Solutions Manual for Pathway to Introductory Statistics 2nd Lehmann

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Instructor's Solutions Manual

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Chapter 1: Performing Operations and Evaluating Expressions

Homework 1.1

2. A constant is a symbol that represents a specific number.

4. Data are quantities or categories that describe people, animals, or things.

6. In 2017, about 37% of children aged 6–12 participated in a team sport (organized or unorganized) on a regular basis.

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

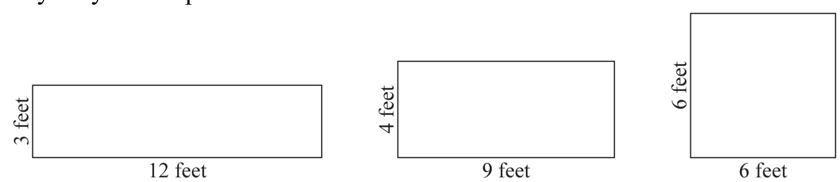
10. The statement $t = -3$ represents the year 2012 (3 years before 2015).

12. Answers may vary. Example: Let *s* be the annual salary (in thousands of dollars) of a person. Then *s* can represent the numbers 25 and 32, but *s* cannot represent the numbers -15 and -9.

14. Answers may vary. Example: Let *n* be the number of students enrolled in a prestatistics class. Then *n* can represent the numbers 15 and 28, but *n* cannot represent the numbers -20 or 0.5.

16. 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 or -450.

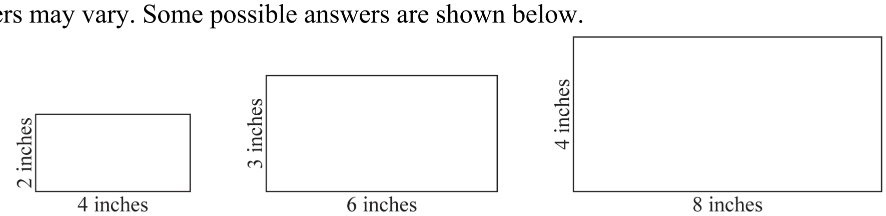
18. a. Answers may vary. Some possible answers are shown below.



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

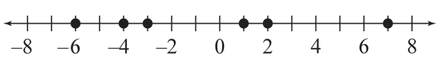
c. In the described situation, the symbol *A* is a constant. Its value is fixed at 36 square feet.

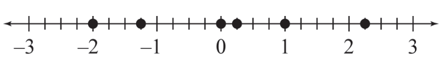
20. a. Answers may vary. Some possible answers are shown below.

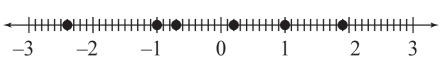


b. In the described situation, the symbols *W*, *L*, and *A* are all variables. All their values can change.

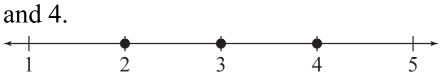
c. In the described situation, none of the symbols are constants. All their values can change.

22. 

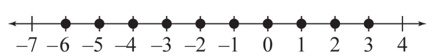
24. 

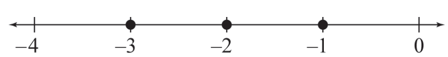
26. 

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

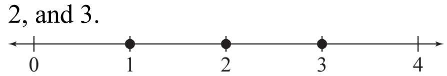


30. The integers between -6 and 3, inclusive, are $-6, -5, -4, -3, -2, -1, 0, 1, 2,$ and 3.



32. 

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



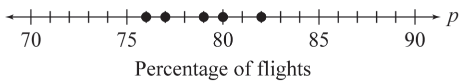
36. Answers may vary. Example: $-2, -5$ and -40.

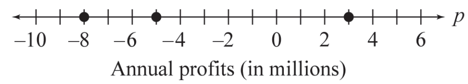
38. Answers may vary. Example: $-2.1, -2.3,$ and -2.8.

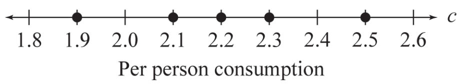
40. The temperature at the top of a skyscraper can be positive or negative, depending on the location of the skyscraper and the time of year. Temperature is not usually reported using fractions. So, among the choices, the integers are the smallest group of number that contains possible data.

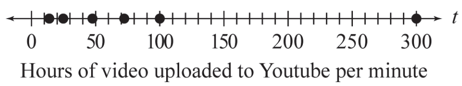
42. The commute time of an employee cannot be negative, but it can be measured in fractions. So, among the choices, the nonnegative real numbers are the smallest group of numbers that contains possible data.

44. McDonald's sells hamburgers every day of every year and there is never just a portion of a hamburger sold. So, among the choices, the counting numbers is the smallest group of numbers that contains possible data.

46. 

50. 

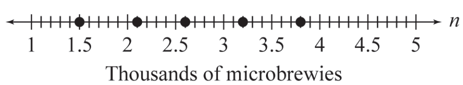
48. 

52. a. 

b. The number of hours of video uploaded to YouTube per minute increased between 2009 and 2014. The number of hours of video uploaded to YouTube per minute went up each year.

c. The annual *increases* in the number of hours of video uploaded to YouTube per minute increased between 2009 and 2014. The annual increases are shown below.

Years	Increase
2009 to 2010	$25-14=11$
2010 to 2011	$48-25=23$
2011 to 2012	$73-48=25$
2012 to 2013	$100-73=27$
2013 to 2014	$300-100=200$

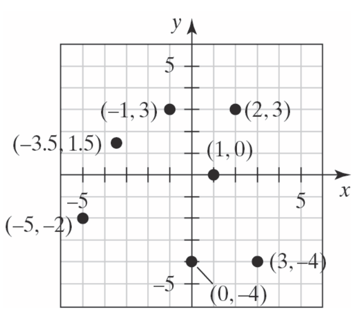
54. a. 

b. The number of microbreweries increased from 2013 to 2017.

c. The increases in the number of microbreweries stayed approximately constant from 2013 to 2017. The annual increases are shown below.

Years	Increase
2013 to 2014	$2.1-1.5=0.6$
2014 to 2015	$2.6-2.1=0.5$
2015 to 2016	$3.2-2.6=0.6$
2016 to 2017	$3.8-3.2=0.6$

56. – 68.

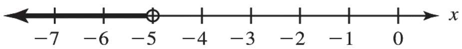


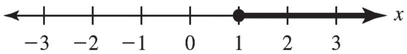
70. The y-coordinate is -4.

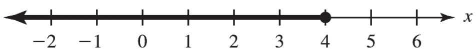
72. Point A is 2 units to the left of the origin and 4 units down. Thus, its coordinates are $(-2,-4)$.
Point B is 3 units to the left of the origin on the x-axis. Thus, its coordinates are $(-3, 0)$.
Point C is 5 units to the left of the origin and 4 units up. Thus, its coordinates are $(-5, 4)$.
Point 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 $(3,-2)$.

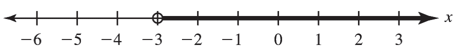
74. True. The number -2 lies to the right of -6 on a number line.

76. False. $-5=-5$, thus -5 is not strictly greater than -5.

78. 

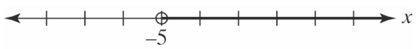
80. 

82. 

84. 

86. Inequality: $x>-5$

Interval notation: $(-5,\infty)$

Graph: 

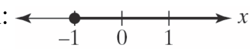
88. Inequality: $x \le 3$

Interval notation: $(-\infty,3]$

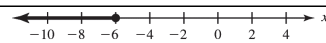
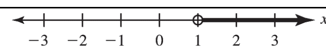
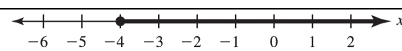
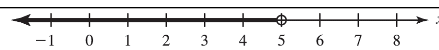
Graph: 

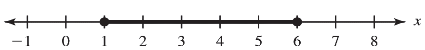
90. Inequality: $x \ge -1$

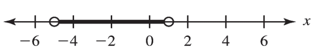
Interval notation: $[-1,\infty)$

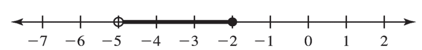
Graph: 

92.

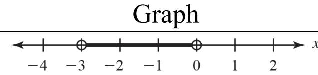
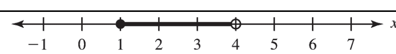
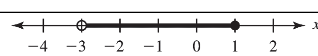
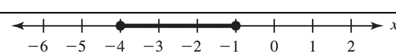
In Words	Inequality	Graph	Interval Notation
numbers less than or equal to −6	$x \le -6$		$(-\infty,-6]$
numbers greater than 1	$x>1$		$(1,\infty)$
numbers greater than or equal to −4	$x \ge -4$		$[-4,\infty)$
numbers less than 5	$x<5$		$(-\infty,5)$

94. 

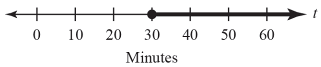
96. 

98. 

100.

In Words	Inequality	Graph	Interval Notation
numbers between −3 and 0	$-3<x<0$		$(-3,0)$
numbers between 1 and 4, as well as 1	$1 \le x<4$		$[1,4)$
numbers between −3 and 1, as well as 1	$-3<x \le 1$		$(-3,1]$
numbers between −4 and −1, inclusive	$-4 \le x \le -1$		$[-4,-1]$

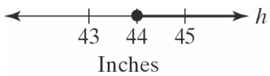
102. The student completes the homework assignment in 30 or more minutes.



104. Inequality: $h \geq 44$

Interval notation: $[44, \infty)$

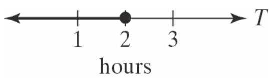
Graph:



106. Inequality: $T \leq 2$

Interval notation: $(-\infty, 2]$

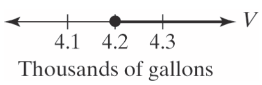
Graph:



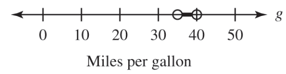
108. Inequality: $V \geq 4.2$

Interval notation: $[4.2, \infty)$

Graph:



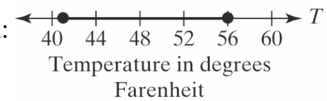
110. The average gas mileage of a car on highways is between 35 and 40 miles per gallon.



112. Inequality: $41 \leq T \leq 56$

Interval notation: $[41, 56]$

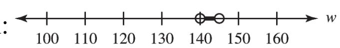
Graph:



114. Inequality: $140 < w < 145$

Interval notation: $(140, 145)$

Graph:



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

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

120. Answers may vary. The inequality represents "4 is less than or equal to 4," and 4 is equal to 4.

122. The types of numbers discussed in this section are real numbers, rational number, irrational numbers, integers, and counting numbers (or natural numbers). Answers may vary.

Homework 1.2

2. We evaluate an expression by substituting a number for each variable in the expression and then calculating the result.

4. The quotient of a and b is a/b, where b is not zero.

6. Substitute 6 for x in $5+x$: $5+(6)=11$

8. Substitute 6 for x in $x-4$: $(6)-4=2$

10. Substitute 6 for x in $x(9)$: $(6)(9)=54$

12. Substitute 6 for x in $30 \div x$: $30 \div (6) = 5$

14. Substitute 6 for x in $x-x$: $(6)-(6)=0$

16. Substitute 6 for x in $x \div x$: $(6) \div (6) = 1$

18. Substitute 47 for r in $r+29$: $47+29=76$. So, if 47% of Republicans favor gays to marry legally in 2017, then in that same year, about 76% of Democrats favor gays to marry legally.

20. Substitute 13.5 for U in $U-6$: $13.5-6=7.5$. So, in 2016 if the average daily shipping volume for UPS was 13.5 million packages, in that same year, the average daily shipping volume for FedEx was about 7.5 million packages.

22. Substitute 17 for n in $599.99n$: $599.99 \cdot 17 = 10{,}199.83$. So, if 17 thousand Fender Standard Jazz Electric Bass Guitars with maple fingerboards are sold, the total revenue is about $10,200,000.

24. Substitute 328 for T in $T \div 4$: $328 \div 4 = 82$. So, if a student earns a total of 328 points on four tests, the student's average test score is 82 points.

26. a.

Speed Limit (miles per hour)	Driving Speed (miles per hour)
35	$35+5$
40	$40+5$
45	$45+5$
50	$50+5$
s	$s+5$

The expression $s+5$ represents the driving speed if the speed limit is s miles per hour.

b. Substitute 65 for s in $s+5$: $65+5=70$. So, if the speed limit is 65 miles per hour, the person will be driving 70 miles per hour.

28. a.

Number of Shares	Total Value (dollars)
1	$74.74 \cdot 1$
2	$74.74 \cdot 2$
3	$74.74 \cdot 3$
4	$74.74 \cdot 4$
n	$74.74n$

The expression $74.74n$ represents the total value of the shares.

b. Substitute 7 for n in $74.74n$: $74.74(7)=523.18$. So, the total value of 7 shares is \$523.18.

30. a.

Number of Siblings	Share of Cost (dollars)
2	$3000 \div 2$
3	$3000 \div 3$
4	$3000 \div 4$
5	$3000 \div 5$
n	$3000 \div n$

The expression $3000 \div n$ represents each sibling's share of the cost in dollars.

b. Substitute 6 for n in $3000 \div n$: $3000 \div 6 = 500$. So, the share of each sibling's cost is \$500.

32. a. We can write an expression $10+v$ to represent the total cost of parking and money spent on a vase.

b. Substitute 25 for v in the expression $10+v$: $10+25=35$. So, if \$10 is spent on parking then the total cost of parking and money spent on a vase is \$35.

34. a. We can write an expression $r-2$ to represent the net price of a shaver whose retail price is r dollars.

b. Substitute 6 for r in the expression $r-2$: $6-2=4$. So, if the retail price of a shaver is \$6, then the net price is \$4.

36. a. We can write an expression $105c$ to represent the total cost of tuition when enrolling in c credits of classes.

b. Substitute 15 for c in the expression $105c$: $105 \cdot 15 = 1575$. So, if a student enrolls in 15 credits of classes, then the total cost of tuition is \$1575.

38. a. We can write an expression $420 \div n$ to represent the equal share each of n siblings will receive of the inheritance.

b. Substitute 3 for n in the expression $420 \div n$: $420 \div 3 = 140$. So, each of 3 siblings will receive an equal share of \$140,000 of a \$420,000 inheritance.

40. $8-x$; substitute 8 for x in $8-x$: $8-(8)=0$.

42. $6+x$; substitute 8 for x in $6+x$: $6+(8)=14$.

44. $x+15$; substitute 8 for x in $x+15$: $(8)+15=23$.

46. $x-7$; substitute 8 for x in $x-7$: $(8)-7=1$.

48. $5x$; substitute 8 for x in $5x$: $5(8)=40$.

50. The quotient of 6 and the number

52. Two less than the number

54. The sum of 4 and the number

56. The product of the number and 5

58. The sum of the number and 3

60. The quotient of the number and 5

62. Substitute 6 for x and 3 for y in the expression $y+x$: $(3)+(6)=9$

64. Substitute 6 for x and 3 for y in the expression xy: $(6)(3)=18$.

66. Substitute 6 for x and 3 for y in the expression $x \div y$: $6 \div 3 = 2$.

68. $x+y$; substitute 9 for x and 3 for y in the expression $x+y$: $(9)+(3)=12$.

70. $x \div y$; substitute 9 for x and 3 for y in the expression $x \div y$: $(9)\div(3)=3$.

72. Substitute 90.0 for c and 104.8 for r in the expression $c+r$: $90.0+104.8=194.8$. So, in 2015 the average annual per-person consumption of chicken and red meat was 194.8 pounds.

74. Substitute 11.26 for w and 19.98 for a in the expression $a-w$: $19.98-11.26=8.72$. So, in 2015 the college enrollments of all students who were not women was 8.72 million.

76. Substitute 2.5 for N and 1.8 for A in the expression NA: $2.5 \cdot 1.8 = 4.5$. So, in 2016 the average number of AP exams taken was 4.5 million.

78. Substitute 205,200 for s and 3.6 for n in the expression $s \div n$: $205{,}200 \div 3.6 = 57{,}000$. So, in 2014 the average money earned by a teacher was about $57,000.

80. a. Substitute 4 for x in the expression $x+2$: $(4)+2=6$. Substitute 5 for x in the expression $x+2$: $(5)+2=7$. Substitute 6 for x in the expression $x+2$: $(6)+2=8$.

b. Substitute 4 for x in the expression $2x$: $2(4)=8$. Substitute 5 for x in the expression $2x$: $2(5)=10$. Substitute 6 for x in the expression $2x$: $2(6)=12$.

c. Observe the values after substitution are different for the two expressions.

x	$x+2$	$2x$
4	$4+2=6$	$2(4)=8$
5	$5+2=7$	$2(5)=10$
6	$6+2=8$	$2(6)=12$

82. a.

n	$3n$
1	$3\cdot 1=3$
2	$3\cdot 2=6$
3	$3\cdot 3=9$
4	$3\cdot 4=12$

The price of bread is $3, $6, $9, and $12 for 1, 2, 3, and 4 loaves, respectively.

b. The cost per loaf of bread is $3. The cost per loaf is a constant while the number of loaves is a variable. In the expression $3n$, the constant is 3 and the variable is n.

c. Answers may vary. Example: For each additional loaf bought, the total price increases by $3.

84. a.

t	$2t$
1	$2\cdot1=2$
2	$2\cdot2=4$
3	$2\cdot3=6$
4	$2\cdot4=8$

The elevator rises are 2 yards, 4 yards, 6 yards, and 8 yards for every 1, 2, 3, and 4 seconds, respectively.

b. The elevator is rising at a speed of 2 yards per second. The distance risen is a constant amount of 2 yards while the number of seconds is a variable. In the expression $2t$, the constant is 2 and the variable is t.

c. Answers may vary. Example: For each second that passes, the distance the elevator rises is another 2 yards.

