

Friction

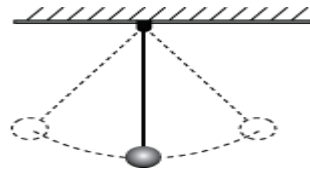
Friction- Introduction

Suresh rubs two stones together. He is surprised to see sparks being generated. **He wonders how?**



Sparks are generated because of the heat produced on striking the two stones together. Heat is produced due to the action of a force known as the **force of friction**, which exists between the two stones when rubbed against each other.

An oscillating pendulum stops after some time. Why is it so?



It happens due to the friction offered by air to the bob of the pendulum. It reduces the speed of the bob, and eventually makes it stop after sometime.



Take a book and push it on the table. **What do you observe?** You will find that the book stops moving, after travelling a small distance. **Why does this happen? Is there any force involved here?**

Without the application of force, a body cannot undergo a change in its state of motion. The force involved in the given example is the **force of friction**. It always acts in the opposite direction of motion. In the above example, when the book is pushed towards the right, friction acts in the left direction. Similarly, when a ball or bicycle moves forward, friction acts in the backward direction and tries to oppose the forward motion.

An important property of friction is that it always acts in the direction opposite to the direction of motion i.e. if an object is moving from left to right, the frictional force acts on it from right to left and vice versa.

A car moving from right to left stops when brakes are applied. It happens due to the frictional force, which acts in between the road and tyres of the car. **Can you determine the direction of this force?**



The force of friction acts between two surfaces when they come in contact with each other.

We are able to walk because of the force of friction, which exists between our feet and the ground. When we walk, we press the ground in the backward direction, using our feet. Since friction acts in the opposite direction of motion, it pushes us forward. Hence, we are able to walk.



When a ball is thrown on the ground, it stops after travelling for some distance. Why can it not continue to move?

Factors Affecting Friction

Take a book and move it on the table. Similarly, take an eraser and try to move it on the table. **Is there any difference in the force required to move the eraser and the book? What do you think is the reason behind this? Now, wrap the eraser in a sheet of paper and move it on the table. Is it easier to move the eraser now?**

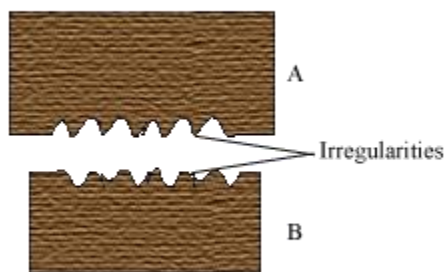


Take a book and incline it at an angle with the table. Take a ball and release it from the top of the book. Mark the distance it covers before coming to rest. Now, take a plastic sheet and spread it on the table. Release the ball again from the top of the book and mark the distance it covers before coming to rest. **Is there any difference in the distance covered by the ball in the two cases? Is It because of the difference in the nature of the surfaces in contact?** The magnitude of friction depends on the nature of the two surfaces. Smoother the surface, lesser will be the friction and vice versa.

Does the smoothness of a surface affect friction?

Origin of friction

Friction is caused by the irregularities present on the surface of two objects in contact. The surface of a body which generally looks smooth is not actually smooth. It possesses irregularities in the form of projections and depressions. When a body moves on the surface of another body, these projections and depressions get interlocked and oppose motion. Hence, an extra force is required to overcome this interlocking.



If a surface is rough, it has a larger number of irregularities. Hence, interlocking is more. Therefore, more force is required to overcome this interlocking. A brick has more irregularities than a book. Hence, it is easier to move a book on the table than a brick.



Take a heavy box and push it gently. **Does it move?** You will see that as we keep on pushing it with more force, eventually it moves. **Is it more difficult to push a heavy box at rest than a moving box?**

The force of friction that comes into play between the surfaces of two bodies, before the body starts moving, is known as **static friction**. The force of friction acting between two surfaces, when one surface moves with a constant speed over another surface, it is called **sliding friction**.

When a body moves on the surface of another body, the time allowed for interlocking is very small. Hence, it is not strong. Therefore, sliding friction is less than static friction. Due to this reason, it is easier to push a heavy box which is moving than a box at rest.

The weight of the body also affects the force of friction. The surface exerts more force of friction on the body having greater weight as compared to the body of lesser weight.

The presence of medium around the moving body also affects the force of friction. The amount of force of friction between different surfaces is: solid-solid > solid-liquid > solid-air

Advantages and Disadvantages of Friction

Friction is a necessary evil. It has many advantages.

1. We are able to walk because of friction. You must have observed that it is very difficult to walk on an oily surface. This is because on an oily surface, friction between our feet and the ground becomes so less that we cannot move forward.

