

# FRICTION

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# Friction

- ▶ The property by which an opposing force is generated between two surfaces in contact with bodies in relative motion is called friction.

## Causes of Friction

- ▶ Friction is a force resisting motion of an object when in contact with another. This resistive force is caused by the surface roughness of the contact area of the materials, molecular attraction or adhesion between materials, and deformations in the materials.
- ▶ When two bodies come into contact, due to the irregularities of the surfaces, the area of contact is less than the actual area of the surfaces. This causes very high pressure at the point of contact. The high pressure causes deformation of the surface of the material and eventually increases the resistance to motion.

# Types of Friction

## 1. Static Friction

The frictional force comes into play when one body tends to move over the surface of another, but the actual motion that has yet not started is called static friction.

The frictional force cannot go beyond a maximum value. When the applied force exceeds this value, the body starts moving over the surface.

**The maximum value of static friction before the body starts moving over a surface is called limiting friction.**

The limiting friction,  $f_{max}$  is directly proportional to

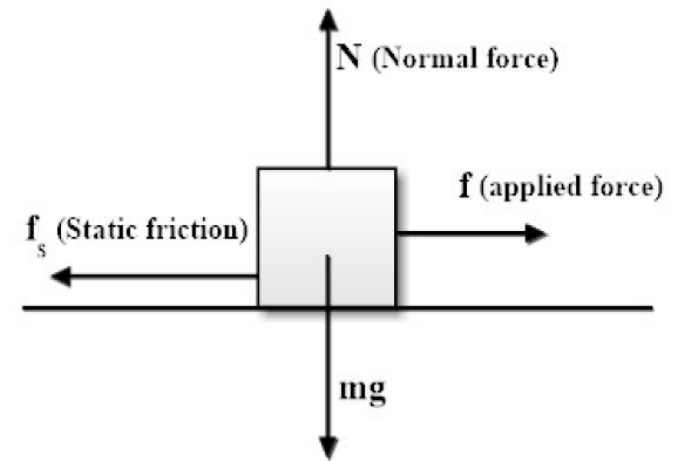
the normal force between the two surfaces

$$f_{max} = \mu_s N$$

► The constant of proportionality  $\mu_s$  is called the coefficient of static friction and its value depends on the material and nature of the two surfaces in contact.

The static friction  $f_s$  is always less than or equal to the limiting friction  $f_{max}$ .

$$f_s \leq f_{max} = \mu_s N$$



**Friction opposes the relative motion between the sliding body and the surface**

- **Kinetic or dynamic friction:** It is the opposing force that comes into play when one body is moving over the surface of another body. The magnitude of kinetic friction,  $f_k$  is directly proportional to the normal force acting between the two bodies.

$$f_k \propto N$$

$$f_{max} = \mu_k N$$

- The constant of proportionality  $\mu_k$  is called the coefficient of kinetic friction and its value also depends on the material and nature of the two surfaces in contact.
- If the surfaces are smooth  $\mu_k$  will be small and if surfaces are rough  $\mu_k$  will be large.

Kinetic friction is classified into two types - sliding friction and rolling friction.

- a) Sliding friction: The frictional force that comes into play when one body is actually sliding over the surface of the other body is called sliding friction.
- b) Rolling friction: The frictional force that plays when one body is actually rolling over the surface of the other body is called rolling friction. Rolling friction is less than sliding friction.

# Laws of friction

1. The Force of friction depends on the nature of surfaces in contact.
2. Friction is independent of the area of contact as long as the normal force is the same.
3. The maximum force of static friction is directly proportional to the normal force acting between the two bodies in contact.
4. Kinetic friction is directly proportional to the normal force acting between the two bodies in relative motion.
5. The direction of kinetic friction on a body is opposite to the velocity of the body.
6. The magnitude of kinetic friction is independent of the velocity of motion of the body.
7. The coefficient of kinetic friction is always less than the coefficient of static friction for the same pair of surfaces.

## Advantages of friction

1. It is the friction between the ground and the feet that help us to walk
2. It helps us to hold things.
3. The friction between tyres and the road helps us to stop the vehicle when the brake is applied.
4. Nails and screws join two surfaces due to the force of friction.
5. Without friction, it is impossible to climb a tree or fix a nail on the wall.

# Disadvantages of friction

1. Friction slows down the motion of moving objects.
2. Friction produces unnecessary heat leading to the wastage of energy.
3. It decreases the efficiency of the machines.
4. It causes wear and tear for the moving parts of the machines.
5. Friction sometimes creates fire accidents like forest fires



# Methods to reduce friction

## a) Lubrication

When the gap between two surfaces is filled with oil or grease, irregularities become filled with this and the friction reduces. This process is called lubrication and the substance used for this are called lubricants. The lubricants are selected based on the nature of the machines.

- ▶ A modern lubricant is a mixture of mineral oil, vegetable oil, and colloidal thin oil. For light machinery, oils are used while for heavy machines grease is used. For light machinery like watches, sewing machines, etc., thin oil is used. In very heavy machinery, solid lubricants like graphite are used.

## b) Polishing of rough surfaces

A hard substance is used to grind and remove the irregularity on the soft surface.

Examples including polishing of wooden surfaces, tiles, marbles, etc. Sandpaper is also used for polishing to a fine level. Harsh chemical treatments are sometimes done to reduce irregularities on surfaces. When the surface becomes smooth, the contact pressure decreases, and hence friction reduces.

## c) Use of ball bearings in moving parts

It is our common experience that it is easier to roll a body than to slide it along the ground. This is the principle in which ball bearings work. Hard steel balls place between the moving parts like coaxial cylinders. The balls rotate as the cylinders turn relative to each other. This considerably reduces friction