86. Answers may vary.

88. Answers may vary.

Homework 1.3

2. The reciprocal of $\frac{a}{b}$ is $\frac{b}{a}$.

4. If an object is made up of two or more parts, then the sum of their proportions equals 1.

6. The numerator of $\frac{2}{5}$ is 2.

8. $18=2\cdot9=2\cdot(3\cdot3)=2\cdot3\cdot3$

10. $24=4\cdot6=(2\cdot2)\cdot(2\cdot3)=2\cdot2\cdot2\cdot3$

12. $27=3\cdot9=3\cdot(3\cdot3)=3\cdot3\cdot3$

14. $105=5\cdot21=5\cdot(3\cdot7)=3\cdot5\cdot7$

16. $\frac{10}{14}=\frac{2\cdot5}{2\cdot7}=\frac{2}{2}\cdot\frac{5}{7}=\frac{5}{7}$

18. $\frac{27}{54}=\frac{3\cdot3\cdot3}{3\cdot3\cdot3\cdot2}=\frac{3\cdot3\cdot3}{3\cdot3\cdot3}\cdot\frac{1}{2}=\frac{1}{2}$

20. $\frac{9}{81}=\frac{3\cdot3}{3\cdot3\cdot3\cdot3}=\frac{3\cdot3}{3\cdot3}\cdot\frac{1}{3\cdot3}=\frac{1}{3\cdot3}=\frac{1}{9}$

22. $\frac{15}{18}=\frac{3\cdot5}{3\cdot3\cdot2}=\frac{3}{3}\cdot\frac{5}{3\cdot2}=\frac{5}{3\cdot2}=\frac{5}{6}$

24. $\frac{5}{7}\cdot\frac{4}{9}=\frac{5\cdot4}{7\cdot9}=\frac{5\cdot2\cdot2}{7\cdot3\cdot3}=\frac{20}{63}$

26. $\frac{2}{3}\cdot\frac{5}{6}=\frac{2\cdot5}{3\cdot6}=\frac{2\cdot5}{3\cdot2\cdot3}=\frac{5}{3\cdot3}=\frac{5}{9}$

28. $\frac{5}{12}\cdot2=\frac{5}{12}\cdot\frac{2}{1}=\frac{5\cdot2}{2\cdot2\cdot3}=\frac{5}{2\cdot3}=\frac{5}{6}$

30. $\frac{7}{12}\div\frac{2}{3}=\frac{7}{12}\cdot\frac{3}{2}=\frac{7\cdot3}{12\cdot2}$
$=\frac{7\cdot3}{2\cdot2\cdot3\cdot2}=\frac{7}{2\cdot2\cdot2}=\frac{7}{8}$

32. $\frac{4}{7}\div\frac{8}{3}=\frac{4}{7}\cdot\frac{3}{8}=\frac{4\cdot3}{7\cdot8}=\frac{2\cdot2\cdot3}{7\cdot2\cdot2\cdot2}=\frac{3}{7\cdot2}=\frac{3}{14}$

34. $\frac{4}{9}\div2=\frac{4}{9}\cdot\frac{1}{2}=\frac{4\cdot1}{9\cdot2}=\frac{2\cdot2}{3\cdot3\cdot2}=\frac{2}{3\cdot3}=\frac{2}{9}$

36. $\frac{2}{15}+\frac{8}{15}=\frac{2+8}{15}=\frac{10}{15}=\frac{2\cdot5}{3\cdot5}=\frac{2}{3}$

38. $\frac{13}{18}-\frac{9}{18}=\frac{13-9}{18}=\frac{4}{18}=\frac{2\cdot2}{2\cdot3\cdot3}=\frac{2}{3\cdot3}=\frac{2}{9}$

40. The LCD is 9: $\frac{1}{3}+\frac{5}{9}=\frac{1}{3}\cdot\frac{3}{3}+\frac{5}{9}=\frac{3}{9}+\frac{5}{9}=\frac{8}{9}$

42. The LCD is 24: $\frac{3}{8}+\frac{1}{6}=\frac{3}{8}\cdot\frac{3}{3}+\frac{1}{6}\cdot\frac{4}{4}=\frac{9}{24}+\frac{4}{24}$
$=\frac{13}{24}$

44. The LCD is 7: $2+\frac{3}{7}=\frac{2}{1}\cdot\frac{7}{7}+\frac{3}{7}=\frac{14}{7}+\frac{3}{7}=\frac{17}{7}$

46. The LCD is 4: $\frac{3}{4}-\frac{1}{2}=\frac{3}{4}-\frac{1}{2}\cdot\frac{2}{2}=\frac{3}{4}-\frac{2}{4}=\frac{1}{4}$

48. The LCD is 42: $\frac{5}{6}-\frac{4}{7}=\frac{5}{6}\cdot\frac{7}{7}-\frac{4}{7}\cdot\frac{6}{6}=\frac{35}{42}-\frac{24}{42}$
$=\frac{11}{42}$

50. The LCD is 7: $1-\frac{9}{7}=\frac{1}{1}\cdot\frac{7}{7}-\frac{9}{7}=\frac{7}{7}-\frac{9}{7}=\frac{-2}{7}$
$=-\frac{2}{7}$

52. $\dfrac{\frac{3}{4}}{\frac{7}{5}} = \dfrac{3}{4} \div \dfrac{7}{5} = \dfrac{3}{4} \cdot \dfrac{5}{7} = \dfrac{15}{28}$

54. $\dfrac{\frac{5}{3}}{\frac{20}{21}} = \dfrac{5}{3} \div \dfrac{20}{21} = \dfrac{5}{3} \cdot \dfrac{21}{20} = \dfrac{5 \cdot 3 \cdot 7}{3 \cdot 2 \cdot 2 \cdot 5} = \dfrac{7}{4}$

56. $\dfrac{\frac{25}{9}}{\frac{15}{3}} = \dfrac{25}{9} \div \dfrac{15}{3} = \dfrac{25}{9} \cdot \dfrac{3}{15} = \dfrac{5 \cdot 5 \cdot 3}{3 \cdot 3 \cdot 3 \cdot 5} = \dfrac{5}{9}$

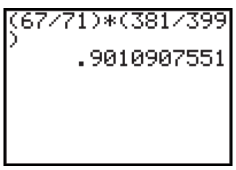
58. Substitute 3 for x and 12 for z in the expression $\dfrac{z}{x}$: $\dfrac{12}{3} = \dfrac{3 \cdot 2 \cdot 2}{3 \cdot 1} = \dfrac{2 \cdot 2}{1} = \dfrac{4}{1} = 4$

60. Substitute 4 for w, 3 for x, 5 for y, and 12 for z in the expression $\dfrac{y}{z} \cdot \dfrac{w}{x}$: $\dfrac{5}{12} \cdot \dfrac{4}{3} = \dfrac{5 \cdot 2 \cdot 2}{2 \cdot 2 \cdot 3 \cdot 3} = \dfrac{5}{3 \cdot 3} = \dfrac{5}{9}$

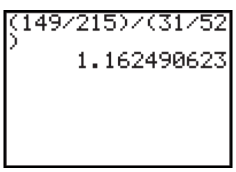
62. Substitute 3 for x, 5 for y, and 12 for z in the expression $\dfrac{y}{x} + \dfrac{y}{z}$: $\dfrac{5}{3} + \dfrac{5}{12}$

The LCD is 12: $\dfrac{5}{3} + \dfrac{5}{12} = \dfrac{5}{3} \cdot \dfrac{4}{4} + \dfrac{5}{12} = \dfrac{20}{12} + \dfrac{5}{12} = \dfrac{25}{12}$

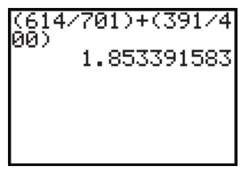
64. $\dfrac{67}{71} \cdot \dfrac{381}{399} \approx 0.90$



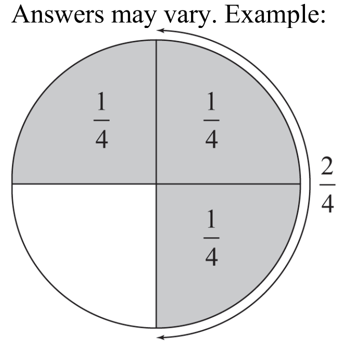
66. $\dfrac{149}{215} \div \dfrac{31}{52} \approx 1.16$



68. $\dfrac{614}{701} + \dfrac{391}{400} \approx 1.85$



70. Answers may vary. Example:



72. In 2018, since 10 of the top 40 songs sold on iTunes were pop songs, we can write a proportion of the songs that were pop songs as $\dfrac{10}{40} = \dfrac{1}{4}$.

74. The whole survey group consists of the proportions of the three political parties, so the sum of the proportions equals 1.

76. The category of American adults who picked football as their favorite sport to watch OR who picked basketball as their favorite sport to watch is the category of adult Americans who picked football together with the adults who picked basketball. So, we add the fractions $\frac{4}{11}+\frac{1}{9}$.

$$\begin{aligned}\frac{4}{11}+\frac{1}{9}&=\frac{4}{11}\cdot\frac{9}{9}+\frac{1}{9}\cdot\frac{11}{11}\\&=\frac{36}{99}+\frac{11}{99}\\&=\frac{47}{99}\end{aligned}$$

78. Proportion of employees who spend at least \$101 on commuting to work: $\frac{1}{5}+\frac{1}{7}=\frac{7}{35}+\frac{5}{35}=\frac{12}{35}$

80. Proportion of the disk that is orange: $1-\frac{2}{7}=\frac{7}{7}-\frac{2}{7}=\frac{5}{7}$

82. Proportion of Hispanic adults that do not use at least one social media site: $1-\frac{8}{11}=\frac{11}{11}-\frac{8}{11}=\frac{3}{11}$.

84. Proportion of the disc that is red and blue: $\frac{1}{2}+\frac{1}{3}=\frac{3}{6}+\frac{2}{6}=\frac{5}{6}$

Proportion of the disc that is yellow: $1-\frac{5}{6}=\frac{6}{6}-\frac{5}{6}=\frac{1}{6}$

86. Proportion of Hispanic and Caucasian undergraduates: $\frac{2}{7}+\frac{1}{2}=\frac{4}{14}+\frac{7}{14}=\frac{11}{14}$.

Proportion of undergraduates of ethnicities other than Hispanic and Caucasian: $1-\frac{11}{14}=\frac{14}{14}-\frac{11}{14}=\frac{3}{14}$.

88. Let m be the proportion of income for mortgage and f be the proportion of income for food. The proportion remaining is given by the expression $1-m-f$. Substitute $\frac{1}{3}$ for m and $\frac{1}{6}$ for f in the expression.

$$\begin{aligned}1-m-f&=1-\frac{1}{3}-\frac{1}{6}\\&=\frac{1}{1}\cdot\frac{6}{6}-\frac{1}{3}\cdot\frac{2}{2}-\frac{1}{6}\\&=\frac{6}{6}-\frac{2}{6}-\frac{1}{6}\\&=\frac{6-2-1}{6}\\&=\frac{3}{6}\\&=\frac{1}{2}\end{aligned}$$

So, $\frac{1}{2}$ of the income remains.

90. a. i. 2370 out of 3180 degrees were bachelor's degrees. Proportion of bachelor's degrees: $\frac{2370}{3180} \approx 0.745$.

ii. $1-\frac{2370}{3180}=\frac{3180}{3180}-\frac{2370}{3180}=\frac{810}{3180}\approx 0.255$

iii. 496 + 84 = 580 degrees were master's and doctoral degrees. Proportion of master's and doctoral degrees: $\frac{580}{3180} \approx 0.182$.

b. The six exact proportions consist of all the degrees the university awards, so the sum of the exact proportions equals 1. This may not be the case for the sum of the approximations. Rounding may cause the sum to differ slightly from 1.

92. $\frac{23 \text{ centimeters}}{1}\cdot\frac{1 \text{ inch}}{2.54 \text{ centimeters}} \approx 9.06 \text{ inches}$

94. $\frac{113 \text{ kilometers}}{1 \text{ hour}}\cdot\frac{1 \text{ mile}}{1.61 \text{ kilometers}} \approx 70.19 \text{ miles per hour}$

96. $\frac{42.5 \text{ milligrams}}{1 \text{ ounce}}\cdot\frac{1 \text{ gram}}{1000 \text{ milligrams}}\cdot\frac{16 \text{ ounces}}{1 \text{ pound}}=\frac{0.68 \text{ grams}}{1 \text{ pound}}=0.68 \text{ grams per pound}$

98. $\frac{25 \text{ meters}}{1 \text{ second}}\cdot\frac{3600 \text{ seconds}}{1 \text{ hour}}\cdot\frac{1 \text{ kilometer}}{1000 \text{ meters}}\cdot\frac{1 \text{ mile}}{1.61 \text{ kilometers}} \approx 55.90 \text{ miles per hour}$

100. $\frac{2250 \text{ milligrams}}{10 \text{ ounces}}\cdot\frac{1 \text{ gram}}{1000 \text{ milligrams}}\cdot\frac{16 \text{ ounces}}{1 \text{ pound}}=3.6 \text{ grams per pound}$

102. $\frac{26 \text{ grams}}{1 \text{ cup}}\cdot\frac{1000 \text{ milligrams}}{1 \text{ gram}}\cdot\frac{\frac{1}{8}\text{ cup}}{1 \text{ ounce}}=\frac{\frac{26{,}000}{8}\text{ milligrams}}{1 \text{ ounce}}=3250 \text{ milligrams per ounce}$

104. Answers may vary. Example: In this case, Student 2 actually did better. When you compare the proportion of question right for Student 1, $\frac{82}{100}=\frac{41}{50}$ with the proportion of question right for Student 2, $\frac{43}{50}$, we see that Student 2 did better since $\frac{43}{50}>\frac{41}{50}$.

106. a. i. $\frac{2}{3}\cdot\frac{3}{2}=\frac{2\cdot 3}{3\cdot 2}=\frac{6}{6}=1$

ii. $\frac{4}{7}\cdot\frac{7}{4}=\frac{4\cdot 7}{7\cdot 4}=\frac{28}{28}=1$

iii. $\frac{1}{6}\cdot\frac{6}{1}=\frac{1\cdot 6}{6\cdot 1}=\frac{6}{6}=1$

b. Answers may vary. Example: The product of a fraction and its reciprocal equals 1.

108. Answers may vary. Example: The student should have only multiplied the numerator by 2. Rewrite 2 as $\frac{2}{1}$ and then multiply across. $2\cdot\frac{3}{5}=\frac{2}{1}\cdot\frac{3}{5}=\frac{2\cdot 3}{1\cdot 5}=\frac{6}{5}$

110. Answers may vary. Example: The denominator of a fraction is the name of the things it represents. The numerator of a fraction is the number of those things it represents. When we add two fractions with the same denominator, we keep the same denominator, or name, and add the two numerators, or number of things.

Homework 1.4

2. The absolute value of a number is the distance the number is from 0 on the number line.

4. False. The sum of –4 and 2 is negative: $-4+2=-2$. The sum of 5 and –1 is positive: $5+(-1)=4$.

6. $-(-9)=9$

8. $-(-(-2))=-(2)=-2$

10. $|6|=6$ because 6 is a distance of 6 units from 0 on a number line.

12. $|-1|=1$ because -1 is a distance of 1 unit from 0 on a number line.

14. $-|5|=-(5)=-5$

16. $-|-9|=-(9)=-9$

18. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|5|-|-3|=5-3=2$
Since $|5|$ is greater than $|-3|$, the sum is positive.
$5+(-3)=2$

20. The numbers have the same sign, so add the absolute values.
$|-3|+|-2|=3+2=5$
The numbers are negative, so the sum is negative.
$-3+(-2)=-5$

22. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|-9|-|6|=9-6=3$
Since $|-9|$ is greater than $|6|$, the sum is negative.
$6+(-9)=-3$

24. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|4|-|-3|=4-3=1$
Since $|4|$ is greater than $|-3|$, the sum is positive.
$-3+4=1$

26. The numbers have the same sign, so add the absolute values.
$|-9|+|-5|=9+5=14$
The numbers are negative, so the sum is negative.
$-9+(-5)=-14$

28. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|8|-|-2|=8-2=6$
Since $|8|$ is greater than $|-2|$, the sum is positive.
$8+(-2)=6$

30. $8+(-8)=0$ because the numbers are opposites and the sum of opposites is 0.

32. $-7+7=0$ because the numbers are opposites and the sum of opposites is 0.

34. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|17|-|-14|=17-14=3$
Since $|17|$ is greater than $|-14|$, the sum is positive.
$17+(-14)=3$

36. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|-89|-|57| = 89-57 = 32$
Since $|-89|$ is greater than $|57|$, the sum is negative.
$-89+57=-32$

38. The numbers have the same sign, so add the absolute values.
$|-347|+|-594| = 347+594 = 941$
The numbers are negative, so the sum is negative.
$-347+(-594)=-941$

40. $127,512+(-127,512)=0$ because the numbers are opposites and the sum of opposites is 0.

