

Investigation

1

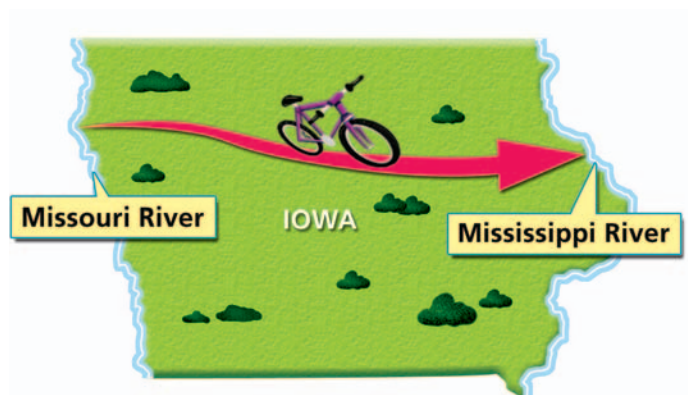
Variables, Tables, and Coordinate Graphs

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.



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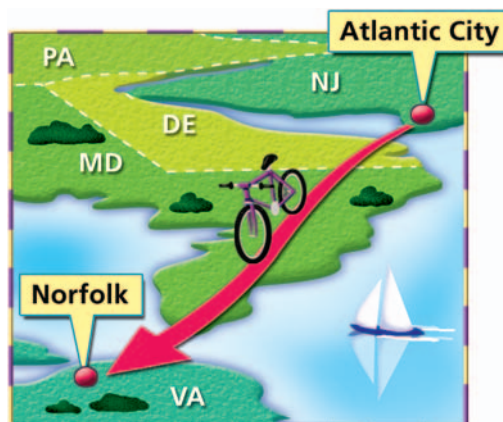
For: Information about RAGBRAI
Web Code: ane-9031

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.

Problem 1.1 Interpreting Tables

- 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?

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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*.

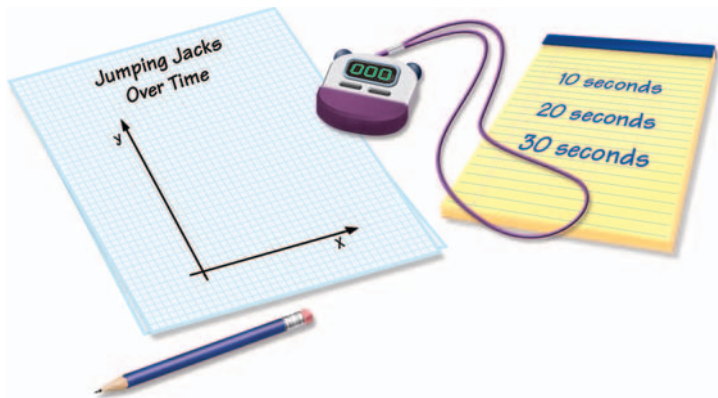
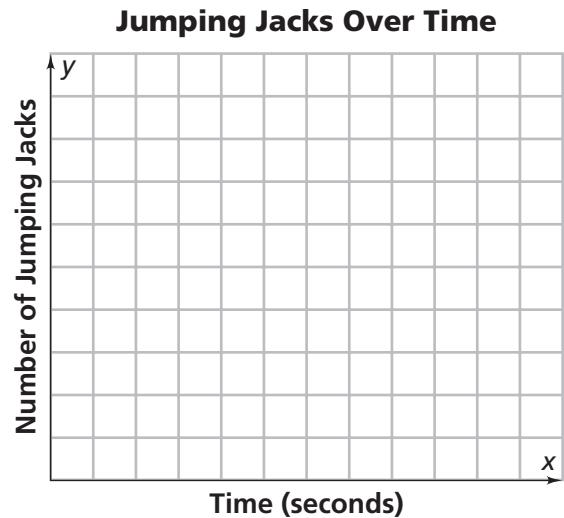
Step 2 Select an axis to represent each variable.

