PHYSICS

NCERT - NCERT PHYSICS(TELUGU)

MOTION IN A STRAIGHT LINE

Example

1. A car is moving along a straight line, say OP in Fig. It moves from O to P in 18 s and returns from P to Q in 6.0 s. What are the average velocity and average speed of the car in going (a) from O to P ? and (b) from O to P and back to Q ?

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2. The position of an object moving along x-axis is given by $x = a + bt^2$ where $a = 8.5m, b = 2.5ms^{-2}$ and t is measured in seconds. What is its velocity at t = 0 s and t = 2.0 s. What is the average velocity between t = 2.0 s and t = 4.0 s ?

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3. Obtain equations of motion for constant acceleration using method of calculus.

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4. A ball is thrown vertically upwards with a velocity of $20ms^{-1}$ from the top of a multistorey building. The height of the point from where the ball is thrown is 25.0 m from the ground. (a) How high will the ball rise ? and (b) how long will it be before the ball hits the ground ? Take $g = 10ms^{-2}$.

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5. Free-fall : Discuss the motion of an object under free fall. Neglect air resistance.

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6. Galileo's law of odd numbers : "The distances traversed, during equal intervals of time, by a body falling from rest, stand to one another in the same ratio as the odd numbers beginning with unity [namely, 1: 3: 5: 7......]." Prove it.

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7. Stopping distance of vehicles : When brakes are applied to a moving vehicle, the distance it travels before stopping is called stopping distance. It is an important factor for road safety and depends on the initial velocity (v_0) and the braking capacity, or deceleration, $-a$ that is caused by the braking. Derive an expression for stopping distance of a vehicle in terms of v_0 and a.

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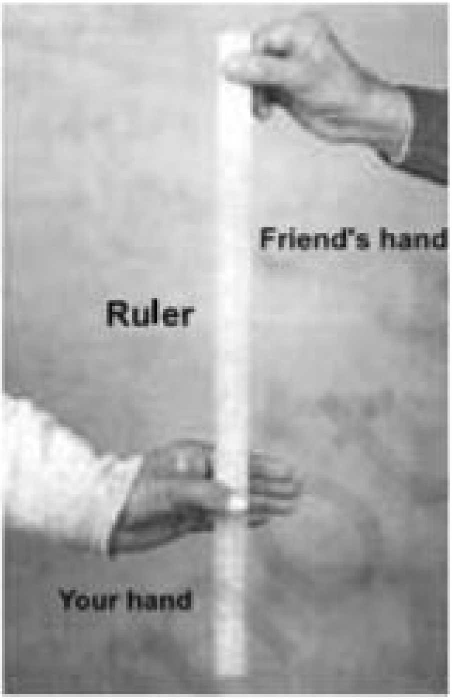
8. Reaction time : When a situation demands our immediate action, it takes some time before we really respond. Reaction time is the time a person takes to observe, think and act. For example, if a person is driving and suddenly a boy appears on the road, then the time elapsed before he slams the brakes of the car is the reaction time. Reaction time depends on complexity of the situation and on an individual. You can measure your reaction time by a simple experiment. Take a ruler and ask your friend to drop it vertically through the gap between your thumb and forefinger (Fig.). After you catch it, find the distance d travelled by the ruler. In a particular case, d was found to be 21.0 cm. Estimate reaction time.



Measuring the reaction time.

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9. Two parallel rail tracks run north-south. Train A moves north with a speed of $54 km h^{-1}$, and train B moves south with a speed of $90 km h^{-1}$. What is the

(a) velocity of B with respect to A ?,

(b) velocity of ground with respect to B ?, and

(c) velocity of a monkey running on the roof of the train A against its motion (with a velocity of $18 km h^{-1}$ with respect to the train A) as observed by a man standing on the ground ?

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Exercises

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.