42. The numbers have the same sign, so add the absolute values.
$|-3.7|+|-9.9| = 3.7+9.9 = 13.6$
The numbers are negative, so the sum is negative.
$-3.7+(-9.9)=-13.6$

44. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|7|-|-0.3| = 7-0.3 = 6.7$
Since $|7|$ is greater than $|-0.3|$, the sum is positive.
$-0.3+7=6.7$

46. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|37.05|-|-19.26| = 37.05-19.26 = 17.79$
Since $|37.05|$ is greater than $|-19.26|$, the sum is positive.
$37.05+(-19.26)=17.79$

48. The numbers have different signs, so subtract the smaller absolute value from the larger.
$\left|\frac{2}{5}\right|-\left|-\frac{1}{5}\right| = \frac{2}{5}-\frac{1}{5}=\frac{1}{5}$
Since $\left|\frac{2}{5}\right|$ is greater than $\left|-\frac{1}{5}\right|$, the sum is positive.
$\frac{2}{5}+\left(-\frac{1}{5}\right)=\frac{1}{5}$

50. The numbers have different signs, so subtract the smaller absolute value from the larger.
$\left|-\frac{5}{6}\right|-\left|\frac{1}{6}\right| = \frac{5}{6}-\frac{1}{6}=\frac{4}{6}=\frac{2}{3}$
Since $\left|-\frac{5}{6}\right|$ is greater than $\left|\frac{1}{6}\right|$, the sum is negative.
$-\frac{5}{6}+\frac{1}{6}=-\frac{2}{3}$

52. The numbers have the same sign, so add the absolute values.
$\left|-\frac{2}{3}\right|+\left|-\frac{5}{6}\right| = \frac{2}{3}+\frac{5}{6}=\frac{2}{3}\cdot\frac{2}{2}+\frac{5}{6}=\frac{4}{6}+\frac{5}{6}=\frac{9}{6}=\frac{3}{2}$
The numbers are negative, so the sum is negative.
$-\frac{2}{3}+\left(-\frac{5}{6}\right)=-\frac{3}{2}$

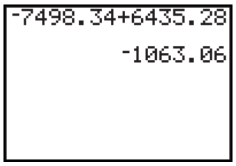
54. The numbers have different signs, so subtract the smaller absolute value from the larger.

$$\left|-\frac{3}{4}\right|-\left|\frac{2}{3}\right|=\frac{3}{4}-\frac{2}{3}=\frac{3}{4}\cdot\frac{3}{3}-\frac{2}{3}\cdot\frac{4}{4}=\frac{9}{12}-\frac{8}{12}=\frac{1}{12}$$

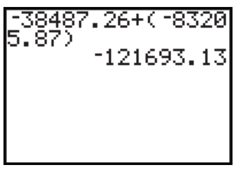
Since $\left|-\frac{3}{4}\right|$ is greater than $\left|\frac{2}{3}\right|$, the sum is negative.

$$\frac{2}{3}+\left(-\frac{3}{4}\right)=-\frac{1}{12}$$

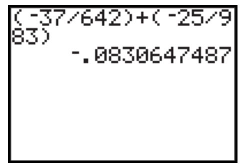
56. $-7498.34+6435.28=-1063.06$



58. $-38,487.26+(-83,205.87)=-121,693.13$



60. $-\frac{37}{642}+\left(-\frac{25}{983}\right)\approx-0.08$



62. The balance is $-112.50+170$ dollars. The numbers have different signs, so subtract the smaller absolute value from the larger.

$|170|-|-112.50|=170-112.50=57.50$

Since $|170|$ is greater than $|-112.50|$, the sum is positive: $-112.50+170=57.50$

So, the balance is \$57.50.

64. We can find the final balance by finding the balance after each transaction.

Transaction	Balance
Paycheck	$-135.00+549.00=414.00$
FedEx Kinko's	$414.00-10.74=403.26$
ATM	$403.26-21.50=381.76$
Barnes and Noble	$381.76-17.19=364.57$

So, the final balance is \$364.57.

66. The new balance is $-2739+530$. The numbers have different signs, so subtract the smaller absolute value from the larger.

$|-2739|-|530|=2739-530=2209$

Since $|-2739|$ is greater than $|530|$, the sum is negative.

$-2739+530=-2209$

So, the new balance is -2209 dollars.

68. The balance after sending the check is $-873+500=-373$.

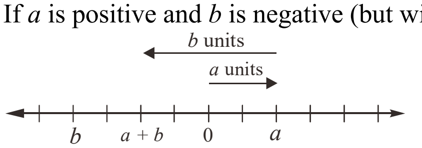
The balance after buying the racquet is $-373+(-249)=-622$.

The balance after buying the outfit is $-622+(-87)=-709$.

So, the final balance is -709 dollars.

70. The current temperature is $-12+8$. The numbers have different signs, so subtract the smaller absolute value from the larger.
$|-12|-|8|=12-8=4$
Since $|-12|$ is greater than $|8|$, the sum is negative.
$-12+8=-4$
So, the current temperature is $-4°$ F.

72. If a is positive and b is negative (but with a larger absolute value), the sum $a+b$ will be negative.



74. If $a+b$ is positive, then both numbers are positive, or the numbers have opposite signs but the number with the larger absolute value is positive.

76. a. Substitute -2 for a and 5 for b:
$a+b=(-2)+5=3$

b. Substitute -2 for a and 5 for b:
$b+a=5+(-2)=3$

c. The results are the same.

d. Substitute -4 for a and -9 for b:
$a+b=-4+(-9)=-13$
$b+a=-9+(-4)=-13$
The results are the same.

e. Answers may vary.

f. Yes; when adding two quantities, the order of the addition does not matter.

78. Answers may vary. Example: The value of a stock investment can be measured in gains and losses. It is possible to assign a as a variable to represent the value of a stock that suffers a loss (when the value of the stock falls below the price of purchase) and to assign b as a variable that represents the value of a stock that experiences a gain (when the value of the stock rises above the price of purchase). Suppose you have two stocks, a and b, in a portfolio and you want to determine the value of the portfolio at the conclusion of a particular day. If on that day $a=-\$300.00$ and $b=\$500.00$ you can find the value of the portfolio by combining a and b: $-300+500=200$. So, the value of the portfolio on that day is \$200.

Homework 1.5

2. To subtract a number, add its opposite.

4. True. A decreasing quantity has negative change.

6. $3-7=3+(-7)=-4$

8. $-3-9=-3+(-9)=-12$

10. $5-(-1)=5+1=6$

12. $-7-(-3)=-7+3=-4$

14. $-4-7=-4+(-7)=-11$

16. $-4-(-7)=-4+7=3$

18. $-7-7=-7+(-7)=-14$

20. $-100-257=-100+(-257)=-357$

22. $-1939-(-352)=-1939+352=-1587$

24. $5.8-3.7=5.8+(-3.7)=2.1$

26. $-1.7-7.4=-1.7+(-7.4)=-9.1$

28. $3.1-(-3.1)=3.1+3.1=6.2$

30. $-159.24-(-7.8)=-159.24+7.8=-151.44$

32. $-\frac{1}{5}-\frac{4}{5}=-\frac{1}{5}+\left(-\frac{4}{5}\right)=-\frac{5}{5}=-1$

34. $-\frac{4}{9}-\left(-\frac{7}{9}\right)=-\frac{4}{9}+\frac{7}{9}=\frac{3}{9}=\frac{1}{3}$

36. $\frac{5}{12}-\left(-\frac{1}{6}\right)=\frac{5}{12}+\frac{1}{6}=\frac{5}{12}+\frac{1}{6}\cdot\frac{2}{2}=\frac{5}{12}+\frac{2}{12}=\frac{7}{12}$

38. $-\frac{2}{3}-\frac{2}{5}=-\frac{2}{3}+\left(-\frac{2}{5}\right)=-\frac{2}{3}\cdot\frac{5}{5}+\left(-\frac{2}{5}\cdot\frac{3}{3}\right)$
$=-\frac{10}{15}+\left(-\frac{6}{15}\right)=-\frac{16}{15}$

40. $-3+9=6$

42. $-4-(-3)=-4+3=-1$

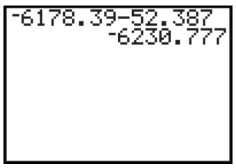
44. $-\frac{5}{6}+\frac{1}{6}=-\frac{4}{6}=-\frac{2}{3}$

46. $-6.4+3.5=-2.9$

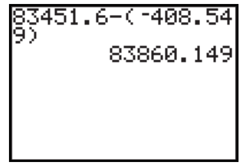
48. $-5+(-8)=-13$

50. $5-9=5+(-9)=-4$

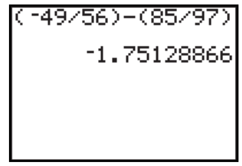
52. $-6178.39-52.387\approx-6230.78$



54. $83,451.6-(-408.549)\approx 83,860.15$



56. $-\frac{49}{56}-\frac{85}{97}\approx-1.75$



58. $-12+18=6$; So, the current temperature is $6°\text{F}$.

60. $-13-(-2)=-13+2=-11$; The change in temperature is $-11°\text{F}$.

62. a. $9-(-6)=9+6=15$; The change in temperature is $15°\text{F}$.

b. To estimate the change in temperature over the past hour, we divide the change over three hours by 3. $\frac{15}{3}=5$; The estimated change in temperature over the past hour is $5°\text{F}$.

c. Answers may vary. Example: The change in temperature is affected by the time of day in addition to the weather conditions. Thus, temperature change need not be uniform.

64. $29,035-(-1312)=29,035+1312=30,347$; The change in elevation is 30,347 feet.

66. a.

Year	Population	Change in Population
2011	98	–
2012	83	$83-98=-15$
2013	95	$95-83=12$
2014	104	$104-95=9$
2015	99	$99-104=-5$
2016	108	$108-99=9$
2017	97	$97-108=-11$

b. The population increased the most from 2012 to 2013. The change in population was 12.

c. The population decreased the most from 2011 to 2012. The change in population was -15.

d. No; the change in population is the difference between births and deaths. An increase of 12 wolves means there were 12 more births than deaths.

68. a. Add the changes in the number of Patriot Groups from 2010 to 2016:
$824+450+86+(-264)+(-222)+124+(-375)=623$
So, there were 623 Patriot Groups in 2016.

b. An increasing number of groups is indicated by positive changes. Thus, the number of Patriot Groups was increasing from 2010 to 2011, from 2011 to 2012, and from 2014 to 2015.

c. A decreasing number of groups is indicated by negative changes. Thus, the number of Patriot Groups was decreasing from 2012 to 2013, from 2013 to 2014, and from 2015 to 2016.

70. Evaluate $a+c$ for $a=-5$ and $c=-7$: $(-5)+(-7)=-12$

72. Evaluate $c-a$ for $a=-5$ and $c=-7$: $(-7)-(-5)=-7+5=-2$

74. Evaluate $b-a$ for $a=-5$ and $b=2$: $(2)-(-5)=2+5=7$

76. $x-4$; Evaluate the expression for $x=-5$: $-5-4=-5+(-4)=-9$

78. $x-5$; Evaluate the expression for $x=-5$: $(-5)-5=-5+(-5)=-10$

80. $x-(-6)$; Evaluate the expression for $x=-5$: $(-5)-(-6)=-5+6=1$

82. The student changed the order of subtraction without changing the sign of the result.
$2-6=2+(-6)=-4$

84. a. i. $2-8=2+(-8)=-6$

ii. $3-9=3+(-9)=-6$

iii. $1-5=1+(-5)=-4$

b. Answers may vary. Example: Since the quantity decreased, the final number is smaller than the beginning number. When finding the change in quantity, we subtract the beginning number from the final number. Since the final number is smaller, the result will be negative.

86. Answers may vary. Example: It is impossible to find the sign. If $|x|$ is greater than $|y|$, then $x-y$ is negative. If $|x|$ is less than $|y|$, then $x-y$ is positive.

88. Answers may vary. Example: To subtract a negative number from another number, take the opposite of the negative number and add it to the number. For instance, to subtract -6 from 4, we write $4-(-6)=4+6=10$.

Homework 1.6

2. One hundred percent of a quantity is all of the quantity.

4. True. The product or quotient of two numbers that have different signs is negative.

6. $\frac{9}{15}=\frac{3}{5}$

8. $\frac{3.7 \text{ million viewers}}{2.8 \text{ million viewers}} \approx \frac{1.32}{1}$; There were about 1.32 times as many viewers of *Good Morning America* as of *CBS This Morning*.

10. a. $\frac{2 \text{ c mushrooms}}{4 \text{ c cooked noodles}}=\frac{0.5 \text{ c mushrooms}}{1 \text{ c cooked noodles}}$; For each cup of cooked noodles, a half cup of sliced mushrooms is required.

b. $\frac{4 \text{ c cooked noodles}}{2 \text{ c mushrooms}}=\frac{2 \text{ c cooked noodles}}{1 \text{ c mushrooms}}$; For each cup of sliced mushrooms, 2 cups of cooked noodles are required.

12. a. Kershaw: $\frac{9}{5} \approx \frac{1.80}{1}$

Scherzer: $\frac{18}{7} \approx \frac{2.57}{1}$

Kluber: $\frac{20}{7} \approx \frac{2.86}{1}$

Strasburg: $\frac{10}{7} \approx \frac{1.43}{1}$

Sale: $\frac{12}{4}=\frac{3.00}{1}$

12. (continued)

b. The pitcher with the largest unit ratio of wins to losses is Sale. The pitcher with the smallest ratio of wins to losses is Strasburg.

c. No, the person is not correct. Answers may vary. Example: Even though Sale's wins are less than Scherzer's wins, Sale had fewer losses than Scherzer's which means that Sale's ratio will be higher than that of Scherzer's.

d. Kershaw: $\frac{155}{161} \approx \frac{0.96}{1}$ Scherzer: $\frac{300}{220} \approx \frac{1.36}{1}$

Kluber: $\frac{222}{215} \approx \frac{1.03}{1}$ Strasburg: $\frac{156}{130} = \frac{1.20}{1}$

Sale: $\frac{237}{158} = \frac{1.50}{1}$

e. The pitcher with the second largest ratio of strikeouts to innings is Scherzer. The pitcher with the second largest unit ratio of wins to losses is Kluber. The unit ratios differ since the values upon which the ratios are based are not linked. That is, a player's wins and losses stand independent of a player's strikeouts versus innings played—they are not directly proportional.

14. a. $\frac{19,849,399}{9,005,644} \approx \frac{2.20}{1}$; The population of New York is about 2.20 times larger than that of New Jersey.

b. $\frac{571,951}{155,959} \approx \frac{3.67}{1}$; The land area of Alaska is about 3.67 times larger than that of California.

c. Alaska: $\frac{739,795}{571,951} \approx \frac{1.29}{1}$ New Jersey: $\frac{9,005,644}{7417} \approx \frac{1214.19}{1}$

California: $\frac{39,536,653}{155,959} \approx \frac{253.51}{1}$ New York: $\frac{19,849,399}{47,214} = \frac{420.41}{1}$

Michigan: $\frac{9,962,311}{56,804} \approx \frac{175.38}{1}$

d. The state with the greatest population density is New Jersey. The state with the least dense population is Alaska.

e. The person is not correct. Answers may vary. Example: Although Michigan has a larger population than New Jersey, it also has a larger land area which serves to lower its population density.

16. $91\% = 91.0\% = 0.91$

18. $0.01 = 1\%$

20. $4\% = 4.0\% = 0.04$

22. $0.089 = 8.9\%$

24. The proportion of books purchased in stores in 2017 was 0.62.

26. The proportion of teenagers who consider Snapchat their favorite social network is 0.47.

28. 37% of 304 executives said they would quit their job and be a stay-at-home parent if they could afford it.

30. Of the 46.9 million Americans who traveled at least 50 miles from home during Independence Day holiday weekend in 2018, 8.1% traveled by air.

32. The proportion is $\frac{287}{2048} \approx 0.14$. Approximately 14% of 2048 surveyed adults do not have a will because they do not like thinking about death.

34. $0.67(4500) = 3015$; so, 67% of 4500 cars is 3015 cars.

36. $0.03(125.35) = 3.7605 \approx 3.76$; so, the sales tax is \$3.76.

38. $0.111(24{,}503) = 2719.833 \approx 2720$; so, there were 2720 undergraduate business majors.

40. $\frac{2.39-2.12}{2.12} \approx 0.127$; So, the percent change in the average price of regular gasoline from 2016 to 2017 is about 12.7%. This means the average price of regular gasoline increased by 12.7%.

42. $\frac{26.5-32.9}{32.9} \approx -0.195$; So, the percent change in viewership for the Academy Awards is –19.5%. This means the viewership for the Academy Awards decreased by about 19.5%.

44. a. McDonald's: $160.84-156.69 = 4.15$; McDonald's stock increased by \$4.15.

 b. La-Z-Boy: $32.75-30.60 = 2.15$; La-Z-Boy's stock increased by \$2.15.

 c. McDonald's: $\frac{4.15}{156.69} \approx 0.0265$; The percent change in McDonald's stock was about 2.6%.

 d. La-Z-Boy: $\frac{2.15}{30.60} \approx 0.0703$; The percent change in La-Z-Boy's stock was about 7.0%.

 e. Answers may vary. Example: Even though McDonald's stock price increased by a greater amount than La-Z-Boy's, La-Z-Boy's stock is actually a better investment because its percentage increase is more than McDonald's stock.

46. $4(-5) = -20$

48. Since the numbers have the same sign, the product is positive: $-8(-9) = 72$.

50. Since the numbers have different signs, the quotient is negative: $24 \div (-3) = -8$.

52. Since the numbers have the same sign, the quotient is positive: $-1 \div (-1) = 1$.

54. Since the numbers have the same sign, the product is positive: $-124(-29) = 3596$.

56. Since the numbers have different signs, the quotient is negative: $1008 \div (-21) = -48$.

58. Since the numbers have the same sign, the product is positive: $-0.3(-0.3) = 0.09$.

60. Since the numbers have different signs, the quotient is negative: $-0.12 \div 0.3 = -0.4$.

62. Since the numbers have different signs, the quotient is negative: $\frac{9}{-3} = 9 \div (-3) = -3$.

64. Since the numbers have the same sign, the quotient is positive: $\frac{-72}{-8} = -72 \div (-8) = 9$.

66. Since the numbers have different signs, the product is negative: $\frac{1}{3}\left(-\frac{7}{5}\right) = -\frac{7}{15}$.

