INSTRUCTOR'S SOLUTIONS MANUAL

DIACRITECH

ELEMENTARY ALGEBRA: GRAPHS AND AUTHENTIC APPLICATIONS

THIRD EDITION

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Chapter 1
Introduction to Modeling

Homework 1.1

2. In 2015, Chris Davis hit 47 home runs.

4. In 2017, about 60 percent of children aged 5–18 participated in organized physical activity.

6. In 2015, 11.1 percent of American workers were in unions.

8. The temperature is $-10°\text{F}$. That is the temperature is 10 degrees below 0 (in Fahrenheit).

10. The statement $t = 13$ represents the year 2018 (13 years after 2005).

12. The statement $t = -2$ represents the year 2008 (2 years before 2010).

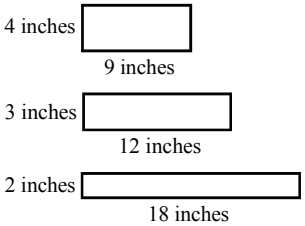
14. Answers may vary. Example:
Let t be the amount of time (in hours) that a student prepares for an exam. Then t can represent the numbers 0 and 4, but t cannot represent the numbers -1 and -3.

16. Answers may vary. Example:
Let n be the number of students enrolled in an algebra class. Then n can represent the numbers 15 and 28, but n cannot represent the numbers -20 and 0.5.

18. Answers may vary. Example:
Let T be the temperature (in degrees Fahrenheit) in an oven. Then T can represent the numbers 300 and 450, but T cannot represent the numbers -300 and -450.

20. Answers may vary. Example:
Let v be the value (in thousands of dollars) of a new home. Then v can represent the numbers 100 and 250, but v cannot represent the numbers -100 and -250.

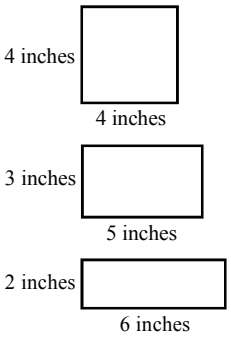
22. a. Answers may vary. Example:



b. In the described situation, the symbols W and L are variables. Their values can change.

c. In the described situation, the symbol A is a constant. Its value is fixed at 36 square inches.

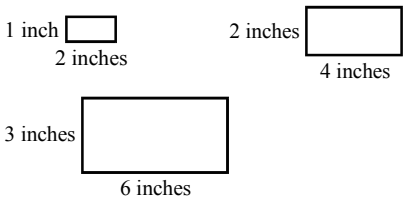
24. a. Answers may vary. Example:



b. In the described situation, the symbols W and L are variables. Their values can change.

c. In the described situation, the symbol P is a constant. Its value is fixed at 16 feet.

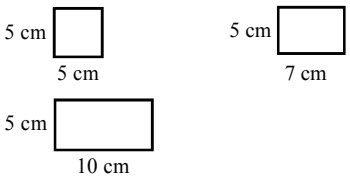
26. a. Answers may vary. Example:



b. In the described situation, the symbols W, L, and A are all variables. All of their values can change.

c. In the described situation, none of the symbols are constants. All of their values can change.

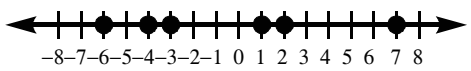
28. a. Answers may vary. Example:



b. In the described situation, the symbols L and A are variables. Their values can change.

c. In the described situation, the symbol W is a constant. Its value is fixed at 5 cm.

30.



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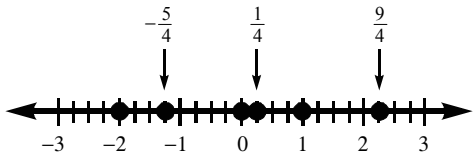
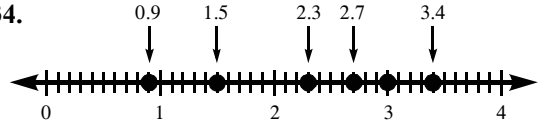
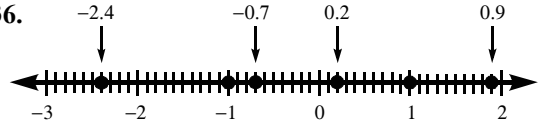


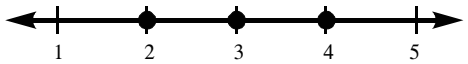
34.



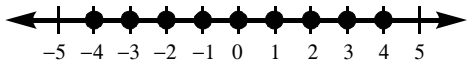
36.



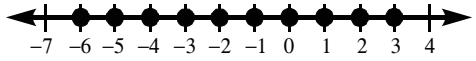
38. The counting numbers between 1 and 5 are 2, 3, and 4.



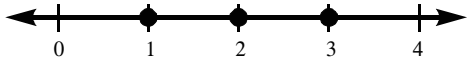
40. The integers between -4 and 4, inclusive, are $-4, -3, -2, -1, 0, 1, 2, 3$, and 4.



42. The integers between -6 and 3, inclusive, are $-6, -5, -4, -3, -2, -1, 0, 1, 2$, and 3.



44. The positive integers between -4 and 4 are 1, 2, and 3.



46. The integers in the list are -4, 0, and 3.

48. The rational numbers in the list are $-9.7, -4, 0, \frac{3}{5}$, and 3.

50. The real numbers in the list are $-9.7, -4, 0, \frac{3}{5}, \sqrt{7}$, 3, and π.

52. Answers may vary. Example: 1, 5, and 12

54. Answers may vary. Example: $-1, -2$, and -3

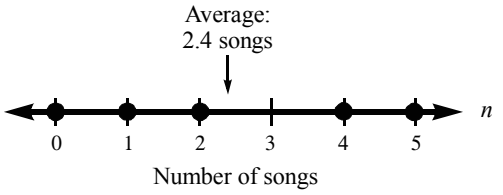
56. Answers may vary. Example: $\frac{1}{2}, \frac{3}{4}$, and $\frac{7}{9}$

58. Answers may vary. Example: $\sqrt{2}, \sqrt{5}$, and π

60. Answers may vary. Example: $\sqrt{2}, \sqrt{5}$, and π

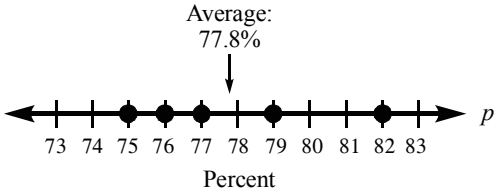
62. $\frac{2+0+1+5+4}{5} = \frac{12}{5} = 2.4$

The average number of songs downloaded per visit is 2.4 songs.

