Phys101 Lecture 2

Kinematics in One Dimension (Review)

Key Points

- Average Velocity and Instantaneous Velocity
- Motion at Constant Acceleration
- Graphical Analysis

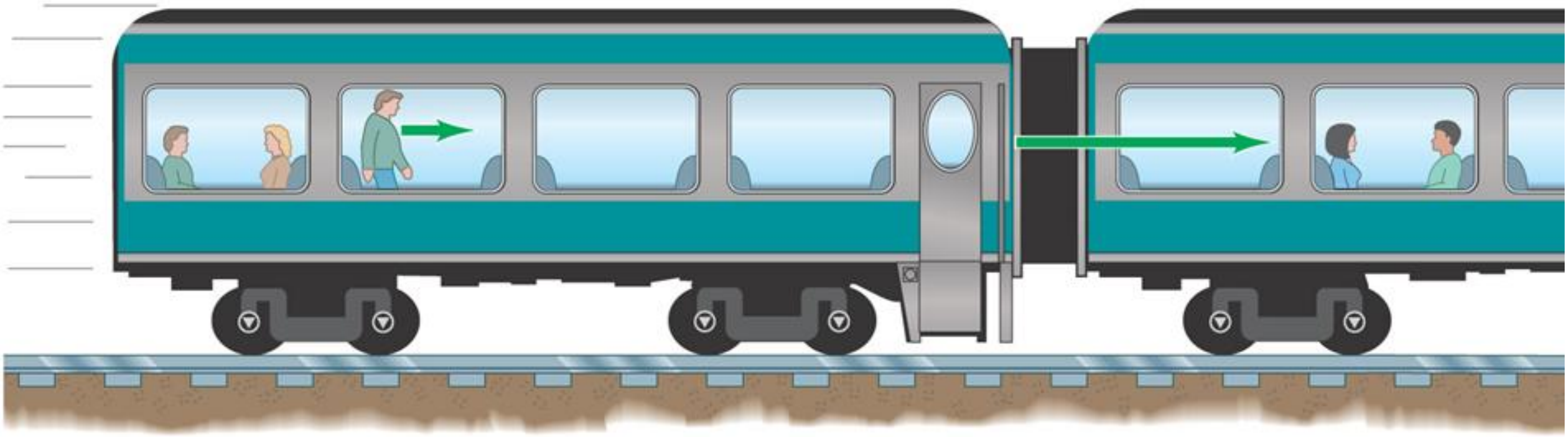
Sections covered:

2-1,2,3,4,5,6,7,8

Reference Frames

Any measurement of position, distance, or speed must be made with respect to a reference frame.

For example, if you are sitting on a train and someone walks down the aisle, their speed with respect to the train is a few miles per hour, at most. Their speed with respect to the ground is much higher.



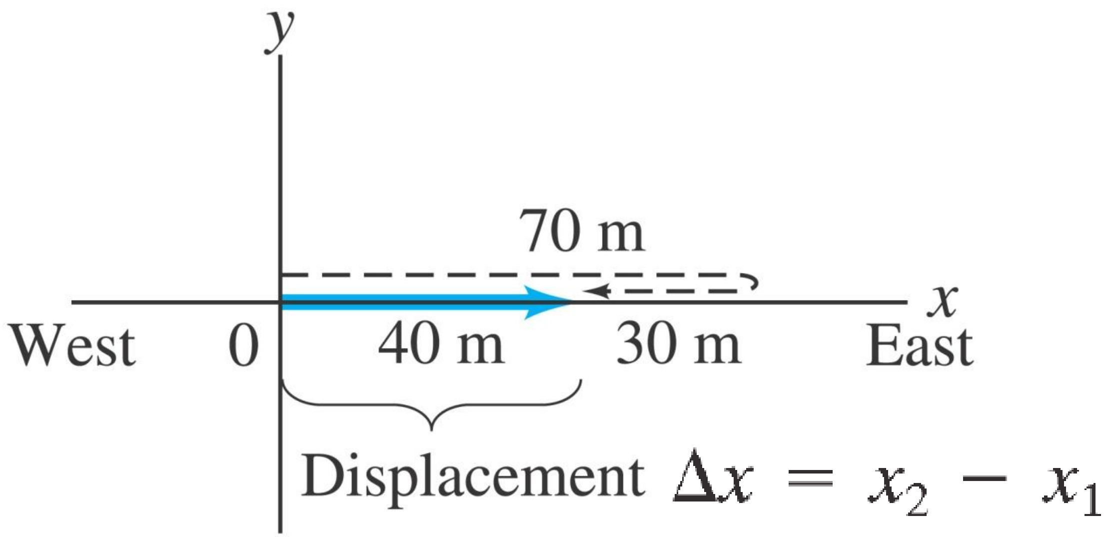
Set up the coordinate system before using formulas!

