Intermediate Algebra - Concepts and Applications 11th edition Bittinger Solutions Manual

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INSTRUCTOR SOLUTIONS MANUAL

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INTERMEDIATE ALGEBRA: CONCEPTS AND APPLICATIONS

ELEVENTH EDITION

Bittinger/Ellenbogen/Johnson

Pearson

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Just-in-Time Review

1 The Factors of a Number

1. $20 = 1 \cdot 20$
$20 = 2 \cdot 10$
$20 = 4 \cdot 5$
The factors are 1, 2, 4, 5, 10, 20.

2. $39 = 1 \cdot 39$
$39 = 3 \cdot 13$
The factors are 1, 3, 13, 39.

3. $81 = 1 \cdot 81$
$81 = 3 \cdot 27$
$81 = 9 \cdot 9$
The factors are 1, 3, 9, 27, 81.

4. $47 = 1 \cdot 47$
The factors are 1, 47.

5. $160 = 1 \cdot 160$
$160 = 2 \cdot 80$
$160 = 4 \cdot 40$
$160 = 5 \cdot 32$
$160 = 8 \cdot 20$
$160 = 10 \cdot 16$
The factors are 1, 2, 4, 5, 10, 16, 20, 32, 40, 80, 160.

6. $45 = 1 \cdot 45$
$45 = 3 \cdot 15$
$45 = 5 \cdot 9$
The factors are 1, 3, 5, 9, 15, 45.

7. $28 = 1 \cdot 28$
$28 = 2 \cdot 14$
$28 = 4 \cdot 7$
The factors are 1, 2, 4, 7, 14, 28.

8. $36 = 1 \cdot 36$
$36 = 2 \cdot 18$
$36 = 3 \cdot 9$
$36 = 4 \cdot 6$
The factors are 1, 2, 3, 4, 6, 9, 12, 18, 36.

2 Prime Factorizations

1. $33 = 3 \cdot 11$
The prime factorization is $3 \cdot 11$.

2. $121 = 11 \cdot 11$
The prime factorization is $11 \cdot 11$.

3. $18 = 2 \cdot 9 = 2 \cdot 3 \cdot 3$
The prime factorization is $2 \cdot 3 \cdot 3$.

4. $56 = 2 \cdot 28 = 2 \cdot 2 \cdot 14 = 2 \cdot 2 \cdot 2 \cdot 7$
The prime factorization is $2 \cdot 2 \cdot 2 \cdot 7$.

5. $120 = 2 \cdot 60 = 2 \cdot 2 \cdot 30 = 2 \cdot 2 \cdot 2 \cdot 15 = 2 \cdot 2 \cdot 2 \cdot 3 \cdot 5$
The prime factorization is $2 \cdot 2 \cdot 2 \cdot 3 \cdot 5$.

6. $90 = 2 \cdot 45 = 2 \cdot 3 \cdot 15 = 2 \cdot 3 \cdot 3 \cdot 5$
The prime factorization is $2 \cdot 3 \cdot 3 \cdot 5$.

7. $210 = 2 \cdot 105 = 2 \cdot 3 \cdot 35 = 2 \cdot 3 \cdot 5 \cdot 7$
The prime factorization is $2 \cdot 3 \cdot 5 \cdot 7$.

8. $91 = 7 \cdot 13$
The prime factorization is $7 \cdot 13$.

3 Multiplying and Dividing with Fraction Notation

1. $\frac{3}{7} \cdot \frac{9}{10} = \frac{3 \cdot 9}{7 \cdot 10} = \frac{27}{70}$

2. $5 \cdot \frac{2}{3} = \frac{5}{1} \cdot \frac{2}{3} = \frac{5 \cdot 2}{1 \cdot 3} = \frac{10}{3}$

3. $\frac{3}{4} \div \frac{3}{7} = \frac{3}{4} \cdot \frac{7}{3} = \frac{3 \cdot 7}{4 \cdot 3} = \frac{\cancel{3} \cdot 7}{4 \cdot \cancel{3}} = \frac{7}{4}$

4. $\frac{15}{16} \cdot \frac{8}{5} = \frac{15 \cdot 8}{16 \cdot 5} = \frac{3 \cdot 5 \cdot 8}{2 \cdot 8 \cdot 5} = \frac{3 \cdot \cancel{5} \cdot \cancel{8}}{2 \cdot \cancel{8} \cdot \cancel{5}} = \frac{3}{2}$

