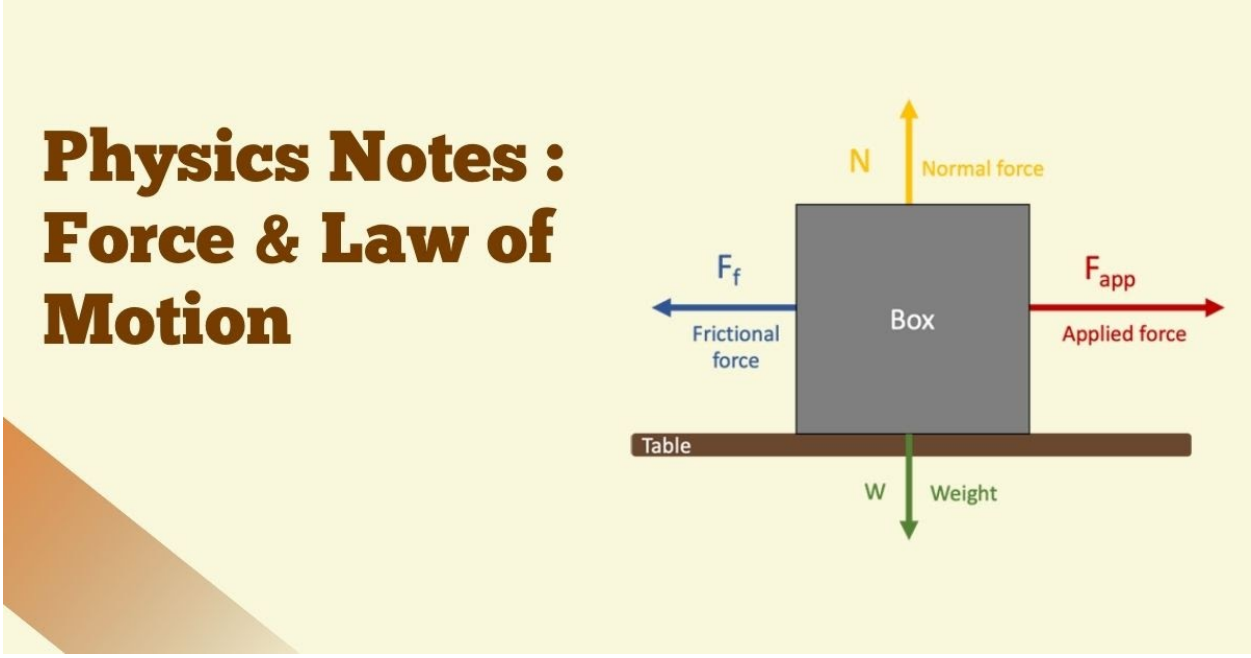


Physics Notes: Force & Law of Motion

➤Force

We can say that force is a push or pull acting on an object or energy as an attribute of physical action or movement. This occurs when two entities are in contact. According to the universal law of gravitation, every object in this universe exerts a force on others. The force acting on an object is given by the following parameter:

• SI unit of Force: **newton(N)** or **$kg.m/s^2$**

• Symbol of Force: **F**

• Type of quantity: **Vector quantity**

• Dimensional Formula: **$M^1L^1T^{-2}$**

• Other units: **dyne, pound-force, kilopond, poundal, kip**

Unit of Force

According to Newton's second law,

"Force is the product of mass and acceleration".

$$F = ma$$

$$1N = (1kg)\ (1\ m/sec^2)$$

Different units of Force in different systems:

System	Force	Mass	Acceleration
SI	Newton (N)	kilogram (kg)	m/sec^2
CGS	dyne	gram (gm)	cm/sec^2
FPS	pound (lb)	slug	ft/sec^2

➤Motion

In simple words, whenever a body is moving, we say it is in motion. For instance, if a boy is walking down the street from his school to his home, we will say that the boy is in motion. But imagine if the boy stops for 5 minutes in the way and sits down. If someone asks at that time if the boy is in motion, the answer will be 'No'. From this, we can infer that the motion of a body is dependent on time. In physics, we say that motion is the change in the position of a body with respect to time.

