

Motion and Forces

Graphing Motion

..... Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.		
Before	Statement	After
	3. You can show the path an object takes using a graph of distance and time.	
	4. You can tell how fast objects are moving if you look at a graph of speed and time.	

..... Read to Learn

Describing Motion with Graphs

Biologists track sea turtles to better understand their movements or migrations. How could you describe the movements of a sea turtle? You could measure the total distance the turtle traveled or how long it took the turtle to reach the ocean. However, neither measurement alone would give a complete picture of its motion. When you study motion, you need to know how position changes as time passes. One way to study motion is to learn how to draw and interpret graphs of motion.

Distance-Time Graphs

A graph that shows how distance and time are related is a **distance-time graph**. The y -axis shows the distance an object travels from a reference point. Time is on the x -axis. The line on a distance-time graph shows how an object's position changes during each time interval. From this, you can figure out an object's speed. ✓

For example, the graph might show that between 2 s and 3 s, the object traveled from 20 m to 30 m, a distance of 10 m. The speed of the object during that time interval was 10 m/s. If the slope of the line changes in the graph, you know that the speed changes. A distance-time graph does not show the actual path the object took.

Key Concepts

- How can you graph an object's motion?
- How can a graph help you understand an object's motion?

Mark the Text

Identify the Main Ideas

Highlight two or three phrases in each paragraph that summarize the main ideas. After you have finished the lesson, review the highlighted text.

Reading Check

1. State What relationship does the line on a distance-time graph represent?

Green Sea Turtle's Distance and Time Data

Time (days)	Distance (km)
0	0
1	16
2	32
3	48
4	64
5	80
6	96

Making a Distance-Time Graph

In order to better understand how sea turtles migrate through the oceans, biologists attach tracking devices to the turtles' shells. When turtles come up for air, the devices send information to satellites orbiting Earth. In this way, the scientists can record the turtles' positions and the times that they come up for air. The biologists can study the data they get from the satellites. This helps them understand turtle behavior and factors that can affect the health of turtles.

The table on the left shows tracking data that was gathered for a green sea turtle off the coast of Florida. The first column is the time since tracking began. The second column shows the distance the turtle swam from a reference point. The figure below shows how to use data similar to data in the table to make a distance-time graph of the turtle's motion. By following the same steps, you can make your own graph from similar data.

Interpreting Tables

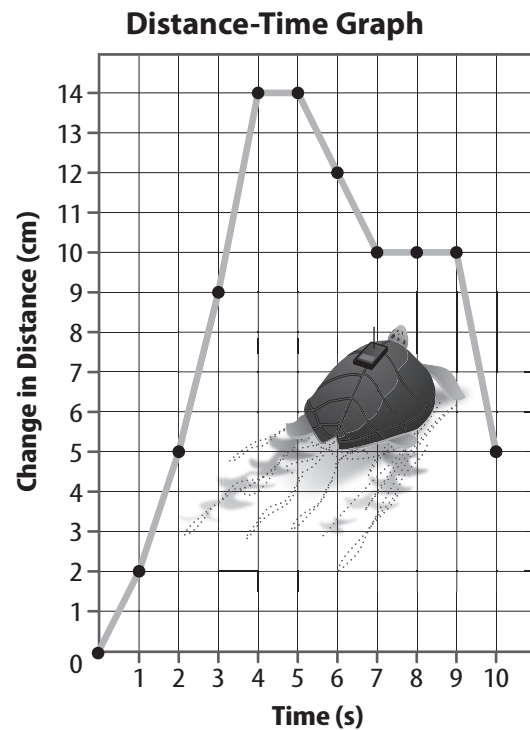
2. Point Out How far did the turtle travel between days 3 and 4?

Use the following steps to make a distance-time graph.

1. Draw x- and y-axes.
2. Label the x-axis for time measured in days. Label the y-axis for distance measured in kilometers.
3. Make tick marks on the axes and number them. Be sure the values you choose allow you to plot all the data.
4. Plot the data from each row of your data table. Move across the x-axis to the correct time and up the y-axis to the correct distance. Draw a small circle.
5. Connect data points with a line.

Visual Check

3. Locate Circle the part of the graph line that shows how far the turtle traveled between days 3 and 4.



Comparing Speed

You can use distance-time graphs to compare the motion of two different objects. The distance-time graph below at left shows satellite-tracking data for two sea turtles. The line showing the motion of the green sea turtle is from data in the table at the top of the previous page.

Recall that average speed is total distance traveled divided by total time. The green sea turtle traveled a greater distance than the Ridley's sea turtle in the same amount of time. The green sea turtle's average speed was greater. Notice that the slope of the line for the green sea turtle is steeper. Steeper lines on distance-time graphs mean that the average speed is greater.