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.

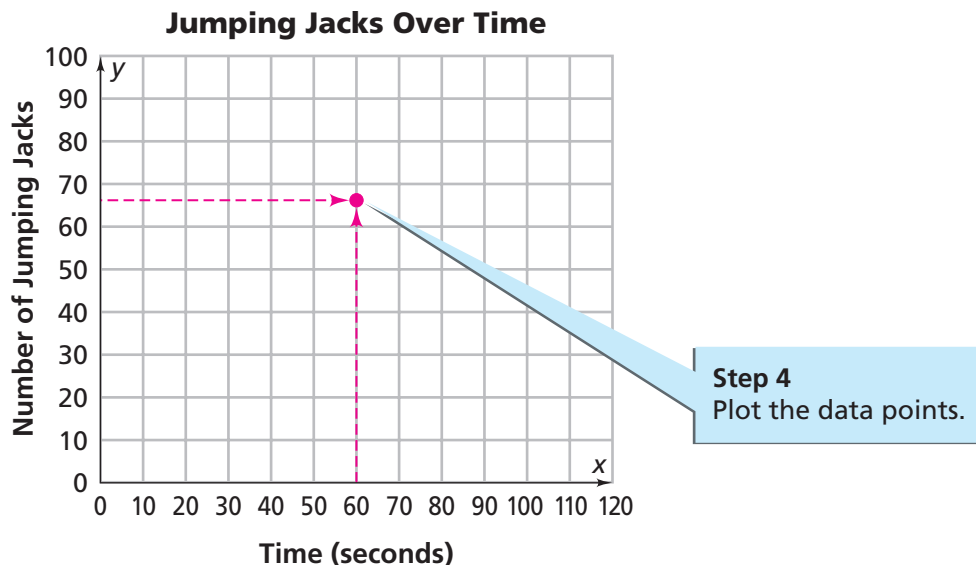
Label your graph so that someone else can see what it represents. You can label the *x*-axis as “Time (seconds)” and the *y*-axis as “Number of Jumping Jacks.” You can use these labels to help you choose a title for your graph. You might title this graph, “Jumping Jacks Over Time.”



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 of 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.



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.

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1.3 Day 1: Atlantic City to Lewes

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

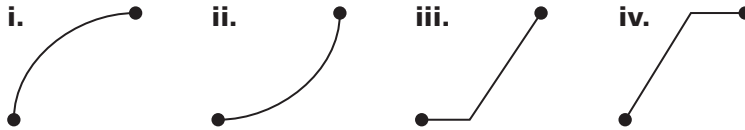
Time (hr)	Distance (mi)
0	0
0.5	8
1.0	15
1.5	19
2.0	25
2.5	27
3.0	34
3.5	40
4.0	40
4.5	40
5.0	45

Problem 1.3 Interpreting Graphs

- Make a coordinate graph of the time and distance data in Sarah's table. Show time on the x -axis.
- Analyze your graph by answering the following questions:
 - Give the coordinate pair for the third point on your graph. What information does this point give?
 - 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:



Match each of these connecting paths with the travel notes below.

- Celia rode slowly at first and gradually increased her speed.
 - Tony and Liz rode quickly and reached the campsite early.
 - Malcolm had to fix a flat tire, so he started late.
 - 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?

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1.4

Day 2: Lewes to Chincoteague Island

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?

