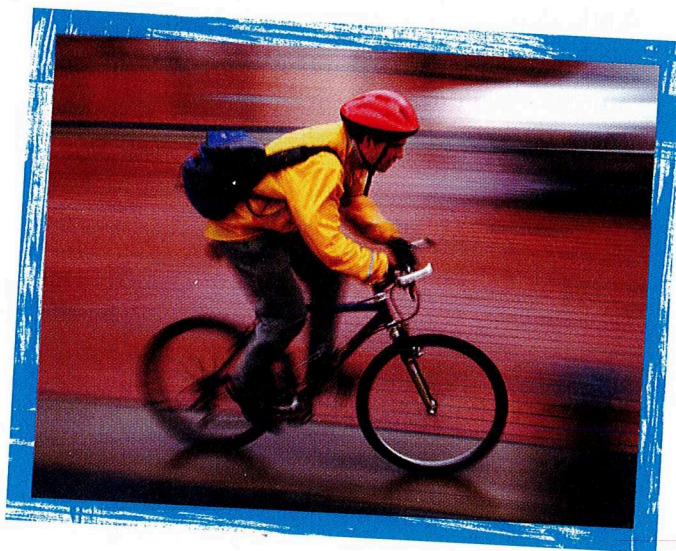# Variables, Tables, and Coordinate Graphs

The bicycle was invented in 1791. People of all ages use bicycles for transportation and sport. Many people spend their vacations taking organized bicycle tours.

Did You Know?

RAGBRAI, which stands for Register's Annual Great Bicycle Ride Across Iowa, is a weeklong cycling tour across the state of Iowa. The event has been held every summer since 1973. Although the tour follows a different route each year, it always begins with as many as 10,000 participants dipping their back bicycle wheels into the Missouri River along Iowa's western border and ends with the riders dipping their front wheels into the Mississippi River on Iowa's eastern border.

Go Online
PHSchool.com
For: Information about RAGBRAI
**Web Code:** ane-9031
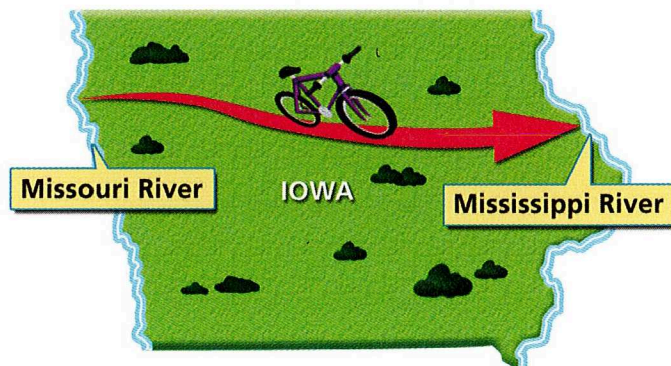
1.1 Preparing for a Bicycle Tour

Sidney, Celia, Liz, Malcolm, and Theo decide to operate bicycle tours as a summer business. The five college students choose a route from Atlantic City, New Jersey, to Norfolk, Virginia. The students name their business Ocean Bike Tours.

While planning their bike tour, the students need to determine how far the touring group can ride each day. To figure this out, they take test rides around their hometowns.
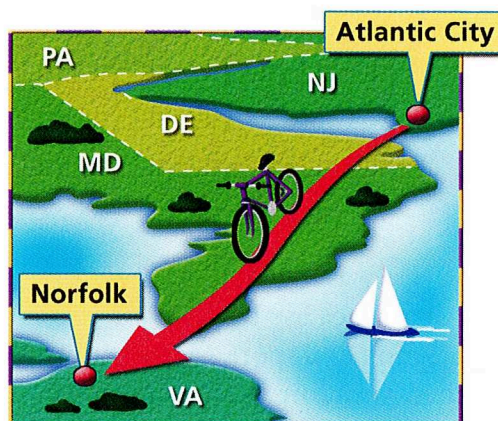
Getting Ready for Problem 1.1

- How far do you think you could ride in a day?
- How do you think the speed of your ride would change during the course of the day?
- What conditions would affect the speed and distance you could ride?

To accurately answer the questions above, you would need to take a test ride yourself. Instead you can perform an experiment involving jumping jacks. This experiment should give you some idea of the patterns commonly seen in tests of endurance.

Jumping Jack Experiment

You will need a group of at least four people:

- a jumper (to do jumping jacks)
- a timer (to keep track of the time)
- a counter (to count jumping jacks)
- a recorder (to write down the number of jumping jacks)

As a group, decide who will do each task.

When the timer says "go," the jumper begins doing jumping jacks. The jumper continues jumping for 2 minutes. The counter counts the jumping jacks out loud. Every 10 seconds, the timer says "time" and the recorder records the total number of jumping jacks the jumper has done.

A. Do the jumping jack experiment. For each jumper, prepare a table for recording the total number of jumping jacks after every 10 seconds, up to a total time of 2 minutes (120 seconds).

Jumping Jack Experiment

Time (seconds)	0	10	20	30	40	50	60	70	...
Total Number of Jumping Jacks									

Use the table of your jumping jack data to answer these questions:

B. How did the jumping jack rates (the number of jumping jacks per second) in your group change as time passed? How is this shown in your tables?

C. What might this pattern suggest about how bike-riding speed would change over a day's time on the bicycle tour?

1.2 Making Graphs

In the jumping jack experiment, the number of jumping jacks and the time are variables. A **variable** is a quantity that changes or varies. You recorded data for the experiment variables in a table. Another way to display your data is in a **coordinate graph.** Making a coordinate graph is a way to show the relationships between two variables.