5. $\frac{2}{5} \div \frac{7}{3} = \frac{2}{5} \cdot \frac{3}{7} = \frac{2 \cdot 3}{5 \cdot 7} = \frac{6}{35}$

6. $\frac{8}{9} \div \frac{4}{15} = \frac{8}{9} \cdot \frac{15}{4} = \frac{2 \cdot 4 \cdot 3 \cdot 5}{3 \cdot 3 \cdot 4} = \frac{2 \cdot \cancel{4} \cdot \cancel{3} \cdot 5}{\cancel{3} \cdot 3 \cdot \cancel{4}} = \frac{10}{3}$

7. $\frac{1}{20} \div \frac{1}{5} = \frac{1}{20} \cdot \frac{5}{1} = \frac{5}{4 \cdot 5} = \frac{1}{4}$

8. $\frac{5}{2} \cdot \frac{8}{5} = \frac{5 \cdot 8}{2 \cdot 5} = \frac{5 \cdot 2 \cdot 4}{2 \cdot 5} = \frac{\cancel{5} \cdot \cancel{2} \cdot 4}{\cancel{2} \cdot \cancel{5}} = 4$

9. $\frac{10}{11} \cdot \frac{11}{10} = \frac{10 \cdot 11}{11 \cdot 10} = 1$

10. $\frac{3}{4} \div 8 = \frac{3}{4} \cdot \frac{1}{8} = \frac{3}{4 \cdot 8} = \frac{3}{32}$

4 Adding and Subtracting with Fraction Notation

1. $\frac{5}{11} + \frac{3}{11} = \frac{5+3}{11} = \frac{8}{11}$

2. $\frac{12}{5} - \frac{2}{5} = \frac{12-2}{5} = \frac{10}{5} = 2$

3. $\frac{11}{12} - \frac{3}{8} = \frac{11}{12} \cdot \frac{2}{2} - \frac{3}{8} \cdot \frac{3}{3} = \frac{22}{24} - \frac{9}{24} = \frac{22-9}{24} = \frac{13}{24}$

4. $\frac{4}{9} + \frac{13}{18} = \frac{4}{9} \cdot \frac{2}{2} + \frac{13}{18} = \frac{8+13}{18} = \frac{21}{18} = \frac{3 \cdot 7}{3 \cdot 6} = \frac{7}{6}$

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5. $\frac{3}{10}+\frac{8}{15}=\frac{3}{10}\cdot\frac{3}{3}+\frac{8}{15}\cdot\frac{2}{2}=\frac{9+16}{30}=\frac{25}{30}=\frac{5\cdot5}{5\cdot6}=\frac{5}{6}$

6. $\frac{3}{16}-\frac{1}{18}=\frac{3}{16}\cdot\frac{9}{9}-\frac{1}{18}\cdot\frac{8}{8}=\frac{27-8}{144}=\frac{19}{144}$

7. $\frac{7}{30}+\frac{5}{12}=\frac{7}{30}\cdot\frac{2}{2}+\frac{5}{12}\cdot\frac{5}{5}=\frac{14+25}{60}=\frac{39}{60}=\frac{3\cdot13}{3\cdot20}=\frac{13}{20}$

8. $\frac{15}{16}-\frac{5}{12}=\frac{15}{16}\cdot\frac{3}{3}-\frac{5}{12}\cdot\frac{4}{4}=\frac{45-20}{48}=\frac{25}{48}$

9. $\frac{11}{12}-\frac{2}{5}=\frac{11}{12}\cdot\frac{5}{5}-\frac{2}{5}\cdot\frac{12}{12}=\frac{55-24}{60}=\frac{31}{60}$

10. $\frac{1}{4}+\frac{1}{3}=\frac{1}{4}\cdot\frac{3}{3}+\frac{1}{3}\cdot\frac{4}{4}=\frac{3+4}{12}=\frac{7}{12}$

11. $\frac{9}{8}+\frac{7}{12}=\frac{9}{8}\cdot\frac{3}{3}+\frac{7}{12}\cdot\frac{2}{2}=\frac{27+14}{24}=\frac{41}{24}$

12. $\frac{147}{50}-2=\frac{147}{50}-\frac{2}{1}\cdot\frac{50}{50}=\frac{147-100}{50}=\frac{47}{50}$

