UNIT 2

MOTION

Unit outcomes: **After completing this unit you should be able to:**

- ✓ **understand concepts related to motion.**
- ✓ **develop skill of manipulating numerical problems related to motion.**
- ✓ **appreciate the interrelatedness of all things.**
- ✓ **use a wide range of possibility for developing knowledge of the major concepts with in physics.**

Introduction

Galileo Galilee(1564-1642.)

In this unit, you will be introduced to the basic concepts and relationships in motion.

Motion is one of the key topics in physics. Everything in the universe moves. We use some basic concepts when we express motion. These concepts are **distance**, **displacement**, **speed**, **velocity** and **acceleration**. Based on the path of a motion, there are different types of motions. Motion in a straight line is one of the forms of motion. It is the simplest form of motion in a specific direction.

Challenging Questions

What are the contributions of Galileo Galilee to science and physics?

2.1 Definition of Motion

Activity 2.1

Discuss the following questions with your friends

i. What is motion?
ii. When would you say an object is at rest?
iii. Assume you are in a car and the car is moving at a certain speed. Are you at rest or in motion?
iv. What do you understand by the term" reference frame"?

Consider your daily travel from your home to your school. When you go to the school, your journey begins from your home. Your home is your original position. After sometimes you will reach your school. Your school is your final position. In this process, you are continuously changing your position. You are increasing the gap between your present position and your home. This continuous change of position is known as **a motion**. Notice that your change of position is, observed by considering the distance from your school to home. Your home is taken as a **reference frame**.

Motion is a continuous change in position of an object relative to the position of a fixed object called reference frame.

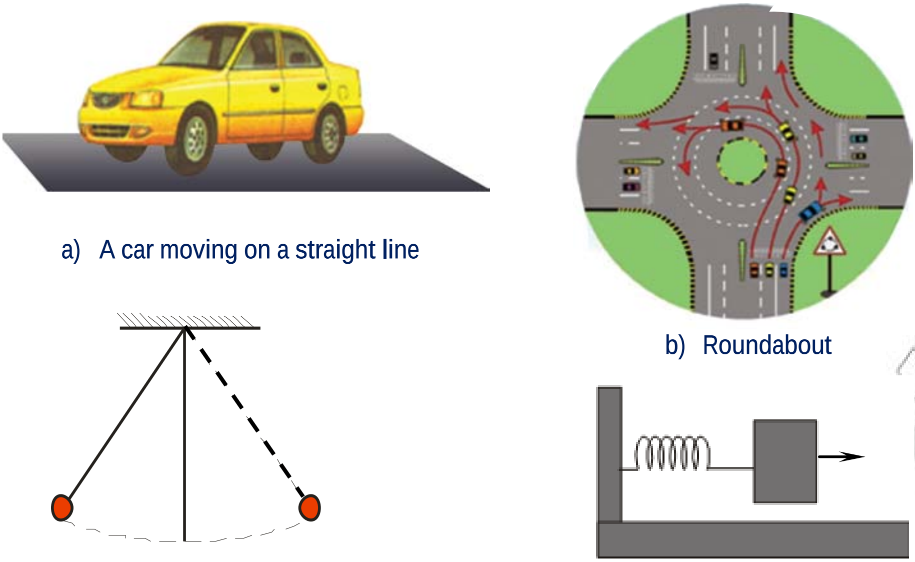
The concepts of rest and motion are completely relative; a body at rest in one reference frame may be in motion in another reference frame.

A body is said to be at **rest** in a frame of reference when its position in that reference frame does not change with time. If the position of a body changes with time in a frame of reference the body is said to be in **motion** in that frame of reference

Types of Motion

Activity 2.2

i. Observe the motions indicated in Fig 2.1.
ii. Have you noticed any difference between the motions in Fig 2.1 (a-d)? Describe them.
iii. Group these motions, based on their path.



a) A car moving on a straight line

b) Roundabout

c) Simple Pendulum

d) Spring-mass system

Fig. 2.1 Types of motion

In Fig 2.1 (a) you observe that a car is moving on a straight road. Its path is a straight line.

Fig 2.1 (b) shows that the path of the moving car is a curved line.
While Fig 2.1 (c and d) show the 'to and fro' motions of an object.
Based on the path followed, a motion is classified into four types. The followings are types of motion of a body.

1. **Rectilinear motion** is the motion of a body along a straight line.

   Examples

   - Motion of a car along a straight level road,
   - A falling ball from a certain height.

2. **Curvilinear Motion** is the motion of a body along a curved path.

   Examples

   - Motion of a car around a circular path,
   - The motion of a ball thrown horizontally from a certain height,
   - The motion of the moon around the earth.

