Name: ______________________________

Skill Sheet 3.3A Analyzing Graphs of Motion Without Numbers

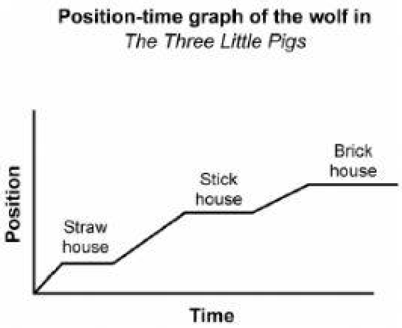
Graphs change columns of figures into images that are easy to interpret. Position-time and speed-time graphs describe the movement of objects. Here are stories for you to tell as graphs and a graph for you to tell as a story. Both will sharpen your graph interpreting skills.

1. Position-time graphs

Data

Remember the "The Three Little Pigs"?

- The wolf started from his house.
- Traveled to the straw house.
- Stayed to blow it down and eat dinner.
- Traveled to the stick house.
- Again stayed, blew it down, and ate seconds.
- Traveled to the brick house.
- Died in the stew pot at the brick house.

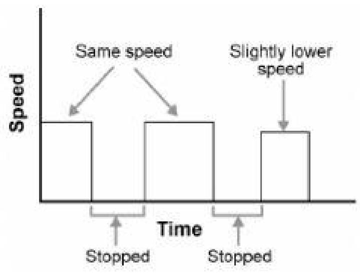


The wolf started at his house, and the graph starts at the origin. Each time the wolf moves farther from his house, the line moves upward with passing time. At each pig's house, the line continues to the right but neither rises nor falls, indicating that the wolf has stopped moving relative to his starting point. We can deduce that the pigs' houses are generally in a line away from the wolf's house and that the brick house was the farthest away. How would the line look if the brick house were on the way back to the wolf's house? Remember that position refers to the starting point—in this case, the wolf's house.

2. Speed-time graphs

A speed-time graph displays the speed of an object over time and is based on position-time data. You know that speed is the relationship between distance and time, $R = D/T$. Look at the first part of the wolf's trip. The line rises steadily to a new position and a new time. It would be easy to calculate a speed for this first leg. What if the wolf traveled this first leg faster? The new line would rise to the same position, but it would take less time. That would make the new line steeper. Here is the speed-time graph for the wolf:

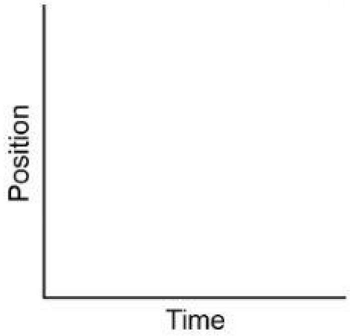
The wolf moved at the same speed toward his first two "visits." His third trip was slightly slower. Except for this slight difference, the wolf was either at one speed or stopped. That is why this graph is so angular.

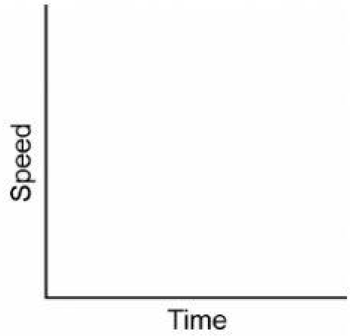


3. Stories for you to tell as graphs

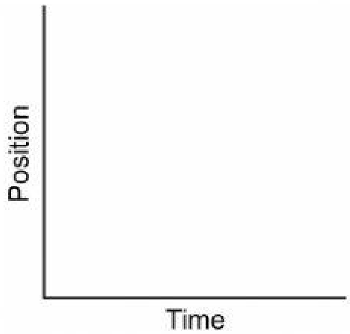
Read each of the following stories. Then sketch in the line for a position-time graph and a speed-time graph.

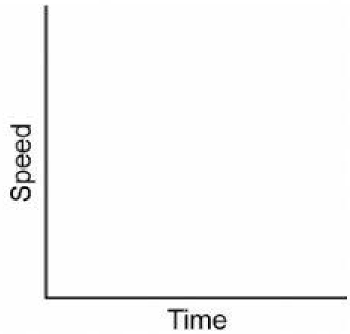
1. "Little Red Riding Hood." Graph Red Riding Hood's movements.
   Data:
   - Little Red Riding Hood set out for Grandmother's cottage at a good walking pace.
   - She stopped briefly to talk to the wolf.
   - She walked a bit slower because they were talking as they walked to the wild flowers.
   - She stopped to pick flowers for quite a while.
   - Realizing she was late, Red Riding Hood ran the rest of the way to Grandmother's cottage.





