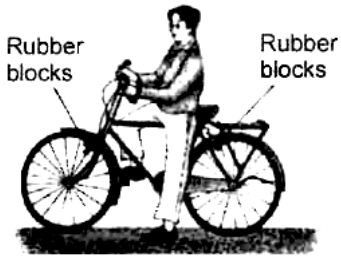
In an effort to walk, we push the earth backward. In return, the earth pushes us forward and we are able to walk. On a highly polished floor, there is a very little grip between the floor and our shoes due to lack of friction. So, on a polished floor, the moment we try to push the earth backward, we slip and fall. So, it is friction that helps our feet to grip the road and enables us to walk. We even provide corrugations on the soles of our shoes to increase friction between our feet and the ground.

The corrugations on the soles of our shoes help us to have a better grip on the road

You must have seen that tyres of all new vehicles have many treads or corrugations on them. The treads on the tyres increases friction between tyre and the road. When the treads on a tyre get worn out, it loses its grip on the road and the vehicle tends to skid.

Treads on tyres help them to have a better grip on the road

Again, we make use of friction while applying brakes to our bicycle. When we apply brakes to our bicycle, we are really clamping rubber blocks against the revolving rim of the wheel. The resulting friction stops the movement of the wheels.



Friction stops the movement

Sometimes, we also use different materials to increase friction. For example, trolley Wheels have rubber washers. The use of wet surfaces generally reduces friction. Therefore, friction can be increased by making the surfaces dry. A wet glass tends to slip more easily from our hands than a dry one. We can increase the grip by increasing the pressure on surfaces in contact. Thus, when any object starts slipping from our hand, we hold it more firmly. This results in an increases of friction between that object and our hand.

Illustrations

Illustration 3

Aeroplanes are given special shapes why?

Solution

All vehicles are designed to have shapes which reduce fluid friction. Aeroplanes have special shapes to reduce air friction.

Illustration 4

Give an example that friction depends upon type of contact.

Solution

Throw a coin on a rough surface it stops after some time. Now throw it in the same way on smooth surface it stops after a longer time as there is less friction in later case.

Illustration 5

Can friction act on a body which is at rest? Which friction is it ?

Solution

Yes, Static friction

Illustration 6

Which friction acts when surfaces in contact are in motion.

Solution

Kinetic friction

Illustration 7

Write some methods to reduce friction?

Solution

(a) Polishing (b) Lubricating (c) Streamlining (d) Use of ball bearings

Illustration 8

Write methods to increase friction.

Solution

(a) Making the surfaces rough or treading.
(b) Increasing normal contact force between the surfaces.

Illustration 9

Heating effect due to friction is undersirable why?

Solution

Because
(a) there is wastage of mechanical energy.
(b) Efficiency is reduced.
(c) Due to heating parts of machines may damage.

Illustration 10

Why we use 'ball bearing'?

Solution

This is due to the fact that rolling friction is smaller than the sliding friction and ball bearing changes sliding friction to rolling friction.

LET US RECAPITULATE

➢ **Friction:** The force which opposes the relative motion between two surfaces in contact is called friction. The force of friction always opposes the applied force that may be a push or pull.

Friction is caused by the irregularities on the two surfaces in contact. Irregularities on the two surfaces lock into one another (interlocking) causing friction.

➢ **Spring Balance:** It is a device used for measuring the force acting on an object. It consists of a coiled spring, a pointer moving on a graduated scale. When a force is applied, stretching of spring takes place. The reading on the scale indicated by the pointer gives the magnitude of the force.

➢ **Static Friction:** The force required to overcome friction at the instant an object just starts moving from rest is a measure of static friction.

➢ **Rolling Friction:** When a body rolls over the surface of another body, the resistance to its movement is called rolling friction. Rolling reduces friction.

➢ **Sliding Friction:** When one body slides over the surface of another body, the resistance to its motion is called sliding friction. It is easier to roll than to slide a body over another. Common example is use of ball bearing between hubs and the axles of various machines.

➢ **Factors Affecting Friction:**

- Friction depends on the nature of surfaces in contact.
- Friction is more between rough surfaces and less in smooth surfaces.
- Friction depends on how hard the two surfaces are press together.
- Friction is independent of the area of contact.

➢ **Friction: A necessary Evil**

- Friction is essential for doing various activities of our daily life.
  - We could not hold articles such as glass tumbler and other things without friction . It becomes very difficult to hold a greasy glass.
  - We could not write with a pen or pencil if there is no friction.
    When we write with chalk on the blackboard, its rough surface rubs off some chalk particles which stick to the blackboard. It helps us to read what is written on the blackboard with a chalk.
  - Friction helps objects to move, stop or to change the direction of motion. We cannot walk without friction.
  - Without friction no building could be constructed.
- **Friction is an evil:**
  - It wears out materials. For example, soles of shoes, ball bearings, steps of a stair, parts of machines etc.
  - Friction produces heat. When a machine is operated, heat generated causes much wastage of energy.

➢ We deliberately increase friction in some cases to get the desired results. For example:
- Soles of shoes are grooved. It is done to provide the shoes better grip on the floor, so that we can safely walk.
- The treated tyres of cars, trucks, buses, bull-dozers provide better grip with the ground.
- Bicycles, scooters and other automobiles are provided with the brake system. When we press the brake lever, brake pads arrest the motion of the rim due to friction. The wheel stops moving.

➢ Sometimes we want to minimise the friction. Friction can be reduced by applying fine powder as in case of carrom. Oil, grease or graphite is applied between the moving parts of a machine to reduce friction. These things avoid interlocking of irregularities that lead to reduction of friction to a great extent. Sometimes an air cushion between the moving parts is used to reduce friction.

➢ **Lubricants :** The substances which reduce friction are called lubricants. Lubricants form a thin layer on the moving surfaces. So, they do not directly rub against each other.

Action of a lubricant.

➢ The wheel is said to be one of the greatest inventions of mankind.

➢ **Fluids:** In Science, the common name of gases and liquids is fluid.

➢ **Fluid Friction:** The force exerted by fluids on objects in motion through them is called fluid friction. 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 shape of the object, and
- the nature of the fluid.

➢ To overcome drag objects are provided with special shape called streamlined. For example, shape of an aeroplane, a bird and a fish.

Streamlined shapes help to reduce friction.