NCERT ANSWERS
CHAPTER 3

1. In which of the following examples of motion, can the body be considered approximately a point object:

(a) A railway carriage moving without jerks between two stations.

(b) A monkey sitting on top of a man cycling smoothly on a circular track.

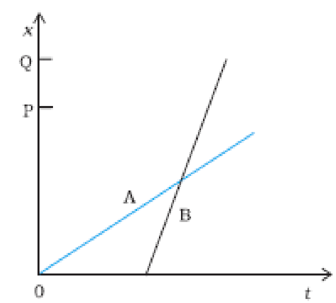
(c) A spinning cricket ball that turns sharply on hitting the ground.

(d) A tumbling beaker that has slipped off the edge of a table.

Ans. (a), (b)

- Size of a carriage <<< distance between two stations. Carriage - point sized object.
- Size of a monkey <<< size of a circular track. Monkey - point sized object on the track.
- Size of a spinning cricket ball is comparable to the distance through which it turns sharply on hitting the ground. So, the cricket ball cannot be considered as a point object.
- Size of a beaker is comparable to the height of the table from which it slipped. So, the beaker cannot be considered as a point object.

2. The position-time (x-t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in Fig. 3.19. Choose the correct entries in the brackets below;



(a) (A/B) lives closer to the school than (B/A)

(b) (A/B) starts from the school earlier than (B/A)

(c) (A/B) walks faster than (B/A)

(d) A and B reach home at the (same/different) time

(e) (A/B) overtakes (B/A) on the road (once/twice).

Ans. (a) **A** lives closer to school than **B.** **[**OP < OQ i.e. distance of school from the **A's** home is less]

(b) **A** starts from school earlier than **B.** **[**for $x = 0$, $t = 0$ for **A**, whereas for $x = 0$, $t \neq 0$]

(c) **A** walks faster than **B.** **[**Slope (speed) of **B** > Slope of **A**. **]**

(d) **A** and **B** reach home at the same time.

(e) **B** overtakes **A** once on the road. [Speed of B is greater than that of **A.** From the graph, it is clear that **B** overtakes **A** only once on the road.]

3. A woman starts from her home at 9.00 am, walks with a speed of 5 kmh^{-1} on a straight road up to her office 2.5 km away, stays at the office up to 5.00 pm, and returns home by an auto with a speed of 25 km h^{-1}. Choose suitable scales and plot the x-t graph of her motion.

Ans. From 3rd eqn of motion

4. A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 steps backward, and so on. Each step is 1 m long and requires 1 s. Plot the *x-t* graph of his motion. Determine graphically and otherwise how long the drunkard takes to fall in a pit 13 m away from the start.

Ans.

5. A jet airplane travelling at the speed of 500 kmh^{-1} ejects its products of combustion at the speed of 1500 kmh^{-1} relative to the jet plane. What is the speed of the latter with respect to an observer on ground?

Ans.

6. A car moving along a straight highway with a speed of 126 kmh^{-1} is brought to a stop within a distance of 200 m. What is the retardation of the car (assumed uniform), and how long does it take for the car to stop?

Ans.

$Given:\quad u = 126kmh^{-1} = 126 \times \frac{5}{18} ms^{-1} = 35ms^{-1}$

$v = 0ms^{-1}$

$s = 200m$

$To\ find:\ a = ?, t = ?$

$Sol^n:\quad From\ 3^{rd}\ eq^n\ of\ motion$

$$v^2 - u^2 = 2as$$

$$0^2 - 35^2 = 2 \times a \times 200$$

$$\boxed{a = \frac{-1225}{400} ms^{-2} = -30.6ms^{-2}}$$

$From\ 1^{st}\ eq^n\ of\ motion$

$$v = u + at$$

$$0 = 35 + \left(\frac{-1225}{400}\right)t$$

$$\boxed{t = \frac{35 \times 400}{1225} = 11.44s}$$

7. Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km h^{-1} in the same direction, with A ahead of B. The driver of B decides to overtake A and accelerates by 1 m/s^2. If after 50 s, the guard of B just brushes past the driver of A, what was the original distance between them?

