9
Chapter

Friction

We'll cover the following key points:

- Friction & Types of Friction
- Friction: Balancing the Necessary
- Fluid Friction

Hi, I'm EeeBee

Do you Remember:

Fundamental concept in previous class.

In class 5th we learnt

- Frictional Force

Still curious? Talk to me by scanning the QR code.

Learning Outcomes

By the end of this chapter, students will be able to:

- Understand the concept of friction and identify the factors that affect it.
- Differentiate between types of friction, including static, sliding, rolling, and fluid friction.
- Analyze the advantages and disadvantages of friction in everyday life and various applications.

Guidelines for Teachers

Teachers can introduce friction by defining it and exploring its real-world applications across various fields, such as engineering and natural systems. They should explain the factors influencing friction, differences between its types, and practical uses in daily life. Engaging students with interactive activities, hands-on experiments, and thought-provoking discussions can deepen their understanding of both theoretical and practical aspects. By fostering a collaborative learning environment, teachers can encourage curiosity, critical thinking, and an appreciation for the role of friction in natural and man-made systems.

NCF Curricular Goals and Competencies

This chapter supports the following educational objectives:

- CG-1 (C 1.1): Explores the properties and behavior of matter and its components.
- CG-6 (C 6.1): Encourages scientific inquiry and understanding by examining natural phenomena and scientific processes.

FRICTION

Mind Map

Friction & Factors affecting

Friction

- Definition :- The force opposes the applied force.
- The force of friction acts between the two surfaces

Factors affecting

- Smoothness of the surface
- Irregularities on the two surfaces
- Interlocking of irregularities in the two surfaces.

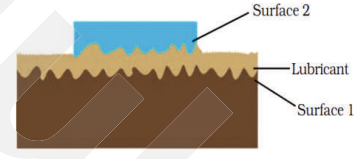
Increasing and Reducing Friction

Increasing Friction

- The tyres of motor cars & Soles of shoes are rough

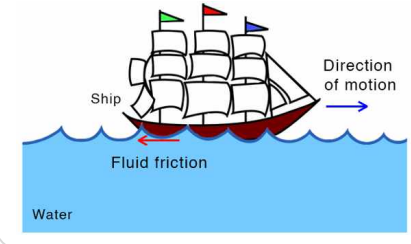
Reducing Friction

- Using lubricants & using ball bearings.



Fluid Friction

- It is the resistance encountered by an object moving through a fluid (liquid or gas).
- **NOTE**:-The frictional force exerted by fluids is also called drag.



Friction : A Necessary Evil

Advantages

- A nail is fixed in the wall due to friction.
- Rubbing of your palms makes you feel warm.
- Stricking a matchstick produces fire by friction.

Disadvantages

- Soles of shoes wear out due to friction.
- Machines need maintenance due to friction.

Types of Friction

Static friction

- Force to start motion from rest.

Rolling friction

- It is resistance when one body rolls over another.

