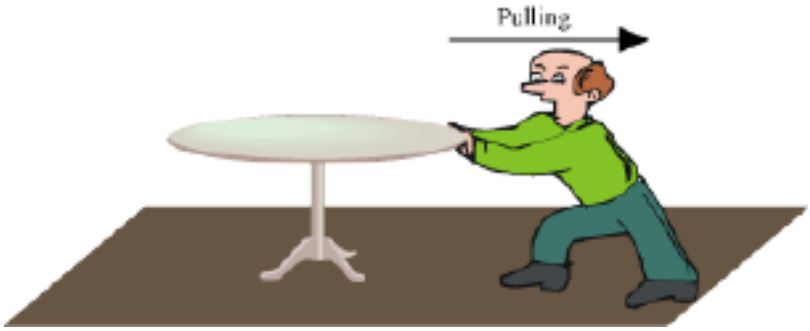
Force

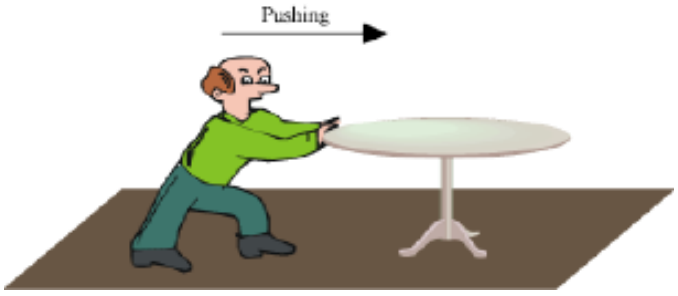
Force: Push or Pull

A table can be moved from one place to another by either pushing it or pulling it. Similarly, you can open a door by either pushing or pulling it. When a ball is thrown with more force, it travels a longer distance. The shape of a bottle can change when it is squeezed. Also, the direction of a moving ball can change by striking it.



Have you wondered how the shape of a bottle changes when squeezed? Or how can the direction of a moving ball change by kicking it in different ways?

All the above activities can be associated with **pushing** or **pulling**. Therefore, whenever an object is moved, we can say that it has either been pushed or pulled.



This push or pull is known as force. In other words, a body moves whenever a force is applied to it. Therefore, a body cannot move unless a force is applied.

Apart from push or pull, force is any action that has the tendency to change the position, shape, or size of an object. Everyday actions such as pushing, pulling, stretching, lifting, squeezing, and twisting are also examples of force.

Let us try to list some examples of everyday force and see if we can classify them as push or pull. A few examples have already been classified for you. Try to classify the rest.

Description	Push or Pull
Hitting a cricket ball with a bat	Push
Opening a door	Push and Pull
Plucking a flower	Pull
Flying a kite	
Moving a wheel barrow	
Hitting a tennis ball with a racquet	
Taking a carrot out of the ground	
Playing on a swing	
Picking up a shopping bag	
Squeezing a toothpaste tube	

Effects of Force

Force cannot be seen, heard, or tasted. Only its effects can be felt or seen. It is correctly defined as a push or pull upon an object resulting from the object's interaction with another object. The various effects of force are:

It can move a body initially at rest.

It can bring a moving body to rest.

It can change the direction of a moving body.

It can change the speed of a moving body.

It can change the shape of a body.

It can change the size of a body.

Let us take an example of a football lying in a field. When a player hits the ball, it starts moving, i.e., it starts moving only when we apply force. Thus, force can move a body initially at rest.

Now, if the goalkeeper catches the moving ball, then it comes to rest. The goalkeeper applies a force to stop the moving ball. Hence, we can say that force can bring a moving body to rest.

If another player kicks the moving ball in the opposite direction, then it starts moving in the direction towards which it is kicked i.e. the direction of the football changes. The player applies force on the football to change its direction.

Hence, force can change the direction of a moving body. Also, if the player hits the ball hard, then the net speed of the ball will also change. Hence, the speed of a moving body can be changed by applying force.

The shape of a deflated football can be changed by inflating it. When you inflate a football, you apply force on the pump.

Hence, force can change the shape of an object. Also, if you keep inflating the football, then its size will keep on increasing. Hence, force can change the size of an object.

A deflated football

Force can change the shape of an object

Force can change the size of an object

Contact Forces

Anuj is cycling on the road. He observes that as he stops pedalling, the cycle stops moving after travelling for some distance. **Let us see why this happens?**

Forces acting between two bodies can be classified into two broad categories: **Contact force** and **non-contact force**. Let us learn about contact forces in detail.

Contact forces are those that act between two objects, which are in direct contact with each other. The two common examples of contact forces are ***muscular*** and ***frictional***.

Frictional Force

Earlier you had seen that as Anuj stops pedalling the bicycle, it stops after some time. This happens due to the external force acting between the road and tyres of the bicycle. This force is known as the **frictional force**.