Ans.

$$Given: \quad u_A = 72kmh^{-1} = 72\times\frac{5}{18}ms^{-1} = 20ms^{-1}, \qquad u_B = 72kmh^{-1} = 72\times\frac{5}{18}ms^{-1} = 20ms^{-1}$$

$$t_A = 50s, \qquad t_B = 50s$$

$$a_A = 0ms^{-2}, \qquad a_B = 1ms^{-2}$$

$$To\ find: \ s_B - s_A = ?$$

$$Sol^n: \quad s_A = u_A t_A + \frac{1}{2}a_A t_A^2 = 20\times 50 + 0 = 1000m$$

$$s_B = u_B t_B + \frac{1}{2}a_B t_B^2 = 20\times 50 + \frac{1}{2}\times 1\times 50^2 = 2250m$$

$$\boxed{s_B - s_A = 2250 - 1000 = 1250m}$$

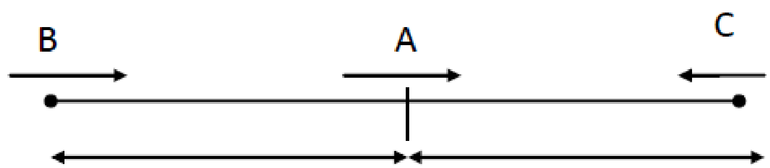
8. On a two-lane road, car A is travelling with a speed of 36 km h^{-1}. Two cars B and C approach car A in opposite directions with a speed of 54 km h^{-1} each. At a certain instant, when the distance AB is equal to AC, both being 1 km, B decides to overtake A before C does. What minimum acceleration of car B is required to avoid an accident?

Ans.

$$v_A = 36kmh^{-1} = 36\times\frac{5}{18}ms^{-1} = 10ms^{-1}$$

$$v_B = 54kmh^{-1} = 54\times\frac{5}{18}ms^{-1} = 15ms^{-1}$$

$$v_C = 54kmh^{-1} = 54\times\frac{5}{18}ms^{-1} = 15ms^{-1}$$



Relative velocity of car B w.r.t A $\quad v_{BA} = v_B - v_A = 15 - 10 = 5ms^{-1}$

Relative velocity of car B w.r.t A $\quad v_{CA} = v_C + v_A = 15 + 10 = 25ms^{-1}$

Time taken by car C to cover distance AC, $\quad \boxed{t = \frac{AC}{v_{CA}} = \frac{1000}{25} = 40s}$

Hence, to avoid an accident, car B must cover the same distance in a maximum of 40 s.

$$s_{AB} = u_{AB}t + \frac{1}{2}at^2$$

$$1000 = 5\times 40 + \frac{1}{2}\times a\times 40^2$$

$$1000 - 200 = 800a$$

$$\boxed{a = 1ms^{-2}}$$

9. Two towns A and B are connected by a regular bus service with a bus leaving in either direction every *T* minutes. A man cycling with a speed of 20 km h^{-1} in the direction A to B notices that a bus goes past him every 18 min in the direction of his motion, and every 6 min in the opposite direction. What is the period *T* of the bus service and with what speed (assumed constant) do the buses ply on the road?

Ans. Speed of bus = v kmh^{-1}(suppose)

Speed of cyclist = 20 kmh^{-1}

Relative velocity of bus in the direction of cyclist = v - 20

Relative velocity of bus in the direction opposite to cyclist = v + 20

Distance covered by the bus plying in the direction of cyclist = $(v-20)\frac{18}{60}km$

Distance covered by the bus plying in the direction opposite to the cyclist = $(v+20)\frac{6}{60}km$

Since one bus leaves after every T minutes, distance travelled by the bus is = $v\frac{T}{60}km$

$$(v-20)\frac{18}{60}=v\frac{T}{60} \qquad \rightarrow (1)$$

$$(v+20)\frac{6}{60}=v\frac{T}{60} \qquad \rightarrow (2)$$

$From\,(1)\ and\,(2)$

$$(v-20)\frac{18}{60}=(v+20)\frac{6}{60}$$

$$3(v-20)=v+20$$

$$3v-60=v+20$$

$$3v-v=80$$

$$2v=80$$

$$v=40kmh^{-1}$$

$From\,(1)$

$$(40-20)\frac{18}{60}=40\times\frac{T}{60}$$

$$T=9\min.$$

10. A player throws a ball upwards with an initial speed of 29.4 ms^{-1}.

(a) What is the direction of acceleration during the upward motion of the ball?

(b) What are the velocity and acceleration of the ball at the highest point of its motion?