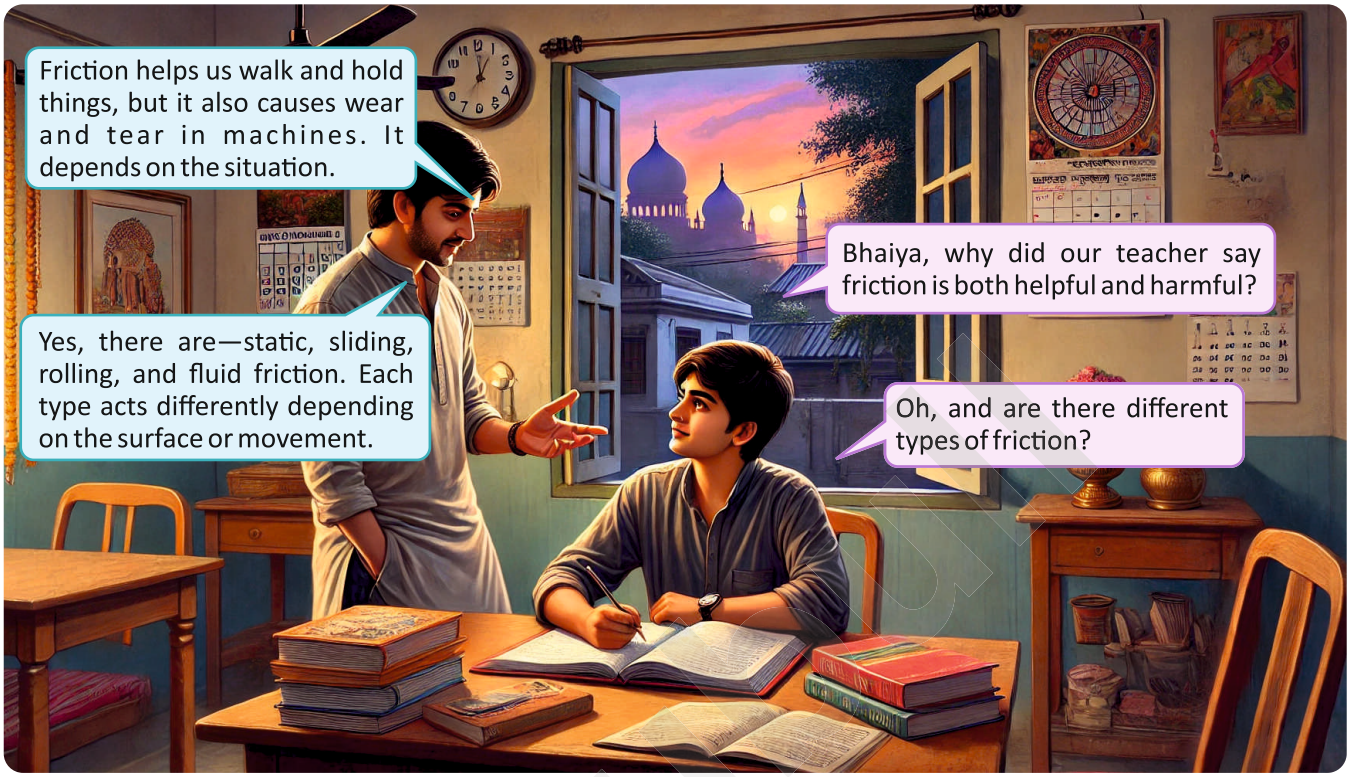
Sliding friction

- It is the resistance to motion between two surfaces sliding past each other.

Based on NCERT*

Types of Friction

Rohan is doing his homework when his elder brother, Arjun, walks in.



Consider the following situations of our day to day experience :

- A car or a scooter also comes to rest once its engine is switched off. Similarly, boat comes to rest if we stop rowing it.
- A ball rolling along the ground gradually slows down and finally comes to rest.
- When we stop pedalling a bicycle, it gradually slows down and finally comes to a stop.
- When we stop pedalling a sewing machine, the speed of its needle gets slow down and finally comes to stop.
- When we switch off the fan, the speed of the fan gradually reduces until the fan completely stops.

In History...

The concept of friction has been known since ancient times, but its scientific study began with the work of Leonardo da Vinci in the late 15th century.

Da Vinci first recognized that friction was a force that resisted motion and could be reduced by lubricating surfaces.

Later, in the 17th century, scientists like Galileo Galilei and Robert Hooke further explored the nature of friction.

Hooke's law of friction, formulated in 1676, described the proportional relationship between the force of friction and the normal force. This early work laid the foundation for understanding how friction affects movement and mechanics.

- A rolling cylindrical object on the ground also stops after covering some distance.
- If we gently push a coin on the surface of a table or a plastered floor, it stops after covering some distance.

Rolling Ball

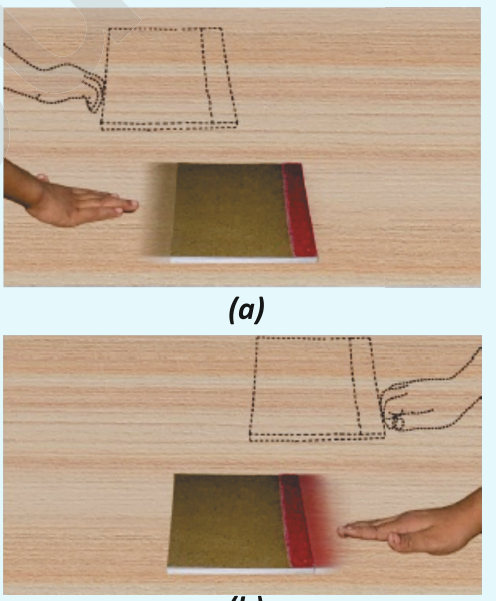
In all these cases, in fact, we are not applying any force from outside to cease the motion of the objects, yet their speed gradually decreases and finally they come to rest after some time. As the speed of the objects gets slowed down and finally comes to rest, it is obvious that there should be some force acting on the objects so that their speed decreases and the objects finally come to rest. The force responsible for changing the state of motion of objects in all these examples is the force of friction.

- It is the force of friction between the surface of the ball, coin, cylinder, tyres of vehicles etc. and the ground that brings these moving objects to rest.
- In case of sewing machine and fan also, the friction is responsible to cease its motion.

Activity

Gently push a book on a table. You observe that it stops after moving for some distance. Repeat this activity pushing the book from the opposite direction. Again it stops after moving some distance. Can you think of an explanation? Can we say that a force must be acting on the book opposing its motion? This force is called the force of friction.

Conclusion : The force of friction acts between the surface of the book and the surface of the table and it always opposes the applied force. If you apply the force along the left, friction acts along the right. If you apply the force along the right, the friction acts along the left direction. In both cases the force opposes the motion of the book.