Distance and Displacement

We make a distinction between distance and displacement.

Displacement (blue line) is how far the object is from its starting point, regardless of how it got there.

Distance traveled (dashed line) is measured along the actual path.



Speed and Velocity

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time elapsed}} \geq 0$$

$$\text{average velocity} = \frac{\text{displacement}}{\text{time elapsed}} \quad (+, -, \text{ or } 0)$$

The instantaneous velocity is the average velocity, in the limit as the time interval becomes infinitesimally short.

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

I-clicker question 2-1

Velocity in One Dimension

If the average velocity is non-zero over some time interval, does this mean that the instantaneous velocity is never zero during the same interval?

A) yes

B) no

C) it depends

Acceleration

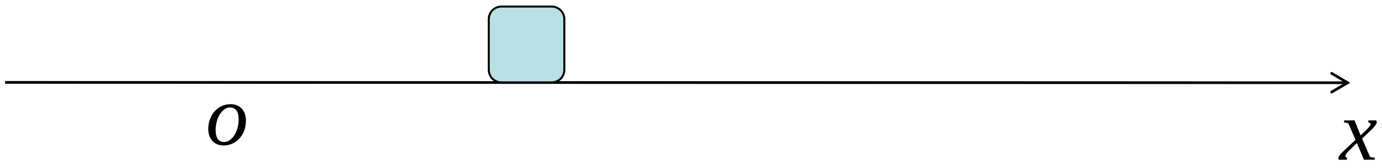
Acceleration is the rate of change of velocity.

$$\text{average acceleration} = \frac{\text{change of velocity}}{\text{time elapsed}}$$

The instantaneous acceleration is the average acceleration, in the limit as the time interval becomes infinitesimally short.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} \qquad \textbf{(2-5)}$$

Motion at Constant Acceleration



At $t=0$, $x=x_0$, $v=v_0$ (initial position and velocity)

$$v = v_0 + at \qquad \text{(2-11a)}$$

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 \qquad \text{(2-11b)}$$

$$v^2 = v_0^2 + 2a(x - x_0) \qquad \text{(2-11c)}$$

$$\bar{v} = \frac{v + v_0}{2}. \qquad \text{(2-11d)}$$

Can we use these formulas if the acceleration varies?

i-clicker question 2-2
Acceleration

When throwing a ball straight up, which of the following is true about its velocity v and its acceleration a at the highest point in its path?