68. Since the numbers have the same sign, the product is positive: $\left(-\frac{7}{25}\right)\left(-\frac{5}{21}\right) = \frac{35}{525} = \frac{1}{15}$.

70. Since the numbers have different signs, the quotient is negative: $-\frac{5}{7} \div \frac{15}{8} = -\frac{5}{7} \cdot \frac{8}{15} = -\frac{40}{105} = -\frac{8}{21}$.

72. Since the numbers have the same sign, the quotient is positive: $-\frac{3}{8} \div \left(-\frac{9}{20}\right) = \frac{3}{8} \cdot \frac{20}{9} = \frac{60}{72} = \frac{5}{6}$.

74. $-9 + (-4) = -13$

76. $-49 \div (7) = -7$

78. $-2-7=-2+(-7)=-9$

80. $(-5)(-9)=45$

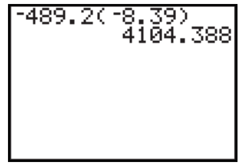
82. $-\frac{3}{8}-\left(-\frac{1}{10}\right)=-\frac{3}{8}+\frac{1}{10}$
$$=-\frac{3}{8}\cdot\frac{5}{5}+\frac{1}{10}\cdot\frac{4}{4}$$
$$=-\frac{15}{40}+\frac{4}{40}$$
$$=\frac{-15+4}{40}$$
$$=-\frac{11}{40}$$

84. $-\frac{22}{9}\div\left(-\frac{33}{18}\right)=-\frac{22}{9}\cdot\left(-\frac{18}{33}\right)$
$$=\frac{2\cdot 11\cdot 2\cdot 9}{9\cdot 3\cdot 11}$$
$$=\frac{2\cdot 2}{3}$$
$$=\frac{4}{3}$$

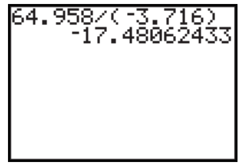
86. $\frac{-15}{35}=-\frac{3\cdot 5}{7\cdot 5}=-\frac{3}{7}$

88. $\frac{-35}{-21}=\frac{7\cdot 5}{7\cdot 3}=\frac{5}{3}$

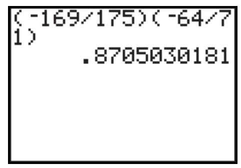
90. $-489.2(-8.39)\approx 4104.39$



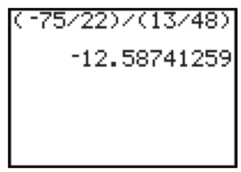
92. $64.958\div(-3.716)\approx -17.48$



94. $-\frac{169}{175}\left(-\frac{64}{71}\right)\approx 0.87$



96. $-\frac{75}{22}\div\frac{13}{48}\approx -12.59$



98. a. $\frac{-6810\text{ dollars}}{-2950\text{ dollars}}=\frac{681}{295}\approx\frac{2.31}{1}$

b. For each \$1 he pays towards his Sears account, he should pay about \$2.31 towards his Visa account.

100. $0.35(1590)=556.50$
$-1590+556.5=-1033.50$
The new balance would be $-\$1033.50$.

102. $3(89.50)=268.50$
$0-268.50=-268.50$
The new balance is $-\$268.50$.

104. Answers may vary. Example: The percentage of women in the U.S. Senate is $\frac{24}{100}\times 100=24\%$. The percentage of women in the U.S. Supreme Court is $\frac{3}{9}\times 100\approx 0.33\times 100$ which is about 33%. Even though there is a greater number of women in the U.S. Senate vs. the U.S. Supreme Court, the fact that 3 seats are taken up by women in the U.S. Supreme Court out of a total of 9 seats means there is greater representation of women there vs the number of women in the U.S. Senate. It would take as many as 33 women Senators to match the relative representation in the U.S. Senate as there is in the U.S. Supreme Court.

106. a. Negative; the quotient of two numbers with opposite signs is negative.

b. Negative; the quotient of two numbers with opposite signs is negative.

c. No; the variables *a* and *b* can take on positive or negative values, so the sign of the result is not clear without knowing the signs of *a* and *b*.

108. Answers may vary. Example: $3(-6)=(-6)+(-6)+(-6)=-18$

110. a. Answers may vary. Example: 1, 2, 3.
 b. Answers may vary. Example: -1, -2, -3.
 c. For $2x$ to equal x, x must be 0.

112. Answers may vary. Example: When comparing the performance of two stocks in the past year, it is more helpful to compare the percent changes in value. Percentage change lets you measure the growth rate of stocks over a period of time, whereas a change in the price of a stock only lets you see the difference in its value. If you know how well one stock is growing compared to others, you can identify whether it is a better investment compared to others.

Homework 1.7

2. If a is a nonnegative number, then $\sqrt{a}$ is the nonnegative number we square to get a.

4. To write 3.56×10^{-4} in standard decimal notation, we move the decimal point k places to the left.

6. $3^4 = 3\cdot3\cdot3\cdot3 = 9\cdot3\cdot3 = 27\cdot3 = 81$

8. $5^3 = 5\cdot5\cdot5 = 25\cdot5 = 125$

10. $-7^2 = -(7\cdot7) = -49$

12. $(-7)^2 = (-7)(-7) = 49$

14. $\left(\frac{3}{5}\right)^3 = \left(\frac{3}{5}\right)\left(\frac{3}{5}\right)\left(\frac{3}{5}\right) = \frac{27}{125}$

16. $(-5)^0 = 1$

18. $4^{-2} = \frac{1}{4^2} = \frac{1}{16}$

20. $6^{-1} = \frac{1}{6^1} = \frac{1}{6}$

22. $10^{-3} = \frac{1}{10^3} = \frac{1}{1000}$

24. $\sqrt{16} = 4$, because $4^2 = 16$.

26. $-\sqrt{25} = -5$

28. $\sqrt{-4}$ is not a real number, because the radicand –4 is negative.

30. $-\sqrt{-16}$ is not a real number, because the radicand –16 is negative.

32. The number 62 is not a perfect square, so $\sqrt{62}$ is irrational. $\sqrt{62} \approx 7.87$

34. The number 81 is a perfect square, so $\sqrt{81}$ is rational. $\sqrt{81} = 9$, because $9^2 = 81$.

36. $8\cdot(2-6) = 8\cdot(-4) = -32$

38. $(2+8)(3-8) = (10)(-5) = -50$

40. $\frac{3+5+4+2+6}{5} = \frac{20}{5} = 4$

42. $\frac{1-9}{2-(-4)} = \frac{-8}{2+4} = \frac{-8}{6} = -\frac{4}{3}$

44. $2\sqrt{41+8} = 2\sqrt{49} = 2(7) = 14$

46. $1+9\cdot(-4) = 1+(-36) = -35$

48. $-16\div(-4)\cdot2 = 4\cdot2 = 8$

50. $3-7+1 = -4+1 = -3$

52. $2-4(9-6) = 2-4(3) = 2-12 = -10$

54. $6(2+3)-5\cdot7 = 6(5)-5\cdot7 = 30-35 = -5$

56.
$$\begin{aligned}-3-[6+2(4-8)] &= -3-[6+2(-4)]\\ &= -3-[6-8]\\ &= -3-[-2]\\ &= -1\end{aligned}$$

58. $\frac{5}{6}+\frac{2}{3}\div\frac{2}{5} = \frac{5}{6}+\frac{2}{3}\cdot\frac{5}{2} = \frac{5}{6}+\frac{10}{6} = \frac{15}{6} = \frac{5}{2}$

60. $8-3^2 = 8-9 = -1$

62. $8(-2)^3 = 8(-8) = -64$

64.
$$\begin{aligned}2(-4)^2+3(-4)-7 &= 2(16)+3(-4)-7\\ &= 32+(-12)-7\\ &= 20-7\\ &= 13\end{aligned}$$

66. $(9-7)^2\cdot(-3)-2^4=(2)^2\cdot(-3)-2^4$
$$=4(-3)-16$$
$$=-12-16$$
$$=-12+(-16)$$
$$=-28$$

68. $\dfrac{(-4)^2+(-1)^2+1^2+4^2}{4-1}$
$$=\frac{(-4)(-4)+(-1)(-1)+1(1)+4(4)}{4-1}$$
$$=\frac{16+1+1+16}{4-1}=\frac{34}{3}$$

70. $\dfrac{(1-3)^2+(2-3)^2+(6-3)^2}{3-1}$
$$=\frac{(-2)^2+(-1)^2+(3)^2}{3-1}$$
$$=\frac{(-2)(-2)+(-1)(-1)+(3)(3)}{3-1}$$
$$=\frac{4+1+9}{2}=\frac{14}{2}=7$$

72. $(30-40)+2\sqrt{\dfrac{6^2}{9}+\dfrac{8^2}{2}}=-10+2\sqrt{\dfrac{6^2}{9}+\dfrac{8^2}{2}}$
$$=-10+2\sqrt{\frac{6(6)}{9}+\frac{8(8)}{2}}$$
$$=-10+2\sqrt{\frac{36}{9}+\frac{64}{2}}$$
$$=-10+2\sqrt{4+32}$$
$$=-10+2\sqrt{36}$$
$$=-10+2(6)$$
$$=-10+12=2$$

74. $\dfrac{84.7+82.9+89.3+80.1}{4}=\dfrac{337.0}{4}=84.25$

76. $\sqrt{\dfrac{0.35(1-0.35)}{50}}=\sqrt{\dfrac{0.35(0.65)}{50}}=\sqrt{\dfrac{0.2275}{50}}$
$$=\sqrt{0.00455}\approx 0.07$$

78. $\dfrac{951-944}{\dfrac{24}{\sqrt{75}}}=\dfrac{7}{\dfrac{24}{\sqrt{75}}}$
$$=7\div\frac{24}{\sqrt{75}}$$
$$=7\cdot\frac{\sqrt{75}}{24}$$
$$=7\cdot\frac{5\sqrt{3}}{24}$$
$$=\frac{35\sqrt{3}}{24}\approx 2.53$$

80. $\sqrt{\dfrac{(5.8-6.2)^2+(9.4-6.2)^2+(3.4-6.2)^2}{3-1}}$
$$=\sqrt{\frac{(-0.4)^2+(3.2)^2+(-2.8)^2}{2}}$$
$$=\sqrt{\frac{(-0.4)(-0.4)+(3.2)(3.2)+(-2.8)(-2.8)}{2}}$$
$$=\sqrt{\frac{0.16+10.24+7.84}{2}}$$
$$=\sqrt{\frac{18.24}{2}}=\sqrt{9.12}\approx 3.02$$

82. Evaluate $\bar{x}+zs$ for $\bar{x}=15$, $z=-2$, and $s=5$: $15+(-2)(5)=15+(-10)=5$

84. Evaluate $\dfrac{x-\bar{x}}{s}$ for $x=5$, $\bar{x}=11$, and $s=2$: $\dfrac{5-11}{2}=\dfrac{-6}{2}=-3$

86. Evaluate $\dfrac{y_2-y_1}{x_2-x_1}$ for $x_1=-3$, $x_2=-8$, $y_1=-5$, and $y_2=-3$: $\dfrac{-3-(-5)}{-8-(-3)}=\dfrac{2}{-5}=-\dfrac{2}{5}$

88. Evaluate $\bar{x}-t\dfrac{s}{\sqrt{n}}$ for $\bar{x}=25$, $t=2$, $s=8$, and $n=4$: $25-2\left(\dfrac{8}{\sqrt{4}}\right)=25-2\left(\dfrac{8}{2}\right)=25-2(4)=25-8=17$

90. Evaluate ab^x for $a=8$, $b=2$, and $x=-3$: $8(2)^{-3}=8\left(\dfrac{1}{2^3}\right)=8\left(\dfrac{1}{8}\right)=\dfrac{8}{1}\cdot\dfrac{1}{8}=\dfrac{8}{8}=1$

92. $\dfrac{\dfrac{\overline{x}-\mu}{\dfrac{s}{\sqrt{n}}}}{}=\dfrac{98.26-95.77}{\dfrac{8.41}{\sqrt{20}}}$

$=\dfrac{2.49}{\dfrac{8.41}{\sqrt{20}}}$

$=2.49\div\dfrac{8.41}{\sqrt{20}}$

$=2.49\cdot\dfrac{\sqrt{20}}{8.41}$

$=2.49\cdot\dfrac{2\sqrt{5}}{8.41}$

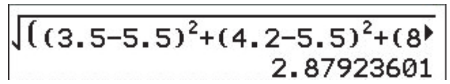
≈ 1.32

94. $\dfrac{\hat{p}-p}{\sqrt{\dfrac{p(1-p)}{n}}}=\dfrac{0.68-0.65}{\sqrt{\dfrac{0.65(1-0.65)}{2000}}}$

$=0.03\div\sqrt{\dfrac{0.65(1-0.65)}{2000}}$

$=0.03\div\sqrt{\dfrac{0.2275}{2000}}$

$\approx 0.03\cdot\dfrac{1}{0.0107}\approx 2.80$

96. 

The answer is about 2.88.

98. $-3-\dfrac{8}{x}$; evaluate the expression for $x=-4$: $-3-\dfrac{8}{-4}=-3-(-2)=-3+2=-1$

100. $x+x(-5)$; evaluate the expression for $x=-4$: $-4+(-4)(-5)=-4+20=16$

102. a.

Years since 1990	Number of unprovoked shark attacks
0	$2.1\cdot 0+19$
1	$2.1\cdot 1+19$
2	$2.1\cdot 2+19$
3	$2.1\cdot 3+19$
4	$2.1\cdot 4+19$
t	$2.1\cdot t+19$

From the last row of the table, we see that the expression $2.1t+19$ represents the number of unprovoked shark attacks in the United States t years after 1990.

b. Substitute 26 for t in $2.1t+19$: $2.1(26)+19=54.6+19=73.6$. So, in 2016 (26 years after 1990) the number of unprovoked shark attacks in the United States was about 73.6.

104. a.

Years since 2014	Percent
0	$84-1.5\cdot 0$
1	$84-1.5\cdot 1$
2	$84-1.5\cdot 2$
3	$84-1.5\cdot 3$
4	$84-1.5\cdot 4$
t	$84-1.5t$

From the last row of the table, we see that the expression $84-1.5t$ represents the percent of U.S. households that use pay TV, t years after 2014.

b. Substitute 4 for t in $84-1.5t$: $84-1.5(4)=84-6=78$. So, in 2018 (4 years after 2014) the percent of U.S. households that use pay TV will be 78%.

106. The increase in Amazon.com's net sales from 2016 to 2017 was 0.308(136.0) billion dollars. To find Amazon.com's net sales (in billions of dollars) in 2017, we add 0.308(136.0) to 136.0:
$136.0+0.308(136.0)=136.0+41.888=177.888$. Amazon.com's net sales were about \$177.9 billion in 2017.

108. The decrease in the U.S. revenue from newspapers from 2016 to 2017 was 0.098(18.3) billion dollars. To find the revenue from newspapers (in billions of dollars) in 2017, we subtract 0.098(18.3) from 18.3: $18.3-0.098(18.3)=18.3-1.7934=16.5066$. The revenue from newspapers was about $16.5 billion in 2017.

110. The leftmost blue bar has width 2 and height 0.07, so its area is $2(0.07)=0.14$.

Each of the other two blue bars have width 2 and height 0.12, so the area of one of these blue bars is $2(0.12)=0.24$.

The total area of all three blue bars is $0.14+0.24+0.24=0.62$.

Because the area of the entire object is 1, the area of the orange bar is $1-0.62=0.38$.

112. The leftmost blue bar has width 4 and height 0.03, so its area is $4(0.03)=0.12$.

The rightmost blue bar has width 4 and height 0.04, so its area is $4(0.04)=0.16$.

The total area of the outside blue bars is $0.12+0.16=0.28$.

Because the area of the entire object is 1, the remaining area of the other two bars is $1-0.28=0.72$.

Since the remaining two bars are equal in area, to get the area of the orange bar, we calculate: $\frac{0.72}{2}=0.36$.

114. For 8.31×10^6, the decimal point must move six places to the right. Thus, the standard decimal is 8,310,000.

116. For 6.488×10^{-5}, the decimal point must move five places to the left. Thus, the standard decimal is 0.00006488.

118. For -8.7×10^{-2}, the decimal point must move two places to the left. Thus, the standard decimal is -0.087.

120. For 280,000, the decimal point needs to be moved five places to the left so that the new number is between 1 and 10. Thus, the scientific notation is 2.8×10^5.

122. For 0.000023, the decimal point needs to be moved five places to the right so that the new number is between 1 and 10. Thus, the scientific notation is 2.3×10^{-5}.

124. For -0.0004, the decimal point needs to be moved four places to the right so that the absolute value of the new number is between 1 and 10. Thus, the scientific notation is -4×10^{-4}.

126. $2E^-5=\frac{2}{100,000}=0.00002$

$3E^-4=\frac{3}{10,000}=0.0003$

$1.14E7=1.14\cdot10,000,000=11,400,000$

$1.71E8=1.71\cdot100,000,000=171,000,000$

128. $2.389\times10^5=2.389\cdot100,000=238,900$ miles

130. $10^{-12}=1\times10^{-12}=\frac{1}{1,000,000,000,000}$

$=0.000000000001$ watt/m^2

132. 25,000,000,000,000

$=2.5\times10,000,000,000,000$

$=2.5\times10^{13}$ miles

134. $0.0000000317=\frac{3.17}{100,000,000}=3.17\times10^{-8}$ year

136. In the first line, the student only squared 3 instead of -3. The correct expression is $(-3)^2+4(-3)+5=9+(-12)+5=-3+5=2$.

