Student's Solutions Manual

College Algebra

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Table of Contents

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Chapter G

Introduction to Graphs and Graphers

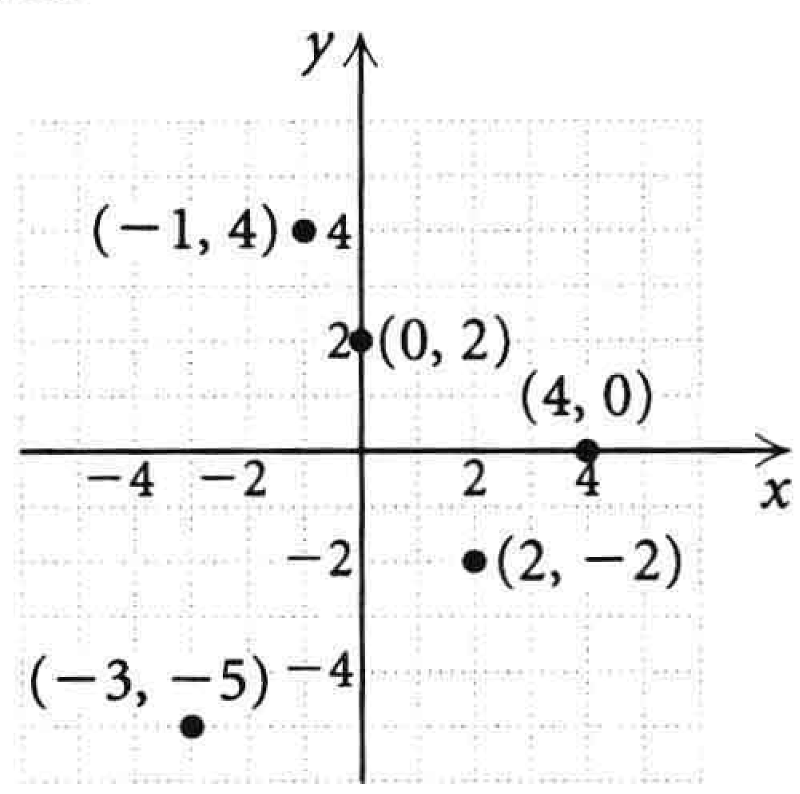
1. To graph $(4,0)$ we move from the origin 4 units to the right of the y-axis. Since the second coordinate is 0, we do not move up or down from the x-axis.

To graph $(-3,-5)$ we move from the origin 3 units to the left of the y-axis. Then we move 5 units down from the x-axis.

To graph $(-1,4)$ we move from the origin 1 unit to the left of the y-axis. Then we move 4 units up from the x-axis.

To graph $(0,2)$ we do not move to the right or the left of the y-axis since the first coordinate is 0. From the origin we move 2 units up.

To graph $(2,-2)$ we move from the origin 2 units to the right of the y-axis. Then we move 2 units down from the x-axis.



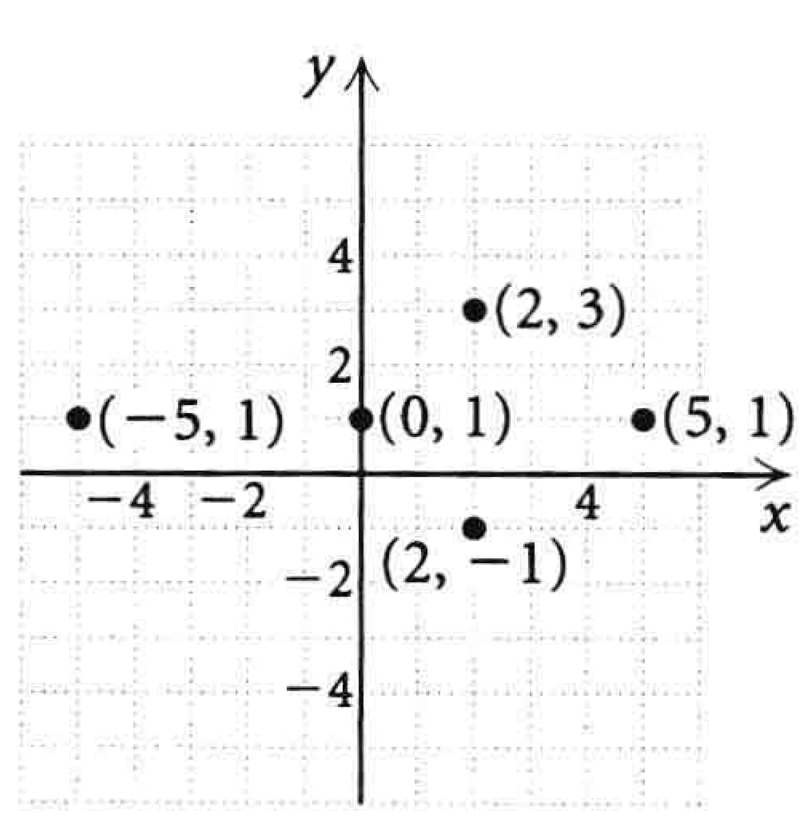
3. To graph $(-5,1)$ we move from the origin 5 units to the left of the y-axis. Then we move 1 unit up from the x-axis.

To graph $(5,1)$ we move from the origin 5 units to the right of the y-axis. Then we move 1 unit up from the x-axis.

To graph $(2,3)$ we move from the origin 2 units to the right of the y-axis. Then we move 3 units up from the x-axis.

To graph $(2,-1)$ we move from the origin 2 units to the right of the y-axis. Then we move 1 unit down from the x-axis.

To graph $(0,1)$ we do not move to the right or the left of the y-axis since the first coordinate is 0. From the origin we move 1 unit up.



5. To determine whether $(1,-1)$ is a solution, substitute 1 for x and -1 for y.

$$\begin{array}{c|c}
\multicolumn{2}{c}{y = 2x - 3} \\
\hline
-1 \;?& 2\cdot 1 - 3 \\
 & 2 - 3 \\
-1 & -1 \qquad \text{TRUE}
\end{array}$$

The equation $-1=-1$ is true, so $(1,-1)$ is a solution.

To determine whether $(0,3)$ is a solution, substitute 0 for x and -3 for y.

$$\begin{array}{c|c}
\multicolumn{2}{c}{y = 2x - 3} \\
\hline
3 \;?& 2\cdot 0 - 3 \\
 & 0 - 3 \\
3 & -3 \qquad \text{FALSE}
\end{array}$$

The equation $3=-3$ is false, so $(0,3)$ is not a solution.

7. To determine whether $\left(-\frac{1}{2},-\frac{4}{5}\right)$ is a solution, substitute $-\frac{1}{2}$ for a and $-\frac{4}{5}$ for b.

$$\begin{array}{c|c}
\multicolumn{2}{c}{2a + 5b = 3} \\
\hline
2\left(-\frac{1}{2}\right) + 5\left(-\frac{4}{5}\right) & ?\; 3 \\
-1 - 4 & \\
-5 & 3 \quad \text{FALSE}
\end{array}$$

The equation $-5=3$ is false, so $\left(-\frac{1}{2},-\frac{4}{5}\right)$ is not a solution.

To determine whether $\left(0,\frac{3}{5}\right)$ is a solution, substitute 0 for a and $\frac{3}{5}$ for b.

$$\begin{array}{c|c}
\multicolumn{2}{c}{2a + 5b = 3} \\
\hline
2\cdot 0 + 5\cdot\frac{3}{5} & ?\; 3 \\
0 + 3 & \\
3 & 3 \quad \text{TRUE}
\end{array}$$

The equation $3=3$ is true, so $\left(0,\frac{3}{5}\right)$ is a solution.

9. To determine whether $(-0.75, 2.75)$ is a solution, substitute -0.75 for x and 2.75 for y.

$$\begin{array}{c|c}
\multicolumn{2}{c}{x^2 - y^2 = 3} \\
\hline
(-0.75)^2 - (2.75)^2 & ?\; 3 \\
0.5625 - 7.5625 & \\
-7 & 3 \quad \text{FALSE}
\end{array}$$

The equation $-7=3$ is false, so $(-0.75, 2.75)$ is not a solution.

To determine whether $(2,-1)$ is a solution, substitute 2 for x and -1 for y.