2. The Tortoise and the Hare. Use two lines to graph both the tortoise and the hare.
   Data:
   - The tortoise and the hare began their race from the combined start-finish line.
   - Quickly outdistancing the tortoise, the hare ran off at a moderate speed.
   - The tortoise took off at a slow but steady speed.
   - The hare, with an enormous lead, stopped for a short nap.
   - With a start, the hare awoke and realized that he had been sleeping for a long time.
   - The hare raced off toward the finish at top speed.
   - Before the hare could catch up, the tortoise's steady pace won the race with an hour to spare.

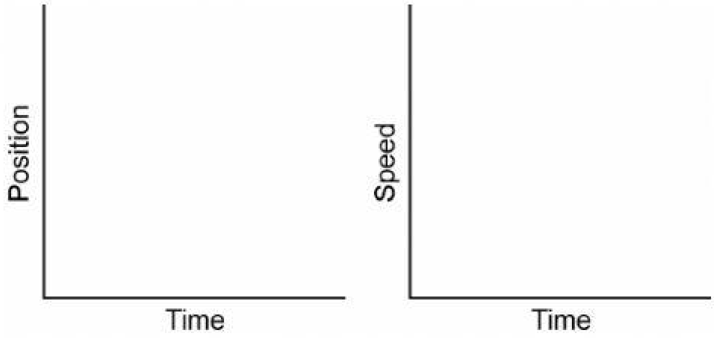




3. The Skyrocket. Graph the altitude of the rocket.

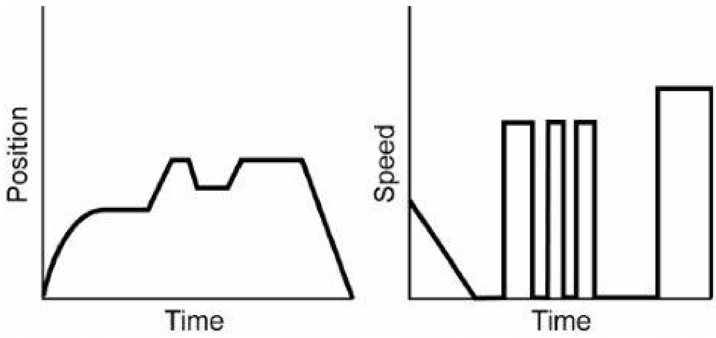
   Data:

   - The skyrocket was placed on the launcher.
   - As the rocket motor burned, the rocket flew faster and faster into the sky.
   - The motor burned out; although the rocket began to slow, it continued to coast ever higher.
   - Eventually, the rocket stopped for a split second before it began to fall back to Earth.
   - Gravity pulled the rocket faster and faster toward Earth until a parachute popped out, slowing its descent.
   - The descent ended as the rocket landed gently on the ground.



4. A story to be told from a graph

Tim, a student at Cumberland Junior High, was determined to ask Caroline for a movie date. Here are the graphs of his movements from his house to Caroline's. You write the story.



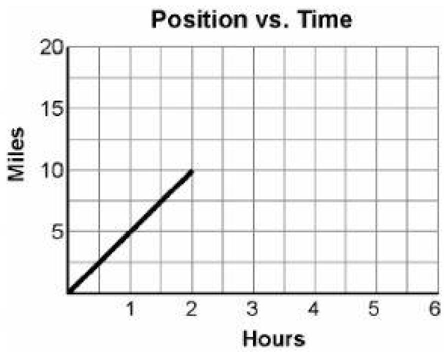
Name: ______________________

Skill Sheet 3.3B Analyzing Graphs of Motion With Numbers

Speed can be calculated from position-time graphs and distance can be calculated from speed-time graphs. Both calculations rely on the familiar speed equation: $R = D/T$.

1. Calculating speed from a position-time graph

This graph shows position and time for a sailboat starting from its home port as it sailed to a distant island. By studying the line, you can see that the sailboat traveled 10 miles in 2 hours.



The speed equation allows us to calculate that the vessel speed during this time was 5 miles per hour.

