Graphing Position & Velocity

Name: _____

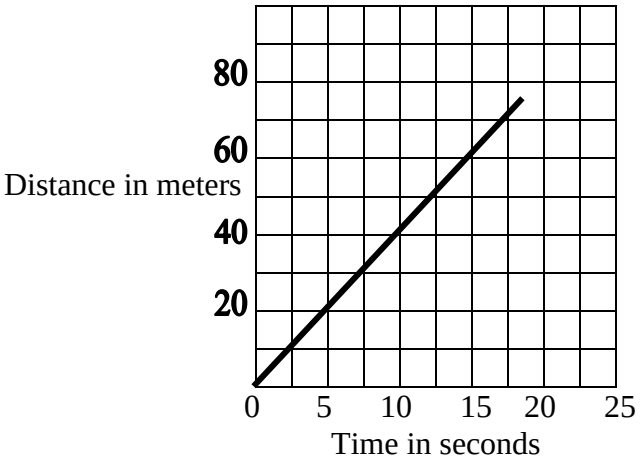
Date: _____

Information: Speed Graphs

Recall that speed is a measure of how fast an object's distance changes. By graphing distance vs. time we can investigate an object's speed graphically.

Critical Thinking Questions

1. Consider the following graph of a car driving. Use the graph to answer the following questions:



a) How long did it take the car to travel 10 meters? About 2.5 seconds

b) Consider the time interval between 0 and 10 seconds.

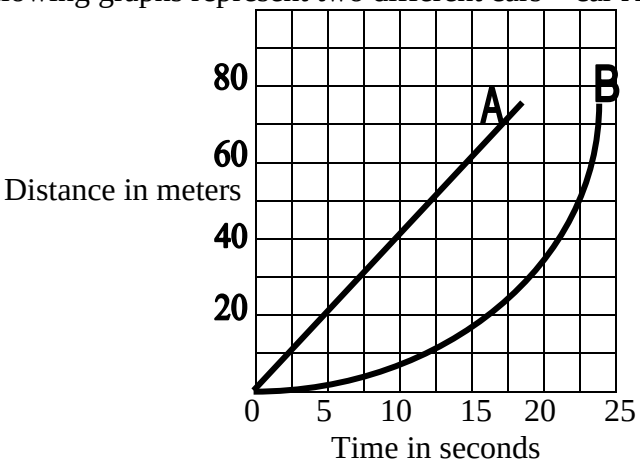
i) How far did the car travel during that time? About 40 meters

ii) What was the car's average speed during that time? 40m ÷ 10s = 4 m/s

c) Consider the time interval between 5 and 15 seconds. What was the car's average speed during that time? Distance = 60-20=40m Time = 15-5=10s
Speed = 40m÷10s = 4 m/s

d) From this graph we can conclude that between 0 and 15 seconds…
   A) the speed was constant
   B) the velocity was constant
   C) both speed and velocity was constant
   D) we can't conclude for sure that the speed or velocity was constant.

2. The following graphs represent two different cars—car A and car B.



a) What is the average speed of Car A during the time interval of 0-10 seconds?
40m ÷ 10s = 4 m/s

b) What was the average speed of Car B during the time interval of 0-10 seconds?
Distance is about 7m so 7m÷10s = 0.7 m/s

c) What was the average speed of Car A during the time interval of 10-20 seconds?
4 m/s

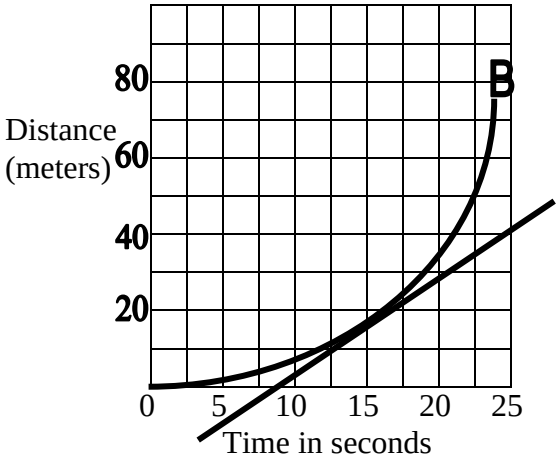
d) What was the average speed of Car B during the time interval of 10-20 seconds?
Distance = 35-7=28m Speed = 28m÷10s = 2.8m/s

3. Only one of the cars from the previous question had a *constant* speed. Which one? Justify your answer.
Car A; we calculated the same answer for part a and c above.

