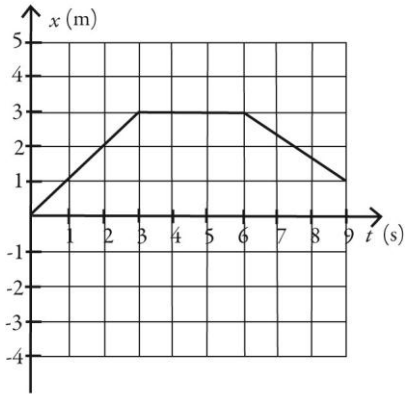
Question 1
Suppose that an object is moving with constant non-zero acceleration. Which of the following is an accurate statement concerning its motion?
A) In equal times its speed changes by equal amounts.
B) In equal times its velocity changes by equal amounts.
C) In equal times it moves equal distances.
D) A graph of its position as a function of time has a constant slope.
E) A graph of its velocity as a function of time is a horizontal line.
F) More than one of the above

The velocity changes by equal amounts but the speed might not, for example if it crosses zero.

The following two problems both deal with the same setup
The figure shows the position of an object as a function of time. During the time interval from time t = 0.0 s and time t = 9.0 s,



Question 2
What is the length of the path the object followed?

A. 1 m
B. 3 m
C. 19.5 m
D. $3+3\sqrt{2}+\sqrt{13}$ m
E. None of the above

For Path Length:
It travels from x=0 m to x=3 m and then back to x=1, for a total of 5 m

For Displacement:
Final Position – Initial Position = 1 m

Question 3
What is the displacement of the object?

A. 1 m
B. 3 m
C. 19.5 m
D. $3+3\sqrt{2}+\sqrt{13}$ m
E. None of the above

Question 4

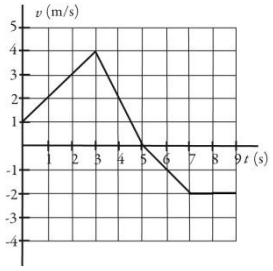
A cart rolling at constant velocity on a level table fires a ball straight up out of a launching tube with a large opening. Neglecting air resistance, when the ball comes back down,

A. it will land in front of the cart.
B. It will land behind the cart.
C. It will land in the tube.
D. It could land in front of the cart, behind it, or in the tube.

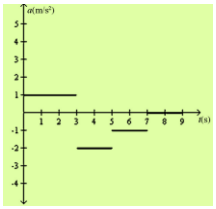
We saw a demonstration (video) of this. The cart and ball both have the same horizontal velocity

Question 5

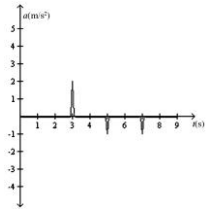
An object is moving in a straight line along the *x*-axis. A plot of its velocity in the *x* direction as a function of time is shown in the figure. Which graph represents its acceleration in the *x* direction as a function of time?



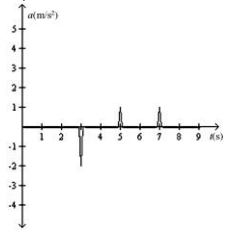
A)



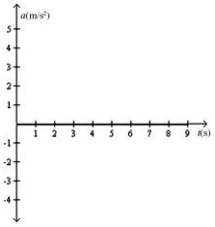
B)



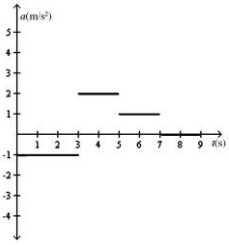
C)



D)



E)

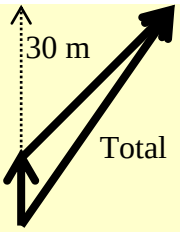


Acceleration is the slope of velocity, so the accelerations are:
(3 m/s)/3 s = 1 m/s^2; (-4 m/s)/2 s = -2 m/s^2; (-2 m/s)/2 s = -1 m/s^2; (0 m/s)/2 s = 0 m/s^2;

Question 6

You walk 10 m to the north, then turn 45° to your right and walk another $30\sqrt{2}$ m. How far are you from where you originally started?

