Chapter 8: Force and Laws of Motion — Detailed Notes

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1. Introduction to Force

Every day, we push, pull, lift, throw, or kick things around us — all these actions involve force.
When you push a door to open it, kick a football, or lift your school bag, you are actually applying a force.
A force is simply a push or pull that can cause an object to move, stop, or change its shape.
It is something that makes things happen — without force, everything would either remain still or keep moving in the same way forever!

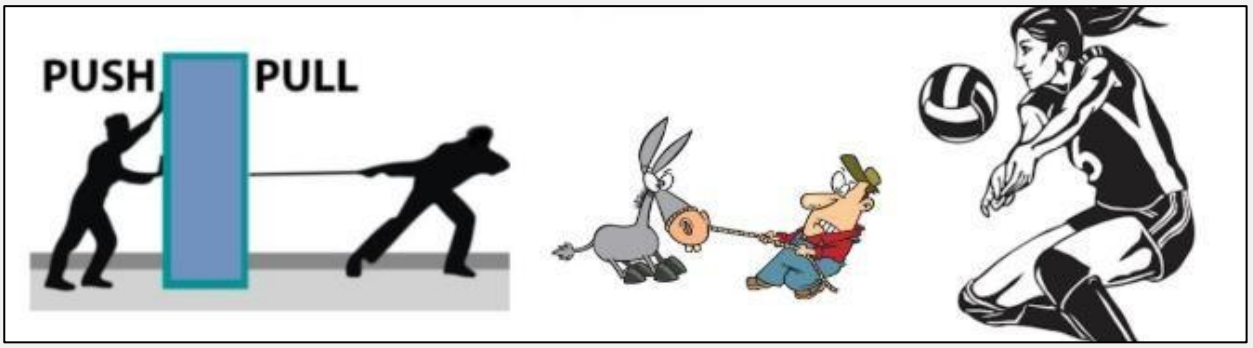
The Real Meaning of Force:

Force does not exist on its own — it always happens when two objects interact. For example:

- *When you hit a ball with a bat, both the bat and the ball interact.*
- *When the Earth pulls a falling apple, it interacts with the apple through gravitational force. So, no interaction → no force.*

Force in Everyday Life:

Force is all around us — it makes cars move, keeps the planets in orbit, and even helps us walk!
Without force, we couldn't perform even the simplest actions like writing, holding things, or jumping.



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2. Effects of Force

Force is not something we can see directly — but we can easily observe its effects on objects around us. Force is not something we can see directly — but we can easily observe its effects on objects around us.

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Whenever a force is applied, it produces some visible change in the object.

Let's explore the main effects of force in an easy and interesting way.

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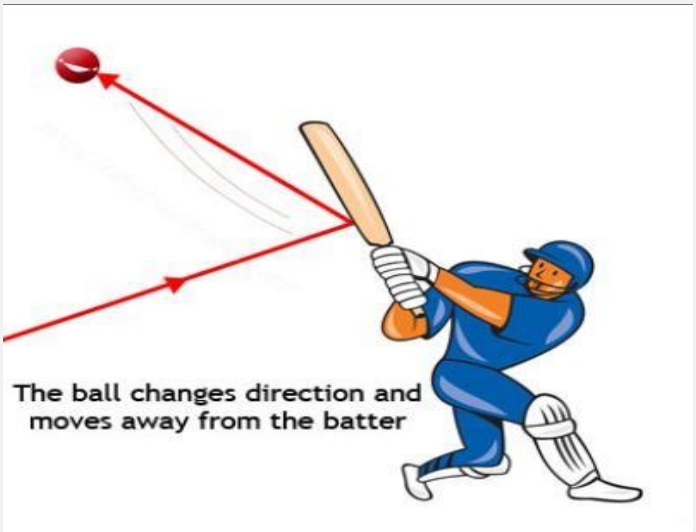
1. Force Can Change the State of Motion:

A force can make a stationary object start moving or a moving object stop.
Example: When you kick a football lying on the ground, it begins to move. When a goalkeeper catches the moving ball, it stops — both actions are due to force.

