15 DATA DISPLAYS AND ANALYSIS

Whether you're a Panther, or a Knight, or a Tiger, it stands to reason that your school has a mascot and nickname to represent your school. Many times, logos are used on sweatshirts, banners, and even face paint to promote school spirit.

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15.1 SCHOOL SPIRIT AND SCATTER PLOTS

Using Scatter Plots to Display and Analyze Two-Variable Relationships

Learning Goals

In this lesson, you will:

- Define the meaning of two-variable data.
- Collect and record two-variable data.
- Construct and interpret a scatter plot.
- Determine if a change in the value of one variable results in a change in the value of the second variable.
- Identify patterns in a scatter plot.

Key Term

- two-variable data set

Chances are that your school has a nickname. Perhaps your school may even have a mascot dress in the school colors or in a costume to promote school spirit. This spirit is especially seen during competition between other schools.

School names and mascots can range from very common names like the Auburn Tigers in Georgia, to the sometimes rare names like the Banana Slugs of the University of California at Santa Cruz. So, what's your school mascot? Does your school mascot get your school spirit juices flowing?

Problem 1 School Spirit, Sweatpants, Sweatshirts, and Scatter Plots

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The School Spirit Club plans to sell sweatpants and sweatshirt sets with the school's logo. The club is determining if there is a way to package sweatshirt and sweatpants sets so that most of the students can buy a set that will fit.

1. Do you think there might be a relationship between the sweatpant size and the sweatshirt size a person would buy? Why or why not?

When collecting information about a person or thing, the specific characteristic of the information gathered can be called a variable. Previously, you have seen variables in mathematics refer to a letter or symbol to represent a number. In this case, a variable can refer to any characteristic that can change, or vary.

2. Name a variable that can affect a sweatshirt size.

3. Do you think collecting information about one sweatshirt characteristic is enough to determine which shirt sizes should be paired with which pant sizes?

The School Spirit Club decides to collect students' heights and arm spans. They hope that collecting this information can determine if there is a relationship between sweatshirt size and sweatpant size. Collecting information about two separate characteristics for the same person or thing can be called a **two-variable data set**.

4. Why is it important to record each student's height and arm span?

5. Analyze the results the School Spirit Club collected.

Name	Height (cm)	Arm Span (cm)	Ordered Pair
Donna	141	143	
Edward	152	157	
Betina	150	151	
Thomas	162	159	
Aaron	176	172	
Julianna	155	153	
Amy	156	159	
Larry	162	164	
Carlos	167	162	
Jermont	163	168	
Shayla	154	154	
Mary	161	157	
Latisha	164	167	
Blake	172	180	
Genifer	154	152	
Ella	161	167	
Felix	167	168	

Can you determine whether there is a relationship between height and arm span, and sweatshirt size and sweatpant size? Why or why not?

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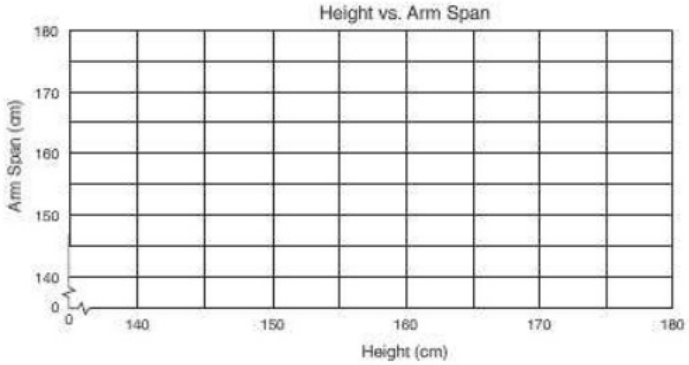
One way to show the relationship between two different characteristics is to create a graph that can represent the two variables. As you learned previously, a scatter plot is a graph in the coordinate plane of a collection of two-variable data plotted as ordered pairs. The ordered pairs are formed by using the values of the first characteristic as the x-coordinate, and using the values of the second characteristic as the y-coordinate.

6. Write the ordered pairs for the data in the table.

7. Complete the scatter plot shown by plotting the data points that the School Spirit Club collected.



8. What patterns do you notice in the scatter plot?

9. Circle the point (150, 151) on the scatter plot. Then, explain what this point means.

10. Suppose two points on the scatter plot are (162, 164) and (164, 162).

a. Grace says that the two points are in different locations, but Jorge disagrees. He thinks they are both the same point. Who is correct? Explain your reasoning.

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b. Describe the locations of the two points on the scatter plot relative to each other.