2. We are able to write because of friction present between the paper and tip of a pen.

3. Due to friction between the tyres and the ground, we are able to drive automobiles. Without friction, it would be impossible to stop our vehicle after starting.

4. To hold a glass of water, friction is necessary. Due to friction present between our fingers and the outer surface of the glass, we are able to grip the glass of water. If there was no friction present, it would not be possible to hold it.



5. Lighting a match stick is possible due to the friction between the matchstick and its cover. When we strike a match stick against its cover, fire is produced because of friction. Likewise, when we rub two stones against each other, friction between them produces fire.



6. A nail can be fixed in a wooden plank because of friction. Without friction, the wooden plank will not be able to hold the nail, when it is pushed on its surface.

7. Friction is required to play the violin, or to move a mouse on the mouse pad. If there was no friction between the bow and strings of violin, no music would have ever been produced.



However, friction has some disadvantages too.

1. Machines wear out and need lubrication after a period of time due to the friction present between the different parts of a machine.

2. Friction also produces heat in machines, when their parts are rubbed against each other. This can lead to over heating of the machine, which may lead to the damage of parts.

3. Tyres or soles of our shoes wear out because of friction. For this reason, we need to change our shoes after a period of time.



4. To overcome excess friction in air, a lot of fuel is wasted in cars and airplanes. Therefore, cars and airplanes are streamlined and given a unique shape to reduce friction.

How to Increase or Decrease Friction



While riding her bicycle, Shivani saw a speed breaker ahead and applies brakes to reduce her speed. After her ride is over, she wonders how the mechanism of brake actually functions.

The brake pads are designed in a way that they are located along the moving wheels of a cycle. Initially, these pads are separated from the wheels [Figure (a)]. When brakes are

applied, the brake pads come in contact with the wheel and stop its motion due to friction between the pads and tyre [Figure (b)].



Before the application of breaks

Figure (a)



After the application of breaks

Figure (b)

Increasing friction

Although friction is considered as a necessary evil, in many cases we need friction to perform various tasks. Some of these cases are discussed below:



Why do we use soles of shoes made of rubber and not of wood?



(i) This is because the friction produced between the rubber and ground is more than the friction produced between the wood and ground. To increase friction further, soles are provided with a ripple or grove pattern.

(ii) In grinder (silbatta), small holes are made to increase friction.



(iii) Before weightlifting, a weight lifter rubs powder on his hands. **Do you know why?** This is because it helps him in acquiring a better grip to hold the load.



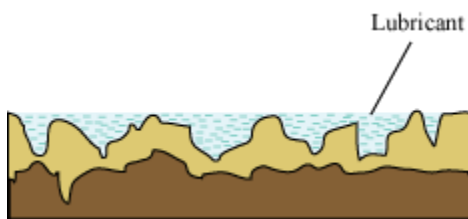
(iv) Stripes are made on the surface of a tyre to provide a better grip on the road.

Do you know why roads are made rough instead of smooth?

Reducing friction

In various applications, friction is considered undesirable and different methods are employed to reduce it. Some of these methods are discussed below:

1) Lubrication



In this method, oil or grease is applied between two materials. This forms a thin layer between the two materials, which prevents them to rub directly against each other. Due to this interlocking, the irregularities decrease. This reduces the friction between the moving parts.

When windows and doors become jammed, we apply grease or oil to their joints to make them move freely again. Similarly, to prevent the wear and tear of machine parts, we apply grease between the moving parts of a machine.

Substances such as oil, grease and graphite used in lubrication are known as lubricants.

In a game of carom, powder is sprinkled on the board. Can you explain the reason behind this?



When you apply soap on your hands, does it become easier to rub your hands against each other? Is this an example of lubrication?

- Although friction can be minimized by the action of lubricants, one can never make friction equal to zero. This is because irregularities are always present on the surface. An excess of lubricants may also result in **fluid friction**.

2) Rolling friction

It is easier to roll an object than to slide it. Hence, heavy luggages are fitted with rollers. Skates are provided with rollers to minimize the friction between the skates and the ground.

- Ball bearings are used in machines to reduce friction. They do this by the changing sliding movement into rolling movement.

3) Streamlining



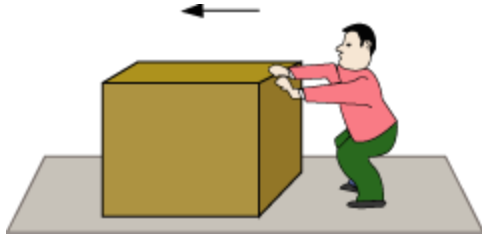
Friction can be reduced by giving a definite shape to an object. Aeroplanes are given a typical shape to reduce friction due to air. Cars also use this method to improve efficiency.