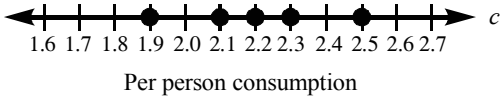


64. $\frac{79+82+75+77+76}{5} = \frac{389}{5} = 77.8$

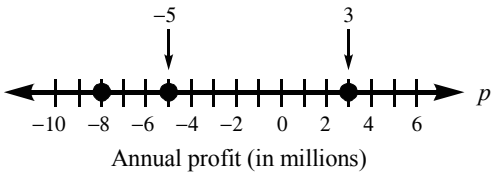
The average percentage of flights in a year that are on time is 77.8% per year.



66.

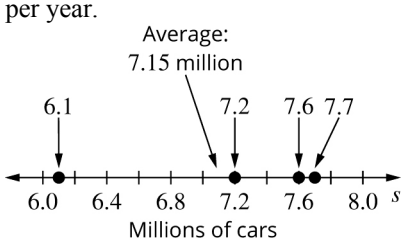


68.



70. a. $\dfrac{6.1+7.2+7.6+7.7}{4}=\dfrac{28.6}{4}=7.15$

The average sales are about \$7.15 million per year.



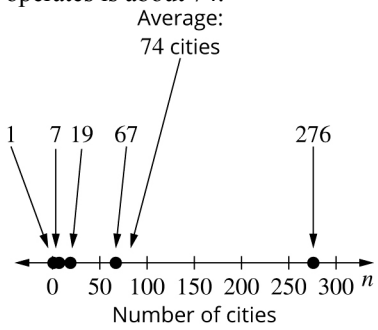
b. Car sales increased from 2011 to 2014. Sales went up each year.

c. The increases in car sales decreased from 2011 to 2014. The decreases were:

Years	Decrease
2011 to 2012	$7.2-6.1=1.1$
2012 to 2013	$7.6-7.2=0.4$
2013 to 2014	$7.7-7.6=0.1$

72. a. $\dfrac{1+7+19+67+276}{5}=\dfrac{370}{5}=74$

The average number of cities where Uber operates is about 74.



b. The number of cities where Uber operates increased from 2010 to 2014. The number of cities where Uber operates went up each year.

c. The increases in the number of cities where Uber operates increased from 2010 to 2014. The increases were

Years	Increase
2010 to 2011	$7-1=6$
2011 to 2012	$19-7=8$
2012 to 2013	$67-19=48$
2013 to 2014	$276-67=209$

74. No. Answers may vary. Example:
The numbers 2 and 5 are not "between 2 and 5." The numbers between 2 and 5 are simply 3 and 4.

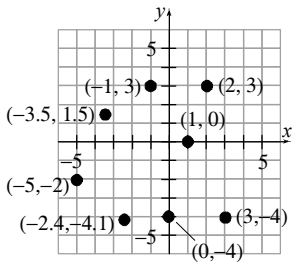
76. Two consecutive integers are 1 unit apart on the number line.
Two consecutive even integers are 2 units apart on the number line.
Two consecutive odd integers are 2 units apart on the number line.

78. Answers may vary. Example:
90 points; the fifth score did not change the average, so it must be the same as the average.

80. Answers may vary. Example:
Negative quantities are graphed to the left of 0 on the number line.

Homework 1.2

2–16 even.



18. The y-coordinate is -4.

20. Presumably, the longer a person works for a company, the higher his or her salary will be. So, the salary s depends on the number of years t. Thus, t is the explanatory variable and s is the response variable.

22. As a student's GPA increases, the percentage of college that would accept him or her would increase. So, the percentage p depends on the GPA g. Thus, g is the explanatory variable and p is the response variable.

24. As the age of men increases, the percentage with gray hair also increases. So, the percentage p depends on the age a. Thus, a is the explanatory variable and p is the response variable.

26. The longer the potato has been out of the oven, the cooler it will be (until it is cooled completely). So, the temperature of the potato F depends on the number of minutes t since it was removed from the oven. Thus, t is the explanatory variable and F is the response variable.

28. The percentage p of people who own computers will change by age a. Thus, p is the explanatory variable and a is the response variable.

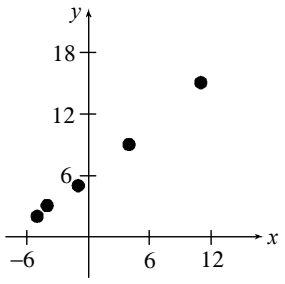
30. The total cost depends on the number of pens purchased. So, n is the explanatory variable and c is the response variable. The ordered pair (5, 10) means that $n = 5$ and $c = 10$. The cost of buying 5 pens is \$10.

32. The percentage of Internet users who use social networking sites depends on the number of social networking sites. So, n is the explanatory variable and p is the response variable. The ordered pair (4,5) means that $n = 4$ and $p = 5$. So, 5% of Internet users use 4 social networking sites.

34. The number of ads in millions blocked by Google depends on the year. So, t is the explanatory variable and n is the response variable. The ordered pair (5, 780) means that $t = 5$ and $n = 780$. In $2010 + 5 = 2015$, 780 million ads were blocked by Google.

36. The percentage of Americans who are satisfied with the size and influence of major corporations depends on the year. So, t is the explanatory variable and p is the response variable. The ordered pair $(-1, 35)$ means that $t = -1$ and $p = 35$. In $2015 - 1 = 2014$, 35% of Americans felt satisfied with the size and influence of major corporations.

38.



40. Point A is 2 units to the left of the origin and 4 units down. Thus, its coordinates are $(-2, -4)$.

Point B is 3 units to the left of the origin on the x-axis. Thus, its coordinates are $(-3, 0)$.

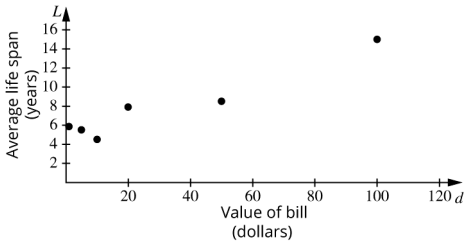
Point C is 5 units to the left of the origin and 4 units up. Thus, its coordinates are $(-5, 4)$.

Point D is 4 units to the right of the origin and 2 units up. Thus, its coordinates are $(4, 2)$.

Point E is 3 units below the origin on the y-axis. Thus, its coordinates are $(0, -3)$.

Point F is 3 units to the right of the origin and 2 units down. Thus, its coordinates are $(3, -2)$.