Problem 2 Video Games and Math Grades

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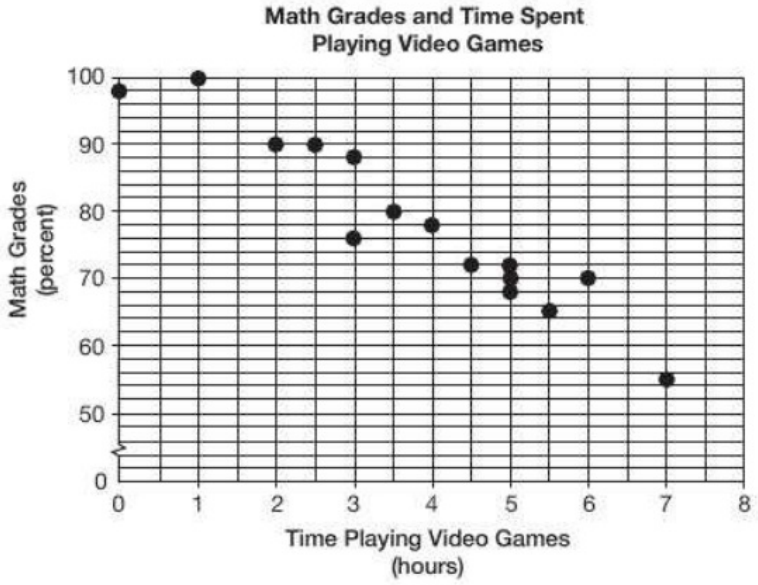
Ms. Liu is trying to determine if there is a relationship between the math grade percentage of her students, and the time spent playing video games. Ms. Liu constructed the scatter plot for the number of hours her math students spent playing video games per weeknight (Monday through Thursday), and their grade percentage in her math class.



1. Circle the point (3.5, 80) on the scatter plot. Explain the meaning of the point.

2. Describe any patterns you see in Ms. Liu's scatter plot.

955-
971

3. Complete the table with the data from Ms. Liu's scatter plot.

Time spent playing video games (hours)	Math Grades (percent)

4. Using the table, identify the student who earned a 76% in math class. How many hours did that student spend playing video games?

Problem 3 Creating a Scatter Plot with a Graphing Calculator

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You can use a graphing calculator to create a scatter plot.

Follow the steps to create a scatter plot for the height and arm span data the School Spirit Club collected. Begin by entering the data set into List 1 and List 2.

Step 1: Press **STAT**. The **EDIT** and **1: EDIT** should be highlighted.

Press **ENTER**.

Enter the data points for the students' height and arm span. It is critical that the *x*-coordinates in List 1 and the *y*-coordinates in List 2 match the ordered pairs from your table.

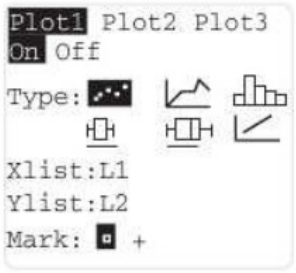
L1	L2	L3 2
161	157	
164	167	
172	180	
154	152	
161	167	
167	168	

L2(18)		

Step 2: Press **Y=** and delete any equations that have been entered.

Press **2nd** followed by **Y=**. Make certain that only Plot 1 is turned on; all other plots are should be turned off.

Press **ENTER**. Use the arrow keys to highlight the scatter plot, and press **ENTER**.

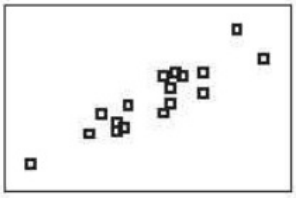


Step 3: Make certain **Xlist:** displays **L1** and **Ylist:** displays **L2**.

There are two ways to have the calculator display the graph.

a. Press **WINDOW** and enter the values for Xmin and Xmax. Then, press **GRAPH**.

b. Press **ZOOM** followed by **9**.



1. Would a student who is 145 centimeters tall be more likely to have an arm span of 150 centimeters or 180 centimeters? Why?

2. Would a student who is 170 centimeters tall be more likely to have an arm span of 150 centimeters or 180 centimeters? Why?

Talk the Talk

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At the beginning of the lesson, the School Spirit Club wanted to see if there was a way to determine if there might be a relationship between the sweatpant size and the sweatshirt size a person could buy together.

1. What conclusions did you reach about the relationship between a student's height and arm span from the data the School Spirit Club collected?

2. How could your conclusion help the School Spirit Club decide how to package their sets of sweatpants and sweatshirts?

Be prepared to share your solutions and methods.