Note: Circular motion is a special case of curvilinear motion, in which the body moves along a circular path.

3. **Rotary motion** is the motion of a body about an axis.

Examples

- The motion of the second or minute hand of a wrist watch,
- The motion of a wheel of a car.

4. **Vibratory motion** is a '**to** and **fro**' or **back** and **forth** or **up** and **down** motion of a body. This motion does not have constant velocity.

Examples

- The motion of a pendulum,
- The motion of objects suspended on a spring,
- Water wave, etc.

Note: Both rotary and vibrational motions are periodic motions. Periodic motions can have constant or non-constant velocities and they repeat themselves.

Activity 2.3

Write down some examples of motion for each type from your daily experiences. Discuss them with your classmates, how they are different.

Types of motion	Practical Examples
1. Rectilinear	• ______________________.
2. Curvilinear	• ______________________.
3. Circular motion	• ______________________.
4. Vibrational motion	• ______________________.
5. Rotary motion	• ______________________.

Check point 2.1

1. State at least four types of motion, and give practical examples for each type.
2. Define what a motion is.

2.2 Motion Along a Straight Line

Motion along straight line path is known as a rectilinear motion.

Activity 2.4

- Discuss about the common features of motion along a straight line.

Fig.2.2 In competition different athletes cover the same distance in different time

In a rectilinear motion, a body moves over a certain **distance** along a straight line and takes a certain **time.**

Athletes run different distances. They run 5,000 m, 10,000 m and so on. To cover these distances they take different times. Which distance is covered in the shortest possible time? What do you call the distance covered in a unit of time?

Activity 2.5

- What do you understand by the terms ' Scalars' and ' Vectors' in relation to motion?(Revision)

Distance: As a car moves along a straight road we can easily observe the change of its position. What is the distance traveled by the car between the initial and the final position?

Distance is a physical quantity which describes the length between two points (places). It is the total path length traveled by a body.
It depends on the path followed.

To describe a distance it is not important to mention its direction. A distance is a scalar quantity.

Observe Fig.2.3, Two persons moved from point A to point B, in different paths: path 1 and 2. What would you say about the distance covered by the two persons?

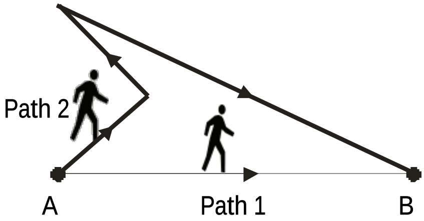


Fig.2.3. Variation of distance with the path followed

Do you remember the units of length from the previous unit? What is the SI unit of length? Do you think the units of length and distance are the same?

The symbol for distance is "s". The SI unit of distance is meter (m). Mostly, the distance covered by a moving car or airplane or train is measured by kilometer (km).

Fig.2.4 Football field

Challenging Questions

What is the distance around a standard football field?

Displacement ($\vec{s}$)

Azeb walked 300 m from A to B and returned back and walked 200 m and then stopped at C. What is her change in position from A to C?

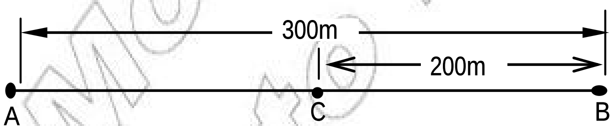


Fig.2.5 Finding change of position

When an object moves, it changes its position. This change of position in a certain direction is known as a **displacement**. A displacement is described by its magnitude and direction. It is a vector quantity.

As shown in Fig. 2.6. a body may move from A to B in different paths such as path 1, path 2 and path 3. The distance of the three paths is different. However, the displacement made is the same.

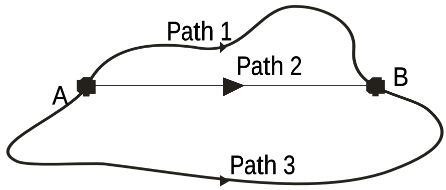


Fig.2.6 Displacement is independent of the path

Activity 2.6 *Discuss with your friends*

Which path is the shortest? Which one of the paths has a fixed direction throughout its motion?(Fig 2.6)

As you know all the lengths of the paths are '**distances**'. Path 2 is a straight line and it is the shortest distance between the initial and final positions of the body. Hence, it is the displacement of the body.

This straight path having a fixed direction is said to be a displacement. Hence a displacement is the shortest distance in a specified direction.

The SI unit of displacement is the same as the SI unit of distance that is meter (m). The symbol of displacement is $\vec{s}$, with an arrow on the head of s. Displacement is independent of the path followed.