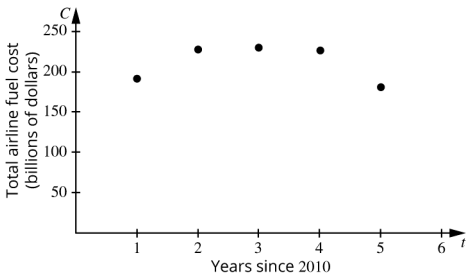
42. a.



b. Answers may vary. Example: The average life span of a \$100 bill is greater than the average life span of a \$10 bill since \$100 bills are used less often than \$10 bills.

c. Answers may vary. Example: Each year, many more \$10 bills are printed than \$100 bills since there is a larger demand for bills with lower value that tend to be used on a more regular basis.

44. a.

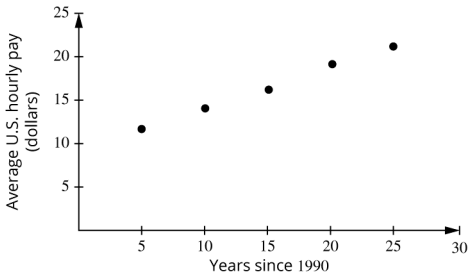


b. The total airline fuel cost was the least in 2015. In 2015, the total airline fuel cost was \$181 billion.

c. The total airline fuel cost was the greatest in 2013. In 2013, the total airline fuel cost was \$230 billion.

d. No. Answers may vary. Example: The total fuel cost may not be the greatest in the same year as the average price per barrel of crude oil since total fuel cost depends on many factors, including the types of planes that were being utilized by airlines as well as flight paths (distances various fleets flew). Such factors would mean more barrels of crude oil were being used.

46. a.



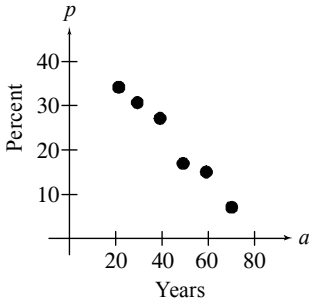
b. The average U.S. hourly pay increased. In each year, the average hourly pay was greater than the previous year.

c. The five-year increase in the average U.S. hourly pay did not follow a pattern of increase or decrease.

Years	Change
1995 to 2000	$14.03 - 11.67 = 2.36$
2000 to 2005	$16.15 - 14.03 = 2.12$
2005 to 2010	$19.06 - 16.15 = 2.91$
2010 to 2015	$21.05 - 19.06 = 1.99$

From 1995 to 2005, the change in average U.S. hourly pay decreased. However, from 2005 to 2010, the change in average hourly pay increased.

48. a.

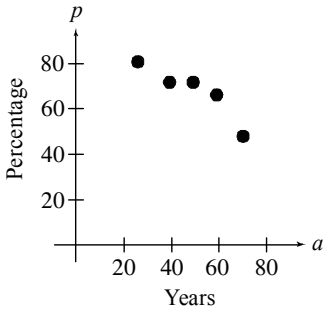


b. The highest point in the scatterplot is (21.0, 34). Answers may vary Example: It means that the 18–24 age group has the highest percentage who are ordering more takeout food than they did two years ago.

c. The lowest point in the scatterplot is (70.0, 7). Answers may vary. Example: It means that the "over 64" age group has the lowest percentage who are ordering more takeout food than they did two years ago.

d. The heights of the points decrease from left to right. Answers may vary. Example: Younger age groups have higher percentages than older age groups who are ordering more takeout food than they did two years ago.

50. a.



b. The 18–34 age group has the most faith in single men raising children on their own

c. The "over 64" age group has the least faith in single men raising children on their own.

d. The percentages of adults of various age groups who approve of single men raising children on their own are decreasing as the age group increases. Therefore, the student's opinion based on the data is correct.

52. a. Robin Ventura's number of career grand slams is 18.

b. The player who holds the record for the greatest number of career grand slams is Alex Rodriguez with 25.

c. The player who hit exactly 21 grand slams is Manny Ramirez.

54. The ordered pairs selected and scatterplots may vary. The points will lie on the same horizontal line. Answers may vary.

56. There are an infinite number of possibilities for the positions of the other two vertices. Answers may vary. Example: (2, 3) and (7, 3); (2, 2) and (7, 2); (2, 10) and (7, 10); $(2,-2)$ and $(7,-2)$.

58. All points on a coordinate system with an x-coordinate of 0 make up the y-axis.

60. Answers may vary.

Homework 1.3

2. The line contains the point $(4,-1)$, so $y=-1$ when $x=4$.

4. The line contains the point $(-6, 4)$, so $x=-6$ when $y=4$.

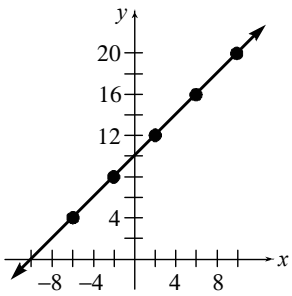
6. The line and the y-axis intersect at $(0,1)$, so the y-intercept is $(0,1)$.

8. The line contains the point $(6, 1)$, so $y = 1$ when $x = 6$.

10. The line contains the point $(3, 0)$, so $x = 3$ when $y = 0$.

12. The line and the x-axis intersect at $(3, 0)$, so the x-intercept is $(3, 0)$.

14. a–b.



c. The line contains the point $(4, 14)$, so $y = 14$ when $x = 4$.

d. The line contains the point $(8, 17)$, so $x = 8$ when $y = 17$.

e. The line and the y-axis intersect at $(0, 10)$, so the y-intercept is $(0, 10)$.

f. The line and the x-axis intersect at $(-10, 0)$, so the x-intercept is $(-10, 0)$.

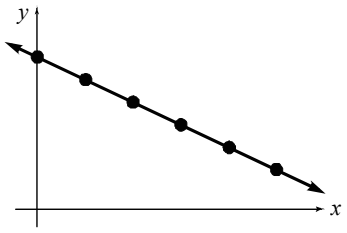
16. a. The line contains the point (3, 1500), so $B = 1500$ when $t = 3$. This means the balance 3 months after the account was opened was \$1500.

b. The line contains the point (5, 500), so $t = 5$ when $B = 500$. This means that 5 months after the account was opened, the balance was \$500.

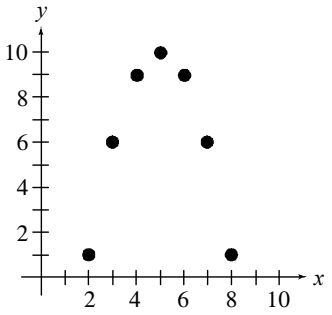
c. The line and the B-axis intersect at (0, 3000), so $B = 3000$ when $t = 0$. This means that the beginning balance of the account was \$3000.

d. The line and the t-axis intersect at (6, 0), so $t = 6$ when $B = 0$. This means that the account will be empty after 6 months.