2. ***Force Can Change the Speed of an Object:***
   Applying a force can either increase or decrease the speed of a moving object.
   Example: When you press the accelerator of a car, the engine applies a forward force that increases the speed. Pressing the brakes applies an opposite force that slows the car down.

3. ***Force Can Change the Direction of Motion:***
   Force can also change the direction in which an object is moving. Example: When a moving cricket ball is hit by a bat, its direction changes instantly.



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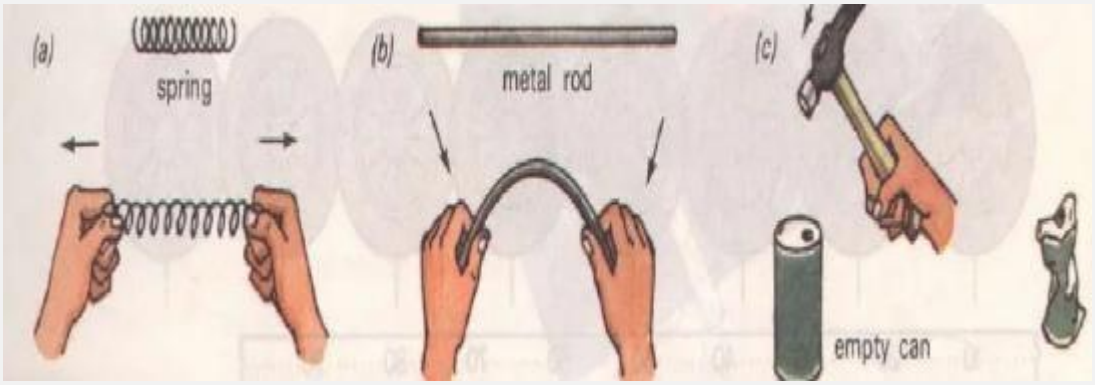
4. ***Force Can Change the Shape or Size of an Object:***
   A force can deform an object — that means it can change its shape or size.
   Example: When you squeeze a rubber ball or stretch a spring, the applied force changes their shape.



In Short:

Force can bring about any of the following changes:

- ***Start or stop motion***
- ***Change speed***
- ***Change direction***
- ***Change shape or size***

Remember:

Force doesn't always cause motion, but whenever there is a change in motion or shape — there's always a force behind it!

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3. Types of Forces

Forces can act in different ways depending on whether the objects are in contact or not.
Broadly, forces are divided into two main types: Contact Forces and Non-Contact Forces.

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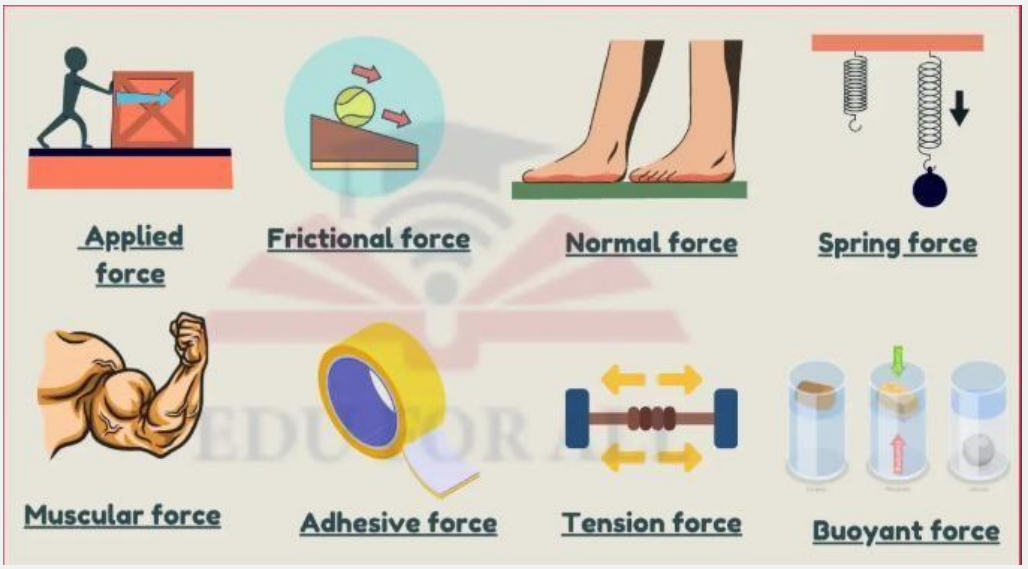
1. Contact Forces

