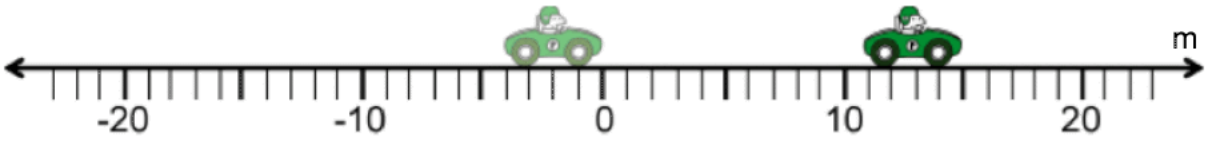
Practice 2.1: Position, Distance, and Change in Position

For problems 1-8, you see two cars on each number line: the front end of the faded car represents the position of the car at the initial time (beginning of motion), and the front end of the solid car represents the position of the car at a later time, the final time.

A car travels as shown below. Calculate the quantities indicated

1.



Initial position, x_i = Final position, x_f =

Mathematical Expression:

Change in position: Distance traveled:

2.

Initial position, x_i = Final position, x_f =

Mathematical Expression:

Change in position: Distance traveled:

3.

Initial position, x_i = Final position, x_f =

Mathematical Expression:

Change in position: Distance traveled:

A car travels as shown below. Calculate the quantities indicated

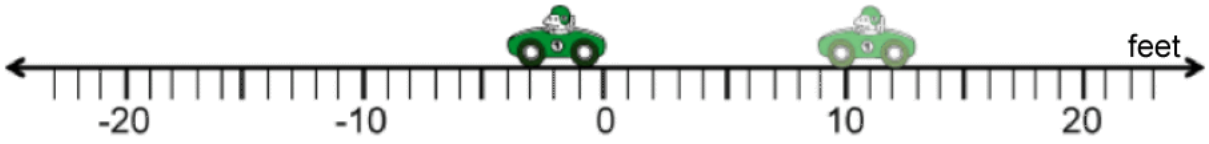
4.

Initial position, x_i = Final position, x_f =

Mathematical Expression:

Change in position: Distance traveled:

5.



Initial position, x_i = Final position, x_f =

Mathematical Expression:

Change in position: Distance traveled:

6.

Initial position, x_i = Final position, x_f =

Mathematical Expression:

Change in position: Distance traveled:

7.

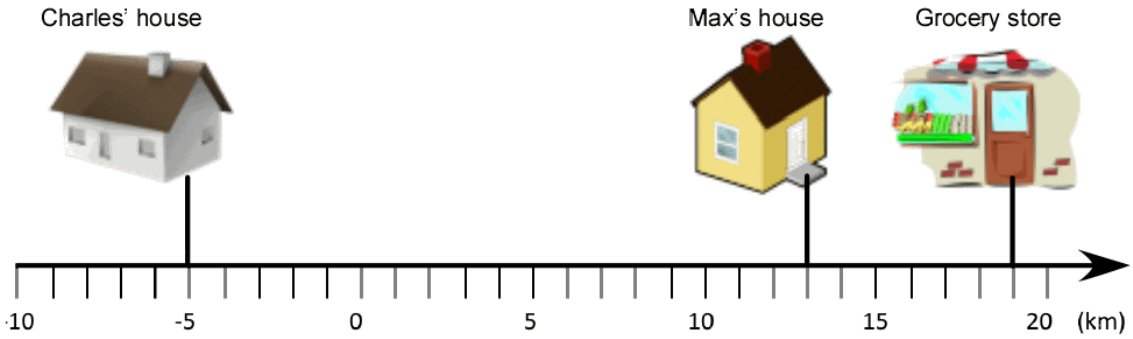
Initial position, x_i = Final position, x_f =

Mathematical Expression:

Change in position: Distance traveled:

© 2009 A TIME for Physics First: Uniform Motion

8. Charles and Max plan to make dinner at Max's house. Charles leaves Max's house and drives to the grocery store. The km-marker of each location is indicated in the diagram.



a) What is Charles' position when he is at the grocery store?

b) What is the change in position for Charles?

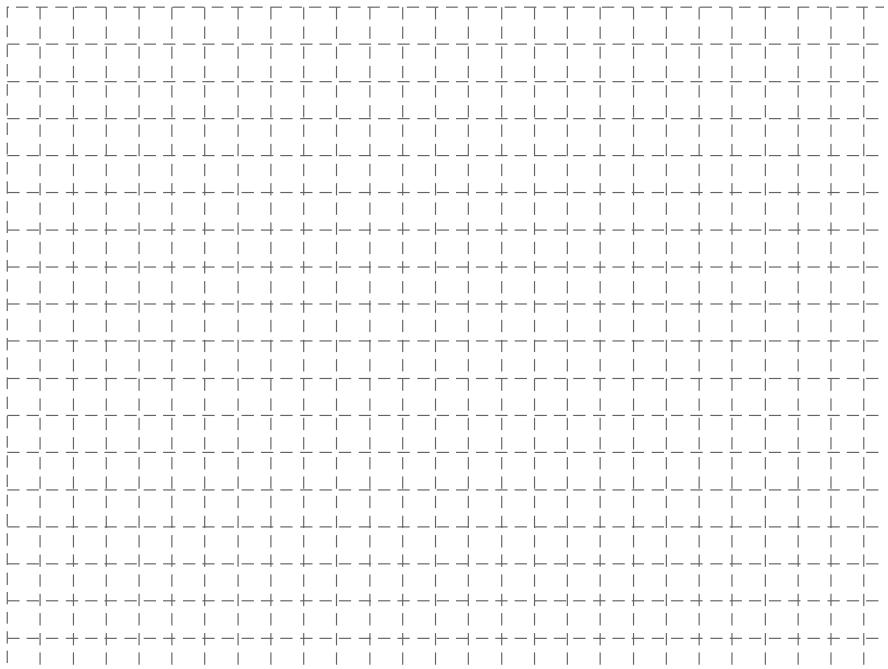
c) When he is done shopping, Charles drives back to Max's house. What is the total change in position for Charles?

d) What is the total distance Charles drove?

Practice 2.2: Analyzing Position, Distance and Slope

1. Jamie marks the position of a traveling toy car as the clock ticks. The data obtained is shown in the table. Draw a graph of the car's position vs. time, and answer the questions below. ("Clock tick" refers to whatever unit you used to measure time intervals – it might be a metronome, or a flashing light, etc.)

Clock tick	Position (cm)
1	4.0
2	6.2
3	7.9
4	10.1
5	12.2
6	13.9
7	16
8	17.8



a) What was the position of the car at clock tick #3? At clock tick # 5?

b) How much distance did the object travel between clock tick #3 and clock tick #5?

c) What is the change in position between clock tick #3 and #5?

© 2009 A TIME for Physics First: Uniform Motion

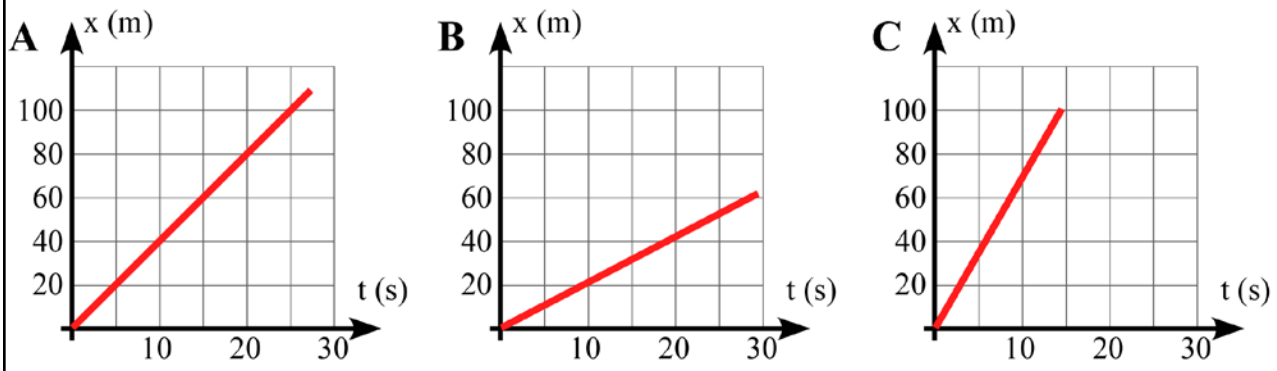
d) What do you think is the difference between the terms “position” and “distance?” Give an everyday example where you might use both position and distance (in the same example).

e) If Δx represents change in position, what do you think Δt would represent? How would you calculate Δt?

f) What is the vertical intercept of your graph, and what do you think it means? How does it relate to the setup of the experiment?

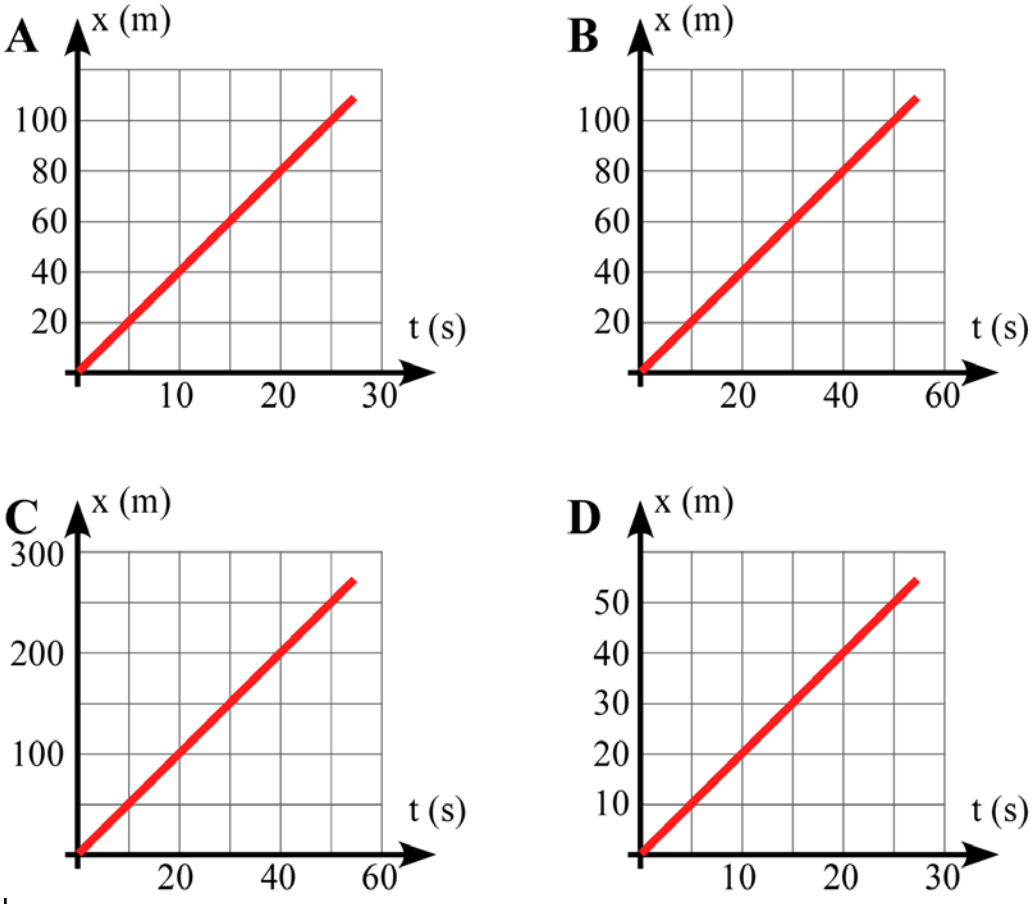
Practice 2.3: Finding Slope

1. By simply looking at the tilt of the lines in the x vs. t graphs below, rank the speed of the motion represented by each graph.