➤Scalar Quantities: Physical quantities which have magnitude only and no direction are called scalar quantities.

Example: Mass, speed, volume, work, time, power, energy etc.

➤Vector Quantities: Physical quantities which have magnitude and direction both and which obey triangle law are called vector quantities.

Example: Displacement, velocity, acceleration, force, momentum, torque etc.

Electric current, though has a direction, is a scalar quantity because it does not obey triangle law.

Moment of inertia, pressure, refractive index, stress are **tensor** quantities.

➤**Distance:** Distance is the actual path travelled by a body in a given period of time.

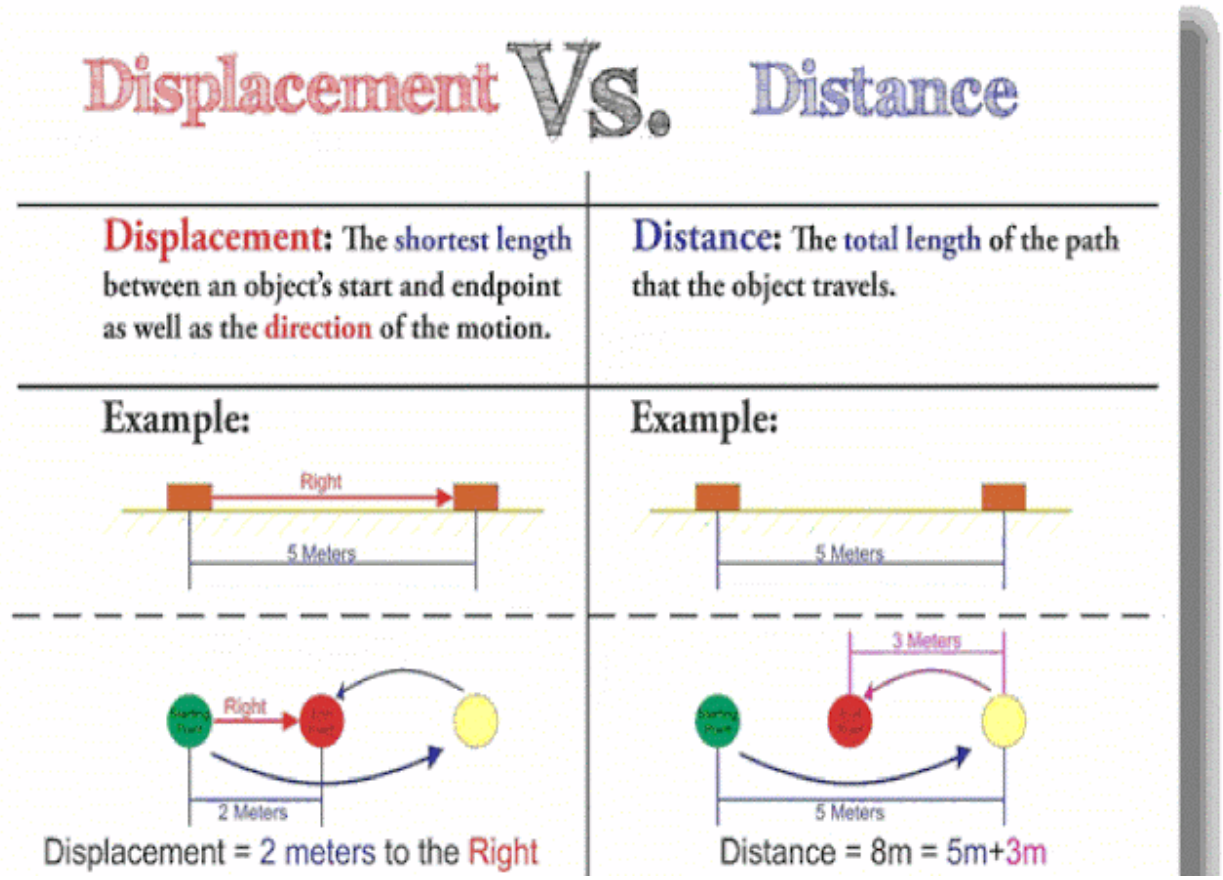
➤**Displacement:**

• Displacement is the shortest distance.