These are the forces that come into play only when two objects touch each other.
In contact forces, physical interaction between objects is necessary.
Examples:

- ***Muscular Force: The force applied by our muscles to lift, push, or pull objects. For example, lifting a bucket of water or pushing a door.***
- ***Frictional Force: The force that opposes the motion of an object when it slides or rolls over a surface. For example, friction between car tyres and the road helps the car move safely.***
- ***Normal Force: The upward force exerted by a surface to support the weight of an object resting on it. For example, a book resting on a table experiences a normal force from the table.***
- ***Tension Force: The force transmitted through a rope, string, or cable when it is pulled tight. For example, the tension in a hanging rope or a tug-of-war rope.***
- ***Applied Force: The force that a person or another object applies to move or stop something. For example, pushing a chair or pulling a suitcase.***



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2. Non-Contact Forces

These are the forces that act even when the objects are not touching each other.

They can act from a distance without any physical contact.

Examples:

- ***Gravitational Force: The force of attraction between any two objects having mass. The Earth attracts everything toward its center — this is why objects fall down when dropped.***
- ***Magnetic Force: The force exerted by magnets on certain materials like iron. For example, a magnet attracting iron nails.***
- ***Electrostatic Force: The force exerted by electrically charged objects on each other. For example, a charged balloon attracting small bits of paper.***

In Short

- ***Contact Forces act through direct touch.***
- ***Non-Contact Forces act from a distance, without touching.***

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4. Newton's Laws of Motion

The motion of all objects in the universe follows certain fundamental laws discovered by Sir Isaac Newton. These are known as Newton's Laws of Motion. They explain how and why objects move when forces act on them. There are three laws of motion, and together they form the foundation of classical mechanics.

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1. Newton's First Law of Motion (Law of Inertia)

This law states that:

"An object will remain at rest or continue to move in a straight line at uniform speed unless an external force acts on it."

In simple words, an object cannot change its state of motion by itself — it resists any change in motion or rest. This tendency of an object to resist change is called inertia.

Examples:

- ***A book lying on a table will remain at rest until someone pushes or lifts it.***
- ***When a moving bus suddenly stops, passengers tend to fall forward because their bodies try to continue in motion. Thus,***

the first law introduces the concept of inertia and explains that a force is needed to change the state of motion of an object.

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2. Newton's Second Law of Motion

This law states that:

"The rate of change of momentum of an object is directly proportional to the applied force and takes place in the direction of the force."

In simpler form, this law gives us the mathematical relation:

Force (F) = Mass (m) × Acceleration (a)

This means a larger force produces greater acceleration in an object of a given mass. It also means that heavier objects require more force to move or stop.

Examples:

- *A cricket player pulls his hands backward while catching a fast-moving ball to reduce its momentum gradually and avoid injury.*
- *It is easier to push an empty cart than a loaded one because the loaded cart has more mass and requires more force to accelerate.*

