Physics 221, January 18

Key Concepts:

- Scalar Quantities and Vector Quantities
- Position, Distance, Displacement
- Average Speed, Average Velocity
- Instantaneous Speed, Instantaneous Velocity
- Average Acceleration, Instantaneous Acceleration

Electronic Devices

Please do not use social media during class.

Physics: the key word is change!

Matter interacts and the interactions change the physical state of matter.
The laws of physics predict when and how the physical state of matter changes.

The laws of mechanics predict when and how things move.
We have to agree on a way to describe motion.
We use vector quantities with magnitude and direction and scalar quantities with only magnitude to describe motion.

Vector quantities:

Position: $\mathbf{r} = a\mathbf{i} + b\mathbf{j} + c\mathbf{k}$

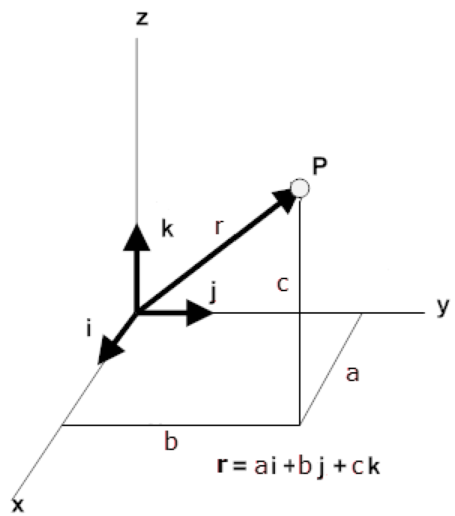
Displacement: $\Delta\mathbf{r} = (x_2 - x_1)\mathbf{i} + (y_2 - y_1)\mathbf{j} + (z_2 - z_1)\mathbf{k}$

Average velocity: $\mathbf{v} = \Delta\mathbf{r}/\Delta t$.

Instantaneous velocity: Let $\Delta t \rightarrow 0$.

Average acceleration: $\mathbf{a} = \Delta\mathbf{v}/\Delta t$.

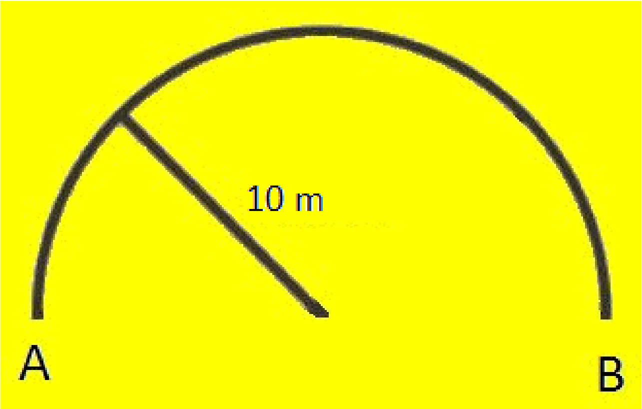
Instantaneous acceleration: Let $\Delta t \rightarrow 0$.



Scalar quantities:
distance, average speed, instantaneous speed

Distance and displacement

A person walks from A to B along a circular path of radius 10.00 m around 1/2 of the circle. What is the magnitude (in m) of the displacement vector?



A. 0 m

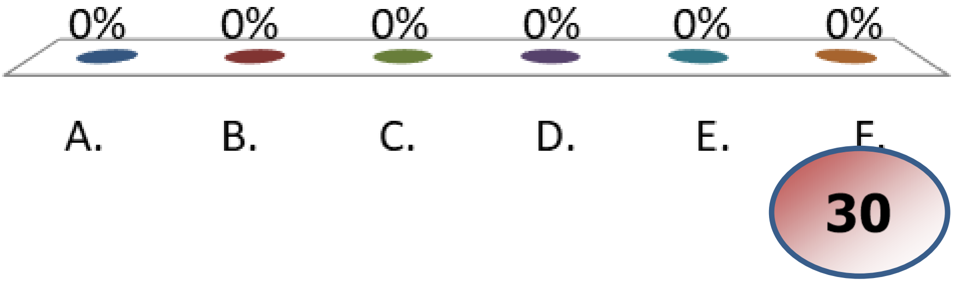
B. 62.8 m

C. 10 m

D. 5 m

E. 31.4 m

F. 20 m

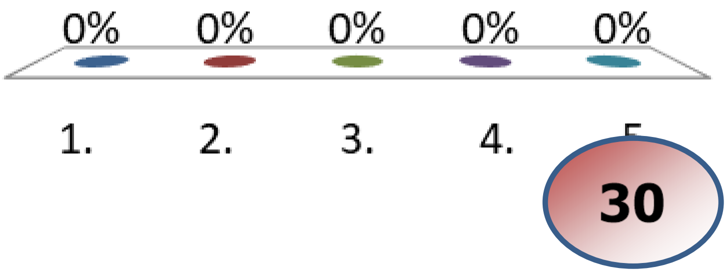


Speed and velocity

A man walks his dog on a very straight path in a park. He can walk back and forth as slow or fast as he wants to, but he has to stay on the path. Which of the following statements is correct for an arbitrary time interval?