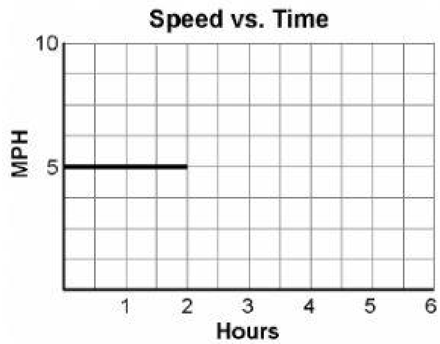
$$R = D/T$$

$$R = 10 \text{ miles}/2 \text{ hours}$$

$$R = 5 \text{ miles/hour, read as 5 miles per hour}$$

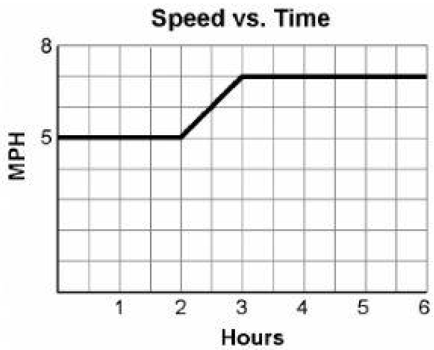
This result can now be transferred to a speed-time graph. Remember that this speed was measured during the first two hours.

The line showing vessel speed is horizontal because the speed was constant during the two-hour period.



2. Calculating distance from a speed-time graph

Here is the speed-time graph of the same sailboat later in the voyage. Between the second and third hours, the wind freshened and the sailboat increased its speed to 7 miles per hour. The speed remained 7 miles per hour to the end of the voyage.



How far did the sailboat go during this time? We will first calculate the distance traveled between the third and sixth hours.

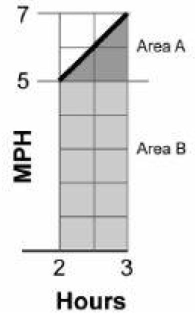
On a speed-time graph, distance is equal to the area between the baseline and the plotted line. You know that the area of a rectangle is found with the equation: $A = L \times W$. Similarly, multiplying the speed from the y-axis by the time on the x-axis produces distance. Notice how the labels cancel to produce miles:

$$\text{speed} \times \text{time} = \text{distance}$$

$$7 \text{ miles/hour} \times (6 \text{ hours} - 3 \text{ hours}) = \text{distance}$$
$$7 \text{ miles/}\cancel{\text{hour}} \times 3 \cancel{\text{ hours}} = \text{distance} = 21 \text{ miles}$$

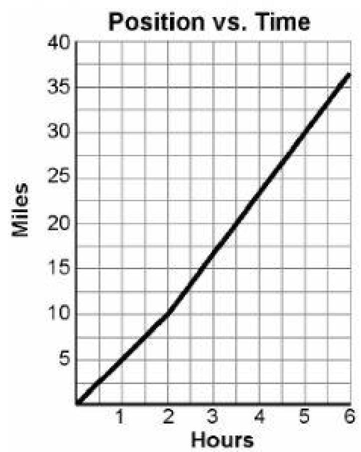
Now that we have seen how distance is calculated, we can consider the distance covered between hours 2 and 3.

The easiest way to visualize this problem is to think in geometric terms. Find the area of the rectangle labeled "1st problem," then find the area of the triangle above, and add the two areas.



Area of triangle A Geometry formula	The area of a triangle is one-half the area of a rectangle. $\text{speed} \times \frac{\text{time}}{2} = \text{distance}$ $(7 \text{ miles/hour} - 5 \text{ miles/hour}) \times \frac{(3 \text{ hours} - 2 \text{ hours})}{2} = \text{distance} = 1 \text{ mile}$
Area of rectangle B Geometry formula	$\text{speed} \times \text{time} = \text{distance}$ $5 \text{ miles/hour} \times (3 \text{ hours} - 2 \text{ hours}) = \text{distance} = 5 \text{ miles}$
Add the two areas	$\text{Area A} + \text{Area B} = \text{distance}$ $1 \text{ miles} + 5 \text{ mile} = \text{distance} = 6 \text{ miles}$

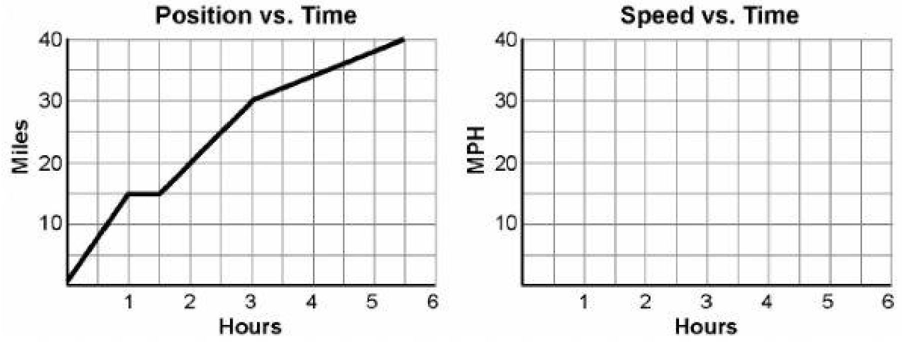
We can now take the distances found for both sections of the speed graph to complete our position-time graph:



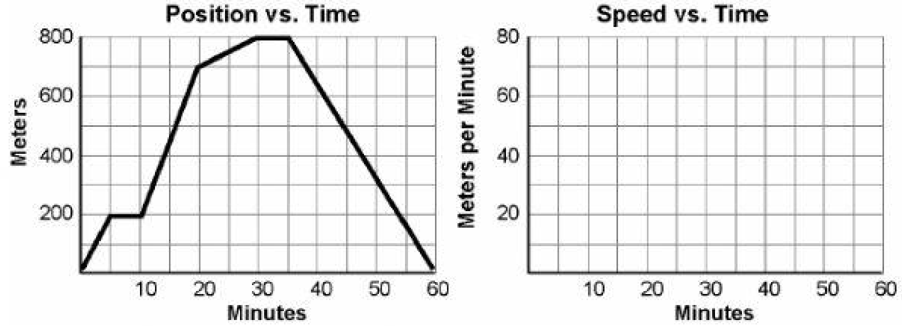
3. Practice: Finding speed from position-time graphs

For each position-time graph, calculate and plot speed on the speed-time graph to the right.

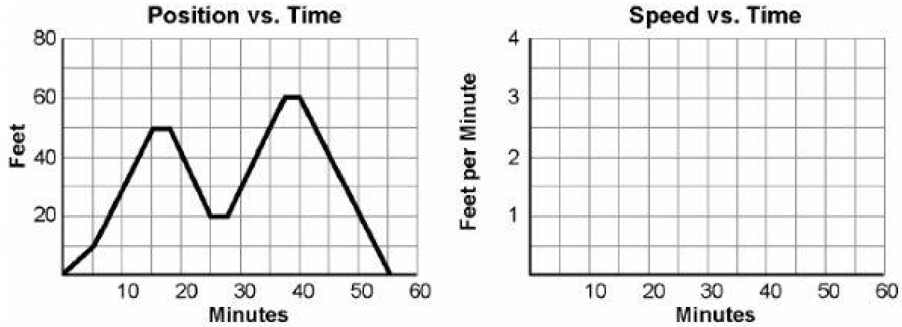
1. The bicycle trip through hilly country.



2. A walk in the park.



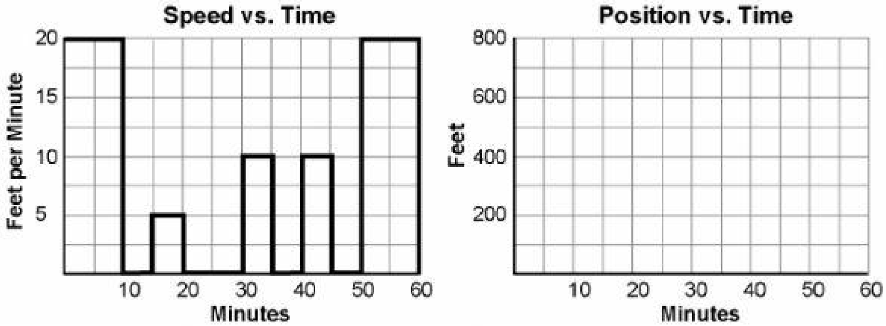
3. Strolling up and down the supermarket aisles.



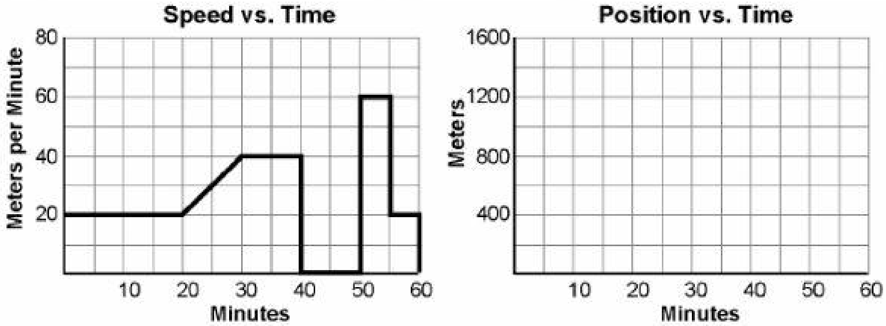
4. Practice: Finding distance from speed-time graphs

For each speed-time graph, calculate and plot the distance on the position-time graph to the right. For this practice, assume that movement is always away from the starting position.

1. The honey bee among the flowers.



2. Rover runs the street.



3. The amoeba.