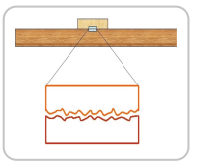
(a)

(b)

Friction opposes relative motion between the surfaces of the book and the table

Cause of friction

When we observe a surface under a powerful microscope, we find that there irregularities on it. Even a smooth-looking surface has a large number of irregularities.



Interlocking of irregularities of surfaces

KEYWORDS

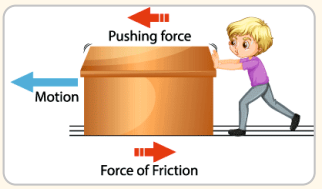
Microscope: An instrument used to view objects that are too small to be seen with the naked eye.

Cease: To bring or come to an end; stop.

These irregularities get interlocked when one object tries to move over another. This is what opposes the motion of a body trying to move and gives rise to friction.

Factors affecting the friction

Force of friction depends upon the following factors.



- **Nature of surface :** Friction is caused by the roughness of the surface. Greater the roughness of the surface, higher is the friction and vice-versa.
- **Mass of the object :** On a horizontal surface, the force of friction is directly proportional to the mass of the object which moves.

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.

Static and sliding friction

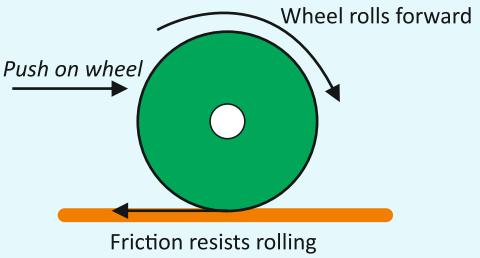
Recall your experience when last time you moved a heavy box from one place to another. If you have no such experience, get that experience now. What is easier—to move the box from rest, or to move it when it is already in motion?

The force required to overcome friction at the instant an object starts moving from rest is a measure of static friction. On the other hand, the force required to keep the object moving with the same speed is a measure of sliding friction. When the box starts sliding, the contact points on its surface, do not get enough time to lock into the contact points on the floor. So, the sliding friction is slightly smaller than the static friction and you find it somewhat easier to move the box already in motion than to get it started.

You have to push on the box to keep it moving

Rolling friction

When a body rolls over the surface, then the frictional force that arises is known as rolling friction. Rolling friction is lesser than sliding friction. It is always easier to roll than to slide a body over the surface.



Friction: A necessary evil

Friction is called a necessary evil, as it is essential for the numerous actions to perform. But at the same time, it has some unavoidable harmful effects also. In order to understand this fact, let us recall some of our experiences.

- Can a person walk with balance on a slippery surface like wet marble floor or wet muddy track? Have you seen a person slipping on a banana peel randomly thrown in his path?
- Is it easy to drive a motorcycle on a wet muddy track?

In the examples given above, we see that:

- Walking on a slippery surface i.e. surface having less friction or smooth surface is difficult.
- It is not easy to drive a motorcycle or any other vehicle on a wet muddy road i.e. on a surface having lesser friction. It means, it is impossible to drive on a frictionless path.
- It is also not possible to hold any object having no friction.

Thus, friction is necessary in most of the action. Without friction, perhaps no any physical action can be performed. Following are some of the advantages of friction.

- Friction is necessary to sit, to walk, to drive, to hold any object, to write, to eat and to chew food and for numerous other activities which we perform to lead daily normal life.
- Brakes on cycles or cars or several other vehicles work because of friction.
- Fixing screws and nails to walls and keeping pieces of furniture together is possible only because of friction.
- Without friction no building could be constructed.
- Without friction, it would not be possible to light a matchstick by rubbing it against the matchbox.
- You could not tie a knot in a rope without friction.

A nail is fixed in the wall due to friction

Summarising these facts, we can say that without friction the whole world will look entirely different which is beyond our imagination. Perhaps nothing will be in the state of rest, everything will be randomly moving and colliding with each other.

KEYWORDS

Frictionless Path: A path with no resistance to the movement of objects, allowing them to move without any frictional forces acting against their motion.

State of Rest: A condition where an object remains stationary and experiences no net force acting on it.

Disadvantages of friction

Friction opposes motion	Friction makes moving or sliding heavy objects difficult. A lot of energy is utilized in overcoming friction.
Friction results in wear and tear	Objects such as tyres of vehicles, soles of shoes, and moving parts of machines wear out with time due to a constant action of friction.
Friction causes heat	Friction produces heat. The moving parts in machines produce a lot of heat, which is lost to the surroundings. This results in wastage of energy. For example, when you touch a mixer-grinder which has been running continuously for a long period of time, it feels warm. This happens because due to friction, a part of the electrical energy is converted into heat. This heat cannot be used by the mixer-grinder and is lost to the surroundings.

Let's recall what we know

Apply Concept in Real-Life Context

Apply

1. Why do objects eventually stop moving when you slide them across a surface?
2. Why is it easier to walk on a dry floor compared to a wet floor?