Hint:
Is the man required to always travel in the same direction on the straight line path?

1. His average speed can be greater than the magnitude of his average velocity.
2. His average speed must be equal to the magnitude of his average velocity.
3. His average speed can be less than the magnitude of his average velocity.
4. Since he is walking along a straight path, his average acceleration must be zero.
5. His average velocity must be zero.



Motion in 1 dimension

If an object is restricted to move in one dimension, for example along the x-axis, we can specify the vector quantities

position, displacement, velocity, and acceleration

by a signed number with units. The sign of the number than specifies the direction.

In one dimension, if the x-component of a vector is positive, the vector is pointing in the positive x-direction, and if the x-component of a vector is negative, the vector is pointing in the negative x-direction.

We can represent one-dimensional motion using a position versus time graph or a velocity versus time graph.

Motion Graphs for 1D motion

Position versus time graph:

The slope gives the instantaneous velocity. ($v_x = \Delta x/\Delta t$)

Positive slope → positive velocity

Negative slope → negative velocity

Constant slope → constant velocity

Changing slope → acceleration

(The position versus time graph of motion with constant acceleration is a section of a parabola.)

Velocity versus time graph:

The slope gives the instantaneous acceleration. ($a_x = \Delta v_x/\Delta t$)

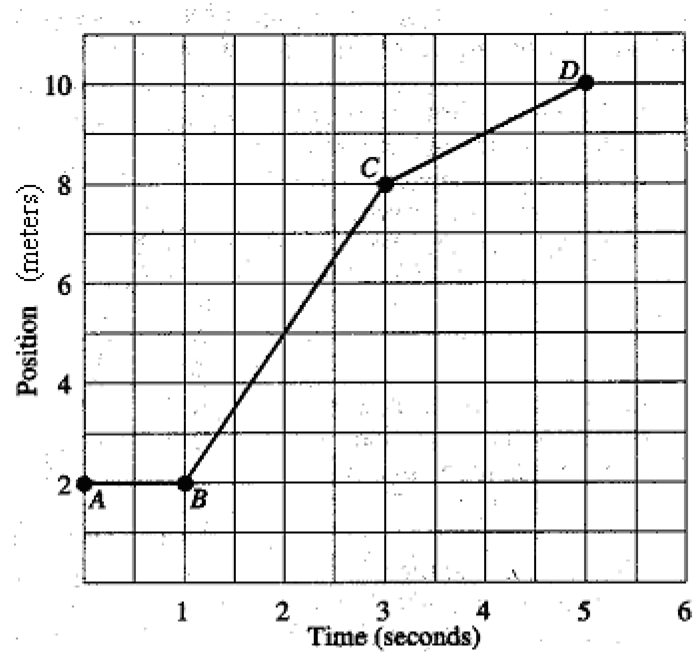
Positive slope → positive acceleration

Negative slope → negative acceleration

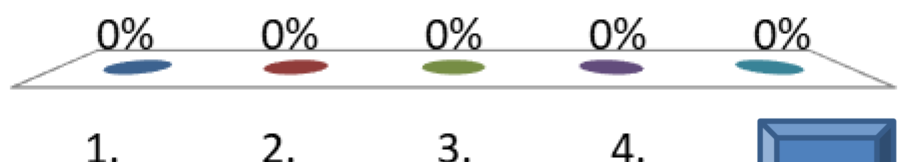
Constant slope → constant acceleration

Getting information from graphs:

The position versus time graph represents the motion of an object moving in a straight line. Find the objects instantaneous velocity at
(a) t = 0.5 s,
(b) t = 2.0s,
(c) t = 4.0s.