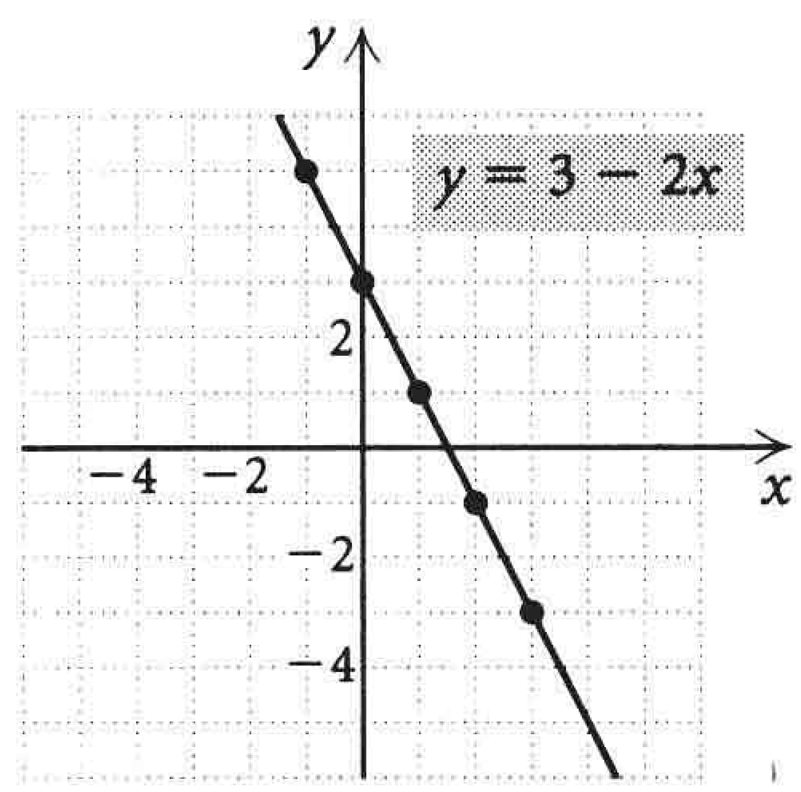
$$\begin{array}{c|c} x^2 - y^2 & = 3 \\ \hline 2^2 - (-1)^2 & ?\ 3 \\ 4 - 1 & \\ 3 & 3 \ \text{TRUE} \end{array}$$

The equation $3 = 3$ is true, so $(2,-1)$ is a solution.

11. Graph $y = 3 - 2x$.

Replace x with the values indicated and calculate the corresponding values for y. Then plot the points (x,y) and draw the graph.

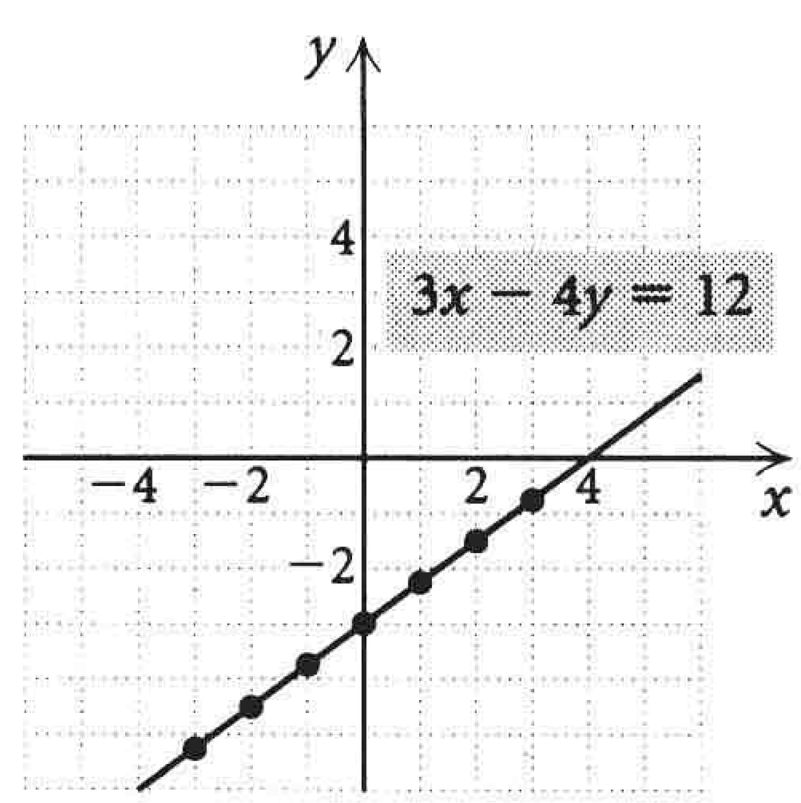
x	y	(x,y)
-3	9	$(-3,9)$
-2	7	$(-2,7)$
-1	5	$(-1,5)$
0	3	$(0,3)$
1	1	$(1,1)$
2	-1	$(2,-1)$
3	-3	$(3,-3)$



13. Graph $3x - 4y = 12$.

Replace x with the values indicated and calculate the corresponding values for y. Then plot the points (x,y) and draw the graph.

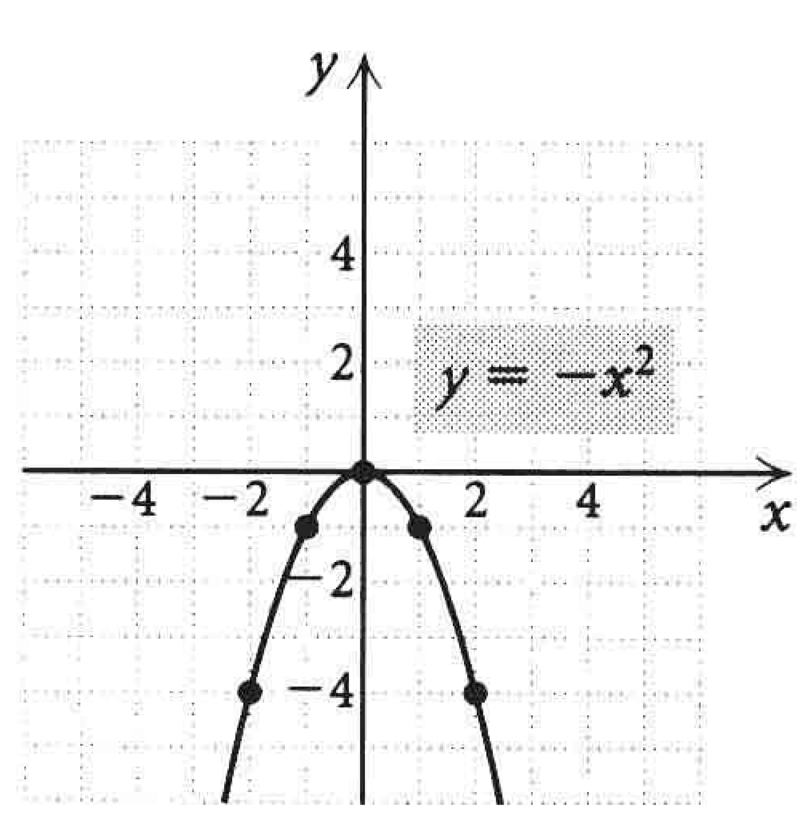
x	y	(x,y)
-3	-5.25	$(-3,-5.25)$
-2	-4.5	$(-2,-4.5)$
-1	-3.75	$(-1,-3.75)$
0	-3	$(0,-3)$
1	-2.25	$(1,-2.25)$
2	-1.5	$(2,-1.5)$
3	-0.75	$(3,-0.75)$



15. Graph $y = -x^2$.

Replace x with the values indicated and calculate the corresponding values for y. Then plot the points (x,y) and draw the graph.

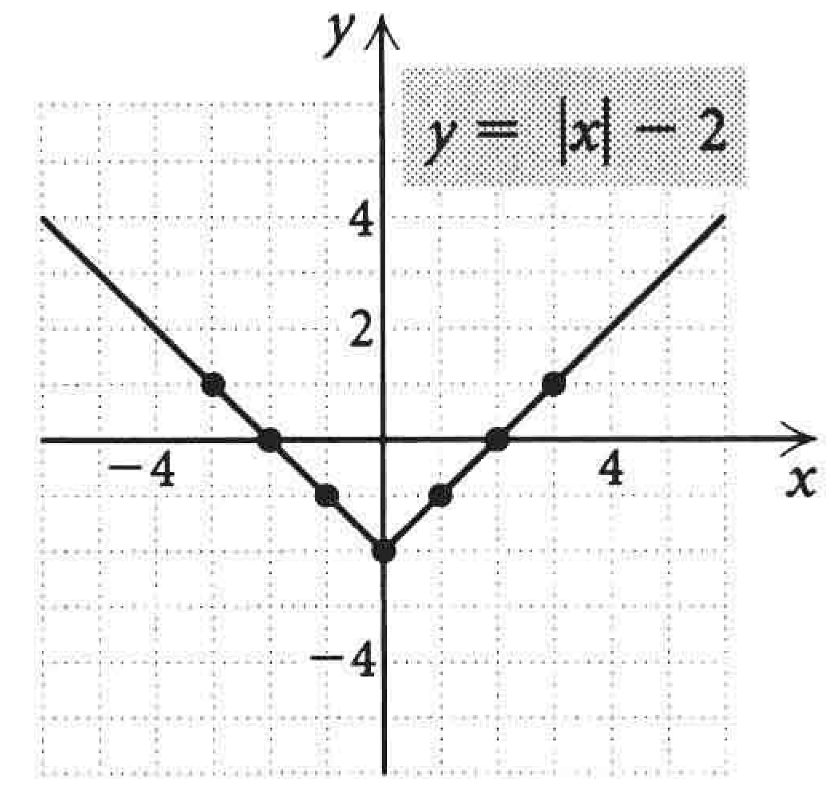
x	y	(x,y)
-3	-9	$(-3,-9)$
-2	-4	$(-2,-4)$
-1	-1	$(-1,-1)$
0	0	$(0,0)$
1	-1	$(1,-1)$
2	-4	$(2,-4)$
3	-9	$(3,-9)$



17. Graph $y = |x| - 2$

Replace x with the values indicated and calculate the corresponding values for y. Then plot the points (x,y) and draw the graph.

