At a Glance Problem 1.1 Pacing $1\frac{1}{2}$ Days

1.1 Getting Ready to Ride: Data Tables and Graphs

Focus Question How can you construct a graph from a table of data that depicts change over time? How is this pattern of change represented in the graph?

Launch

Tell the class about bicycles and the yearly bicycle tour across Iowa.

Ask for some predictions about the jumping jack stamina experiment:

- *How many jumping jacks do you think you could complete in 2 minutes?*
- *How do you think your jumping jack rate would change over the 2-minute test?*

Materials

Labsheets
- 1.1A: Jumping Jack Fitness Test
- 1.1B: Jumping Jack Tables and Graphs
- Graph Paper
- stopwatches (1 per group)

Explore

Check in with each group to be sure they are plotting pairs correctly.

- *What patterns do you see in the graph? Explain.*
- *What would it take to have the data points lie in a straight-line?*
- *What pattern of growth do you observe between adjacent points?*

Summarize

The core scientific issue in this Problem is how performance rates change over time.

- *Could you have chosen a different time interval for recording data in a table?*
- *How would your choice have affected your observations in Question B?*
- *What does the experiment suggest about bicycle-riding speed over time?*

Pick a point on one of the graphs and ask:

- *What are its coordinates? What information do the coordinates provide?*

ACE Assignment Guide for Problem 1.1

Applications: 1–3 | Connections: 14–15
Extensions: 20

Answers to Problem 1.1

A. Student data will vary. In one class, several students started jumping at a rate of 10 jumping jacks for every 10 seconds. After 1 minute, they started to slow down slightly. Many had data entries of 107 and 108 jumping jacks for 120 seconds.

B. Some students will have data that show their jumping jack rate decreases as time passes. Even though the total number of jumps increases for each 10-second interval in the table, the rate decreases since the number of jumps in each 10-second interval decreases as time passes.

C. **1.** The most likely pattern of jumping jack data is greater numbers in the early 10-second intervals than in the later intervals. Since the directions ask students to record the total number of jumping jacks at the end of each 10-second interval (not the number during the preceding 10 seconds), the total will grow more rapidly at first than later. The difference between two adjacent table entries (divided by 10 to get a rate per second) will tell the rate of jumping jacks.

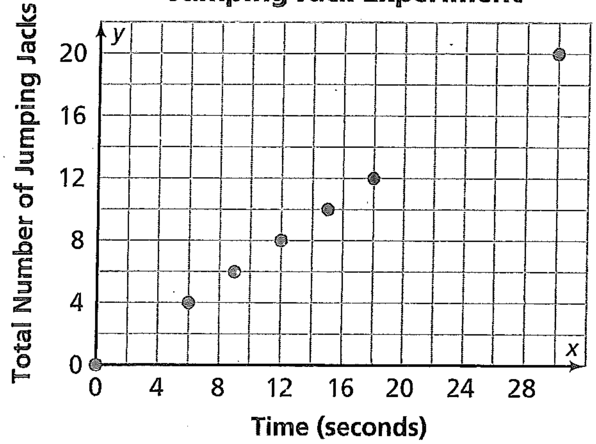
2. On a graph, greater rates will be shown by bigger steps upward from one data point to the next.

D. It seems likely that students will find that their rate of jumping jacks slows near the end of the experimental time period. The analogy to bike riding would suggest that the speed of riding will slow as the day wears on.

1. a. If a student jumped at a steady pace of 8 jumping jacks for every 10 seconds, the table of sample *time* and *jumps* data would look like this: (See Figure 1.)

b. A plot of the points corresponding to (*time, jumping jack total*) pairs in the table will produce a linear pattern with the points rising up 8 for every 10 over.