• The change in the position of the object in a given period of time

• Distance is a scalar quantity whereas displacement is a vector quantity both having the same unit (metre)

• Displacement may be **positive, negative or zero** whereas distance is always **positive.**



➤**Speed:**

• Distance travelled by the moving object in the unit time interval is called speed i.e. speed = Distance/ Time

• It is a scalar quantity and its SI unit is meter/second (m/s).

• The speed of an object at any instant is called instantaneous speed.

• An object is said to be travelled with non-uniform speed if it covers the unequal distance in equal interval of time.

➤Velocity:

• The velocity of a moving object is defined as the displacement of the object in unit time interval i.e., velocity =

• It is a vector quantity and its SI unit is meter/second.

• If a body goes equal displacement in equal interval of time then it is called uniform velocity.

• If a body undergoes unequal displacement in equal interval of time then it is called variable velocity.

➤Relative velocity

= $V_1 + V_2$ if two travels in the **opposite** direction

= $V_1 - V_2$ if two travels in the **same** direction

➤Acceleration:

• Acceleration of an object is defined as the rate of change of velocity of the object.

• It is a **vector** quantity and its SI unit is meter/second^2 (m/s^2)

• If velocity decreases with time then acceleration is negative and is called **retardation.**

• If acceleration does not change with time it is called **constant** acceleration.

• Some equation of acceleration;

$V=u+at$

$S=ut+at^2/2$

$V^2= u^2+2as$

Here v=final velocity, u is initial velocity, t is a time interval, a is acceleration and s is the distance travel.

➤Circular Motion:

• The motion of an object along a circular path it is called circular motion.

• If the object moves with uniform speed, its motion is uniform circular motion.

• Uniform circular motion is an accelerated motion because the direction of the velocity changes continuously.

➤Angular Displacement and Velocity:

• The angle subtended at the centre of a circle by a body moving along the circumference of the circle is called angular displacement of the body.

• Its unit is radian.

• Angular displacement= length of arc/radius of the circle

• The time rate of change of angular displacement is called angular velocity.

• It is generally denoted by ω and

➤Force:

• Force is that external cause which when acts on a body change or tries to change the initial state of the body.

• Its SI unit is **Newton(N).**

• A body is said to be in equilibrium if the sum of all the forces acts on the body is **Zero.**

• The nuclear force is the strongest force.

➤Momentum:

• Momentum is the property of a moving body and is defined as the product of mass and velocity of the body i.e.