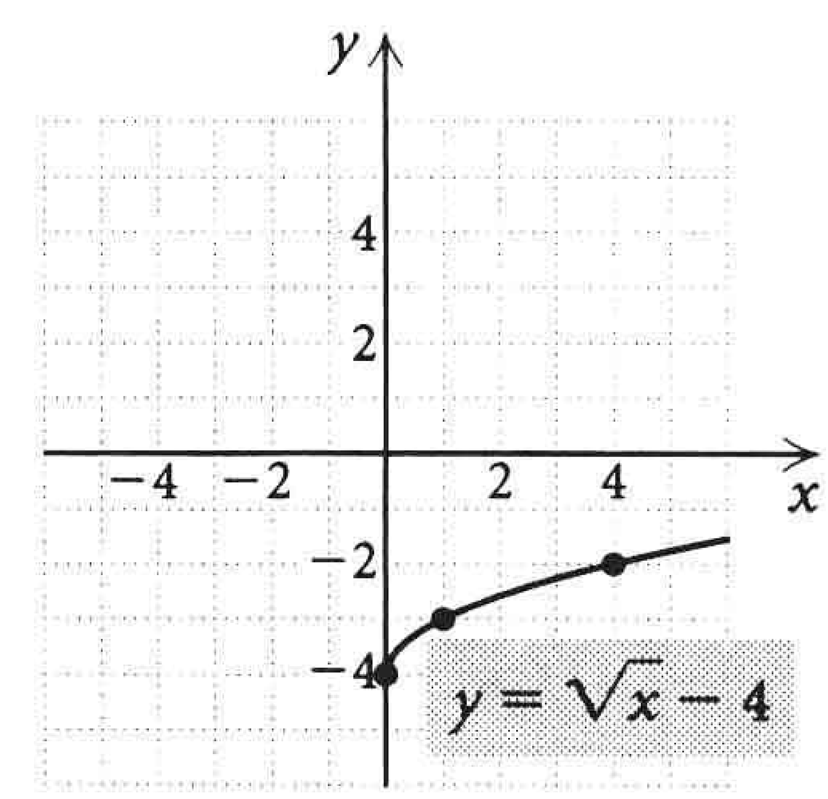
x	y	(x,y)
-3	1	$(-3,1)$
-2	0	$(-2,0)$
-1	-1	$(-1,-1)$
0	-2	$(0,-2)$
1	-1	$(1,-1)$
2	0	$(2,0)$
3	1	$(3,1)$



19. Graph $y = \sqrt{x} - 4$.

Replace x with the values indicated and calculate the corresponding values for y. Then plot the points (x,y) and draw the graph.

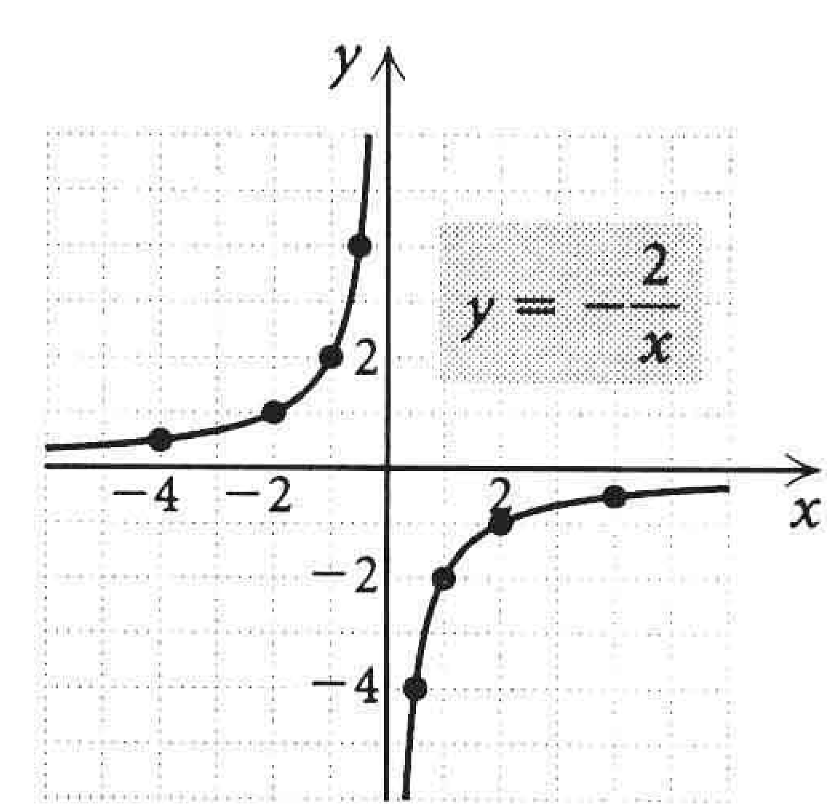
x	y	(x,y)
0	-4	$(0,-4)$
1	-3	$(1,-3)$
4	-2	$(4,-2)$
9	-1	$(9,-1)$



21. Graph $y = -\dfrac{2}{x}$.

Replace x with the values indicated and calculate the corresponding values for y. Then plot the points (x,y) and draw the graph.

x	y	(x,y)
-4	$\frac{1}{2}$	$\left(-4,\frac{1}{2}\right)$
-2	1	$(-2,1)$
-1	2	$(-1,2)$
$-\frac{1}{2}$	4	$\left(-\frac{1}{2},4\right)$
$\frac{1}{2}$	-4	$\left(\frac{1}{2},-4\right)$
1	-2	$(-2,1)$
2	-1	$(1,-2)$
4	$-\frac{1}{2}$	$\left(4,-\frac{1}{2}\right)$



23. Graph (f) is the graph of $y = 3 - 4x$.

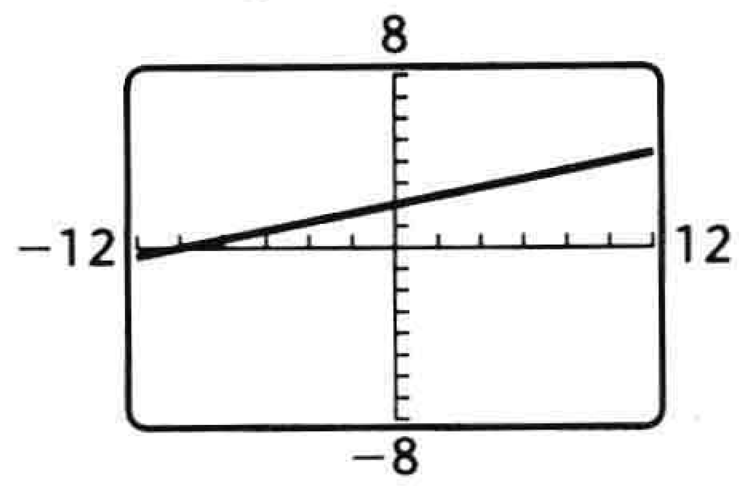
25. Graph (c) is the graph of $y = 3 + 6x - x^2$.

27. Graph (b) is the graph of $x = y^2 - 3$.

29. Graph (d) is the graph of $y = 12.4 + 9.1x + 3.07x^2 - 1.1x^3$.

31. A window with dimensions $[-12, 12, -8, 8]$, Xscl $= 2$, Yscl $= 1$, gives a good representation of $y = \frac{1}{5}x + 2$.

$y = \frac{1}{5}x + 2$



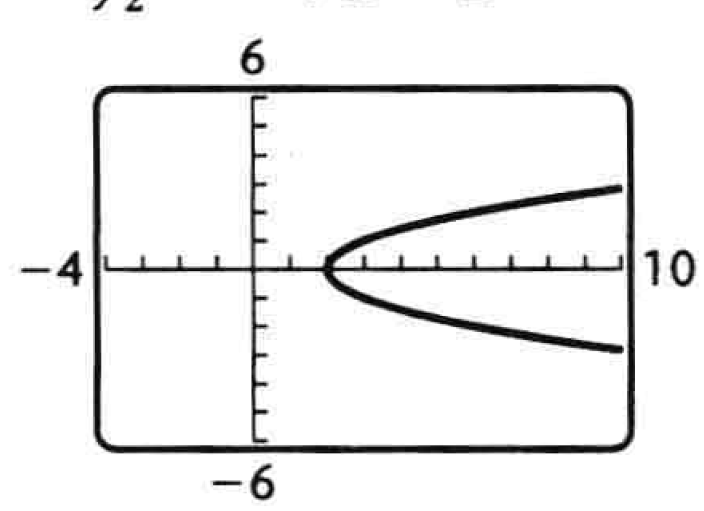
Xscl = 2, Yscl = 1

33.

$$x = y^2 + 2$$
$$x - 2 = y^2$$
$$\pm\sqrt{x-2} = y$$

Graph $y_1 = \sqrt{x+2}$, $y_2 = -\sqrt{x-2}$. The window $[-4, 10, -6, 6]$, Xscl $= 1$, Yscl $= 1$, gives a good representation.