There are four steps to follow when you make a coordinate graph.

Step 1 Identify two variables.

In Problem 1.1, the two variables are *time* and *number of jumping jacks*.

Step 2 Select an axis to represent each variable.

Often, you can assign each variable to an axis by thinking about how the variables are related. If one variable depends on the other, put the **dependent variable** on the **y-axis** (the vertical axis) and the **independent variable** on the **x-axis** (the horizontal axis). You may have encountered the terms *dependent variable* and *independent variable* in your science classes.

If time is a variable, you usually put it on the *x*-axis. This helps you see the "story" that occurs over time as you read the graph from left to right.

In Problem 1.1, the number of jumping jacks depends on time. So, put number of jumping jacks (the dependent variable) on the *y*-axis and time (the independent variable) on the *x*-axis.

Label your graph so that someone else can see what it represents. You can label the *x*-axis as "Time (seconds)" and the *y*-axis as "Number of Jumping Jacks." You can use these labels to help you choose a title for your graph. You might title this graph, "Jumping Jacks Over Time."

Jumping Jacks Over Time
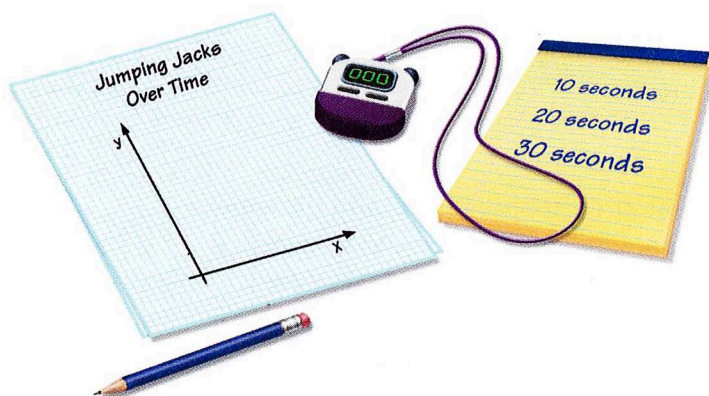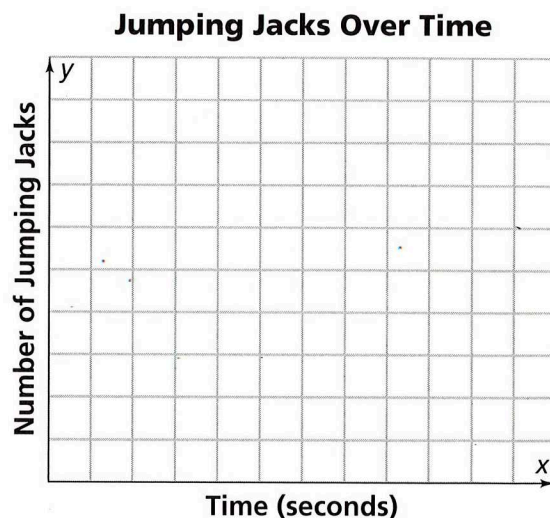
Step 3 Select a **scale** for each axis. For each axis, determine the least and greatest values to show. Then decide how to space the scale marks.

In Problem 1.1, the values for time are between 0 and 120 seconds. On the graph, label the *x*-axis (time) from 0 to 120. Because you collected data every 10 seconds, label by 10's.

The scale you use on the *y*-axis (number of jumping jacks) depends on the number òf jumping jacks you did. For example, if you did 97 jumping jacks, you could label your scale from 0 to 100. Because it would take a lot of space to label the scale for every jumping jack, you could label by 10's.

Jumping Jacks Over Time

Step 4
Plot the data points.
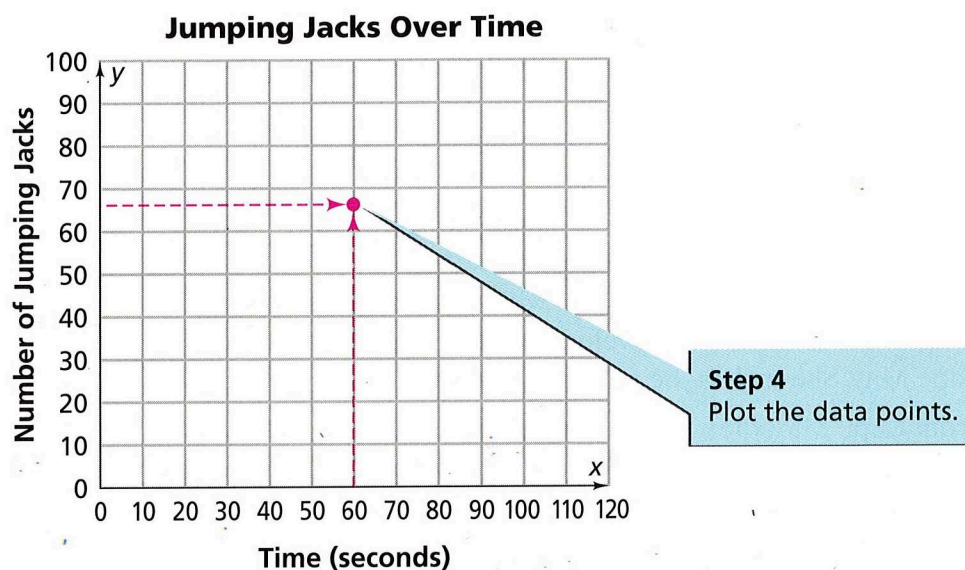
Step 4 Plot the data points.