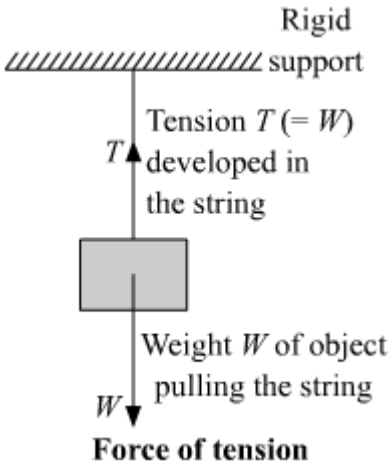
The force of friction acts between all moving bodies, which are in contact with one another. The force of friction always acts opposite to the direction of motion.

The magnitude of this force depends on the nature of the surface in contact.

Frictional force is a contact force.
Frictional force always acts between two moving objects, which are in contact with one another.
Frictional force always acts opposite to the direction of motion.
Frictional force depends on the nature of the surface in contact.

Tension Force

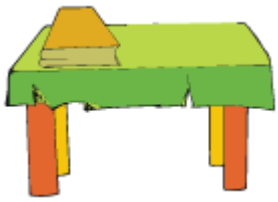
This force appears in a string, attached to a rigid support, when an object is suspended by it. In such case, the object pulls the string vertically downwards due to it weight and the string in its stretched condition pulls the object upwards by a force which balances the weight of the object. This force developed in the string is called tension *T*.



Force of tension

Muscular Force
The force applied by the action of muscles in our body is termed as a ***muscular force***.

For example, when you pick up a book placed on the table using your hands, you apply muscular force.



For lifting the book from the table using your hands, you had to touch the book. You cannot lift the book without making contact with it. Hence, ***muscular force is a contact force***.

Like humans, animals also use muscular force to perform various activities. For example, birds fly in the air by flapping their wings.

Mechanical Force

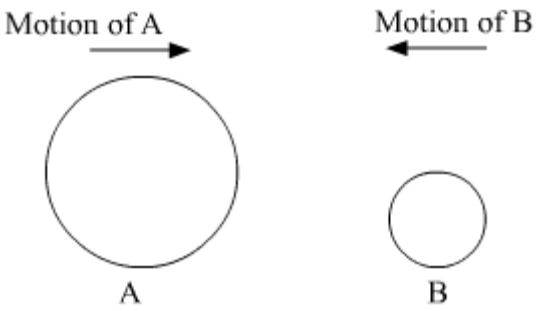
One more common example of contact forces is a **mechanical force** which is defined as the force generated by a machine. All the mechanical works are done by the mechanical force.

For example, when the car gets started the car's engine creates a mechanical force on the tyres that helps the car to accelerate. So here, the movement of car occurs due to the force generated by the machine on the tyres.

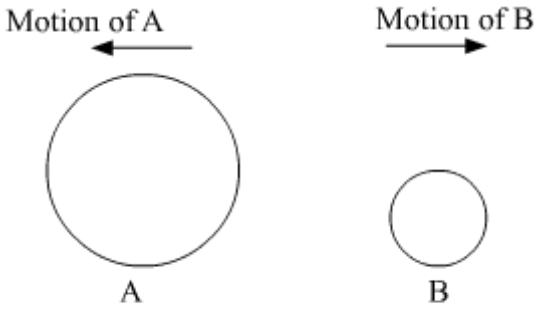
Force Exerted During Collision

Two objects push each other with an equal but opposite forces if collision occurs between them. These forces are known as the force of action and force of reaction. Let us consider a situation in which an object B in motion collides with a moving object A and applies a force F_{AB} on the object A i.e. an action force.

At the same instant, the object A also applies an equal but opposite force of reaction F_{BA} on the object B. Because of this, they move apart from each other after collision.



Two objects moving towards each other



Objects moving away from each other after collision

Do you know the force(s) involved in the movement of trolley bags?

When we pull the trolley we are applying muscular force on it and at the same time, there is a frictional force acting between the tyres of the trolley and floor. These two forces are together responsible for the movement of the trolley.

So we can say that, **Combined forces** are nothing but varieties of forces acting on an object at the same time.

Non-Contact Forces

Does force act only when two objects are in contact?

To understand, let us perform a small activity. Take a bar magnet and an iron nail. Bring the magnet close to the iron nail, but do not bring them in contact.

What do you observe?

The iron nail moves towards the magnet. This means that there must be a force that is acting between the magnet and the iron nail.

Since the iron piece moves towards the magnet (even when they are not in contact), we can say that the force exerted by the magnet on the iron piece is a **non-contact force**.

Non-contact forces are those forces that act between two objects, but are not in direct contact with each another. Examples of non-contact forces include magnetic force, electrostatic force, and gravitational force.