$y_1 = \sqrt{x-2}$ and
$y_2 = -\sqrt{x-2}$



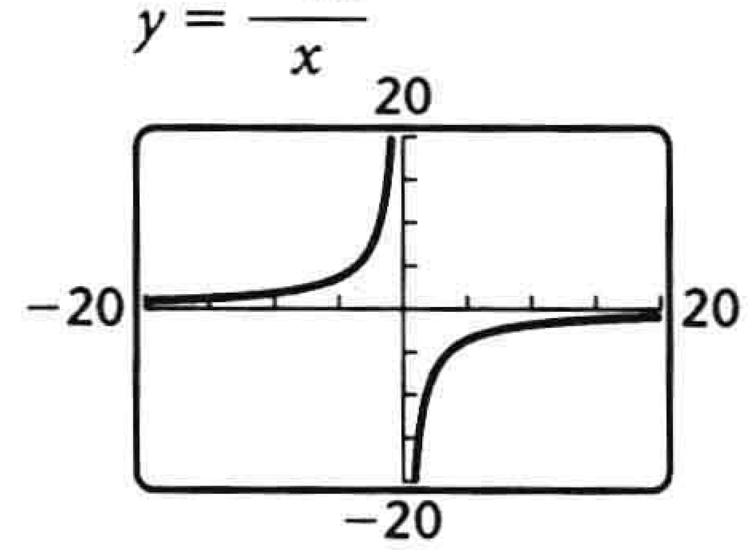
Xscl = 1, Yscl = 1

35. $xy = -18$

$$y = \frac{-18}{x}$$

The window $[-20, 20, -20, 20]$, Xscl $= 5$, Yscl $= 5$, gives a good representation.

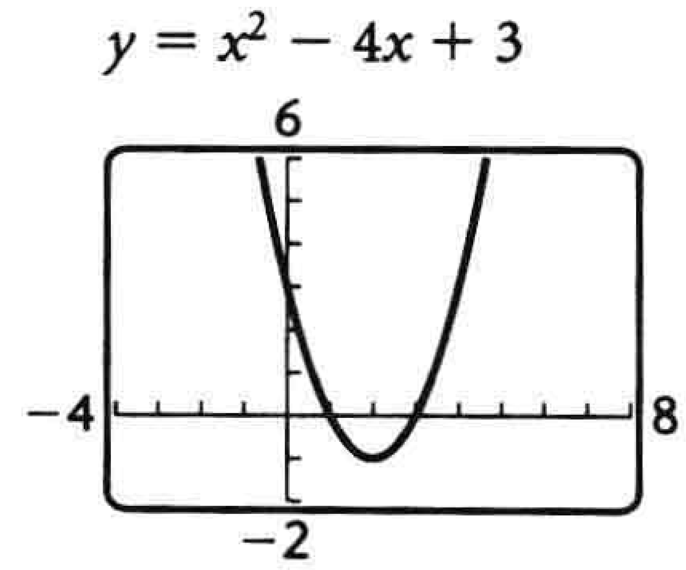
$y = \frac{-18}{x}$



Xscl = 5, Yscl = 5

37. The window $[-4, 8, -2, 6]$, Xscl $= 1$, Yscl $= 1$, gives a good representation of $y = x^2 - 4x + 3$.

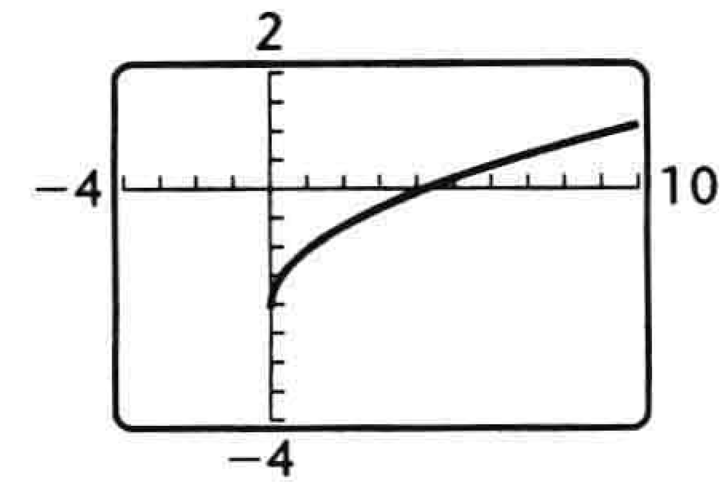
$y = x^2 - 4x + 3$



Xscl = 1, Yscl = 1

39. The window $[-4, 10, -4, 2]$, Xscl $= 1$, Yscl $= 0.5$, gives a good representation of $y = \sqrt{x} - 2$.

$y = \sqrt{x} - 2$



Xscl = 1, Yscl = 0.5

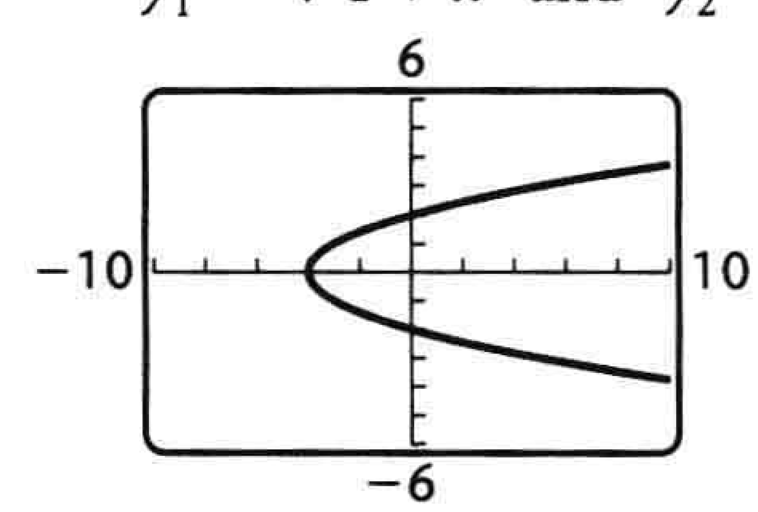
41. $y^2 = 4 + x$

$$y = \pm\sqrt{4+x}$$

Graph $y_1 = \sqrt{4+x}$, $y_2 = -\sqrt{4-x}$. The window $[-10, 10, -6, 6]$, Xscl $= 2$, Yscl $= 1$, gives a good representation.

$y^2 = 4 + x$

$y_1 = \sqrt{4+x}$ and $y_2 = -\sqrt{4+x}$



Xscl = 2, Yscl = 1

43. (a) This option does not show the curvature of the graph.

(b) Of the options given, this is the best choice.

(c) The tick marks on both axes are too close together.

(d) This option does not show the curvature of the graph, and the tick marks on both axes are too close together.

45. (a) This option does not show the curvature of the graph.

(b) Of the options given, this is the best choice.

(c) This option does not show the curvature of the graph as well as option (b).

(d) The graph cannot be seen.

47. The entries in the Y_1 column, from top to bottom, are ERROR, ERROR, .6245, 1, 1.261, 1.4697, 1.6462. The entries in the Y_2 column, from top to bottom, are −32, −40, −53.33, −80, −160, ERROR, 160.

When the table is extended from −2.6 to 3.3, the entries in the Y_1 column range from 1.8 when X= −2.6 to .6245 when $x = 3.1$. The entry ERROR appears for $x = 3.2$ and $x = 3.3$. The entries in the Y_2 column range from 80 when $x = -2.6$ to 2.623 when $x = 3.3$.

49. The graphs of $y_1 = (x-5)^2$ and $y_2 = x^2-10x+25$ appear to coincide. Thus, $(x-5)^2 = x^2-10x+25$ seems to be an identity.

51. The graphs of $y_1 = x^3 + x^4$ and $y_2 = x^7$ do not coincide. Thus, $x^3 + x^4 = x^7$ is not an identity.

53. The graphs of $y_1 = x^3 - 1$ and $y_2 = (x-1)(x^2+x+1)$ appear to coincide. Thus, $x^3 - 1 = (x-1)(x^2+x+1)$ seems to be an identity.

55. The graphs of $y_1 = \sqrt{x^2-16}$ and $y_2 = x-4$ do not coincide. Thus, $\sqrt{x^2-16} = x-4$ is not an identity.

57. The graphs of $y_1 = \dfrac{x^5}{x^2}$ and $y_2 = x^3$ appear to coincide. Thus, $\dfrac{x^5}{x^2} = x^3$ seems to be an identity.

59. Solve $\dfrac{3}{4}x + 2 = -4$.

One method is to graph $y_1 = \dfrac{3}{4}x + 2$ and $y_2 = -4$ and find the first coordinate of the point of intersection using TRACE and ZOOM or INTERSECT. Another method is to write $\dfrac{3}{4}x + 2 + 4 = 0$ or $\dfrac{3}{4}x + 6 = 0$ and use the ROOT feature or find the first coordinate of the x-intercept of $y = \dfrac{3}{4}x + 6$. The SOLVE feature could also be used. The solution is -8.

61. Solve $3x + 4 = -\dfrac{2}{5}x + 1$.

One method is to graph $y_1 = 3x+4$ and $y_2 = -\dfrac{2}{5}x + 1$ and find the first coordinate of the point of intersection using TRACE and ZOOM or INTERSECT. Another method is to write $3x + 4 - \left(-\dfrac{2}{5}x + 1\right) = 0$ and use the ROOT feature or find the first coordinate of the x-intercept of $y = 3x + 4 - \left(-\dfrac{2}{5}x + 1\right)$. The SOLVE feature could also be used. The solution is -0.882.