Suppose that at 60 seconds, you had done 66 jumping jacks. To plot this information, start at 60 on the *x*-axis (time) and follow a line straight up. On the *y*-axis (number of jumping jacks), start at 66 and follow a line straight across. Make a point where the two lines intersect. You can describe this point with the **coordinate pair** (60, 66). The first number in a coordinate pair is the *x*-coordinate, and the second number is the *y*-coordinate.

Problem 1.2 Making Graphs

A. Make a graph of the jumping jack data for one of the jumpers in your group.

B. What does your graph show about the jumping jack rate as time passes? (Another way to say this is, what does your graph show about the **relationship** between the number of jumping jacks and time?)

C. Is the relationship you found between the number of jumping jacks and time easier to see in the table or in the graph? Explain.

ACE Homework starts on page 15.

Sidney, Liz, Celia, Malcolm, and Theo found they could comfortably ride from 60 to 90 miles in one day. They use these findings, as well as a map and campground information, to plan a three-day tour route. They wonder if steep hills and rough winds coming off the ocean might make the trip too difficult for some riders.

It is time to test the projected tour route. The students want the trip to attract middle school students, so Sidney asks her 13-year-old brother, Tony, and her 14-year-old sister, Sarah, to come along. The students will collect data during the trip and use the data to write detailed reports. Using the reports, they can improve their plans and explain the trip to potential customers.

They begin their bike tour in Atlantic City and ride five hours south to Cape May, New Jersey. Sidney and Sarah follow in a van with camping gear. Sarah records distances traveled until they reach Cape May. She makes the table at the right.

From Cape May, they take a ferry across the Delaware Bay to Lewes (LOO-is), Delaware. They camp that night in a state park along the ocean.

Atlantic City to Cape May

Time (hr)	Distance (mi)
0	0
0.5	8
1.0	15
1.5	19
2.0	25
2.5	27
3.0	34
3.5	40
4.0	40
4.5	40
5.0	45

Problem 1.3 Interpreting Graphs

A. Make a coordinate graph of the time and distance data in Sarah's table. Show time on the *x*-axis.

B. Analyze your graph by answering the following questions:

1. Give the coordinate pair for the third point on your graph. What information does this point give?

2. Connecting the points on a graph sometimes helps you see a pattern more clearly. You can connect the points to consider what is happening in the intervals between the points.

Connect the points on your graph with straight line segments. Use the line segments to estimate the distance traveled after $\frac{3}{4}$ of an hour (0.75 hours).

3. The straight-line segment you drew from (4.5, 40) to (5.0, 45) shows the progress if the riders travel at a steady rate for the entire half hour. The actual pace of the group, and of individual riders, may vary throughout the half hour. These paths show some possible ways the ride may have progressed:

i.　　　　ii.　　　　iii.　　　　iv.
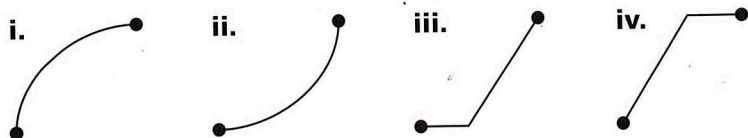
Match each of these connecting paths with the travel notes below.

   a. Celia rode slowly at first and gradually increased her speed.

   b. Tony and Liz rode quickly and reached the campsite early.

   c. Malcolm had to fix a flat tire, so he started late.

   d. Theo started off fast. He soon felt tired and slowed down.

C. Sidney wants to describe Day 1 of the tour. Using information from the table or the graph, what can she write about the day's travel? Consider the following questions:

   • How far did the group travel? How much time did it take them?

   • During which time interval(s) did they go the greatest distance? During which time interval(s) did they go the least distance?

   • Did the riders go farther in the first half or the second half of the day's ride?

D. Sidney wants to include either the table or the graph in her report. Which do you think she should include? Why?

ACE Homework starts on page 15.

On Day 2, the students leave Lewes, Delaware, and ride through Ocean City, Maryland. They stop for the day on Chincoteague (SHING kuh teeg) Island, which is famous for its annual pony auction.

Did You Know?

Assateague (A suh teeg) Island is home to herds of wild ponies. To survive in a harsh environment of beaches, sand dunes, and marshes, these sturdy ponies eat saltmarsh, seaweed, and even poison ivy!

To keep the population of ponies under control, an auction is held every summer. During the famous "Pony Swim," the ponies that will be sold swim across a quarter mile of water to Chincoteague Island.

Go Online
PHSchool.com
For: Information about the "Pony Swim"
Web Code: ane-9031

Celia collects data along the way and uses it to make the graph below. Her graph shows the distance the riders are from Lewes as the day progresses. This graph is different from the graph made for Problem 1.3, which showed the total distance traveled as Day 1 progressed.