(c) Choose the x = 0 m and t = 0 s to be the location and time of the ball at its highest point, vertically downward direction to be the positive direction of x-axis, and give the signs of position, velocity and acceleration of the ball during its upward, and downward motion.

(d) To what height does the ball rise and after how long does the ball return to the player's hands? (Take g = 9.8 ms^{-2} and neglect air resistance).

Ans. (a) Always downwards

(b) Velocity = 0 ms^{-1}, acceleration = 9.8 ms^{-2}

(c)

Direction of motion	Position	Velocity	Acceleration
Upward	Positive	Negative	Positive
Downward	Positive	Positive	Positive

(d)

$Given:\quad u = 29.4ms^{-1}$

$v = 0ms^{-1}$

$g = -9.8ms^{-2}$

$To\ find:\ s = ?, t = ?$

$Sol^n:\quad From\ \ 3^{rd}\ eq^n\ \ of\ motion$

$v^2 - u^2 = 2gs$

$0^2 - (29.4)^2 = 2\times(-9.8)\times s$

$$\boxed{s = \frac{864.36}{19.6}m = 44.1m}$$

$From\ \ 1^{st}\ eq^n\ \ of\ motion$

$v = u + at$

$0 = 29.4 - 9.8t$

$$\boxed{t = \frac{29.4}{9.8} = 3s}$$

11. Read each statement below carefully and state with reasons and examples, if it is true or false;

A particle in one-dimensional motion

(a) with zero speed at an instant may have non-zero acceleration at that instant

(b) with zero speed may have non-zero velocity,

(c) with constant speed must have zero acceleration,

(d) with positive value of acceleration must be speeding up.

Ans.

Case	**True/False**	**Reason/Example**
zero speed may have non-zero acc.	**T**	Example- Object thrown vertically upward in the air Reason - Speed at maximum height = 0 Acceleration = 9.8ms^{-2} (acting downwards)

with zero speed may have non-zero velocity	**F**	Reason - Speed is the magnitude of velocity, so if speed is zero, then velocity must be zero.
constant speed must have zero acceleration	**T**	Example- Object moving with constant speed in straight line Reason - Speed/velocity = 0 so acc. = 0
positive acceleration must be speeding up	**F**	Reason: when acceleration is positive and velocity is negative at the instant time taken as origin. Then, for all the time before velocity becomes zero, there is slowing down of the particle. Example - a particle is projected upwards
	T	Reason: when both velocity and acceleration are positive, at the instant time taken as origin. Example - a particle is moving with positive acceleration or falling vertically downwards from a height.

12. A ball is dropped from a height of 90 m on a floor. At each collision with the floor, the ball loses one tenth of its speed. Plot the speed-time graph of its motion between t = 0 to 12 s.

Ans.

13. Explain clearly, with examples, the distinction between:

(a) magnitude of displacement (sometimes called distance) over an interval of time, and the total length of path covered by a particle over the same interval;

(b) magnitude of average velocity over an interval of time, and the average speed over the same interval. [Average speed of a particle over an interval of time is defined as the total path length divided by the time interval].

Show in both (a) and (b) that the second quantity is either greater than or equal to the first.

When is the equality sign true? [For simplicity, consider one-dimensional motion only].

Ans.

14. A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 km h^{-1}. Finding the market closed, he instantly turns and walks back home with a speed of 7.5 km h^{-1}. What is the

(a) magnitude of average velocity, and

(b) average speed of the man over the interval of time (i) 0 to 30 min, (ii) 0 to 50 min, (iii) 0 to 40 min?

[Note: You will appreciate from this exercise why it is better to define average speed as total path length divided by time, and not as magnitude of average velocity. You would not like to tell the tired man on his return home that his average speed was zero!]