Ranking: (slowest) _____ _____ _____ (fastest)

2. Look at the graphs given below.



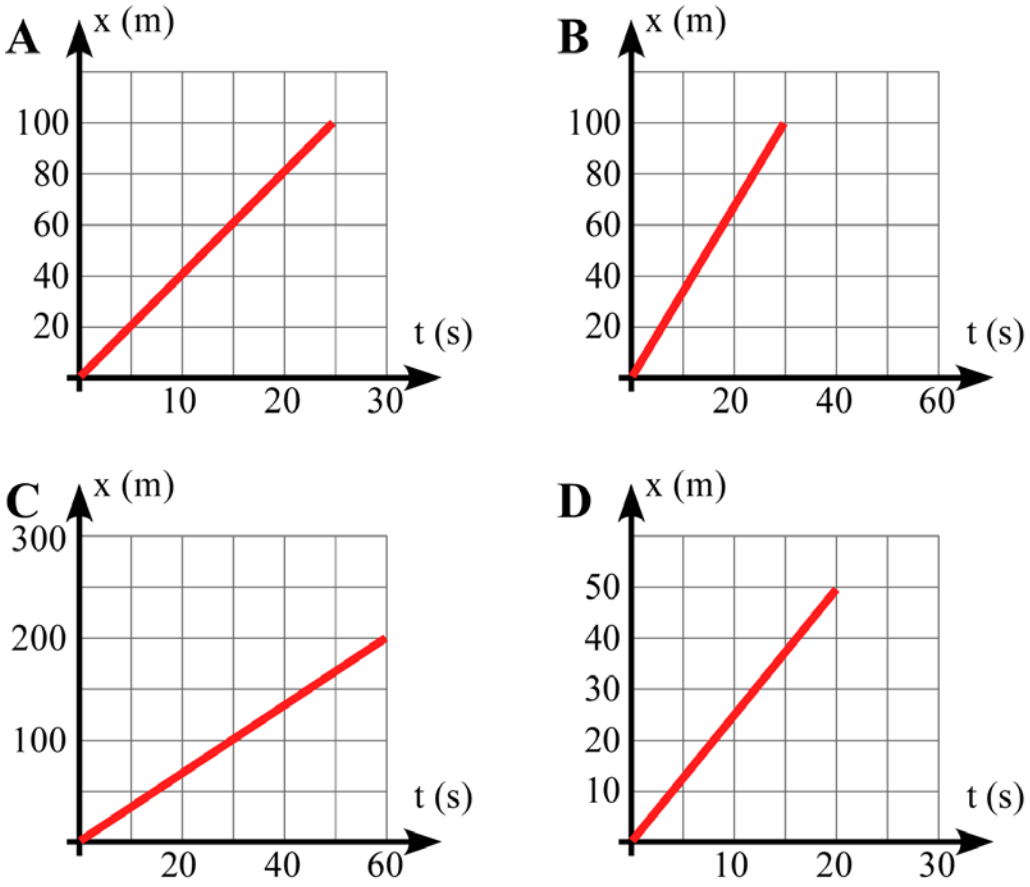
a) Can you rank the slopes of those graphs by simply looking at the line? Explain how you got your answer.

© 2009 A TIME for Physics First: Uniform Motion

b) Calculate the slope of each of the x vs t graphs.

c) Rank the speed of the motion represented by each graph (slowest first):

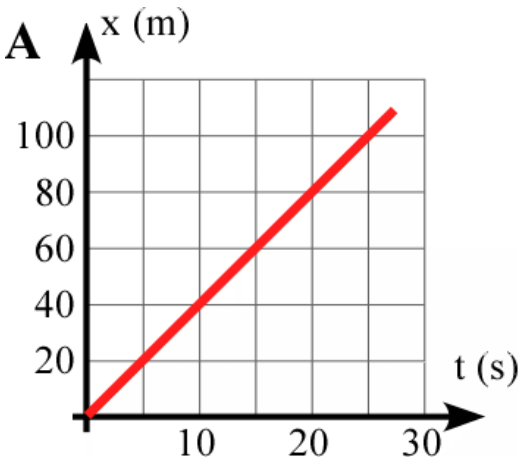
3. In the graphs given below,



a) Calculate the slope of each of the x vs t graphs

b) Rank the speed of the motion represented by each graph from slowest to fastest.

4. Each one of the graphs below shows how the position of an object changes with time.

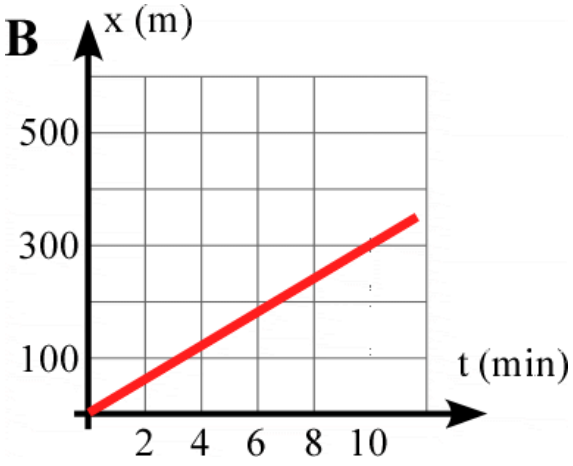


Calculate the speed:

Speed in m/s

Position at t = 15s is:

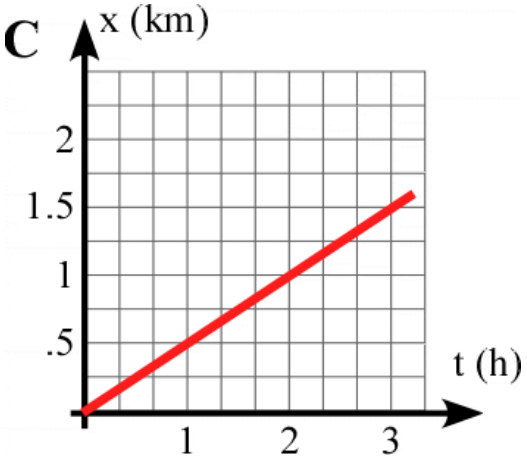
Position at t = 25s is:



Calculate the speed:

Speed in m/s

Position at t = 10 min is:



Calculate the speed:

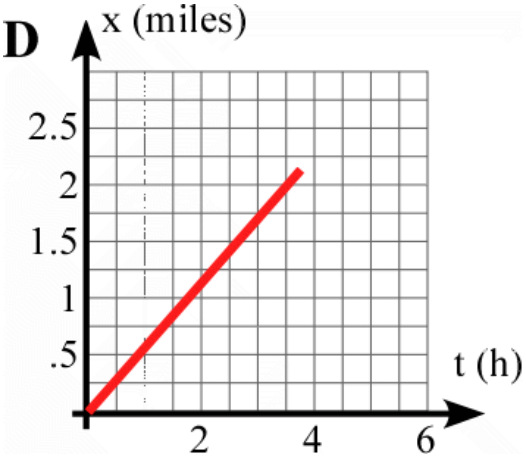
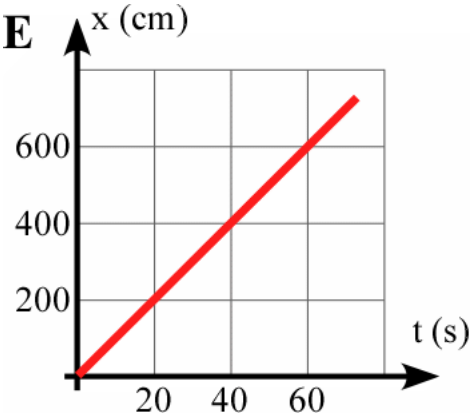
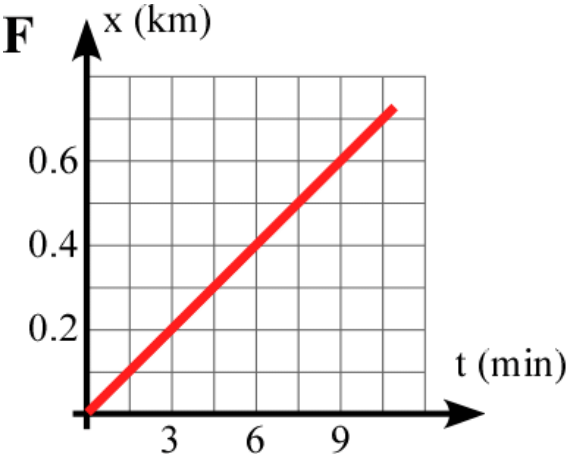
Speed in m/s

Position at t = 3h is:

Position at t = 2h is:

Position at t = 1h 20 min is:

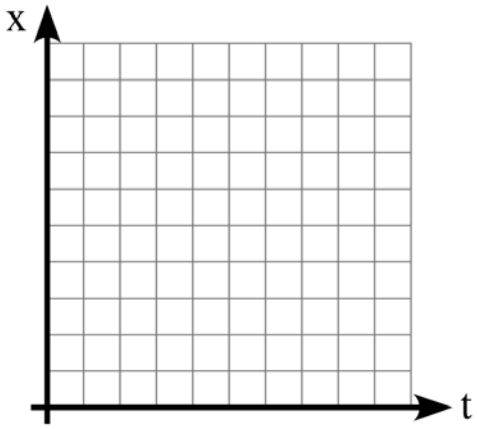
© 2009 A TIME for Physics First: Uniform Motion

D  	Calculate the speed: Speed in m/s Position at t = 30 min is: Position at t = 1h 30 min is:
E  	Calculate the speed: Speed in m/s Position at t = 20 sec is: Position at t = 60 sec is:
F  	Calculate the speed: Speed in m/s Position at t = 3 min is: Position at t = 9 min is:

Practice 2.4: Motion with Constant Speed

1. Robin was roller skating down a marked sidewalk. She was observed to be at the following positions at the times listed:

t (s)	x (m)
0.0	10
1.0	12
2.0	14
5.0	20
8.0	26
10.0	30



a) Plot Robin's position vs. time graph.

b) How far from her starting point was she at t = 6s? How do you know?