A. $10 + 30\sqrt{2}$ m
B. 40 m
C. 50 m
D. 70 m
E. None of the above



The components of a 45 degree path of length $30\sqrt{2}$ m are 30 m. So,

$\vec{\mathbf{r}} = 30\,\text{m}\hat{\mathbf{i}} + 40\,\text{m}\hat{\mathbf{j}}$

By the Pythagorean theorem, r = 50 m

The following two problems both deal with the same setup

Susan stands on a street corner and observes an object to have a position (relative to her) given by $\vec{\mathbf{r}} = \left[2.0\ \text{m} + \left(3.0\,\frac{\text{m}}{\text{s}}\right)t\right]\hat{\mathbf{i}} + \left[3.0\,\text{m} - \left(2.0\,\frac{\text{m}}{\text{s}^2}\right)t^2\right]\hat{\mathbf{j}}$

Question 7

What is the magnitude of the acceleration of the object at time *t* = 2.0 s?

A. 0.0 m/s^2
B. 1.0 m/s^2
C. 2.0 m/s^2
D. 3.0 m/s^2
E. 4.0 m/s^2
F. 5.0 m/s^2
G. None of the above

$\vec{\mathbf{r}} = \left[2.0\ \text{m} + \left(3.0\,\frac{\text{m}}{\text{s}}\right)t\right]\hat{\mathbf{i}} + \left[3.0\,\text{m}$

$\vec{\mathbf{v}} = \dot{\vec{\mathbf{r}}} = \left[\left(3.0\,\frac{\text{m}}{\text{s}}\right)\right]\hat{\mathbf{i}} + \left[-\left(4.0\,\frac{\text{m}}{\text{s}^2}\right)t\right.$

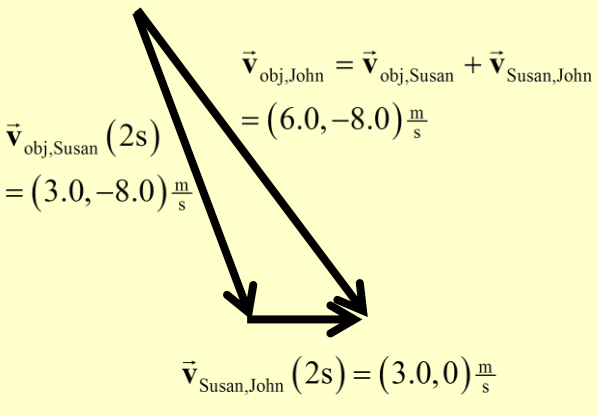
$\vec{\mathbf{a}} = \dot{\vec{\mathbf{v}}} = 0\,\hat{\mathbf{i}} + \left[-\left(4.0\,\frac{\text{m}}{\text{s}^2}\right)\right]\hat{\mathbf{j}}$