Skills Covered: Critical and logical thinking, Identification, Application thinking

Further Analysis

Analyse

1. Explain the difference between static friction and kinetic friction, and provide examples of each.
2. How does the roughness or smoothness of a surface affect the amount of friction?

Skills Covered: Critical analysis, logical reasoning, brainstorming

Self-Assessment Questions

Evaluate

1. What is friction? Explain its role in daily life with two examples.
2. How does friction benefit us in performing everyday tasks?

Bloom's Taxonomy

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Take a Task

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Creative Task

Create

Design an experiment to observe the difference between static and sliding friction:

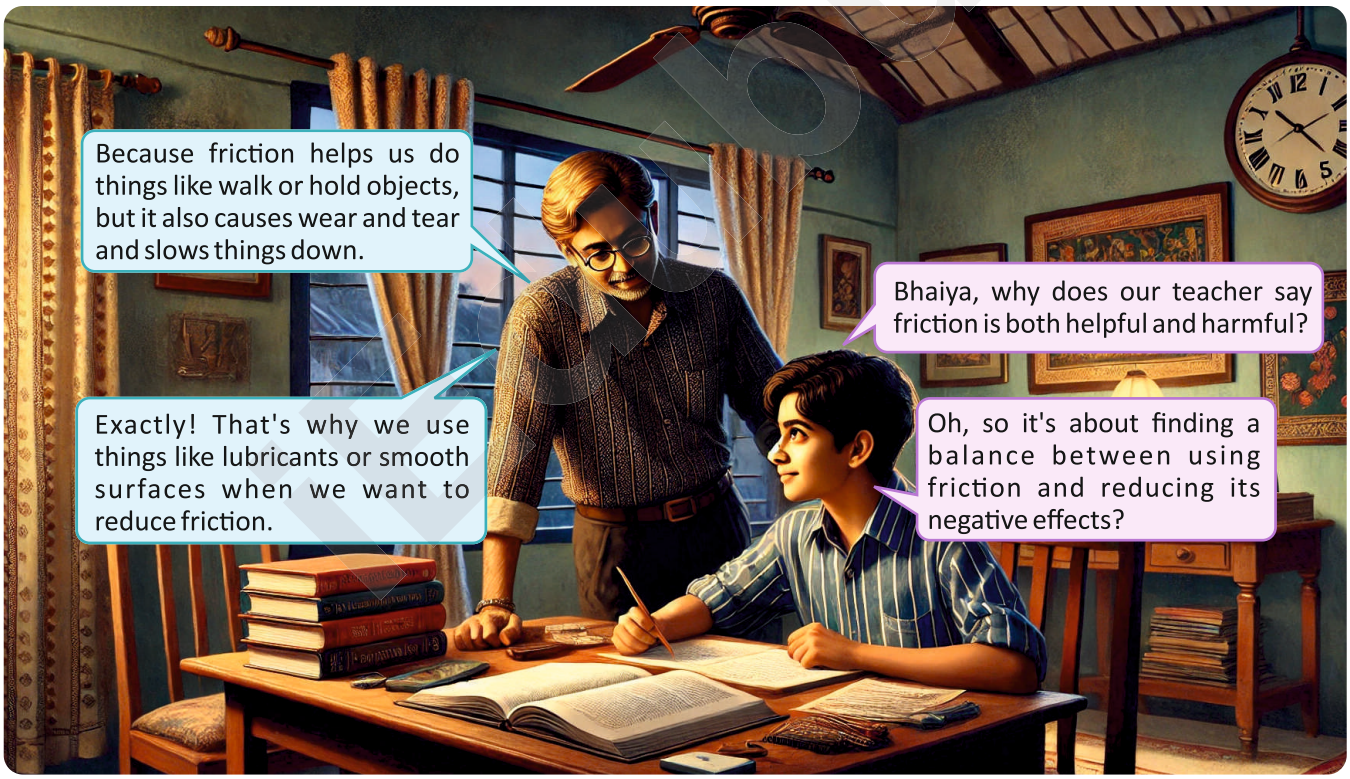
1. Take a small object like a book and place it on a flat table.
2. Gradually push the book until it starts to move. Observe the force needed to overcome static friction.
3. Once the book starts moving, keep pushing it and observe how sliding friction affects its motion.

Write your observations and conclusions in your notebook, explaining how static and sliding friction differ.

Skills Covered: Brainstorming, research, digital literacy, creativity

Friction: Balancing the Necessary

Aarav is doing his homework when his elder brother, Rohan, walks in.



As you have seen in the previous section, friction is desirable in some situations. In some situations we also need to increase friction. There are two methods of increasing friction, one is by making surface rough and the other by increasing the mass of the object that is moving. Following are the examples of increasing friction.

- Soles of the shoes and tyres of the automobiles are made corrugated and rough to in crease the friction and to provide a better grip on the road.

