Al-Mustaqbal University
Department (Biomedical Engineering)
Class (First Stage)
Subject (Physics)
Lecturer (Asst.lec.Hiba Diaa Alrubaie)
1st/term – Lect. (Motion of one and two dimensions)

Motion in One and Two Dimensions in Physics

In physics, **motion** is analyzed by describing how objects move through space and time. Motion in one and two dimensions is governed by the principles of **kinematics**, focusing on position, velocity, and acceleration. Let's delve deeper into these concepts.

Motion in One Dimension (1D)

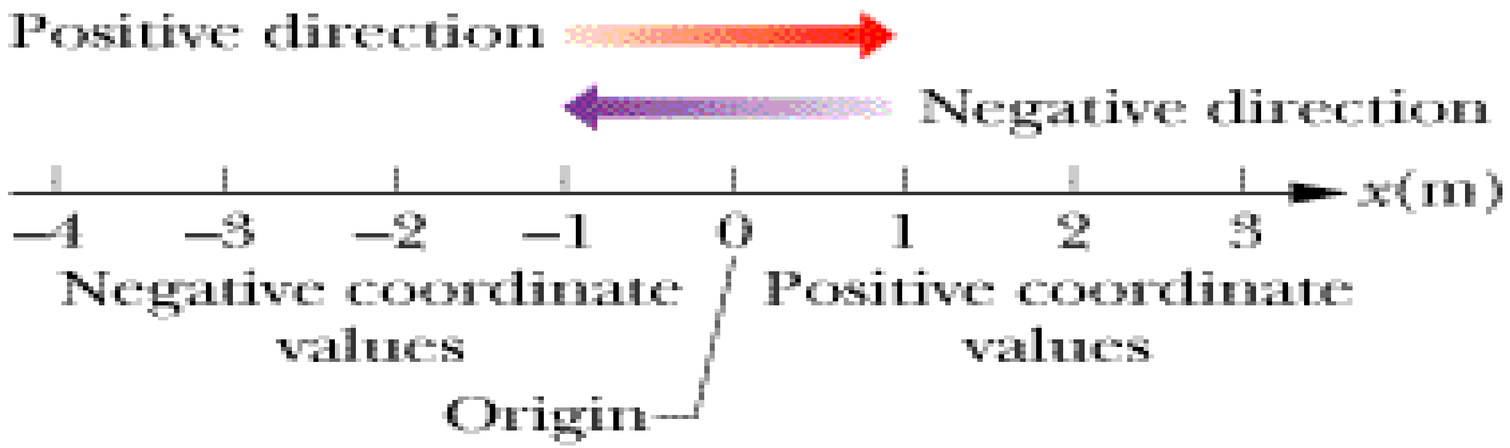
Motion occurs along a straight line.

Position (x):

•Describes the location of an object relative to a reference point.

•Can be positive, negative, or zero depending on the chosen coordinate system. And it is a vector quantity.

•measured in meters (m).

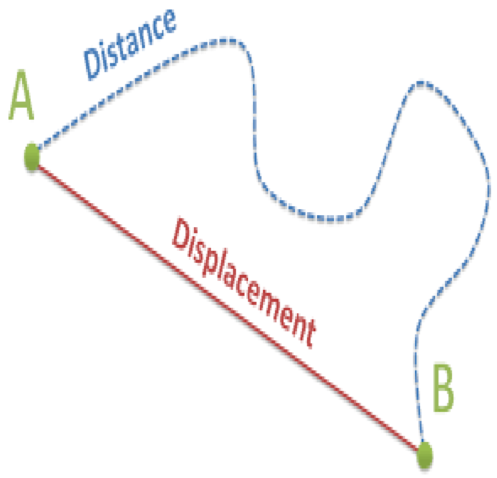


Displacement (Δx):

•The change in the object's position.

$\Delta x = x\ final\ - x\ initial$

•**vector quantity** (includes direction). Displacement can be positive, negativeandevenzero



Distance:

- The total path length traveled, regardless of direction.
- A **scalar quantity** (only magnitude). Distance can only have positive values

Speed and velocity

Speed : is defined as. The rate of change of position of an object in any direction. Speed is measured as the ratio of distance to the time in which the distance was covered. and its SI unit is m/s. The speed of the object will never be negative; it will either be positive or zero. Mathematically, we define speed as:

Speed$= \frac{d}{t}$

where (d) is the total distance traveled and (t) is the elapsed time.