Day 2 Progress
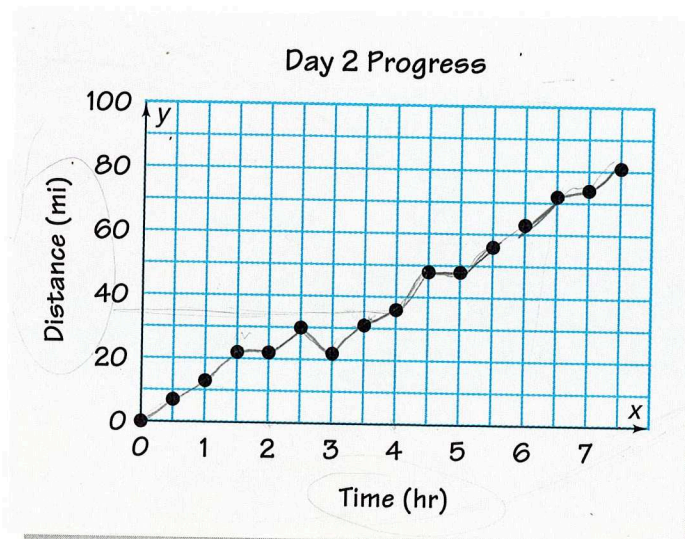
Problem 1.4 Reading Data from Graphs

A. Does it make sense to connect the points on this graph? Explain.

B. Make a table of (*time, distance*) data that matches the coordinate pairs of the graph. (You will need to estimate many of the distance values.)

C. What might have happened between hours 2 and 4? What do you think happened between hours 1.5 and 2?

D. During which interval(s) did the riders make the most progress? During which interval(s) did they make the least progress?

E. Which method of displaying the data helps you see the changes better, a table or a graph? Explain.

F. Use the graph to find the total distance the riders travel on Day 2. How did you find your answer?

ACE Homework starts on page 15.

Did You Know?

The Global Positioning System (GPS) is a satellite navigation system funded and operated by the U.S. Department of Defense. However, there are many thousands of civilian users of GPS worldwide. With the use of a portable computer, a Braille keyboard, and a GPS receiver, a blind person is able to get directions.
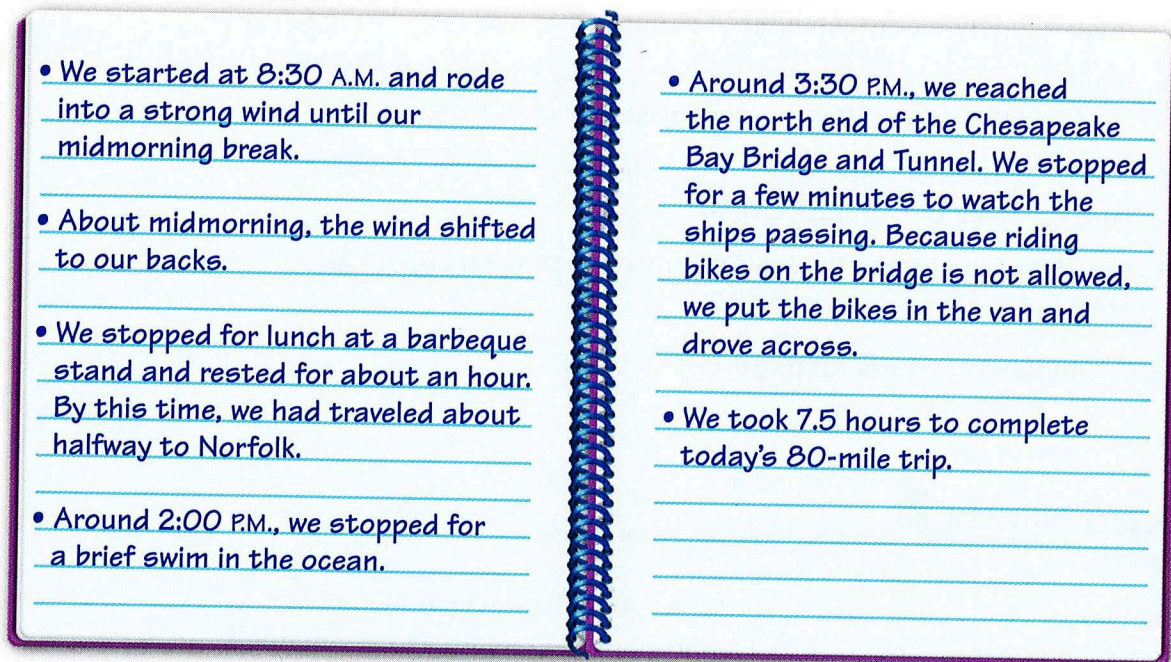
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On Day 3, the group travels from Chincoteague Island to Norfolk, Virginia. Malcolm and Tony ride in the van. They forget to record the distance traveled each half hour, but they do write some notes about the trip.

- We started at 8:30 A.M. and rode into a strong wind until our midmorning break.

- About midmorning, the wind shifted to our backs.

- We stopped for lunch at a barbeque stand and rested for about an hour. By this time, we had traveled about halfway to Norfolk.

- Around 2:00 P.M., we stopped for a brief swim in the ocean.

- Around 3:30 P.M., we reached the north end of the Chesapeake Bay Bridge and Tunnel. We stopped for a few minutes to watch the ships passing. Because riding bikes on the bridge is not allowed, we put the bikes in the van and drove across.

- We took 7.5 hours to complete today's 80-mile trip.

Problem 1.5 Finding Average Speed

A. Make a table of (*time, distance*) data that reasonably fits the information in Malcolm and Tony's notes.

B. Sketch a coordinate graph that shows the same information.

C. Explain how you used each of the six notes to make your table and graph.

D. The riders traveled 80 miles in 7.5 hours. Suppose they had traveled at a constant speed for the entire trip. This constant speed would be the same as the *average speed* of the real trip. What was the average speed for this trip?