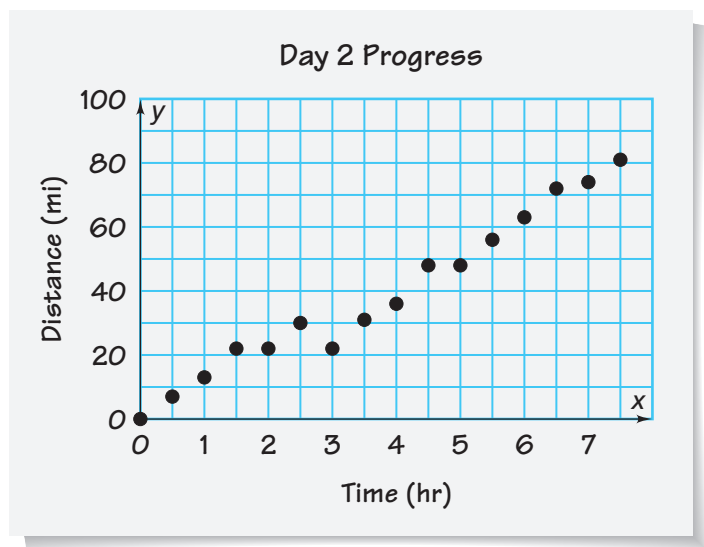
Assateague (A suh teeg) Island is home to herds of wild ponies. To survive in a harsh environment of beaches, sand dunes, and marshes, these sturdy ponies eat saltmarsh, seaweed, and even poison ivy!

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 For: Information about the “Pony Swim”
 PHSchool.com 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.



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?

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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.

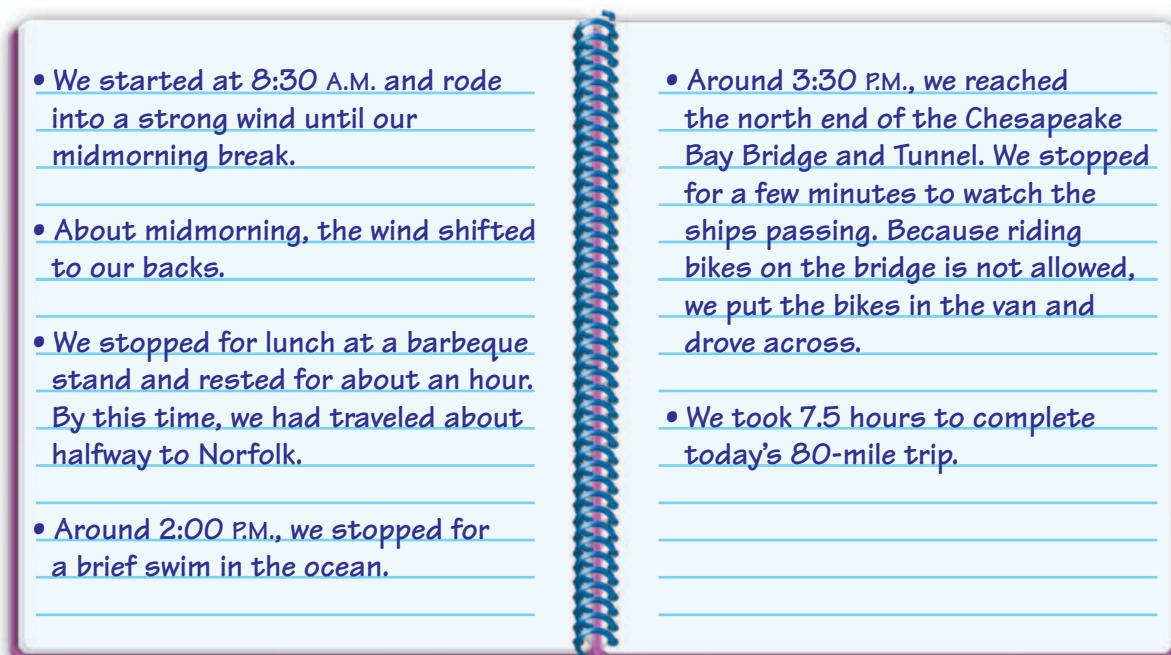
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1.5

Day 3: Chincoteague Island to Norfolk

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.

**Problem 1.5 Finding Average Speed**

- Make a table of (*time, distance*) data that reasonably fits the information in Malcolm and Tony's notes.
- Sketch a coordinate graph that shows the same information.
- Explain how you used each of the six notes to make your table and graph.
- 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?
- 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?

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