A) both $v = 0$ and $a = 0$

B) $v \neq 0$, but $a = 0$

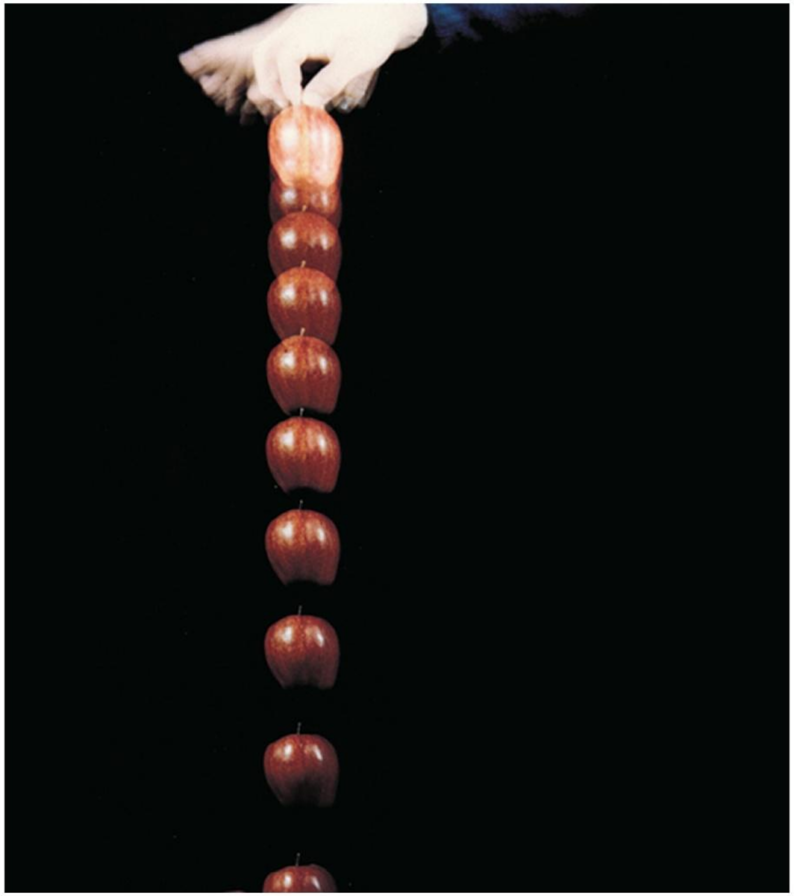
C) $v = 0$, but $a \neq 0$

D) both $v \neq 0$ and $a \neq 0$

E) not really sure

Falling Objects

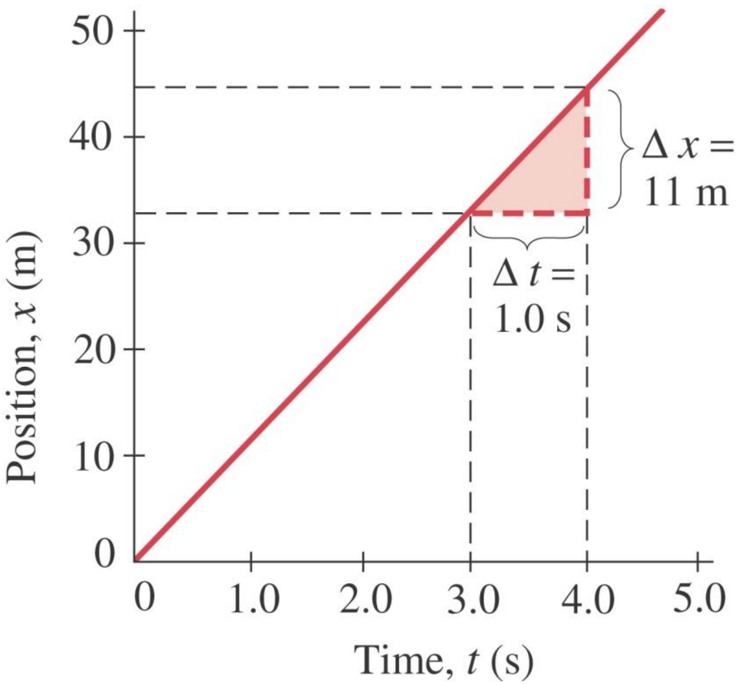
Near the surface of the Earth, all objects experience approximately the same acceleration due to gravity.



This is one of the most common examples of motion with constant acceleration.

The acceleration due to gravity at the Earth's surface is approximately $g = 9.80\ m/s^2$.