18. Yes.

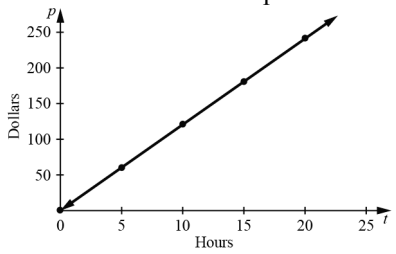


20. a.



b. No, there is not a linear relationship between x and y. The data points do not lie close to one line.

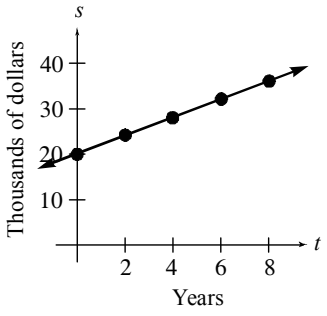
22. a. Construct the scatterplot.



b. The line contains the point (7, 84), so $p = 84$ when $t = 7$. This means the student's pay for working 7 hours is \$84.

c. The line contains the point (13, 156), so $t = 13$ when $p = 156$. This means that the student must work 13 hours to earn \$156.

24. a.



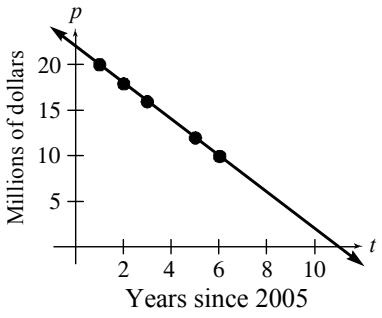
b. The line contains the point (5, 30), so $s = 30$ when $t = 5$. We estimate that

person's salary will be \$30 thousand after he has worked 5 years at the company.

c. The line contains the point (7, 34), so $t = 7$ when $s = 34$. We estimate that the person will have worked 7 years at the company when his salary is \$34 thousand.

d. The line and the s-axis intersect at (0, 20), so $s = 20$ when $t = 0$. This means that the person's beginning salary at the company was \$20 thousand.

26. a.

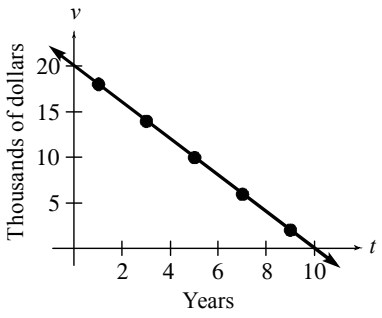


b. The line contains the point (10, 2), so $t = 10$ when $p = 2$. This means that the company's annual profit will be \$2 million in the year 2005 + 10 = 2015.

c. The line and the p-axis intersect at (0, 22), so $p = 22$ when $t = 0$. This means that the company's annual profit was \$22 million in the year 2005.

d. The line and the t-axis intersect at (11, 0), so $t = 11$ when $p = 0$. This means that the company's annual profit will be \$0 in the year 2005 + 11 = 2016.

28. a.



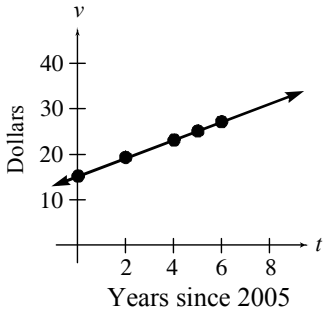
b. The line contains the point (8, 4), so $v = 4$ when $t = 8$. This means that the car will be worth \$4 thousand when it is 8 years old.

c. The line contains the point (6, 8), so $v = 8$ when $t = 6$. This means the value of the car will be \$8 thousand when it is 6 years old.

d. The line and the v-axis intersect at (0, 20), so $v = 20$ when $t = 0$. This means that the value of the car was \$20 thousand when new.

e. The line and the t-axis intersect at (10, 0), so $t = 10$ when $v = 0$. This means that the car will have no value after 10 years.

30. a.

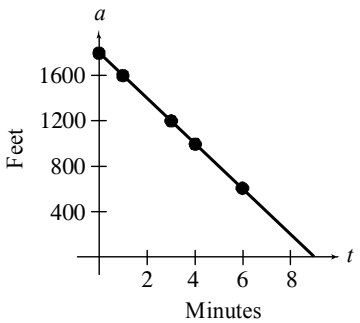


b. The line contains the point (3, 21), so $v = 21$ when $t = 3$. This means the value of the stock was \$21 in the year 2008.

c. The line contains the point (10, 35), so $t = 10$ when $v = 35$. This means the value of the stock will be \$35 in 2005 + 10 = 2015.

d. The line and the v-axis intersect at (0, 15), so $v = 15$ when $t = 0$. This means that the value of the stock was \$15 in the year 2005.

32. a.

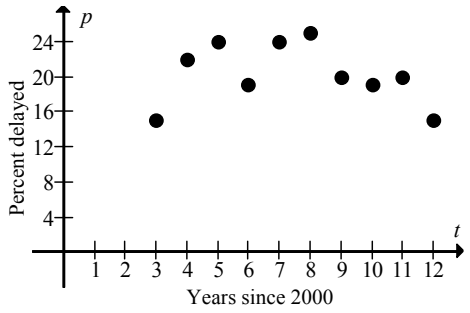


b. The line contains the point (5, 800), so $a = 800$ when $t = 5$. This means the altitude of the balloon is 800 feet after air has been released for 5 minutes.

c. The line contains the point (9, 0), so $t = 9$ when $a = 0$. This means that it will take 9 minutes for the balloon to reach the ground.

d. The prediction in part (c) will be an overestimate. A faster decent the last 400 feet means it will take less time to reach the ground than predicted.

34. a.

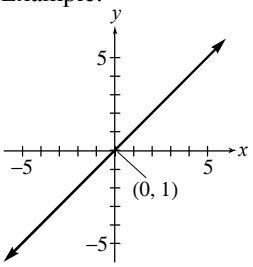


b. No, there is not a linear relationship between t and p. The data points do not lie close to one line.

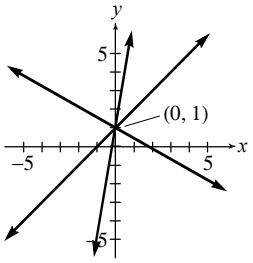
36. No. The -3 is the x-coordinate of ordered pair $(-3, 4)$, not the x-intercept.

38. No. The x-coordinate of a y-intercept must be 0. The y-intercept might be (0, 5), but not (5, 0).

40. Yes. Any line that passes through the origin (0, 0) will have an x-intercept that is the same as the y-intercept. Answers may vary. Example:



42. Answers may vary. Example:



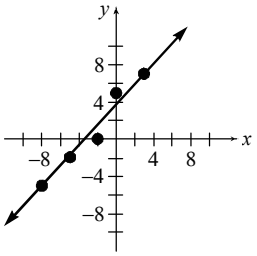
44. Answers may vary. Example:
Every point on the y-axis has an x-coordinate of 0. So the y-intercept of a line must have an x-coordinate of 0.

