# CHAPTER SEVEN

# MOTION

## Introduction:

- This is recognised as a change in the position of a body or of a system.
- The study of bodies in motion is called dynamics, and a body which is not in motion is said to be static.

## Types of motion:

- There are different types of motion and some examples are:

**(1) Rectilinear motion:** This is motion in a straight line.

**(2) Circular motion:** This refers to the motion of an object in a circle eg, the whirling of a stone in a circle.

**(3) Rational motion or spin:** This is the motion of a body which spins on its axis, e.g the spin of the earth.

**(4) Random motion:** This is the motion of a body, in which the direction of movement is not specific and can change at any time.

- An example is the movement of gas particles within a container.

## Rectilinear motion:

### Speed:

- This is the rate of change of distance with time, and it is the term used to describe an object which does not move in a straight line.
- It describes how fast an object is moving.
- It is a scalar quantity, since it has only magnitude but no direction.

### Average speed:

- When a body moves at different speeds in the course of a journey, the ratio of the total distance travelled to the total time taken is called the average speed.

### Instantaneous speed:

- This is the measure of the speed of a body at a specific moment.
- Speed = $\frac{Distance}{Time}$

(Q1) A car covers a distance of 20Km within a time interval of 2hours. Calculate its speed or its average speed.

Soln:

Distance = 20Km, time = 2hrs.

Speed = $\frac{Distance}{Time} = \frac{20}{2} = \frac{10km}{h} = 10km/h$

(Q2) A man travels a distance of 50m within 10 seconds. Find the average speed.

Soln:

Distance = 50m, and time = 10seconds.

Speed = $\frac{Distance}{Time} = \frac{50}{10} = 5m/s.$

(Q3) A lorry covers a distance of 100km in 120 minutes. Find its average speed.

Soln:

Distance = 100km. Time = 120 minutes = $\frac{120}{60} = 2hrs.$

Speed = $\frac{Distance}{Time} = \frac{100}{2} = 50km/h.$

(Q4) A cyclist covers a distance of 50, 000m within 4 hours. Find his speed.

N/B:

- Convert the metres into kilometre by dividing by 1000.
- If the distance is in kilometres, then the time must be in hours, and the speed will be in km/h.
- If the distance is in metres, then time should be in seconds and speed will be in m/s.

  Soln:

  Distance = 50,000m = $\frac{50,000}{1000} = 50km$

  Speed = $\frac{Distance}{Time} = \frac{50}{4} = \frac{12.5}{h} km/h.$

## Displacement:

- This is distance moved in a specific direction, or the distance moved in a straight line.

- It is measured in metres and it is a vector quantity.

## Velocity:

- This is defined as speed in a specified direction, or it is the rate of change of displacement.
- The term velocity is used when an object moves in a constant direction, or along a straight line.

- Velocity = $\frac{Distance\ travelled\ in\ straihgt\ line}{Time\ taken}$

## Uniform velocity:

- This occurs when a body travels in a straight line, and moves equal distances within equal time intervals.
- If the motion of a body moving in a straight line, is such that the body travels equal interval in equal time interval, no matter how small the time interval, then the body is said to be moving with a uniform velocity.

(Q5) The distance moved in a straight line by an aeroplane is 20km. If the time interval is 10hours, determine its velocity.

Soln:

Distance travelled in straight line = 200km.

Time = 10 hours.

Velocity = $\frac{200}{10} = 20km/h.$

## Acceleration:

- This is the rate of change of velocity with time.

## Uniform acceleration:

- If the motion of a body moving in a straight line is such that its velocity increases by equal amount in equal time interval, no matter how small the interval, the body is said to have a uniform acceleration.

(Q6) The velocity of a car increased from 10m/s to20m/s in 5 seconds. Calculate its acceleration (or average acceleration).

Soln:

Acceleration = $\frac{Increase\ in\ velocity}{Time\ taken}$

= $\frac{(20-10)}{5} = \frac{10}{5} = 2m/s^2$.