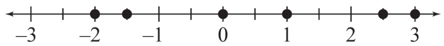
138. The student did not perform multiplication and division in the correct order (from left to right). $16\div2\cdot4=8\cdot4=32$

140. Answers may vary.

Chapter 1 Review Exercises

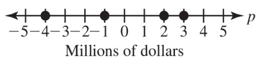
1. The total box office gross from U.S. and Canada movie theaters was \$11.4 billion in 2016.

2. 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.

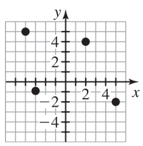
3. 

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

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

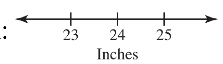


6. The amount of time a student plays a video game cannot be negative, but it can be measured in fractions. So, among the choices, the nonnegative real numbers are the smallest group of numbers that contains possible data.

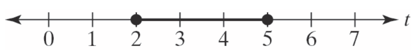
7. 

8. Inequality: $c \geq 24$

Interval notation: $[24, \infty)$

Graph: 

9. A teenager spends between 2 and 5 hours, inclusive, playing a video game.



10. Substitute 20.7 for F and 9.6 for X in the expression $F - X$: $20.7 - 9.6 = 11.1$. So, in 2017 Fujifilm's annual revenue was \$11.1 billion more than Xerox's annual revenue.

11. Proportion of consumers who prefer to pay for purchases and other transactions with debit cards OR credit cards is the sum of the proportions: $\frac{2}{5} + \frac{1}{4} = \frac{8}{20} + \frac{5}{20} = \frac{13}{20}$.

12. Proportion of the disc that is red and blue: $\frac{2}{3} + \frac{1}{4} = \frac{8}{12} + \frac{3}{12} = \frac{11}{12}$

Proportion of the disc that is green: $1 - \frac{11}{12} = \frac{12}{12} - \frac{11}{12} = \frac{1}{12}$

13. $\frac{121 \text{ gallons}}{1 \text{ year}} \cdot \frac{4 \text{ quarts}}{1 \text{ gallon}} \cdot \frac{4 \text{ cups}}{1 \text{ quart}} \cdot \frac{1 \text{ year}}{365 \text{ days}} \approx 5.3$ cups per day

14. $7 + (-10) = -3$

15. $3 - (-5) = 3 + 5 = 8$

16. Since the numbers have different signs, the product will be negative: $5(-9) = -45$

17. Since the numbers have different signs, the quotient will be negative: $8 \div (-2) = -4$

18. $-24 \div (10 - 2) = -24 \div (8) = -3$

19. $(2-6)(5-8) = (-4)(-3) = 12$

20. $\frac{5+2+7+6}{4} = \frac{20}{4} = 5$

21. $\frac{2-8}{3-(-1)} = \frac{2-8}{3+1} = \frac{-6}{4} = -\frac{6}{4} = -\frac{3}{2}$

22. $-4 + 2(-6) = -4 + (-12) = -16$

23. $8 \div (-2) \cdot 5 = (-4) \cdot 5 = -20$

24. $$\begin{aligned} 2(4-7)-(8-2) &= 2(-3)-(6) \\ &= (-6)-(6) \\ &= (-6)+(-6) \\ &= -12 \end{aligned}$$

25. $-14 \div (-7) - 3(1-5) = -14 \div (-7) - 3(-4)$
$= 2 - 3(-4)$
$= 2 - (-12)$
$= 2 + 12$
$= 14$

26. $-5 - [3 + 2(1-7)] = -5 - [3 + 2(-6)]$
$= -5 - [3 - 12]$
$= -5 - [-9]$
$= -5 + 9$
$= 4$

27. $4.2 - (-6.7) = 4.2 + 6.7 = 10.9$

28. $\left(-\frac{8}{15}\right) \div \left(-\frac{16}{25}\right) = \left(-\frac{8}{15}\right)\left(-\frac{25}{16}\right)$
$= \frac{8}{15} \cdot \frac{25}{16}$
$= \frac{200}{240}$
$= \frac{5}{6}$

29. $\frac{5}{9} - \left(-\frac{2}{9}\right) = \frac{5}{9} + \frac{2}{9} = \frac{5+2}{9} = \frac{7}{9}$

30. $-8^2 = -(8 \cdot 8) = -64$

31. $4^{-3} = \frac{1}{4^3} = \frac{1}{4 \cdot 4 \cdot 4} = \frac{1}{64}$

32. $-\sqrt{49} = -7$

33. $-6(3)^2 = -6(3 \cdot 3) = -6(9) = -54$

34. $(-2)^3 - 4(-2) = (-2)(-2)(-2) - 4(-2)$
$= -8 - 4(-2)$
$= -8 - (-8)$
$= -8 + 8$
$= 0$

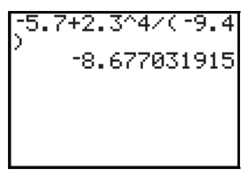
35. $\frac{17 - (-3)^2}{5 - 4^2} = \frac{17 - (-3)(-3)}{5 - (4 \cdot 4)}$
$= \frac{17 - 9}{5 - 16} = \frac{8}{-11} = -\frac{8}{11}$

36. $-3(2)^2 - 4(2) + 1$
$= -3(2 \cdot 2) - 4(2) + 1$
$= -3(4) - 4(2) + 1$
$= -12 - 8 + 1$
$= -20 + 1$
$= -19$

37. $7^2 - 3(2-5)^2 \div (-3)$
$= 7^2 - 3(-3)^2 \div (-3)$
$= (7 \cdot 7) - 3[(-3)(-3)] \div (-3)$
$= 49 - 27 \div (-3)$
$= 49 - (-9)$
$= 49 + 9$
$= 58$

38. $\frac{(2-4)^2 + (3-4)^2 + (7-4)^2}{3-1}$
$= \frac{(-2)^2 + (-1)^2 + (3)^2}{3-1}$
$= \frac{(-2)(-2) + (-1)(-1) + (3)(3)}{3-1}$
$= \frac{4+1+9}{2} = \frac{14}{2} = 7$

39. $-5.7 + 2.3^4 \div (-9.4) \approx -8.68$



40. $\sqrt{\frac{0.15(1-0.15)}{200}} = \sqrt{\frac{0.15(0.85)}{200}}$
$= \sqrt{\frac{0.1275}{200}} = \sqrt{0.0006375} \approx 0.03$

41. $\frac{-28}{-40} = \frac{4 \cdot 7}{4 \cdot 10} = \frac{7}{10}$

42. $\frac{\frac{15}{8}}{\frac{9}{10}} = \frac{15}{8} \div \frac{9}{10} = \frac{15}{8} \cdot \frac{10}{9} = \frac{3 \cdot 5}{2 \cdot 4} \cdot \frac{2 \cdot 5}{3 \cdot 3} = \frac{5 \cdot 5}{3 \cdot 4} = \frac{25}{12}$

43. $$\begin{aligned} -4789+800-(102.99+3.50) &= -4789+800-106.49 \\ &= -3989-106.49 \\ &= -4095.49 \end{aligned}$$

The student now owes the credit card company \$4095.49.

44. a. $-8-4=-12$; The change in temperature is $-12°\text{F}$.

b. Divide the change for the past three hours by 3 to estimate the change over 1 hour.

$\frac{-12}{3}=-4$; The estimated change for the past hour is $-4°\text{F}$.

c. Answers may vary. Example: Temperature need not change uniformly.

45. a. $722-745=-23$; The change in total fundraising for the Democratic nominee from 2008 to 2012 was $-\$23$ million.

b. $368-367=1$; The change in total fundraising for the Republican nominee from 2004 to 2008 was \$1 million.

c. $745-328=417$; The greatest change in total fundraising for the Democratic nominee occurred between 2004 and 2008. The change was \$417 million.

d. $450-368=82$; The greatest change in total fundraising for the Republican nominee occurred between 2008 and 2012. The change was \$82 million.

46. $\frac{\text{65 billion messages per day}}{\text{35 billion messages per day}} \approx \frac{1.86}{1}$; The number of messages sent per day in 2018 is 1.86 times larger than the number of messages sent per day in 2015.

47. $\frac{863}{1541} \approx 0.5600 = 56.0\%$; 56% of adults surveyed think climate change is the biggest threat to the United States.

48. $0.137(45{,}500) = 6233.5$; In a survey of 45,500 high school students, about 6234 used marijuana in the past month.

49. $\frac{34-74}{74} \approx -0.5405$; So, the percent change in the number of cases of worldwide polio decreased by about 54.1%.

50. $0.20(-5493) = -1098.6$; The person pays off \$1098.60 of the balance.

$-5493-0.20(-5493) = -5493+1098.6 = 4394.4$ So, after paying off 20% of the balance, the person has a balance of –4394.40 dollars.

51. Evaluate $-b-c^2$ for $a=2$, $b=-5$, $c=-4$, and $d=10$: $-(-5)-(-4)^2 = 5-16 = -11$

52. Evaluate $\frac{a-b}{c-d}$ for $a=2$, $b=-5$, $c=-4$, and $d=10$: $\frac{2-(-5)}{-4-10} = \frac{7}{-14} = -\frac{1}{2}$

53. Evaluate $\overline{x}-t\cdot\frac{s}{\sqrt{n}}$ for $\overline{x}=30$, $t=2$, $s=12$, and $n=9$: $30-2\left(\frac{12}{\sqrt{9}}\right) = 30-2\left(\frac{12}{3}\right) == 30-2\cdot 4 = 30-8 = 22$

54. $-7-x$; substitute -3 for x in $-7-x$: $-7-(-3) = -7+3 = -4$

55. $1+\frac{-24}{x}$; substitute -3 for x in $1+\frac{-24}{x}$: $1+\frac{-24}{-3} = 1+8 = 9$

56. a.

Years since 2010	Foreclosure Inventory (millions of houses)
0	$1.18-0.13\cdot 0$
1	$1.18-0.13\cdot 1$
2	$1.18-0.13\cdot 2$
3	$1.18-0.13\cdot 3$
4	$1.18-0.13\cdot 4$
t	$1.18-0.13t$

From the last row of the table, we see that the expression $1.18-0.13t$ represents the foreclosure inventory in millions of houses, t years after 2010.

b. Substitute 6 for t in $1.18-0.13t$: $1.18-0.13(6)=0.4$. So, the foreclosure inventory in the year 2016 (6 years after 2010) was 0.4 million houses.

57. The decrease in the number (in thousands) of Pfizer employees from 2016 to 2017 was 0.065(96.5). To find the number of employees (in thousands) in 2017, we subtract 0.065(96.5) from 96.5:
$96.5-0.065(96.5)=96.5-6.2725=90.2275$. The number of employees was about 90.2 thousand in 2017.

58. Each of the two blue outside bars have width 2 and height 0.08, so the area of one of these blue bars is $2(0.08)=0.16$.

The total area of the two outside blue bars is $2(0.16)=0.32$.

Because the area of the entire object is 1, the remaining area of the other two bars is $1-0.32=0.68$.

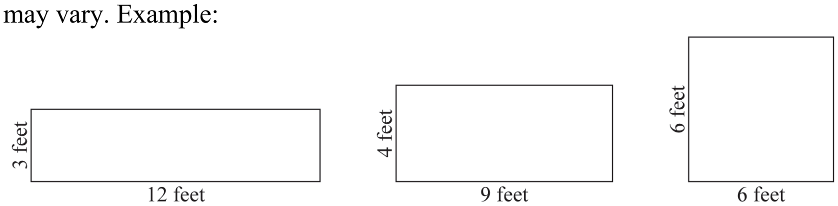
Since the remaining two bars are equal in area, to get the area of the orange bar, calculate $0.68\div 2=0.34$.

59. For 3.85×10^{-4}, the decimal point must move four places to the left. Thus, the standard decimal is 0.000385.

60. For 54,000,000, the decimal point needs to be moved seven places to the left so that the new number is between 1 and 10. Thus, the scientific notation is 5.4×10^{7}.

Chapter 1 Test

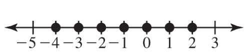
1. a. Answers may vary. Example:

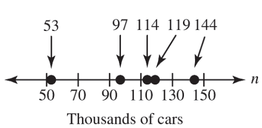


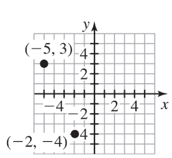
b. In the described situation, the symbols W and L are variables. Their values can change.

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.

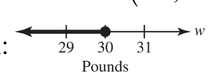


3. 

4. 

5. Inequality: $w\le 30$

Interval notation: $(-\infty, 30]$

Graph: 

6. Substitute 16,873 for r and 378 for n in $r \div n$: $16{,}873 \div 378 \approx 44.64$. This means in 2015, the average monthly cell phone bill was \$44.64.

7. Proportion of adults that gave the response of "Often justified" and "Sometimes justified": $\frac{1}{4}+\frac{3}{8}=\frac{2}{8}+\frac{3}{8}=\frac{5}{8}$

   Proportion of adults that gave other responses: $1-\frac{5}{8}=\frac{8}{8}-\frac{5}{8}=\frac{3}{8}$

8. $\frac{0.62 \text{ pound}}{1} \cdot \frac{16 \text{ ounces}}{1 \text{ pound}} = \frac{9.92 \text{ ounces}}{1} = 9.92 \text{ ounces}$

9. $-3+9\div(-3)=-3+(-3)=-6$

10. $(4-2)(3-7)=(2)(-4)=-8$

11. $\frac{4-7}{-1-5}=\frac{-3}{-6}=\frac{1}{2}$

12. $3\sqrt{32+4}=3\sqrt{36}=3(6)=18$

13. $5-(2-10)\div(-4)=5-(-8)\div(-4)=5-2=3$

14.
$$\begin{aligned} &-20\div 5-(2-9)(-3) \\ &=-20\div 5-(-7)(-3) \\ &=-4-21 \\ &=-25 \end{aligned}$$

15. Since the two numbers have different signs, the product will be negative: $0.4(-0.2)=-0.08$

16.
$$\begin{aligned} -\frac{27}{10}\div\frac{18}{75} &= -\frac{27}{10}\cdot\frac{75}{18} \\ &= -\frac{3\cdot 3\cdot 3\cdot 3\cdot 5\cdot 5}{2\cdot 5\cdot 2\cdot 3\cdot 3} \\ &= -\frac{3\cdot 3\cdot 5}{2\cdot 2} \\ &= -\frac{45}{4} \end{aligned}$$

17.
$$\begin{aligned} -\frac{3}{10}+\frac{5}{8} &= -\frac{3}{10}\cdot\frac{4}{4}+\frac{5}{8}\cdot\frac{5}{5} \\ &= \frac{-12}{40}+\frac{25}{40} \\ &= \frac{-12+25}{40} \\ &= \frac{13}{40} \end{aligned}$$

18. $2^{-5}=\frac{1}{2^5}=\frac{1}{2\cdot 2\cdot 2\cdot 2\cdot 2}=\frac{1}{32}$

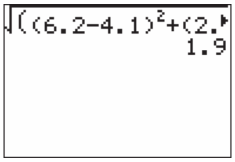
19.
$$\begin{aligned} 7+2^3-3^2 &= 7+(2\cdot 2\cdot 2)-(3\cdot 3) \\ &= 7+8-9 \\ &= 15-9 \\ &= 6 \end{aligned}$$

20.
$$\begin{aligned} &1-(3-7)^2+10\div(-5) \\ &=1-(-4)^2+10\div(-5) \\ &=1-(-4)(-4)+10\div(-5) \\ &=1-16+(-2) \\ &=-15+(-2) \\ &=-17 \end{aligned}$$

21.
$$\begin{aligned} &\frac{(-5)^2+(-2)^2+2^2+5^2}{4-1} \\ &=\frac{(-5)(-5)+(-2)(-2)+2(2)+5(5)}{4-1} \\ &=\frac{25+4+4+25}{4-1}=\frac{58}{3} \end{aligned}$$

22. $\frac{84}{-16}=-\frac{2\cdot 2\cdot 3\cdot 7}{2\cdot 2\cdot 2\cdot 2}=-\frac{21}{4}$

23.
$$\begin{aligned} \frac{\frac{14}{25}}{\frac{21}{20}} &= \frac{14}{25}\div\frac{21}{20} \\ &= \frac{14}{25}\cdot\frac{20}{21} \\ &= \frac{2\cdot 7}{5\cdot 5}\cdot\frac{2\cdot 2\cdot 5}{3\cdot 7} \\ &= \frac{2\cdot 2\cdot 2}{5\cdot 3} \\ &= \frac{8}{15} \end{aligned}$$

24. 

25. a. $11.1-10.3=0.8$; The change in the tax audit rate from 2009 to 2011 was 0.8 audit per 1000 tax returns.
    b. $9.6-11.1=-1.5$; The change in the tax audit rate from 2011 to 2013 was -1.5 audits per 1000 tax returns.
    c. From 2003 to 2005, the change was 3.2 audits per 1000 returns.

26. $\frac{32.44}{9.14}\approx\frac{3.55}{1}$; The average ticket price in 2018 was about 3.55 times the average price in 1991.

27. $\frac{7175-6121}{6121}\approx 0.172$; The percent change in the number of hate crime incidents from 2016 to 2017 is about 17.2%.

