

Overview

- Kinematics: Description of Motion
 - Position and displacement
 - velocity
 - » average
 - » instantaneous
 - acceleration
 - » average
 - » instantaneous

Speed and Velocity

• Speed

• Velocity

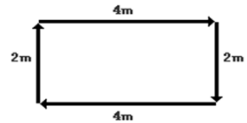
Speed & Velocity

$$\text{Average Speed} = \frac{\text{Distance Traveled}}{\text{Time of Travel}}$$

$$\text{Average Velocity} = \frac{\Delta \text{ position}}{\text{time}} = \frac{\text{displacement}}{\text{time}}$$

Velocity & Speed

A physics teacher walks 4 meters East, 2 meters South, 4 meters West, and finally 2 meters North.



Instantaneous and Average

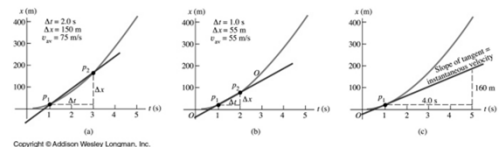
- **Instantaneous Speed** - speed at any given instant in time
- **Average Speed** - total distance divided by total time of travel

Instantaneous Velocity

- Instantaneous velocity is the limit of the average velocity as the time interval approaches 0.

$$\vec{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

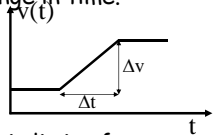
- It is the instantaneous rate of change of position with time.
- Instantaneous rate of change is the derivative – which means slope of a graph at a point



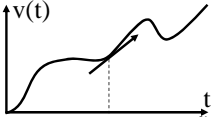
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Acceleration (m/s/s)

- The average acceleration is the change in velocity divided by the change in time.

$$\bar{a} = \frac{\Delta v}{\Delta t}$$


- Instantaneous acceleration is limit of average velocity as Δt gets small. It is the slope of the $v(t)$ plot



Acceleration Units

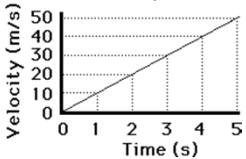
- Speed/time
- $m/s/s = m/s^2$
- $mi/hr/s = mi/hr-s$
- $km/hr/s = km/hr-s$
- Distance/time/time
- or distance/time²

Acceleration - Slope of V_T

0s 1s 2s 3s 4s 5s
 0m 5m 20m 45m 80m 125m

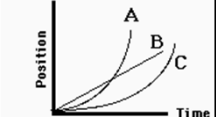
Time (s)	Velocity (m/s)
0	0
1	10
2	20
3	30
4	40
5	50


$a = 10 \text{ m/s}^2 = \text{slope}$



Acceleration

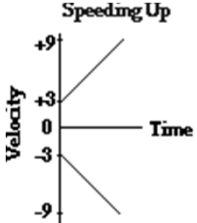
- Acceleration** is a vector quantity defined as the rate at which an object changes its velocity. An object is accelerating if it is changing its velocity.



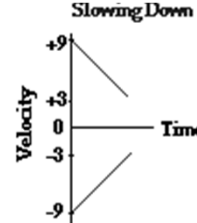


Speeding Up & Slowing Down

Speeding Up



Slowing Down

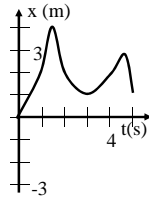


Position vs Time Plots

Position at $t=3s$, $x(3) = 1m$

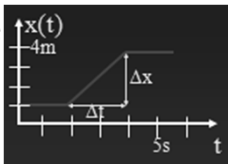
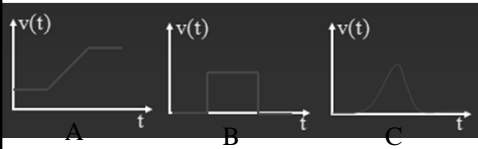
Displacement between $t=1s$ and $t=3s$.
 $\Delta x =$

Average velocity between $t=1$ and $t=3$
 $v =$



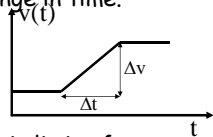
Which plot best represents a plot of velocity vs time corresponding to the position vs time?

1. A
2. B
3. C

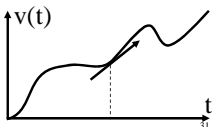



Acceleration (m/s²)

- The average acceleration is the change in velocity divided by the change in time.

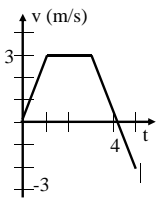
$$\bar{a} = \frac{\Delta v}{\Delta t}$$


- Instantaneous acceleration is limit of average velocity as Δt gets small. It is the slope of the v(t) plot



Velocity vs Time Plots

- Gives velocity at any time.
- Area gives displacement
- Slope gives acceleration.



Velocity at t=2, v(2) =

Displacement between t=0 and t=3:
t=0 to t=1:
t=1 to t=3:

Average velocity between t=0 and t=3?