Graphical Analysis

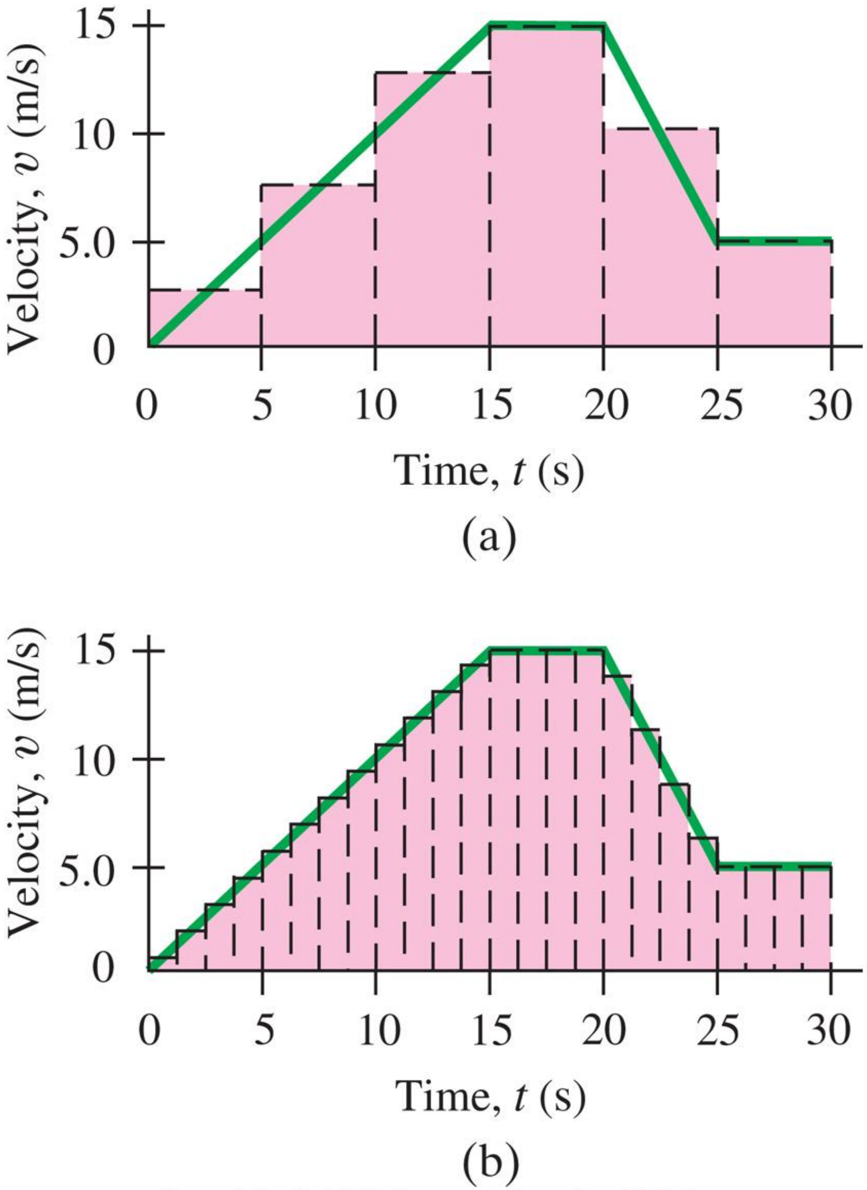


The velocity is the slope of the *x-t* curve.

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

Similarly, the acceleration is the slope of the *v-t* curve.

Graphical Analysis of Linear Motion

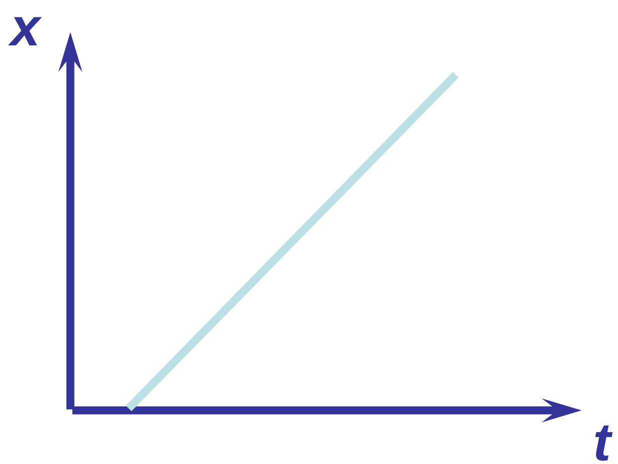


The displacement, *x*, is the area under the *v* vs. *t* curve.

$$\Delta x = \text{area under the } v\text{-}t \text{ curve}$$

i-clicker question 2-3   Graphing Velocity I

The graph of position versus time for a car is given below. What can you say about the velocity of the car over time?



A) it speeds up all the time

B) it slows down all the time

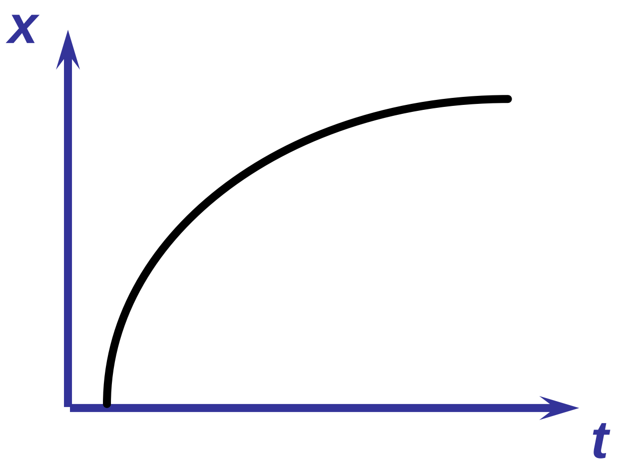
C) it moves at constant velocity

D) sometimes it speeds up and sometimes it slows down

E) not really sure

i-clicker question 2-4 Graphing Velocity II

The graph of position vs. time for a car is given below. What can you say about the velocity of the car over time?



