Friction

Introduction to Friction

Friction is a force that opposes the relative motion or tendency of such motion of two surfaces in contact. It acts in the direction opposite to the applied force or motion. For example, when a vehicle slows down after applying brakes, it is due to friction between the tires and the road. Similarly, a moving ball on the ground eventually stops because of frictional forces acting on it.

Force of Friction

The force of friction arises due to the contact between two surfaces. It depends on the nature of the surfaces and the force pressing them together. The frictional force can be calculated using the formula:

$f = \mu N$

where f is the frictional force, μ is the coefficient of friction (depends on the materials in contact), and N is the normal force (force pressing the surfaces together).

Types of Friction

There are mainly two types of friction:

- **Static Friction:** The frictional force that acts when an object is at rest and prevents it from moving.
- **Sliding Friction:** The frictional force that acts when an object slides over another surface.

Static friction is generally greater than sliding friction, which is why it is harder to start moving an object than to keep it moving.

Factors Affecting Friction

Friction depends on:

- The nature of the surfaces in contact (rough or smooth).
- The force pressing the two surfaces together (normal force).

Rougher surfaces have higher coefficients of friction, leading to greater frictional forces.

Advantages and Disadvantages of Friction

Advantages:

- Friction allows us to walk without slipping.
- It helps in stopping vehicles by applying brakes.
- It enables writing with pen or pencil.
- It holds nails firmly in walls.

Disadvantages:

- Friction causes wear and tear of materials like shoe soles and machine parts.
- It produces unwanted heat, leading to energy loss.

Increasing and Reducing Friction

Friction can be increased by making surfaces rougher or using treaded soles and tires for better grip. It can be reduced by using lubricants like oil, grease, or powder, which form a thin layer between surfaces to prevent direct contact and reduce friction.

Rolling Friction

Rolling friction occurs when a body rolls over a surface. It is much smaller than sliding friction, which is why wheels and ball bearings are used to reduce friction and make movement easier.

Fluid Friction

Fluids like air and water exert frictional force called drag on objects moving through them. The amount of fluid friction depends on the speed, shape of the object, and the nature of the fluid. Streamlined shapes, inspired by birds and fishes, help reduce fluid friction.

Solved Examples

Example 1: A book weighing 10 N is resting on a table. The coefficient of friction between the book and the table is 0.3. Calculate the force of friction acting on the book.

Solution:

Given:

- Weight of book, W = 10 N (This is the normal force, N)
- Coefficient of friction, ⍰BC = 0.3

Using the formula for frictional force:

f = ⍰BC N = 0.3 D7 10 = 3 N

Therefore, the force of friction acting on the book is 3 N.

Example 2: A brick is pulled with a spring balance and the reading just before it starts moving is 15 N. What is this force called and what does it represent?

Solution:

The force of 15 N is the force of static friction. It represents the maximum force that must be overcome to start moving the brick from rest.

Practice Set

Conceptual Questions:

- Why is it easier to keep an object moving than to start moving it from rest?
- Explain why the soles of shoes and tires have grooves.

Application-based Question:

A box of mass 5 kg is resting on a floor. The coefficient of static friction between the box and the floor is 0.4. Calculate the minimum force required to start moving the box. (Take g = 9.8 m/s^2)

Answer Key

Conceptual Questions:

- It is easier to keep an object moving because sliding friction (friction when moving) is less than static friction (friction when at rest).
- Grooves on soles and tires increase friction by increasing surface roughness, providing better grip and preventing slipping.

Application-based Question:

Given:

- Mass, m = 5 kg
- Coefficient of static friction, ⊠BC = 0.4
- Acceleration due to gravity, g = 9.8 m/s^2

Normal force, N = mg = 5 D7 9.8 = 49 N

Force of static friction, f = ⊠BC N = 0.4 D7 49 = 19.6 N

Minimum force required to start moving the box = 19.6 N

Quick Reference Table

Friction: Force opposing relative motion between surfaces.

Formula: f = □BC N

Types: Static friction, Sliding friction, Rolling friction, Fluid friction (drag)

Static friction: Prevents motion; usually greater than sliding friction.

Sliding friction: Acts during sliding motion.

Rolling friction: Much smaller than sliding friction; reduces resistance.

Coefficient of friction (□BC): Depends on surface materials.

Normal force (N): Force pressing surfaces together, usually weight.

Common Mistakes and Misconceptions

- Friction always opposes motion, not the applied force direction.
- Static friction is not constant; it varies up to a maximum value.
- Friction does not depend on the area of contact but on the nature of surfaces and normal force.
- Friction can never be completely eliminated.
- Rolling friction is not zero; it is just smaller than sliding friction.

Glossary

- **Friction:** Force resisting relative motion between surfaces.

- **Static Friction:** Frictional force preventing start of motion.
- **Sliding Friction:** Frictional force opposing sliding motion.
- **Rolling Friction:** Frictional force opposing rolling motion.
- **Coefficient of Friction (□BC):** A number representing surface roughness.
- **Normal Force (N):** Force pressing two surfaces together.
- **Lubricant:** Substance reducing friction between surfaces.
- **Drag:** Frictional force exerted by fluids.