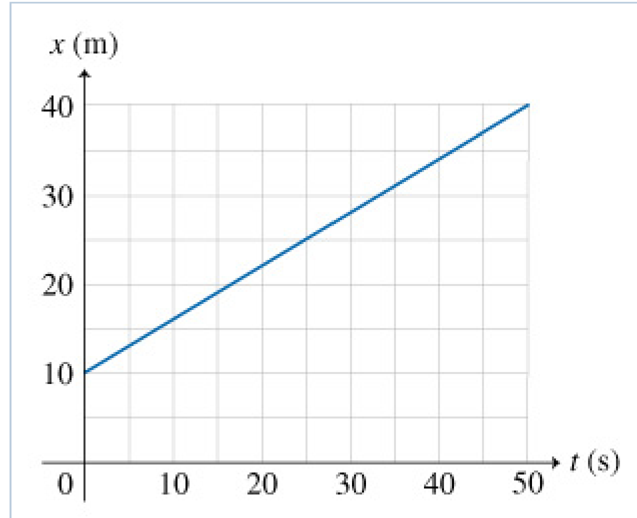
Description: Find average and instantaneous velocity given an x vs. t graph. The relation between area under the v vs. t curve and distance traveled is presented.

Constants | Periodic Table

To describe the motion of a particle along a straight line, it is often convenient to draw a graph representing the position of the particle at different times. This type of graph is usually referred to as an *x vs. t graph.* To draw such a graph, choose an axis system in which time t is plotted on the horizontal axis and position x on the vertical axis. Then, indicate the values of x at various times t. Mathematically, this corresponds to plotting the variable x as a function of t. An example of a graph of position as a function of time for a particle traveling along a straight line is shown below. Note that an x vs. t graph like this does *not* represent the path of the particle in space.

Now let's study the graph shown in the figure in more detail. Refer to this graph to answer Parts A, B, and C.



Part A

What is the overall displacement Δx of the particle?

Express your answer in meters.

▸ **View Available Hint(s)** (2)

ANSWER:

$\Delta x =$ 30 m

In this example, the magnitude of the displacement is also equal to the total *distance* traveled by the particle (30 m).

Part B

What is the average velocity v_{av} of the particle over the time interval $\Delta t = 50.0 \text{ s}$?

Express your answer in meters per second.

▶ **View Available Hint(s)** (2)

ANSWER:

v_{av} = 0.600 m/s

The average velocity of a particle between two positions is equal to the slope of the line connecting the two corresponding points in an x vs. t graph.

Part C

What is the instantaneous velocity v of the particle at $t = 10.0 \text{ s}$?

Express your answer in meters per second.

▶ **View Available Hint(s)** (1)

ANSWER:

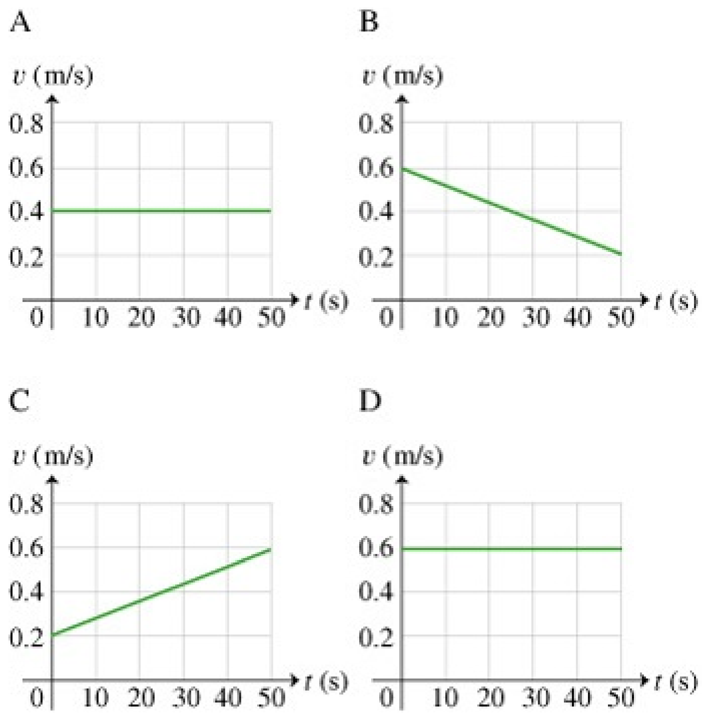
v = 0.600 m/s

The instantaneous velocity of a particle at any point on its x vs. t graph is the slope of the line tangent to the curve at that point. Since in the case at hand the curve is a straight line, the tangent line is the curve itself. Physically, this means that the instantaneous velocity of the particle is *constant* over the entire time interval of motion. This is true for any motion where distance increases linearly with time.

Another common graphical representation of motion along a straight line is the *v vs. t graph*, that is, the graph of (instantaneous) velocity as a function of time. In this graph, time t is plotted on the horizontal axis and velocity v on the vertical axis. Note that by definition, velocity and acceleration are vector quantities. In straight-line motion, however, these vectors have only one nonzero component in the direction of motion. Thus, in this problem, we will call v the velocity and a the acceleration, even though they are really the components of the velocity and acceleration vectors in the direction of motion.

Part D

Which of the graphs shown is the correct v vs. t plot for the motion described in the previous parts?



▸ **View Available Hint(s)** (1)

ANSWER:

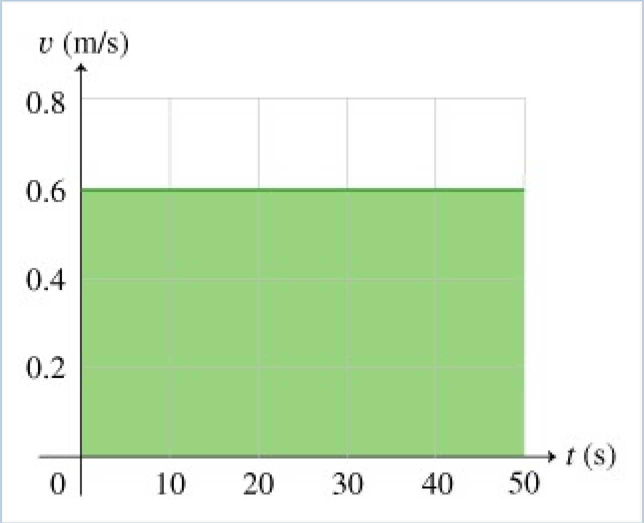
- ○ Graph A
- ○ Graph B
- ○ Graph C
- ◉ Graph D

Whenever a particle moves with constant nonzero velocity, its x vs. t graph is a straight line with a nonzero slope, and its v vs. t curve is a horizontal line.

Part E

Shown in the figure is the v vs. t curve selected in the previous part. What is the area A of the shaded region under the curve?

Express your answer in meters.



▸ **View Available Hint(s)** (1)

ANSWER:

$A =$ 30 m

Compare this result with what you found in Part A. As you can see, the area of the region under the v vs. t curve equals the overall displacement of the particle. This is true for any velocity curve and any time interval: The area of the region that extends over a time interval Δt under the v vs. t curve is always equal to the displacement over Δt.