28. Substitute -6 for a, -2 for b, and 5 for c in the expression $ac-\frac{a}{b}$:

$$\begin{aligned}(-6)(5)-\frac{(-6)}{(-2)}&=-30-\frac{(-6)}{(-2)}\\&=-30-3\\&=-30+(-3)\\&=-33\end{aligned}$$

29. Substitute -6 for a, -2 for b, and 5 for c in the expression $a+b^3+c^2$:

$$\begin{aligned}(-6)+(-2)^3+(5)^2&=(-6)+(-2)(-2)(-2)+(5\cdot 5)\\&=-6+(-8)+25\\&=-14+25\\&=11\end{aligned}$$

30. Evaluate $\frac{x-\mu}{s}$ for $x=4$, $\mu=10$, and $s=2$: $\frac{4-10}{2}=\frac{-6}{2}=-3$

31. $2x-3x$; evaluate the expression for $x=-5$:

$$\begin{aligned}2(-5)-3(-5)&=-10-(-15)\\&=-10+15\\&=5\end{aligned}$$

32. $\frac{-10}{x}-6$; evaluate the expression for $x=-5$: $\frac{-10}{-5}-6=2-6=-4$

33. a.

Years since 2012	First-Class Mail Volume (billions of pieces)
0	$-1.9(0)+68.8$
1	$-1.9(1)+68.8$
2	$-1.9(2)+68.8$
3	$-1.9(3)+68.8$
4	$-1.9(4)+68.8$
t	$-1.9t+68.8$

From the last row of the table, we see that the expression $-1.9t+68.8$ represents the U.S. Postal Service first-class mail volume (in billions of pieces) in the year that is t years since 2012.

b. Substitute 5 for t in $-1.9t+68.8$: $-1.9(5)+68.8=-9.5+68.8=59.3$. So, the first-class mail volume was 59.3 billion pieces in 2017.

34. The decrease in the number of Subway stores (in thousands) from 2016 to 2017 was 0.03(26.7). To find the number of Subway stores (in thousands), we subtract 0.03(26.7) from 26.7:
$26.7-0.03(26.7)=26.7-0.801=25.899$
The number of Subway stores in 2017 was about 25.9 thousand.

35. For 0.0000678, the decimal point needs to be moved five places to the right so that the new number is between 1 and 10. Thus, the scientific notation is 6.78×10^{-5}.

INSTRUCTOR'S RESOURCE MANUAL

JAY LEHMANN
College of San Mateo

A PATHWAY TO INTRODUCTORY STATISTICS

SECOND EDITION

Jay Lehmann
College of San Mateo

Pearson

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Contents

Chapter 1

An Overview

Thank you for considering or deciding to use *A Pathway to Introductory Statistics*. This manual contains the following forms of instructor support:

- Chapter 1 contains suggestions about course pacing, homework assignments, technology, explorations, collaborative learning, structures of class meetings, project assignments, and the evaluation of students.
- Chapter 2 consists of section-by-section lecture notes and teaching tips.

1.1 Course Pacing

The pace of the course can vary greatly, depending on the number of class meetings per quarter/semester and the extent to which explorations are assigned as class activities. Some departments' *Pathway* courses meet only 3 hours per week for 14 weeks. Other departments' *Pathway* courses meet as many as 8 hours per week for 16 weeks, which is approximately 3 times the number of contact hours as meeting 3 hours per week for 14 weeks!

Table 1.1 describes the pacing for a course in the "middle" (5 hours per week for 15 weeks). Although the total number of contact hours may not match your department's course's hours, the ratios of time spent per section will hopefully be helpful. In the table, "R" stands for review and "T1" stands for test 1 (and so on). I did not include Chapters 11 and 12 (available only online) because most departments will not use this material.

Table 1.1: Course Schedule

Week	Mon	Tues	Wed	Thurs	Fri
1	1.1	1.2	1.3	1.4	1.5
2	1.6	1.7	2.1	2.2	2.2
3	2.3	2.3	R	T1	3.1
4	3.2	3.3	3.4	3.4	3.5
5	4.1	4.1	4.2	4.2	4.3
6	4.3	R	T2	5.1	5.2
7	5.3	5.4	5.5	5.5	5.6
8	6.1	6.2	6.2	6.3	6.3
9	R	T3	7.1	7.2	7.2
10	7.3	7.3	7.4	7.4	8.1
11	8.2	8.3	8.3	8.4	8.4
12	8.5	R	T4	9.1	9.1
13	9.2	9.2	9.3	9.3	10.1
14	10.2	10.3	10.4	10.4	10.5
15	10.5	R	T5	R	R

Lean, Statistics-Heavy Approach If you have a tight schedule and wish to emphasize statistics, consider skipping Chapter 1 and portions of Chapters 7 and 8. Many departments plan to skip Chapter 10 because exponential modeling is not covered in introductory statistics, but students will have a better sense of linear models if they are compared with exponential models. And most departments skip Chapters 11 and 12, which have been included for departments who want their prestatistics course to feed students into statistics as well as liberal arts math.

1.2 Homework Assignments

In Chapter 2 of this manual, suggested homework assignments are included in the section-by-section lecture notes. These assignments are summarized in Tables 1.2 and 1.3.

Table 1.2: Homework Assignments

Section	Assignment
1.1	1, 3, 5, 9, 15, 17, 29, 39, 47, 53, 59, 71, 77, 79, 89, 91, 97, 105, 119
1.2	1, 3, 11, 19, 21, 27, 29, 31, 33, 41, 45, 57, 71, 77, 79, 85
1.3	1, 3, 13, 21, 25, 33, 41, 47, 55, 61, 65, 71, 75, 79, 83, 85, 89, 95, 103
1.4	1, 3, 5, 15, 17, 21, 25, 41, 47, 51, 59, 63, 67, 69, 75, 77
1.5	1, 3, 5, 7, 9, 11, 21, 35, 47, 53, 59, 63, 65, 67, 73, 79, 85, 87
1.6	1, 3, 7, 13, 19, 21, 25, 27, 37, 39, 41, 43, 47, 49, 61, 71, 87, 95, 97, 103
1.7	1, 3, 5, 15, 19, 25, 31, 37, 45, 61, 69, 73, 79, 81, 87, 91, 95, 99, 103, 107, 109, 127, 133, 135
2.1	1, 3, 7, 13, 17, 23, 25, 27, 33, 35, 37, 41, 45, 61, 65
2.2	1, 3, 5, 7, 9, 11, 13, 19, 23, 27, 29, 31, 33, 39, 43, 47, 55
2.3	1, 3, 5, 7, 11, 13, 15, 17, 19, 23, 25, 29, 33, 35, 41
3.1	1, 3, 5, 7, 13, 17, 25, 27, 29, 35, 37, 39, 45, 47, 57, 59
3.2	1, 3, 5, 9, 11, 15, 17, 19, 21, 23, 25, 27, 29, 33, 39
3.3	1, 3, 5, 7, 13, 17, 19, 21, 25, 27, 29, 35, 39, 43, 45, 51
3.4	1, 3, 5, 7, 9, 11, 15, 19, 21, 25, 27, 31, 33, 35, 39, 41, 47, 53, 63, 65
3.5	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 22
4.1	1, 3, 7, 11, 17, 21, 25, 29, 37, 39, 43, 47, 53, 57, 63, 69, 83, 87, 93
4.2	1, 3, 7, 11, 17, 21, 23, 31, 33, 37, 39, 43, 47, 51, 55, 57, 61, 69, 79, 87
4.3	1, 5, 7, 11, 13, 19, 21, 25, 27, 29, 31, 35, 37, 39, 47, 55, 57, 63
5.1	1, 3, 5, 7, 15, 19, 23, 29, 33, 39, 43, 53, 55, 61, 67, 75, 87
5.2	1, 3, 5, 9, 13, 15, 19, 21, 29, 35, 39, 43, 45, 51, 57, 61, 69, 71
5.3	1, 3, 5, 9, 11, 15, 19, 21, 25, 27, 29, 33, 35, 39, 41, 45, 53, 55, 59, 69
5.4	1, 3, 5, 7, 13, 19, 21, 23, 27, 29, 31, 33, 37, 39, 41, 43, 51
5.5	1, 3, 7, 9, 13, 19, 25, 29, 31, 35, 43, 47, 51, 55, 59, 61, 73, 79
5.6	1, 3, 5, 7, 9, 13, 15, 17, 19, 21, 23, 25, 29, 31, 33, 35, 37, 43, 47
6.1	1, 3, 5, 11, 15, 23, 29, 33, 37, 43, 47, 49, 53, 57, 61, 65, 69
6.2	1, 3, 5, 11, 13, 19, 21, 23, 25, 27, 29, 33, 37, 39, 47, 51
6.3	1, 3, 5, 11, 25, 27, 29, 31, 33, 39, 41, 45, 49, 53, 57, 69
7.1	1, 3, 7, 9, 15, 27, 33, 35, 39, 47, 51, 55, 73, 77, 87
7.2	1, 3, 7, 11, 17, 23, 25, 31, 39, 53, 59, 63, 65, 73, 75, 85, 97
7.3	1, 3, 7, 19, 21, 37, 41, 45, 51, 55, 57, 63, 65, 69, 75, 77, 79, 87, 97
7.4	1, 3, 5, 13, 19, 25, 29, 33, 37, 41, 49, 53, 55, 59, 65, 69, 73, 81, 85, 91, 99
8.1	1, 3, 7, 11, 15, 25, 31, 41, 47, 53, 59, 67, 75, 81, 91, 97, 113
8.2	1, 3, 7, 11, 21, 33, 41, 51, 59, 65, 69, 71, 77, 79, 89, 93, 95, 107

Table 1.3: Homework Assignments (continued)

Section	Assignment
8.3	1, 3, 5, 11, 17, 25, 33, 41, 43, 45, 55, 57, 63, 75, 79, 83, 87, 89, 99, 105
8.4	1, 3, 5, 9, 13, 23, 29, 31, 37, 41, 47, 57, 63, 71, 75, 77, 85, 93, 107, 113
8.5	1, 3, 5, 11, 17, 29, 47, 53, 59, 63, 65, 77, 81, 87, 93, 95, 107
9.1	1, 3, 7, 15, 19, 25, 29, 43, 47, 51, 55, 57, 63, 69, 73
9.2	1, 3, 7, 9, 11, 17, 21, 25, 27, 29, 31, 33
9.3	1, 3, 5, 9, 13, 17, 21, 23, 25, 29, 33, 35, 43, 45, 47, 53, 59, 60, 61
10.1	1, 3, 7, 13, 25, 33, 35, 55, 61, 67, 75, 87, 91, 97, 103, 105, 111
10.2	1, 3, 11, 17, 27, 33, 41, 43, 53, 59, 67, 69, 75, 77, 79, 81
10.3	1, 3, 5, 9, 13, 25, 27, 31, 33, 37, 41, 45, 49, 53, 57, 75, 79, 83, 85
10.4	1, 3, 11, 15, 21 33, 35, 45, 53, 55, 59, 61, 63, 73
10.5	1, 3, 7, 9, 13, 17, 19, 23, 25, 27, 29, 31, 33, 37, 41, 47, 53, 59
11.1	1, 7, 21, 23, 29, 31, 33, 51, 55, 63, 65, 69, 71, 77, 81
11.2	1, 5, 7, 9, 27, 33, 43, 55, 65, 73, 83, 89, 91, 93, 100
11.3	1, 9, 13, 25, 35, 37, 41, 43, 49, 61, 63, 65, 71, 77, 81, 85, 91
11.4	5, 15, 23, 29, 31, 37, 41, 45, 51, 53, 61, 63, 67, 71, 81, 89, 91, 101, 105
11.5	1, 5, 7, 13, 17, 21, 27, 29, 35, 37, 39
11.6	1, 3, 7, 11, 13, 15, 19, 23, 25, 35, 37, 41, 45, 47, 52
11.7	1, 11, 19, 21, 31, 37, 41, 49, 55, 61, 63, 67, 69, 73, 76, 91, 95
12.1	3, 5, 7, 15, 19, 23, 25, 27, 35, 37, 45, 47, 57, 59, 67
12.2	3, 5, 11, 13, 19, 21, 27, 33, 35, 43, 45, 47, 49, 53, 55
12.3	5, 11, 21, 23, 29, 35, 37, 41, 45, 53, 59, 61, 65, 67, 71
12.4	1, 3, 5, 11, 15, 19, 21, 25
12.5	1, 7, 9, 13, 17, 27, 31, 35, 45, 49, 53, 57, 61
12.6	3, 7, 9, 23, 29, 31, 37, 45, 53, 55, 59, 65, 69, 73, 83

Homework Organization The exercises in the textbook are presented in the following order: fill-in-the blank and true/false, skill, modeling, Conceptual, Hands-On Research, and Big Data. Some of these features are described in the following paragraphs.

Progression of Homework Data-Set Size For each concept that involves data, the exercises are organized so that there are first at least two exercises that contain about 10 observations. Next, there are at least two exercises that contain about 25 observations. Finally, there are at least two exercises that involve at least 50 observations. The exercises usually do not specify whether they should be completed by hand or by using technology because the extent to which professors have their students use technology varies. For exercises that involve constructing frequency histograms, I tell students to construct histograms by hand when there are up to 25 observations and to use technology when there are more than 25 observations. The cutoff I use when students calculate standard deviation is much lower: 5 observations.

"DATA" Icon To support the appropriate use of technology, data sets in exercises and explorations that involve approximately 12 or more data values are available to download at MyLab Math and at the Pearson Downloadable Student Resources for Math and Statistics website: http://www.pearsonhighered.com/mathstatsresources. Such exercises are flagged by a purple icon that reads "DATA."

Big Data It can make a significant, positive impression on students the first time they use technology to construct a histogram of about 100 observations when up to that point they have only constructed histograms of about 20 observations by hand. Students are understandably struck by the ease, speed, and accuracy of using technology. But they can gain an even higher level of appreciation by using technology to describe a data set that consists of thousands of rows and multiple columns.

Such an activity is especially relevant in today's age of big data. Although most *Pathway* students will not perform statistics in their career, some *will* work with large data sets. And as part of their general education, all students should have some sense of what statisticians do.

To this end, exercises that involve large data sets are sprinkled throughout the textbook. They directly follow the heading "Big Data" at the end of homework sections. Some of these data sets contain thousands of rows and tens of columns.

Hands-On Research Even though every authentic data set in *Pathway* provides a source, some students still think that the data are fabricated. Having students find data sets themselves drives home the point that the concepts they are learning can truly be applied to authentic situations. Students begin to see that statistics can be used not only to inform but also to persuade.

To guide students in this process, the textbook contains exercises that direct students to analyze data found by online searches of blogs, newspapers, magazines, and scientific journals. These exercises are at the end of select homework sections, directly following the heading "Hands-On Research."

1.3 Technology

If you and your colleagues all use the same software package for your introductory statistics course, then it would be a good idea to use that same technology for *Pathway*. However, if a variety of packages are used, the following paragraphs may help you decide which one to use.

Software used for introductory statistics courses at community colleges and four-year colleges includes the TI-84 Plus graphing calculator, StatCrunch, Excel, SPSS, MINITAB, SAS, and R. At the community-college level, the majority of courses require the TI-84 Plus, although StatCrunch is gaining in popularity. To keep the page count as under control as possible, the textbook includes screenshots and instructions only for the TI-84 Plus and StatCrunch. Of the two technologies, StatCrunch is easier to learn, constructs more types of diagrams, and is more flexible in constructing diagrams and computing measures. Because StatCrunch does not construct tables for functions, can only graph functions within the "Scatterplot" command, and does not perform exponential regression, the TI-84 Plus is much better suited for algebra and exponential regression. In sum, StatCrunch is the better tool for Chapters 2–6 and 9, and the TI-84 Plus is the better tool for Chapters 7, 8, 10, 11, and 12.

If students could have access to StatCrunch during tests, then StatCrunch is probably the better choice. Otherwise, the TI-84 Plus is probably the better choice, although a workaround is to provide StatCrunch output on tests and have students interpret the results.

TI-84 Plus Graphing Calculator At some campuses, many students already own TI-84 Plus graphing calculators, and many of the other students can borrow them from friends. The calculator is incredibly sturdy, so it is low-risk to purchase a used one, which has a median online price of about $70. If your college bookstore does not offer calculator rentals, consider asking it to do so. The bookstore at my campus rents them for $35 per semester. For students who wish to buy a new one, it's a good idea to comparison shop because the TI-84 Plus varies greatly in price (with median price about $100 online).

For students who have an iPhone or iPad, there is an app called GraphNCalc83 that is programmed like the TI-83 Plus and sells for only $5.99 at iTunes. I have not used the app, but a colleague of mine says it works great. The key difference between the TI-83 Plus and the TI-84 Plus is that the TI-83 Plus does not have the invT command, which is not needed for *Pathway* but is needed for introductory statistics. There is a workaround for the command, for which you can find instructions online (search for the keywords "TI-83" and "invT").

Usually a few students will have access to graphing calculators other than the TI-83 or TI-84. I give them the option of using these calculators, but I caution them that I will demonstrate how to use only the TI-83 and TI-84 during class.

Appendix A contains instructions on how to use the TI-84 Plus. A subset of the appendix can serve as a tutorial early in the course. In addition, each time the textbook introduces a TI-84 Plus command, students are referred to the appropriate section of the appendix.

Students will first need access to the TI-84 Plus in Section 1.3, where they will perform calculations (see pages 29 and 31 of the textbook). In Chapter 2, students will first need access to the TI-84 Plus in Section 2.1, where they will randomly select numbers (see Example 6 on pages 101 and 102 of the textbook).

When error messages such as "ERR:SYNTAX" start popping up on students' calculators, it is well worth taking the time to explain what students should do to clear up the errors. For example, with the syntax error, students should choose the "Goto" option, which will disclose where the syntax error was made. Appendix A.30 describes the types of error messages shown by TI-84 Plus graphing calculators.