15.2 JUMP IN! THE WATER'S FINE!

Interpreting Patterns in Scatter Plots

Learning Goals

In this lesson, you will:

- Interpret patterns in a scatter plot.
- Determine if a pattern in a scatter plot has a linear relationship.
- Identify potential outliers in a scatter plot.

Key Terms

- independent variable (explanatory variable)
- dependent variable (response variable)
- association
- linear association
- cluster
- positive association
- negative association
- outlier

For many East Coast residents visiting sunny Southern California for the first time, a trip to a white sandy beach and warm water is usually on the agenda. However, the ocean temperature in the Pacific Ocean along California's coast is part of a cold current. This means that the average ocean temperature rarely breaks 70°F! The world's oceans and seas fall into one of two categories: cold currents and warm currents. Generally, the warmest bodies of water are found near the equator while many of the cold currents are closer to the earth's poles. Why does it seem that warm currents are near the equator while cold currents seem to be closer to the North and South Poles?

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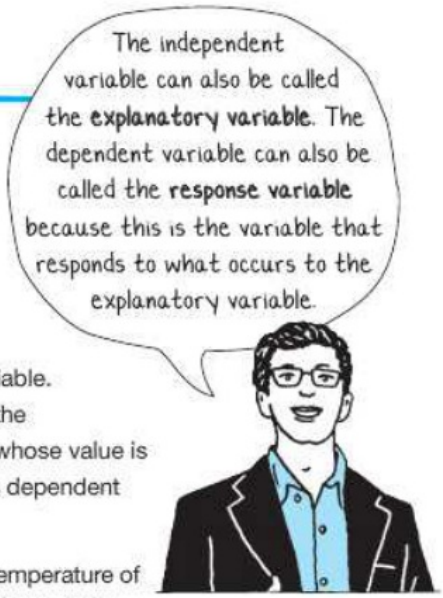
Problem 1 Ocean Temperatures



As you learned previously, a two-data variable set is a data set in which two separate characteristics are measured for a person or a thing. Sometimes, the two-data variable set is designated as two different variables: the *independent variable* and the *dependent variable*. The **independent variable** is the variable whose value is not determined by another variable. Generally, the independent variable is represented by the *x*-coordinate. The **dependent variable** is the variable whose value is determined by an independent variable. Generally, this dependent variable is represented by the *y*-coordinate.

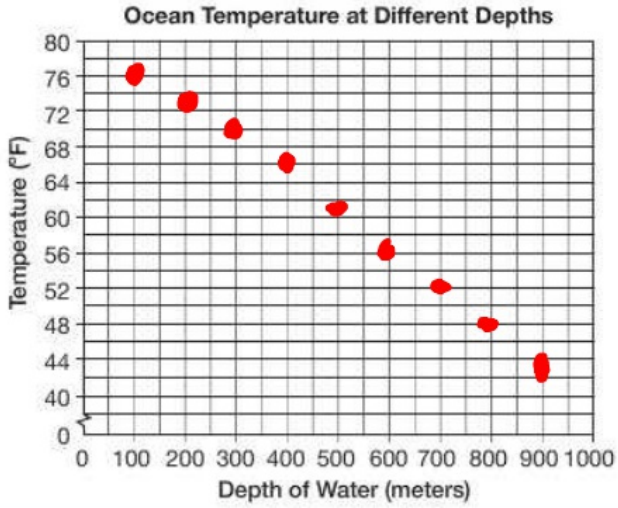
1. Erica, who is an oceanographer, is measuring the temperature of the ocean at different depths. Her results are listed in the table.

Depth (m)	100	200	300	400	500	600	700	800	900
Temperature (°F)	76	73	70	66	61	56	52	48	43

a. Identify the independent and dependent variables in Erica's data table.

Temp: dependent
Depth: independent

b. Create a scatter plot using the data Erica gathered for the ocean temperatures at different depths.



2. Explain the meaning of the point (400, 66).

At 400m down, the temp was 66°

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3. What relationship does the scatter plot show between the depth of the ocean water and the temperature of the water?

Further down, colder water

As you have experienced, scatter plots can be great tools to identify patterns in a two-variable data set. Sometimes, these patterns or relationships are called **associations**. One common pattern that exists in data is when the points on a scatter plot form a *linear association*. A **linear association** occurs when the points on the scatter plot seem to form a line. In most cases the points will not form a perfect line, but they are *clustered*. When data values are **clustered**, the data values are arranged in such a way that as you look at the graph from left to right, you can imagine a line going through the scatter plot with most of the points being clustered close to the line.