Time taken by man to reach market, $t_1 = \frac{2.5}{5} = 0.5h = 30\,\text{min}.$

Time taken to reach home, $t_2 = \frac{2.5}{7.5} = 0.3h = 20\,\text{min}.$

(i) 0 to 30 min

Total time taken, $t = t_1 = 30\,\text{min}. = 0.5hr$

Total distance covered = 2.5 km

Total displacement = 2.5 km

$$\text{Average speed/velocity} = \frac{\text{Total distance/displacement}}{\text{Total time}} = \frac{2.5}{0.5} = 5kmh^{-1}$$

(ii) 0 to 50 min

Total time taken, $t = t_1 + t_2 = 20 + 30 = 50\,\text{min}. = \frac{50}{60}hr = \frac{5}{6}hr$

Total distance covered = 2.5 + 2.5 =5 km

Total displacement = 0 km

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{5}{\frac{5}{6}} = 6kmh^{-1}$$

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}} = \frac{0}{\frac{5}{6}} = 0kmh^{-1}$$

(iii) 0 to 40 min

Total time taken, $t = 40\,\text{min}. = \frac{40}{60}hr = \frac{2}{3}hr$

Total distance covered = 2.5 + 1.25 =3.75 km

Total displacement = 2.5-1.25=1.25km

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{3.75}{\frac{2}{3}} = 5.62kmh^{-1}$$

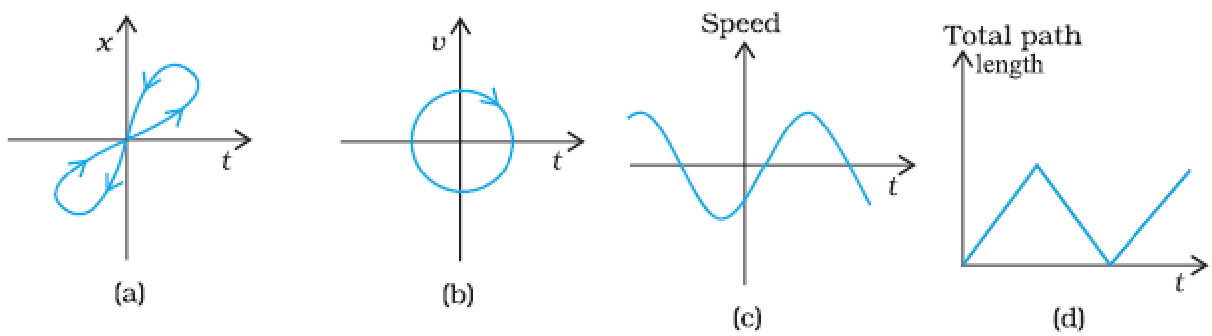
$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}} = \frac{1.25}{\frac{2}{3}} = 1.875kmh^{-1}$$

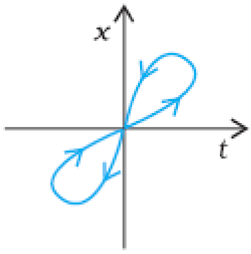
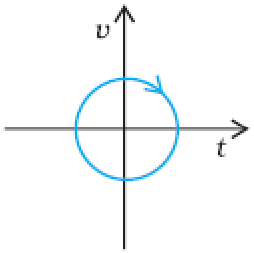
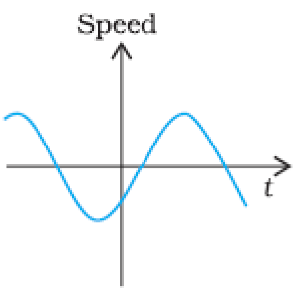
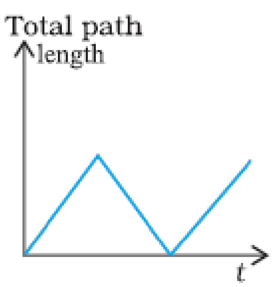
15. In Exercises 3.13 and 3.14, we have carefully distinguished between *average* speed and magnitude of *average* velocity. No such distinction is necessary when we consider instantaneous speed and magnitude of

velocity. The instantaneous speed is always equal to the magnitude of instantaneous velocity. Why?

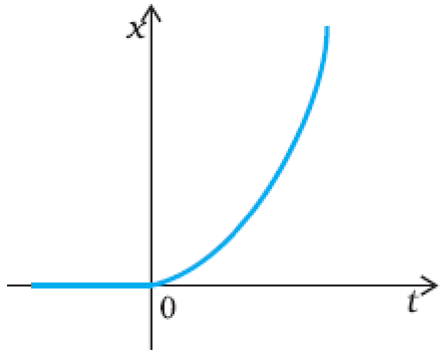
- Instantaneous velocity $v = \frac{dx}{dt}$
- dt being small so it is assumed that the particle will not change its direction of motion.
- Hence, both the total path length and magnitude of displacement become equal is this interval of time.
- So, instantaneous speed is always equal to instantaneous velocity.