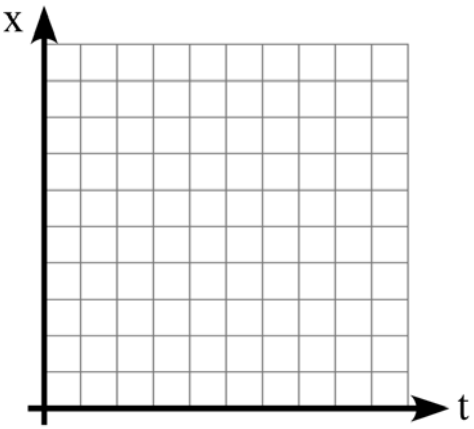
c) Was her speed constant over the entire time interval? How do you know?

d) What was her speed? Show your work.

© 2009 A TIME for Physics First: Uniform Motion

2. Later that day, the following data were obtained when Andy was skating:

t (s)	x (m)
0.0	4
2.0	10
4.0	16
6.0	22
8.0	28
10.0	34



a) Plot Andy's position vs. time graph.

b) What was Andy's initial position? How do you know?

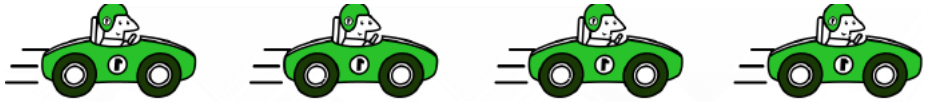
c) How far from his starting point was he at t = 5 s? How do you know?

d) Was his speed constant over the entire time interval? If so, what was it?

e) Robin was further along at 2 s than Andy was. Does this mean that she was going faster? Explain your answer.

Practice 2.5: Motion Diagrams

1. Describe the motion of the cars below and draw the motion diagram in each case: The time interval between images of the car for each of the questions below is the same.

A. 

Description:

Motion Diagram:

B. 

Description:

Motion Diagram:

C. 

Description:

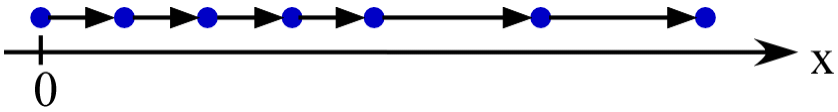
Motion Diagram:

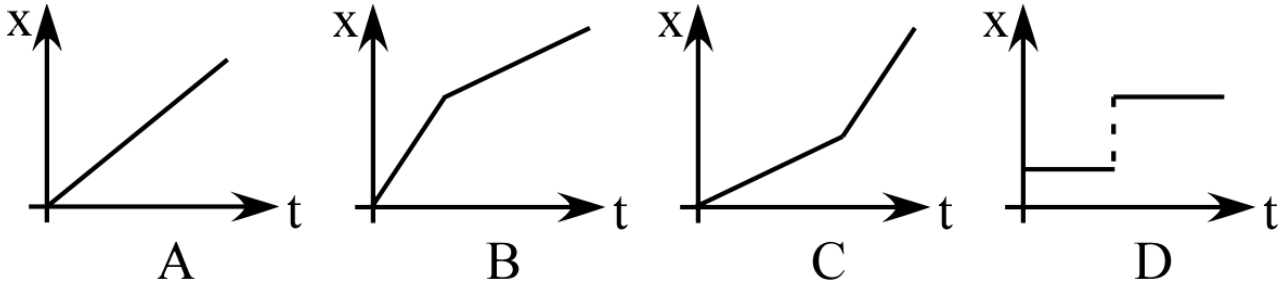
D. 

Description:

Motion Diagram:

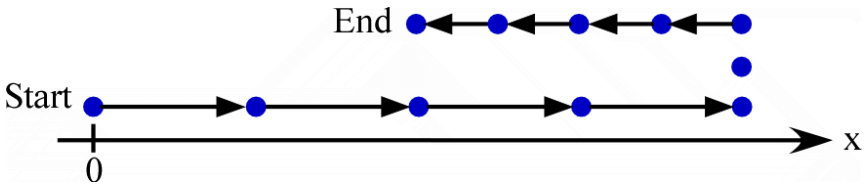
2. Which position versus time graph below best describes the following motion diagram?

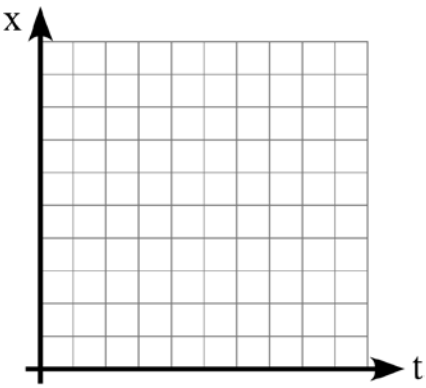




3. Draw motion diagrams for the three other graphs in problem 2.

4. Angela walks as shown in the motion diagram below.





a) Using words, explain what she does.

b) Draw a qualitative x vs t graph for this motion using the graph above.

© 2009 A TIME for Physics First: Uniform Motion

5. Brad and Mike decide to race their cars. They start the race at Mike's house, which is 500 m down a straight street from Brad's house. Use different colors for Brad and Mike:

a) Draw a motion diagram for the two cars when they are both at the starting line, ready to begin the race. Be sure to label the x=0 point for each diagram below.

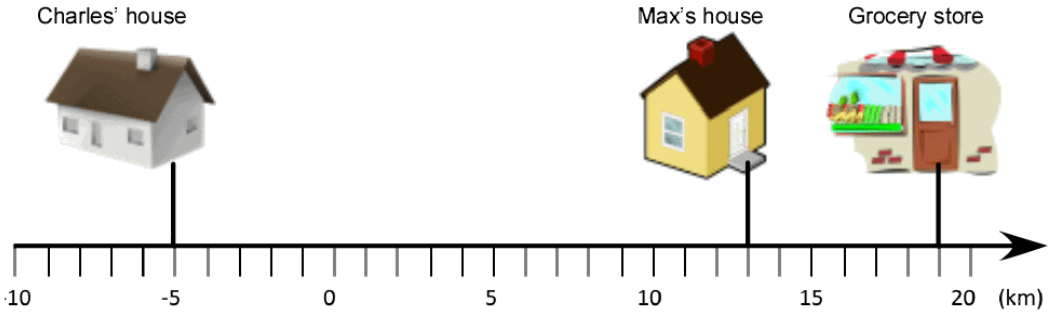
b) Mike drives with a constant speed of 20 m/s and Brad drives his car at a constant speed of 25 m/s. Draw a motion diagram for both cars when they are moving towards Brad's house.

c) When Brad reaches his house he does not wait for Mike but turns around and drives back to Mike's house. Draw a motion diagram for the case where Brad drives towards Mike's house but Mike is still driving toward Brad's house.

d) When Mike reaches Brad's house he stops even though Brad is still driving. Draw a motion diagram for this case.

e) After Brad arrives at Mike's house, he calls Mike to see what happens. After talking to Brad, Mike decides to drive back to his house. Draw a motion diagram for this case.

6. Charles and Max plan to make dinner at Max's house. Charles leaves his house and takes 36 min to drive to the grocery store to get the ingredients for dinner. He spends 12 min at the grocery store, and then drives to Max's house, which takes 16 min. Assume that his speed within each segment is constant; however his speed in one segment might be different from another segment. Draw a motion diagram of Charles' travels.



7. Charles leaves his house during rush hour and takes 48 min to drive to Max's house: they are making dinner at Max's house again. They go to the grocery store together, taking 12 minutes to drive there. They spend 20 min picking up the groceries, then they take 16 minutes to drive back to Max's house. Use the distances shown in the diagram above, and assume that their speed within each segment is constant. Draw a motion diagram of Charles' travels.

Practice 2.6: Word Problems – Speed

Notes on solving problems: Follow the procedure set in Reading Page – Speed and Distance in solving word problems. Alternatively, refer to the segment entitled "GUPPiES."
Conversion factors:

1 mile = 1.61 km; 1 mile = 5280 feet; 1 hour = 60 min; 1 min = 60 sec; 1 day = 24 hours

1. Rita drives her car from Columbia to Kansas City at a constant speed. She takes 2.25 hours to travel 120 miles. Calculate her speed.

2. One of the fastest humans on earth can run 100 m in 10 seconds. How many m can he/she run in 45 sec?

3. Lannie takes her eye off the road for 3 sec while she adjusts the dial on her radio. If she is traveling at 60 miles/hr, how many feet does her car travel as she adjusts the radio dial?

4. Michael Phelps and his teammates won eight gold medals at the 2008 Olympics. Examine the events and times listed below. Times for team events are for the whole team. Rank his (or the team's) speed in the different events from fastest to slowest. Use the columns in the table for calculations, as needed.

Swim Event	**Time taken (min:sec)**		
Men's 200m Individual Medley	1:54.23		
Men's 100m Butterfly	0:50.58		
Men's 200m Butterfly	1:52.03		
Men's 200m Freestyle	1:42.96		
Men's 4 x 200m Freestyle Relay	6:58.56		
Men's 400m Individual Medley	4:03.84		
Men's 4 x 100m Medley Relay	3:29.34		
Men's 4 x 100m Freestyle Relay	3:08.24		

5. In the 2004 Olympics, Shawn Crawford ran 200m in 19.79 sec. Justin Gatlin ran the 100 m race in 9.85 seconds.

a) Calculate their speeds (round to two decimal places).

b) Whose speed was faster and by how much?

6. Which trip takes longer:

a) To fly 635.0 miles from St. Louis to Detroit on an airplane going 575.0 mi/hr, or

b) To drive 120 miles from Columbia to St. Louis in a car traveling at 70.0 mi/hr on average?