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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. Choose the correct entries in the brackets below ,

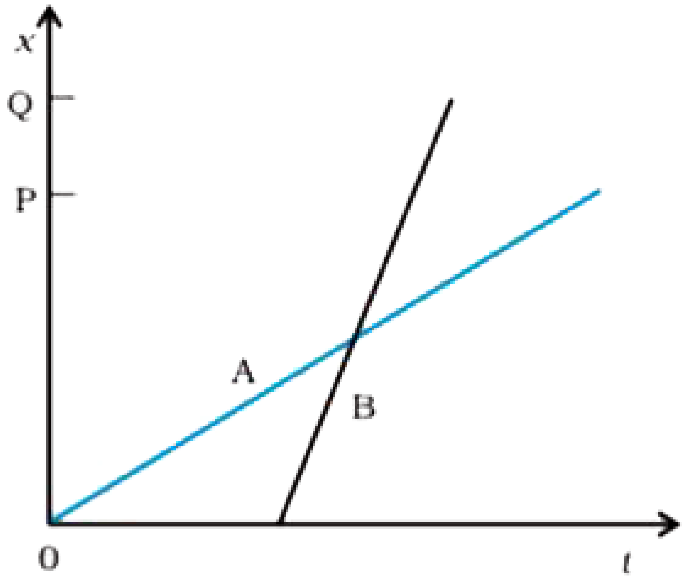
(a) (A/B) lives closer to the school than (B/A)

(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).



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3. A woman starts from her home at 9.00 am, walks with a speed of $5 km h^{-1}$ 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.

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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.

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

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6. A car moving along a straight highway with 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 ?

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

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8. On a two-lane road, car A is travelling with a speed of $36kmh^{-1}$. Two cars B and C approach car A in opposite directions with a speed of $54kmh^{-1}$ 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 ?

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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 $20kmh^{-1}$ 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 ?

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

(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 $g = 9.8ms^{-2}$ and neglect air resistance).

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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.

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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.

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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].

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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 !]

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15. 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 ?

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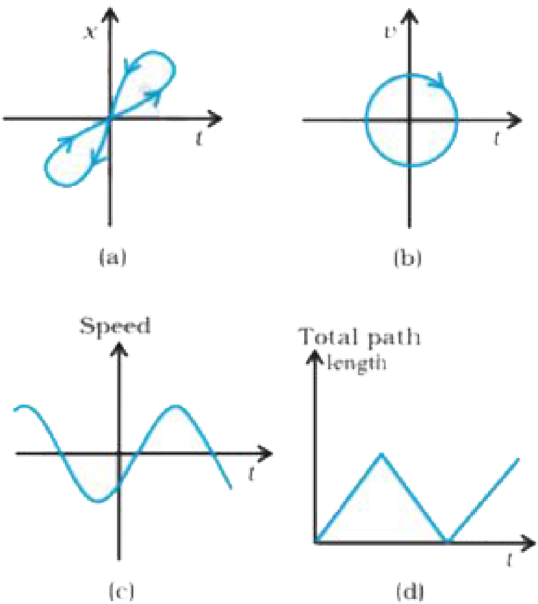
16. Look at the graphs (a) to (d) (Fig.) carefully and state, with reasons, which of these cannot possibly represent one-dimensional motion of a particle.



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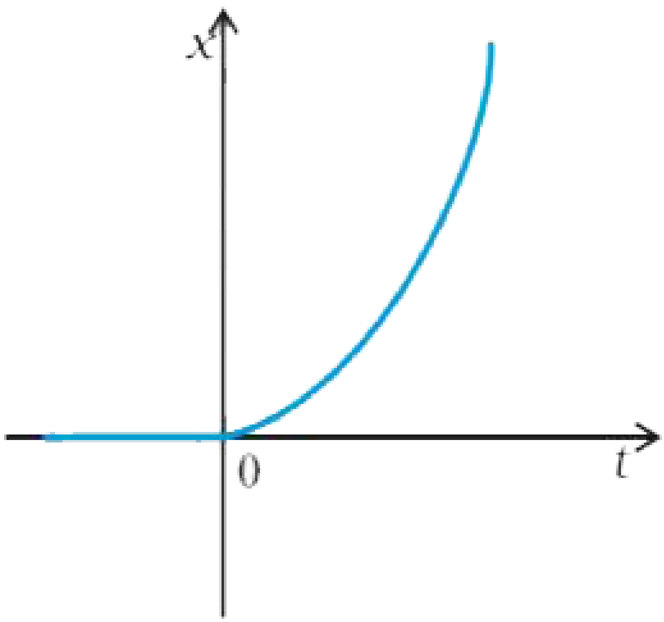
17. Figure. shows the x-t plot of one-dimensional motion of a particle. Is it correct to say from the graph that the particle moves in a straight line for $t < 0$ and on a parabolic path for $t > 0$? If not, suggest a suitable physical context for this graph.