Constant Speed The graph below on the left shows that the green sea turtle traveled 16 km per day; the Ridley's sea turtle traveled 10 km per day. An object moving the same distance in the same amount of time moves at constant speed. The two lines in the graph at left below are straight. This shows the turtles moved with constant average speed.

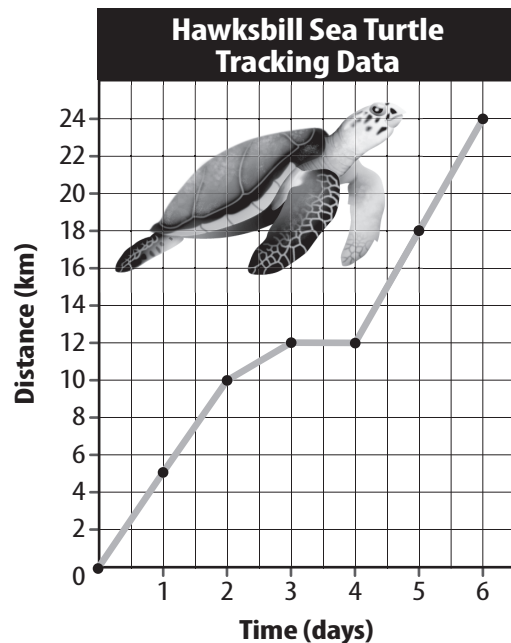
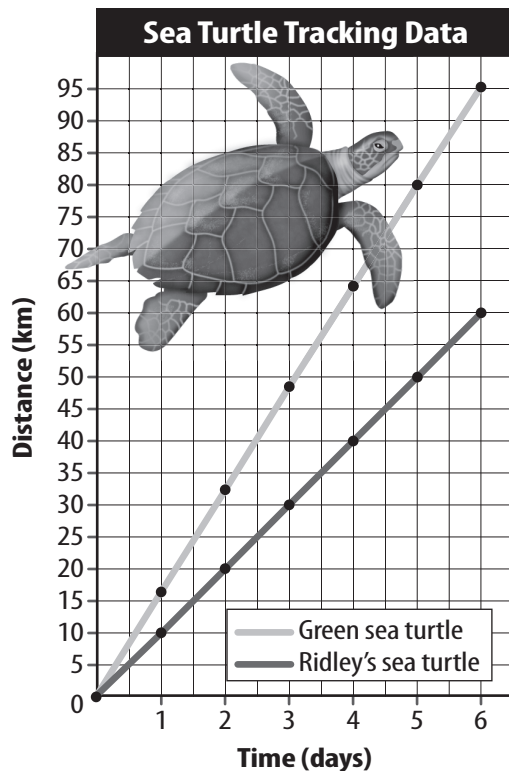
Changing Speed The distance-time graph of a hawksbill sea turtle is shown in the graph below at right. How is the line on this graph different from the ones in the graph to the left? The line is not straight. Its slope changes. Each change in slope means that the average speed of the object changed during that time interval.

Key Concept Check

4. Generalize How can a graph show you how the motion of an object is changing?

Visual Check

5. Analyze What is the speed of the hawksbill sea turtle between days 3 and 4?

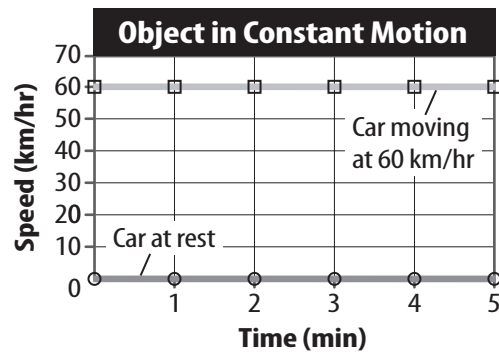


Speed-Time Graphs

You have read how distance-time graphs can help you describe an object's motion by showing how the distance that the object travels changes during each unit of time. Another type of graph, called a speed-time graph, shows motion in a different way. A **speed-time graph** shows the speed of an object on the y -axis and time on the x -axis. A speed-time graph shows how the speed of the object changes during each interval of time.

Resting

Imagine you are in a parked car. What is your speed? You read in Lesson 1 that speed describes how much an object changes position in a unit of time. Because a parked car does not change position, your speed is zero. Your speed stays zero as long as the car stays at rest. The speed-time graph for an object at rest is a horizontal line at $y = 0$, shown as the lower of the two straight lines in the graph below. ✓



Constant Speed

Have you ever been in a car that had the cruise control turned on? The cruise control keeps the car moving at a constant speed, such as 60 km/hr. On a speed-time graph, an object moving with constant speed is a horizontal line similar to the top line in the graph above.