Jumping Jack Experiment



3. a. If a student jumped at a steady pace of 4 jumping jacks for every 6 seconds, the table of sample *time* and *jumps* data would look like this:

Jumping Jack Experiment

Time (seconds)	0	6	9	12	15	18	30
Total Number of Jumping Jacks	0	4	6	8	10	12	20

b. A plot of the points corresponding to (*time, jumping jack total*) numbers in the table of part (a) would produce a linear pattern with the points rising up 4 for every 6 over. As in part (1), it is a linear pattern except it is not as steep.

Jumping Jack Experiment

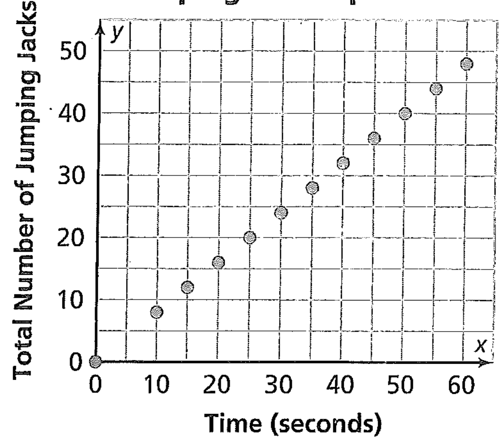


Figure 1

Jumping Jack Experiment

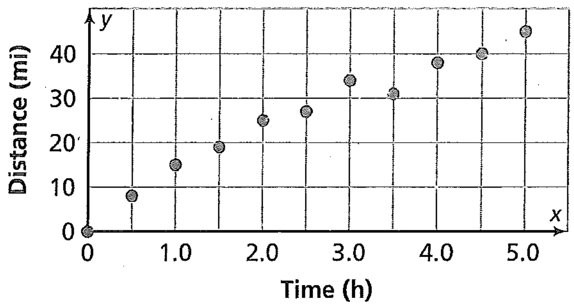
Time (seconds)	0	10	15	20	25	30	35	40	45	50	55	60
Total Number of Jumping Jacks	0	8	12	16	20	24	28	32	36	40	44	48

Assignment Guide for Problem 1.2

Applications: 4–9 | Connections: 16–19
Extensions: 23

Answers to Problem 1.2

A. 1. **Atlantic City to Cape May**



2–4. Students will have a variety of observations about the pattern of travel shown in the table and the graph. They will probably notice that the cyclists went faster in the first hour than in later time periods, though the speed from hour 2.5 to hour 3 is equal to that during hour 0.5 to hour 1.0. This kind of observation is easiest to quantify by finding the difference of adjacent distance values in the data table. However, it is shown visually by greater jumps in the plotted points of the graph. Students might notice that there is a 'dip' in the graph between hour 3 and hour 4 and wonder what this could mean. One possible explanation would be that the cyclists made a wrong turn and had to backtrack to get on course. Or, one of the cyclists might have dropped something and had to turn back to retrieve it.

B. 1–3. Adjacent distance values in the table and the amount of jump between adjacent points on the graph show the speed. The data shows greatest speed in the first half-hour (8 miles covered or 16 miles per hour). There are several other half-hour time intervals in which the cyclists covered 7 miles (14 miles per hour).

The slowest riding happens between 2.0 and 2.5 hours (2 miles or 4 miles per hour). The slowdown might have been caused by a break for snack or rest. In some sense, the half hour of backtracking (from 3.0 to 3.5 hours) might be said to be slowest, with a rate of –6 miles per hour. However, the actual riding speed in that half hour was 6 miles per hour.

C. The match of stories and graph connections would be 1(V), 2(I), 3(III), 4(IV), 5(II).

D. Students who choose the table may say that it gives exact distances for given times. Students who choose the graph may say that it shows the "picture" of all the data for the day. It is easy to see from the graph when the change in distance is great, when it is small, and when it does not change. A disadvantage is that you need to estimate some values from a graph, rather than knowing exact values.

- *There are three breaks: at mid-morning, at lunch time, and at around 2:00 P.M. (or around hour 6.0).*
- *The class might assume that when the cyclists load their bicycles in the van, they will cover a greater distance in a shorter time than when they were pedaling.*

End the Summarize by discussing the advantages and disadvantages of each representation for looking at patterns of change in distance over time.