5 Converting between Percent Notation and Decimal Notation

1. 63% = 0.63

2. 94.1% = 0.941

3. 240% = 2.4

4. 0.81% = 0.0081

5. 2.3% = 0.023

6. 100% = 1

7. 0.76 = 76%

8. 5 = 500%

9. 0.093 = 9.3%

10. 0.0047 = 0.47%

11. 0.675 = 67.5%

12. 1.34 = 134%

6 Unit Conversion

1. $3.5\text{ ft}=3.5\cdot1\text{ ft}=3.5\cdot12\text{ in.}=42\text{ in.}$

2. $1\frac{1}{5}\text{ mi}=1\frac{1}{5}\cdot1\text{ mi}=1\frac{1}{5}\cdot5280\text{ ft}=6336\text{ ft}$

3. $4.06\text{ km}=4.06\cdot1\text{ km}=4.06\cdot1000\text{ m}=4060\text{ m}$

4. $15\text{ in.}=15\cdot1\text{ in.}=15\cdot2.54\text{ cm}=38.1\text{ cm}$

5. $2000\text{ cm}=\frac{2000\ \cancel{\text{cm}}}{1}\cdot\frac{1\text{ m}}{100\ \cancel{\text{cm}}}=20\text{ m}$

6. $1760\text{ ft}=\frac{1760\ \cancel{\text{ft}}}{1}\cdot\frac{1\text{ mi}}{5280\ \cancel{\text{ft}}}=\frac{1760}{3\cdot1760}\text{ mi}=\frac{1}{3}\text{ mi}$

7. $13{,}200\text{ in.}=\frac{13{,}200\ \cancel{\text{in}}}{1}\cdot\frac{1\ \cancel{\text{ft}}}{12\ \cancel{\text{in}}}\cdot\frac{1\text{ mi}}{5280\ \cancel{\text{ft}}}=\frac{5}{24}\text{ mi}$

8. $3\text{ km}\approx\frac{3\text{ km}}{1}\cdot\frac{1\text{ mi}}{1.609\text{ km}}\approx1.86\text{ mi}$

9. $5\frac{1}{3}\text{ yd}=5\frac{1}{3}\cdot1\text{ yd}=5\frac{1}{3}\cdot3\text{ ft}=16\text{ ft}$

10. $66\text{ in.}=\frac{66\text{ in.}}{1}\cdot\frac{1\text{ ft}}{12\text{ in.}}=5\frac{1}{2}\text{ ft}$

11. $2\frac{1}{2}\text{ km}=2\frac{1}{2}\cdot1\text{ km}=2\frac{1}{2}\cdot1000\text{ m}=2500\text{ m}$

12. $6.1\text{ km}=\frac{6.1\text{ km}}{1}\cdot\frac{1000\text{ m}}{1\text{ km}}\cdot\frac{100\text{ cm}}{1\text{ m}}=610{,}000\text{ cm}$

13. $8\text{ cm}\approx\frac{8\text{ cm}}{1}\cdot\frac{1\text{ in.}}{2.54\text{ cm}}\approx3.15\text{ in.}$

14. $6\text{ km}\approx\frac{6\text{ km}}{1}\cdot\frac{1\text{ mi}}{1.609\text{ km}}\cdot\frac{5280\text{ ft}}{1\text{ mi}}\approx19{,}689\text{ ft}$

7 Order for the Real Numbers

1. $-5<-4$, since -5 is to the left of -4

2. $-\frac{1}{4}>-\frac{1}{2}$, since $-\frac{1}{4}$ is to the right of $-\frac{1}{2}$

3. $87>67$, since 87 is to the right of 67

4. $-9.8<-4\frac{2}{3}$, since -9.8 is to the left of $-4\frac{2}{3}$

5. $6.78>-6.77$, since 6.78 is to the right of -6.77

6. $-\frac{4}{5}>-0.86$, since $-\frac{4}{5}=-0.8$ is to the right of -0.86

7. $\frac{14}{29}<\frac{17}{32}$, since $\frac{14}{29}\approx0.48$ is to the left of $\frac{17}{32}\approx0.53$

8. $-\frac{12}{13}>-\frac{14}{15}$,
since $-\frac{12}{13}\approx-0.92$ is to the right of $-\frac{14}{15}\approx-0.93$

9. $1.8>1.08$, since 1.8 is to the right of 1.08

10. $0>-4$, since 0 is to the right of -4

11. $6<x$

12. $7>-4$

13. True

14. True

15. False

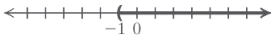
16. True

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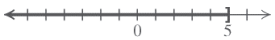
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8 Graphing Inequalities on the Number Line