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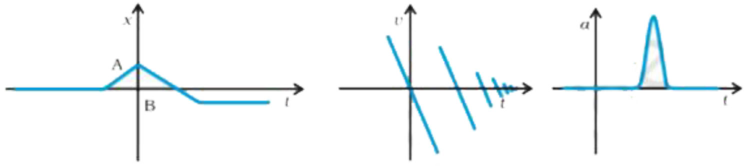
18. A police van moving on a highway with a speed of $30kmh^{-1}$ fires a bullet at a thief's car speeding away in the same direction with a speed of $192kmh^{-1}$. If the muzzle speed of the bullet is $150ms^{-1}$, with what speed does the bullet hit the thief's car ? (Note: Obtain that speed which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

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



(a) (b) (c)

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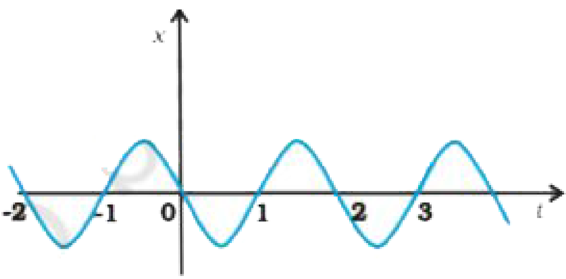
20. Figure. gives the x-t plot of a particle executing one-dimensional simple harmonic motion. (You will learn about this motion in more detail in Chapter14). Give the signs of position, velocity and acceleration variables of the particle at $t = 0.3s, 1.2s, \ - 1.2s.$



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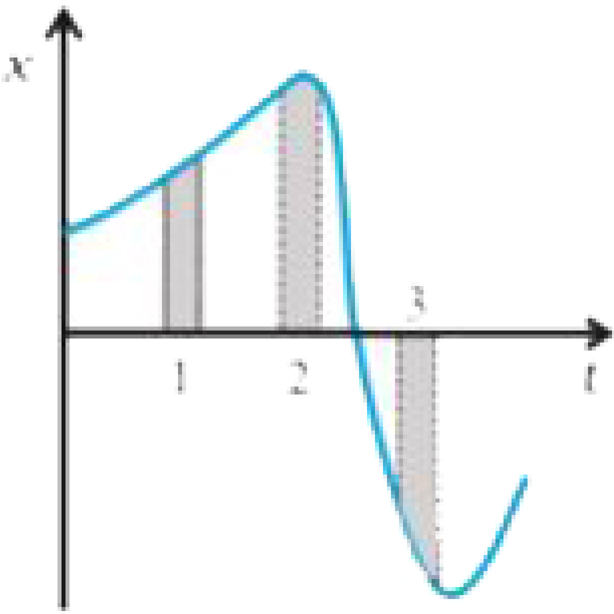
21. Figure. gives the x-t plot of a particle in one-dimensional motion. Three different equal intervals of time are shown. In which interval is the average speed greatest, and in which is it the least ? Give the sign of average velocity for each interval.