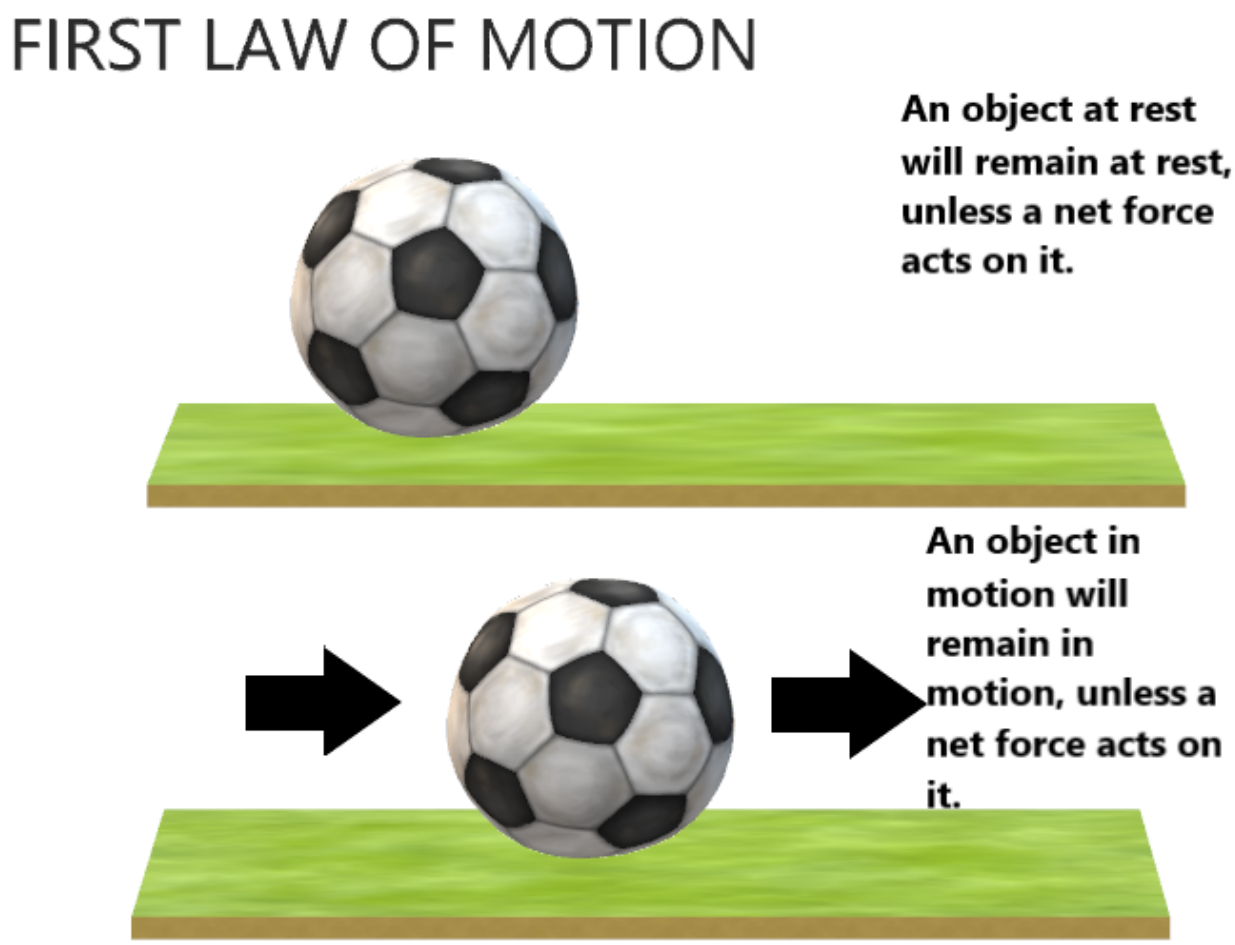
• Momentum = mass x velocity.

• It is a vector quantity. Its SI unit is kg-m/s.

➤Newton's Law

1. Newton first law

If no external force acts on a body then it remains in the same state of rest or motion that is in its present state.



The inertia of Rest:

• **Inertia** is the property of a body by virtue of which it opposes any change in its state of rest or of uniform motion.

• When a bus or train at rest starts to move suddenly the passengers sitting in it feels a jerk in backward direction due to the inertia of rest.

• **Dust particle** comes out of a carpet if we beat it with the stick.

• A passenger jumping out of a train is advised to jump in the direction of the bus and ran for a short distance.

The inertia of Motion:

When a running bus or train stops suddenly, the passengers sitting in it jerk in the forward direction due to the inertia of motion.

2. Newton's second law of motion:

• The rate of change in momentum of a body is directly proportional to the applied force on the body and takes place in the direction of the force.

If F = force applied, a = acceleration produced and m = mass of body

then F = ma.