7. You are heading toward Hollywood Theaters to catch the 4:50 show. You are still on the other side of town and the movie is going to start in 5 minutes.

a) If the movie theater is still 5 miles away, at what speed will you have to travel to get to the movie on time? Will you exceed the speed limit of 30 mi/hr, putting you in danger of receiving a ticket?

b) If you traveled at the speed limit of 30 miles/hr, how long would it take to get there?

c) Draw a motion diagram that shows both (a) and (b)

© 2009 A TIME for Physics First: Uniform Motion

Additional Problems

8. Apollo Anton from the US skated in the 1500 m Short Track race in 2 minutes and 24 seconds. Calculate his speed in m/sec.

9. Norwegian Marit Bjorgen placed second in the 10 km Cross Country Ski Race with a time of 28 min 12.7 seconds. Calculate her speed in m/sec.

10. The Luge is an event in the Winter Olympics where the competitor is on a sled traveling down an icy track. Courtney Zablocki from the US placed third in her heat on the Luge with a time of 47.109 sec. The speed for her race was 126.9 km/hr. How long is the Luge track in meters?

11. The 2004 Olympic winners for women's track events are listed in the table below.

a) Figure out a factor you can use to compare who runs the fastest, calculate it, and rank their speeds from fastest to slowest.

b) Take the two fastest runners from part (a). If each of them ran at the speed you calculated above, calculate how far would they run in 35 seconds?

c) What would their positions be at that time? (They all start from x = 0).

Women's track event:	**Time (3:21.46 = 3 min, 21.46 sec)**
200 m	22.05
800 m	1:56.38
5000 m	14:45.65
400 m	49.41
100 m	10.93

12. A city bus travels at a speed of 48 km/hr. How far would you travel in 20.0 minutes?

13. Tammie rides her bike in Oakland Park. She rides for 3.50 miles at a speed of 8.00 mi/hr. How long does it take Tammie to finish her ride (in minutes)?

14. A race car driver travels at 110 m/s for 20.0 seconds. How far has the driver traveled?

15. If you planned to bike to a park that was 15.4 miles away, what speed would you have to keep up to arrive in 1.5 hours?

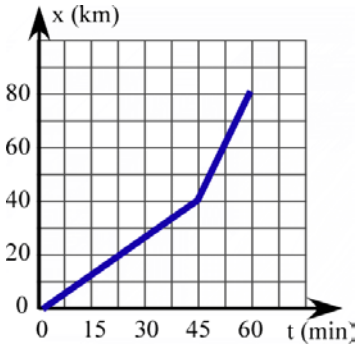
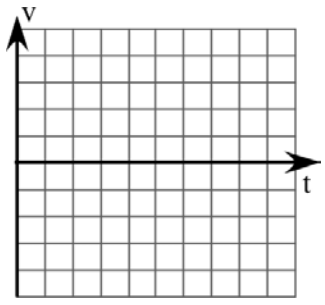
16. If your response time is 0.50 seconds and your car is traveling 25 m/s, how far does your car travel in your response time?

Practice 2.7: Average Speed

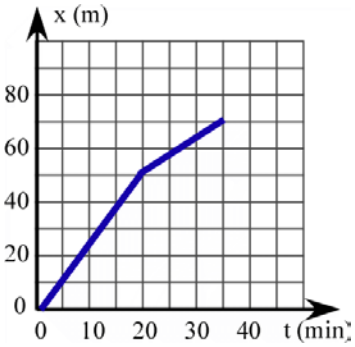
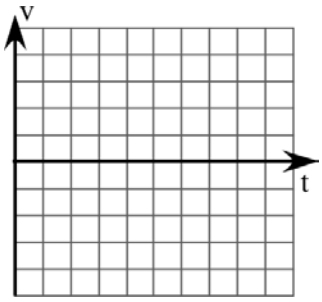
Part I. Graphical Problems

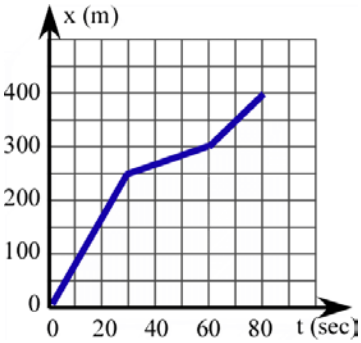
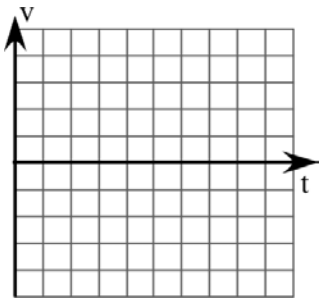
1. In the problems below, descriptions should include the following information (in words or in a table). Remember to include units in the velocity-time graphs.

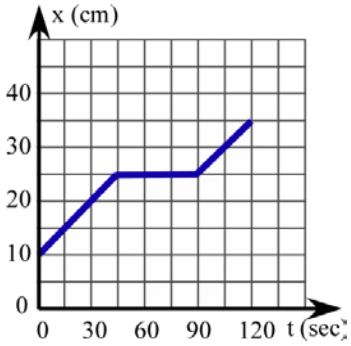
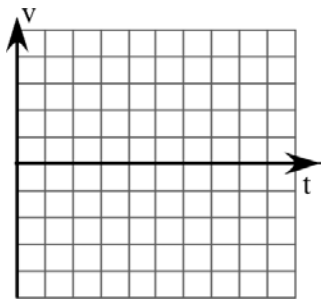
	For Segment 1	**For Segment 2**
Initial position x_i		
Final position x_f		
Time interval Δt		
Is speed constant? Slow/fast/none?		
direction: + or -		

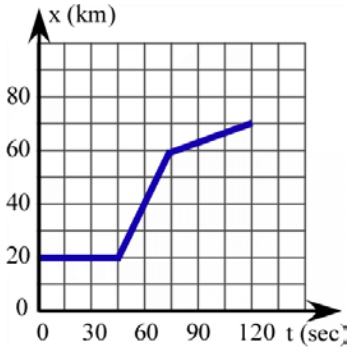
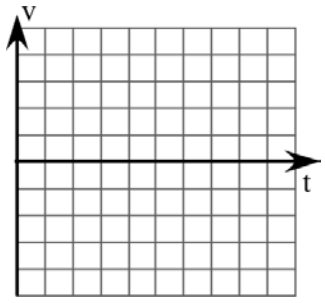
1A. Motion of a car:  	Describe in words the motion represented in the graph:
Draw a quantitative velocity vs time graph:  	Calculate the average speed of this motion.

© 2009 A TIME for Physics First: Uniform Motion

1B. Motion of a cat	Describe in words the motion represented in the graph:
	
Draw a quantitative velocity vs time graph 	Calculate the average speed of this motion.

1C. Motion of a bicycle	Describe in words the motion represented in the graph:
	
Draw a quantitative velocity vs time graph: 	Calculate the average speed of this motion.

1D. Motion of a beetle:	Describe in words the motion represented in the graph:
	
Draw a quantitative velocity vs time graph: 	Calculate the average speed of this motion.

1E. Motion of a super-frog:	Describe in words the motion represented in the graph:
	
Draw a quantitative velocity vs time graph: 	Calculate the average speed of this motion.

© 2009 A TIME for Physics First: Uniform Motion

Part II. Word Problems

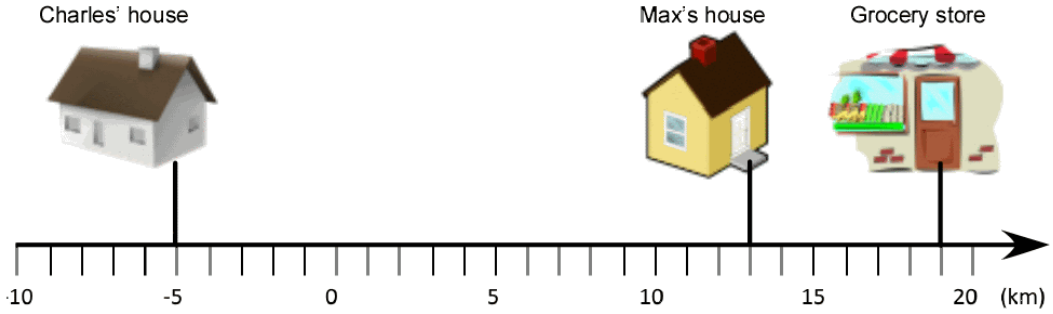
Conversion factors are given in the appendix.

2. Julie travels to a distant city. She does the first 40 km in 30 minutes, the next 60 km in 45 min, the final 20 km in 15 min. Calculate her average speed. Draw a motion diagram.

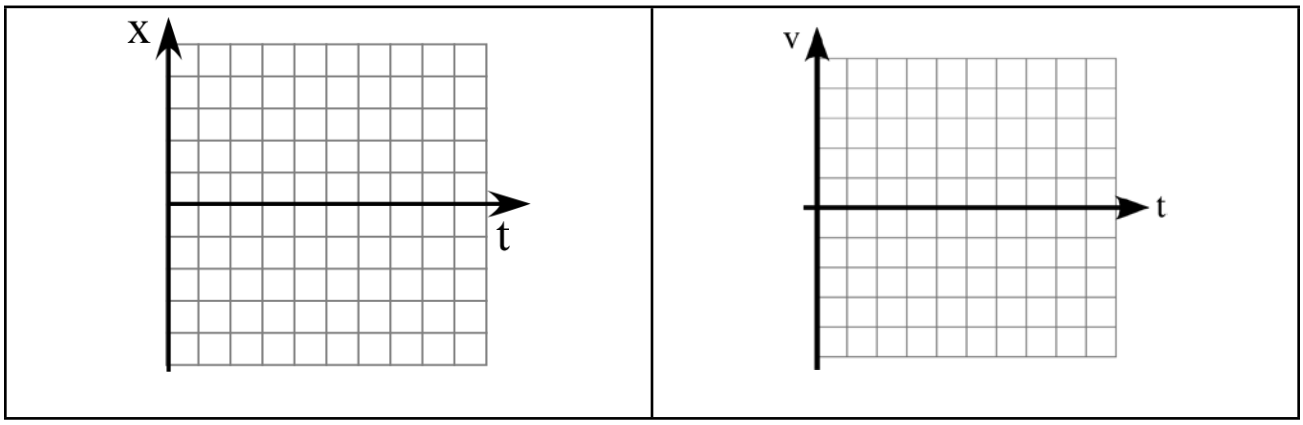
3. Adrian flies his plane to Washington DC (now, wouldn't that be nice?). He flies the first 300 miles at 550 miles/hr, the next 220 miles at 600 miles / hour and the final 300 miles at 500 miles / hour. Calculate his average speed.