Assignment Guide for Problem 1.3

Applications: 10–11 | Connections: 21
Extensions: 24–26

Answers to Problem 1.3

A. Here is one possible table:
(See Figure 1.)

B. The data given in Question A will yield a graph like that below. In this situation, it does make sense to connect the dots because riding was continuous over time. However, the way that the dots would be connected is somewhat arbitrary. Failing specific guidance, it usually makes sense to connect the dots with line segments. The result will often reveal an overall pattern that is not as clear with only discrete points plotted.
(See Figure 2.)

C. The data given in Question A and the graph in Question B match the story in the following respects:

- The trip covers 80 miles in 9 hours.
- The break for lunch occurs at noon (four hours after the 8 A.M. start) and no distance is covered in the next hour.
- The speed increases after 2 hours, when the wind shifts to the cyclists' backs.
- The swim break occurs at hour 6 (about 2 P.M.), so the cyclists cover less distance in that hour.
- The cyclists slow down in the afternoon, until they pack their bikes and ride in the van for the last hour to cover 15 miles.

D. Students will have different ideas about which presentation of the data is more informative.

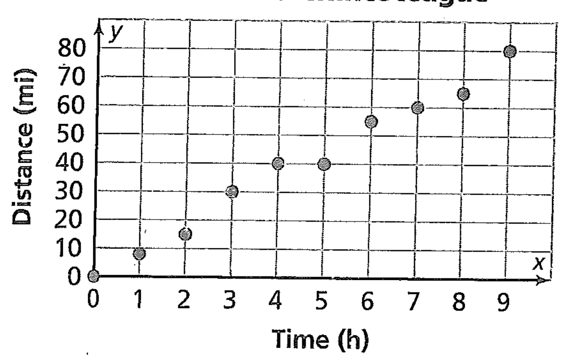
Figure 1

Lewes to Chincoteague

Trip Time (h)	0	1	2	3	4	5	6	7	8	9
Distance (mi)	0	8	15	30	40	40	55	60	65	80

Figure 2

Lewes to Chincoteague



- *How did you decide when the cyclists put their bikes in the van and rode in the van?*
- *How can you tell from the graph where the fastest speed is occurring?*

ACE

Assignment Guide for Problem 1.4

Applications: 12–13
Extensions: 22

Answers to Problem 1.4

A. A table of (*time, distance*) data might look like this: (See Figure 1.)

1. The point (3, 25) is fourth from the left. It tells us that after 3 hours the cyclists had covered 25 miles.
2. The points (9, 60) and (10, 110) are respectively 10th and 11th from the left. They tell the distance covered after 9 hours (60 miles) and 10 hours (110 miles). Together, they tell that during the tenth hour, the cyclists (now in the van) traveled at an average speed of 50 miles per hour.
3. The average speed for the trip was approximately 13.2 miles per hour. You can find this from the graph or the table by using the point (11, 145) and finding 145 ÷ 11 (the distance divided by the time).

B. Speeds for the biking and van riding parts of the trip:

1. Speed increases dramatically after 9 hours, because the van moves much faster than the bikes.
2. Average bike riding speed was 60 ÷ 9 or approximately 6.7 miles per hour.
3. Average van speed was 85 ÷ 2 or approximately 42.5 miles per hour.
4. The difference between typical biking and van speed is shown by the fact that the last two data points on the graph jump much higher in one hour than do the earlier data points representing distance traveled by bicycle.

C. 1. If a professional cyclist covered 145 miles in 8 hours, his/her average speed would be 145÷8 or approximately 18.1 miles per hour.

2. Traveling at a constant speed would be reflected in a graph with points that lie in a straight line from (0, 0) to (8, 145).

Figure 1

Chincoteague to Williamsburg

Trip Time (h)	0	1	2	3	4	5	6	7	8	9	10	11
Distance (mi)	0	10	20	25	30	30	40	50	55	60	110	145