Kinematics pre-class assignment

Due: 11:59pm on Thursday, May 5, 2022

You will receive no credit for items you complete after the assignment is due. Grading Policy

---

± Average Velocity from a Position vs. Time Graph

Learning Goal:
To learn to read a graph of position versus time and to calculate average velocity.

In this problem you will determine the average velocity of a moving object from the graph of its position $x(t)$ as a function of time t. A traveling object might move at different speeds and in different directions during an interval of time, but if we ask at what *constant* velocity the object would have to travel to achieve the same displacement over the given time interval, that is what we call the object's *average velocity*. We will use the notation $v_{\mathrm{ave}}[t_1, t_2]$ to indicate average velocity over the time interval from t_1 to t_2. For instance, $v_{\mathrm{ave}}[1, 3]$ is the average velocity over the time interval from $t = 1$ to $t = 3$.
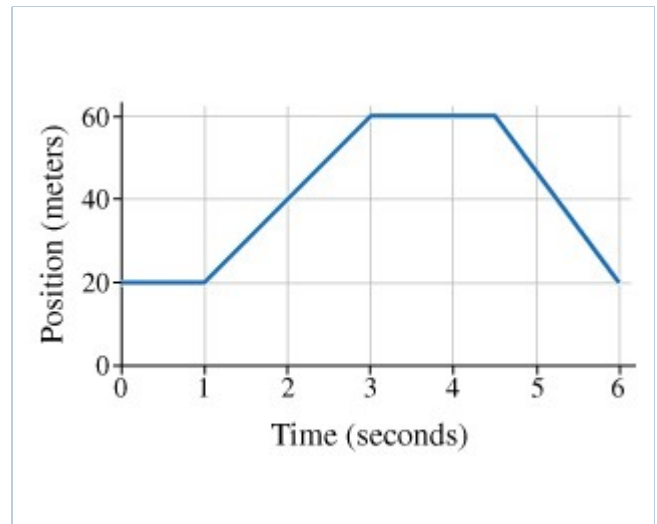
Part A

Consulting the graph shown in the figure, find the object's average velocity over the time interval from 0 to 1 second.

Answer to the nearest integer.

> **Hint 1.** Definition of average velocity
>
> Average velocity is defined as the constant velocity at which an object would have to travel to achieve a given displacement (difference between final and initial positions, which can be negative) over a given time interval, from the initial time t_{i} to the final time t_{f}. The average velocity is therefore equal to the displacement divided by the given time interval. In symbolic form, average velocity is given by
>
> $$v_{\mathrm{ave}}[t_{\mathrm{i}}, t_{\mathrm{f}}] = \frac{x(t_{\mathrm{f}}) - x(t_{\mathrm{i}})}{t_{\mathrm{f}} - t_{\mathrm{i}}}.$$

ANSWER:

$v_{\mathrm{ave}}[0, 1]$ = 0 m/s

Correct

Part B

Find the average velocity over the time interval from 1 to 3 seconds.

Express your answer in meters per second to the nearest integer.

Hint 1. Find the change in position

The final and initial positions can be read off the y axis of the graph. What is the displacement during the time interval from 1 to 3 seconds?

Express your answer numerically, in meters

ANSWER:

$x_f - x_i = \ 40 \ \ \mathrm{m}$

Hint 2. Definition of average velocity

Average velocity is defined as the constant velocity at which an object would have to travel to achieve a given displacement (difference between final and initial positions, which can be negative) over a given time interval, from the initial time t_i to the final time t_f. The average velocity is therefore equal to the displacement divided by the given time interval. In symbolic form, average velocity is given by

$$v_{\mathrm{ave}}[t_i, t_f] = \frac{x(t_f) - x(t_i)}{t_f - t_i}.$$

ANSWER:

$v_{\mathrm{ave}}[1, 3] = \ 20 \ \ \mathrm{m/s}$

Correct

A note about instantaneous velocity. The instantaneous velocity at a certain moment in time is represented by the slope of the graph at that moment. For straight-line graphs, the (instantaneous) velocity remains constant over the interval, so the instantaneous velocity at any time during an interval is the same as the average velocity over that interval. For instance, in this case, the instantaneous velocity at any time from 1 to 3 seconds is the same as the average velocity of $20 \ \mathrm{m/s}$.

Part C

Now find $v_{\mathrm{ave}}[0, 3]$.