16. Look at the graphs (a) to (d) (Fig. 3.20) carefully and state, with reasons, which of these *cannot* possibly represent one-dimensional motion of a particle.



	One dimensional – Y/N	Reason
	No	A particle cannot have two positions at the same instant of time.
	No	A particle can never have two values of velocity at the same instant of time.
	No	speed being a scalar quantity cannot be negative.
	No	the total path length travelled by the particle cannot decrease with time

17. Figure 3.21 shows the *x-t* plot of one-dimensional motion of a particle. Is it correct to say from the graph that the particle moves in a straight line for $t < 0$ and on a parabolic path for $t > 0$? If not, suggest a suitable physical context for this graph.



- No.
- Reason: the given particle does not follow the trajectory of path followed by the particle as $t = 0$, $x = 0$.
- Physical context: a freely falling body held for sometime at a height

18. A police van moving on a highway with a speed of 30 kmh^{-1} fires a bullet at a thief's car speeding away in the same direction with a speed of 192 km h^{-1}. If the muzzle speed of the bullet is 150 ms^{-1}, with what speed does the bullet hit the thief's car? (Note: Obtain that speed which is relevant for damaging the thief's car).

$$Given: \quad v_p = 30kmh^{-1} = 30 \times \frac{5}{18} ms^{-1} = \frac{25}{3} ms^{-1}$$

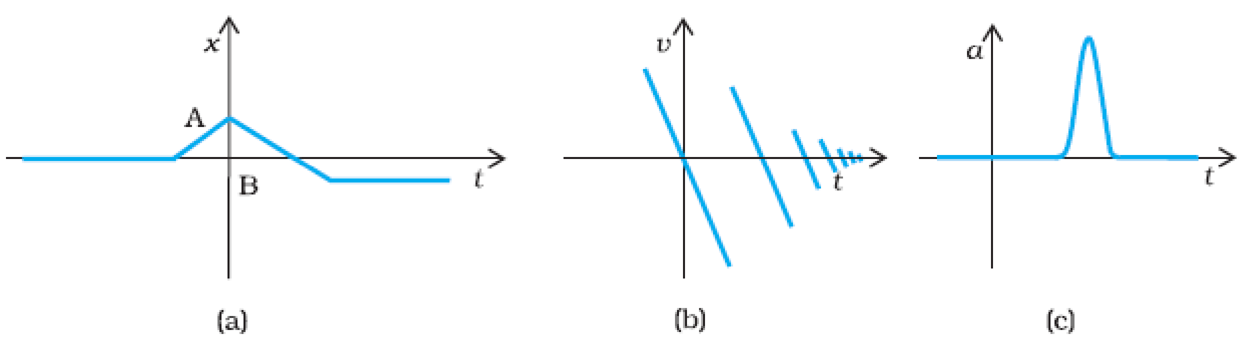
$$v_T = 192kmh^{-1} = 192 \times \frac{5}{18} ms^{-1} = \frac{160}{3} ms^{-1}$$

$$v_b = \left(150 + \frac{25}{3}\right) ms^{-1} = \frac{475}{3} ms^{-1}$$

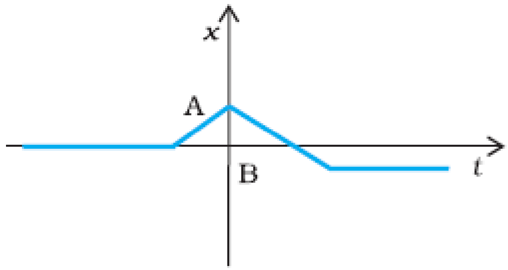
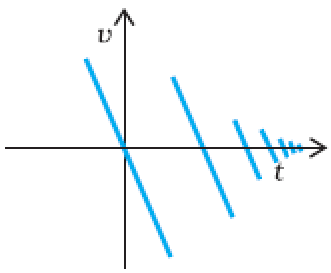
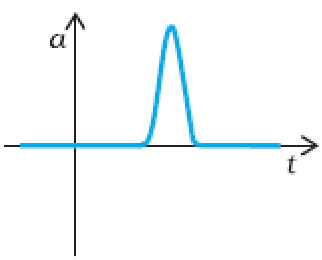
$$To\ find: \ v_{bT} = ?$$

$$Sol^n: \quad v_{bT} = v_b - v_T = \frac{475}{3} - \frac{160}{3} = \frac{315}{3} = 105 ms^{-1}$$