## Deceleration or retardation:

- This is the rate of decrease of velocity with time, which is also referred to as negative acceleration.
-When the velocity of moving body is decreasing, it is said to be undergoing retardation.

- Retardation = $\frac{Final\ velocity - Initial\ Velocity}{Time}$

(Q7) The velocity of a car decreased from 30m/s to 19m/s in 3 seconds.

(a) Calculate its retardation.
(b) Determine its velocity after 2 seconds.

Soln:

(a) Final velocity = V = 18m/s.
Initial velocity = U = 30m/s.
Time = t = 3seconds
Retardation = $\frac{V-U}{t} = \frac{18-30}{3}$
= $\frac{-12}{3} = -4m/s^2$.

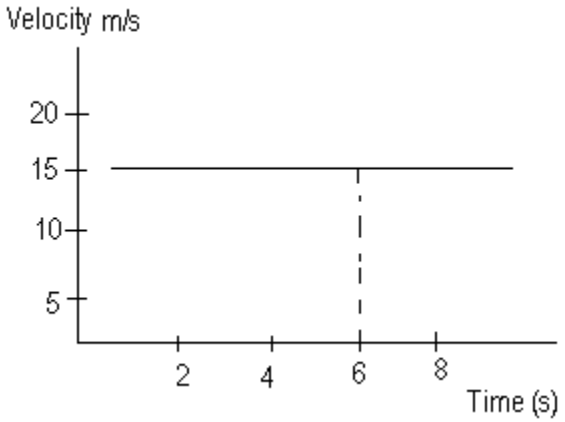
N/B: The negative sign implies that it is retardation.

(b) If the retardation is uniform, then 2 seconds later, the velocity will be reduced by $4 \times 2 = 8$ m/s$^2$.

The velocity will therefore be (18 – 8) = 10m/s$^2$.

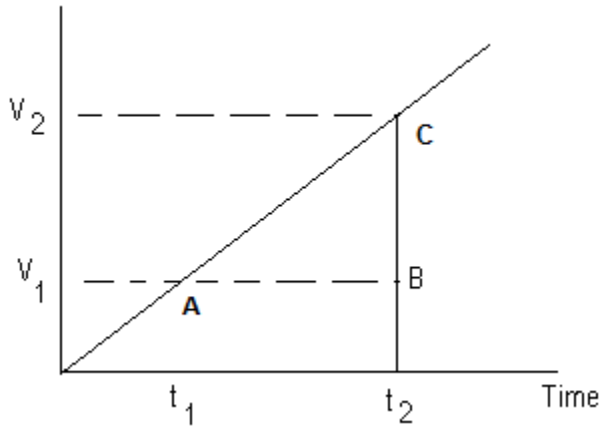
## Graphs of motion:

(1) Velocity – time graphs:




- The graph is that for a body which is moving with a constant or a uniform velocity.
- The distance covered by the body in 6 seconds = velocity × time = 15 × 6 = 90m.
- When a body moves with a constant velocity, the graph is a straight line, which is parallel to the horizontal axis.
- Because the gradient of the line is zero, the acceleration is also zero.

(b)



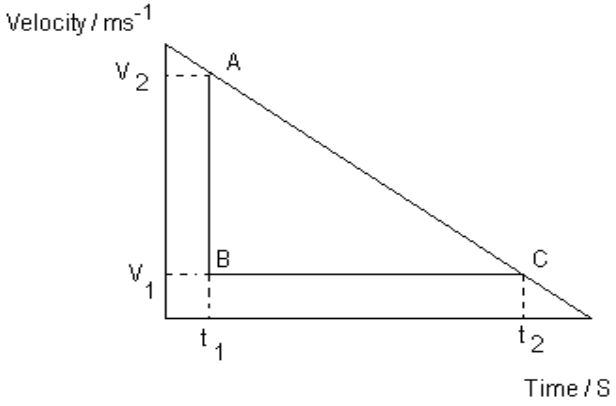
- This graph is that for a body which starts or takes off from rest.
- Since the velocity increases uniformly, then the body is moving within uniform acceleration.
- With respect to velocity – time graph, the gradient of the line or the line graph, gives us the acceleration or the retardation of the body or the object.
- If the gradient is positive, then the object is undergoing acceleration, but if it is negative, then the body is undergoing retardation.
- In the case under consideration.