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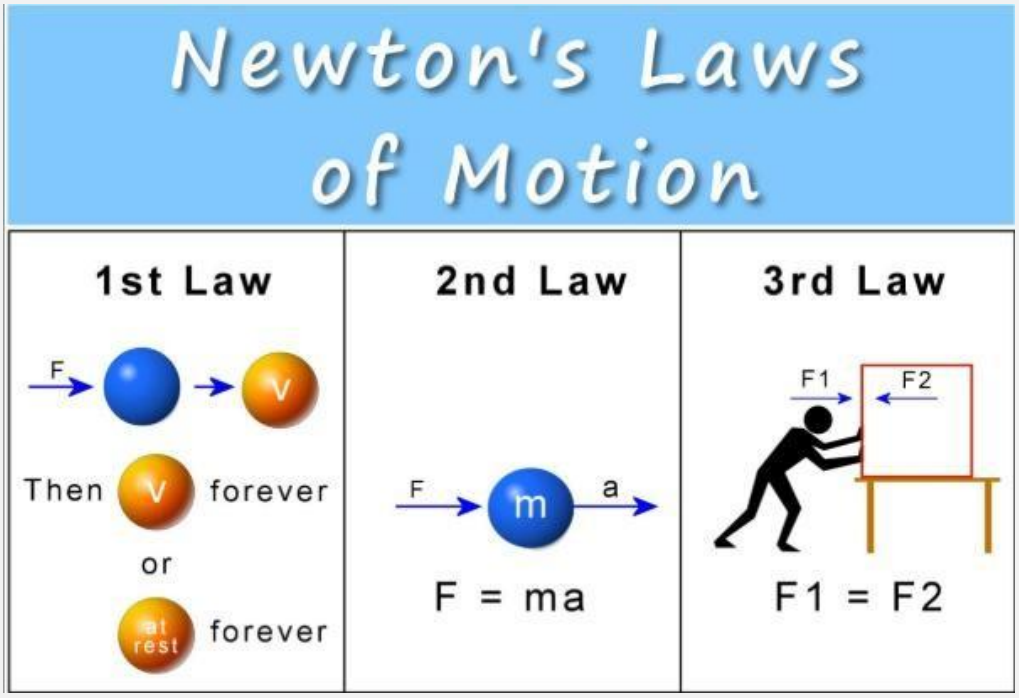
3. Newton's Third Law of Motion

This law states that:

"For every action, there is an equal and opposite reaction." It means whenever one object applies a force on another, the second object applies an equal force in the opposite direction on the first object. These two forces always act on different bodies.

Examples:

- *When you jump off a boat, you push the boat backward (reaction) while moving forward (action).*
- *A gun recoils backward when a bullet is fired forward.*
- *When a rocket launches, gases are expelled downward, and the rocket moves upward with equal and opposite force.*



In Short

- ***First Law: Explains inertia — objects resist change in motion.***
- ***Second Law: Relates force, mass, and acceleration (F = m × a).***
- ***Third Law: Every action has an equal and opposite reaction.***

Remember:

These three laws describe how forces affect the motion of objects — from a rolling ball to a launching rocket — and form the foundation of all motion in physics.

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5. Momentum

Momentum is a concept that describes the "quantity of motion" an object has. It depends on both the mass of the object and its velocity.

Mathematically, momentum (p) = mass (m) × velocity (v)

- ***p = momentum***
- ***m = mass of the object***
- ***v = velocity of the object***

Momentum is a vector quantity, which means it has both magnitude and direction. The direction of momentum is the same as the direction of the object's velocity.

Key Points About Momentum:

- ***The more massive an object, the greater its momentum for the same speed.***
- ***The faster an object moves, the greater its momentum for the same mass.***
- ***Momentum is directly proportional to both mass and velocity.***
Examples:
- ***A moving truck has more momentum than a moving bicycle even if both are moving at the same speed, because the truck has more mass.***
- ***A fast-moving bullet has high momentum even though its mass is small because its velocity is very high.***

Law of Conservation of Momentum
The total momentum of a system remains constant if no external force acts on it.
In simple words:
Momentum cannot be created or destroyed; it can only be transferred from one object to another.
Example:

- ***When a gun is fired, the bullet moves forward, and the gun recoils backward. The momentum of the bullet is equal and opposite to the momentum of the gun, so the total momentum of the system remains zero.***

In Short:

- ***Momentum measures how hard it is to stop a moving object.***
- ***Formula: $p = m \times v$***
- ***It is a vector quantity (has magnitude and direction).***
- ***Momentum is conserved in the absence of external forces.***

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6. Inertia and Types of Inertia

Inertia is the tendency of an object to resist any change in its state of motion.

In other words, an object at rest wants to stay at rest, and an object in motion wants to keep moving at the same speed and in the same direction, unless acted upon by an external force.
This concept is introduced by Newton's First Law of Motion, also called the Law of Inertia.