4. Terrence walks to school every day. He walks for 12 minutes at 8 km/h, and for 10 min at 6 km/h. Calculate his average speed.

5. Charles and Max are making dinner at Max's house. Charles leaves his house and takes 36 min to drive to the grocery store to get stuff for dinner. He spends 12 min at the store, and then drives back to Max's house, which takes 15 min. Assume that his speed within each segment is constant.



a) Draw an x-t graph and a v-t graph of Charles' travels (be sure to include units on the axes).



b) Calculate Charles' average speed.

6. Travis travels to St. Louis (110 miles away) at 50.0 miles/h on his way to St. Louis, and 70.0 miles/h on his way back. Calculate his average speed (NO, it is not 60 mph!)

© 2009 A TIME for Physics First: Uniform Motion

Additional Problems

7. Raj travels to Minneapolis (310 miles away) at 70 miles/h on his way to Minneapolis and 78 miles/h on his way back. Calculate his average speed. Draw Raj's motion diagram.

8. My cat Tammy has a way of wandering away from home. One day she walked 220 meters at a speed of 15 meters/min, then 300 meters at 18 meters/min, then 40 meters at 12 meters/min, and finally 150 meters at 16 meters/min. Calculate her average speed.

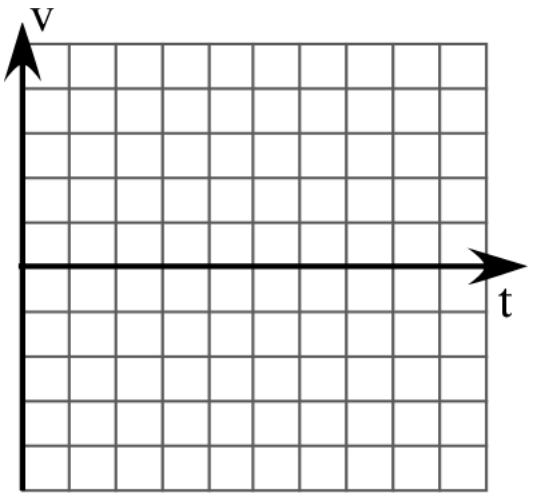
9. My friend Giovanni trains for marathons. One day last year he ran for 45 min at 10 km/h, then 35 min at 8 km/h and finally 50 min at 9 km/h. Calculate his average speed.

10. Anna takes a weekend drive to the mountains. She drives 120 km at a speed of 60 km/hr, then drives a distance of 150 km over 3 hours, and finally completes the last leg of her journey in 1.5 hours at 40 km/hr. Calculate her average speed.

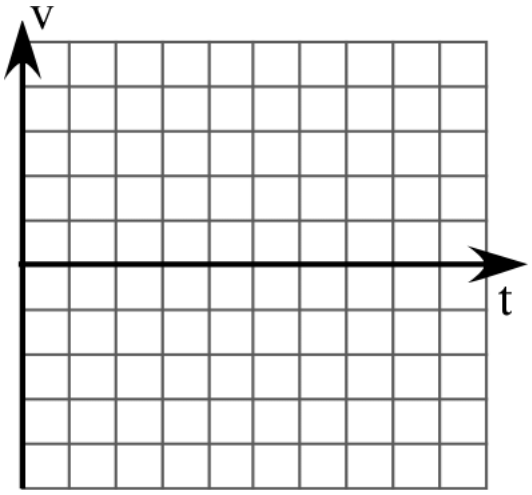
Practice 2.8: Words and Graphs

1. Sketch velocity vs. time graphs corresponding to the following descriptions of the motion of an object.

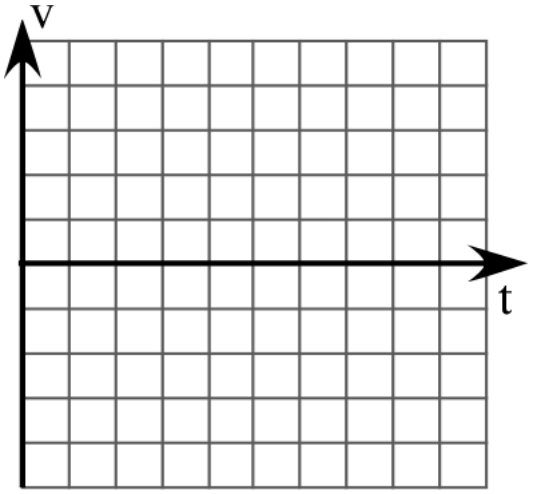
1A. The object is moving away from position x=0 in the positive x direction at a constant (steady) speed.



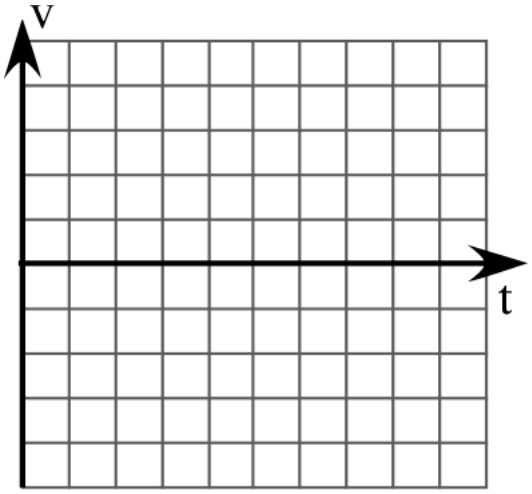
1B. The object is standing still at a position +x.



1C. The object moves from a position +x toward x=0 at a steady speed for 10s, then stands still for 10s.



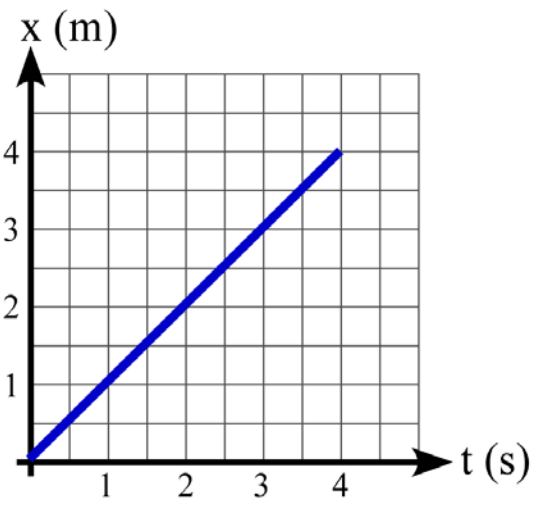
1D. The object moves in the +x direction from position x=0 at a steady speed for 10s, reverses direction and moves back toward position 0 at the same speed.

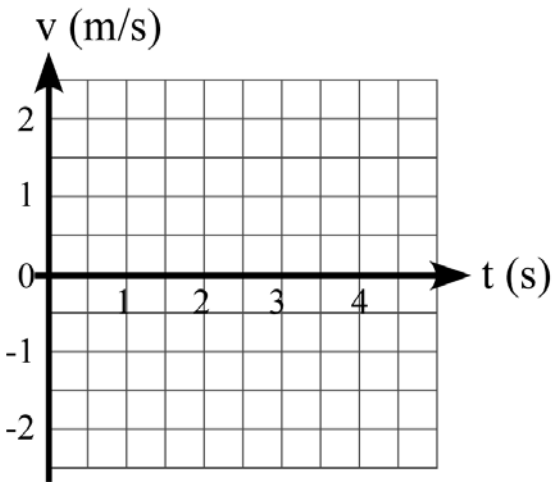


© 2009 A TIME for Physics First: Uniform Motion

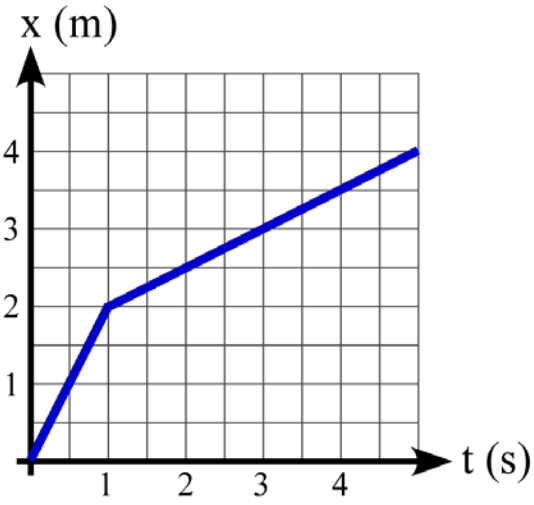
2. Draw velocity vs. time graphs for objects whose position vs. time graphs shown on the left.

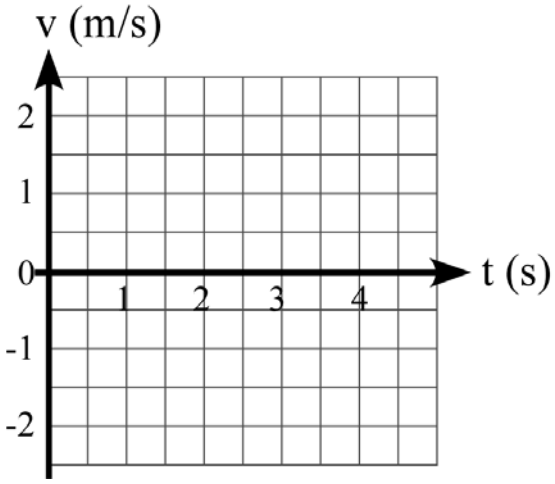
2A.