46. Answers may vary. Example:
A linear model is a line that describes the relationship between two quantities in an authentic situation.

Homework 1.4

Throughout this section, answers may vary.

2. a.



b. The variables are approximately linearly related.

c. Draw a line that comes close to the points. See the graph in part (a).

d. Approximately $(-1, 2.6)$

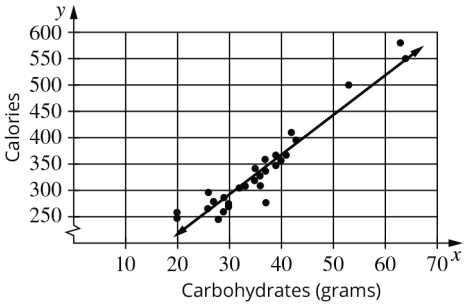
e. Approximately $(-6.2, -3)$

f. Approximately (0, 3.7)

g. Approximately $(-3.4, 0)$

4. a. The variables x and y are approximately linearly related. The points in the scatterplot lie close to a line.

b. Draw a line that comes close to the points to create the linear model as shown.



c. We estimate that the line contains the point (30, 290), so $y = 290$ when $x = 30$. We estimate that a pizza with 30 carbohydrate has 290 calories.

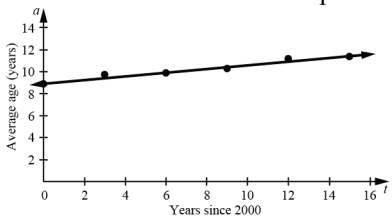
d. We estimate that the line contains the point (50, 450), so $x = 50$ when $y = 450$ We estimate that a pizza with 450 calories has 50 carbohydrates.

e. The line in the scatterplot goes up from left to right. Answers may vary. Example: A line going up from left to right makes sense because it shows that an increase in the number of carbohydrates results in an increase in the number of calories.

6. a. First, we list the values of t and a in the table below. For example, $t = 3$ represents 2003 because 2003 is 3 years after 2000.

Years since 2000 t	Average Age a
0	8.9
3	9.7
6	9.9
9	10.3
12	11.2
15	11.4

We then construct the scatter plot.

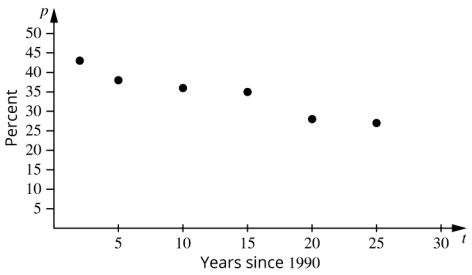


b. Draw a line that comes close to the points to create the linear model. See the graph in part (a).

c. The year 2010 corresponds to $t = 10$. We estimate that the line contains the point (10, 10.6), so $a = 10.6$ when $t = 10$. We predict the average age of light vehicles in 2010 was 10.6 years.

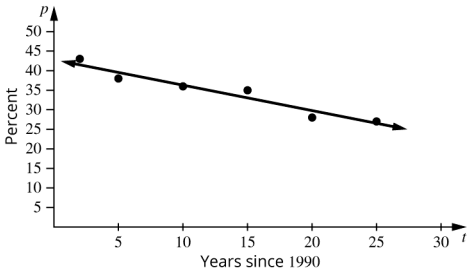
d. We estimate that the line contains the point (1.9, 9.3), so $t \approx 2$ when $a = 9.3$. We estimate the average age of light vehicles was 9.3 years in 2002.

8. a.



b. The variables t and p are approximately linearly related. The points in the scatterplot lie close to a line.

c. Draw a line that comes close to the points to create the linear model as shown.



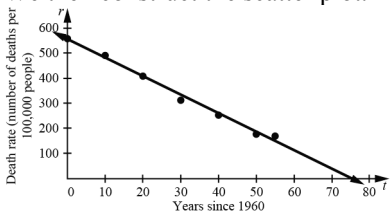
d. According to the model, 31% of Americans said there should be a ban on possession of handguns around 2014.

e. According to the model, about 27% of Americans will say there should be a ban on possession of handguns in 2021.

10. a. First, we list the values of t and r in the table below. For example, $t = 10$ represents 1970 because 1970 is 10 years after 1960.

Years since 1960 t	Death Rate (number of deaths per 100,000 people) r
0	559
10	492
20	409
30	317
40	253
50	177
55	169

We then construct the scatter plot.



b. Draw a line that comes close to the points to create the linear model. See the graph in part (a).

c. We estimate that the line and the t-axis intersect at (75.0, 0), so $t = 75$ when $r = 0$.

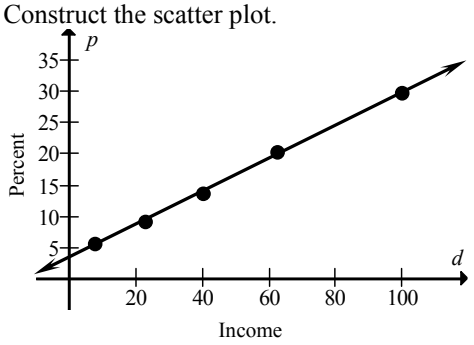
This means that the death rate due to heart disease will be 0 in the year 2035. Model breakdown has likely occurred.

d. The year 2020 corresponds to $t = 60$. We estimate that the line contains the point (60, 111), so $r = 111$ when $t = 60$. We predict that the death rate in 2020 will be 111 people per 100,000 people.
If the population of the U.S. is 335 million in 2020, then the number of people who will die from heart disease that year will be:

$$335,000,000 \cdot \frac{111}{100,000} = 371,850 .$$

We predict that 371,850 people in the U. S. will die from heart disease in 2020.

12. a. Construct the scatter plot.



b. Draw a line that comes close to the points to construct the linear model. See the graph in part (a).

c. We estimate that the line contains the point (50, 17), so $p = 17$ when $d = 50$. We estimate that 17% of elementary school students from households with income of $50 thousand participate in an after-school arts activity.

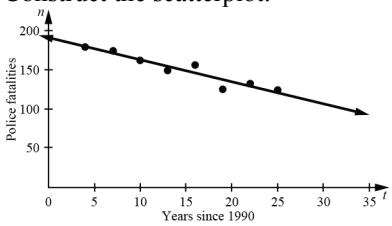
d. We estimate that the line contains the point (82, 25), so $d = 82$ when $p = 25$. We estimate that the income is $82 thousand in households from which 25% of elementary school students participate in an after-school arts activity.

e. We estimate that the p-intercept is about $(0, 3)$. This means that approximately 3% of elementary school students from households with no income participate in an after-school arts activity.