Velocity (v):

Velocity in One Dimension: In one-dimensional motion, velocity is typically along a straight line, so only magnitude and direction (positive or negative) are considered. velocity is a **vector quantity**, meaning it has both magnitude and direction.

- The total displacement divided by the total time taken.

$$v_{avg} = \frac{\Delta x}{\Delta t}$$

Where:

- $\Delta x = x_{final} - x_{initial}$: Displacement.
- $\Delta t = t_{final} - t_{initial}$: Time interval.

Example: If a car travels 100 m east in 10 seconds, the average velocity is:

$$v_{avg} = \frac{100\ \text{m}}{10\ \text{s}} = 10\ \text{m/s (east)}.$$

Acceleration (a):

•Describes how velocity changes over time.

Average Acceleration:

$$a_{\text{avg}} = \frac{\Delta v}{\Delta t}$$

Equations of Motion for Uniform (Constant) Acceleration:

When acceleration is constant, the following equations apply:

1. $v = u + at$
2. $x = ut + \frac{1}{2}at^2$
3. $v^2 = u^2 + 2a\Delta x$
4. $x = vt - \frac{1}{2}at^2$

Where:

•u: Initial velocity

•v: Final velocity

•x: Displacement

•a: Acceleration

•t: Time

Motion in Two Dimensions (2D)

Position Vector ($\vec{r}$):

- Describes the object's location in the plane.

$$\vec{r} = x\hat{i} + y\hat{j}$$

Where:

- x, y: Positions along the horizontal and vertical axes.
- $\hat{i}, \hat{j}$: Unit vectors in the x and y directions.

Displacement Vector ($\Delta\vec{r}$):

- The change in position:

$$\Delta\vec{r} = (x_{\text{final}} - x_{\text{initial}})\hat{i} + (y_{\text{final}} - y_{\text{initial}})\hat{j}$$

Velocity Vector ($\vec{v}$):

- Velocity has components in the x and y directions:

$$\vec{v} = v_x\hat{i} + v_y\hat{j}$$

Where:

- $v_x = \frac{dx}{dt}$: Horizontal velocity.
- $v_y = \frac{dy}{dt}$: Vertical velocity.

Acceleration Vector ($\vec{a}$):

- Components of acceleration:

$$\vec{a} = a_x\hat{i} + a_y\hat{j}$$

Where:

- $a_x = \frac{d^2x}{dt^2}$: Horizontal acceleration.
- $a_y = \frac{d^2y}{dt^2}$: Vertical acceleration.

- Example: An airplane has a lift-off speed of 30 m/s after a take-off run of 300m, what minimum constant acceleration? What is the corresponding take-off time?

Solution: $v^2 = u^2 + 2as$

v = final velocity (lift-off speed) = 30 m/s

u = initial velocity = 0 (since the airplane starts from rest)

a = acceleration (which we want to find) , s = distance traveled = 300 m

$$30^2 = 0^2 + 2a(300) \rightarrow a = \frac{900}{600}$$

$$\therefore a = 1.5 \frac{m}{s^2}$$

Now, to find the corresponding take-off time, we can use the following kinematic equation: $v = u + at \rightarrow 30 = 0 + 1.5t$

$$\therefore t = \frac{30}{1.5} \rightarrow t = 20second$$

- Example

  A ball is dropped from rest from a height of 20 m. How long does it take to hit the ground? Ignore air resistance.

- **Solution:**

Initial velocity (u) = 0 m/s

Acceleration (a) = 9.8 m/s2

Displacement (x) = 20 m

Using the equation:

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

$$20 = 0 \cdot t + \frac{1}{2} \cdot 9.8 \cdot t^2$$

$$20 = 4.9t^2$$

$$t^2 = \frac{20}{4.9} \approx 4.08$$

$$t \approx 2.02\,\mathrm{s}$$

The ball takes approximately $2.02\,\mathrm{s}$ to hit the ground.