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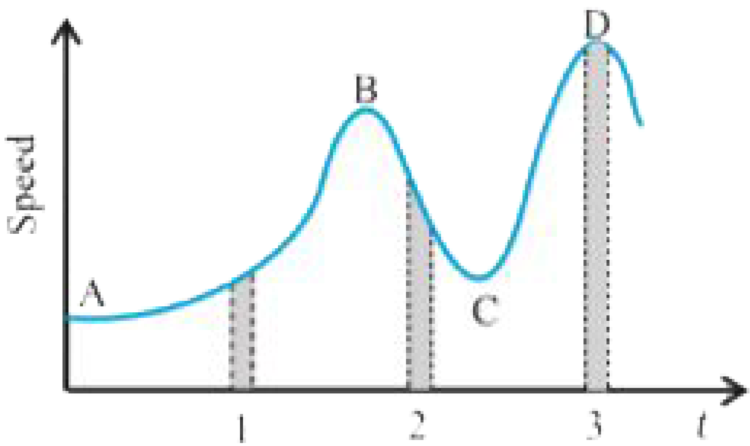
22. Figure. gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown. In which interval is the average acceleration greatest in magnitude ? In which interval is the average speed greatest ? Choosing the positive direction as the constant direction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



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23. A three-wheeler starts from rest, accelerates uniformly with $1ms^{-2}$ on a straight road for 10 s, and then moves with uniform velocity. Plot the distance covered by the vehicle during the nth second (n = 1,2,3....) versus n. What do you expect this plot to be during accelerated motion : a straight line or a parabola ?

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Additional Exercises

1. A boy standing on a stationary lift (open from above) throws a ball upwards with the maximum initial speed he can, equal to $49ms^{-1}$. How much time does the ball take to return to his hands ? If the lift starts moving up with a uniform speed of $5ms^{-1}$ and the boy again throws the ball up with the maximum speed he can, how long does the ball take to return to his hands ?

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2. On a long horizontally moving belt (Fig.), a child runs to and fro with a speed $9kmh^{-1}$ (with respect to the belt) between his father and mother located 50 m apart on the moving belt. The belt moves with a speed of

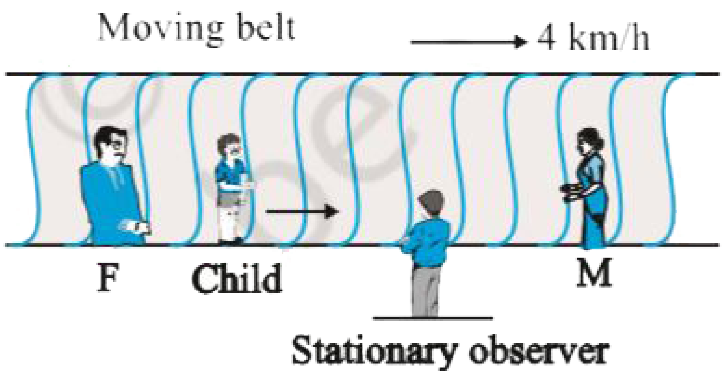
$4kmh^{-1}$. For an observer on a stationary platform outside, what is the

(a) speed of the child running in the direction of motion of the belt ?.

(b) speed of the child running opposite to the direction of motion of the belt ?

(c) time taken by the child in (a) and (b) ?

Which of the answers alter if motion is viewed by one of the parents ?



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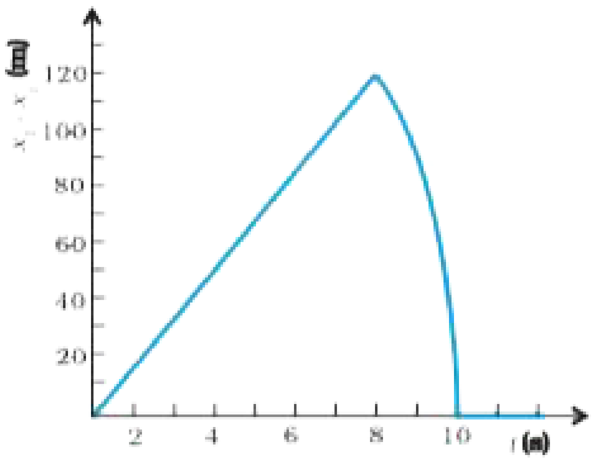
3. Two stones are thrown up simultaneously from the edge of a cliff 200 m high with initial speeds of $15 m s^{-1}$ and $30 m s^{-1}$. Verify that the graph shown in Fig. correctly represents the time variation of the relative position of the second stone with respect to the first. Neglect air resistance and assume that the stones do not rebound after hitting the ground. Take $g = 10 m s^{-2}$. Give the equations for the linear and curved parts of the plot.