In Fig 2.7, you observe that displacement is the difference between the final position $\mathbf{x_f}$ and the initial position $\mathbf{x_i}$.

a) A displacement to the right of the origin, 'O' will be a positive displacement. That is,

$$s > 0 \text{ since } x_i < x_f .$$

For example, starting with $x_i = 60$ m and ending at $x_f = 150$m, the displacement is

$$\vec{S} = x_f - x_i = 150 \text{ m} - 60 \text{ m} = 90 \text{ m, to the right.}$$

b) A displacement to the left of the origin, 0 will be a negative displacement. That is,

$$\vec{s} < 0 \text{ since } x_i > x_f .$$

For example, starting with $x_i = 150$ m and ending at $x_f = 60$m, the displacement is

$$\vec{s} = x_f - x_i = 60 \text{ m} - 150 \text{ m} = -90 \text{ m (to the left direction)}$$

c) Positions to the right of the origin are positive.
Positions to the left of the origin are negative.

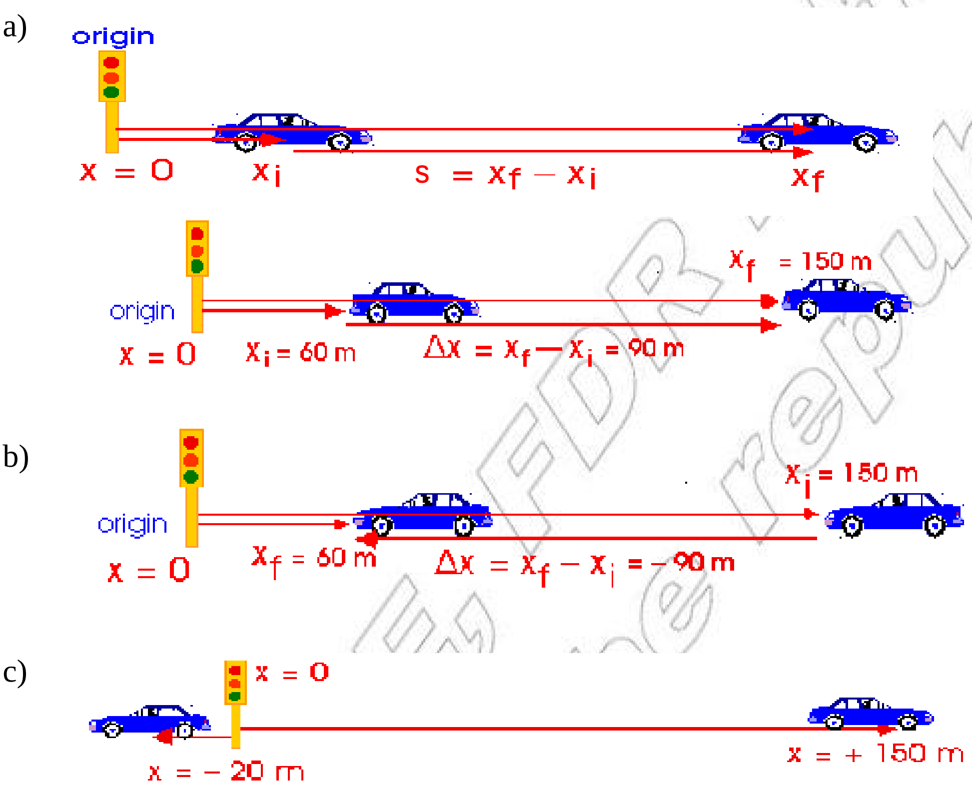


Fig.2.7 Displacement of a car at different time along x -axis

Comparison of distance and displacement

Activity 2.7

- List down the similarities and differencec between a distance and displacement for rectilinear motion.

	Similarities	Differences
Distance and Displacement		

Speed (v)

Activity 2.8

Tirunsh Dibaba ran Bejing Olympic and covered 10,000 m distance in 28 minutes. Sileshi ran the same distance and it took him 24 minutes. What were thier average speeds? Who is the fastest?

Both athletes covered the same distance in different time. From the given informaton you can compute the distance they covered in one second. i.e. Tirunesh covered an average distance of 5.95 m in one second. While Sileshi covered 6.94 m in one second. Thus, the distance covered per unit time is called speed.

Speed is a quantity that describes how fast a body moves. Its symbol is ''v''
The SI unit of speed is meter per second (m/s).

In reality, a moving body does not have a uniform speed throughout its motion. Sometimes the body will speed up, sometimes it will go at a constant speed and at other times it may slowdown. For this reason the speed you calculate is an average speed.

An average speed is the total distance traveled divided by the total time taken.

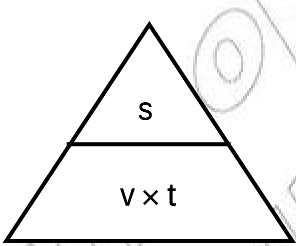
$$\text{Average speed} = \frac{\text{total distance traveled}}{\text{total time taken}} \Rightarrow v_{av} = \frac{s}{t}$$

The SI unit of average speed is m/s.