- Brake pads are used in bicycles and automobiles to increase friction while being applied. When brake is pressed, these pads arrest the motion of the rim due to friction.
- Kabaddi players rub their hands with soil to increase friction for a better grip of their opponents.

Soles of shoes and tyres are treaded to increase friction

- Gymnasts apply some coarse substance on their hands to increase friction for better grip.

In some situations, however, friction is undesirable and we would want to minimize it. Following are the ways to reduce friction.

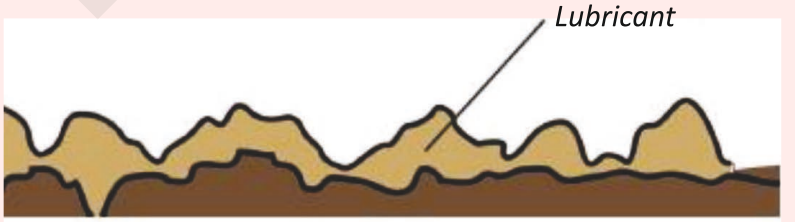
By sprinkling a soft slippery fine powder on the surfaces

A small quantity of fine soft powder sprinkled on the wooden surfaces reduces the friction. For example, a soft fine powder is sprinkled on the carrom board to reduce the friction.

Powder is sprinkled on the carrom board to reduce friction

By applying oil or grease on the surface

You might have noticed that when a few drops of oil are poured on the hinges of a door, the door moves smoothly. A bicycle and a motor mechanic use grease between the moving parts of these machines. In all the above cases, we want to reduce friction in order to increase efficiency. Oil/grease form a thin layer between the two surfaces which reduces the interlocking of the surfaces and hence friction. The substances which reduce friction are called lubricants. In some machines, it may not be advisable to use oil as lubricant. An air cushion between the moving parts is used to reduce friction.



Action of lubricant Lubricant

KEYWORDS

Lubricant types for reduce friction

1. Grease
2. Oil
3. Dry Lubricants
4. Solid Lubricants

By using ball-bearings, wheels and roller-bearings

as we have learned that rolling friction is lesser than sliding friction, ball-bearing, wheels and roller-bearings reduce the friction. Attaches and other pieces of luggage are fitted with rollers so that they can be easily carried due to lesser frictional force.

Can we reduce friction to zero by polishing surfaces or using large amount of lubricants? Friction can never be entirely eleminated. No surface is perfectly smooth. Some irregularities are always there.

Rolling reduces friction

Let's recall what we know

Apply Concept in Real-Life Context

Apply

1. Why is it easier to walk on a concrete road than on an icy surface?
2. Why do bicycle brakes work more effectively when the brake pads press tightly against the wheels?

Skills Covered: Critical and logical thinking, Identification, Application thinking

Further Analysis

Analyse

1. How does the amount of friction between two surfaces depend on the nature of the surfaces in contact? Provide examples.
2. Why is friction sometimes considered a disadvantage in machines and how can it be reduced effectively?

Skills Covered: Critical analysis, logical reasoning, brainstorming

Self-Assessment Questions

Evaluate

1. What is friction, and how does it affect motion?
2. What are the differences between static friction and kinetic friction?
3. Name two advantages and two disadvantages of friction in daily life.
4. How does friction help us in activities like writing or driving?

Creative Task

Create

Conduct a simple experiment to observe the effects of friction:

1. Take a toy car and roll it on different surfaces like a wooden table, a carpet, and a smooth floor.
2. Observe and record how far the car moves on each surface.
3. Analyze which surface provides the most friction and which provides the least.

Write your observations and conclusions in your notebook, explaining how friction varies across different surfaces.