E. Suppose you made a (*time, distance*) graph for a rider who made the entire 7.5-hour trip traveling at the average speed you found in Question D. What would the graph look like? How would it compare with the graph you made in Question B?

ACE Homework starts on page 15.

Applications

1. A convenience store has been keeping track of its popcorn sales.

Popcorn Sales

Time	Total Bags Sold
6:00 A.M.	0
7:00 A.M.	3
8:00 A.M.	15
9:00 A.M.	20
10:00 A.M.	26
11:00 A.M.	30
noon	45
1:00 P.M.	58
2:00 P.M.	58
3:00 P.M.	62
4:00 P.M.	74
5:00 P.M.	83
6:00 P.M.	88
7:00 P.M.	92

a. Make a coordinate graph of the data in the table above. Which variable did you put on the *x*-axis? Why?

b. Describe how the number of bags of popcorn sold changed during the day.

c. During which hour did the store sell the most popcorn? During which hour did it sell the least popcorn?

active math online

**For:** Climbing Monkeys Activity
Visit: PHSchool.com
Web Code: and-1101

2. At the right is a graph of jumping jack data. (On the x-axis, 20 means the interval from 0 seconds to 20 seconds, 40 means the interval 20 seconds to 40 seconds, and so on.)

   a. What does the graph tell you about Mary's experiment?

   b. How is this graph different from the graph you made in Problem 1.2?

   c. What total number of jumping jacks did Mary do?

Mary's Graph
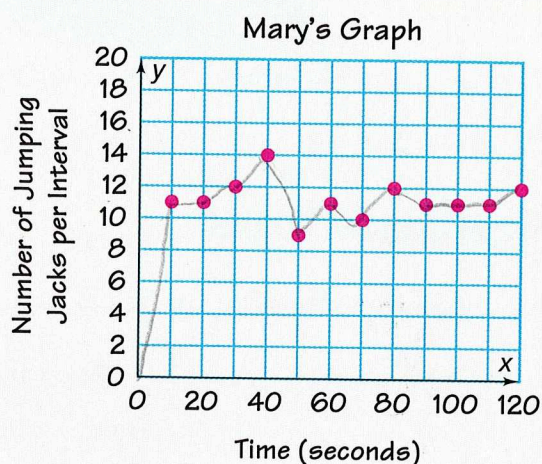
3. After doing the jumping jack experiment, Andrea and Ken compare their graphs. Because the points on his graph are higher, Ken said he did more jumping jacks in the 120 seconds than Andrea did. Do you agree? Explain.

Andrea's Graph

Ken's Graph
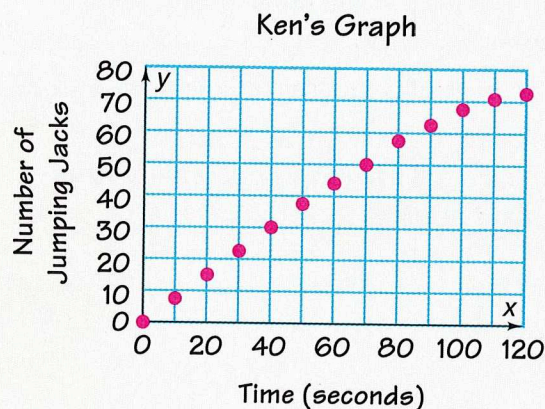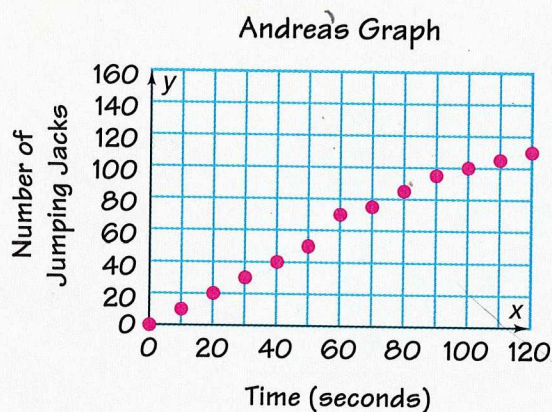
4. Katrina's parents kept this record of her growth from her birth until her 18th birthday.

Katrina's Height

Age (yr)	Height (in.)
birth	20
1	29
2	33.5
3	37
4	39.5
5	42
6	45.5
7	47
8	49
9	52
10	54
11	56.5
12	59
13	61
14	64
15	64
16	64
17	64.5
18	64.5
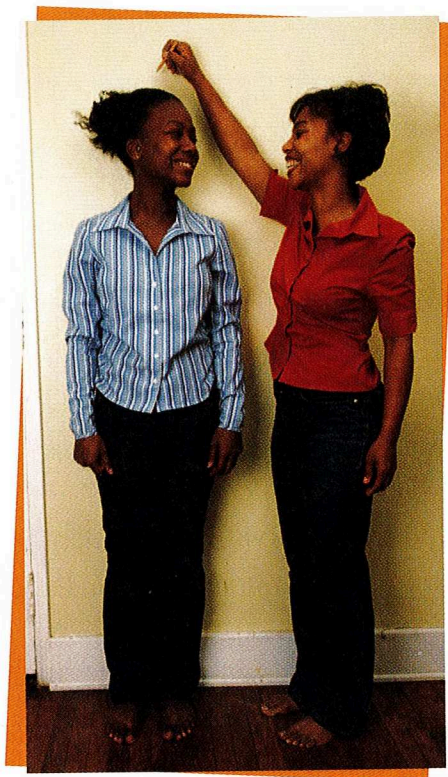
a. Make a coordinate graph of Katrina's height data.

b. During which time interval(s) did Katrina have her greatest "growth spurt"?

c. During which time interval(s) did Katrina's height change the least?

d. Would it make sense to connect the points on the graph? Why or why not?

e. Is it easier to use the table or the graph to answer parts (b) and (c)? Explain.