14. a. First, we list the values of t and n in the table below. For example, $t = 4$ represents 1994 because 1994 is 4 years after 1990.

Years since 1990 t	Number of Fatalities n
4	179
7	173
10	162
13	150
16	156
19	125
22	131
25	123

Construct the scatterplot.



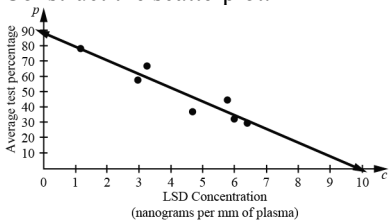
b. Draw a line that comes close to the points to create the linear model. See the graph in part (a).

c. We estimate that the line and the n-axis intersect at (0, 191), so $n = 191$ when $t = 0$. We estimate that the number of police fatalities was 191 in 1990.

d. The year 2020 is represented by $t = 30$. We estimate that the line contains the point (30, 106), so $n = 106$ when $t = 30$. We predict that the number of police fatalities will be 106 in 2020.

e. We estimate that the line contains the point (32, 100), so $t = 32$ when $n = 100$. We predict the number of police fatalities will be 100 in 2022.

16. a. Construct the scatterplot.



b. Draw a line that comes close to the points to create the linear model. See the graph in part (a).

c. We estimate that the line contains the point (4, 53), so $p = 53$ when $c = 4$. We estimate that the average test percentage would be 53% for an LSD concentration of 4 nanograms per milliliter of plasma.

d. We estimate that the line and the c-axis intersect at (9.9, 0), so $c = 9.9$ when $p = 0$. We estimate that the average test percentage would be 0% for an LSD concentration of 9.9 nanograms per milliliter of plasma.

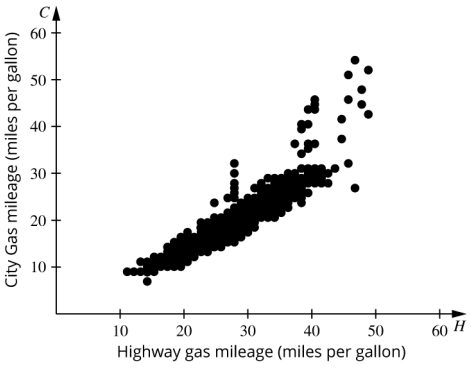
e. We estimate that the line and the p-axis intersect at (0, 89), so $p = 89$ when $c = 0$. We estimate that the average test percentage would be 89% for an LSD concentration of 0 nanograms per milliliter of plasma. The model clearly has broken down, because p was defined as the percentage of the number of problems subjects could do before being injected with LSD. At an LSD concentration of 0, p should be 100%.

18. a. According to the model, the number of ride-related injuries in 2013 was about 1.2 thousand.

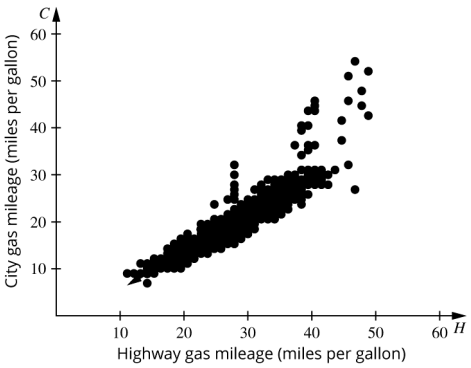
b. According to the table, the actual number of ride-related injuries in 2013 was 1.4 thousand.

c. The result in part (a) is an underestimate. The line is below the data point. The error is $1.4 - 1.2 = 0.2$ thousand injuries.

20. a.



b.



c. According to the model, the city gas mileage for a car with a highway gas mileage of 30 miles per gallon is about 22 miles per gallon.

d. According to the model, the highway gas mileage of a car with a city gas mileage of 14 miles per gallon is about 20 miles per gallon.

e. The H-intercept is (3.3, 0). This means that a car with a highway gas mileage of 3.3 miles per gallon has a city gas mileage of 0 miles per gallon. This seems unlikely since a car must use some amount of gas to run, and we assume that the cars in question are cars that run on gas. Model breakdown occurs in this case.

f. Going back to the original data, if you sort the data numerically, you will see that there are cars for which the highway and city gas mileages match. For example, there are several cars that have a city gas mileage of 13 and a highway gas mileage of 19. In other cases, there are cars whose city and gas mileages are unique and therefore don't match other cars. When the data is graphed on a scatterplot, we cannot show how a point like (13, 19) represents multiple cars; we see just one point at (13, 19). We may see other points like this that represent multiple cars, but there is no way for us to tell looking at the scatterplot alone. In other cases, a single point represents just one car since there are cars whose city and gas mileages are unique. Because a single data point might possibly represent gas mileages of several cars and another data point might represent only a single car, we shouldn't give the same weight to each data point. In other words, using a scatterplot, we cannot know which data values occur most frequently.

Therefore, the line we draw is not necessarily the best one since it may not trend toward the points where the data is actually the most frequent.

g. The data points that are farthest from the model are mostly above the trendline. The type of car that most of these points represent is the hybrid, which makes sense because a hybrid vehicle tends to get better city mileage than highway mileage.

22. The model underestimates the value of p when $t = c$. In this case, (t, p) represents a point on the model, whereas (c, d) is an actual data point. Since (c, d) is above the model, then the point on the model at (t, p) is an underestimate.

24. It is more desirable to find a linear model that does not contain any data points but comes close to all data points. Answers may vary.

26. This short cut is dangerous because the linear model may not come close to the non-selected data points. Answers may vary.

28. No, this is not an example of model breakdown. Answers may vary. Example: Although time cannot be negative, the number of years since 2010 can be negative. A negative value for t means that the event occurs before 2010.

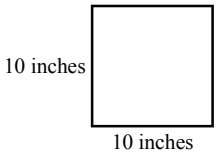
Chapter 1 Review Exercises

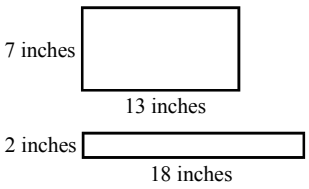
1. If B represents the total box office gross in billions of dollars and if $B = 11.13$ in 2015, then this means in 2015, the total box office gross was \$11.13 billion.

2. $t = 26$ represents the year $1995 + 26 = 2021$.

3. Answers may vary. Example:
Let p be the percentage of students who are full-time students. Then p can represent the numbers 60 and 70, but p cannot represent the numbers -12 and 107.