1. $x > -1$



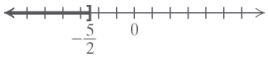
2. $x \le 5$



3. $x > 0$



4. $x \le -\frac{5}{2}$



9 Exponential Notation

1. $yyyyyy = y^6$

2. $8 \cdot 8 \cdot 8 \cdot 8 = 8^4$

3. $(3.8)(3.8)(3.8)(3.8)(3.8) = (3.8)^5$

4. $\left(-\frac{4}{5}\right)\left(-\frac{4}{5}\right)\left(-\frac{4}{5}\right) = \left(-\frac{4}{5}\right)^3$

5. $2^4 = 2 \cdot 2 \cdot 2 \cdot 2 = 16$

6. $(-1)^3 = (-1)(-1)(-1) = -1$

7. $(-1)^4 = (-1)(-1)(-1)(-1) = 1$

8. $(-2)^6 = (-2)(-2)(-2)(-2)(-2)(-2) = 64$

9. $(-7)^3 = (-7)(-7)(-7) = -343$

10. $\left(\frac{1}{3}\right)^3 = \left(\frac{1}{3}\right)\left(\frac{1}{3}\right)\left(\frac{1}{3}\right) = \frac{1}{27}$

11. $(0.1)^6 = (0.1)(0.1)(0.1)(0.1)(0.1)(0.1) = 0.000001$

12. $\left(-\frac{5}{7}\right)^2 = \left(-\frac{5}{7}\right)\left(-\frac{5}{7}\right) = \frac{25}{49}$

13. $-(3)^4 = -(3)(3)(3)(3) = -81$

14. $(-3)^4 = (-3)(-3)(-3)(-3) = 81$

15. $-3^4 = -3 \cdot 3 \cdot 3 \cdot 3 = -81$

16. $2^3 5^2 = 2 \cdot 2 \cdot 2 \cdot 5 \cdot 5 = 200$

17. $-(-1)^5 = -(-1)(-1)(-1)(-1)(-1) = 1$

18. $(3x)^2 = 3x \cdot 3x = 3 \cdot 3 \cdot x \cdot x = 9x^2$

19. $(xy)^3 = xy \cdot xy \cdot xy = x \cdot x \cdot x \cdot y \cdot y \cdot y = x^3 y^3$

20. $2(5x)^2 = 2 \cdot 5x \cdot 5x = 2 \cdot 5 \cdot 5 \cdot x \cdot x = 50x^2$

21. $\left(\frac{3}{4}\right)^1 = \frac{3}{4}$

22. $17^0 = 1$

23. $(-3.9)^0 = 1$

24. $(-723)^1 = -723$

10 Order of Operations

1. $9[8 - 7(5 - 2)] = 9[8 - 7(3)]$
$= 9[8 - 21]$
$= 9[-13]$
$= -117$

2. $(9 - 12)^2 = (-3)^2 = 9$

3. $4 \div (8 - 10)^2 + 1 = 4 \div (-2)^2 + 1$
$= 4 \div 4 + 1$
$= 1 + 1$
$= 2$

4. $[64 \div (-4)] \div (-2) = [-16] \div (-2) = 8$

5. $9^2 - 12^2 = 81 - 144 = -63$

6. $[24 \div (-3)] \div \left(-\frac{1}{2}\right) = [-8] \div \left(-\frac{1}{2}\right) = \frac{-8}{1} \cdot \frac{-2}{1} = 16$

7. $9 \div (-3) + 16 \div 8 = -3 + 2 = -1$

8. $20 + 4^3 \div (-8) = 20 + 64 \div (-8) = 20 + (-8) = 12$

9. $256 \div (-32) \div (-4) = -8 \div (-4) = 2$

10. $9[(8 - 11) - 13] = 9[(-3) - 13] = 9[-16] = -144$

11. $18 - 2 \cdot 3 - 9 = 18 - 6 - 9 = 12 - 9 = 3$

12. $(13 \cdot 2 - 8 \cdot 4)^2 = (26 - 32)^2 = (-6)^2 = 36$

13. $12 - 4(5 - 1) = 12 - 4(4) = 12 - 16 = -4$

14. $[2 \cdot (5 - 3)]^2 = [2 \cdot (2)]^2 = [4]^2 = 16$

15. $[5(8 - 6) + 12] - [24 - (8 - 4)]$
$= [5(2) + 12] - [24 - 4]$
$= [10 + 12] - [20]$
$= 22 - 20$
$= 2$