  Acceleration = $\frac{Change\ in\ velocity}{Time}$

= $\frac{BC}{AB} = \frac{V_2 - V_1}{t_2 - t_1}$

- In this particular case, the gradient is positive and as such the object or body is undergoing acceleration.

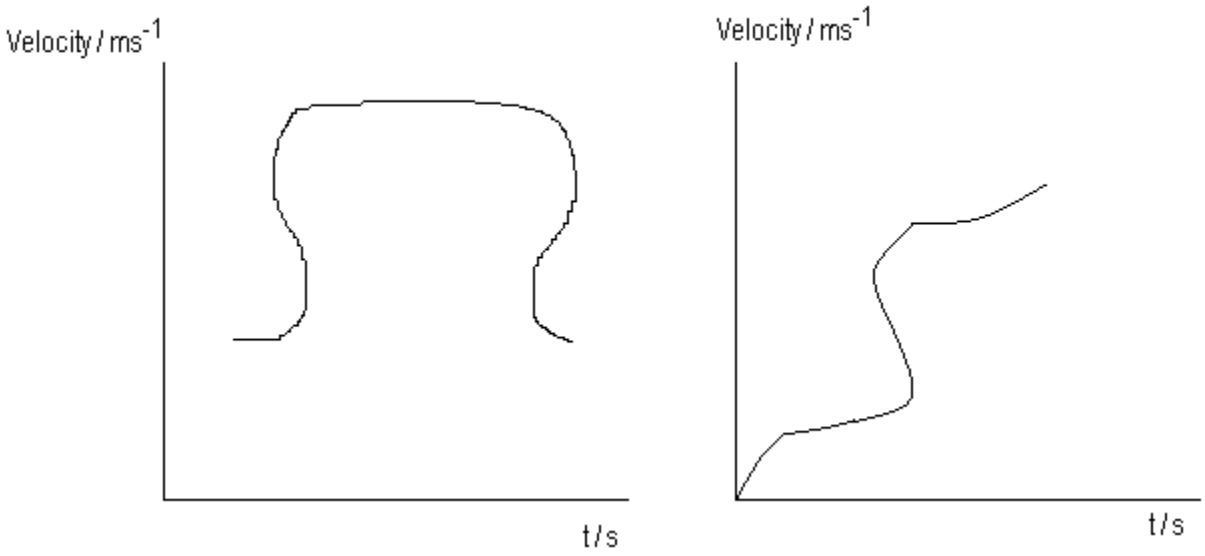
(c)




- Gradient = $\frac{AB}{BC} = \frac{V_2 - V_1}{t_2 - t_1}$

  = $\frac{Change\ in\ velocity}{Time}$
- The case just given is retardation since the gradient is negative.

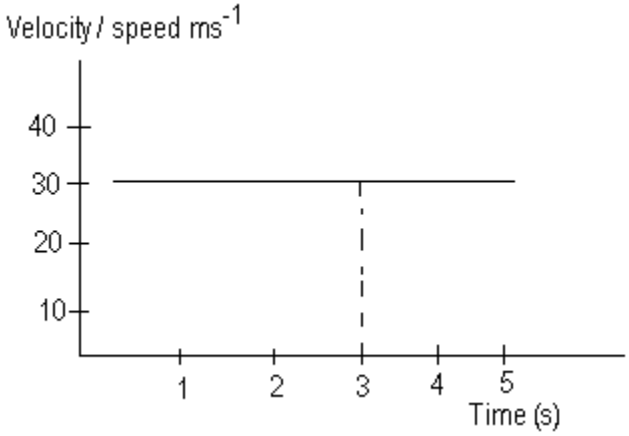
(d)




- The two given cases are the velocity – time graphs of a body, moving with non uniform acceleration.

## Summary:

(1)




The velocity – time graph of a body moving with a constant velocity, and as such zero acceleration.