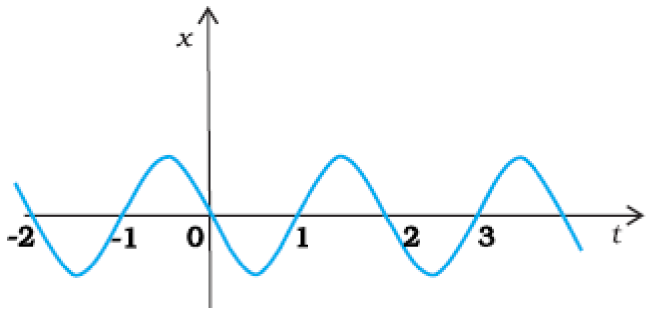
19. Suggest a suitable physical situation for each of the following graphs (Fig 3.22):



Graph	Interpretation	Physical situation

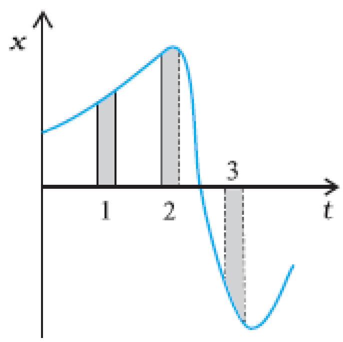
	• Initially body at rest. • Velocity increases with time & attains an instantaneous constant value. • Velocity then reduces to zero with an increase in time. • Velocity increases with time in the opposite direction and acquires a constant value.	A carrom disk (initially at rest) is hit by the striker, it rebounds, passes from the striker position and ultimately gets stopped after sometime.
 (b)	• Sign of velocity changes • Magnitude decreases with a passage of time.	A ball is dropped on the hard floor from a height[It strikes the floor with some velocity and upon rebound, its velocity decreases by a factor. This continues till the velocity of the ball eventually becomes zero].
	• Initially the body is moving with a certain uniform velocity. • Acceleration increases for a short interval of time and again drops to zero. • The body again starts moving with the same constant velocity.	A hammer moving with a uniform velocity strikes a nail.

20. Figure 3.23 gives the *x-t* plot of a particle executing one-dimensional simple harmonic motion. (You will learn about this motion in more detail in Chapter14). Give the signs of position, velocity and acceleration variables of the particle at t = 0.3 s, 1.2 s, – 1.2 s.



Interval	Position(x)	Velocity	Acceleration
0.3	Negative	Negative (slope negative)	Positive
1.2	Positive	Positive(slope positive)	Negative
-1.2	Negative	Positive(both x and t negative)	Positive

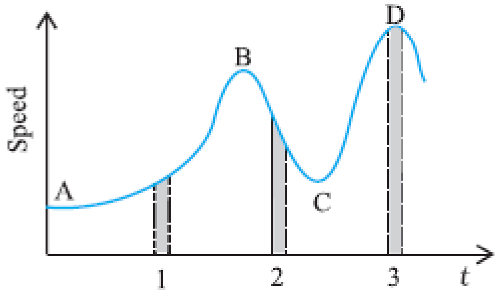
21. Figure 3.24 gives the *x-t* plot of a particle in one-dimensional motion. Three different equal intervals of time are shown. In which interval is the average speed greatest, and in which is it the least? Give the sign of average velocity for each interval.



Interval	Average speed	Reason
1	Positive	Slope positive
2	Positive(Least)	Slope positive
3	Negative(Greatest)	Slope negative

22. Figure 3.25 gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown. In which interval is the average acceleration greatest in magnitude? In which interval is

the average speed greatest? Choosing the positive direction as the constant direction of motion, give the signs of *v* and *a* in the three intervals. What are the accelerations at the points A, B, C and D?



- Average acceleration is greatest in interval 2 as slope is maximum.
- Average speed is greatest in interval 3 as height of curve is maximum in 3.
- *v* is positive in intervals 1, 2, and 3 *a* is positive in intervals 1 and 3 and negative in interval 2 *a* = 0 at A, B, C, D

Interval	v	a
1	positive	positive
2	Positive(scalar)	Negative(slope negative)
3	positive	Zero(slope zero)

- As points A, B, C, and D are all parallel to the time-axis so, the slope is zero at these points and hence acceleration is zero at these points.

23.