Skills Covered: Brainstorming, research, digital literacy, creativity

SCAN TO ACCESS

Take a Task

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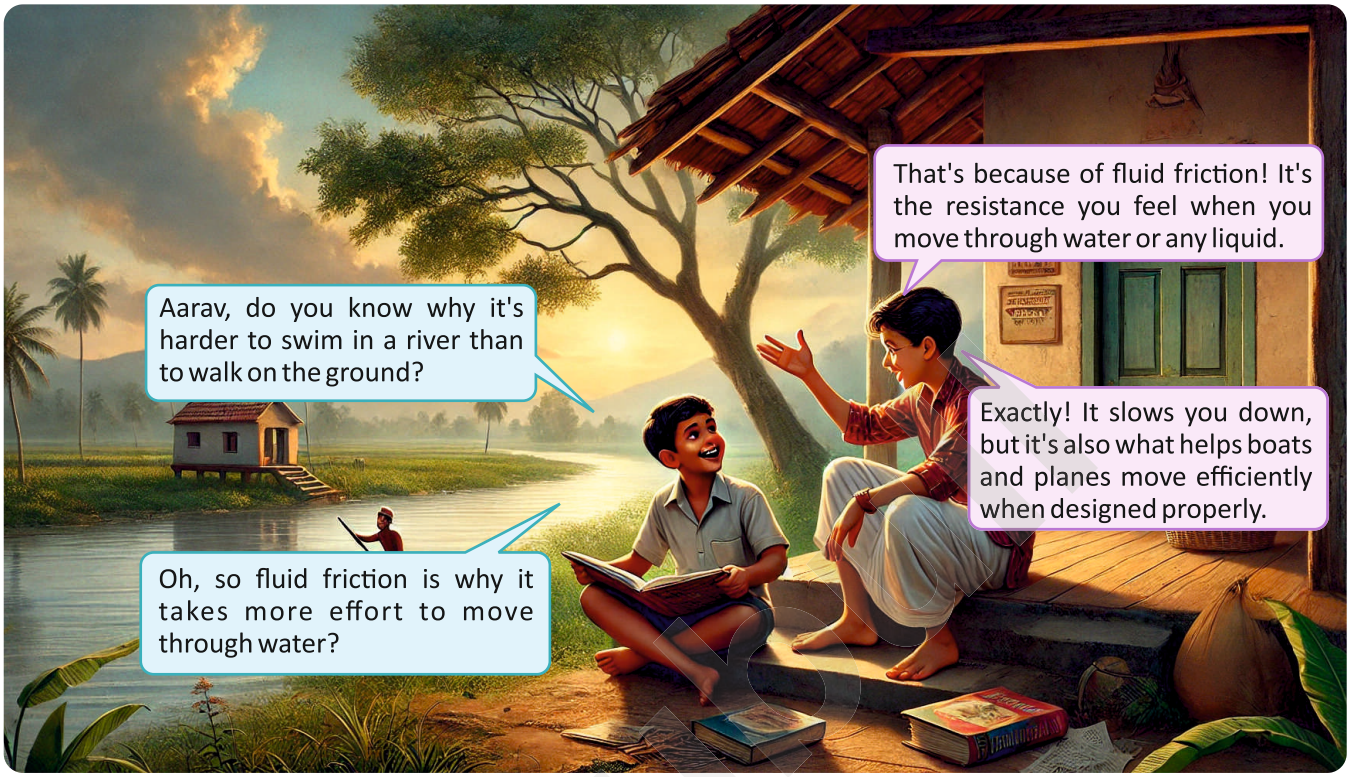
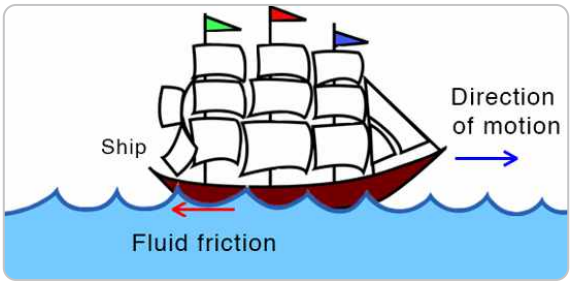
Bloom's Taxonomy

Fluid Friction

Rohan is working on his science homework when his friend Aarav visits him.



Air exerts frictional force on objects moving through it. Similarly, water and other liquids exert force of friction when objects move through them. Gases and liquids are commonly called fluids. So we can say that fluids exert force of friction on objects in motion through them. The frictional force exerted by fluids is also called drag. The frictional force on an object in a fluid depends on the following:



Example of Fluid friction

- Its speed with respect to the fluid.
- The shape of the object and
- The nature of the fluid.

It is obvious that when objects move through fluids, they have to overcome friction acting on them. In this process they lose energy. Efforts are, therefore, made to minimize the friction. So, objects are given special shapes.

Ways to Reduce Fluid Friction

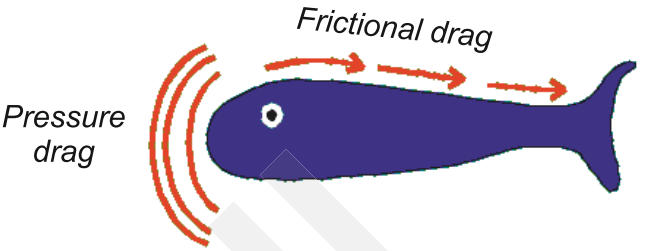
When objects move through fluids, they lose energy while overcoming fluid friction, which reduces their efficiency. To address this, methods to minimize fluid friction are essential.

One effective way to reduce fluid friction is by designing objects with shapes that offer minimal resistance to fluid flow. A streamlined shape is ideal for such purposes. This shape resembles a thin wedge, allowing the object to cut through air or water smoothly and move forward with less friction.

Examples:

Aeroplanes: Aeroplanes are designed with streamlined shapes to minimize air resistance and enhance efficiency.

Boats, birds, and fishes: These naturally have streamlined shapes, which help them reduce friction in water or air, conserving energy and aiding smooth movement.



Let's recall what we know

Apply Concept in Real-Life Context

Apply

1. Why do swimmers wear streamlined swimsuits while competing in races?
2. Why do objects moving in water, like boats or submarines, require more energy compared to moving through air?