Rearranging the formula gives

$$s = vt \quad \text{and} \quad t = \frac{s}{v}$$

Using the triangular symbol you can perform the above rearrangement of the formula



The unit of speed m/s can also be written as m s^{-1}.
Using the exponential expression, we write:

$$\frac{m}{s} = m \cdot \frac{1}{s^{+1}} = m \cdot s^{-1}$$

Activity 2.9

i. State some units of speed other than m/s.
ii. Express 1 km/hr in m/s.
iii. What is the conversion factor between m/s and km/hr?

Example 2.1

1. Tirunesh Dibaba covers a distance of 5000m in 14.5 minutes. Calculate the average speed of Tirunesh in m/s.

Given	Required	Solution
s = 5000 m t = 14.5 min = 870s	v_{av} = ?	$v_{av} = \frac{S_{tot}}{t_{tot}} = \frac{5000m}{870s} = 5.75m/s$

2. A bus is moving in a straight line at a speed of 25m/s. What time does the bus take to cover 5km?

Given	Required	Solution
$v = 25m/s$ $s = 5km = 5000m$	$t = ?$	$v = s/t \Rightarrow t = s/v$ $= \frac{5000\cancel{m}}{25\cancel{m}/s}$ $= 200sec$

3. Convert 20 m/s to km/hr.

Solution

$1\ m/s = 3.6\ km/hr$

$20\ m/s = x \quad \Rightarrow x = \frac{20\ \cancel{m/s} \times 3.6\ km/hr}{1\ \cancel{m/s}} = 72\ km/hr$

4. Convert 60 km/hr to m/s.

Solution

$km/h = \frac{1}{3.6}\ m/s$

$60\ km/hr = x$

$$x = \frac{60\ \cancel{km/hr} \times \frac{1}{3.6}\ m/s}{1\ \cancel{km/hr}} = 16.67\ m/s$$

Exercises

Suppose four students. Almaz, Abebe, Sofia and Gemechu are running a 100m race. Alamz takes 12s, Gemuchu takes 13s, Sofia takes 14s and Abebe takes 15s to finish the race.

Calculate their speeds and record them on the chart given below. From the chart find:

a) Who is the fastest runner?
b) Who is the slowest runner?
c) What can you conclude about the relationship between speed and time?

	Distance (m)	Time (s)	Speed (ms^{-1})
Almaz			
Abebe			
Sofia			
Gemechu			

Do you notice from the above chart that the speed increases as the time decreases to cover the same distance?

Velocity

Velocity is a physical quantity that describes how fast a body moves as well as the direction in which it moves. Hence, velocity is a vector quantity. Its symbol is $\vec{v}$ (v with an arrow on the head)

Velocity is the rate of change of displacement $\vec{s}$ i.e. it is the displacement covered by the body per unit time.

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

$$\vec{v} = \frac{\vec{s}}{t}$$

The SI unit of $\vec{v}$ is $\frac{m}{s}$

Average velocity $(\vec{v}_{av})$ is the total displacement divided by the total time taken.

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time taken}}$$

$$\overrightarrow{v_{av}} = \frac{\vec{s}_T}{t_T}$$

Example 2.2

1. A car moves at a speed of 20m/s for 120 seconds due East. What is the displacement of the car?

Given	Required	Solution
$\vec{V}$ = 20m/s due East t = 120s	$\vec{S}$ = ?	$\vec{v} = \frac{\bar{s}}{t} \Rightarrow \vec{s} = vt$ $\vec{s}$ = 20m/s, East × 120 s = 2400 m due East = 2.4 km, due East

2. A bus is moving due north for 2 hr and covered a distance of 72 km. What is the velocity of the bus?

Given	Required	Solution
$\vec{s}$ = 72 km, due North t = 2 hrs	$\vec{v}$ = ?	$\vec{v} = \frac{\vec{s}}{t} = \frac{72\text{km}}{2\text{hr}}$ due North = 36 km/hr due North

Activity 2.10

- List down the similarities and differences between speed and velocity for a rectilinear motion.

	Similarities	Differences
Speed and Velocity		

Check point 2.2

1. What do you call a speed that has direction?
2. What are the main features of a velocity in a uniform motion?
3. A car moves at a speed of 20m/s east ward. What is the car's velocity in magnitude and direction?
4. A bus travels 43 km in the first hour, 40km in the second hour and 46 km in the third hour of its journey. Calculate its average speed.
5. The speed of an airplane is 360 km/hr, and another air plane has a speed of 120 m/s. which one of these two air planes has a greater speed?