A) it speeds up all the time

B) it slows down all the time

C) it moves at constant velocity

D) sometimes it speeds up and sometimes it slows down

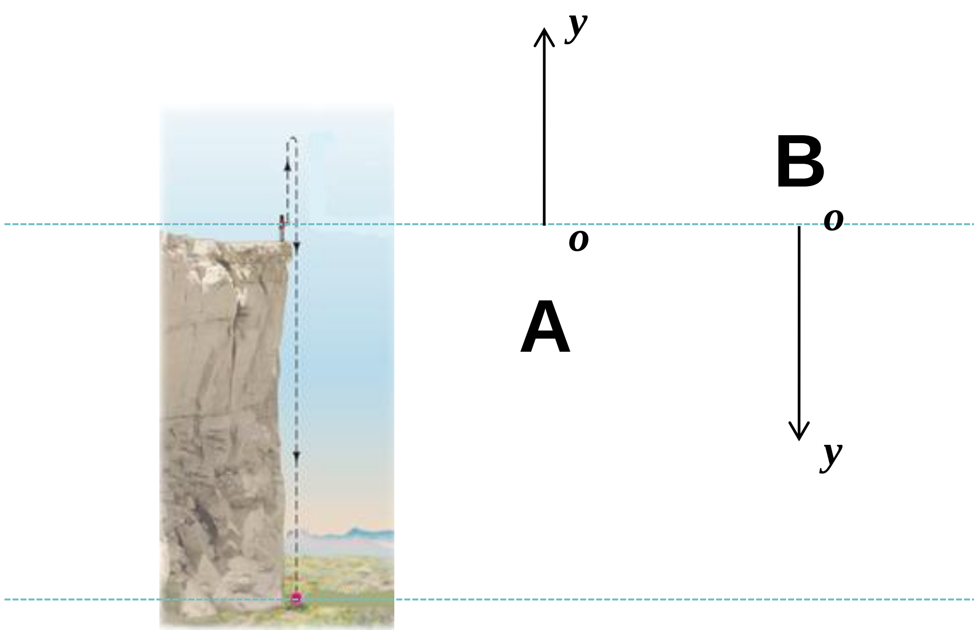
E) not really sure

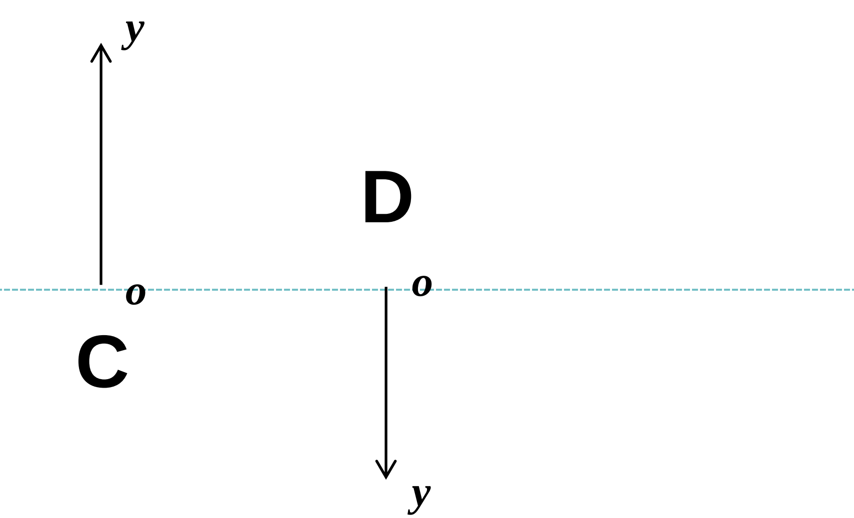
Example: Ball thrown upward at edge of cliff.

A ball is thrown upward at a speed of 15.0 m/s by a person standing on the edge of a cliff. How long does it take for the ball to reach the base that is 50.0m below the cliff?

i>Clicker question (2-5): Which coordinate system can be used?