1. 2 m/s, (b) 5 m/s, (c) 6 m/s
2. 2 m/s, (b) 8 m/s, (c) 10 m/s
3. 0 m/s, (b) 8/3 m/s, (c) 2 m/s
4. 0 m/s, (b) 3 m/s, (c) 1 m/s
5. 0 m/s, (b) 3/2 m/s, (c) 1/2 m/s



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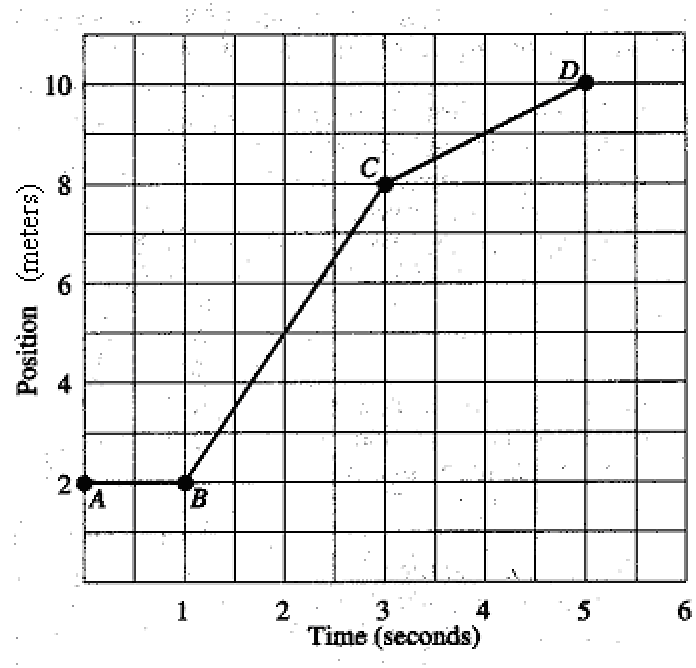
The position versus time graph represents the motion of an object moving in a straight line. Is the magnitude of the average velocity equal to the average speed between A and D?



1. Yes
2. No

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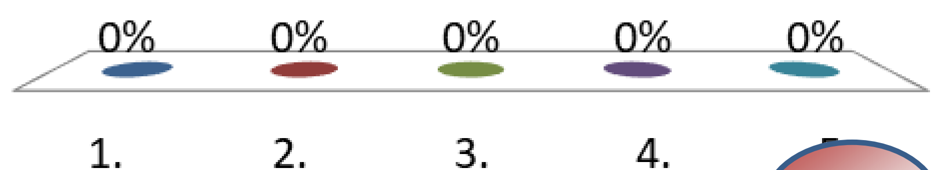
Relative velocity

The water of a river flows with a velocity of +2 m/s in the positive x-direction with respect to the shore. A boat as a velocity of +7 m/s in the positive x-direction with respect to the shore. What is the velocity of the boat with respect to the water?

1. +9 m/s
2. +7 m/s
3. +5 m/s
4. -2 m/s
5. -5 m/s



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Acceleration

$$\mathbf{a} = \Delta\mathbf{v}/\Delta t$$

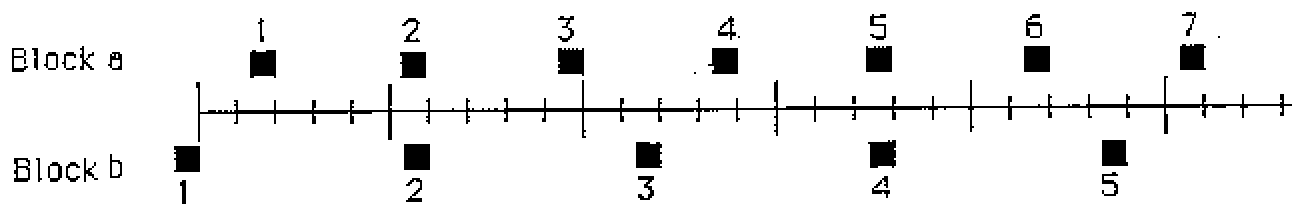
The acceleration **a** is a vector. It is the rate at which the velocity vector is changing. The velocity vector changes when its magnitude changes or its direction changes.

Whenever your velocity is CHANGING, you are accelerating.

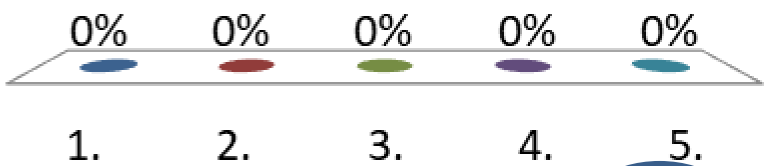
You are accelerating when you CHANGE your speed, CHANGE your direction of travel, and when you change both.