2.3 Qualitative Exploration of Uniform Motion and Uniformly Accelerated Motion

2.3.1 Uniform Motion

Activity 2.11

The motions of two bodies are measured and recorded in tables ‘A’ and 'B'.

A)

s(m)	6	12	18	24	30	36	42	48
t(s)	1	2	3	4	5	6	7	8
v(m/s)								

B)

s(m)	4	9	15	22	30	39	49	60
t(s)	1	2	3	4	5	6	7	8
v(m/s)								

i. Calculate the speed of the two bodies and complete the tables.
ii. What is the difference between the speeds in A and B?
iii. What do you call the type of speed in A and in B

From table A you observe that when a body makes equal changes of displacement within equal interval of time, its velocity is said to be a **uniform velocity.** i.e. its speed is constant and the direction is fixed. A motion with a uniform velocity is called a **uniform motion**. For uniform motion $\vec{v} = \frac{\vec{s}}{t}$ and $\vec{s} = \vec{v} \times t$

Uniform motion is the motion of an object along a straight line with a constant velocity or speed in a given direction.

Activity 2.12

Suppose an object is moving at a constant speed of 2m/s in straight line. At the end of the first second, it travelled 2m away from its starting point. At the end of 2 second the distance travelled is 4m. Complete the table by filling the distance travelled in 3, 4 and 5 seconds.

t(s)	1	2	3	4	5
s(m)	2	4	---	----	---

Note that for a uniform motion, as the time increases the displacement also increases. If you plot a graph of s against t using data from the above table you will get the graph shown in Fig 2.8

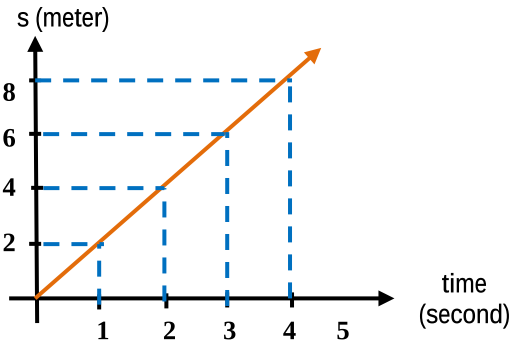


Fig.2.8 Graph of s against t for motion with constant velocity

From the graph in Fig.2.8, you can find the slope of the graph.

The slope of the graph $= \dfrac{\text{change in displacement}}{\text{change in time}}$,

$$\frac{\Delta\vec{s}}{\Delta t} = \frac{\vec{s}_f - \vec{s}_i}{t_f - t_i} = \frac{\vec{s}}{t}$$

But by definition: $\vec{v}_{av} = \dfrac{\vec{s}}{t}$

Hence, the slope of s against t graph of uniform motion equals average velocity.

2.3.2 Uniformly Accelerated Motion

In section 2.3.1 you learnt about uniform motion. That is, where the speed is constant and the direction is fixed in a straight line. In this section you will study another kind of motion; in which the velocity changes uniformly.

Activity 2.13

i. Explain what it means by the change of velocity.
ii. Describe the factors which could be affected when the velocity changes.
iii. What is acceleration? How is it different from velocity?

Acceleration

Whenever the velocity of an object changes in magnitude, or direction or both simultaneously, it is said to be accelerated.

Acceleration is a measure of how much the velocity of an object changes in a unit of time (usually in one second).

Acceleration is the time rate of change of velocity.

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_t}{t}$$

The symbol for acceleration is $\vec{a}$. It is a vector quantity

$\vec{v}_i$ is the initial velocity

$\vec{v}_f$ is the final velocity

t is the time taken

The SI unit of acceleration is meter/second/second = m/s^2

If a body starts from rest, then the initial velocity is zero ($\vec{v}_i = 0$). If the velocity of a body decreases then the final velocity is less than the initial velocity. Such motion is called decelerating. **Deceleration** is called a negative acceleration. (that is $\vec{v}_f < \vec{\mathbf{v}}_i$).

If the body comes to rest then, the final velocity is zero ($\vec{v}_f = 0$).

Uniformly accelerated motion is motion of an object along a straight line with a constant increase in its velocity.

Examples 2.3

1. The speed of a car increases uniformly from 8m/s to 48 m/s in 10s . Calculate the acceleration of the car.

Given	Required	Solution
$\vec{v}_i = 8m/s$ $\vec{v}_f = 48m/s$ $t = 10s$	$\vec{a} = ?$	$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$ $= \frac{(48-8)\,m/s}{10\,s}$ $= \frac{40\,m/s}{10\,s}$ $\vec{a} = 4\ m/s^2$

2. A car started from rest and accelerated uniformly and reached a speed of 20m/s after 5 s. What is the acceleration of the car?