Give your answer to three significant figures.

Hint 1. A note on the displacement

Since the object's position remains constant from time 0 to time 1, the object's displacement from 0 to 3 is the same as in Part B. However, the time interval has changed.

ANSWER:

$v_{\mathrm{ave}}[0, 3] = \ 13.3 \ \ \mathrm{m/s}$

Correct

Note that $v_{\mathrm{ave}}[0, 3]$ is not equal to the simple arithmetic average of $v_{\mathrm{ave}}[0, 1]$ and $v_{\mathrm{ave}}[1, 3]$, i.e., $\frac{v_{\mathrm{ave}}[0,1] + v_{\mathrm{ave}}[1,3]}{2}$, because they are averages for time intervals of different lengths.

Part D

Find the average velocity over the time interval from 3 to 6 seconds.

Express your answer to three significant figures.

Hint 1. Determine the displacement

What is the displacement?

Answer to the nearest integer.

ANSWER:

$x(6.0) - x(3.0) =$ -40   m

Hint 2. Determine the time interval

What is the time interval?

Answer to two significant figures.

ANSWER:

$t_f - t_i =$ 3.0   s

ANSWER:

$v_{ave}[3.0, 6.0] =$ -13.3   m/s

Correct

Part E

Finally, find the average velocity over the whole time interval shown in the graph.

Express your answer to three significant figures.

Hint 1. Determine the displacement

What is the displacement?

Answer to the nearest integer.

ANSWER:

$x(6.0) - x(0.0) =$ 0   m

ANSWER:

$v_{ave}[0.0, 6.0] =$ 0   m/s

> **Correct**
>
> Note that though the *average* velocity is zero for this time interval, the *instantaneous* velocity (i.e., the slope of the graph) has several different values (positive, negative, zero) during this time interval.
>
> Note as well that since average velocity over a time interval is defined as the change in position (displacement) in the given interval divided by the time, the object can travel a great distance (here 80 meters) and still have zero average velocity, since it ended up exactly where it started. Therefore, zero average velocity does not necessarily mean that the object was standing still the entire time!

Exercise 2.1

A car travels in the $+x$-direction on a straight and level road. For the first 2.00 s of its motion, the average velocity of the car is $v_{\mathrm{av}-x}$ = 7.86 $\mathrm{m/s}$.

Part A

How far does the car travel in 2.00 s ?

Express your answer with the appropriate units.

ANSWER:

Δx =   15.7 m

> **Correct**

Exercise 2.3

You normally drive on the freeway between San Diego and Los Angeles at an average speed of 105 $\mathrm{km/h}$, and the trip takes 2 h and 20 min. On a Friday afternoon, however, heavy traffic slows you down and you drive the same distance at an average speed of only 71.5 $\mathrm{km/h}$.

Part A

How much longer does the trip take?

ANSWER:

t =   65.6 min

> **Correct**

Exercise 2.4

Starting from a pillar, you run a distance 200 m east (the $+$ x-direction) at an average speed of 5.0 m/s, and then run a distance 280 m west at an average speed of 4.0 m/s to a post.

Part A

Calculate your average speed from pillar to post.

Express your answer using two significant figures.

ANSWER:

$v =$ 4.4   m/s

Correct

Part B

Calculate your average velocity from pillar to post.

Express your answer using two significant figures.

ANSWER:

-0.73 $\hat{i}$ m/s

Correct

Exercise 2.6

A Honda Civic travels in a straight line along a road. Its distance x from a stop sign is given as a function of time t by the equation $x(t) = \alpha t^2 - \beta t^3$, where α = 1.48 m/s^2 and β = 0.0540 m/s^3.

Part A

Calculate the average velocity of the car for the time interval $t = 0$ to t_1 = 2.10 s.

Express your answer in meters per second.

ANSWER:

$v =$ 2.87   m/s

Correct

Part B

Calculate the average velocity of the car for the time interval $t = 0$ to t_2 = 4.10 s.

Express your answer in meters per second.

ANSWER:

$v = $ 5.16 m/s

Correct

Part C

Calculate the average velocity of the car for the time interval t_1 = 2.10 s to t_2 = 4.10 s.

Express your answer in meters per second.

ANSWER:

$v = $ 7.57 m/s

Correct

Score Summary:

Your score on this assignment is 99.4%.
You received 99.4 out of a possible total of 100 points.