$\vec{\mathbf{v}}(t) = -4\,\frac{\text{m}}{\text{s}}\,\hat{\mathbf{i}}$

Question 8

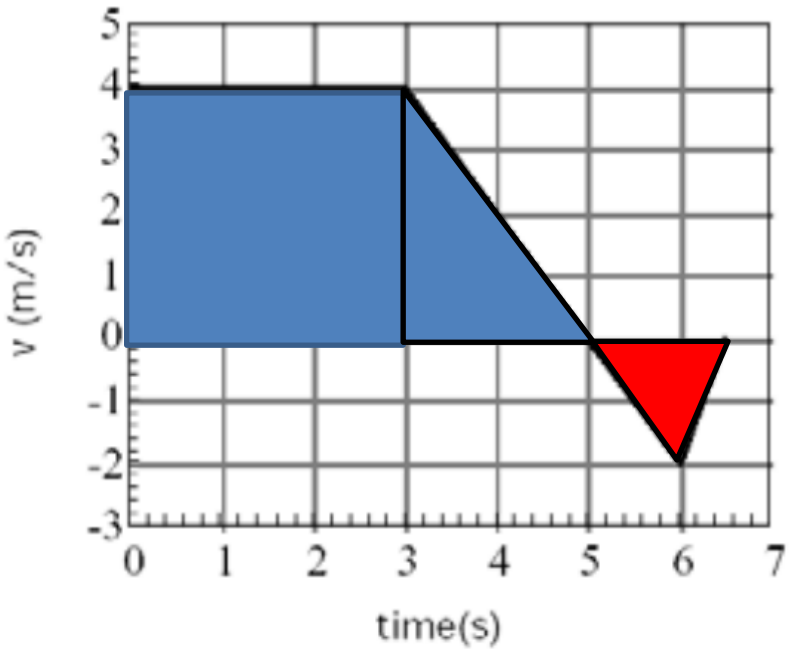
John runs by Susan, who, in his reference frame appears to be moving with velocity $3.0\,\frac{\text{m}}{\text{s}}\,\hat{\mathbf{i}}$. At what speed does John see the object moving at time *t* = 2.0 s?

A. 3 m/s
B. 6 m/s
C. 8 m/s
D. 10 m/s
E. None of the above



Question 9

The figure shows the velocity as a function of time for a particle. What is the particle's position at t = 6.5 s if it starts at x = 0 m at t = 0?



A. 11.5 m
B. 14.5 m
C. 16.0 m
D. 17.5 m
E. 27.0 m
F. 34.0 m

To find displacement we integrate the velocity (find the area under the curve). It consists of both forward motion (to t=5 s) and backward.

$$\Delta x = \left(4\,\tfrac{\text{m}}{\text{s}}\right)(3\text{s}) + \tfrac{1}{2}\left(4\,\tfrac{\text{m}}{\text{s}}\right)(2\text{s}) - \tfrac{1}{2}\left(2\,\tfrac{\text{m}}{\text{s}}\right)(1.5\text{s}) = 14.5\text{ m}$$

Since it starts from x=0 at t=0, its position at t = 6.5 s is just its displacement!

Question 10

Ball bearings are made by letting spherical drops of molten metal fall inside a tall tower – called a *shot tower* – and solidify as they fall. If a bearing needs 4.0 s to solidify enough for impact and is dropped from rest, about how high must the tower be (use g = 10 m/s^2)?

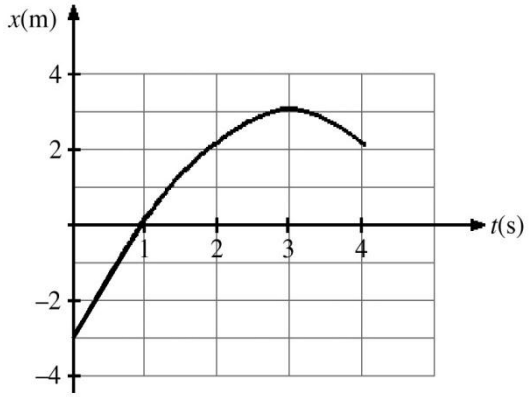
A. 20 m
B. 40 m
C. 80 m
D. 160 m
E. None of the above

Integrating twice (or using a constant acceleration kinematic equation) we have

$$\Delta y = \tfrac{1}{2}at^2 = \tfrac{1}{2}\left(10\,\tfrac{\text{m}}{\text{s}^2}\right)(4\text{s})^2 = 80\text{ m}$$

Question 11

The figure represents the position of a particle as it travels along the *x*-axis. Between t = 2 s and t = 4 s, what are (a) the average velocity $\langle \vec{\mathbf{v}} \rangle$ of the particle and (b) the average speed of the particle – to be precise, the average of the speed $\langle |\vec{\mathbf{v}}| \rangle$ NOT the magnitude of the average velocity $|\langle \vec{\mathbf{v}} \rangle|$?