4. Explain how there seems to be a linear association between the depth of the ocean water and the water temperature.

The clustered dots are decreasing

If the two variables have a linear association, you can then determine the type of association between two variables. You can typically look for a pattern in the dependent variable on the *y*-axis as the independent variable on the *x*-axis increases from left to right. The two variables have a **positive association** if, as the independent variable increases, the dependent variable also increases. If the dependent variable decreases as the independent variable increases, then the two variables have a **negative association**. Once you identify the pattern for two variables with a linear relationship, you can state the association between the two variables.

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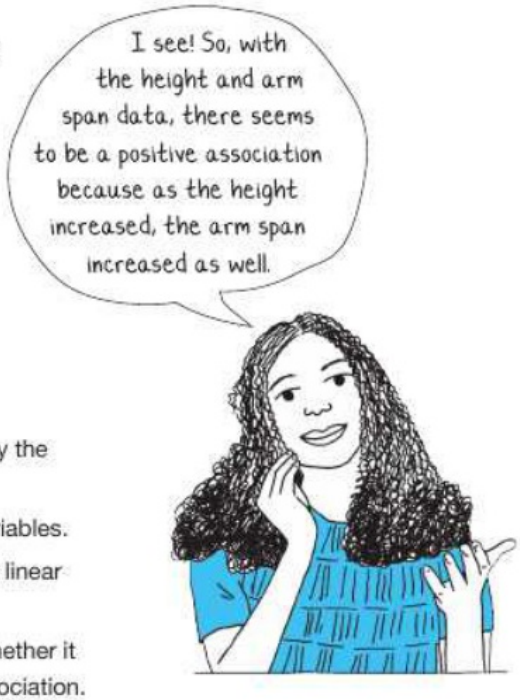
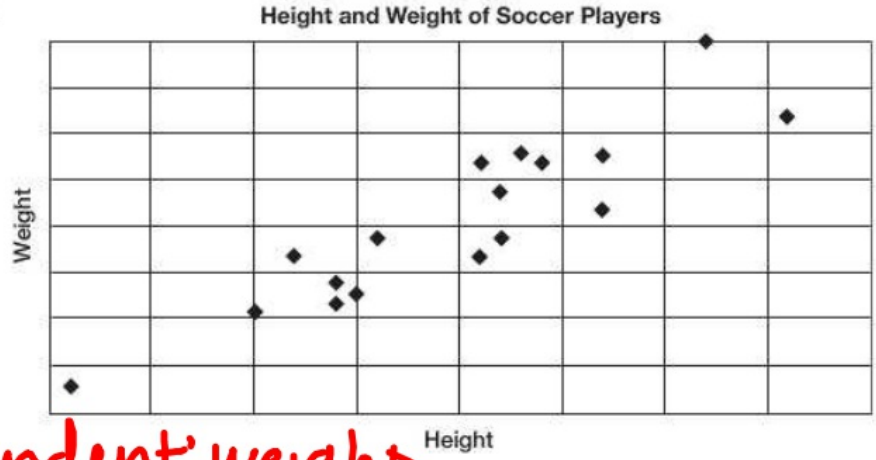
5. Describe the type of association that exists between the depth of the ocean water and the water temperature. State the association in terms of the variables.

Negative correlation



6. Analyze each scatter plot shown. Then, identify the following for each:
   - Identify the independent and dependent variables.
   - Determine whether the scatter plots show a linear association.
   - If there is a linear relationship, determine whether it has a positive association or a negative association.
   - State the association in terms of the variables.

a.



→ dependent: weight
→ independent: height
→ yes, linear association
→ positive association/correlation
→ the taller you are, the more you weigh