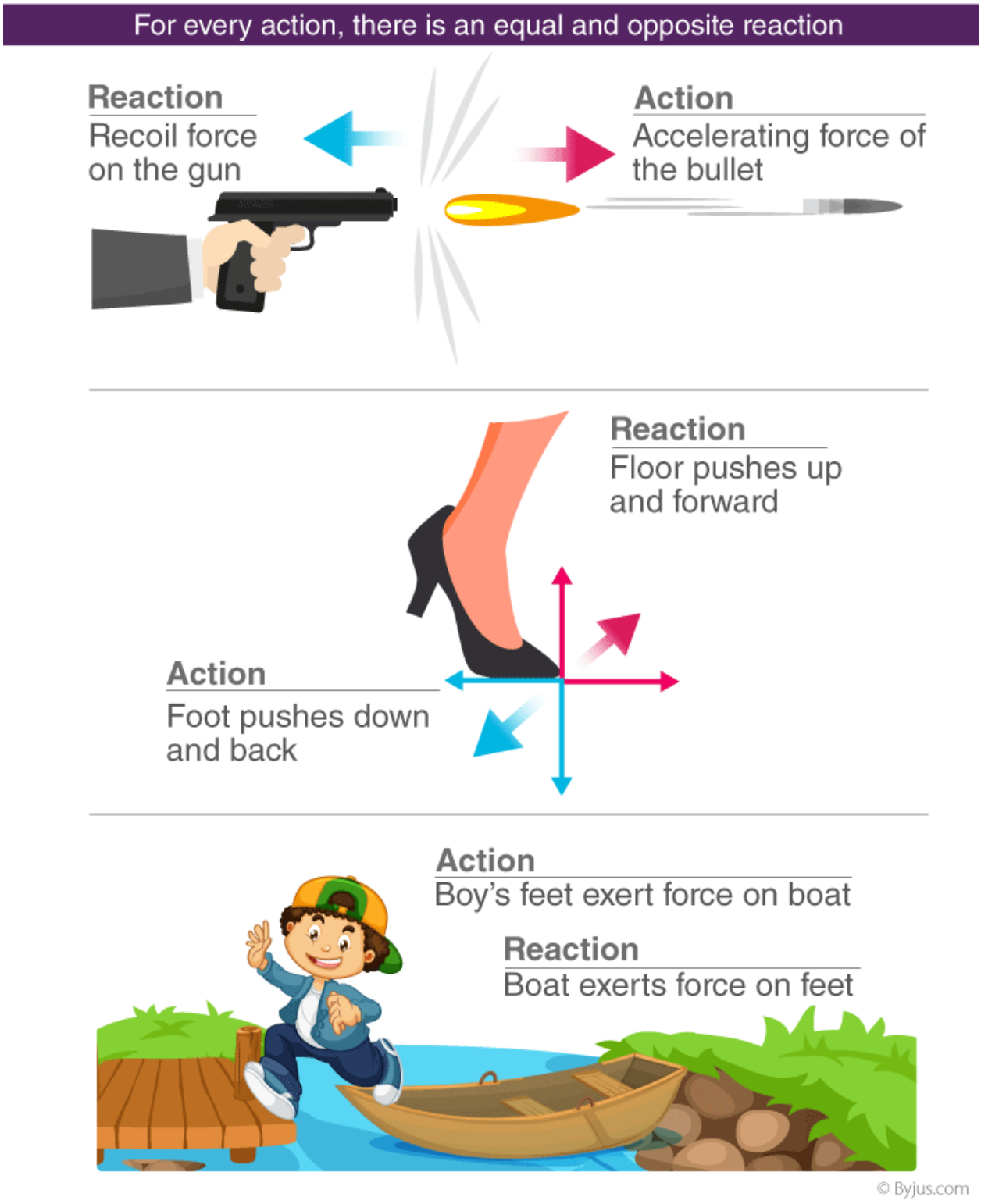
3. Newton's Third Law of Motion: To every action, there is an equal and opposite reaction.

Examples of third law –

• Recoil of a gun

• Motion of rocket

• While drawing water from the well, if the string breaks up the man drawing water falls back.