4. Given a graph of distance vs. time, how can you tell if the object had constant speed?
It will have a straight line.

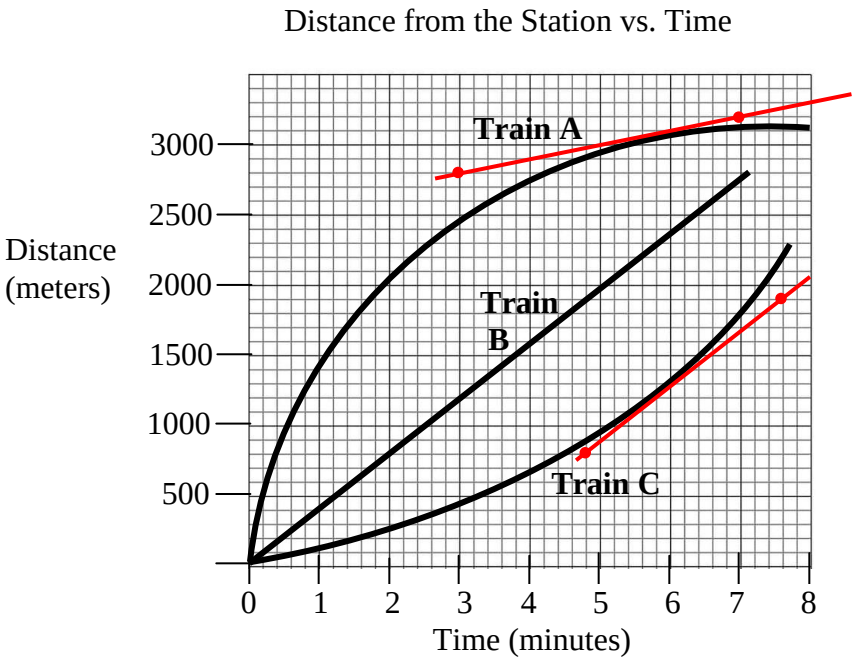
Information: Finding Instantaneous Speed from a Graph

To the right is the graph showing Car B's change in distance per time. The speed of Car B is changing; it is NOT constant. We saw in question 2 (b) and (d) that we could calculate the average speed over an interval of time. To find the instantaneous speed we need to use a **tangent line**. For example, to find the instantaneous speed at time=15 seconds, I have drawn a **tangent line** at 15 seconds. A **tangent line** is a line that only touches the curve at one place—in our example it is at 15 seconds. The slope of the tangent line will be equal to the instantaneous speed of Car B at 15 seconds.



Critical Thinking Questions

5. Three trains departed the train station. Consider the following graph of the distance of each train from the station.



a) Train **B** is going a constant speed the entire time. Train **A** starts fast, but then slows down. Train **C** starts slow and then speeds up.

b) Calculate the average speed of each train between 2 and 5 minutes.

$$\text{Train A speed} = \frac{\Delta\text{distance}}{\Delta\text{time}} = \frac{(2950-2050)}{5-2} = 300 \text{ m/min}$$

$$\text{Train B speed} = \frac{\Delta\text{distance}}{\Delta\text{time}} = \frac{(1950-800)}{5-2} = 383 \text{ m/min}$$

$$\text{Train C speed} = \frac{\Delta\text{distance}}{\Delta\text{time}} = \frac{(950-250)}{5-2} = 233 \text{ m/min}$$

c) Find the instantaneous speed of each train at 6 minutes. Draw a tangent line whenever necessary.

$$\text{Slope of tangent A} = \frac{\Delta y}{\Delta x} = \frac{(3200-2800)}{7-3} = 100 \text{ m/min}$$

$$\text{Slope of tangent C} = \frac{\Delta y}{\Delta x} = \frac{(1900-800)}{7.6-4.8} = 321 \text{ m/min}$$

Since train B has a constant slope, the slope remains the same as what we calculated in part (b) = 383 m/min

Information: Graphing Velocity vs. Time

Imagine that a friend lives straight down the road. Let's say you drove to your friend's house and then turned around and returned home. The trip can be summarized by the following two graphs. Note that Graph A is position vs. time and Graph B is velocity vs. time. Also, note that both graphs describe the same trip to your friend's house and back.