5. Below is a chart of the water depth in a harbor during a typical 24-hour day. The water level rises and falls with the tides.

Effect of the Tide on Water Depth

Hours Since Midnight	0	1	2	3	4	5	6	7	8
Depth (m)	10.1	10.6	11.5	13.2	14.5	15.5	16.2	15.4	14.6

Hours Since Midnight	9	10	11	12	13	14	15	16
Depth (m)	12.9	11.4	10.3	10.0	10.4	11.4	13.1	14.5

Hours Since Midnight	17	18	19	20	21	22	23	24
Depth (m)	15.4	16.0	15.6	14.3	13.0	11.6	10.7	10.2

a. At what time is the water the deepest? Find the depth at that time.

b. At what time is the water the shallowest? Find the depth at that time.

c. During what time interval does the depth change most rapidly?

d. Make a coordinate graph of the data. Describe the overall pattern you see.

e. How did you determine what scale to use for your graph? Do you think everyone in your class used the same scale?
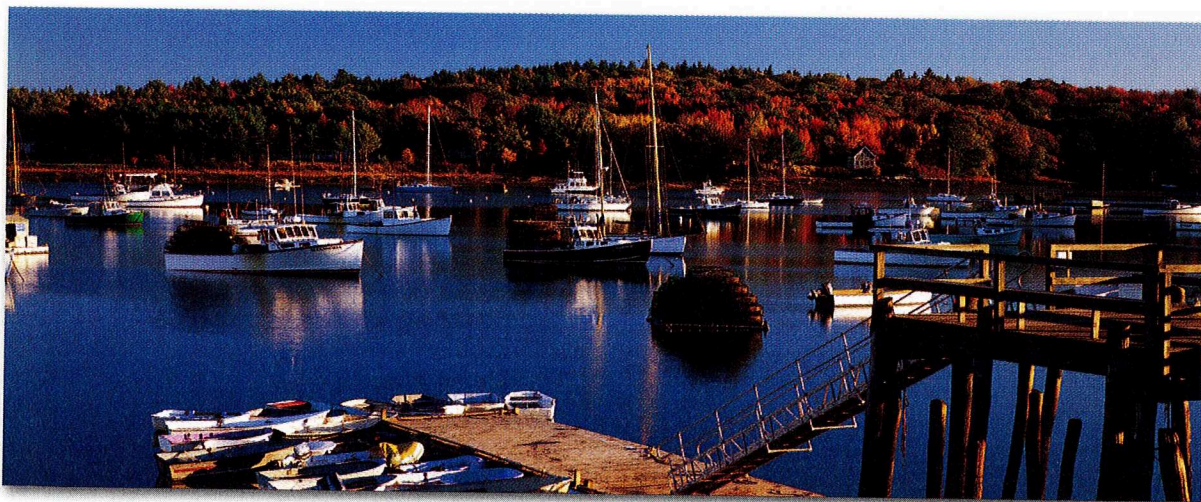
6. Three students made graphs of the population of a town called Huntsville. The break in the *y*-axis in Graphs A and C indicates that there are values missing between 0 and 8.
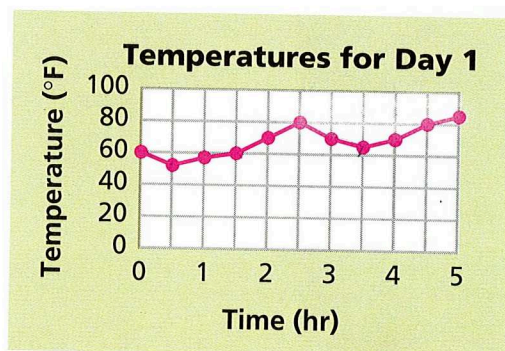
Graph A
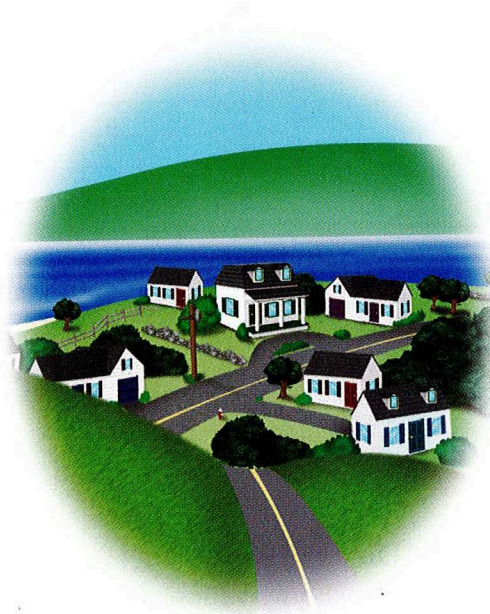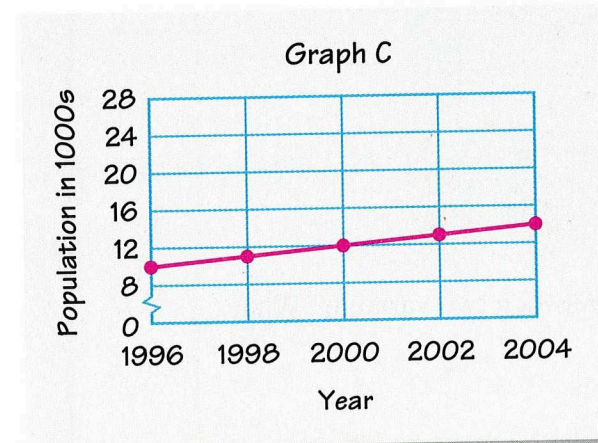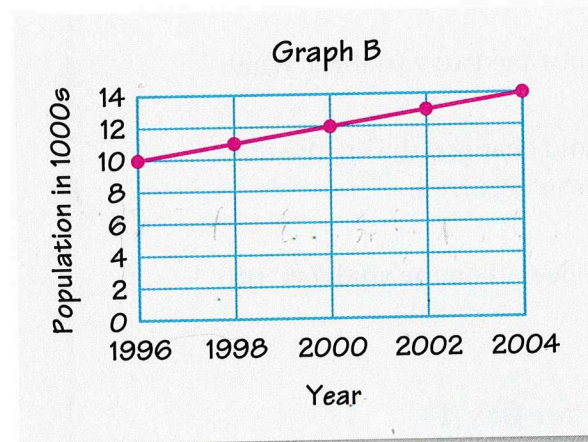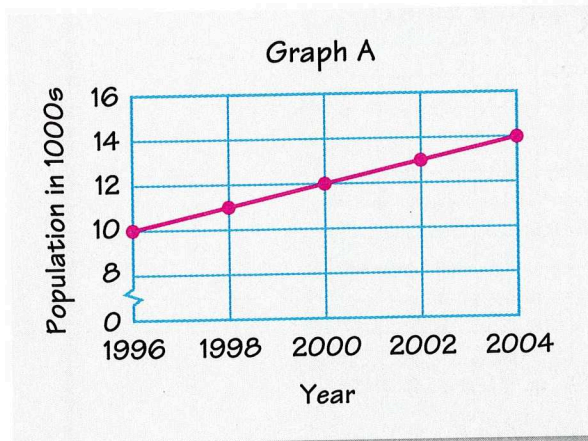
Graph B