63. Solve $1.4x + 0.7 = 0.9x - 2.2$.

One method is to graph $y_1 = 1.4x+0.7$ and $y_2 = 0.9x-2.2$ and find the first coordinate of the point of intersection using TRACE and ZOOM or INTERSECT. Another method is to write $1.4x+0.7-(0.9x-2.2) = 0$ and use the ROOT feature or find the first coordinate of the x-intercept of $y = 1.4x + 0.7 - (0.9x - 2.2)$. The SOLVE feature could also be used. The solution is -5.8.

65. Solve $x - 7.4 = 2.8\sqrt{x+1.1}$.

One method is to graph $y_1 = x-7.4$ and $y_2 = 2.8\sqrt{x+1.1}$ and find the first coordinate of the point of intersection using TRACE and ZOOM or INTERSECT. Another method is to write $x - 7.4 - 2.8\sqrt{x+1.1} = 0$ and use the ROOT feature or find the first coordinate of the x-intercept of $y = x - 7.4 - 2.8\sqrt{x+1.1}$. The SOLVE feature could also be used. The solution is 20.376.

67. Solve $x^3 - 6x^2 = -9x - 1$.

One method is to graph $y_1 = x^3-6x^2$ and $y_2 = -9x-1$ and find the first coordinate of the point of intersection using TRACE and ZOOM or INTERSECT. Another method is to write $x^3 - 6x^2 - (-9x-1) = 0$ and use the ROOT feature or find the first coordinate of the x-intercept of $y = x^3 - 6x^2 - (-9x-1)$. The SOLVE feature could also be used. The solution is -0.104.

69. Solve $1.09x^2 - 0.8x^4 = -7.6$.

One method is to graph $y_1 = 1.09x^2-0.8x^4$ and $y_2 = -7.6$ and find the first coordinates of the points of intersection using TRACE and ZOOM or INTERSECT. Another method is to write $1.09x^2 - 0.8x^4 - (-7.6) = 0$ or $1.09x^2 - 0.8x^4 + 7.6 = 0$ and use the ROOT feature or find the first coordinates of the x-intercepts of $y = 1.09x^2 - 0.8x^4 + 7.6$. The SOLVE feature could also be used. The solutions are -1.959 and 1.959.

71. Solve $x^4 + 4x^3 + 300 = 36x^2 + 160x$.

One method is to graph $y_1 = x^4 + 4x^3 + 300$ and $y_2 = 36x^2 + 160x$ and find the first coordinates of the points of intersection using TRACE and ZOOM or INTERSECT. Another method is to write $x^4+4x^3+300-(36x^2+160x) = 0$ and use the ROOT feature or find the first coordinates of the x-intercepts of $y = x^4 + 4x^3 + 300 - (36x^2 + 160x)$. The SOLVE feature could also be used. The solutions are 1.489 and 5.673.

73. Solve $|x+1| + |x-2| = 5$.

One method is to graph $y_1 = |x+1|+|x-2|$ and $y_2 = 5$ and find the first coordinates of the points of intersection using TRACE and ZOOM or INTERSECT. Another method is to write $|x+1| + |x-2| - 5 = 0$ and use the ROOT feature or find the first coordinates of the x-intercepts of $y = |x+1| + |x-2| - 5$. The SOLVE feature could also be used. The solutions are -2 and 3.

75. $y_1 = x^3 + 3x^2 - 9x - 13$, $y_2 = 0$

Since the graph of $y_2 = 0$ is the x-axis, we find the points where the graph of y_1 intersects the x-axis. This is equivalent to solving $x^3 + 3x^2 - 9x - 13 = 0$. Using TRACE and ZOOM, INTERSECT, ROOT, or SOLVE, we find that the points of intersection are $(-4.378, 0)$, $(2.545, 0)$, and $(-1.167, 0)$.

77. $y = x^3 - 3x^2$, $4x - 7y = 20$

We solve the second equation for y.

$4x - 7y = 20$

$-7y = -4x + 20$ Subtracting $4x$ on both sides

$y = \dfrac{4}{7}x - \dfrac{20}{7}$ Dividing by -7 on both sides

We can use TRACE and ZOOM or INTERSECT to find the coordinates of the points of intersection of the graphs of $y_1 = x^3 - 3x^2$ and $y_2 = \dfrac{4}{7}x - \dfrac{20}{7}$. Another method is to solve $y_1 - y_2 = 0$ or $x^3 - 3x^2 - \left(\dfrac{4}{7}x - \dfrac{20}{7}\right) = 0$ using ROOT or SOLVE. This method gives us the first coordinates of the points of intersection of the graphs of y_1 and

y_2. To compute the second coordinates, substitute the x-values into either y_1 or y_2. (Answers may vary according to the number of decimal places used in the substitution.) The points of intersection are $(-0.929, -3.388)$, $(1.080, -2.240)$, and $(2.848, -1.229)$.

79. Find the points of intersection of the graphs of $y_1 = \dfrac{8x}{x^2+1}$ and $y_2 = 0.9x$ using TRACE and ZOOM or INTERSECT. Another method is to find the first coordinates by solving $y_1 - y_2 = 0$ or $\dfrac{8x}{x^2+1} - 0.9x = 0$ using ROOT or SOLVE. Then substitute the x-values into either y_1 or y_2 to compute the second coordinates. (Answers may vary according to the number of decimal places used in the substitution.) The points of intersection are $(-2.809, -2.528)$, $(0, 0)$, and $(2.809, 2.528)$.

81. Answers will vary depending on the grapher used.

83. It appears that the first five y-values given were found by squaring the corresponding x-values and then adding 1. Then when $x = 5$, $y = 5^2 + 1 = 25 + 1 = 26$. Given a y-value we can find the corresponding x-value by subtracting 1 and then finding the square roots. When $y = 82$, first subtract 1: $82 - 1 = 81$. Then find the square roots: $x = \pm\sqrt{81} = \pm 9$. When $y = 122$, first subtract 1: $122 - 1 = 121$. Then find the square roots: $x = \pm\sqrt{121} = \pm 11$. An equation that fits the data is $y = x^2 + 1$.

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Chapter R

Basic Concepts of Algebra

Exercise Set R.1

1. Whole numbers: $\sqrt[3]{8}$, 0, 9, $\sqrt{25}$ $\quad(\sqrt[3]{8}=2,\ \sqrt{25}=5)$

3. Irrational numbers: $\sqrt{7}$, 5.242242224..., $-\sqrt{14}$, $\sqrt[5]{5}$, $\sqrt[3]{4}$ (Although there is a pattern in 5.242242224..., there is no repeating block of digits.)

5. Rational numbers: -12, $5.\overline{3}$, $-\frac{7}{3}$, $\sqrt[3]{8}$, 0, -1.96, 9, $4\frac{2}{3}$, $\sqrt{25}$, $\frac{5}{7}$

7. Answers may vary. Some examples are $-\frac{3}{4}$, $5.7\overline{6}$, $9\frac{1}{8}$, -1.067.

9. Answers may vary. Some examples are -1, -5, -352.

11. Since 6 is an element of the set of natural numbers, the statement is true.

13. Since 3.2 is not an element of the set of integers, the statement is false.

15. Since $-\frac{11}{5}$ is an element of the set of rational numbers, the statement is true.

17. Since $\sqrt{11}$ is an element of the set of real numbers, the statement is false.

19. Since 24 is an element of the set of whole numbers, the statement is false.

21. Since 1.089 is not an element of the set of irrational numbers, the statement is true.

23. Since every whole number is an integer, the statement is true.

25. Since every rational number is a real number, the statement is true.

27. Since there are real numbers that are not integers, the statement is false.

29. The distance of -7.1 from 0 is 7.1, so $|-7.1| = 7.1$.

31. The distance of $\frac{5}{4}$ from 0 is $\frac{5}{4}$, so $\left|\frac{5}{4}\right| = \frac{5}{4}$.

33. $|-8b| = |-8|\cdot|b| = 8|b|$

35. $|-5xz| = |-5|\cdot|xz| = 5|xz|$, or $5|x|\cdot|z|$

37. $\left|\frac{0.02x}{y}\right| = \frac{|0.02x|}{|y|} = \frac{|0.02|\cdot|x|}{|y|} = \frac{0.02|x|}{|y|}$, or $0.02\left|\frac{x}{y}\right|$

39. $|-5-6| = |-11| = 11$, or
$|6-(-5)| = |6+5| = |11| = 11$

41. $|-2-(-8)| = |-2+8| = |6| = 6$, or
$|-8-(-2)| = |-8+2| = |-6| = 6$

43. $|12.1-6.7| = |5.4| = 5.4$, or
$|6.7-12.1| = |-5.4| = 5.4$

45. The sentence $6x = x6$ illustrates the commutative property of multiplication.

47. The sentence $-3\cdot 1 = -3$ illustrates the multiplicative identity property.

49. The sentence $5(ab) = (5a)b$ illustrates the associative property of multiplication.

51. The sentence $2(a+b) = (a+b)2$ illustrates the commutative property of multiplication.

53. The sentence $-6(m+n) = -6(n+m)$ illustrates the commutative property of addition.

55. The sentence $8\cdot\frac{1}{8} = 1$ illustrates the multiplicative inverse property.

57. The graphs of $y_1 = |x|$ and $y_2 = |-x|$ appear to coincide, so $|x| = |-x|$ seems to be an identity.

59. The graphs of $y_1 = |-5x|$ and $y_2 = 5x$ do not coincide, so $|-5a| = 5a$ is not an identity.

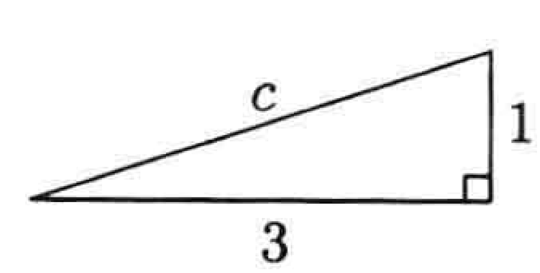
61. The graphs of $y_1 = x+7$ and $y_2 = 7+x$ appear to coincide, so $x+7 = 7+x$ seems to be an identity.