4. a. Answers may vary. Example:

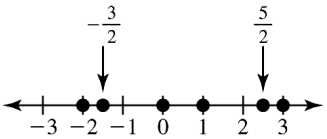




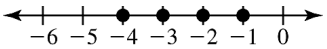
b. In the described situation, the symbols W and L are variables. Their values can change.

c. In the described situation, the symbol P is a constant. Its value is fixed at 40 inches.

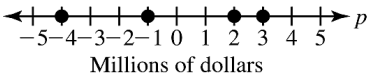
5.



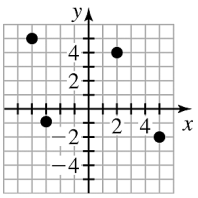
6. The negative integers between -5 and 5 are $-4, -3, -2,$ and -1.



7. The numbers listed (in millions) are: 2, $-4, -1$, and 3.



8.



9. The y-coordinate is -6.

10. The x-coordinate is -4.

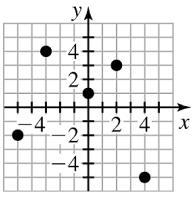
11. The percentage p of home owners depends on age a. Thus, a is the explanatory variable and p is the response variable.

12. Presumably, the more education a person has, the higher his or her salary will be. So, the average salary a depends on the years of education t. Thus, t is the explanatory variable and a is the response variable.

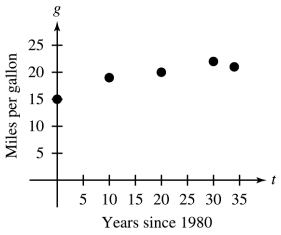
13. If n represents the total number of U.S. billionaires at t years since 2010, then n is the response variable and t is the explanatory variable which takes the form (t, n) as an ordered pair. So, the ordered pair (6, 540) means that in 2016 ($2010 + 6 = 2016$), there were 540 billionaires in the United States.

14. If r represents the annual revenue (in billions of dollars) from ADHD drugs at t years since 2000, then r is the response variable and t is the explanatory variable which takes the form (t, r). So, the ordered pair (14, 11) means that in 2014 ($2000+14=2014$), the annual revenue from ADHD drugs was \$11 billion.

15.



16. a.



b. According to the table, the average gas mileage of cars was the highest in 2010.

c. According to the table, the average gas mileage of cars was the lowest in 1980.

17. a. The country that generates the largest percentage of its electricity by nuclear power is France at about 76%.

b. Of the countries listed, the two that generate the smallest percentage of their electricity by nuclear power are Belgium and Slovenia, each at about 38%.

c. The percentage of Ukraine's electricity that is generated by nuclear power is about 57%.

18. The line contains the point $(-2,-1)$, so $y=-1$ when $x=-2$.

19. The line contains the point $(6,-5)$, so $y=-5$ when $x=6$.

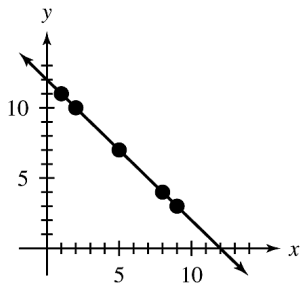
20. The line contains the point $(4,-4)$, so $x=4$ when $y=-4$.

21. The line contains the point $(-6,1)$, so $x=-6$ when $y=1$.

22. The line and the y-axis intersect at $(0,-2)$, so the y-intercept is $(0,-2)$.

23. The line and the x-axis intersect at $(-4,0)$, so the x-intercept is $(-4,0)$.

24. a.



b. See the graph in part (a).

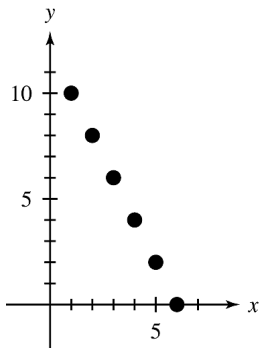
c. The line contains the point (11, 1), so $y = 1$ when $x = 11$.

d. The line contains the point (7, 5), so $x = 7$ when $y = 5$.

e. The line and the x-axis intersect at (12, 0), so the x-intercept is (12, 0).

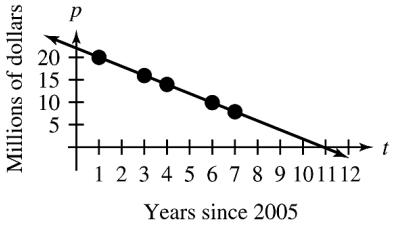
f. The line and the y-axis intersect at (0, 12), so the y-intercept is (0, 12).

25. a.



b. The variables x and y are linearly related.

26. a.



b. The year 2015 is represented by $t=10$. The line contains the point (10, 2), so $p = 2$ when $t = 10$. We estimate that the annual profit is \$2 million in 2015.

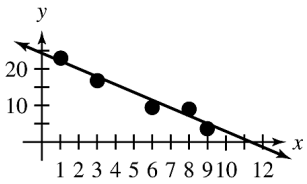
c. The line contains the point (2, 18), so $t = 2$ when $p = 18$. We estimate that the annual profit was \$18 million in the year $2005 + 2 = 2007$.

d. The line and the p-axis intersect at (0, 22), so $p = 22$ when $t = 0$. This means that the annual profit was \$22 million in the year 2005.

e. The line and the t-axis intersect at (11, 0), so $t = 11$ when $p = 0$. This means that the annual profit will be \$0 in the year 2016.

27. The y-coordinate of an x-intercept of a line is 0.

28. a.



b. The variables are approximately linearly related.

c. See the graph in part (a).

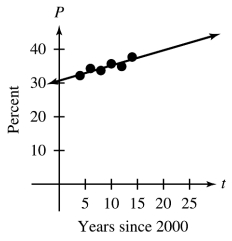
d. (5, 13.5)

e. (2, 20)

f. (0, 24.3)

g. (11.2, 0)

29. a.



b. Draw a line that comes close to the points to create the linear model. See the graph in part (a).

c. According to the model, the percentage of American adults who will be obese 2021 is about 40%.

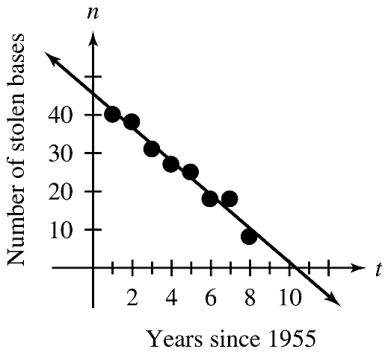
d. According to the model, 41% of Americans will be obese in 2023.

e. Answers may vary. Example: Since participants in the Gallup study gave self-reported heights and weights, it is likely the data is more variable since the methods used to take heights and weights varied (for example, participants were not all weighed on the same scale). It is also the case that self-reported data is often biased. That is, the participants may have provided less accurate measurements (for example, they may have indicated their weights were lower than they actually were and/or indicated they were taller than they actually were)

30. a. First, we list the values of t and n in the table below. For example, $t = 1$ represents 1956 because 1956 is 1 year after 1955.