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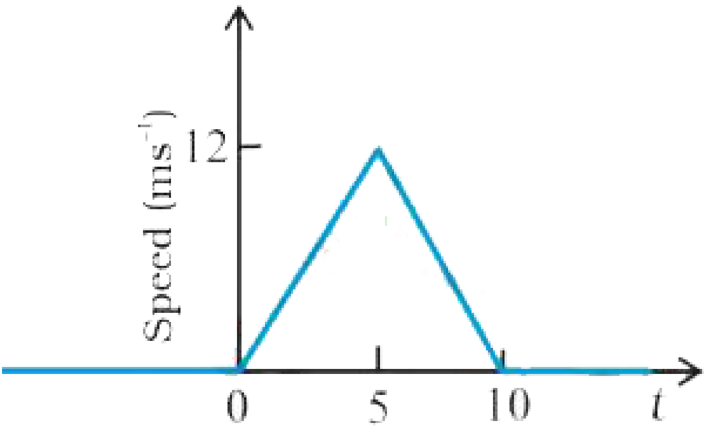
4. The speed-time graph of a particle moving along a fixed direction is shown in Fig. Obtain the distance traversed by the particle between (a) t = 0 s to 10 s, (b) t = 2s to 6s.



What is the average speed of the particle over the intervals in (a) and (b) ?

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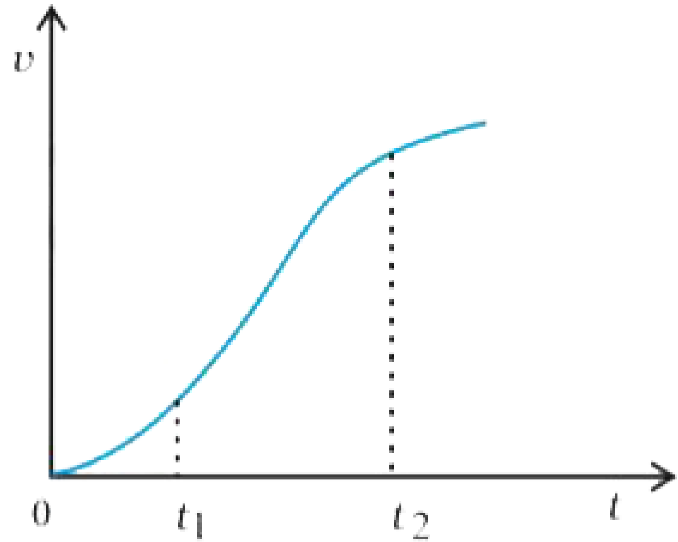
5. The velocity-time graph of a particle in one-dimensional motion is shown in Fig.



Which of the following formulae are correct for describing the motion of the particle over the time-interval t_1 to t_2 :

(a) $x(t_2) = x(t_1) + v(t_1)(t_2 - t_1) + (1/2)a(t_2 - t_1)^2$

(b) $v(t_2) = v(t_1) + a(t_2 - t_1)$

(c) $v_{\text{average}} = (x(t_2) - x(t_1)) / (t_2 - t_1)$

(d) $a_{\text{average}} = (v(t_2) - v(t_1)) / (t_2 - t_1)$

(e)

$x(t_2) = x(t_1) + v_{\text{average}}(t_2 - t_1) + (1/2)a_{\text{average}}(t_2 - t_1)^2$

(f) $x(t_2) - x(t_1) =$ area under the $v - t$ curve bounded by the t-axis and the dotted line shown.

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