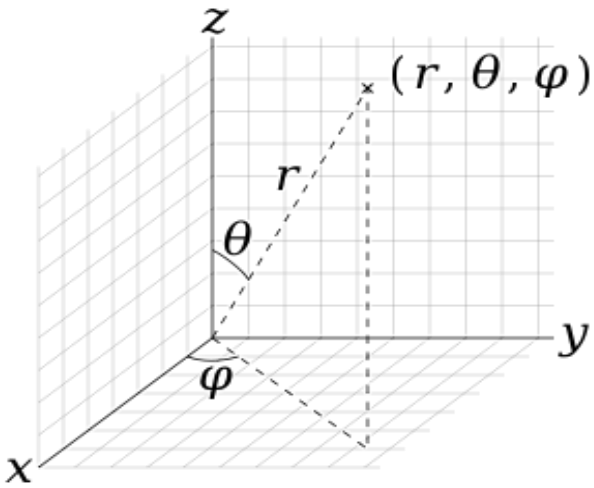
Chapter I



Kinematics of a particle

In this chapter, we will provide an overview of particle kinematics. Kinematics is a branch of physics that deals with the description and analysis of motion, primarily focusing on the positions, velocities, and accelerations of objects, **without consideration for the forces that cause these motions**. In simpler terms, kinematics is concerned with the "what" and "how" of motion, rather than the "why," which is addressed by dynamics. Five key aspects that define kinematics include:

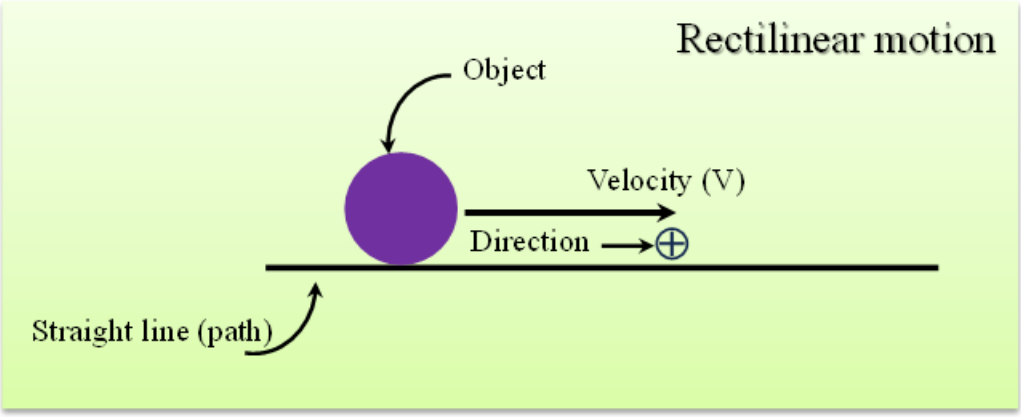
1. **Position:** Kinematics describes the object's spatial position at different points in time. It utilizes coordinate systems to specify the object's location relative to a reference point or axis.
2. **Velocity:** In kinematics, velocity represents the rate of change of an object's position with respect to time. It provides information about both the object's speed and its direction of motion.
3. **Acceleration:** Acceleration is the rate of change of an object's velocity with respect to time. It indicates how an object's speed or direction of motion is changing.
4. **Time**: Kinematics often involves the parameter of time, as it tracks how position, velocity, and acceleration change over time.
5. **Trajectories:** Kinematics can be used to describe the paths or trajectories that objects follow during their motion.

I.1. Type of motion

I.1.1. Rectilinear motion

Rectilinear motion refers to the type of motion in which an object moves along a straight line or path. In rectilinear motion, the object's position changes with respect to time, but its path remains a straight line, without deviation. Rectilinear motion is characterized by the following elements:

1. **Straight Path:** The object moves in a single, straight line, and its position changes exclusively along this line.
2. **Constant or Variable Speed:** The object may maintain a constant speed (uniform rectilinear motion) or alter its speed over time (non-uniform rectilinear motion).
3. **No Change in Direction:** In rectilinear motion, there is no alteration in the direction of motion; the object continues moving along the same straight line.
4. **One Dimension:** Rectilinear motion is typically described in one dimension, focusing only on the position along the chosen straight path, without considering motion in other directions.