Graph C

a. Describe the relationship between time and population as shown in each of the graphs.

b. Is it possible that all three graphs correctly represent the population growth in Huntsville? Explain.

7. On the *x*-axis of the graph below, 6 means the time from 5:00 to 6:00, 7 means the time from 6:00 to 7:00, and so on.

Juice Vending Machine Sales

Cans Sold vs. Time of Day (starting with 6 A.M.)
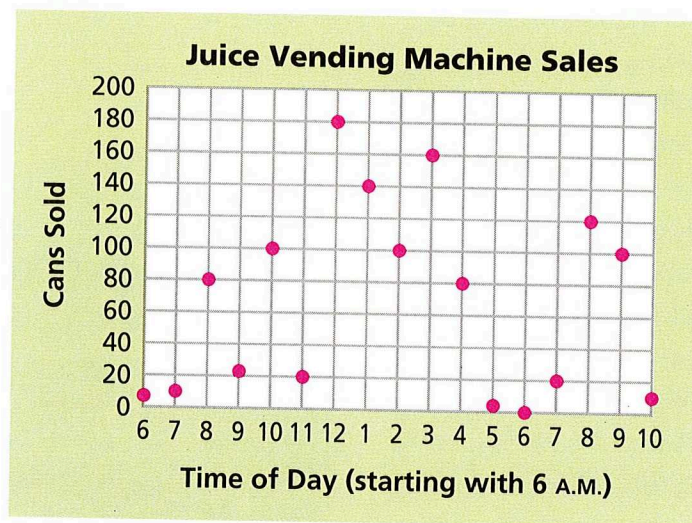
a. The graph shows the relationship between two variables. What are the variables?

b. Describe how the number of cans sold changed during the day. Explain why these changes might have occurred.

8. Here is a graph of temperature data collected on the students' trip from Atlantic City to Lewes.

Temperatures for Day 1

Temperature (°F) vs. Time (hr)

a. This graph shows the relationship between two variables. What are they?

b. Make a table of data from this graph.

c. What is the difference between the day's lowest and highest temperatures?