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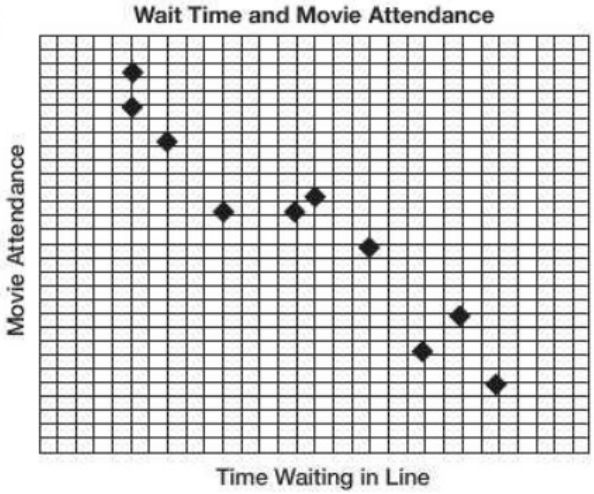
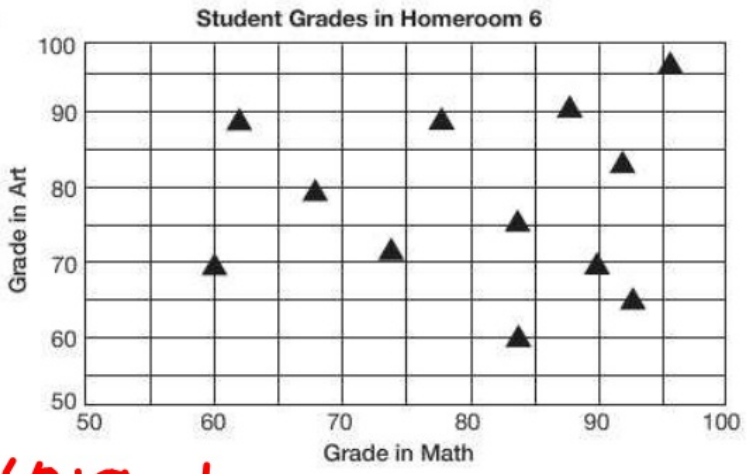
yes
neg

b.



c.



NO correlation

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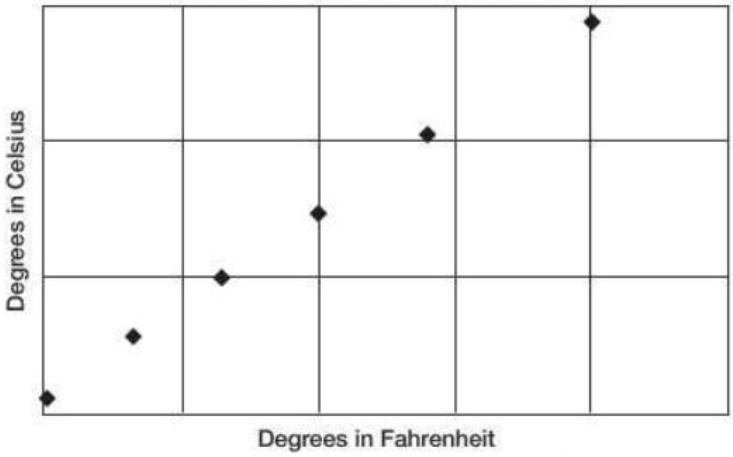
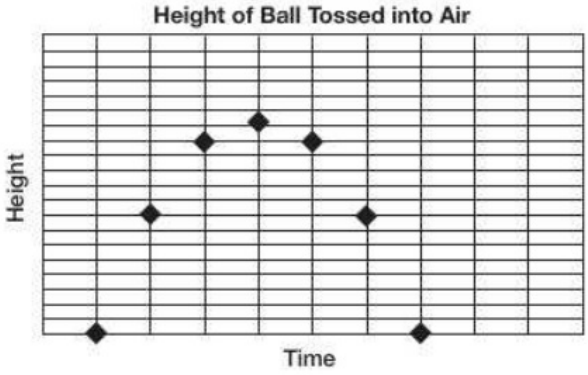
d.



pos

e.

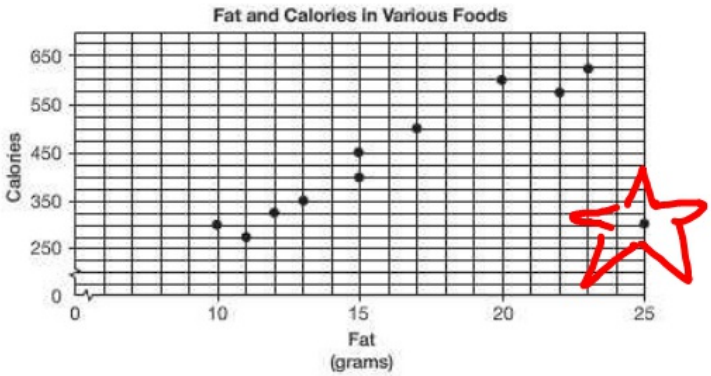


no

Problem 2 Other Patterns in Scatter Plots

Another pattern that can occur in a scatter plot is an *outlier*. An **outlier** for two-variable data is a point that varies greatly from the overall pattern of the data.