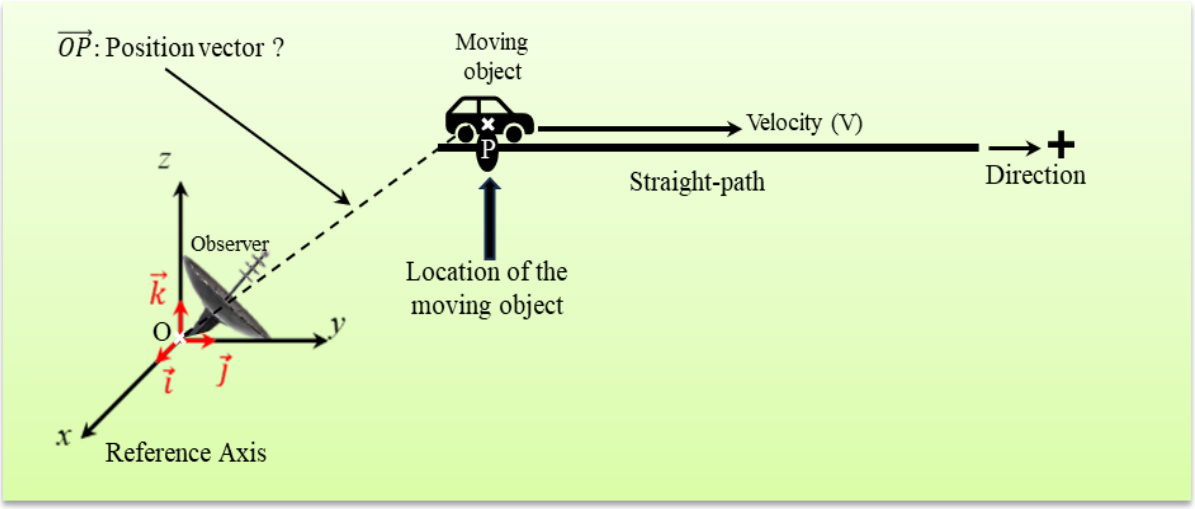


Remark: Another definition of the rectilinear motion can be stated as the motion that occurs along a **single-direction path**, specifically a straight-line motion

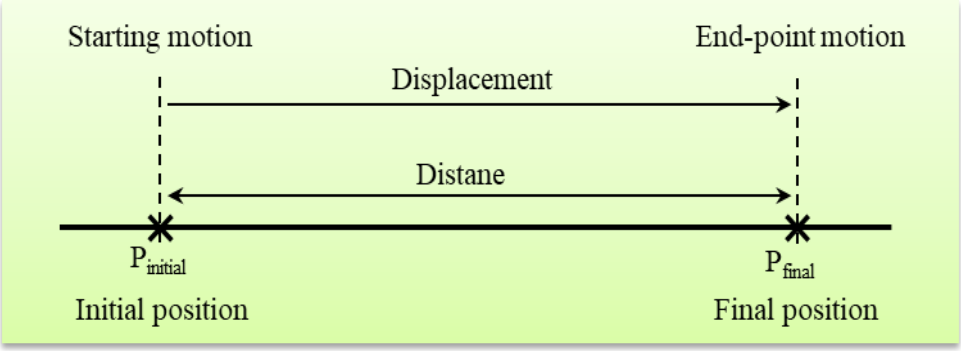
I.1.1.2. Quantities involved in rectilinear motion

In linear motion, or rectilinear motion, several important quantities can be discussed, including:

1. **Position:** Position refers to the location of an object relative to a reference point or axis. It is typically measured in units like meters, feet, or any other appropriate unit of length.



2. **Displacement:** Displacement is the change in an object's position from its initial to final location. It considers both the distance and direction of movement and is also measured in units of length.
3. **Distance:** Distance is the actual length of the path covered by an object during its motion. It is a scalar quantity and is measured in units like meters (m).
4. **Initial Position:** This is the starting point or location of the object at the beginning of its motion. It's often used to calculate displacement.
5. **Final Position:** The final position is the location of the object at the end of its motion. It's crucial for determining displacement.



6. **Velocity:** Velocity is the rate of change of an object's position concerning time. It indicates both the speed (magnitude of the velocity) and the direction of motion. Velocity is typically measured in units like meters per second (m/s).
   6.a. Average velocity: It is determined by the displacement $(X_2 - X_1)$ divide by the total time interval $(t_2 - t_1)$ it takes cover; in other words :

$$\bar{V} = \frac{X_2 - X_1}{t_2 - t_2}$$

   6.b. Instantaneous velocity: It is the limit of the average velocity $(\bar{V})$ as the time interval $(t_2 - t_1)$ approaches zero. It provides the velocity of an object at a specific instant.

$$V = \lim_{(t_2 - t_1) \to 0} \left(\frac{X_2 - X_1}{t_2 - t_1} \right) = \lim_{\Delta t \to 0} \frac{\Delta X}{\Delta t} = \frac{dX}{dt}$$

   Thus, this is the time derivative of displacement $(\frac{dX}{dt})$
7. **Speed:** Speed (v) is a scalar quantity that represents how fast an object is moving, regardless of its direction. It is the magnitude of velocity and is measured in meters per second (m/s).
8. **Acceleration:** Acceleration is the rate of change of an object's velocity concerning time. It can indicate how an object's speed or direction of motion is changing. Unit of acceleration is typically meters per second squared (m/s^2).

$$a = \frac{dV}{dt} = \frac{d^2X}{d^2t}$$

9. **Time:** Time is a fundamental parameter in the study of linear motion. It's used to track changes in position, velocity, and acceleration over time and is typically measured in seconds (s).
10. **Time Interval:** The time interval is the duration over which the motion occurs. It's the difference between the final time and the initial time $(t_2 - t_1)$ and is measured in seconds.

Understanding and calculating these quantities is fundamental to analyzing and describing linear motion in physics. They provide the basis for formulating equations and solving problems related to objects in motion.

I.1.1.3. Type of rectilinear motion

1. **Uniform Rectilinear Motion:** In uniform rectilinear motion, velocity remains constant ($v = cste$). There is no acceleration ($a = 0$), and no net external force acts on the object ($\sum F = 0$).
2. **Uniformaly accelerated rectilinear motion:** In this linear motion, velocity is changing but the acceleration is constant also known as Kinematic Equations. The motion of the body can be given by the three equations of motion.

$$v = a.t + v_0$$

$$x = \frac{1}{2}at^2 + v_0 t + x_0$$

$$v_2^2 - v_1^2 = 2a(x_2 - x_1)$$

I.1.2. Coordinate Systems and Components of a Vector

I.1.2.1. What is a Vector?

Vector quantities possess both magnitude and direction; direction is understood to include both the angle that the line of action makes with a given reference line and the sense of the vector along the line of action.