The keyword is CHANGE.

The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure below. The blocks are moving towards the right. The accelerations of the blocks are related as follows:



1. The acceleration of a is greater than the acceleration of b.
2. The acceleration of a equals the acceleration of b. Both accelerations are greater than zero.
3. The acceleration of b is greater than the acceleration of a.
4. The acceleration of a equals the acceleration of b. Both accelerations are zero.
5. Not enough information is given to answer the question.



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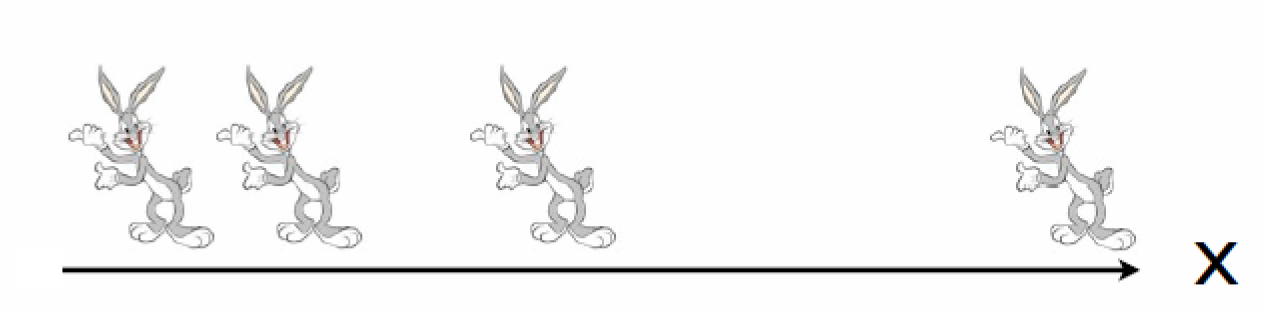
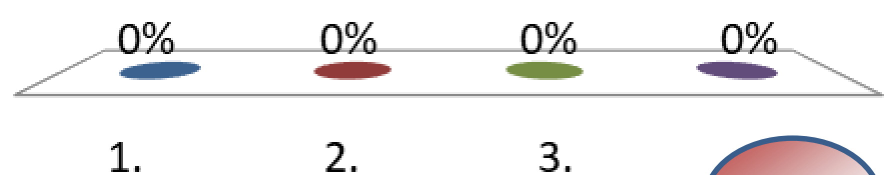
A "motion diagram" is shown. It is a series of snapshots of a bunny's position taken every 1.0 seconds. What is the direction of the acceleration vector if the bunny is moving to the left?



1. In the positive x-direction
2. In the negative x-direction
3. The acceleration is zero.
4. The acceleration does not have a direction.



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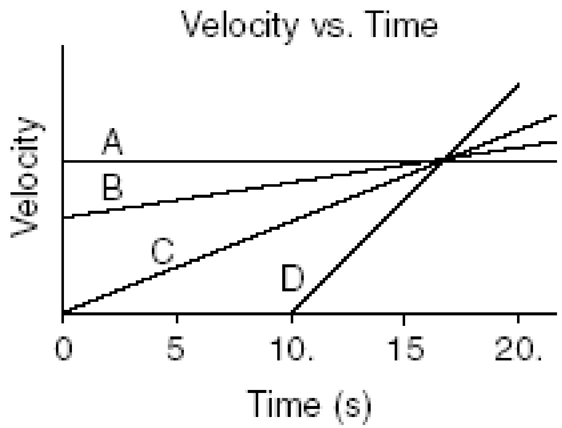
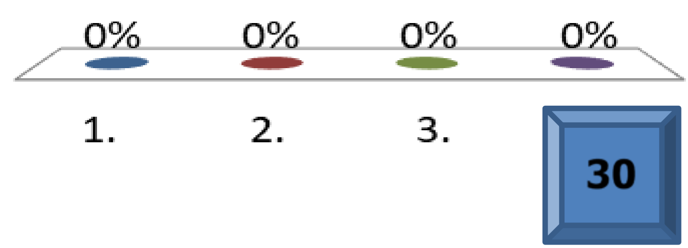
Velocity versus time graphs are shown for 4 objects, A, B, C, and D. Which statement is true?