Rolling and Sliding Friction

So, what is rolling friction?

Rolling friction is the resistance that acts against the motion of a body when it is rolled on the surface of another body.

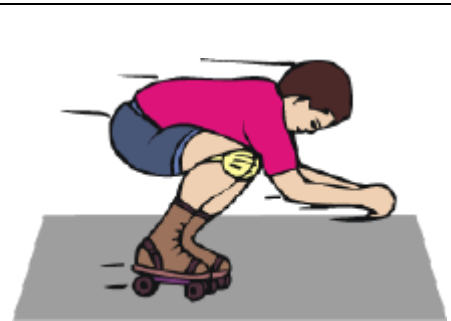
Sliding friction is the resistance that acts against the motion of a body when it slides over the surface of another body.



Pushing a heavy box and lighting a matchstick are examples of sliding friction.

Apart from the definition, there is another important difference between the rolling friction and sliding friction. Let us find that out.

It is always easier to roll a body than to push it. Therefore, we can say that rolling friction is always smaller than sliding friction. Due to this, skates are provided with rollers.

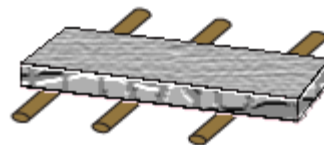


Why is it easier to roll an object than slide it?

In the case of rolling an object over a surface, the contact surface changes continuously. As a result, irregularities of the two surfaces do not have enough time to get interlocked with each other. On the other hand, irregularities between the two surfaces have enough time to interlock with each other when the object slides over a surface. Hence, rolling friction is smaller than sliding friction. Therefore, it is easier to roll an object than slide it.

Rolling friction is always smaller than sliding friction.

In ancient times, round logs were put under heavy stones to take them from one place to another.



Can you say which one is easier to do – pushing a suitcase fitted with rollers or a suitcase without rollers?



We know that rolling friction is smaller than sliding friction. Hence, it is better to work with rolling friction. This can be done by using ball bearings. A ball bearing is a small metal sphere placed between two surfaces. Ball bearings change sliding friction into rolling friction. They are vastly used in machines, cars, bicycles, and electric motors to change sliding friction into rolling friction.

Friction in Fluids

So, you see that air opposes motion through it. Not only air, all gases and liquids oppose motion through them.

- In science, liquids and gases are collectively referred to as **fluids**. This is because these substances have a tendency 'to flow'.

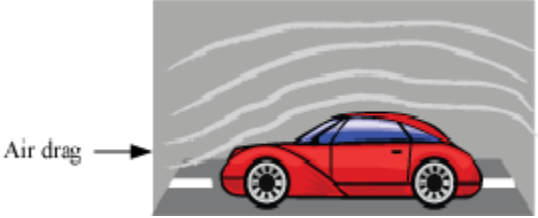
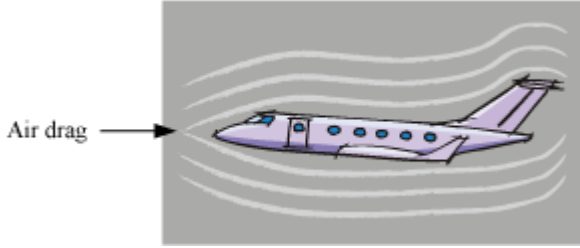
The frictional force exerted by fluids is also known as 'drag'.

- Like solids, fluids (all liquids and gases) also exert frictional force on objects that pass through them.

The frictional force experienced by a body moving through a fluid depends on a number of factors. For better understanding of these factors, let us see an animation.

What have you heard? **Streamlined shape**? What is that?

A body moving in a fluid (liquid or air) has to overcome fluid friction (drag). This results in the loss of energy. Since drag depends on the shape of an object, it can be minimized by giving objects a special shape. For example, cars and aircrafts are designed in such a way that fluids can pass through them smoothly. For that purpose, they are given a streamlined body.

	
Streamlined shape of a car helps in reducing the amount of air drag.	Pointed nose of an aircraft allows the smooth flow of air, thereby reducing the air drag.



In a ship, the part which is above the water experiences the force of friction from air and the part which is inside the water experiences the force of friction from water. Hence, these parts have been given a unique shape to overcome the force of friction by both fluids.

Formula 1 (also referred to as F1) is the fastest motor car race in the world. The shape of a formula one car is designed in such a way that it helps in reducing the air drag and allows it to achieve an average speed of 360 km/hr!	
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