Years since 1955 t	**Stolen Bases** n
1	40
2	38
3	31
4	27
5	25
6	18
7	18
8	8

We then construct the scatterplot.



b. Draw a line that comes close to the points to create the linear model. See the graph in part (a).

c. The line and the n-axis intersect at (0, 45.2), so $n = 45.2$ when $t = 0$. This means that, according to the model, Mays stole 45 bases in 1955.

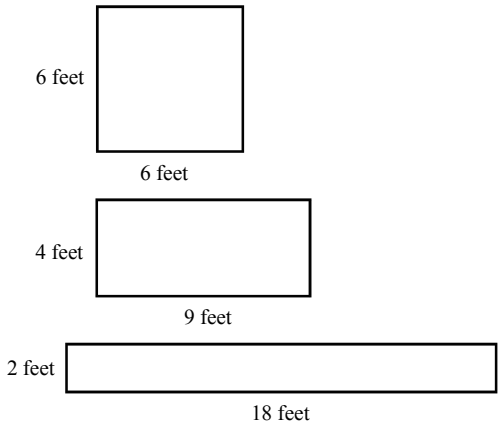
d. The line and the t-axis intersect at (10.4, 0), so $t = 10.4$ when $v = 0$. Now 1955 + 10.4 = 1965.4. According to the model, Mays did not steal any bases in 1965.

e. Since the predicted number of stolen bases (45) is higher than the actual number of stolen bases (24), the prediction is an overestimate. Model breakdown has occurred. Answers may vary.

f. For the year 1971, our linear model will predict a negative number of stolen bases, which is an underestimate. Model breakdown has occurred. Answers may vary.

Chapter 1 Test

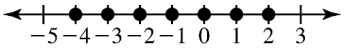
1. a. Answers may vary. Example:



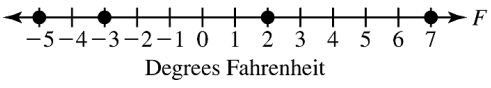
b. In the described situation, the symbols W and L are variables. Their values can change.

c. In the described situation, the symbol A is a constant. Its value is fixed at 36 square feet.

2. The integers between -4 and 2, inclusive, are $-4, -3, -2, -1, 0, 1,$ and 2.

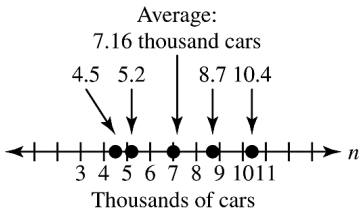


3. The numbers listed are: -5, 7, 2, and -3.



4. $\dfrac{4.5 + 5.2 + 7.0 + 8.7 + 10.4}{5} = \dfrac{35.8}{5} = 7.16$

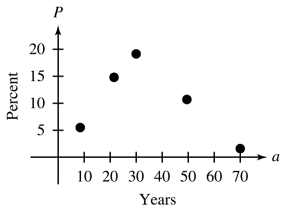
The average number of electric cars in use per year is 7.16 thousand cars.



5. As the number of tickets increases, so will the cost. So, the cost c depends on the number of tickets n. Thus, n is the explanatory variable and c is the response variable.

6. If s represents the salary in millions of dollars of Joe Mauer in the year that is t years since 2010, then s is the response variable and t is the explanatory variable which takes the form (t, s) as an ordered pair. So, the ordered pair (6, 23) means that in 2016 ($2010 + 6 = 2016$), Joe Mauer earned a salary of \$23 million.

7. a.



b. The highest point in the scatterplot is (30, 18.5). Since 30 represents the age group 26–34 and this value corresponds to 18.5%, this means that Americans in the age group 26–34 are the most likely to be without health insurance at 18.5%.

c. The lowest point in the scatterplot is (70, 1.6). Since 70 represents the age group "over 64," this means that Americans who are older than 64 years are the least likely to be without health insurance at 1.6%.

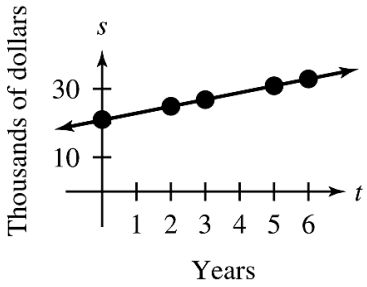
8. The line contains the point $(-4, -3)$, so $y = -3$ when $x = -4$.

9. The line contains the point $(4, 1)$, so $x = 4$ when $y = 1$.

10. The line and the y-axis intersect at $(0, -1)$, so the y-intercept is $(0, -1)$.

11. The line and the x-axis intersect at $(2, 0)$, so the x-intercept is $(2, 0)$.

12. a.



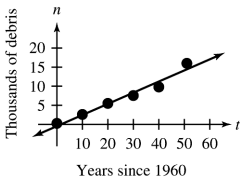
b. The line contains the point (4, 29), so $s = 29$ when $t = 4$. We predict the person's salary will be \$29 thousand after she has worked 4 years at the company.

c. The line contains the point (7, 35), so $t = 7$ when $s = 35$. We predict that person's salary will be \$35 thousand after she has worked 7 years at the company.

d. The line and the s-axis intersect at (0, 21), so $s = 21$ when $t = 0$. This means that, when the person was initially hired, her salary was \$21 thousand.

13. Answers may vary.

14. a.



b. Draw a line that comes close to the points to create the linear model. See the graph in part (a).

c. According to the model, there were 9 thousand space debris in around $1960 + 32 = 1992$.

d. According to the model, the number of space debris in 2010 ($t = 50$) was about 14.2 thousand.

e. The total number of debris created by the events in 2007 and 2009 was about 1.8 thousand. We estimate the debris, using the model, to be about 14 thousand in 2009 ($t = 49$). (We use 2009 since it includes debris amounts from the 2009 event as well as the 2007 event.) If we remove the actual data point (50, 16) and adjust our model with a new line, we can estimate the amount of debris had the events from 2007 and 2009 not occurred. In that case, we estimate the amount of debris to be about 12.2 thousand. By subtracting the two estimates, we get a value of 1.8 thousand pieces of debris. This is the amount of extra debris resulting from the events in 2007 and 2009.

15. Answers may vary. Example:
Model breakdown occurs when a model yields a prediction that does not make sense or an estimate that is not a good approximation. An example would be any negative value in a model that predicts an average person's height based on their age: neither height nor age can be less than zero. If we use a model to make an estimate and the result is not equal to the actual value, model breakdown has not necessarily occurred; models provide approximations, not exact values.