The distance between the line and the x -axis tells you the speed of the object. The top line in the graph shows $y = 60$ km/hr, which is the speed of the object. A horizontal line farther from the x -axis represents an object moving faster than an object represented by a horizontal line closer to the x -axis. Thus, the motion of a car moving at a constant speed of 30 km/hr would appear on the graph as a horizontal line halfway between the lines for $y = 0$ and $y = 60$.

Changing Speed

Suppose you are in a car that is pulling away from a traffic light that has just turned green. As the driver steps on the accelerator, the car's speed increases. When the driver sees a red traffic light, the driver takes his or her foot off the accelerator and applies the brakes. The car's speed decreases. What does the speed-time graph look like when the speed of an object changes?

✓ Reading Check

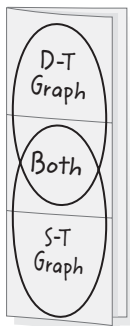
6. Identify What does the y -axis of a speed-time graph stand for?

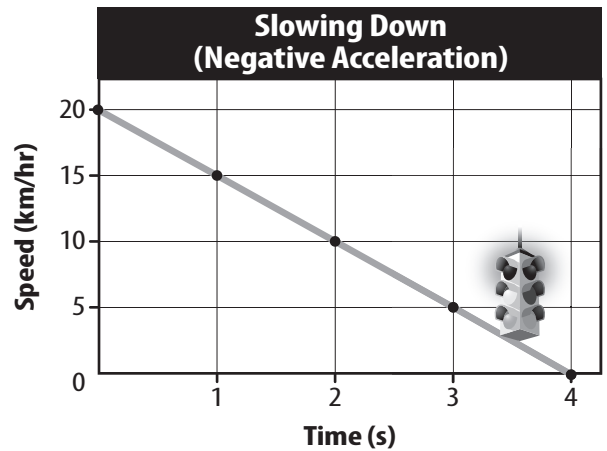
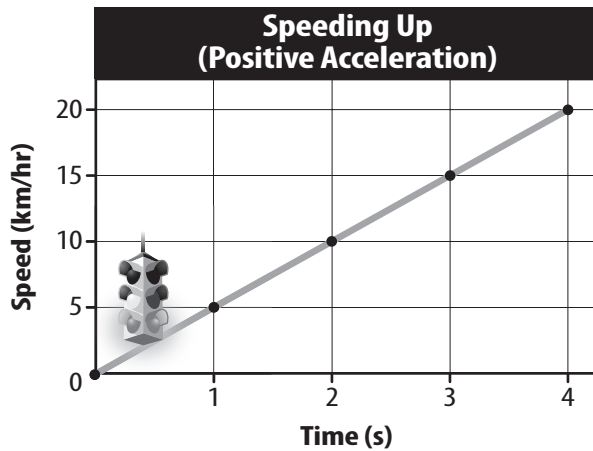
✓ Visual Check

7. Draw a line on the graph for an object moving at a constant speed of 25 km/hr.

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Make a vertical three-tab book. Draw a Venn diagram on the front and label the tabs. Record what you have learned about distance-time graphs and speed-time graphs under the tabs. Draw examples of each on the front tabs. Under the middle tab, describe what the two graphs have in common.





Speeding Up As a car pulls away from the traffic light, its speed increases. The car covers a greater distance each second. Look at the graph on the left above. The line on the graph shows the motion of an object with increasing speed. This line representing increasing speed slopes upward from left to right. A line that slopes upward shows positive acceleration.

Slowing Down When a car slows down, its speed decreases and the car covers a smaller distance each second. The car's motion is a line that slopes downward from left to right, as shown on the graph on the right. This line represents negative acceleration.

In Lesson 1, you read that when the speed of an object changes, it accelerates. Therefore, if the line on a speed-time graph is not horizontal, you know that the object is accelerating. Objects also accelerate when their direction changes, but that is not shown on the speed-time graph. The line on the graph shows only the change in speed, not the direction in which the object is traveling. 

 **Visual Check**

8. Draw a line on the right-hand graph representing a car that has negative acceleration from 15 km/hr to 0 km/hr in 3 seconds.

 **Key Concept Check**

9. Compare What is the difference between an upward-sloping line on a speed-time graph and one on a distance-time graph?

..... After You Read

Mini Glossary

distance-time graph: a graph that shows how distance and time are related

speed-time graph: a graph that shows the speed of an object on the y -axis and time on the x -axis and how the speed of the object changes during each interval of time

- Review the terms and their definitions in the Mini Glossary. Write a sentence that compares and contrasts the two glossary terms in this lesson.

- Write the correct term in each row of the table below. The first row has been completed for you.

	Distance-Time Graph	Speed-Time Graph
Measurement described by x -axis	time	time
Measurement described by y -axis		
What does constant speed look like?		
What does changing speed look like?		

- Explain how highlighting the main ideas in each paragraph of text in the lesson helped you study.

What do you think **NOW?**

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?



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