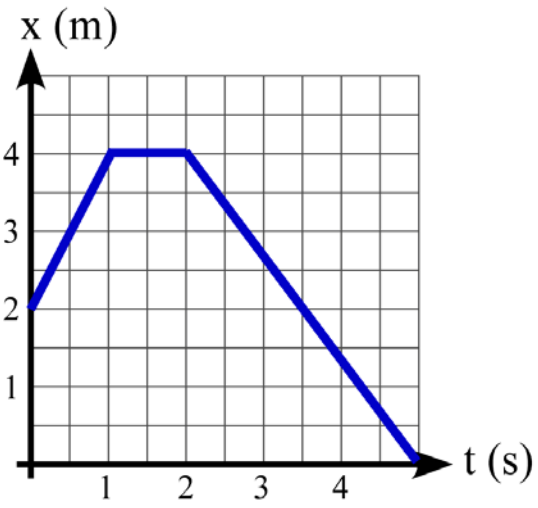


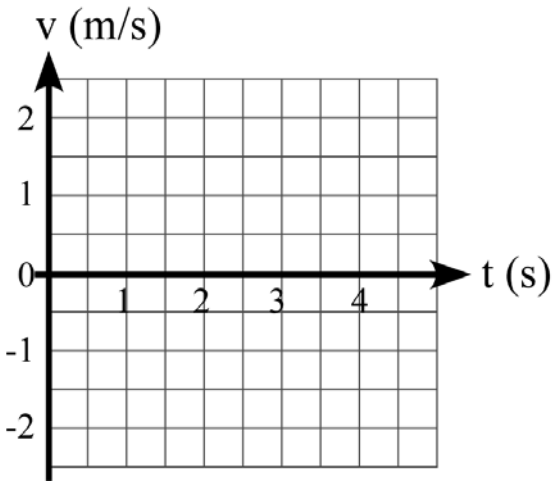
2B.





2C.





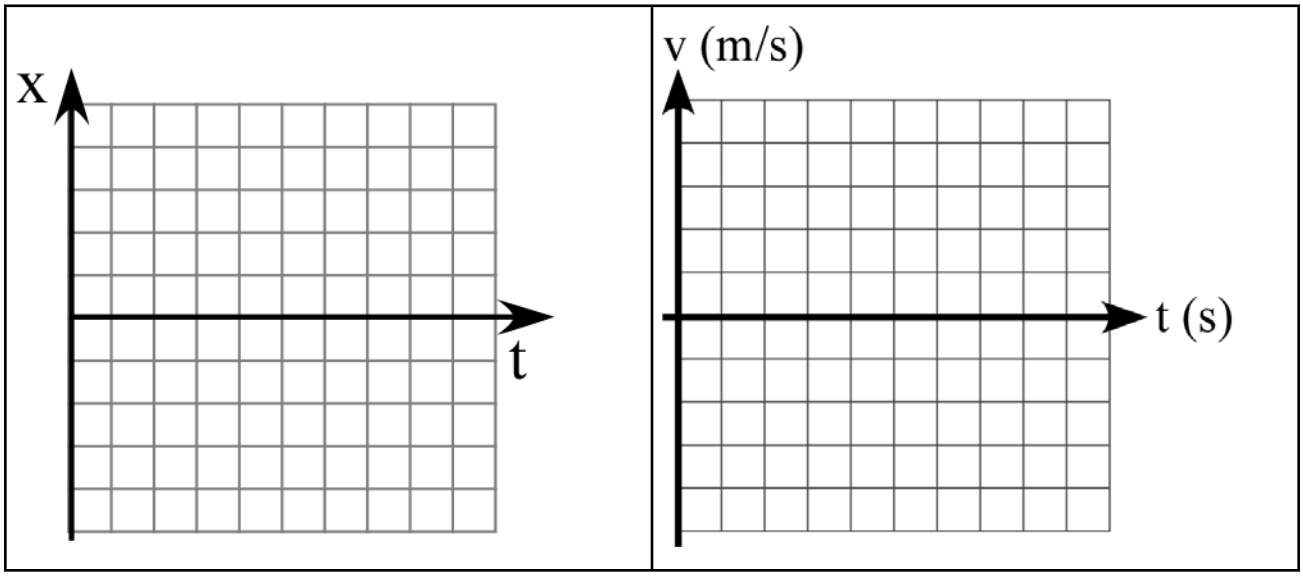
Practice 2.9: Words, Graphs and Motion Diagrams

1. Abby and Whitney are having breakfast at Whitney's house. Suddenly, Whitney remembers that they have track practice that morning stands up and starts running at a constant speed of 2 m/s toward the track field that is 800 m away from Whitney's house. After 2 minutes, Abby finishes her breakfast and starts running toward the track field at a constant speed of 4 m/s.

a) How much time did Whitney take to reach the track field?

b) How much time did Abby take to reach the track field?

c) Graph Whitney's and Abby's position and velocity as a function of time below.



d) Make a motion diagram for both Whitney and Abby.

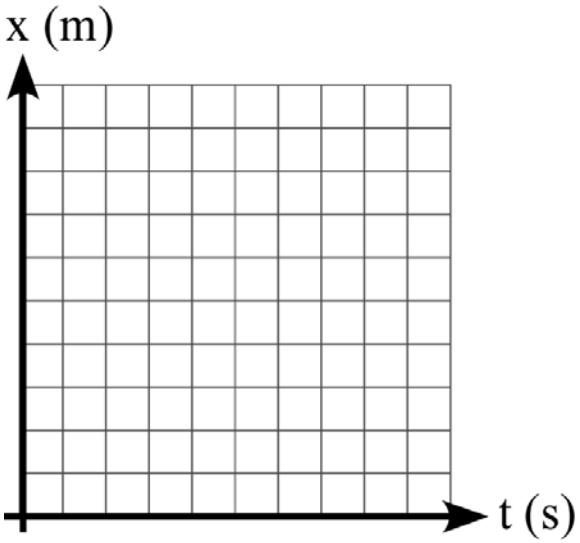
e) Using the graphs, figure out at what time Abby passes Whitney on their way to the track field. Explain your reasoning.

f) Using the area under the v-t graph, calculate Whitney's displacement.

© 2009 A TIME for Physics First: Uniform Motion

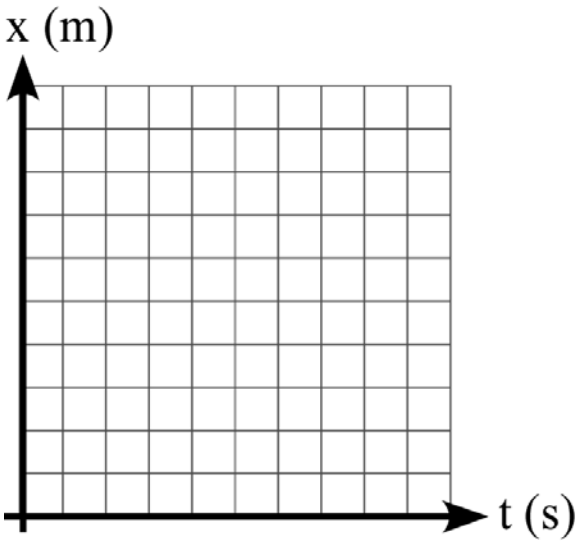
2. A car travels at 20 m/s starting at x = 0. Fill the x-values in the table below, and draw an x-t graph for its motion

t (s)	x (m)
0	0
2	
4	
6	
8	
10	



3. A bus starts at x = 2000m, and moves toward x = 0 at 20 m/s. Fill out the table below, and draw an x-t graph for its motion

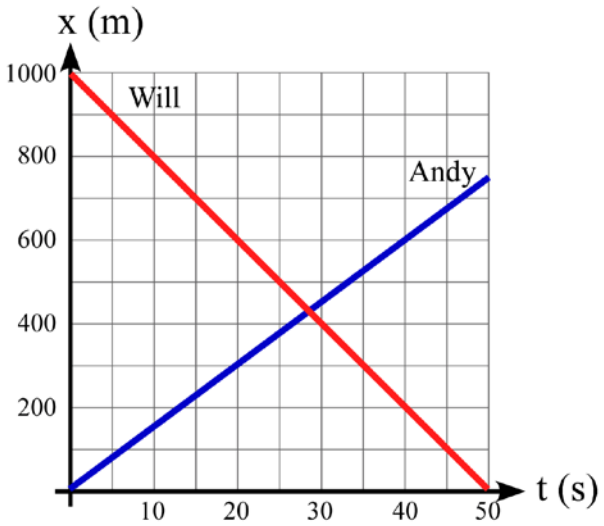
t (s)	x (m)
0	2000
2	
4	
6	
8	
10	

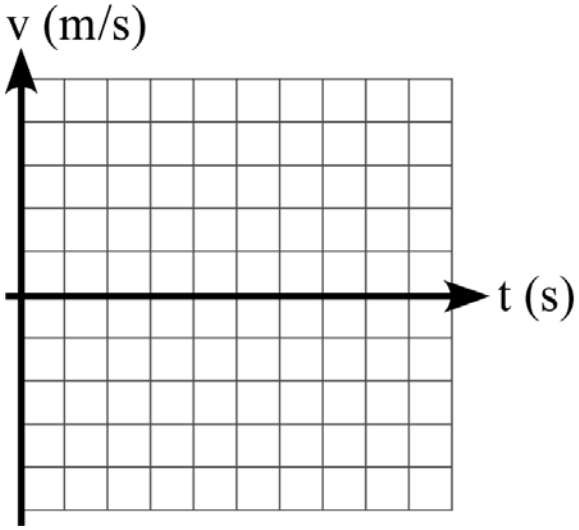


4. Will and Andy are driving their new cars.

a) Describe the race shown in the position versus time graph provided below.

b) Calculate Will's and Andy's velocities.





c) Draw v(t) graphs for both Will and Andy on the graph provided above (label the lines).

d) Draw a motion diagram for both Will and Andy.

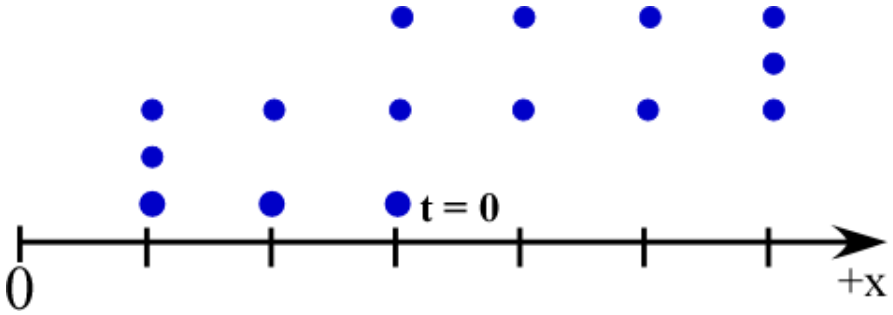
e) At what time do Andy and Will pass each other?

f) At what position do they pass each other?

g) From the velocity-time graph, calculate Will's displacement, and Andy's displacement.