d. During which time interval(s) did the temperature rise the fastest? During which time interval did it fall the fastest?
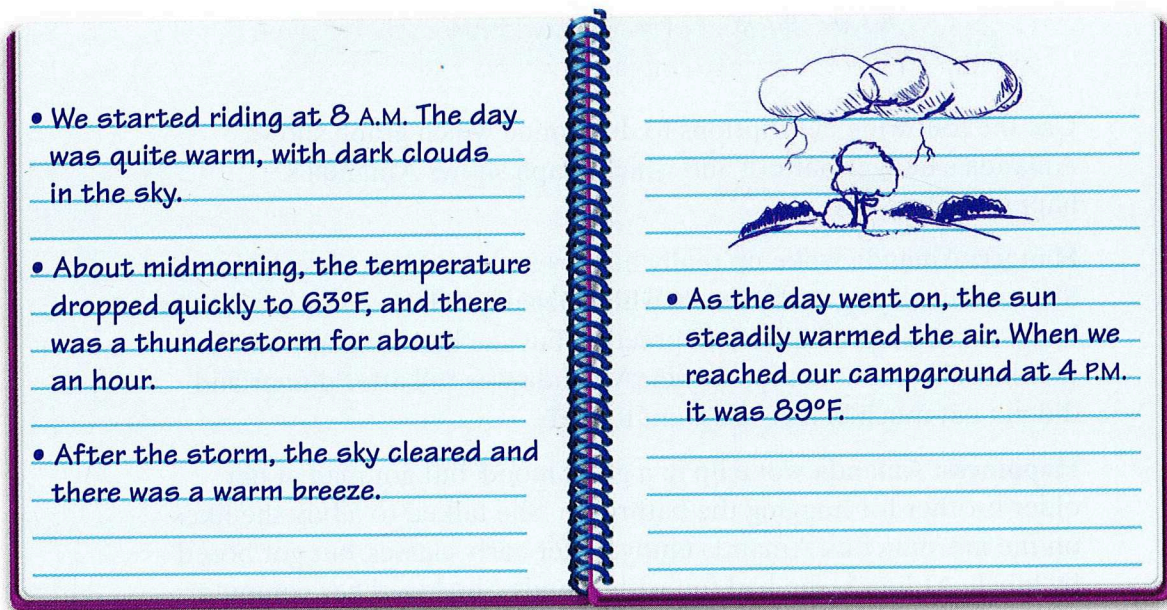
e. Is it easier to use the table or the graph to answer part (c)? Why?

f. Is it easier to use the table or the graph to answer part (d)? Why?

g. What information can you get from the lines connecting the points? Do you think it is accurate information? Explain.

9. Here is a graph Celia drew on the bike trip.

a. What does this graph show?

b. Is this a reasonable pattern for the speed of a cyclist? Is this a reasonable pattern for the speed of the van? Is this a reasonable pattern for the speed of the wind? Explain each of your conclusions.

Celia's Graph
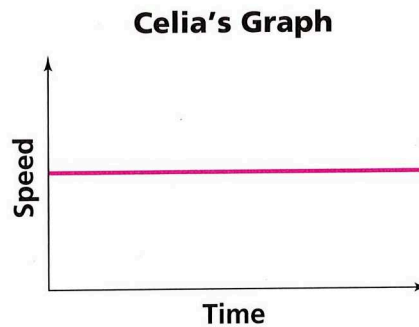
10. Make a table and a graph of (*time, temperature*) data that fit the following information about a day on the road:

- We started riding at 8 A.M. The day was quite warm, with dark clouds in the sky.

- About midmorning, the temperature dropped quickly to 63°F, and there was a thunderstorm for about an hour.

- After the storm, the sky cleared and there was a warm breeze.

- As the day went on, the sun steadily warmed the air. When we reached our campground at 4 P.M. it was 89°F.

11. When Ben first started to play the electric guitar, his skill increased quite rapidly. Over time, Ben seemed to improve more slowly.

a. Sketch a graph to show how Ben's guitar-playing skill progressed over time since he began to play.

b. Your graph shows the relationship between two variables. What are those variables?

c. What other variables might affect the rate at which Ben's playing improves?

12. Amanda made the graphs below to show how her level of hunger and her feelings of happiness changed over the course of a day. She forgot to label the graphs.

Graph I

Graph II
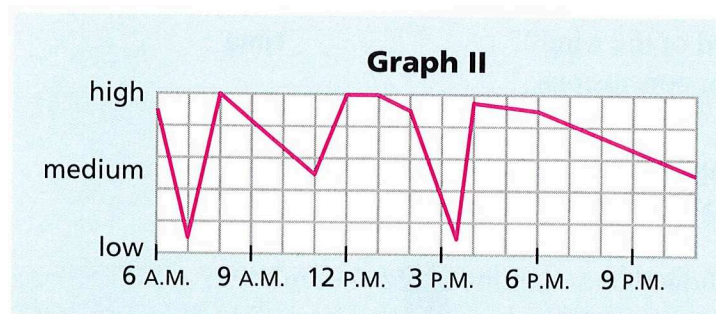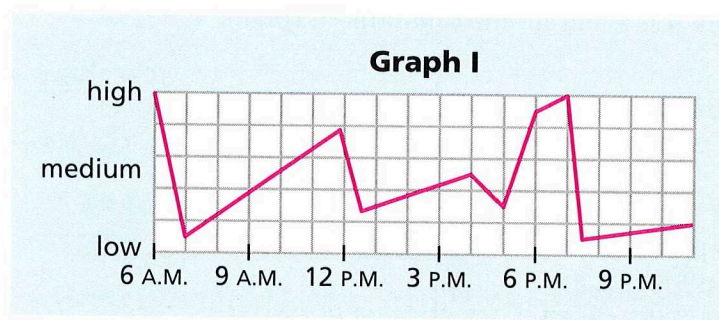
Use the following descriptions to determine which graph shows Amanda's hunger pattern and which graph shows Amanda's happiness. Explain.

Hunger: Amanda woke up really hungry and ate a large breakfast. She was hungry again by lunch, which began at 11:45. After school, she had a snack before basketball practice, but she had a big appetite by the time she got home for dinner. Amanda was full after dinner and did not eat much before she went to bed.

Happiness: Amanda woke up in a good mood, but got mad at her older brother for hogging the bathroom. She talked to a boy she likes on the morning bus. Amanda enjoyed her early classes, but got bored by lunch. At lunch, she had fun with friends. She loved her computer class, which was right after lunch, but she didn't enjoy her other afternoon classes. After school, Amanda had a good time at basketball practice. After dinner, she did homework and chores.