You can project the image on a TI-84 Plus screen onto a whiteboard or a screen by using the TI-SmartView™ CE Emulator Software. By projecting the image onto a whiteboard, you can draw on the image. Texas Instruments offers the product for free to mathematics departments after 250 students have purchased TI graphing calculators for any math courses at your college. To request a Technology Rewards Program Request Form, e-mail ti-educators@ti.com or download the form at the TI website (Google "TI Technology Rewards Program").

If you avoid using a Viewscreen, this can motivate students to bring their graphing calculators to class every day and to use them in order to see what you are doing. Students tend to be much more involved if they use their graphing calculators rather than watch an instructor display images on a screen.

StatCrunch If your students purchase MyLab Math, then StatCrunch is free. If they do not buy MyLab Math, StatCrunch can be purchased for 6 months of access for $14.99, and 12 months of access for $24.99 (at the time of the printing of this manual).

For students who use MyLab Math, they can easily download any data set in the textbook flagged by the purple "DATA" icon into StatCrunch by clicking on a drop-down menu.

Appendix B contains instructions on how to use StatCrunch. A subset of the appendix can serve as a tutorial early in the course. In addition, each time the textbook introduces a StatCrunch command, students are referred to the appropriate section of the appendix.

Students will first need access to StatCrunch in Section 2.1, where they will randomly select numbers (see pages 101 and 102 of the textbook). They can use a scientific calculator to perform calculations in Chapter 1.

How to Introduce the Technology Requirement On the first day of class, I advise announcing that technology is required and students should purchase it that day (unless it comes free with the textbook). You could explain that homework assignments cannot be completed without it. Giving a quiz that involves technology as soon as possible can motivate students to obtain the technology promptly.

I tell my class that students from past courses have shared that they really got a lot out of using technology and they enjoyed using it. If your students will use the same technology in your department's *Pathway* and introductory statistics courses, your students will be pleased to hear that.

Most students are very comfortable using technology, but some students might be nervous about using technology in a math course. I reassure them that I will demonstrate how to use it every step of the way. I encourage them to experiment on their own, using the appropriate appendix to guide them.

Teaching Technology I take a "just in time" approach with technology instruction. That way, plenty of statistics or algebra concepts can still be discussed each day. When going over technology commands, it helps if students are in groups so students can help each other rather than me having to run about the classroom putting out fires while everyone else waits.

1.4 Explorations

Directed-discovery learning is a powerful, meaningful, and exciting way for students to learn math. If you have never used such an approach before, you will be struck by the high level of students' enthusiasm. They will get excited by the discoveries they make, and their confidence will increase with time. In addition, students' work on exams will tend to be more thoughtful.

The basic tool in this textbook for this type of learning is the Group Exploration. Every section contains at least one exploration. There are many more explorations in the workbook, which you can download at MyLab Math. I will first describe how the explorations can fit into the course and then suggest what to do before, during, and after facilitating explorations.

How Explorations Fit into the Course Explorations can be used for class activities or for homework assignments. Students will likely get more out of the explorations if they are assigned during class time because they can work together in groups and deepen their understanding of concepts by discussing them. Research has shown that students tend to learn concepts better within a collaborative learning environment.

However, you may not have time in your course schedule to assign many explorations as class activities. In that case, assigning them as homework is a nice alternative.

What to Do Before an Exploration There are two types of explorations. Some are "Section Opener" explorations that serve as an introduction to concepts addressed in the section. These explorations are meant to be used at the start of class.

The rest of the explorations have students reflect on concepts just learned or have them consider new but related concepts. These explorations are meant to be used near the end of class.

When planning a class meeting that will include an exploration, keep in mind that directed-discovery learning takes time. I have tried to keep many of the explorations short to counterbalance this, but groups will take longer than you might expect on the first several explorations, especially if they have never done collaborative work in a math course.

As the semester progresses, you will notice a great improvement in the efficiency of groups, especially if you monitor their behavior at various points. For example, I spend quite a bit of time touting the benefits of productive struggle: Through hard work, students can increase the number of dendrites in their brains and improve their problem-solving ability significantly.

What to Do During an Exploration When it's time for groups to begin an exploration, I tell my students to break up into groups and get started. At the beginning of the semester, I insist that they move their chairs close enough so they can see each other's work easily. For information on forming groups and collaborative learning, see Section 1.5 of this manual.

For the first few minutes, groups will generally be quiet as they take time to sort out what is being asked. Later in the semester, as students get to know each other, they will often engage in small talk for a little bit before getting to work. Provided that this small talk does not go beyond 30 to 60 seconds, this can be a bonding event that may lead to a group working better together. Some groups may even choose to prepare for exams by studying together outside of class.

Some groups may become *too* social. If this happens, tell such a group that they have to consistently stay on task or you will break up their group. Sometimes this verbal warning will not deter a group from talking too much, so be prepared to follow through on your promise. If there is more than one talkative group, you can scramble these groups. If there is only one such group, you can have each member join a different existing group. Or you can divide up a four-person group into two groups of two members and have them sit near the front of the classroom.

In fact, I usually pair all students in the class because I find that they tend to be more actively involved. It's hard to drift off in a conversation with just one other student!

While groups progress through an exploration, you should walk about the classroom, answering questions or asking leading questions of groups that are stuck. However, if a group is making progress or is productively arguing about a concept, it's best to not intervene. Research has shown that a group of students can learn a great deal when they have different answers and they try to convince each other that they are right. One way to support groups in progressing through an exploration is for you to write solutions of the exploration on the board at regular intervals. That way, no group will get stuck on one part of the exploration for too long.

As you circulate about the room, take note of each group's progress. When most groups have completed the exploration or are nearly done, announce that time is up.

When a group finishes an exploration well ahead of the rest of the groups, I sometimes keep them busy with a challenging problem that serves as an extension to the exploration.

See Section 1.5 of this manual for additional comments about management of groups.

What to Do After an Exploration When most groups have made significant progress or have completed an exploration, it's best to highlight key concepts of the exploration. I emphasize that groups should reflect on these concepts rather than focus solely on whether they have found the correct answers to the questions.

One way to summarize an exploration is to have one or more groups share their findings with the class. Although this would be ideal, I'm usually strapped for time. So, instead, I highlight a few crucial concepts addressed in the exploration and field any student questions. It's important not to lecture on the entire exploration because students will likely have already made most of, if not all, the discoveries.

Due to time constraints, I'll sometimes need to stop an exploration before any group has completed it. When I cut an exploration short, I sometimes pick up from where groups left off and do a quick lecture/discussion on the remainder of the exploration. In other cases, I'll assign the rest of the exploration as homework or lecture on it at the start of the next class period.

1.5 Collaborative Learning

As I mentioned in Section 1.4 of this manual, the explorations in the textbook can be used as collaborative activities during class time. If you have not had much experience facilitating collaborative learning, a good resource is *A Practical Guide to Collaborative Learning in Collegiate Mathematics*, edited by Barbara E. Reynolds et al and published by the MAA.

I will suggest a few ways to form groups, how to get them started working, and how to manage them.

Hands-Off Approach to Form Groups The easiest way to form teams is to group students according to where they are currently seated. So, members of groups may change from day to day, depending on who is present and which seats they choose, although the compositions of groups are quite consistent throughout the semester except for students who withdraw from the course.

This method of forming groups has several advantages over forming permanent groups. In addition to it being efficient, no group need be too small on any day due to absences. Also, if you allow students to choose different seats during the semester, students can relocate themselves if they don't like how a certain group functions. The greatest disadvantage of forming groups this way is that friends may be in the same group, which may result in too much socializing during explorations. But you can always change the composition of groups if this turns out to be a problem.

Groups of two-to-four students work well together. Groups of five students are too large because at least one student tends to retreat into silence during the explorations. As I mentioned earlier, I find that pairs of students working especially well together.

Using Clickers or Learning Catalytics to Form Groups You can form groups by first having students work independently on a problem. Students can then enter their responses using Learning Catalytics (https://learningcatalytics.com), which then direct students to form groups so that each group has members who found different answers. This is ideal because students can learn a great deal while they try to sort out whose solution is correct.

Random Assignment of Groups Within each class period that you want to facilitate group work, groups can be formed using a deck of playing cards. Before class, organize a deck so that the aces are stacked together, kings are stacked together, and so on. Once in class, count how many students you have and keep that many cards, preserving as many four of a kinds as possible. Then shuffle the cards and give one to each student. Then point to sets of four chairs and tell students where each group will sit ("aces here, kings here," and so on).

Another option is to have students count off. You can vary the order in which students count from day to day.

Nonrandom Assignment of Groups Once I know my students well, which usually takes about six weeks, I form permanent pairs of students. I pair students who

- Have worked well together up until then.
- Have similar ability; this way one student won't dominate the problem-solving.

- Are non-native and speak the same native language.
- Won't distract each other; I pair a student who tends to get distracted with a student who tends to stay on task.
- Will get along well; I often have to lean into my intuition for this.

Not all pairings work out well, but this leads to me knowing my students even better. I preserve pairs that are working well together and redistribute those who aren't. It often takes several iterations until all pairs are functioning well. Of all the ways I've formed groups over the years, I've found pairing students in this manner to be most effective.

How to Get Started Once students know to which groups they belong and where they should sit, I have them rearrange their chairs so they are facing one another. From past experience, I know that most group members don't sit close enough to see each other's work, so I usually say, "Move your chairs so that all your group members' tablets form one big rectangle." It is important that you give this directive before students begin moving their chairs. Doing so will increase the chances that all groups will oblige. If a group does not comply, it is important that you approach them immediately and repeat the request. If you wait until later in the course, they may comply for that day but revert back to old habits quickly.

At this point, have group members introduce themselves and exchange phone numbers. If the groups are permanent, also pass out a sheet of paper for groups to list their members' names on. The list will help you keep track of the number of members in each group as students add and drop the course. The list also comes in handy when a student forgets to which group he or she belongs.

After students exchange their phone numbers, I like to assign a short ice-breaking exercise. One of my favorites is to have each group find three characteristics that the members share and a characteristic unique to each member. For each group, you can pick one of the characteristics the members share to name the group.

How to Coach and Manage Groups Although some groups will function well from the beginning, others will need some coaching on how to be an effective group. There are two ways that groups tend to progress through an exploration. Some groups will work through an exploration together problem by problem. Other groups will work independently and compare their findings when they are done. The latter type of group generally does not communicate often enough, so I have to spend a fair amount of time reminding those groups to compare their results with their members' results.

Some groups may form bad habits as the semester progresses. For example, a group may rely on one person to do all the work. One way to confront this is to put questions similar to exploration questions on quizzes and/or tests to hold each student accountable. Or, when walking about the room, check that each member is up to speed with the rest of the group.

Some instructors deal with this issue by having one person called the "scribe" do a write-up of a particular exploration and then have the role of scribe rotate amongst members as they do different explorations. The write-ups are collected and graded. One problem with this technique is that the other members may be less inclined to take notes. This also requires you to deal with more paperwork and record more scores. Furthermore, explorations are meant for students to discover concepts, not for students to be evaluated. For these reasons, I avoid using the role of scribe.

I've found that a more effective way to keep teams on task is to announce that I will call on them to respond to questions about the exploration. Usually I let anyone in the group respond, but if the same student always responds, which is often the case, I sometimes address the question to another group member. As I discussed earlier, I believe the most effective solution is to pair students. Using the criteria I described earlier to form permanent teams can be especially successful, especially after some fine-tuning.

1.6 Structures of Class Meetings

One of the benefits of using MyLab Math is that my students hardly ever have questions about the homework. When they do have questions, I usually encourage them to meet with me in my office because most students have already successfully completed the exercise.

The way I structure a class meeting varies, depending on my goals for that day. Class meetings fall into one of the following classifications:

- I alternate between lecturing and having students work in groups. I often switch back and forth between these two platforms several times in one class meeting. I do this most of the time.
- I intersperse problems for individual students to complete within a lecture. I rarely do this.
- The day before a test, I devote the entire class meeting to collaborative learning. The groups work on problems that address challenging concepts or ones that I suspect students have forgotten. I warn students that the problems will not address all the concepts on the upcoming test and that students must study all the relevant material to prepare on their own.

Lecturing allows for greater coverage of the number of topics, and explorations allow for greater depth of student understanding of concepts. I tend to use explorations to address key concepts, and I tend to lecture over less important ones.

1.7 Hands-On Projects

Compelling Hands-On Project assignments have been included near the end of most chapters. Some of the assignments are similar to the Hands-On Research exercises, but they are more extensive and challenging. The projects reinforce the idea that statistics is a powerful tool that can be used to analyze authentic situations. They are also an excellent opportunity for more in-depth writing assignments.

The textbook contains three types of projects: surveys, research, and physical experiments.

Survey Projects For each of these projects, students ask questions or measure heights of others. It is strange that some students do not apply the concepts they have learned in Chapter 2 when they complete this type of project. In particular, they do not avoid as much sampling bias as possible. To counteract this, I collect this type of project in two stages. First students turn in their study's design. Once I give them the go-ahead, sometimes after several submittals of their design, they can move forward with the rest of the assignment. This structure greatly improves the quality of their projects. Also, by turning in the assignment in stages on established deadlines, students are more likely to finish in time because they won't try to do the entire project at the last minute.

Research Projects For these projects, students perform online searches for data, read extensive background information provided in the project assignment, or use extensive data provided in the assignment.

In particular, *Pathway* contains four projects on climate change, which have been written at a higher reading level than the rest of the textbook in order to give students a sense of what it is like to perform research. Students will find that by carefully reading (and possibly rereading) the background information, they can comprehend the information and apply concepts they have learned in the course to make meaningful estimates about this compelling, current, and authentic situation. The climate-change projects have been designed as much as possible to be stand-alone so that professors can successfully assign any subset of the projects.

If the project requires students to collect data, I collect the project in stages as I described earlier about the survey projects.

Physical Experiments Each of these projects is well-suited for analyzing the association between two variables, so they are included in Chapters 7, 9, 10, and 11. The amount of equipment is minimal, on the order of a timing device or thermometer. But in case you don't want students to bother collecting data, a data set is included in each project assignment.

Some of the projects such as the Golf Ball Project can be done in the classroom, although you might want to use rubber balls instead of golf balls to cut down on the noise!

Motivating Students to Do the Project Assignments When I first assigned projects, most of my students did mediocre work. Some students did not even make an attempt. I believe that this lack of follow-through had to do with my students' misconception that they could pass the course if they just passed the quizzes and tests. I have found that I can improve the percentage of students who complete projects considerably by reminding them of my grading scheme. By making the project assignments worth 10% of the course points, I can warn students that this part of the course is worth a full letter grade; this gets their attention!

Quality of Projects Many of the students' write-ups for their first project are disorganized and missing important details. I find that I can counteract this to a large extent by passing around one copy of a strong write-up (on a different topic) from a previous semester so that students see what I expect of them. I collect the sample project at the end of class so that no one tries to plagiarize the work. If this is your first semester assigning projects, you could create a mock write-up.

When appropriate, collecting a project in stages as I described about survey projects can greatly improve the quality of students' work.

Number of Projects to Assign Although the project assignments are not *that* demanding, students are not used to such work, and as a result, I find that assigning about two or three projects is enough for a semester.

Project Requirements I have students complete the projects individually because when I used to let students work in groups, usually one or two students out of a group of four students ended up doing all or most of the work. Depending on the type of project, I include some or all of the following requirements with point values specified by a rubric:

- The cover is creative and visually appealing.
- The project is typed and well-organized.
- The topic is interesting.
- The write-up includes a thoughtful introduction and conclusion.
- The responses to all questions are correct, and the work is shown.
- Each table includes units and a title.
- Each diagram includes units, uniform scaling, and a title.
- An adequate amount of data has been collected.
- For each regression project, the data set is modeled well by the selected regression model.

I value using a rubric because it makes it very clear to my students how their projects will be evaluated, which increases the chances of them meeting my expectations.

Grading Group Projects When I used to let students work in groups, I allowed each group to turn in just one write-up. When the project was assigned, I warned groups that they would have to estimate the percentage of work completed by each group member. After groups had completed their projects, I instructed them to have a five-minute conference to determine their percent contributions to the project. Groups almost always arrived quickly and smoothly at a decision. To evaluate the projects, I first decided on a preliminary group grade. Then I determined the individual members' grades based on the peer evaluations and any casual observations I made of students' attendance and general involvement in the course during the project assignment.

Oral Presentations Many years ago, I used to have students deliver short oral presentations about their projects, which is a great way for them to see a large number of applications of statistics and algebra. But I no longer do this because it takes up a lot of valuable class time.

1.8 Evaluating Students

I've listed my allocation of points for my *Pathway* course in Table 1.4 and percent grade cutoffs in Table 1.5.

Table 1.4: Allocation of Points

	Percent
Homework	10
Project	10
Quizzes	10
Tests	50
Final	20

Table 1.5: Percent Cutoffs

Grade	Percent Cutoff
A	90
B	80
C	70
D	50

Quizzes and Tests I usually administer about 11 quizzes and 7 tests during the 17-week semester. I drop each student's lowest quiz and lowest test scores to account for illness and/or off days. Quizzes are meant to give my students and myself an idea of what areas my students need to work on before the upcoming test.

I have found that cumulative testing has greatly improved my students' performance on the final exam; my students' scores have increased on average by about 15 percentage points. Each test (except the first one) contains problems that are similar to those that gave my students trouble on the preceding test. Sometimes this means that a certain type of problem may be included on several exams. This practice has been the most beneficial change I have made in my 30 years of teaching!

Chapter 2

Lecture Notes and Teaching Tips

This chapter includes chapter overviews, section-by-section lecture notes, and teaching tips for the lecture notes. The lecture notes include homework assignments.