63. ◈

65. Answers may vary. One such number is 0.1241244412444....

67. Answers may vary. Since $-\frac{1}{101} = 0.\overline{0099}$ and $-\frac{1}{100} = -0.01$, one such number is -0.00999.

69. Since $1^2+3^2 = 10$, the hypotenuse of a right triangle with legs of lengths 1 unit and 3 units has a length of $\sqrt{10}$ units.



$$c^2 = 1^2+3^2$$
$$c^2 = 10$$
$$c = \sqrt{10}$$

Exercise Set R.2

1. $5^8 \cdot 5^{-6} = 5^{8+(-6)} = 5^2$, or 25

3. $m^{-5} \cdot m^5 = m^{-5+5} = m^0 = 1$

5. $7^3 \cdot 7^{-5} \cdot 7 = 7^{3+(-5)+1} = 7^{-1}$, or $\frac{1}{7}$

7. $2x^3 \cdot 3x^2 = 2 \cdot 3 \cdot x^{3+2} = 6x^5$

9. $(5a^2b)(3a^{-3}b^4) = 5 \cdot 3 \cdot a^{2+(-3)} \cdot b^{1+4} = 15a^{-1}b^5$, or $\frac{15b^5}{a}$

11. $(2x)^3(3x)^2 = 2^3x^3 \cdot 3^2x^2 = 8 \cdot 9 \cdot x^{3+2} = 72x^5$

13. $\frac{b^{40}}{b^{37}} = b^{40-37} = b^3$

15. $\frac{x^2y^{-2}}{x^{-1}y} = x^{2-(-1)}y^{-2-1} = x^3y^{-3}$, or $\frac{x^3}{y^3}$

17. $\frac{32x^{-4}y^3}{4x^{-5}y^8} = \frac{32}{4}x^{-4-(-5)}y^{3-8} = 8xy^{-5}$, or $\frac{8x}{y^5}$

19. $(2ab^2)^3 = 2^3a^3(b^2)^3 = 2^3a^3b^{2\cdot 3} = 8a^3b^6$

21. $(-2x^3)^4 = (-2)^4(x^3)^4 = (-2)^4x^{3\cdot 4} = 16x^{12}$

23. $(-5c^{-1}d^{-2})^{-2} = (-5)^{-2}c^{-1(-2)}d^{-2(-2)} = \frac{c^2d^4}{(-5)^2} = \frac{c^2d^4}{25}$

25. $\left(\frac{24a^{10}b^{-8}c^7}{3a^6b^{-3}b^5}\right)^5 = (8a^4b^{-5}c^2)^5 = 8^5a^{20}b^{-25}c^{10}$, or $\frac{8^5a^{20}c^{10}}{b^{25}}$

27. Convert 405,000 to scientific notation.

We want the decimal point to be positioned between the 4 and the first 0, so we move it 5 places to the left. Since 405,000 is greater than 10, the exponent must be positive.

$$405,000 = 4.05 \times 10^5$$

29. Convert 0.00000039 to scientific notation.

We want the decimal point to be positioned between the 3 and the 9, so we move it 7 places to the right. Since 0.00000039 is a number between 0 and 1 the exponent must be negative.

$$0.00000039 = 3.9 \times 10^{-7}$$

31. Convert 0.000016 to scientific notation.

We want the decimal point to be positioned between the 1 and the 6, so we move it 5 places to the right. Since 0.000016 is a number between 0 and 1, the exponent must be negative.

$$0.000016 \text{ m}^3 = 1.6 \times 10^{-5} \text{ m}^3$$

33. Convert 8.3×10^{-5} to decimal notation.

The exponent is negative, so the number is between 0 and 1. We move the decimal point 5 places to the left.

$$8.3 \times 10^{-5} = 0.000083$$

35. Convert 2.07×10^7 to decimal notation.

The exponent is positive, so the number is greater than 10. We move the decimal point 7 places to the right.

$$2.07 \times 10^7 = 20,700,000$$

37. Convert 4.69×10^{12} to decimal notation.

The exponent is positive, so the number is greater than 10. We move the decimal point 12 places to the right.

$$\$4.69 \times 10^{12} = \$4,690,000,000,000$$

39.
$$\begin{aligned} &(3.1 \times 10^5)(4.5 \times 10^{-3}) \\ &= (3.1 \times 4.5) \times (10^5 \times 10^{-3}) \\ &= 13.95 \times 10^2 && \text{This is not scientific notation.} \\ &= (1.395 \times 10) \times 10^2 \\ &= 1.395 \times 10^3 && \text{Writing scientific notation} \end{aligned}$$

41.
$$\begin{aligned} \frac{6.4 \times 10^{-7}}{8.0 \times 10^6} &= \frac{6.4}{8.0} \times \frac{10^{-7}}{10^6} \\ &= 0.8 \times 10^{-13} && \text{This is not scientific notation.} \\ &= (8 \times 10^{-1}) \times 10^{-13} \\ &= 8 \times 10^{-14} && \text{Writing scientific notation} \end{aligned}$$

43. First find the number of seconds in 1 hour:

$$1 \text{ hour} = 1 \cancel{\text{hr}} \times \frac{60 \cancel{\text{min}}}{1 \cancel{\text{hr}}} \times \frac{60 \text{ sec}}{1 \cancel{\text{min}}} = 3600 \text{ sec}$$

The number of disintegrations produced in 1 hour is the number of disintegrations per second times the number of seconds in 1 hour.

$$\begin{aligned} &37 \text{ billion} \times 3600 \\ &= 37,000,000,000 \times 3600 \\ &= 3.7 \times 10^{10} \times 3.6 \times 10^3 && \text{Writing scientific notation} \\ &= (3.7 \times 3.6) \times (10^{10} \times 10^3) \\ &= 13.32 \times 10^{13} && \text{Multiplying} \\ &= (1.332 \times 10) \times 10^{13} \\ &= 1.332 \times 10^{14} \end{aligned}$$

One gram of radium produces 1.332×10^{14} disintegrations in 1 hour.

45. The average cost per mile is the total cost divided by the number of miles.

$$\begin{aligned} &\frac{\$210 \times 10^6}{17.6} \\ &= \frac{\$210 \times 10^6}{1.76 \times 10} \\ &\approx \$119 \times 10^5 \\ &\approx (\$1.19 \times 10^2) \times 10^5 \\ &\approx \$1.19 \times 10^7 \end{aligned}$$

The average cost per mile was about $\$1.19 \times 10^7$.

47. $3 \cdot 2 - 4 \cdot 2^2 + 6(3-1)$

$= 3 \cdot 2 - 4 \cdot 2^2 + 6 \cdot 2$ Working inside parentheses

$= 3 \cdot 2 - 4 \cdot 4 + 6 \cdot 2$ Evaluating 2^2

$= 6 - 16 + 12$ Multiplying

$= -10 + 12$ Adding in order

$= 2$ from left to right

49. $16 \div 4 \cdot 4 \div 2 \cdot 256$

$= 4 \cdot 4 \div 2 \cdot 256$ Multiplying and dividing in order from left to right

$= 16 \div 2 \cdot 256$

$= 8 \cdot 256$

$= 2048$

51. $\dfrac{4(8-6)^2 - 4 \cdot 3 + 2 \cdot 8}{3^1 + 19^0}$

$= \dfrac{4 \cdot 2^2 - 4 \cdot 3 + 2 \cdot 8}{3+1}$ Calculating in the numerator and in the denominator

$= \dfrac{4 \cdot 4 - 4 \cdot 3 + 2 \cdot 8}{4}$

$= \dfrac{16 - 12 + 16}{4}$

$= \dfrac{4 + 16}{4}$

$= \dfrac{20}{4}$

$= 5$

53. Since interest is compounded semiannually, $n = 2$. Substitute \$2125 for P, 6.2% or 0.062 for i, 2 for n, and 5 for t in the compound interest formula.

$A = P\left(1 + \dfrac{i}{n}\right)^{nt}$

$= \$2125\left(1 + \dfrac{0.062}{2}\right)^{2 \cdot 5}$ Substituting

$= \$2125(1 + 0.031)^{2 \cdot 5}$ Dividing

$= \$2125(1.031)^{2 \cdot 5}$ Adding

$= \$2125(1.031)^{10}$ Multiplying 2 and 5

$\approx \$2125(1.357021264)$ Evaluating the exponential expression

$\approx \$2883.670185$ Multiplying

$\approx \$2883.67$ Rounding to the nearest cent

55. Since interest is compounded quarterly, $n = 4$. Substitute \$6700 for P, 4.5% or 0.045 for i, 4 for n, and 6 for t in the compound interest formula.