Magnetic force

What will happen if you bring the South Pole of a bar magnet close to the North Pole of another bar magnet? The magnets will attract each other. They attract each other with ***magnetic force***.

What will happen if you bring the North Pole of both bar magnets close to each other? The bar magnets will repel each other. The force with which they repel each other is known as **magnetic force**.

Magnetic force can be attractive as well as repulsive.

Magnetic force is a non-contact force.

Magnetic force acts between two magnets, or between a magnet and a magnetic material (such as iron).

Magnetic force depends on the strength of the magnet used.

Magnetic force also depends on the distance between the interacting bodies.

Electrostatic force

Take a paper and tear it into pieces. Now, rub a plastic scale against dry hair and bring this scale close to the paper pieces. **What do you observe?**

You will observe that the pieces of paper are attracted towards the scale. This happens because rubbing of the scale against dry hair produces an electrostatic charge. Thus, the scale attracts the pieces of paper by a non-contact force known as **electrostatic force**.

Electrostatic force is a non-contact force.

Electrostatic force can be attractive as well as repulsive.

Electrostatic force is the force that exists either between two charged bodies, or between a charged and uncharged body.

Electrostatic force depends on the magnitude of charge present in the bodies.

Electrostatic force also depends on the distance between the interacting bodies.

Gravitational force

Do you know why apples fall towards the ground from trees? Why does water from a tap flow down?

The Earth attracts everything (that is near or on its surface) towards its centre by a non-contact force known as **gravitational force**. It is

this force that makes an apple fall towards the ground from the tree and makes the water from a tap flow down.

Gravitational force is a non-contact force.

Gravitational force is an attractive force.

Gravitational force is the force that is exerted by the earth on every object, which is near or on its surface.

Gravitational force depends on the mass of the body.

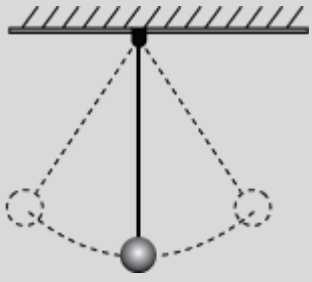
Gravitational force also depends on the distance between the Earth and body.

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?**

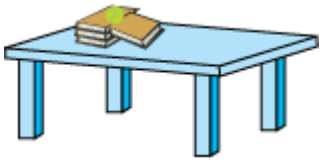
The force of friction acts between two surfaces when they come in contact with each other.

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?**

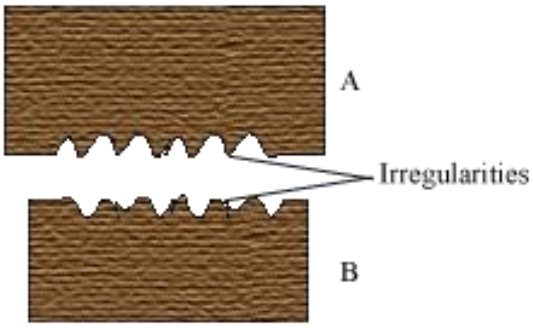


Take a book and incline it at an angle with the table. Take a ball and release it from the top of the book. Mark the distance it covers before coming to rest. Now, take a plastic sheet and spread it on the table. Release the ball again from the top of the book and mark the distance it covers before coming 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.

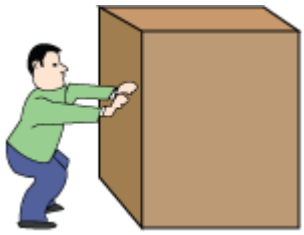
Does the smoothness of a surface affect friction?

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.

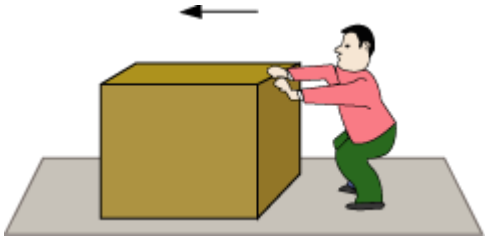
The presence of medium around the moving body also affects the force of friction. The amount of force of friction between different surfaces is: solid-solid > solid-liquid > solid-air

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.

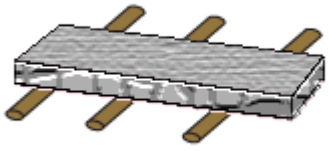
Apart from the definition, there is another important difference between the rolling friction and sliding friction. Let us find that out.

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.

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.

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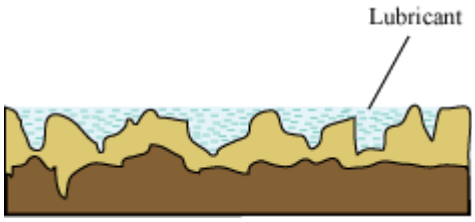
Do you know why roads are made rough instead of smooth?

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.

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.