CHAPTER THREE

MOTION:

Introduction: This is recognized as a change in the position of a body or of a system. The study of bodies which are 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.

(3) Rational motion (spin):

- This refers to the motion of a body, which spins on its axis.
- An example is 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.

Rectilinear motion:

Speed:

- This is the rate at which the distance of a moving body, changes with time.
- It is used to describe the motion of an object which does not move in a straight line.
- 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 travels a distance of 20km within a time interval of 2hours. Calculate its speed or its average speed.

Soln:

Distance = 20km and Time = 2hours.

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

(Q2)Determine the speed of a car, which travels a distance of 100km within 120 minutes.

N/B: Since the distance is given in kilometres, the time in minutes must be changed into hours.

- If the distance is in kilometres, then the time must be in hours and the speed will be in km/h. However, if distance is in metres, then the time must be in seconds and our speed will be in m/s.

Soln:

Distance = 100km.

Time = 120 minutes = $\frac{120}{60}$

= 2 hours.

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

N/B: To convert time in minutes into hours, we divide by 60, since there are 60 minutes in an hour.

(Q3) A man travels a distance of 50 metres within 10 seconds. Find his average speed.

Soln:

Distance = 50m and Time = 10seconds.

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

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

N/B: The distance given in metes must be converted into kilometres, by using 1000 to divide since the time is in hours.

Soln:

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

Time = 4hours.

Speed = $\frac{Distance}{Time} = \frac{50}{4}$

= 12.5 km/h.

Displacement:

- This is the distance moved by a body in a straight line, or in a specific direction.
- It is measured in metres and it is a vector quantity.

Velocity:

- This is speed in a specified direction or is the rate of change of displacement.
- The term velocity is used to describe the speed of a body which moves in a straight line or in a specified direction.

Velocity = $\frac{Distance\ oved\ in\ a\ straight\ line}{Time\ taken}$

(Q1) The distance moved in a straight line by an aeroplane is 200km. If the time interval is 10hours, determine its velocity.

Soln:

Distance moved in straight line = 200km.

Time = 10hours.

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

Uniform Velocity:

This occurs when a body travels in a straight line, and moves equal distances within equal time intervals.

Acceleration:

- This is the rate of change of velocity with time, or the rate at which the velocity increases with time.
- Its unit is m/s^2 (ms^{-2}), i.e. metres per second squared.
- Both acceleration and velocity are vector quantities.

Uniform acceleration:

If the motion of a body moving in a straight line increases by equal amount in equal time interval, then the body is said to have a uniform acceleration.

(Q1)The velocity of a car increased from 10m/s to 20m/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 in velocity with the time, and it is also referred to as negative acceleration.
- When the velocity of a moving body is decreasing, then it is said to be undergoing retardation.

- Retardation = $\frac{Final\ velocity - initial\ velocity}{Time.}$

(Q1) The velocity of a car decreased from 30m/s to 18m/s in 3 seconds.

(a) Calculate its retardation.

(b) Determine the velocity after 2 seconds.

Soln:

(a) Final Velocity = 18m/s. Initial velocity = 30m/s.

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

= $\frac{18-30}{3} = \frac{-12}{3} = -4m/s^2$.

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 x 2 = 8m/s^2.

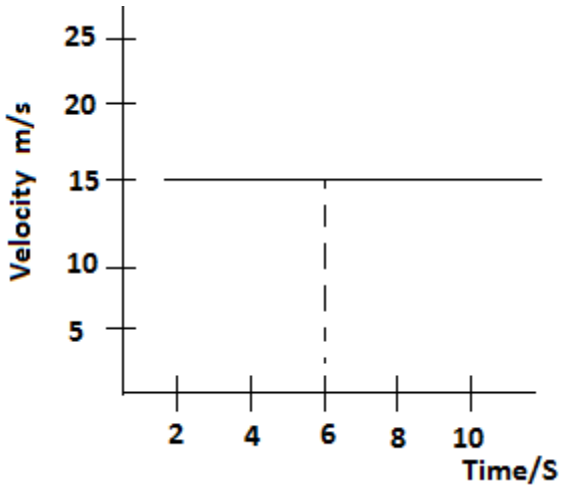
=>The Velocity will be 18 – 8 = 10m/s^2.