Given	Required	Solution
$\vec{v}_i = 0\text{m/s}$ $\vec{v}_f = 20\text{m/s}$ $t = 5\text{ sec}$	$\vec{a} = ?$	$\vec{a} = \dfrac{\vec{v}_f - \vec{v}_i}{t}$ $= \dfrac{(20-0)\text{ m/s}}{5\text{ s}}$ $= \dfrac{20\text{ m/s}}{5\text{ s}}$ $\vec{a} = 4\text{ m/s}^2$

3. A bus initially at rest accelerated uniformly with an acceleration of 4 m/s^2. What is the speed of the bus at the end of 5?

Given	Required	Solution
$\vec{v}_i = 0$ $\vec{a} = 4\text{ m/s}^2$ $t = 5\text{ sec}$	$\vec{v}_f = ?$	$\vec{a} = \dfrac{\vec{v}_f - \vec{v}_i}{t}$ $\vec{v}_f - \vec{v}_i = \vec{a} \times t$ $\vec{v}_f = \vec{a} \times t + \vec{v}_i$ $\vec{v}_f = 4\text{m/s}^2 \times 5\text{s} + 0$ $= 20\text{m/s}$

Falling bodies

Activity 2.13

Discuss what happens to the motion of a stone.

i. When you throw a stone vertically upward in air.

ii. When you drop a stone from some height above the ground.

Gravity is the pulling force of the earth on a body. The first person who studied about motion of a falling body was **Galileo Galilee**. He showed that all bodies dropped from the same height fall to the earth with the same acceleration, which is known as the **gravitational acceleration** ($\vec{g}$). All objects falling freely in air accelerates uniformly by 9.8 m/s every second.

Motion of a freely falling body is the natural example of a uniformly accelerated rectilinear motion.

Free fall is the motion of a body under the action of the force of gravity.

2.3.3 Representation of Uniform Motion and Accelerated Motion Qualitatively Using Table

Walk one pace every 2 seconds. This is represented using dot plot.

s against t Table	
t	s
2s	2 dot
4s	4 dot
6s	6 dot

Dot plot for a constant velocity (Fig 2.8)

•   •   •   •   • .

2s   2s   2s   2s

$$\text{Velocity} = \frac{1\,\text{dots}}{2\text{s}} = ½\ \text{dot/s}$$

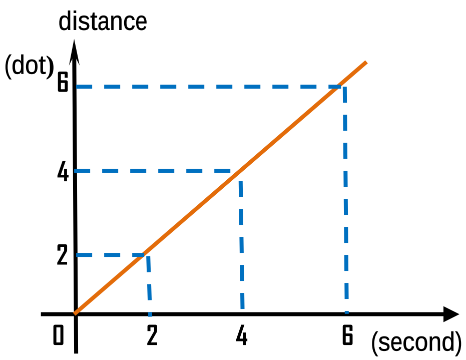


Fig. 2.9 Average velocity = slope of the s against t graph

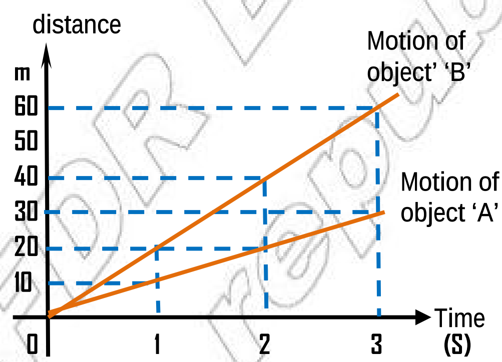


Fig. 2.10 Graphs of two bodies A and B travelling at different speeds.

From Fig 2.10 we calculate that:

$$\vec{v}_{av}(A) = \frac{10}{1}\text{dot/s} = \frac{20}{2s}\text{dot/s} = \frac{30}{3}\text{dot/s} = 10\ \text{dots/s}$$

$$\vec{v}_{av}(B) = \frac{20}{1}\text{dot/s} = \frac{40}{2}\text{dot/s} = \frac{60}{3}\text{dot/s} = 20\ \text{dots/s}$$

The slope with 20 dots/s has higher velocity than slope with 10 dot/s.

This means a steep slope has higher velocity than a gradual slope.