Types of Inertia

1. Inertia of Rest

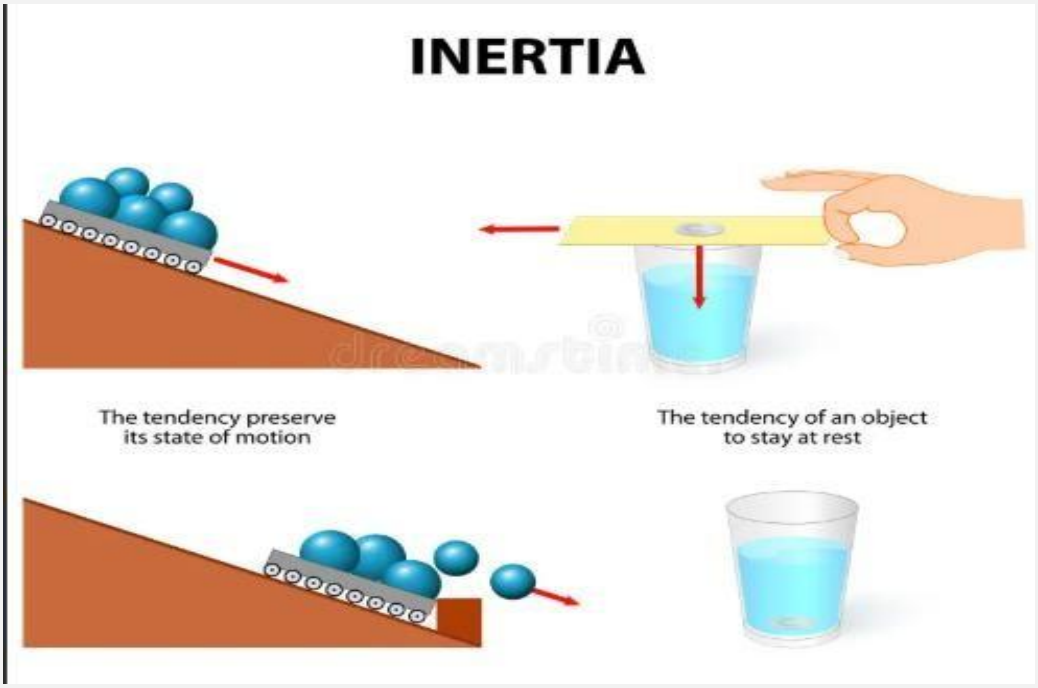
- *This is the tendency of an object to remain at rest until a force is applied to move it.*
- *Example: A book lying on a table does not move until you push it.*

2. Inertia of Motion

- *This is the tendency of a moving object to continue moving in the same direction and at the same speed unless a force stops it.*
- *Example: A moving ball keeps rolling on the ground until friction or another force slows it down and stops it.*

3. Inertia of Direction

- *This is the tendency of an object to resist a change in its direction of motion.*
- *Example: When a car turns suddenly, passengers lean outward because their bodies try to continue moving in a straight line.*



Key Points to Remember:

- ***Inertia is directly related to mass — heavier objects have more inertia.***
- ***Inertia does not depend on whether an object is moving or at rest; it depends on resistance to change in motion.***

In Short:
Inertia is the property of an object to resist any change in its motion, and it can be observed in rest, motion, or change of direction.

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7. Force and Acceleration Relationship

The relationship between force and acceleration is explained by Newton's Second Law of Motion.
This law states that:
"The acceleration produced in an object is directly proportional to the net force applied on it and inversely proportional to its mass."
Mathematically:
F = m × a Where:

- ***F = Force applied (in Newtons, N)***
- ***m = Mass of the object (in kilograms, kg)***
- ***a = Acceleration produced (in m/s^2)***

◇ ***Key Points***

1. Direct Proportionality with Force

- ***If the mass is constant, the acceleration of an object increases as the applied force increases.***
- ***Example: Pushing a bicycle gently makes it move slowly; pushing harder makes it accelerate faster.***

2. Inverse Proportionality with Mass

- ***If the force is constant, the acceleration of an object decreases as the mass increases.***
- ***Example: It is easier to push an empty cart than a loaded cart because the loaded cart has more mass, so the same force produces less acceleration.***

3. Direction of Acceleration

- *Acceleration occurs in the same direction as the applied force.*

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8. Applications of Newton's Laws

- *Seat belts in cars prevent passengers from continuing forward motion.*
- *Rockets move forward due to action-reaction forces.*
- *Pushing a heavier object requires more force.*

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9. Friction

Friction is a force that opposes the relative motion or tendency of motion between two surfaces in contact.
In simple words, friction always acts in the opposite direction to the motion or applied force.
Friction is everywhere around us and affects our daily life in both helpful and resisting ways.