Graphs of motion:

Velocity – time graphs:

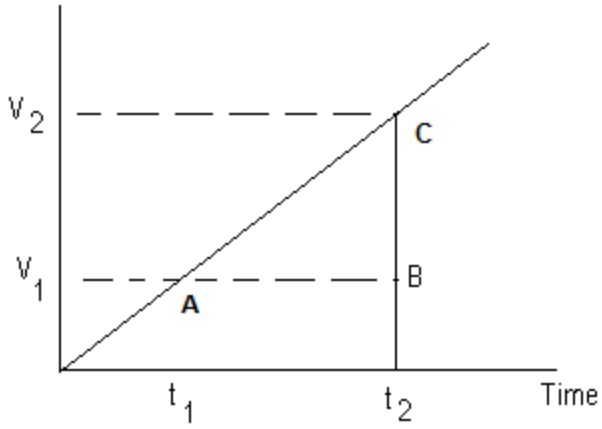
- There are various types of these graphs and some examples are**:**

(a)

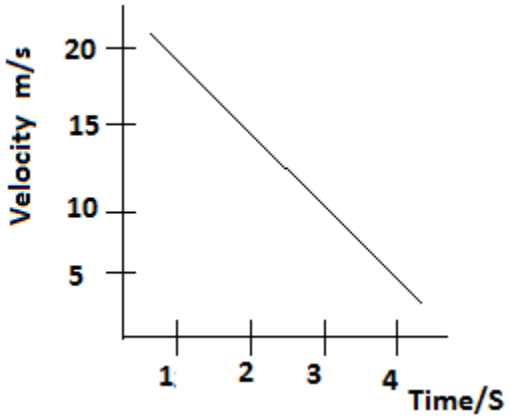


- This graph is that for a body which is moving with a constant or uniform velocity.
- In this case, this uniform velocity is 15m/s.
- The distance covered by the body in 6 seconds = 15 x 6 = 90m.
- When a body moves with a constant velocity, the graph is a straight line which is parallel to the horizontal axis.

(b)

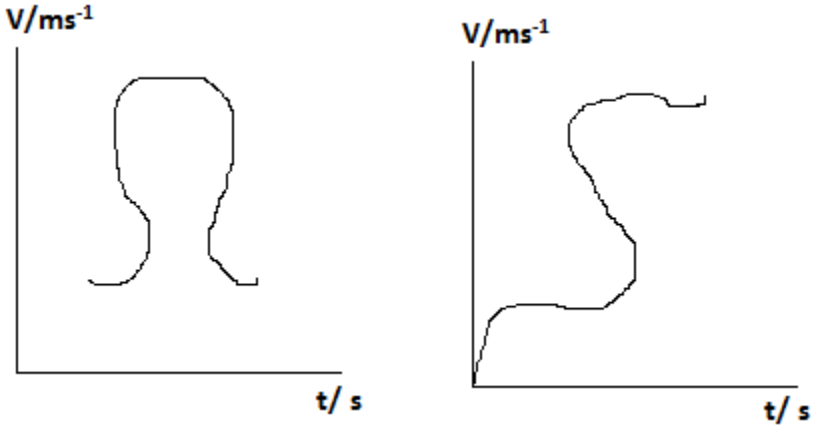


- This graph is that for a body which takes off from rest.
- In this case, the velocity increases uniformly and as such, the body is moving with uniform acceleration.
- If the gradient of the line drawn is positive as shown in the diagram drawn, then the body is under going acceleration, but if the gradient of the line is negative as shown in the next diagram, then the body is undergoing retardation.



- With reference to this velocity – time graph, the gradient of the line graph gives us the acceleration or the retardation.

(c)



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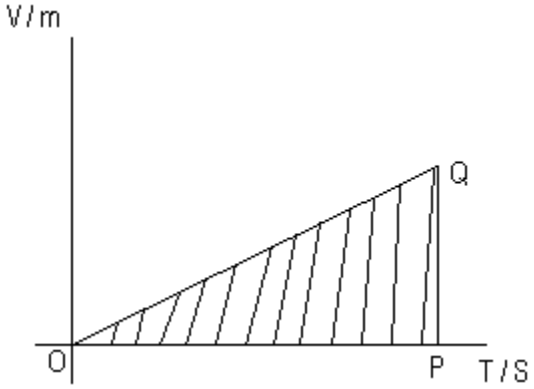
- These two graphs represent the velocity – time graphs of a body, which moves with non-uniform acceleration.

N/B: - For a velocity – time graph, the distance travelled = the area under the graph.

Example:



- This distance travelled = the area of the triangle = $\frac{base \times height}{2} = \frac{OP \times PQ}{2}$