The teaching tips for the lecture notes describe typical student difficulties and what an instructor can do to help students overcome these obstacles.

CHAPTER 1 OVERVIEW

Chapter 1 contains a large number of concepts. If you cannot afford the time to address them all, focus on Sections 1.1, 1.2, and 1.7 because they contain important algebra concepts.

Of these three sections, Section 1.7 is the most important because it contains the key concepts exponents, square roots, order of operations, and scientific notation. Exponents and scientific notation are presented so early because they are necessary to interpret calculator outputs when finding normal probabilities in Section 5.5. I considered postponing these two concepts until Chapter 5, but I was concerned that doing so would break the flow of students learning statistics in Chapters 2–5.

Proportions (Section 1.3) should be discussed because they will be used throughout Chapters 2–5. Converting units (Section 1.3) will come in handy for a few exercises in subsequent chapters. The concept change in a quantity (Section 1.5) should be discussed because this concept lays the foundation for slope of a line and other concepts. Ratios and percents (Section 1.6) should also be addressed because they are foundational concepts for statistics.

I strongly advise obtaining data about your students by anonymously surveying them. Although there are plenty of current, compelling, authentic data sets to choose from in the textbook, students will get a kick out of analyzing data about themselves. This data can first be used in Chapter 3. Collecting it now will buy you time to input it electronically, although StatCrunch and other technologies can do that automatically.

Here are questions I typically include in my survey:

1. How many units are you taking right now?

2. How many classes are you taking right now?

3. What is your major? (If you don't have one, write "undecided.")

4. How many hours did you work last week?

5. What is your gender? (male, female, nonbinary, etc)

6. What is the total number of people living in your household at this time? (include yourself)

7. Do you exercise? If yes, how many minutes do you spend exercising per day, on average?
8. What is your favorite genre of music? (e.g. hip hop, rap, electronic, rock, country, classical, folk, etc)
9. How many novels do you read last year for fun? (not for a class)
10. Which political party do you tend to be in line with? (e.g. Republican, Democrat, Independent, etc)
11. What is your religious affiliation? (e.g. Catholic, Protestant, Mormon, etc)
12. How many friends did you have during your senior year in high school? How many of those people are you still in touch with and consider to still be friends with?
13. How many cigarettes did you smoke last month?
14. Do you drive a car? If yes, have you ever intentionally entered an intersection when the light was red ("run" a red light)?
15. How many hours did you spend online yesterday?
16. How many hours do you spend watching TV shows, movies, and videos yesterday?
17. What is your age?
18. What is your height?
19. How many languages do you speak?
20. What is the total number of cars owned by people in your household?
21. How many tattoos do you have?
22. For this course, estimate your professor's age.
23. Is your mother alive? If yes, what is her age?
24. How many states have you lived in?
25. How many times do you not tell the truth yesterday?
26. How many times did you go to church last month?
27. How many times did you go to a movie theater last month?
28. Do you have a Facebook account? If yes, how many friends do you have on Facebook?
29. Circle the social media that you use:

    Facebook Twitter Instagram Pinterest Vine Snapchat

30. How many texts did you send yesterday?
31. How many e-mails did you send yesterday?
32. How many tweets did you send yesterday?
33. How many times did you eat at a restaurant (not including fast food) last week?
34. How many times did you eat at fast-food restaurant last week?
35. If you could have one superpower, what would it be?
36. How many alcoholic drinks did you have last week?

Also consider adding another dimension to your course by finding data about your college, the college's neighborhood, and breaking news about your state. Analysis of such data will impress upon students that statistics is truly relevant.

SECTION 1.1 LECTURE NOTES

Objectives

1. Describe the meaning of *variable* and *constant*.
2. Identify and graph types of numbers.
3. Graph data on a number line.
4. Plot points on a coordinate system.
5. Graph an inequality on a number line.
6. Use inequality notation, interval notation, and graphs to describe possible values of a variable for an authentic situation.
7. Describe a concept or procedure.

OBJECTIVE 1

Definition *Variable*

A **variable** is a symbol that represents a quantity that can vary.

1. Let p be the price (in dollars) to see a Modest Mouse concert. What is the meaning of $p = 60$?
2. Let t be the number of years since 2015. What is the meaning of $t = 7$? of $t = -5$?
3. Choose a symbol to represent the number of students in a class. Explain why the symbol is a variable. Give two numbers that the variable can represent and two numbers that it cannot represent.

Definition *Constant*

A **constant** is a symbol that represents a specific number (a quantity that does *not* vary).

4. A rectangle has an area of 16 square feet. Let W be the width (in feet), L be the length (in feet), and A be the area (in square feet).
   - **a.** Sketch three possible rectangles of area 16 square feet.
   - **b.** Which of the symbols W, L, and A are variables? Explain.
   - **c.** Which of the symbols W, L, and A are constants? Explain.

OBJECTIVE 2

- The **counting numbers**, or **natural numbers**, are the numbers 1, 2, 3, 4, 5, ...
- The **integers** are the numbers ..., -3, -2, -1, 0, 1, 2, 3, ...
- The **positive integers** are the numbers 1, 2, 3, ...
- The **negative integers** are the numbers -1, -2, -3, ...
- The number 0 is neither positive nor negative.
- The **rational numbers** are the numbers that can be written in the form $\frac{n}{d}$, where n and d are integers and d is nonzero.
- The numbers represented on the number line that are *not* rational are called **irrational numbers**.
- The **real numbers** are all of the numbers represented on the number line.
- The **negative numbers** are the real numbers less than 0.
- The **positive numbers** are the real numbers greater than 0.

5. Among the following groups of numbers, determine the smallest group that contains any possible data for the given situation: counting numbers, integers, nonnegative real numbers, and real numbers. Explain.

a. A student's score on a 20-question math contest in which two points are awarded for each correct answer and one point is taken away for each incorrect answer.

b. The rainfall (in inches) at some location on May 1, 2025

c. The annual total number of songs listened to on Spotify in some year between 2008 and 2019

OBJECTIVE 3

6. Graph the integers between -4 and 2, inclusive, on one number line.

7. Graph the integers between -4 and 2 on one number line.

8. Graph all the numbers 3, -5, $\frac{7}{2}$, 0, -2.7, and -1.3 on one number line.

9. The average student debts per borrower are shown in the following table for the five states with the largest per-student debts. Let d be a state's average student debt (in thousands of dollars). Graph the average debts shown in the table on a number line.

State	Average Student Debt (thousands of dollars)
Georgia	30.4
Maryland	30.0
Virginia	28.5
South Carolina	28.3
Florida	27.9

Source: *U.S. Department of Education*

When we write numbers on a number line, they should increase by a fixed amount and be equally spaced.

10. Let T be the temperature (in degrees Fahrenheit). What value of T represents the temperature 20 degrees Fahrenheit below 0? Graph the number on a number line.

OBJECTIVE 4

11. Plot the points $(2, 5)$, $(-3, 1)$, $(-2, -4)$, and $(6, -3)$ on a coordinate system.

OBJECTIVE 5

Here are the definitions of **inequality symbols**:

Symbol	**Meaning**	**Examples of Inequalities**
$<$	Is less than	$3 < 7$, $0 < 9$, $-5 < -2$
$\leq$	Is less than or equal to	$2 \leq 5$, $4 \leq 4$, $-8 \leq -2$
$>$	Is greater than	$7 > 3$, $-1 > -5$, $2 > -1$
$\geq$	Is greater than or equal to	$6 \geq 3$, $2 \geq 2$, $-4 \geq -9$

An **inequality** contains one of the symbols $<$, $\leq$, $>$, and $\geq$ with a constant or variable on one side and a constant or variable on the other side.

12. Decide whether the inequality statement is true or false.

a. $4 < 7$ **b.** $3 \leq 3$ **c.** $-4 > -4$ **d.** $-6 \geq -2$

13. Write the inequality in interval notation, and graph the values of x.

a. $x < 4$ **b.** $x \geq -3$ **c.** $-2 < x \leq 5$

14. Describe the values of x as an inequality, in interval notation, and as a graph.

a. The values of x are at least 2.

b. The values of x are no more than -3.

OBJECTIVE 6

15. A person held his breath for at least 50 seconds. Let t be the length of time (in seconds) that he held his breath. Describe the length of time he held his breath using inequality notation, interval notation, and a graph.

16. An elevator can accept a total weight of no more than 2200 pounds. Let w be the total weight (in pounds) that the elevator can accept. Describe the total weight that the elevator can accept using inequality notation, interval notation, and a graph.

17. Let t be the time (in minutes) it takes for a student to drive to college. Interpret and graph the inequality $19 < t < 23$.

OBJECTIVE 7

Here are some guidelines on writing a good response:

- Create an example that illustrates the concept or outlines the procedure. Looking at examples or exercises may jump-start you into creating your own example.
- Using complete sentences and correct terminology, describe the key ideas or steps of your example. You can review the text for ideas, but write your description in your own words.

- Describe also the concept or the procedure in general without referring to your example. It may help to reflect on several examples and what they all have in common.
- In some cases, it will be helpful to point out the similarities and the differences between the concept or the procedure and other concepts or procedures.
- Describe the benefits of knowing the concept or the procedure.
- If you have described the steps in a procedure, explain why it's permissible to follow these steps.
- Clarify any common misunderstandings about the concept, or discuss how to avoid making common mistakes when following the procedure.

18. Describe how inequality notation, interval notation, and graphs can be used to describe possible values of a variable for an authentic situation.

HW 1, 3, 5, 9, 15, 17, 29, 39, 47, 53, 59, 71, 77, 79, 89, 91, 97, 105, 119

SECTION 1.1 TEACHING TIPS

This section contains a lot of objectives, but students have an easy time with this section, so I advise not getting too bogged down. Aside from the obvious importance of variables, it's a good idea to focus on inequalities because these are used so much with probability (Chapter 5). Students' greatest challenge in this section tends to be using interval notation correctly.

OBJECTIVE 1 COMMENTS

Problem 2 is good preparation for working with time-series data because students will sometimes get a negative value when using a model to make an estimate for the explanatory variable. Most students think that time cannot be negative and are surprised that $t = -5$ represents the year 2010.

In Problem 3, discussing unreasonable values of the variable is a nice primer for the concept of model breakdown (Section 6.3).

After completing Problems 1–3, I quickly mention several more examples of variables, pointing out that variables "are all around us." I suggest that throughout the rest of the day, my students should notice quantities that can be represented by variables. I say that a variable is a key building block of algebra and statistics.

In Section 2.1, a key distinction will be made between how variables are defined and used in algebra and statistics. But for now I restrict my discussion about variables to the scope of algebra.

When discussing constants, I give π and a number such as 5 as examples.

Before completing Problem 4, I discuss the meaning of the area of a flat surface. Most students do not know that the area is the number of unit squares that it takes to cover the surface. I remind my students that the area of a rectangle is equal to the rectangle's length times its width and explain this by breaking up a rectangle into unit squares. Although these are simple concepts, they are critical development for the frequent use of density histograms in Chapters 3–5.

OBJECTIVE 2 COMMENTS

When I define counting numbers and integers, I make sure that students understand the meaning of the ellipsis. I emphasize that 0 is neither negative nor positive because students lose sight of this otherwise. I quickly define the various types of numbers, giving especially light treatment to defining rational and irrational numbers because even though these terminologies are used in the textbook, a superficial understanding of them will suffice.

Comparing the differences between the integers and the real numbers can help prepare students to learn about discrete and continuous variables (Section 3.3).

GROUP EXPLORATION: Reasonable values of a variable

The exploration is a good primer for the concept of model breakdown (Section 6.3).

OBJECTIVE 3 COMMENTS

Graphing numbers on the number line is good preparation for constructing dotplots, time-series plots, and scatterplots. Discussing how to graph decimal numbers is especially important for work with authentic data (Problem 9). Most students do not understand how Problems 6 and 7 differ. This issue will keep coming up throughout the course (e.g. "Find the probability that the outcome of rolling a six-sided die is between 2 and 5, inclusive.").

For Problem 9, I emphasize that the number-line sketch should include a title, the variable "d", and the units of d. I also emphasize that when we write numbers on a number line, they should increase by a fixed amount and be equally spaced. Without giving such a warning several times, many students will make related errors when constructing number lines and various types of statistical diagrams.

To further engage students when discussing Problem 9, I ask them to identify in which region(s) the states are located. And I ask for some possible reasons why the average student debt is higher in those five states. Then I generalize, suggesting that students should be this engaged when working with data sets throughout the course.

OBJECTIVE 4 COMMENTS

When plotting a point, I remark that it's similar to looking up a date on a calendar. This skill is a precursor to constructing time-series plots (Section 3.3) and scatterplots (Section 6.1).

OBJECTIVE 5 COMMENTS

Students tend to have difficulty with Problem 12(b) and sometimes 12(c). Even if students have seen interval notation before, they tend to have forgotten it. Understanding the meaning of the inequalities in Problem 13 will be good preparation for probability problems throughout Chapter 5. Problem 13(c) also provides a lead-in to confidence intervals, whose foundation will be further developed in Section 8.5.

OBJECTIVE 6 COMMENTS

Throughout the course, I look for every opportunity to have students work with the phrases *less than*, *at most*, *no more than*, *greater than*, *at least*, and *no less than* because many students struggle with their meanings in introductory statistics. Problems 14–16 are a great way to get that process started.

A subtle issue to explore for Problem 15 is that an answer of $[50, \infty)$ does not imply that we believe the person could hold their breath for an extremely long time such as a 1000 minutes. Rather, it is impossible to know what upper limit to choose. For example, it may surprise you or your students that Stig Severinsen set a Guinness World Record by holding his breath for 22 minutes. Here's a link at the Guinness World Records site: http://www.guinnessworldrecords.com/world-records/24135-longest-time-breath-held-voluntarily-male.

OBJECTIVE 7 COMMENTS

When asked to describe concepts, students tend to write a single sentence or two. They need me to model a thorough response: describing a concept's meaning, listing benefits and drawbacks, comparing, contrasting, stating exceptions, and so on. Most students are astounded by how much there is to say.

I will model this for students several times throughout the course, but in the meantime I tell them to read Example 14 in the textbook and the preceding "Guidelines on Writing a Good Response" on page 12 of the textbook at home. Students will be asked to explain concepts or procedures in most homework sections. This is very much in line with introductory statistics, where students will have to describe statistical practices and interpret concepts and results.

SECTION 1.2 LECTURE NOTES

Objectives

1. Describe the meaning of *expression* and *evaluate an expression*.
2. Use expressions to describe authentic quantities.
3. Evaluate expressions.
4. Translate English phrases to and from mathematical expressions.
5. Evaluate expressions with more than one variable.

OBJECTIVE 1

1. A person is driving 3 miles per hour over the speed limit. For each speed limit shown, find the diving speed.

a. 55 mph **b.** 70 mph **c.** s mph

We call $s + 3$ is an *expression*.

Definition *Expression*

An **expression** is a constant, a variable, or combination of constants, variables, operation symbols, and grouping symbols, such as parentheses.

Here are some examples of expressions: $x + 9$, 5, $x - 7$, π, $\frac{20}{x}$, xy.

OBJECTIVE 2

2. A certain type of pen costs \$3. Complete the following table to help find an expression that describes the total cost (in dollars) of n pens. Show the arithmetic to help see the pattern.

Number of Pens	Total Cost (dollars)
5	
6	
7	
8	
n	

- Each of the following expressions describes multiplying 3 by n: $3n$, $3 \cdot n$, $3(n)$, $(3)n$, and $(3)(n)$.
- We avoid using $\times$ for the multiplication operation.

OBJECTIVE 3

3. In Problem 1, we found the expression $s+3$, which describes a person's driving speed (in mph) if the speed limit is s mph. Substitute 65 for s in the expression $s + 3$ and discuss the meaning of the result.

We say we have *evaluated the expression* $s + 3$ at $s = 65$.

Definition *Evaluate an expression*

We **evaluate an expression** by substituting a number for each variable in the expression and then calculating the result. If a variable appears more than once in the expression, the same number is substituted for that variable each time.

4. In Problem 2, we found the expression $3n$, which describes the total cost (in dollars) of n pens. Evaluate $3n$ for $n = 10$. What does your result mean in this situation?

OBJECTIVE 4

Mathematics is a language.

Definition *Product, factor, and quotient*

Let a and b be numbers. Then

- The **product** of a and b is ab. We call a and b **factors** of ab.
- The **quotient** of a and b is $a \div b$, where b is not zero.

5. Use phrases such as "2 plus x" and sentences such as "Add 2 and x." to complete the second column of the following table. Enter many phrases for each row of the second column.

Mathematical Expression	English Phrase or Sentence
$2 + x$	
$2 - x$	
$2 \cdot x$	
$2 \div x$	

Warning: Subtracting 2 from 7 is $7 - 2$, not $2 - 7$.

6. Let x be a number. Translate the English phrase into a mathematical expression or vice versa, as appropriate:

a. The difference of the number and 9 **c.** $7 + x$

b. The product of 5 and the number **d.** $x \div 4$

7. Let x be a number. Translate the sentence "Subtract the number from 10." into a mathematical expression. Evaluate the expression at $x = 7$.

OBJECTIVE 5

Recall that the area of a rectangle is equal to the length times the width of the rectangle.

8. Write the phrase "the quotient of x and y" as a mathematical expression, and then evaluate the result for $x = 24$ and $y = 3$.

9. Let T and I be the average daily media consumption (in minutes) per person of television and the Internet, respectively. For 2018, the values of T and I are 167 and 149, respectively (Source: *Business Insider*). Evaluate $T - I$ for $T = 167$ and $I = 149$. What does the result mean in this situation?