1. The scatter plot shows the fat and calories in 11 different foods.



a. Determine the independent and dependent variables in the two-variable data set.

b. Does there appear to be a linear association between the fat and calories of the foods?

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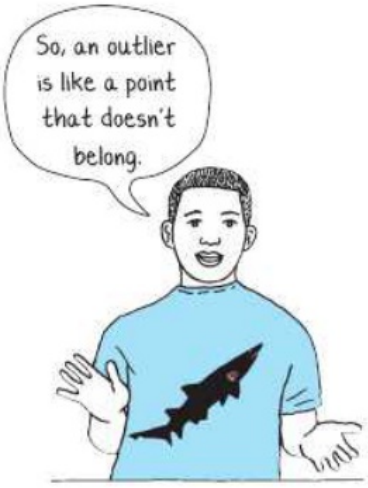
2. Complete a table of values for the points displayed in the scatter plot, beginning with the item with the lowest amount of fat.

Fat (g)	Calories



3. Do any of the points appear to vary greatly from the other points? If so, place a star around any outliers in the scatter plot and identify the outlier in the table.

4. Explain why the point (25, 300) is a potential outlier.

5. Examine the values in the table. How can you determine that (25, 300) is a possible outlier?

6. Place your finger on top of the point (25, 300) and examine the scatter plot. What do you notice?

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Talk the Talk

1. Explain the difference between a positive association and a negative association of a two-variable data set.

2. Explain how you can identify an outlier in a two-variable data set. Do the data need to have a linear association?

Be prepared to share your solutions and methods.

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15.3 HOW FAST ARE YOUR NERVE IMPULSES?

Connecting Tables and Scatter Plots for Collected Data

Learning Goals

In this lesson, you will:

- Conduct an experiment and collect the data.
- Connect tables and scatter plots for collected data.
- Interpret collected data displayed on a scatter plot and in a table.

You've done it before. Even though your server told you your plate was hot, your hand accidently touches a side and—ouch! Just as quickly as your skin touches the plate, your muscles quickly move your hand away from the plate thanks to the central nervous system! One of the quickest communication systems resides in your body. The central nervous system is responsible for communicating information between your brain, spinal chord, and other tissues, coordinating movements of the muscles and other body parts. It regulates breathing, your heartbeat, and other bodily functions that you don't even think about. So, just how fast can the central nervous system work?

Problem 1 Human Wrist Chain

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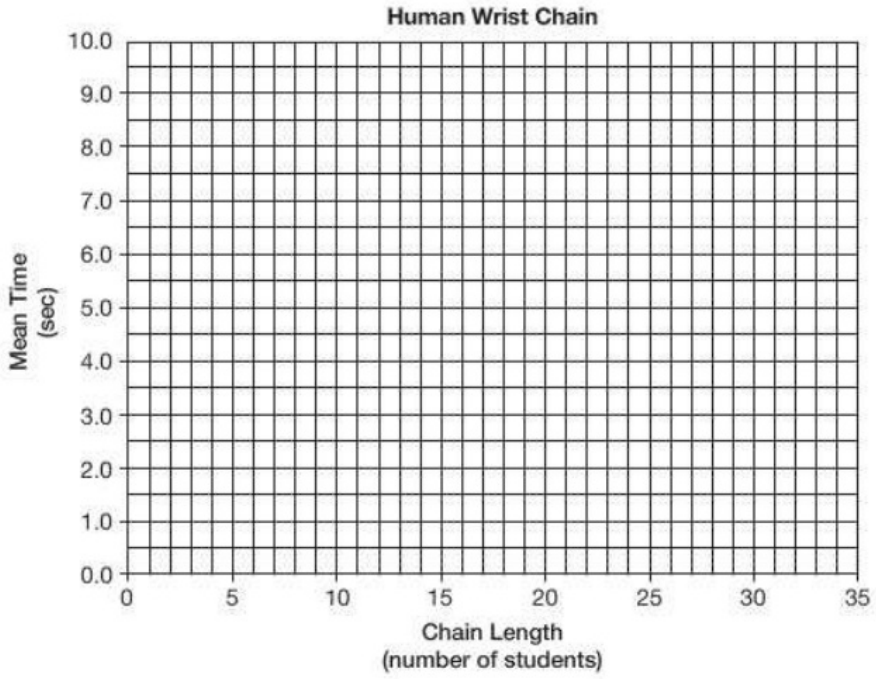
Your class is going to explore the speed of nerve impulses in the body by performing an experiment that involves a human chain. In this experiment, a group of students forms a circle with each person gently holding the wrist of the person to his or her right. One student begins the chain, and another student ends the chain. Also, one student in the group must be the timekeeper. The group members must keep their eyes closed. When the experiment begins, the timekeeper says, "Go," and the first student carefully, but quickly squeezes the student's wrist to their right, then this next student squeezes a wrist, and so on. After the last student's wrist is squeezed, he or she says "Stop," and releases the next student's wrist. The amount of time from when the word *go* is spoken until the word *stop* is spoken (the amount of time it takes to complete the chain) is recorded by the timekeeper.