$A = P\left(1 + \dfrac{i}{n}\right)^{nt}$

$= \$6700\left(1 + \dfrac{0.045}{4}\right)^{4 \cdot 6}$ Substituting

$= \$6700(1 + 0.01125)^{4 \cdot 6}$ Dividing

$= \$6700(1.01125)^{4 \cdot 6}$ Adding

$= \$6700(1.01125)^{24}$ Multiplying 4 and 6

$\approx \$6700(1.307991226)$ Evaluating the exponential expression

$\approx \$8763.541217$ Multiplying

$\approx \$8763.54$ Rounding to the nearest cent

57. ◈

59. $(x^t \cdot x^{3t})^2 = (x^{4t})^2 = x^{4t \cdot 2} = x^{8t}$

61. $(t^{a+x} \cdot t^{x-a})^4 = (t^{2x})^4 = t^{2x \cdot 4} = t^{8x}$

63. $\left[\dfrac{(3x^a y^b)^3}{(-3x^a y^b)^2}\right]^2 = \left[\dfrac{27x^{3a}y^{3b}}{9x^{2a}y^{2b}}\right]^2$

$= \left[3x^a y^b\right]^2$

$= 9x^{2a}y^{2b}$

65. $p = \$98,000 - \$16,000 = \$82,000$, $i = 8\frac{1}{2}\%$, or 0.085

$n = 12 \cdot 25 = 300$

$$M = P\left[\frac{\frac{i}{12}\left(1 + \frac{i}{12}\right)^n}{\left(1 + \frac{i}{12}\right)^n - 1}\right]$$

$$M = \$82,000\left[\frac{\frac{0.085}{12}\left(1 + \frac{0.085}{12}\right)^{300}}{\left(1 + \frac{0.085}{12}\right)^{300} - 1}\right]$$

$\approx \$660.29$ Using a calculator

67. Turn off the graph of y_2 and inspect the graphs of y_1 and y_3 in a suitable window such as $[-2, 2, -2, 2]$. The graph of y_3 lies above the graph of y_1 for $x < -1$ or $x > 1$.

Exercise Set R.3

1. $-5y^4 + 3y^3 + 7y^2 - y - 4 = -5y^4 + 3y^3 + 7y^2 + (-y) + (-4)$

Terms: $-5y^4$, $3y^3$, $7y^2$, $-y$, -4

The degree of the term of highest degree, $-5y^4$, is 4. Thus, the degree of the polynomial is 4.

3. $3a^4b - 7a^3b^3 + 5ab - 2 = 3a^4b + (-7a^3b^3) + 5ab + (-2)$

Terms: $3a^4b$, $-7a^3b^3$, $5ab$, -2

The degrees of the terms are 5, 6, 2, and, 0, respectively, so the degree of the polynomial is 6.

5. $(5x^2y - 2xy^2 + 3xy - 5) + (-2x^2y - 3xy^2 + 4xy + 7)$

$= (5-2)x^2y + (-2-3)xy^2 + (3+4)xy + (-5+7)$

$= 3x^2y - 5xy^2 + 7xy + 2$

7. $(2x+3y+z-7)+(4x-2y-z+8)+(-3x+y-2z-4)$
$= (2+4-3)x+(3-2+1)y+(1-1-2)z+(-7+8-4)$
$= 3x+2y-2z-3$

9. $(3x^2-2x-x^3+2)-(5x^2-8x-x^3+4)$
$= (3x^2-2x-x^3+2)+(-5x^2+8x+x^3-4)$
$= (3-5)x^2+(-2+8)x+(-1+1)x^3+(2-4)$
$= -2x^2+6x-2$

11. $(x^4-3x^2+4x)-(3x^3+x^2-5x+3)$
$= (x^4-3x^2+4x)+(-3x^3-x^2+5x-3)$
$= x^4-3x^3+(-3-1)x^2+(4+5)x-3$
$= x^4-3x^3-4x^2+9x-3$

13. $(a-b)(2a^3-ab+3b^2)$
$= (a-b)(2a^3)+(a-b)(-ab)+(a-b)(3b^2)$ Using the distributive property
$= 2a^4-2a^3b-a^2b+ab^2+3ab^2-3b^3$ Using the distributive property three more times
$= 2a^4-2a^3b-a^2b+4ab^2-3b^3$ Collecting like terms

15. $(x+5)(x-3)$
$= x^2-3x+5x-15$ Using FOIL
$= x^2+2x-15$ Collecting like terms

17. $(2a+3)(a+5)$
$= 2a^2+10a+3a+15$ Using FOIL
$= 2a^2+13a+15$ Collecting like terms

19. The graphs of $y_1=(2x+3)(x+5)$ and $y_2=2x^2+13x+15$ appear to coincide.

21. $(2x+3y)(2x+y)$
$= 4x^2+2xy+6xy+3y^2$ Using FOIL
$= 4x^2+8xy+3y^2$

23. $(x+5)^2$
$= x^2+2\cdot x\cdot 5+5^2$ $[(A+B)^2=A^2+2AB+B^2]$
$= x^2+10x+25$

25. $(5y-3)^2$
$= (5y)^2-2\cdot 5y\cdot 3+3^2$ $[(A-B)^2=A^2-2AB+B^2]$
$= 25y^2-30y+9$

27. The graphs of $y_1=(5x-3)^2$ and $y_2=25x^2-30x+9$ appear to coincide.

29. $(2x+3y)^2$
$= (2x)^2+2(2x)(3y)+(3y)^2$ $[(A+B)^2=A^2+2AB+B^2]$
$= 4x^2+12xy+9y^2$

31. $(2x^2-3y)^2$
$= (2x^2)^2-2(2x^2)(3y)+(3y)^2$ $[(A-B)^2=A^2-2AB+B^2]$
$= 4x^4-12x^2y+9y^2$

33. $(a+3)(a-3)$
$= a^2-3^2$ $[(A+B)(A-B)=A^2-B^2]$
$= a^2-9$

35. The graphs of $y_1=(x+3)(x-3)$ and $y_2=x^2-9$ appear to coincide.

37. $(3x-2y)(3x+2y)$
$= (3x)^2-(2y)^2$ $[(A-B)(A+B)=A^2-B^2]$
$= 9x^2-4y^2$

39. $(2x+3y+4)(2x+3y-4)$
$= [(2x+3y)+4][(2x+3y)-4]$
$= (2x+3y)^2-4^2$
$= 4x^2+12xy+9y^2-16$

41. $(x+1)(x-1)(x^2+1)$
$= (x^2-1)(x^2+1)$
$= x^4-1$

43. ◈

45. $(a^n+b^n)(a^n-b^n)=(a^n)^2-(b^n)^2$
$= a^{2n}-b^{2n}$

47. $(a^n+b^n)^2=(a^n)^2+2\cdot a^n\cdot b^n+(b^n)^2$
$= a^{2n}+2a^nb^n+b^{2n}$

49. $(x-1)(x^2+x+1)(x^3+1)$
$= [(x-1)x^2+(x-1)x+(x-1)\cdot 1](x^3+1)$
$= (x^3-x^2+x^2-x+x-1)(x^3+1)$
$= (x^3-1)(x^3+1)$
$= (x^3)^2-1^2$
$= x^6-1$

51. $(x^{a-b})^{a+b}$
$= x^{(a-b)(a+b)}$
$= x^{a^2-b^2}$

53. $(a+b+c)^2$
$= (a+b+c)(a+b+c)$
$= (a+b+c)(a)+(a+b+c)(b)+(a+b+c)(c)$
$= a^2+ab+ac+ab+b^2+bc+ac+bc+c^2$
$= a^2+b^2+c^2+2ab+2ac+2bc$

55. $(a+b)^4$
$= [(a+b)^2]^2$
$= (a^2+2ab+b^2)^2$
$= [(a^2+2ab)+b^2]^2$
$= (a^2+2ab)^2+2(a^2+2ab)(b^2)+(b^2)^2$
$= a^4+4a^3b+4a^2b^2+2a^2b^2+4ab^3+b^4$
$= a^4+4a^3b+6a^2b^2+4ab^3+b^4$

Exercise Set R.4

1. $2x-10 = 2\cdot x - 2\cdot 5 = 2(x-5)$

3. $3x^4-9x^2 = 3x^2\cdot x^2 - 3x^2\cdot 3 = 3x^2(x^2-3)$

5. $4a^2-12a+16 = 4\cdot a^2 - 4\cdot 3a + 4\cdot 4 = 4(a^2-3a+4)$

7. $a(b-2)+c(b-2) = (b-2)(a+c)$

9. $x^3+3x^2+6x+18$
$= x^2(x+3)+6(x+3)$
$= (x+3)(x^2+6)$

11. $y^3-3y^2-4y+12$
$= y^2(y-3)-4(y-3)$
$= (y-3)(y^2-4)$
$= (y-3)(y+2)(y-2)$

13. The graphs of $y_1 = x^3+3x^2+6x+18$ and $y_2 = (x+3)(x^2+6)$ appear to coincide.

15. p^2+6p+8

We look for two numbers with a product of 8 and a sum of 6. By trial, we determine that they are 2 and 4.

$$p^2+6p+8 = (p+2)(p+4)$$

17. $2n^2+9n-56$

We look for factors $(pn+q)(rn+s)$ for which $pn\cdot rn = 2n^2$ and $q\cdot s = -56$. When we multiply the inside terms, then the outside terms, and add, we must have $9n$. By trial, we determine the factorization:

$$2n^2+9n-56 = (2n-7)(n+8)$$

19. y^4-4y^2-21

Think of this polynomial as $u^2-4u-21$, where we have mentally substituted u for y^2. Then we look for factors of -21 whose sum is -4. By trial we determine the factors to be -7 and 3, so

$$u^2-4u-21 = (u-7)(u+3).$$

Then, substituting y^2 for u, we obtain the factorization of the original trinomial.

$$y^4-4y^2-21 = (y^2-7)(y^2+3)$$

Neither of these factors can be factored further, so the factorization is complete.