A. A only
B. A or C
C. A or B
D. C only
E. A or B or C or D





Example: Ball thrown upward at edge of cliff.

A ball is thrown upward at a speed of 15 m/s by a person standing on the edge of a cliff. How long does it take for the ball to reach the base that is 50m below the cliff?

i>Clicker question (2-6): For coordinate system D,

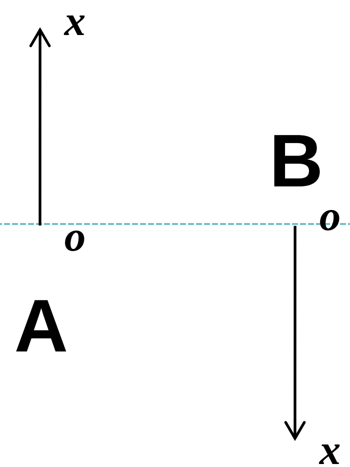
A. $x_0=50m,\ v_0=15m/s,\ a=9.8m/s^2$

B. $x_0=-50m,\ v_0=15m/s,\ a=9.8m/s^2$

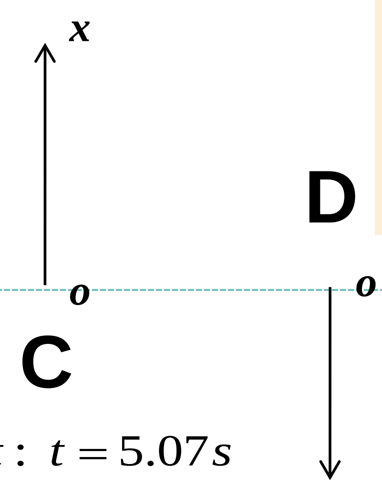
C. $x_0=-50m,\ v_0=-15m/s,\ a=9.8m/s^2$

D. $x_0=-50m,\ v_0=-15m/s,\ a=-9.8m/s^2$

E. $x_0=0,\ v_0=-15m/s,\ a=9.8m/s^2$



$$v = v_0 + at$$
$$x = x_0 + v_0 t + \tfrac{1}{2}at^2$$
$$v^2 = v_0^2 + 2a(x - x_0)$$
$$\bar{v} = \frac{v + v_0}{2}.$$

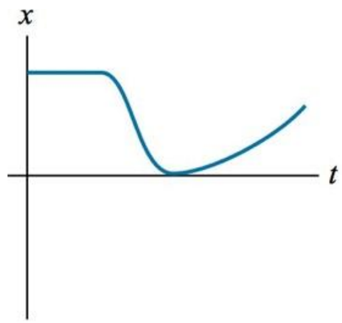


[Solution]

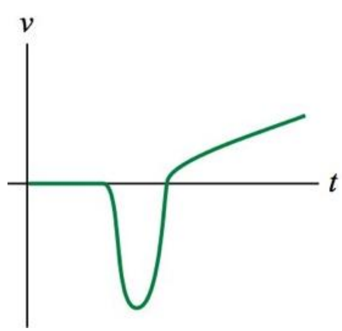
$$x = 0,\ \text{i.e.,}\ 0 = -50 - 15t + \frac{1}{2}(9.8)t^2,\ \text{solve for } t:\ t = 5.07s$$

Demo: x-t, v-t and a-t of a falling basket ball.

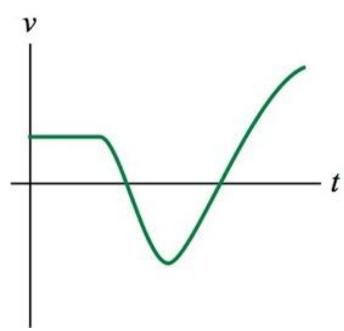
I-clicker question 2-7:
A particle moves with the position-versus-time graph shown. Which graph best illustrates the velocity of the particle as a function of time?



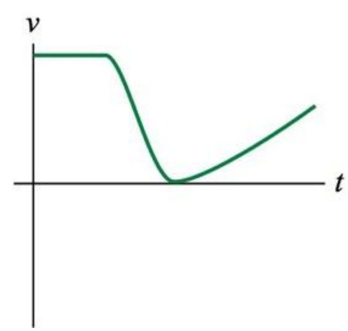
A.



B.



C.



D.