1. Conduct the experiment 10 times, using a different number of students in the chain each time. For each number of students in the chain, run 3 trials of the experiment. Record the data for the experiment in the table shown. Then, calculate the mean time for each row and record the result in the last column of the table. Round your average times to the nearest tenth.

Chain length (number of students)	Trial 1	Trial 2	Trial 3	Average time (seconds)

2. Write the ordered pairs from the table with the number of students in the chain as the independent variable and the mean time as the dependent variable.

3. Create a scatter plot of the ordered pairs on the coordinate plane.



4. Does there appear to be a linear association between the chain length and mean time? Explain your reasoning. If so, identify the linear association as either a positive or negative association.

5. State the association between the two variables.

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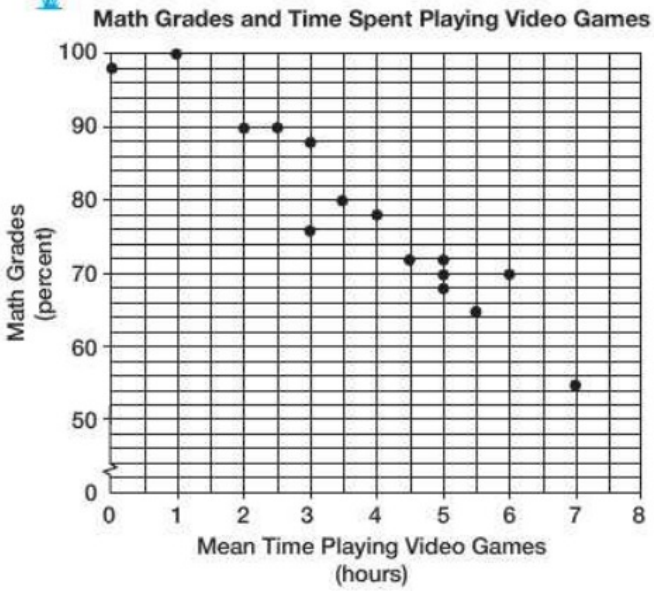
6. On the scatter plot, identify the point representing the longest chain. Then, identify the values of the point in the table. Explain how you identified the point and values.

7. On the scatter plot, identify the point representing the least mean time. Then, identify the values of the point in the table. Explain how you identified the point and values.

Problem 2 Video Games and Math Grades Revisited

The scatter plot and table of values represent the mean time spent playing video games and grades for Ms. Liu's math students.



Average Time Spent Playing Video Games	Math Grades
0	98
1	100
2	90
2.5	90
3	76
3	88
3.5	80
4	78
4.5	72
5	68
5	70
5	72
5.5	65
6	70
7	55

1. Place a star around the point on the scatter plot representing the student with the greatest grade percentage. Explain how you identified the point.

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2. Identify the student with the greatest grade percentage in the table. Explain how you identified the student.

3. Write the ordered pair for the student with the highest grade. Then, explain the meaning of each of the coordinates.

4. Place a star around the point on the scatter plot representing the student who spent the most mean time playing video games. Explain how you identified the point.

5. Identify the student with the greatest mean time playing video games in the table. Explain how you identified the student.

6. Write the ordered pair for the student with the greatest mean time playing video games. Then, explain the meaning of each of the coordinates.

7. Write the ordered pairs for two students who earned the same grade in math. What grade did the students receive, and how many mean hours did each student spend playing video games?

8. Write the ordered pairs for three students who had the same mean time playing video games. What grade did these students receive, and on average how many hours did each student spend playing video games?

9. Martha is puzzled by the scatter plot. There are only 15 points on the plot, but there are 20 students in the class. Explain to Martha how all 20 students could be represented in the scatter plot.

Talk the Talk

15

1. Does every data set in a scatter plot always have a linear association?

2. What must be true for the data points in a two-data variable set to have a positive or negative association?

Be prepared to share your solutions and methods.