© 2009 A TIME for Physics First: Uniform Motion

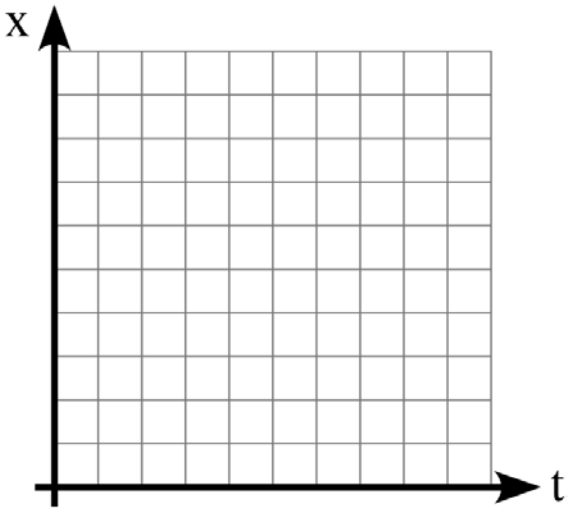
5. Kerry skates on ice moving as shown in the motion diagram below. Look at the motion diagram and answer the following questions regarding Kerry's motion:



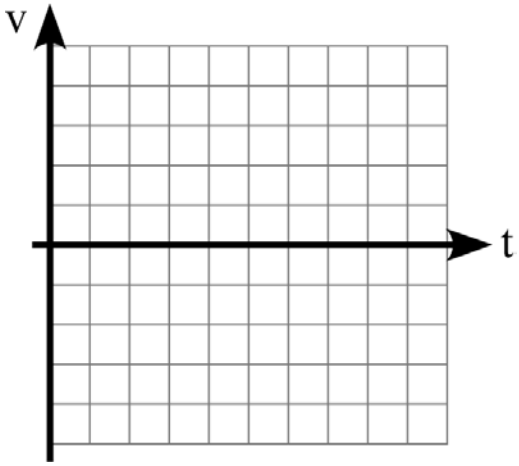
a) Draw arrows in the motion diagram to represent Kerry's velocity.

b) From the motion diagram, describe how Kerry is moving.

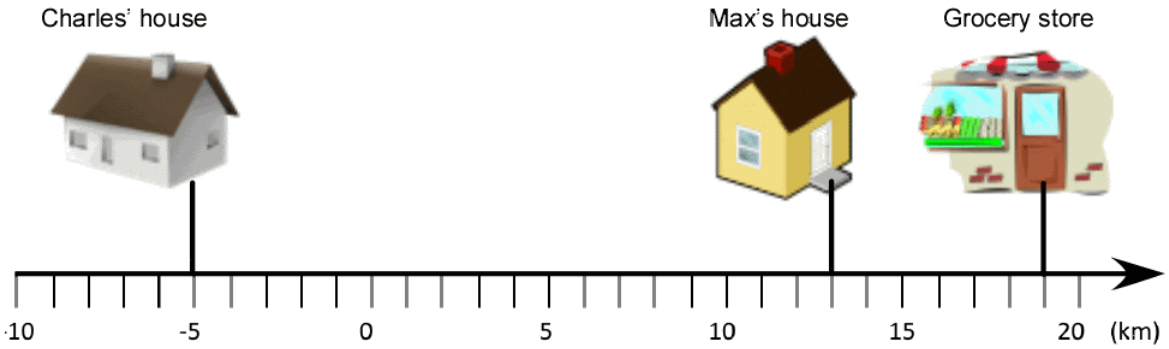
c) Draw a qualitative graph of Kerry's position as a function of time.



d) Draw a qualitative graph of Kerry's velocity as a function of time on the graph.

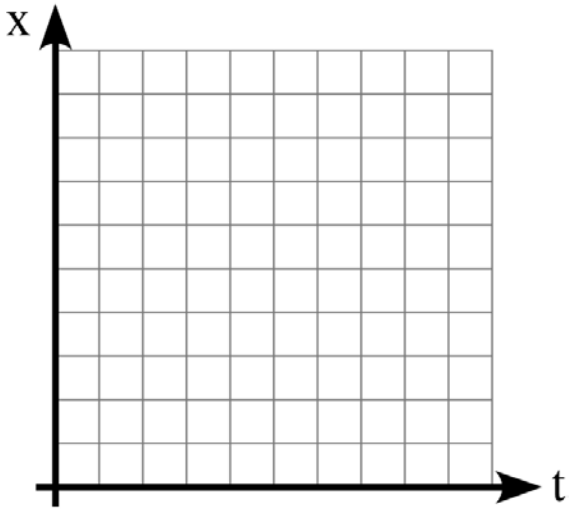


6. Charles and Max decide to watch a movie at Max's house. Max's mom, Maria, wants to drive over to Charles house to meet his parents. Charles starts from his home at 10 AM and drives at 0.75 km/min. Maria leaves Max's home at 10:10 am, and drives at 1 km/min.



a) Draw an x-t graph that shows the motion of both Charles and Maria (include units on the axes).

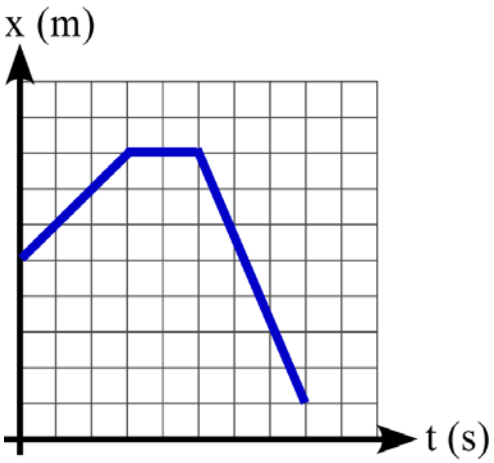
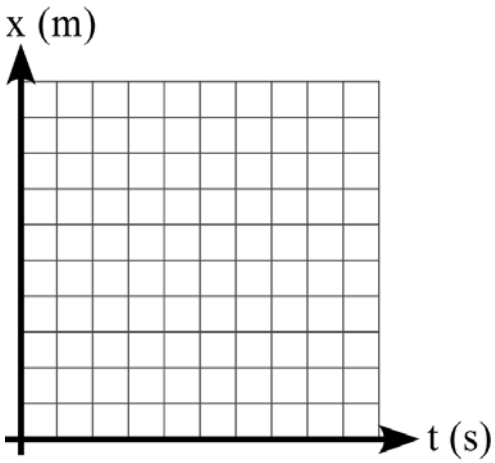
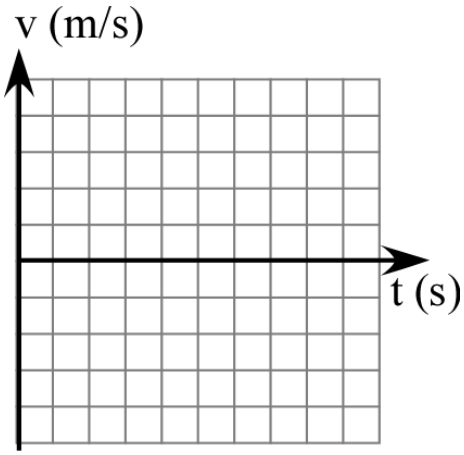
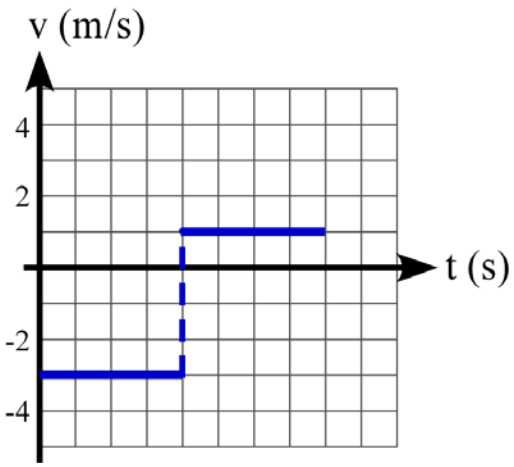
b) From the graph, where will they cross paths, and at what time?



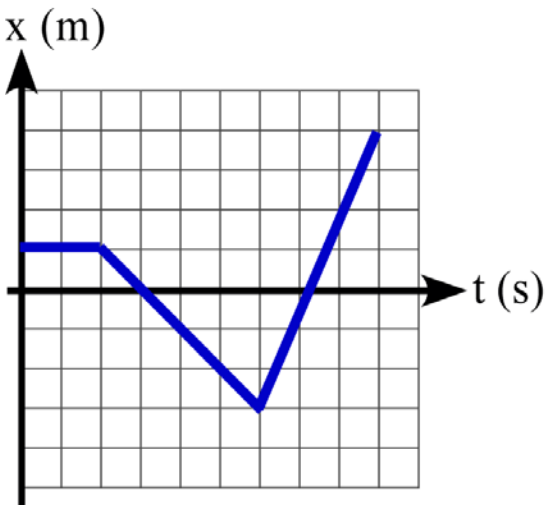
© 2009 A TIME for Physics First: Uniform Motion

Practice 2.10: Equivalent Representations

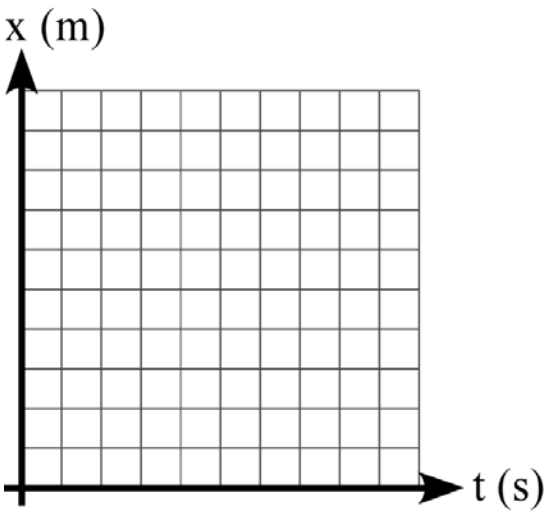
Fill in the other representations for the motion shown.

