1. Laws of Motion

- Motion of an object is the **change in its position with time**.
- **Types of motion**:
  - If the object moves in a line such that each point of the object covers equal distance in equal time, the object is said to posses **translatory motion**.
  - When an object moves along a straight line, it possesses **rectilinear motion**. For example- Motion of car moving on straight road.
  - An object moving in a curve path is said to posses **curvilinear motion**. For example - A car moving in a curvy path
  - When there is a change in speed of object moving in a straight line, it is called **non-uniform rectilinear motion** (for example a launching rocket) and when there is no change in the speed of the object, it is called **uniform linear rectilinear motion**(for example a moving convoy).
  - When the distance of the object from a fixed point remains constant, it possesses **circular motion**. For example- Motion of electric fan.
  - When an object repeats its motion after a fixed time, it possesses **periodic motion**. For example - Motion of a pendulum.
  - The motion which does not repeat itself after regular interval of time is called **non-periodic motion.** For example-An athele running on a field
  - When the movement of object swings about a mean position, it possesses **oscillatory motion**. For example - Motion of a swing.
  - Vibratory motion is a kind of oscillatory motion in which a part of body always remains fixed and the rest part moves to and fro about the fixed position. Also, in vibratory motion, the shape and size of the body changes. For example- Expansion and contraction of our chest.
  - When the motion of path does not follow any path and its speed and direction changes continuously, it possesses **random motion.** For example- the movement of fishes.
- The motion of a ball rolling on the ground is a combination of rectilinear as well as rotational motion.
- The fastness or slowness of the movement of an object is determined by measuring the distance traveled with time.

- An object is at rest when the position of the object does not change with time and with respect to its surroundings.
- An object is in motion when the position of the object changes with time and with respect to its surroundings.
- Rest and motion are relative.
- If the distance covered by an object is much greater than its size during its motion, then the object is considered as point mass object.
- Distance or path length — Total length of the path covered by a body (scalar quantity)
- Displacement — Shortest distance between initial and final positions measured along a particular direction

- Speed is the rate of change of position in ‘distance’. Distance can be measured by ‘odometer’.

$$\text{Speed} = \frac{\text{Total distance covered}}{\text{Total time}}$$

- Velocity is the rate of change of ‘displacement’. Velocity is a quantity that has both magnitude and direction.

$$\text{Velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

- Magnitude of velocity = Magnitude of average speed, only when there is no change in direction.

$$\text{Average velocity} = \frac{\text{final velocity} + \text{initial velocity}}{2} = \frac{v+u}{2}$$

- Uniform motion: A body is said to be in uniform motion if there is no change in **velocity**. That is, no change in speed or direction. Eg. A body moving in a straight line

- Non-uniform motion – Velocity (in terms of speed/ direction or both) changes with time

- Acceleration: A body is said to be ‘accelerating’ when its velocity changes with time.

- $$\text{Acceleration} = \frac{\text{Final velocity - Initial velocity}}{\text{Time}} = \frac{v-u}{t}$$

- Uniform acceleration: Uniform change in velocity with time is uniform acceleration.

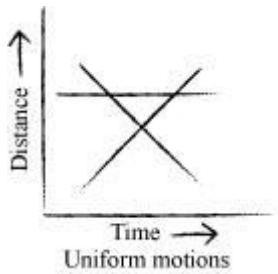
- Non-uniform acceleration: Non-uniform change in velocity with time.

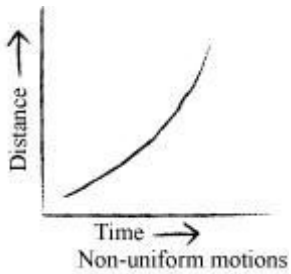
- The acceleration is positive when the velocity of the moving body increases with time .

- The acceleration is negative when the velocity of the moving body decreases with time .