Note that when you draw graphs of motions, you must

1. *Label the axes*
2. *Put units clearly on both axes*
3. *Label each slope*
4. *Put their names on the graph*

Calculate the slope of the graph from initial and final as well as for several intervals. (see Fig 2.9 and 2.10)

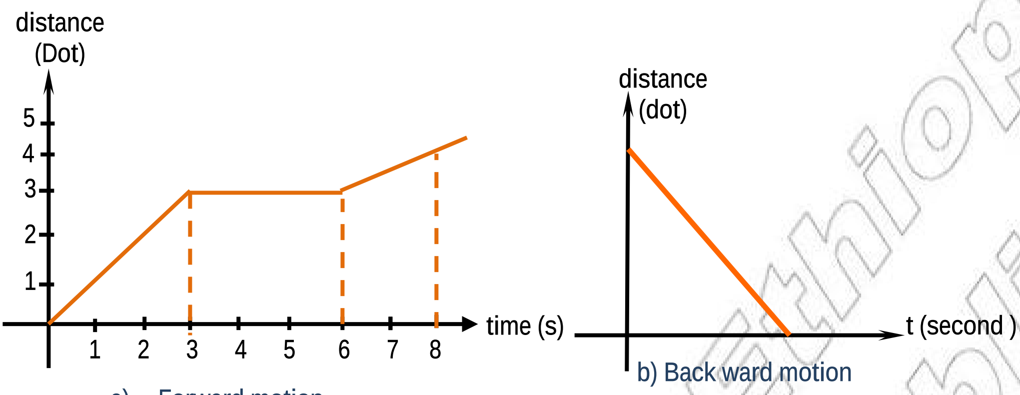


Fig 2.11 Graph of dot against t for constant velocity

Dot plot for a constant velocity (Fig 2.11 (a))

Jemila walked for 3 seconds. She then stopped for 3 seconds and started to move. (see Fig 2.11a)

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$0 \quad 1 \quad 2 \quad \underbrace{3 \quad 4 \quad 5 \quad 6}_{\text{3 second rest}} \quad 7 \quad 8 \quad 9$

Average velocity = slope of the s against t graph

$$\vec{v}_{av} = \frac{3-0}{3-0}\left(\frac{dots}{s}\right)$$

$$= \frac{3}{3}\left(\frac{dot}{s}\right)$$

$$= 1 dot/s$$

Graphical representation of uniformly accelerated motion

Dot plot for a uniformly accelerated motion

● ● ● ● ●

0s 2s 4s 6s 8s

The above dot spaces represent distances for accelerated motion every 2 seconds. Let us see the following examples that describe a uniformly accelerated motion. The tables are based on the motions of a bus and a car accelerating along a straight line.

Table 1. Motion of a bus						
$\vec{v}$ (m/s)	0	10	20	30	40	50
t (s)	0	5	10	15	20	25
$\vec{a}$ (m/s2)						

Table 2. Motion of a car						
$\vec{v}$ (m/s)	0	20	40	60	80	100
t(s)	0	5	10	15	20	25
$\vec{a}$ (m/s2)						

Challenging questions

1. What are the accelerations of the bus and the car?
2. What difference do you observe from the above tables?

Motions of a bus and a car are given in Tables 1 and 2. Draw the v against t graphs for both objects.

Slope of the v against t graph is the acceleration of the moving object.

$$\text{Accelerations} = \text{slope} = \frac{\text{Change in velocity}}{\text{Change in time}}$$

$$\text{Acceleration of the Bus} = \frac{20 - 0\text{m/s}}{10 - 0\,(\text{s})} = 2\text{m/s/s} = 2\text{m/s}^2$$

$$\text{Acceleration of the Car} = \frac{40 - 0\text{m/s}}{10 - 0(\text{s})} = 4\text{m/s/s} = 4\text{m/s}^2$$

The slopes of $\vec{s}$ against t and $\vec{v}$ against t graph show velocity and acceleration respectively. But the area under the curves of graphs of $\vec{v}$ against t and $\vec{a}$ against t gives the total distance covered and change in velocity respectively.

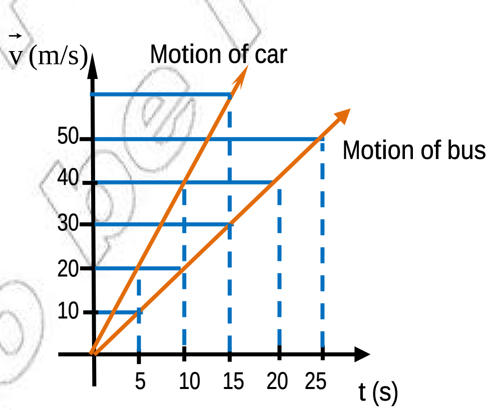

Fig 2.12 v against t graph for the motion of a bus and car

Challenging Questions

1. Explain the difference between velocity and acceleration.
2. Describe the difference between uniform motion and uniformly accelerated motion.
3. A body accelerates uniformly from rest at $2 m/s^2$ for 5 seconds. Calculate its average velocity in this time.