A) a) 2 m/s, b) 2m/s
B) a) 0 m/s, b) 1 m/s
C) a) 2 m/s, b) 1.5 m/s
D) a) 0 m/s, b) 0 m/s
E) a) 0.75 m/s, b) 1.25 m/s
F) None of the above

Between t = 2 s and 4 s the object has a zero displacement (it starts and ends at x = 2 m) and travels a total distance of 2 m (from x =2 m to x =3 m and back). It does this in 2 seconds. So as velocity is distance over time we have

$\langle \vec{\mathbf{v}} \rangle = 0\text{m}/2\text{s} = 0\,\frac{\text{m}}{\text{s}}; \langle |\vec{\mathbf{v}}| \rangle = 2\text{m}/2\text{s} = 1\,\frac{\text{m}}{\text{s}}$

Question 12

The table gives the velocity of a particle as a function of time. What is the average acceleration in the time interval from t = 0 to t = 20 s?

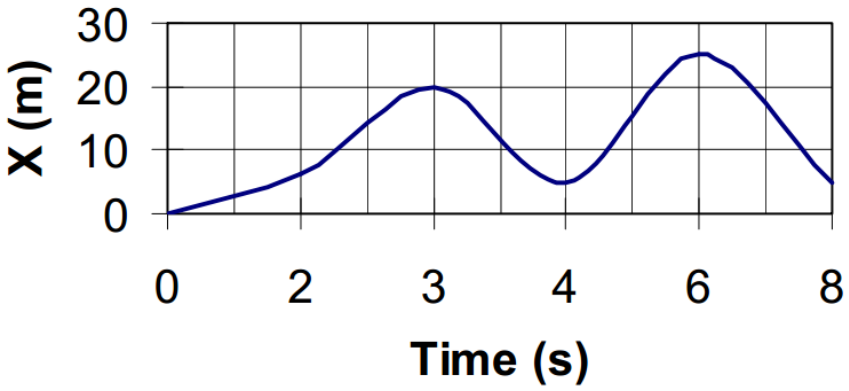
t(sec)	v(m/s)	t(s)	v(m/s)
-5	-10	15	10
0	-10	20	15
5	-10	25	20
10	0	30	25

A. 0
B. 1.0 m/s^2
C. -1.0 m/s^2
D. 1.5 m/s^2
E. -1.5 m/s^2
F. None of the above

Ave. acceleration is defined as change in velocity over change in time. In the 20 seconds between t = 0 and t = 20 s, the object has a change in velocity of 15 m/s - -10 m/s = 25 m/s so $\langle \vec{\mathbf{a}} \rangle = 25\,\frac{\text{m}}{\text{s}}/20\text{s} = 1.2\,\frac{\text{m}}{\text{s}^2}$

Question 13

The figure below shows the position versus time for a particle. Around what time(s) is the particle subject to a negative acceleration?



A. From 6 s to 8 s only

B. Around 3 s and 6 s

C. Around 3 s, 4 s and 6 s

D. Around 6 s only

E. Not at any times shown here

As the second time derivative of position, acceleration gives the concavity of the plot. That is, a negative acceleration means that the velocity is becoming more negative (steeper downhill slope). That happens around t = 3 s (from + to – velocity) and around t = 6 s (same thing). At t = 4 s the change in velocity is positive (concave up).

Question 14

A girl wishes to swim across a river to a point directly opposite. She can swim at 2 m/s in still water and the river is flowing at 1 m/s. At what angle with respect to the line joining the starting and finishing points should she swim?

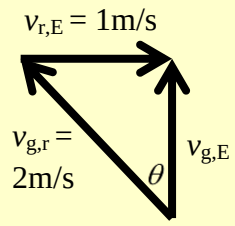
A. 30°

B. 45°

C. 60°

D. 90°

E. None of the above



$\sin\theta = \frac{1}{2} \Rightarrow \theta = 30^\circ$

Question 15

An object is released from rest and falls a distance h during the first second after its release. How far will it fall during the next second?

A. h

B. 2h

C. 3h

D. 4h

E. h^2

For constant acceleration motion we have $\Delta y \propto t_f^2 - t_0^2$. So the change from t = 1 s to t = 2 s ($\propto 4-1=3$) is 3 times as big as the change from t = 0 to t = 1 s.