➤**Centripetal Force:**

• When a body is in a circular motion, a force always acts on the body towards the centre of the circular path, this force is called **centripetal force.**

• If a body of mass m is moving on a circular path of radius R with uniform speed v, then the required centripetal force

F = mv 2 /r

➤Centrifugal Force:

• Centrifugal force is such a pseudo force.

• It is equal and opposite to centripetal force.

➤Application of centripetal and Centrifugal forces:

• Roads are banked at turns to provide required centripetal force for taking a turn.

• The cream is separated from milk when it is rotated in a vessel about the same axis.

• The gravitational force of attraction between earth and sun acts as centripetal force.

• Orbital motion of electrons around the nucleus

• Cyclist inclined itself from vertical to obtain required centripetal force.

➤The principle of conservation of linear momentum:

• If no external force acts on a system of bodies, the total linear momentum of the system of bodies remains constant.

• As a consequence, the total momentum of bodies before and after collision remains the same.

• As in the case of the rocket, ejecting gas exerts a forward force which helps in accelerating the rocket in the forward direction.

➤Impulse:

• When a large force acts on a body for a very small time, then the force is called impulsive force.

• Impulse is defined as the product of force and time.

• Impulse = force x time = change in momentum.

• It is a vector quantity and its direction is the direction of the force. Its SI unit is newton second (Ns).

➤Friction:

It is the force which acts on a body when two bodies are in contact and one tries to move over others.

Types of Friction:

1. Static Friction: The opposing force which acts on acts on a body when it tries to move over the other but actual motion has yet not started.

2. Limiting friction: It is the force that comes to play when a body is on the verge of moving over the other body.

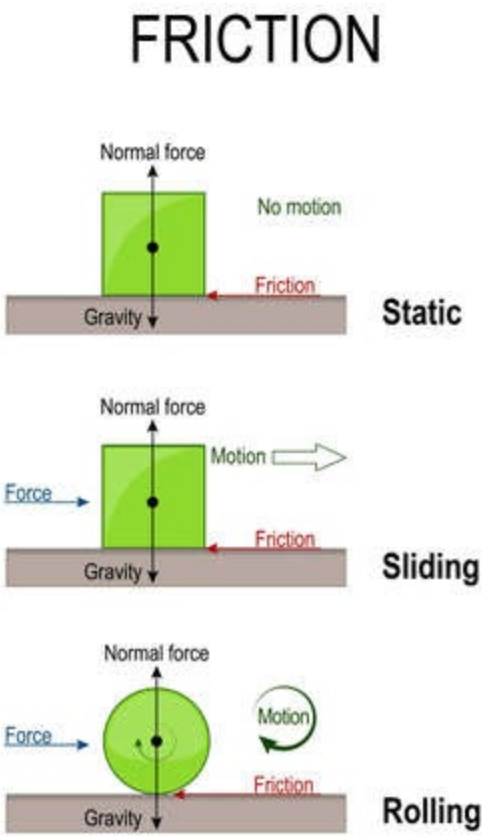
3. Kinetic Friction: This is the opposing force that comes to play when one body actually moves over the surface of another body is called kinetic friction. It is of two types which are as follows:

4. Sliding Friction: When a body slides over the surface of other

5. Rolling Friction: When a body rolls over the surface of another body

• It is easier to roll a body than to slide because the sliding friction is greater than the rolling friction.

• It is easy to drive a bicycle when its tyres are fully inflated because it decreases rolling friction.



➤Application of Friction:

• A ball bearing is used to reduce the rotational friction.

• Friction is necessary for walking and to apply breaks in vehicles.

• When a pedal is applied to a bicycle, the force of friction on the rear wheel is in the forward direction and on front-wheel it is in the backward direction.

• Friction can be reduced by applying the polishing or applying any lubricants.

• The tyre is made up of synthetic rubber because its coefficient of friction with the road is larger and stops sliding the bicycle.