<table>
<tr>
<td>Problem 1. x vs. t graph
 
</td>
<td>Problem 2. x vs. t graph
 
</td>
</tr>
<tr>
<td>v vs. t graph
 
</td>
<td>v vs. t graph
 
</td>
</tr>
<tr>
<td>Written Description:</td>
<td>Written Description:</td>
</tr>
<tr>
<td rowspan="2">Motion Diagram:</td>
<td>Motion Diagram:</td>
</tr>
<tr>
<td>Calculate the displacement, assuming that the entire motion shown took 16 s:</td>
</tr>
</table>

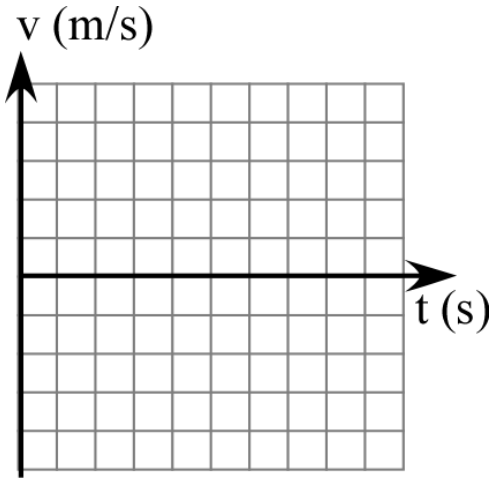
Problem 3. x vs. t graph



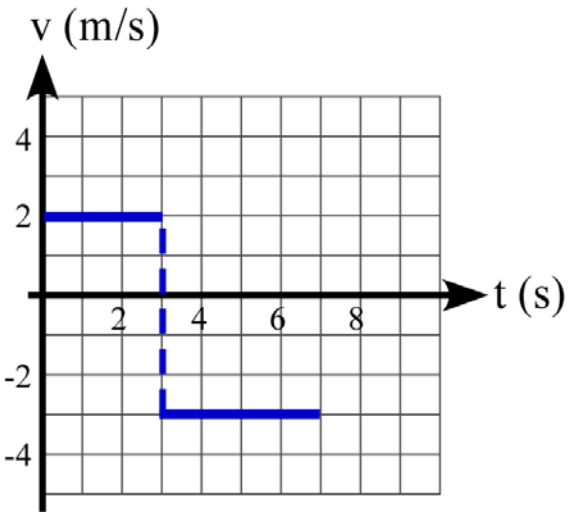
Problem 4. x vs. t graph



v vs. t graph



v vs. t graph



Written Description:

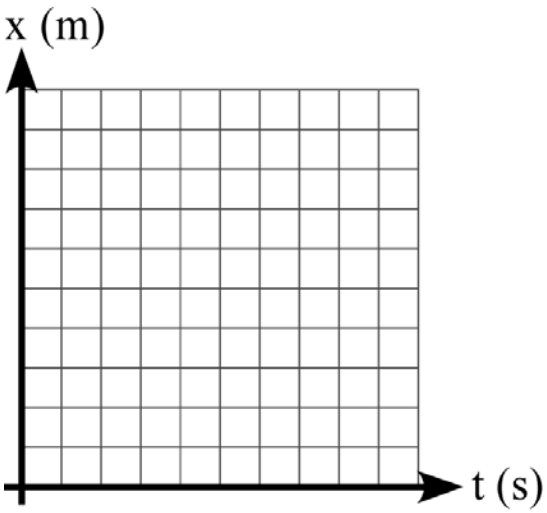
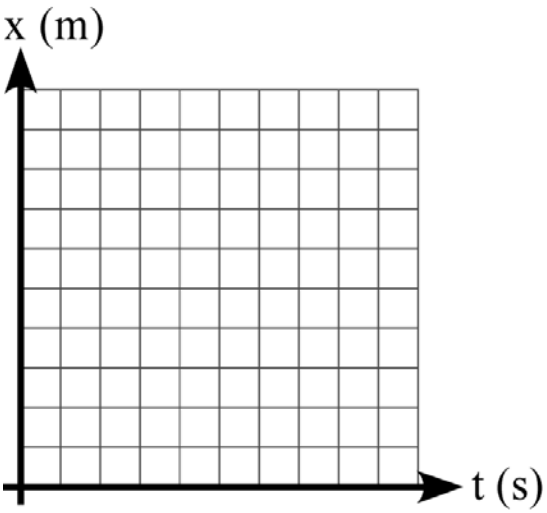
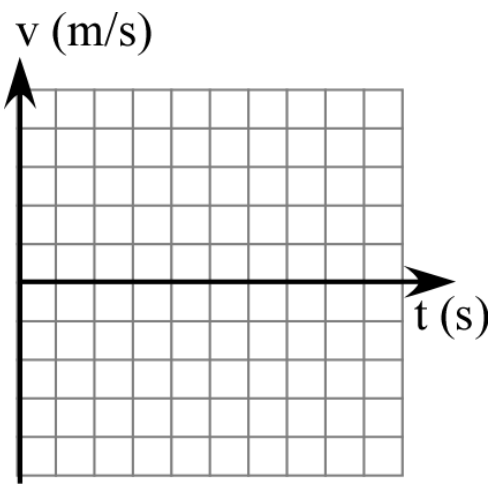
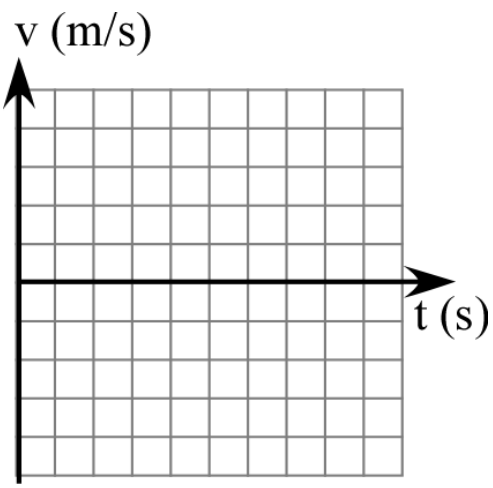
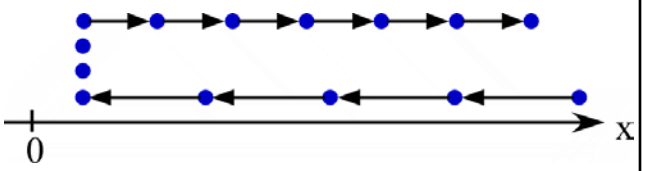
Written Description:

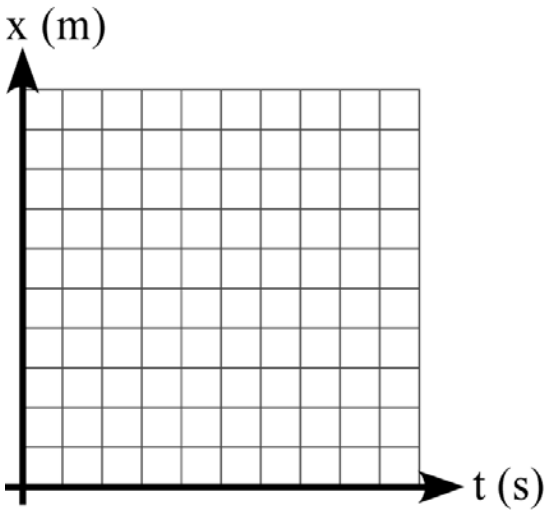
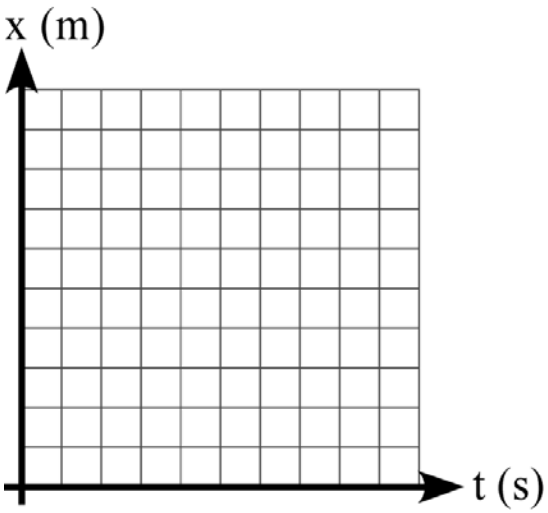
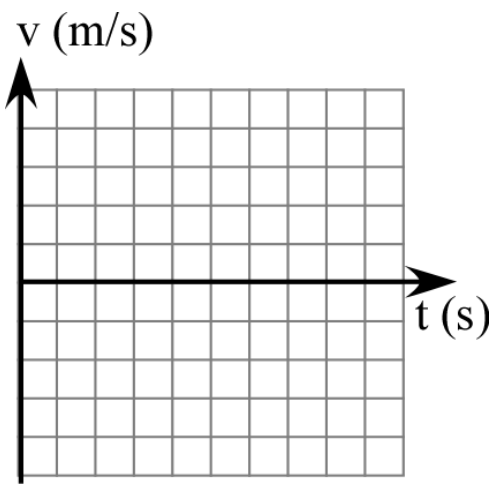
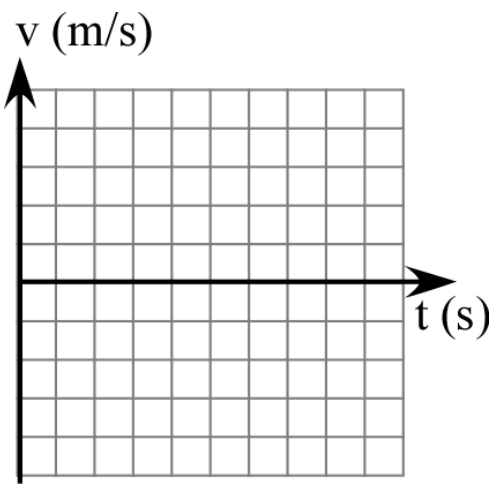
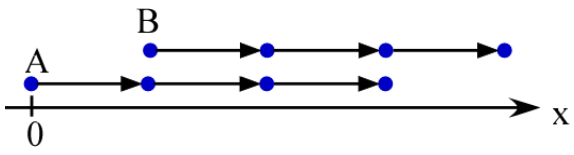
Motion Diagram:

Motion Diagram:

Calculate the displacement:

© 2009 A TIME for Physics First: Uniform Motion

Problem 5. x vs. t graph 	Problem 6. x vs. t graph 
v vs. t graph 	v vs. t graph 
Written Description:	Written Description: Ally runs with a constant positive velocity for 4 seconds. Then, she stops for 2 seconds and returns to her initial position in 2 seconds.
Motion Diagram: 	Motion Diagram:

Problem 7. x vs. t graph 	Problem 8. x vs. t graph 
v vs. t graph 	v vs. t graph 
Written Description:	Written Description: Chris, who is standing 10 m to the right of the origin, starts moving to the left at a constant velocity of 2 m/s. Timi, who is standing at the origin, starts moving at the same time to the right at 3 m/s.
Motion Diagram of two objects A (top) and B (bottom) 	Motion Diagram:

© 2009 A TIME for Physics First: Uniform Motion