Skills Covered: Critical and logical thinking, Identification, Application thinking

Further Analysis

Analyse

1. Explain how fluid friction impacts the motion of objects in liquids and gases. Provide examples.
2. Why do airplanes and ships have streamlined shapes, and how does it reduce fluid friction?

Skills Covered: Critical analysis, logical reasoning, brainstorming

Self-Assessment Questions

Evaluate

1. Define fluid friction and explain how it is different from dry friction.
2. What factors influence the amount of fluid friction experienced by an object?
3. Explain how fluid friction is useful in some cases and a disadvantage in others. Provide examples.
4. What measures can be taken to reduce fluid friction for vehicles moving in water or air?

Bloom's Taxonomy

SCAN TO ACCESS

Take a Task

Watch Remedial

SUMMARY

Friction: An Overview

Friction is the resistance to motion that occurs when two surfaces come into contact. It plays a crucial role in everyday life, making activities like walking, driving, and holding objects possible. However, friction can also lead to wear and tear or energy loss, making its management an essential aspect of technology and engineering.

1. Friction and Its Types

Friction can be categorized based on the nature of the interacting surfaces and the type of motion involved.

Static Friction:

- Acts on objects that are stationary.
- Prevents motion until an external force exceeds this resistance.
- **Examples:** Pushing a heavy box that doesn't move at first, or a parked car on a slope held in place by friction.

Kinetic (Sliding) Friction:

- Occurs when two surfaces slide against each other.
- Generally weaker than static friction, making it easier to maintain motion than to start it.
- **Examples:** Dragging furniture across the floor or braking a moving vehicle.

Fluid Friction:

- Occurs when an object moves through a fluid (liquid or gas).
- Resistance depends on the fluid's viscosity and the object's speed.
- **Examples:** A swimmer moving through water or an airplane flying through air.

2. Friction: Balancing the Necessary

Advantages of Friction:

- Provides traction for walking, running, or driving.
- Enables objects to stay in place, such as books on a shelf.
- Allows controlled motion, such as gripping tools or brakes stopping vehicles.

Disadvantages of Friction:

- Causes wear and tear, reducing the lifespan of machines.
- Leads to energy loss in the form of heat, impacting efficiency.

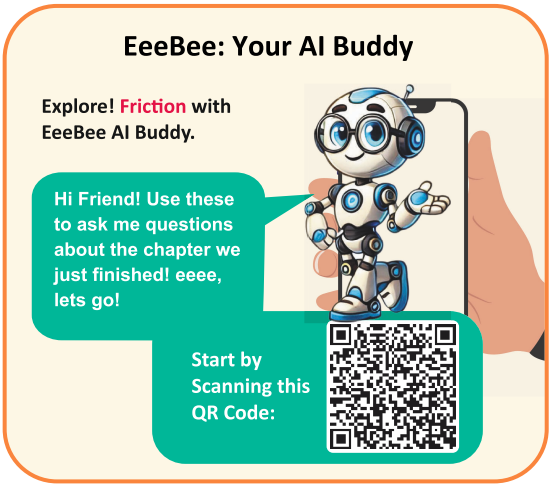
3. Fluid Friction

Factors Affecting Fluid Friction:

- Speed of the Object
- Shape and Surface Area
- Viscosity of the Fluid
- Surface Roughness

Applications of Fluid Friction:

- Aerodynamics
- Marine Engineering
- Sports Science



Gap Analyzer™
Take a Test

EXERCISE

That turn curiosity into confidence—let's begin!

A. Choose the correct answer.

1. What is the force that opposes the relative motion between two surfaces in contact?
   (a) Gravity ☐ (b) Friction ☐
   (c) Tension ☐ (d) Magnetism ☐
2. Which of the following is an example of static friction?
   (a) A rolling ball ☐ (b) A parked car on a slope ☐
   (c) Water flowing ☐ (d) A moving cart ☐
3. Which type of friction occurs when an object moves through a fluid?
   (a) Static friction ☐ (b) Kinetic friction ☐
   (c) Fluid friction ☐ (d) Rolling friction ☐
4. Which factor does not affect the force of friction?
   (a) Surface texture ☐ (b) Weight of the object ☐
   (c) Color of the object ☐ (d) Contact area ☐
5. Which method is used to reduce friction?
   (a) Using rough surfaces ☐ (b) Using lubricants ☐
   (c) Increasing contact force ☐ (d) Removing all air ☐

B. Fill in the blanks.

1. Friction always acts in the _____ direction to the motion.
2. _____ friction is the type of friction that exists between stationary surfaces.
3. The use of lubricants _____ the force of friction between moving parts.
4. Fluid friction depends on the _____ and shape of the object moving through the fluid.
5. Rolling friction is _____ than sliding friction for the same surfaces.