Graph A

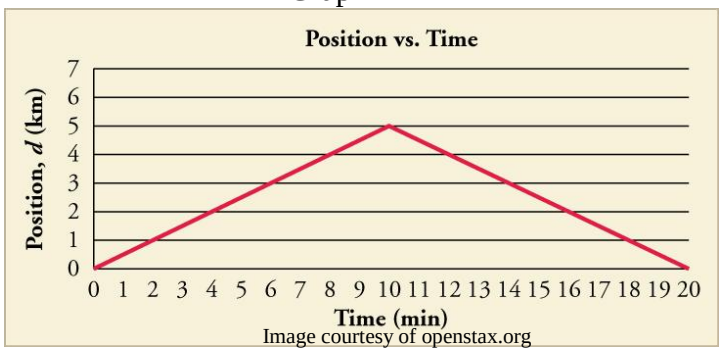


Image courtesy of openstax.org

Graph B

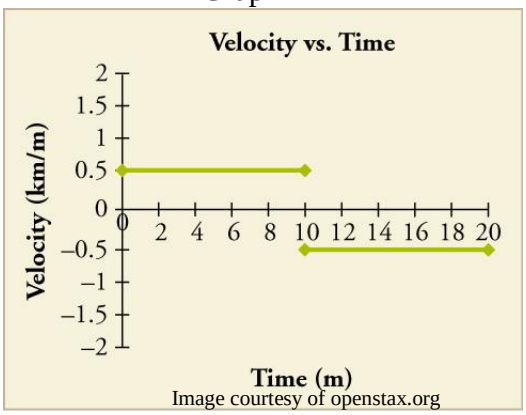
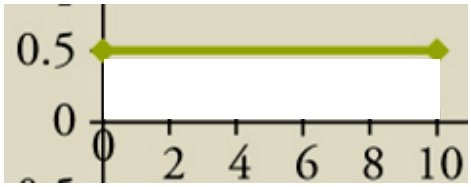


Image courtesy of openstax.org

Critical Thinking Questions

6. Given Graph A, how far away is your friend's house? 5 km from your house

7. Consider the first 10 minutes of Graph B. Calculate the area under the graph. (In Graph B, the area is simply a rectangle with two sides equal to 0.5 and two sides equal to 10.)



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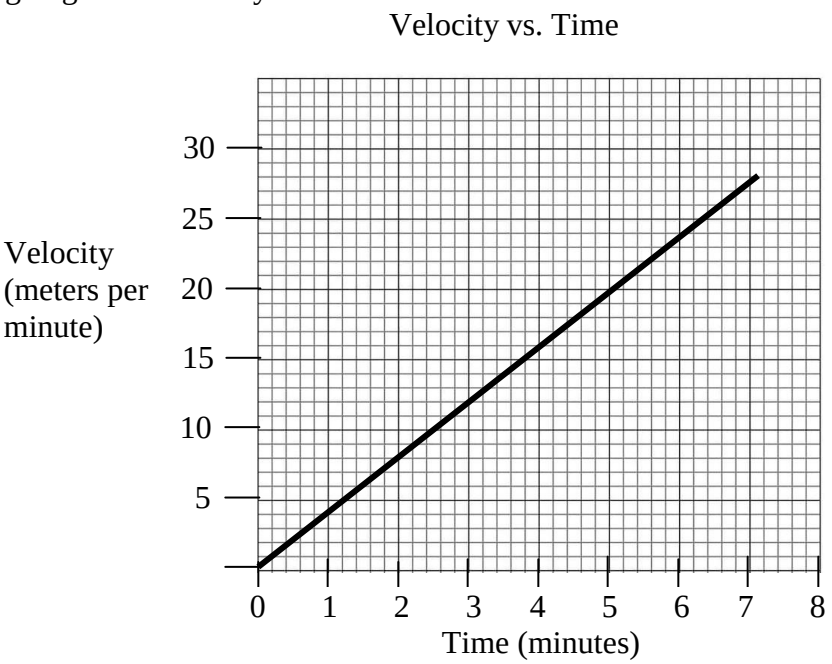
8. From your answers to questions 6 and 7 we learn that on a velocity vs. time graph, the area under the graph is equal to the _____distance traveled_____.

9. From 10-20 minutes, why is the velocity negative?

   The direction of motion is opposite of the original direction.

10. Explain from each graph how we know the velocity is constant during the first 10 minutes.
    In Graph A, the line is straight. In Graph B the line is horizontal (flat).

11. Consider the following graph of velocity vs. time for an airplane beginning to go start going on the runway.



a) Is the velocity constant on this graph? How do you know?

It is not constant because the line is sloping upward. This indicates that as the time changes so does the velocity.

b) Recall from questions 6-8 what the area under a velocity vs. time graph tells you. Calculate and compare the distance travelled during the 1st minute and the 2nd minute.

Distance traveled during the 1st minute = 2 meters

Distance traveled during the 2nd minute = 6 meters