◇ *Causes of Friction*

Friction arises due to microscopic irregularities on the surfaces of objects in contact.
Even surfaces that appear smooth have tiny bumps and grooves, which catch on each other, creating resistance to motion.

◇ *Types of Friction*

1. Static Friction

- *The friction that prevents a stationary object from moving.*
- *Example: A book lying on a table does not move until the applied force exceeds the static friction.*

2. Sliding Friction

- *The friction that opposes the motion of an object sliding over a surface.*
- *Example: Pushing a box across the floor experiences sliding friction.*

3. Rolling Friction

- *The friction that opposes the motion of a rolling object.*
- *Example: A rolling bicycle wheel or ball experiences rolling friction, which is much smaller than sliding friction.*

4. Fluid Friction

- *The friction experienced by an object moving through a fluid (liquid or gas).*
- *Example: A boat moving through water or a plane moving through air experiences fluid friction.*

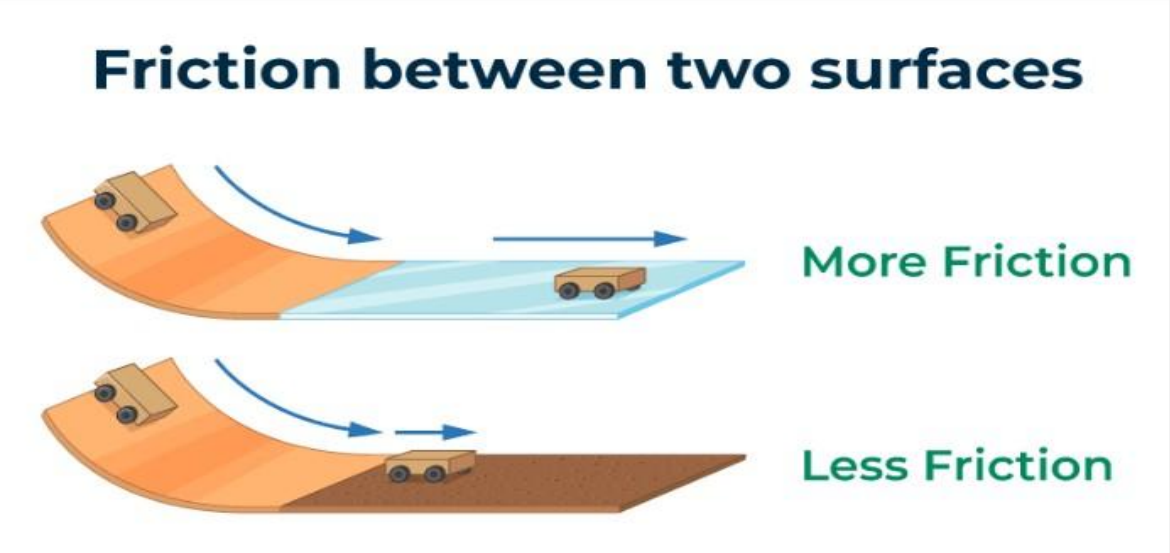
◇ *Effects of Friction*

Helpful Effects:

- *Friction allows us to walk or run without slipping.*
- *Friction between car tyres and the road helps vehicles stop safely.*
- *Friction enables us to write with a pen or pencil. Harmful Effects:*
- *Friction causes wear and tear of machine parts.*
- *Friction in engines reduces efficiency because energy is lost as heat.*

◇ *Reducing or Increasing Friction*

- *To reduce friction: Use lubricants (oil or grease), smooth surfaces, or ball bearings.*
- *To increase friction: Use rough surfaces or textured materials where grip is needed, like shoes or tyres.*



In Short:

Friction is a force that opposes motion. It can be both useful (helps in walking, driving) and harmful (causes wear and energy loss). Its strength depends on the nature of surfaces and the normal force between them.