C. Write True or False.

1. Friction is always undesirable and should be eliminated. _____
2. Static friction is greater than kinetic friction for the same surfaces. _____
3. Fluid friction increases with the speed of the moving object. _____
4. Friction depends only on the weight of the object and not on the surface material. _____

D. Define the following terms.

1. Friction
2. Static friction
3. Kinetic friction
4. Rolling friction
5. Fluid friction

E. Match the columns.

Column A	Column B
1. Static friction	(a) Motion through air
2. Kinetic friction	(b) Opposes starting motion
3. Rolling friction	(c) Ball bearings
4. Fluid friction	(d) Sliding surfaces
5. Lubricants	(e) Reduces friction

F. Give reasons for the following statements.

1. Friction is called a necessary evil.
2. Lubricants are applied to machine parts.
3. Ball bearings are used in bicycles and cars.
4. Rolling friction is less than sliding friction.
5. Ships and airplanes are designed with streamlined shapes.

G. Answer in brief.

1. What is friction and why is it important in everyday life?
2. Explain the difference between static and kinetic friction.
3. What factors affect fluid friction?
4. How does the application of lubricants reduce friction?
5. Discuss two methods to reduce undesirable friction.

H. Answer in detail.

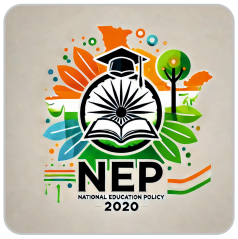
1. Explain the different types of friction with examples.
2. Why does static friction have a higher value than kinetic friction?
3. Describe how friction is both beneficial and harmful in various situations.
4. How does fluid friction act on objects moving through air and water? Explain with examples.
5. Discuss the role of friction in designing vehicle tires and sports equipment.

NEP Corner

Know about NEP 2020

Learn For Life, Not Exams!

Assessments are now competency-based, focusing on your actual understanding, problem-solving skills, and critical thinking.



Skill-based Activity

Activity Time

STEM

Understanding Friction in Daily Life

1. Create a chart showing examples of different types of friction (static, sliding, rolling, fluid friction).
2. Conduct a simple experiment: Slide objects of different materials (e.g., wood, metal, plastic) on a smooth surface and observe the effect of friction.
3. Write a brief explanation of how friction affects the movement of objects.
4. Reflect on situations where friction is beneficial and situations where it is undesirable. Suggest methods to reduce or increase friction accordingly.

Skills Covered: Creativity, Observation, Critical Thinking, Data Analysis, Responsibility, Research

Exploring the Role of Friction in Machines

Art

Research and Analyze

1. Define friction and explain how it acts as both a friend and a foe in machines.
2. Research the role of lubricants in reducing friction in engines and machines.
3. Compare situations where high friction is essential (e.g., brakes) and where low friction is required (e.g., ball bearings).

Skills Covered: Creativity, Imagination, Problem-solving, Environmental Awareness

Friction in Nature

Group Activity

1. Research how friction affects natural phenomena such as the movement of glaciers or the erosion of rocks.
2. Create a model or presentation demonstrating how friction plays a role in natural events like avalanches or river flows.

3. Discuss how reducing or increasing friction affects these natural processes.
4. Share your group's findings through a creative medium, such as a skit, video, or model.

Skills Covered: Critical thinking, Planning, Collaboration, Communication, Creativity, Teamwork, Problem-solving, Responsibility

Friction in Sports

Case to Investigate

1. Investigate how athletes use friction to their advantage in sports like football, tennis, or skating.
2. Write about how surfaces (e.g., grass, ice, or clay) impact the level of friction in sports.
3. Create an infographic showing how sports equipment, such as shoes or tires, is designed to optimize friction.

Skills Covered: Observation, Critical thinking, Research, Analytical skills, Communication

Friction in Everyday Life

Aligning with SDGs

1. Write about how friction is used in everyday tasks, such as walking, writing with a pencil, or lighting a matchstick.
2. Identify situations where reducing friction is important (e.g., skiing) and where increasing friction is beneficial (e.g., gripping tools).
3. Create a visual representation or mind map of the effects of friction in household activities.
4. Discuss safety precautions for handling situations where excessive or insufficient friction can cause problems (e.g., slippery floors, worn-out tires).

Aligned with SDGs:

SDG 9: Industry, Innovation, and Infrastructure, SDG 11: Sustainable Cities and Communities, SDG 12: Responsible Consumption and Production, SDG 3: Good Health and Well-being, SDG 13: Climate Action

Skills Covered: Research, Brainstorming, Problem-solving, Presentation skills

Applications of Friction in Technology

Integrated Learning

1. Research the use of friction in technologies like brakes, tires, or conveyor belts.
2. Identify and explain how anti-friction materials, such as Teflon or lubricants, improve the efficiency of machines.
3. Design a simple model using household items to demonstrate the effect of friction (e.g., a toy car on different surfaces).
4. Discuss how advancements in understanding friction have impacted industries like transportation, manufacturing, or healthcare.

Integrated Learning: Technology and Industries

Skills Covered: Brainstorming, Research, Investigation, Critical Thinking