Check point 2.3

1. What does the slope of s against t graph stand for?
2. What happens to a velocity in a uniformly accelerated motion?

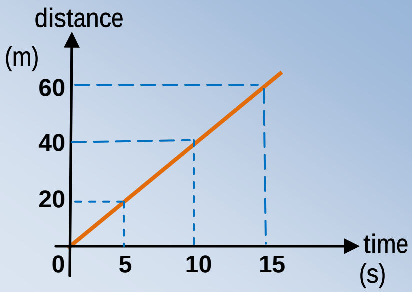

Fig 2.13 s against t graph

3. From the graph of Fig 2.13, answer the following questions.
   a) What is the distance travel by the body in 20 second?
   b) What is the time taken by it to cover a distance of 30 m?
   c) What is the speed of the body?

SUMMARY

In this unit you learnt that:

- motion is a continuous change of position relative to a reference point. There are four types of motion. They are rectilinear, curvilinear, rotary and vibrational motion.
- distance is the length of a path between two points
- speed is the distance travelled divided by time taken. It describes how fast an object is moving in a unit time. When an object moves with constant speed in a straight line, the motion is known as Uniform rectilinear motion.
- displacement is the shortest distance in specified direction. It has both magnitude and direction. Hence it is a vector quantity.
- velocity is the time rate of change of displacement. It has both magnitude and direction.
- acceleration is the time rate of change in velocity
- the velocity of a body may increase or decrease with time. A body whose velocity is increasing is said to have 'acceleration' and a body whose velocity is decreasing is said to have deceleration or negative acceleration. Acceleration may happen due to:
    - either change in speed, or change in direction or change in both speed and direction simultaneously.
- uniformly accelerated motion of an object is a motion with constant acceleration in a given duration.
- freely falling body is a practical example of a uniformly accelerated motion on the earth.

Review Questions and Problems

Solve the following

1. A bicyclist travels with an average velocity of 15 km/h North, for 20 minutes. What is his displacement in km?
2. A car accelerates from rest to 90km/h in 10 seconds. What is its acceleration in m/s^2?
3. An aircraft landing on an aircraft carrier is brought to a complete stop from an initial velocity of 215 km/h in 2.7 seconds. What is its acceleration in m/s^2?
4. A certain car has an acceleration of $2.4 m/s^2$. Assume that its acceleration remains constant. Starting from rest, how long does the car require to reach a velocity of 90 km/h? How far does it travel while reaching that velocity?
5. *From the graph of Fig 2.14*
   a) Calculate the velocity of the motion
   b) What is the slope of the graph equals to?
   c) What is the distance traveled when t = 6 seconds?

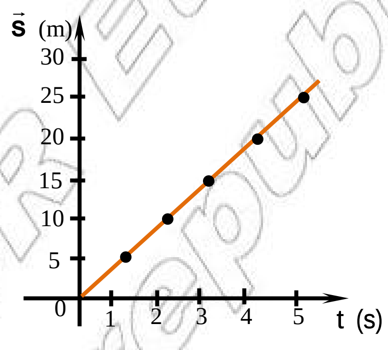

Fig. 2.14 Graph of s against t

6. *From the graph of Fig 2.15*
   a) Calculate the acceleration of the motion
   b) What is the slope of the graph equals to?
   c) What is the velocity when the time taken is 8 seconds?

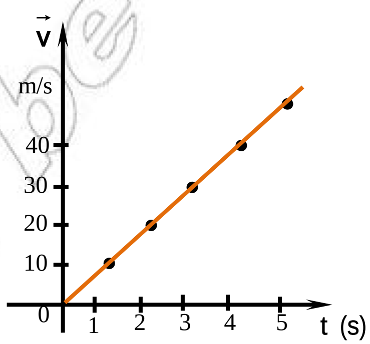

Fig. 2.15 Graph of v against t

7. Data for a freely falling body is recorded as in table below : *Using the given data:*

t(s)	v(m/s)
0	0
1	9. 8
2	19.6
3	29.4
4	39.2

a) draw the graph of velocity versus time.

b) calculate the acceleration due to gravity at the place where the data are taken.

c) Is the acceleration changing or constant?

8. What is the relationship between velocity and acceleration?
9. How does the velocity of a freely falling body change with time? How does the distance it has fallen change? How about the acceleration?
10. a) A car travels at a speed of 25 m/s. How far does it travel in 5 s?
    b) Draw a graph showing the distance versus time for the above car.
    c) What is the slope of the graph?
11. A train initially at rest, has a constant acceleration of 0.5 m/s^2
    a) What is its speed after 15s?
    b) What would be the total time it would take to reach a speed of 25 m/s?
    c) Draw the graph of speed against time for the train.