Change in v between t=3 and t=5. Δv =


Average acceleration between t=3 and t=5:
a =

Acceleration Units

- Speed/time
- m/s/s = m/s²
- ft/s/s = ft/s²
- mi/hr/s = mi/hr-s
- km/hr/s = km/hr-s
- Distance/time/time
- or distance/time²

The Ninja

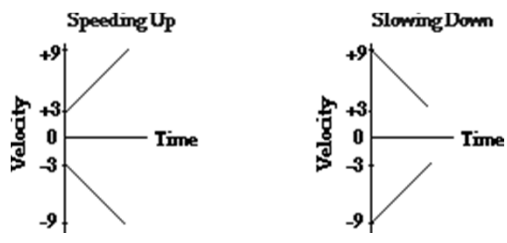
- The Ninja motorcycle can accelerate from 0 to 60 mi/h in 3.8 s.
- What is its average acceleration?



$$a = \frac{\Delta v}{\Delta t} = \frac{60 \text{ mi/h} - 0}{3.8 \text{ s}}$$

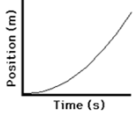
- 15.8 mi/h/s
- 23 ft/s/s or 7 m/s/s

Speeding Up & Slowing Down



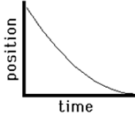
• Negative acceleration can mean speeding up or slowing down. The same is true with positive acceleration.

Position-Time Graphs Constant Acceleration




Position (m)
Time (s)

positive velocity
positive acceleration



position
Time

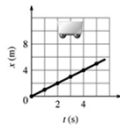
negative velocity
positive acceleration



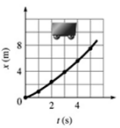
position
time

negative velocity
negative acceleration

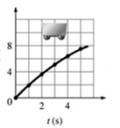
Which x vs t plot shows positive acceleration?



(A)



(B)

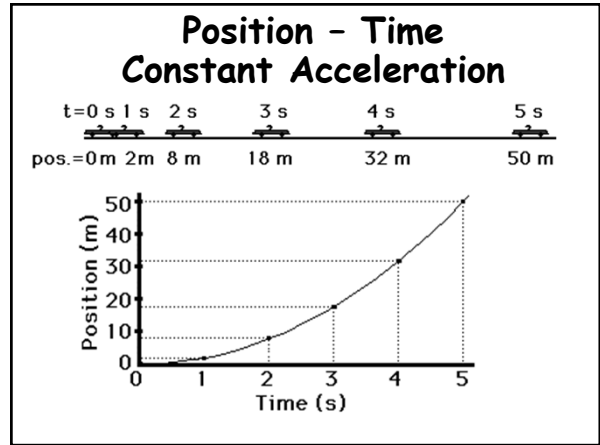


(C)


1. A
2. B
3. C

Summary of Concepts

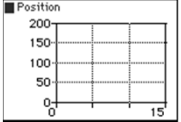
- kinematics: A description of motion
- position:
- displacement:
- velocity:
 - average :
 - instantaneous:
- acceleration:
 - average:
 - instantaneous:



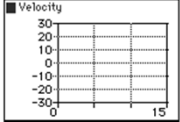
Constant Positive Velocity



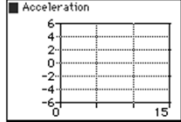
Position-Time Graph




Velocity-Time Graph



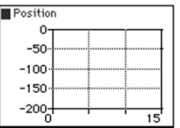
Acceleration-Time Graph



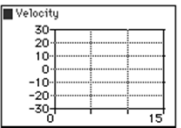
Constant Negative Velocity



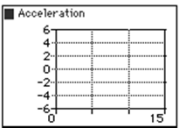
Position-Time Graph



Velocity-Time Graph



Acceleration-Time Graph



Positive Velocity Positive Acceleration

Position-Time Graph

Velocity-Time Graph

Acceleration-Time Graph

Positive Velocity Negative Acceleration

Position-Time Graph

Velocity-Time Graph

Acceleration-Time Graph

Negative Velocity Negative Acceleration

Position-Time Graph

Velocity-Time Graph

Acceleration-Time Graph

Negative Velocity Positive Acceleration

Position-Time Graph

Velocity-Time Graph

Acceleration-Time Graph

Review

- Kinematics : Description of Motion
 - Position
 - Displacement
 - Velocity $\vec{v} = \frac{\Delta x}{\Delta t}$
 - » average
 - » Instantaneous
 - Acceleration $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$
 - » average
 - » instantaneous

Equations for Constant Acceleration (text, page 34)

- $v = v_0 + at$
- $v_{av} = \frac{1}{2} (v_0 + v)$
- $x = x_0 + v_0t + \frac{1}{2} at^2$
- $v^2 = v_0^2 + 2a(x-x_0)$

- A cheetah can accelerate from rest to 25.0 m/s in 6.22 s. Assuming constant acceleration,

→A. how far has the cheetah run in this time?
first find acceleration

then find distance

- A cheetah can accelerate from rest to 25.0 m/s in 6.22 s. Assuming constant acceleration,

→C. what is the cheetah's average speed for the first 3.11 s?

- A cheetah can accelerate from rest to 25.0 m/s in 6.22 s. Assuming constant acceleration,

→D. calculate the distance covered by the cheetah in the first 3.11 s.

A cheetah can accelerate from rest to 25.0 m/s in 6.22 s. Assuming constant acceleration, after sprinting for just 3.11 s, the cheetah's speed is

1. < 12.5 m/s
2. = 12.5 m/s
3. > 12.5 m/s

A car accelerates uniformly from rest. If it travels a distance D in time t then how far will it travel in a time $2t$?

1. $D/4$
2. $D/2$
3. D
4. $2D$
5. $4D$

A car accelerates uniformly from rest. If the car has speed v at time t then what is its speed at time $2t$?

1. $v/4$
2. $v/2$
3. v
4. $2v$
5. $4v$