Chapter 15 Summary

Key Terms

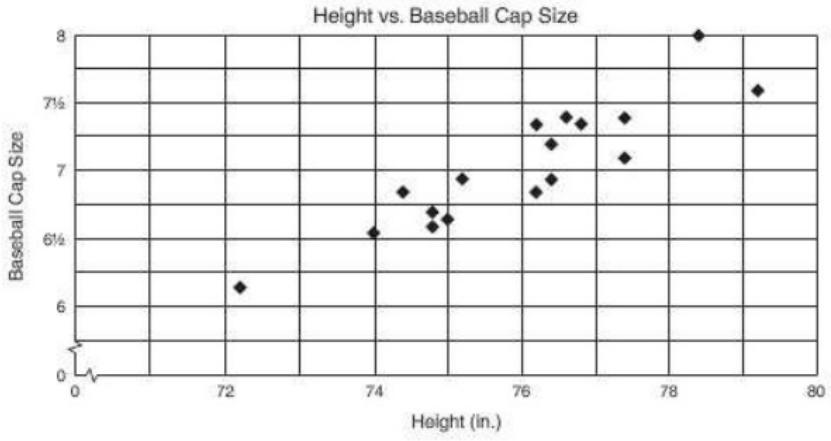
- variable (15.1)
- two-variable data set (15.1)
- independent variable (explanatory variable) (15.2)
- dependent variable (response variable) (15.2)
- association (15.2)
- linear association (15.2)
- cluster (15.2)
- positive association (15.2)
- negative association (15.2)
- outlier (15.2)

15.1 Creating and Interpreting Scatter Plots

A scatter plot is a graph of a set of ordered pairs. The ordered pairs are formed by using the values of the first characteristic as the first, or x-coordinate, and the values of the second characteristic as the second, or y-coordinate. By analyzing the data points, it can be determined if there is a relationship between the two variables.

Example

The graph shown represents players' height on a baseball team and the cap size they wear.



It appears that as a player's height becomes greater, the player's cap size increases.

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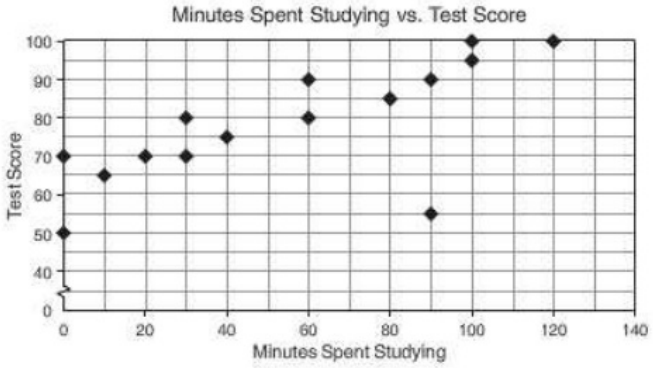
15.2

In a linear plot, if one variable increases as the other variable increases, then the two variables are said to have a positive association. If one variable increases as the other variable decreases, then the two variables are said to have a negative association. An outlier is a point that varies greatly from the overall pattern of the scatter plot.

Example

Fifteen students recently took a math test. The table lists the time each student spent studying for the test and the student's corresponding test score.

Minutes Spent Studying	30	0	40	10	60	0	120	100	90	60	20	100	80	30	90
Test Score	80	50	75	65	90	70	100	95	55	80	70	100	85	70	90



The data are linear and have a positive association because the test scores increase, in general, as the minutes spent studying increase. There is an outlier at the point (90, 55).

15.3 Conducting an Experiment to Display and Interpret Data Using a Scatter Plot

Data from an experiment can be collected in a table, but can be hard to interpret. The dependent and independent variables from the experiment can be listed as ordered pairs and plotted on a scatter plot. Then, patterns or associations can be determined and interpreted from the scatter plot.

Example

Students set up an experiment to compare leg muscle fatigue to the ability to balance on one leg. Two trials of the balancing (one on each leg) were recorded, starting with 0 lunges being performed. Then the students performed 10 lunges and two more trials were recorded. With each experiment, the students performed 10 more lunges. Then they plotted the results on a scatter plot with the total number of lunges performed as the independent variable and the average balance time as the dependent variable. A negative linear association can be seen on the scatter plot. So, as the number of lunges performed increases, the average time a student can balance on one leg decreases.

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Total Number of Lunges Performed	Trial 1 Right Leg (seconds)	Trial 2 Left Leg (seconds)	Average Time Balanced on One Leg (seconds)
0	120	110	115
10	72	75	73.5
20	58	55	56.5
30	47	45	46
40	35	37	36
50	29	26	27.5
60	20	18	19