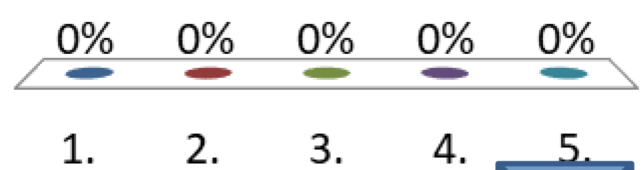
Hint: $a_x = \Delta v_x / \Delta t$ (slope)

1. Sometime between t = 16 and 17 s the objects have the same acceleration.
2. Object A is at rest.
3. All objects are moving with constant velocity.
4. None of the above.



Consider motion in one dimension along the x-axis.
Which statement is TRUE?

1. An object that is slowing down always has a positive acceleration, regardless of the direction it travels.
2. An object that is slowing down always has a negative acceleration, regardless of the direction it travels.
3. An object that is slowing down while traveling in the negative x-direction always has a positive acceleration.
4. An object that is speeding up while traveling in the negative x-direction always has a positive acceleration.
5. An object that is speeding up always has a positive acceleration, regardless of the direction it travels.



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1D Kinematic equations (constant acceleration)

Let $\Delta t = t_f - t_i$.

Then

$v_{xf} = v_{xi} + a_x\Delta t$ or $\Delta v_x = a_x\Delta t$,

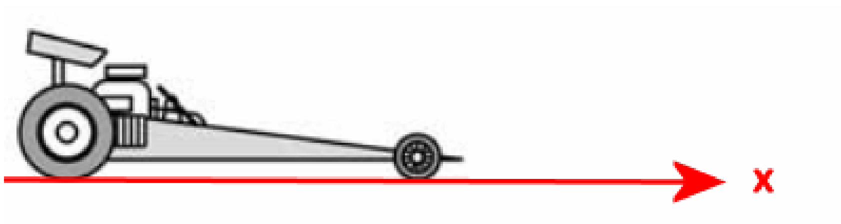
$v_{x(avg)} = (v_{xf} + v_{xi})/2$,

$x_f = x_i + v_{xi}\Delta t + ½a_x\Delta t^2$ or $\Delta x = v_{xi}\Delta t + ½a_x\Delta t^2$.

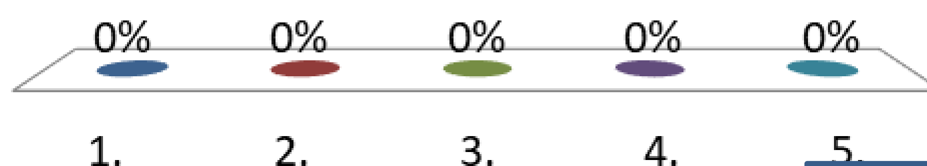
Combining these equations we get

$v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i)$.

Let the x-axis of your coordinate system point along a drag strip. A drag racer starts from rest and accelerates uniformly to a speed of 76.5 m/s in 8.5 seconds. What is the acceleration of the car?



1. 2.1 m/s^2
2. 68 m/s^2
3. 9 m/s^2
4. 650 m/s^2
5. 76.5 m/s^2



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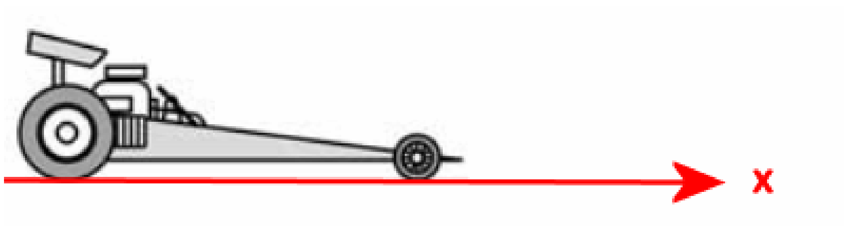
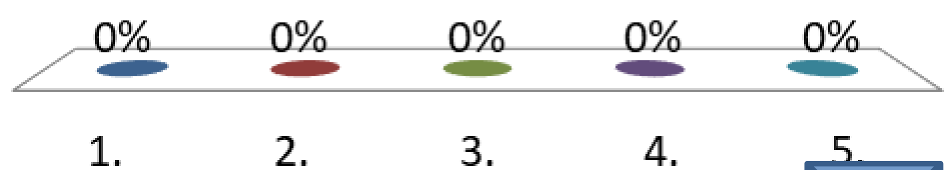
Let the x-axis of your coordinate system point along a drag strip. A drag racer starts from rest and accelerates uniformly to a speed of 76.5 m/s in 8.5 seconds. What is the distance traveled by the car in the 8.5 s?



1. 688 m
2. 38 m
3. 76.5 m
4. 650 m
5. 325 m



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