21. The graphs of $y_1 = x^2+6x+8$ and $y_2 = (x+2)(x+4)$ appear to coincide.

23. $9x^2-25 = (3x)^2-5^2$
$= (3x+5)(3x-5)$

25. $4xy^4-4xz^2 = 4x(y^4-z^2)$
$= 4x[(y^2)^2-z^2]$
$= 4x(y^2+z)(y^2-z)$

27. $y^2-6y+9 = y^2-2\cdot y\cdot 3+3^2$
$= (y-3)^2$

29. $1-8x+16x^2 = 1^2-2\cdot 1\cdot 4x+(4x)^2$
$= (1-4x)^2$

31. The graphs of $y_1 = 1-8x+16x^2$ and $y_2 = (1-4x)^2$ appear to coincide.

33. $x^3+8 = x^3+2^3$
$= (x+2)(x^2-2x+4)$

35. $m^3-1 = m^3-1^3$
$= (m-1)(m^2+m+1)$

37. The graphs of $y_1 = x^3-1$ and $y_2 = (x-1)(x^2+x+1)$ appear to coincide.

39. $18a^2b-15ab^2 = 3ab\cdot 6a - 3ab\cdot 5b$
$= 3ab(6a-5b)$

41. $x^3-4x^2+5x-20 = x^2(x-4)+5(x-4)$
$= (x-4)(x^2+5)$

43. $8x^2-32 = 8(x^2-4)$
$= 8(x+2)(x-2)$

45. $4x^2-5$

There are no common factors. We might try to factor this polynomial as a difference of squares, but there is no integer which yields 5 when squared. Thus, the polynomial is prime.

47. The graphs of $y_1 = x^3-4x^2+5x-20$ and $y_2 = (x-4)(x^2+5)$ appear to coincide.

49. $x^2+9x+20$

We look for two numbers with a product of 20 and a sum of 9. They are 4 and 5.

$$x^2+9x+20 = (x+4)(x+5)$$

51. y^2-6y+5

We look for two numbers with a product of 5 and a sum of -6. They are -5 and -1.

$$y^2-6y+5 = (y-5)(y-1)$$

53. $2a^2+9a+4$

We look for factors $(pa+q)(ra+s)$ for which $pa\cdot qa = 2a^2$ and $q\cdot s = 4$. When we multiply the inside terms, then the outside terms, and add, we must have $9a$. By trial, we determine the factorization:

$$2a^2+9a+4 = (2a+1)(a+4)$$

55. $6x^2 + 7x - 3$

We look for factors $(px+q)(rx+s)$ for which $px \cdot rx = 6$ and $q \cdot s = -3$. When we multiply the inside terms, then the outside terms, and add, we must have $7x$. By trial, we determine the factorization:

$$6x^2 + 7x - 3 = (3x-1)(2x+3)$$

57. $$\begin{aligned} y^2 - 18y + 81 &= y^2 - 2 \cdot y \cdot 9 + 9^2 \\ &= (y-9)^2 \end{aligned}$$

59. $$\begin{aligned} x^2y^2 - 14xy + 49 &= (xy)^2 - 2 \cdot xy \cdot 7 + 7^2 \\ &= (xy-7)^2 \end{aligned}$$

61. $$\begin{aligned} 4ax^2 + 20ax - 56a &= 4a(x^2 + 5x - 14) \\ &= 4a(x+7)(x-2) \end{aligned}$$

63. $$\begin{aligned} 3z^3 - 24 &= 3(z^3 - 8) \\ &= 3(z^3 - 2^3) \\ &= 3(z-2)(z^2 + 2z + 4) \end{aligned}$$

65. $$\begin{aligned} &16a^7b + 54ab^7 \\ &= 2ab(8a^6 + 27b^6) \\ &= 2ab[(2a^2)^3 + (3b^2)^3] \\ &= 2ab(2a^2 + 3b^2)(4a^4 - 6a^2b^2 + 9b^4) \end{aligned}$$

67. The graphs of $y_1 = 6x^2 + 7x - 3$ and $y_2 = (3x-1)(2x+3)$ appear to coincide.

69.

71. $$\begin{aligned} &y^4 - 84 + 5y^2 \\ &= y^4 + 5y^2 - 84 \\ &= u^2 + 5u - 84 \qquad \text{Substituting } u \text{ for } y^2 \\ &= (u+12)(u-7) \\ &= (y^2+12)(y^2-7) \quad \text{Substituting } y^2 \text{ for } u \end{aligned}$$

73. $$\begin{aligned} y^2 - \frac{8}{49} + \frac{2}{7}y &= y^2 + \frac{2}{7}y - \frac{8}{49} \\ &= \left(y + \frac{4}{7}\right)\left(y - \frac{2}{7}\right) \end{aligned}$$

75. $$\begin{aligned} t^2 - 0.27 + 0.6t &= t^2 + 0.6t - 0.27 \\ &= (t+0.9)(t-0.3) \end{aligned}$$

77. $$\begin{aligned} &(x+h)^3 - x^3 \\ &= [(x+h) - x][(x+h)^2 + x(x+h) + x^2] \\ &= (x+h-x)(x^2 + 2xh + h^2 + x^2 + xh + x^2) \\ &= h(3x^2 + 3xh + h^2) \end{aligned}$$

79. $(x+3)^2 - 2(x+3) - 35$

Think of this polynomial as $u^2 - 2u - 35$, where we have mentally substituted u for $x+3$. Then we look for factors of -35 whose sum is -2. By trial we determine the factors to be -7 and 5, so

$$u^2 - 2u - 35 = (u-7)(u+5).$$

Then, substituting $x+3$ for u, we obtain the factorization of the original trinomial.

$$\begin{aligned} (x+3)^2 - 2(x+3) - 35 &= (x+3-7)(x+3+5) \\ &= (x-4)(x+8) \end{aligned}$$

81. $3(a-b)^2 + 10(a-b) - 8$

Think of this polynomial as $3u^2 + 10u - 8$, where we have mentally substituted u for $a-b$. Then we look for factors of $(pu+q)(ru+s)$ for which $pu \cdot ru = 3u^2$ and $q \cdot s = -8$. When we multiply the inside terms, then the outside terms, and add, the sum must be $10u$. By trial, we determine the factorization to be

$$(3u-2)(u+4).$$

Then, substituting $a-b$ for u, we obtain the factorization of the original trinomial.

$$\begin{aligned} &3(a-b)^2 + 10(a-b) - 8 \\ &= [3(a-b) - 2](a-b+4) \\ &= (3a - 3b - 2)(a-b+4) \end{aligned}$$

83. $$\begin{aligned} x^{2n} + 5x^n - 24 &= (x^n)^2 + 5x^n - 24 \\ &= (x^n + 8)(x^n - 3) \end{aligned}$$

85. $$\begin{aligned} x^2 + ax + bx + ab &= x(x+a) + b(x+a) \\ &= (x+a)(x+b) \end{aligned}$$

87. $$\begin{aligned} &\frac{1}{4}t^2 - \frac{2}{5}t + \frac{4}{25} \\ &= \left(\frac{1}{2}t\right)^2 - 2 \cdot \frac{1}{2}t \cdot \frac{2}{5} + \left(\frac{2}{5}\right)^2 \\ &= \left(\frac{1}{2}t - \frac{2}{5}\right)^2 \end{aligned}$$

89. $$\begin{aligned} &25y^{2m} - (x^{2n} - 2x^n + 1) \\ &= (5y^m)^2 - (x^n - 1)^2 \\ &= [5y^m + (x^n - 1)][5y^m - (x^n - 1)] \\ &= (5y^m + x^n - 1)(5y^m - x^n + 1) \end{aligned}$$

91. $$\begin{aligned} &3x^{3n} - 24y^{3m} \\ &= 3(x^{3n} - 8y^{3m}) \\ &= 3[(x^n)^3 - (2y^m)^3] \\ &= 3(x^n - 2y^m)(x^{2n} + 2x^ny^m + 4y^{2m}) \end{aligned}$$

93. $$\begin{aligned} &(y-1)^4 - (y-1)^2 \\ &= (y-1)^2[(y-1)^2 - 1] \\ &= (y-1)^2[y^2 - 2y + 1 - 1] \\ &= (y-1)^2(y^2 - 2y) \\ &= y(y-1)^2(y-2) \end{aligned}$$

Exercise Set R.5

1. Since $-\frac{3}{4}$ is defined for all real numbers, the domain is $\{x|x \text{ is a real number}\}$.

3. $\dfrac{3x-3}{x(x-1)}$

The denominator is 0 when the factor $x = 0$ and also when $x - 1 = 0$, or $x = 1$. The domain is $\{x|x \text{ is a real number and } x \neq 0 \text{ and } x \neq 1\}$.

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