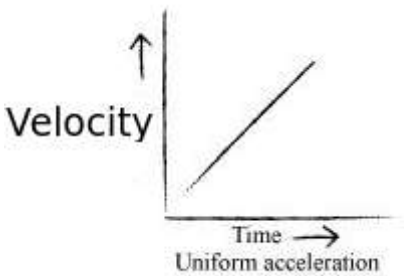
- The acceleration of a body is considered to be zero when the velocity of the moving body does not change.

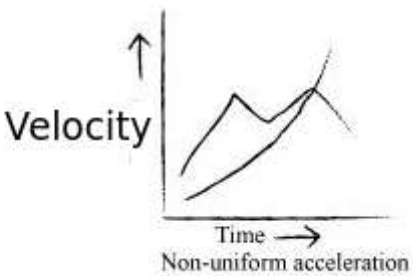
- **Distance-time graph**





- **Velocity-time graph**





- **Equation of motion**

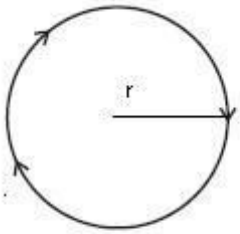
1st equation $v = u + at$

- 2nd equation

$$s = ut + \frac{1}{2}at^2$$

- 3rd equation $2as = v^2 - u^2$

- Circular motion: A body is said to be in circular motion when it rotates about a fix point.

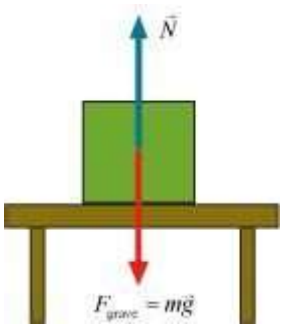


speed = v, radius = r,
time to complete 1 rotation = T

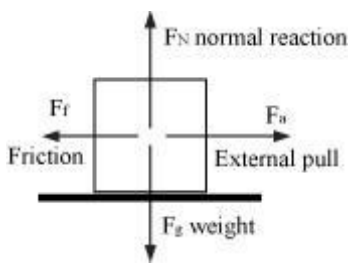
$v = 2\pi r/T$

- Uniform circular motion: If the speed of rotation is constant, then the circular motion is uniform.

- **Balanced force:** If the total force acting on a body cancels out such that there is no change in state of motion or of rest. The forces are said to be balanced.

	The normal reaction N balances the force due to gravity, hence no movement of the block on the table.

- **Unbalanced force:** A net force acts on the body. This is the reason of change in state of motion or of rest.

	The normal reaction N balances the weight, so there is no movement in vertical direction, but there will be movement along the horizontal (towards right) if the external pull F_a exceeds the friction F_f.

- **First law of motion**
  - A body at rest remains at rest and a body in uniform motion continues its uniform motion unless an external force is applied.

- **Inertia:**
  - It is the tendency of a body to resist any change in its state of rest or of uniform motion along a straight line.
  - Mass of an object is the measure of its inertia, more is the mass more is the inertia.

- Types of inertia: Inertia of rest and motion

- **Second law of motion**
  - The second law of motion says, when a force F is subjected to a body of mass m, an acceleration a is gained by the body in the direction of the force and the magnitude of acceleration is directly proportional to the F and inversely proportional to the m.
  - Rate of change of momentum $\propto$ Applied unbalanced force
  - Direction of change in momentum is the same as the direction of unbalanced force

    $F = ma$

    Unit of force is Newton

    $1\ \text{N} = 1\ \text{kg} \times 1\ \text{m} / \text{s}^2$

- **Third law of motion**
  - For every action force there is an equal and opposite reaction force.
  - The horse and the cart: From the third law of motion the pull by the horse in the forward direction is equal to the pull by the cart in the backward direction. The sum of these forces is therefore zero. Why should then the cart accelerate forward? Apart from the pulls of the horse and the cart there is frictional force and the reaction of the ground on the horse and the cart is also present. The resultant force of this normal reaction and the friction together helps the horse to move the cart in the forward direction.

- **Conservation of momentum**
  - Momentum of a system is always conserved when there is no net external force on the system.
  - Momentum before collision = Momentum after collision

    $m_A u_A + m_B u_B = m_A v_A + m_B v_B$