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16. $-32-18\div[4-(-2)]=-32-18\div[4+2]$
$=-32-18\div[6]$
$=-32-3$
$=-35$

17. $2^5-[4\cdot3-2(1+4\cdot2)]=2^5-[4\cdot3-2(1+8)]$
$=2^5-[4\cdot3-2(9)]$
$=2^5-[12-18]$
$=2^5-[-6]$
$=32+6$
$=38$

18. $10-3\{8\div[4-(11-6)]\}=10-3\{8\div[4-5]\}$
$=10-3\{8\div[-1]\}$
$=10-3\{-8\}$
$=10+24$
$=34$

19. $\dfrac{4|6-7|-5\cdot4}{6\cdot7-8|4-1|}=\dfrac{4|-1|-5\cdot4}{6\cdot7-8|3|}$
$=\dfrac{4(1)-5\cdot4}{6\cdot7-8(3)}$
$=\dfrac{4-20}{42-24}$
$=\dfrac{-16}{18}$
$=-\dfrac{8}{9}$

20. $\dfrac{(8-3)^2+(7-10)^2}{3^2-2^3}=\dfrac{(5)^2+(-3)^2}{3^2-2^3}=\dfrac{25+9}{9-8}=34$

11 Evaluating Algebraic Expressions

1. $57y=57(-8)=-456$

2. $\dfrac{x}{y}=\dfrac{30}{-6}=-5$

3. $\dfrac{5}{p+q}=\dfrac{5}{20+30}=\dfrac{5}{50}=\dfrac{1}{10}$

4. $\dfrac{18m}{n}=\dfrac{18(7)}{18}=7$

5. $4x-y=4(3)-(-2)=12+2=14$

6. $2c\div3b=2(6)\div3(4)=12\div3(4)=4(4)=16$

7. $25-x(3-y)=25-(-2)(3-[-1])$
$=25+2(3+1)$
$=25+2(4)$
$=25+8$
$=33$

8. $25-r^2+s\div r^2=25-3^2+27\div3^2$
$=25-9+27\div9$
$=25-9+3$
$=16+3$
$=19$

12 Equivalent Fraction Expressions

1. $\dfrac{7}{8}=\dfrac{7}{8}\cdot1=\dfrac{7}{8}\cdot\dfrac{x}{x}=\dfrac{7x}{8x}$

2. $\dfrac{3}{10}=\dfrac{3}{10}\cdot1=\dfrac{3}{10}\cdot\dfrac{5y}{5y}=\dfrac{15y}{50y}$

3. $\dfrac{1}{17}=\dfrac{1}{17}\cdot1=\dfrac{1}{17}\cdot\dfrac{3b}{3b}=\dfrac{3b}{51b}$

4. $\dfrac{300}{49}=\dfrac{300}{49}\cdot1=\dfrac{300}{49}\cdot\dfrac{2w}{2w}=\dfrac{600w}{98w}$

5. $\dfrac{25x}{15x}=\dfrac{5\cdot5x}{3\cdot5x}=\dfrac{5}{3}\cdot\dfrac{5x}{5x}=\dfrac{5}{3}\cdot1=\dfrac{5}{3}$

6. $\dfrac{36y}{18y}=\dfrac{2\cdot18y}{1\cdot18y}=\dfrac{2}{1}\cdot\dfrac{18y}{18y}=2\cdot1=2$

7. $-\dfrac{100a}{25a}=-\dfrac{4\cdot25a}{1\cdot25a}=-\dfrac{4}{1}\cdot\dfrac{25a}{25a}=-4\cdot1=-4$

8. $-\dfrac{625t}{15t}=-\dfrac{125\cdot5t}{3\cdot5t}=-\dfrac{125}{3}\cdot\dfrac{5t}{5t}=-\dfrac{125}{3}\cdot1=-\dfrac{125}{3}$

13 Combining Like Terms

1. $7x+5x=(7+5)x=12x$

2. $8b-11b=(8-11)b=-3b$

3. $14y+y=(14+1)y=15y$

4. $12a-a=(12-1)a=11a$

5. $t-9t=(1-9)t=-8t$

6. $5x-3x+8x=(5-3+8)x=(2+8)x=10x$

7. $3c+8d-7c+4d=3c-7c+8d+4d$
$=(3-7)c+(8+4)d$
$=-4c+12d$

8. $4x-7+18x+25=4x+18x-7+25$
$=(4+18)x+(-7+25)$
$=22x+18$

9. $1.3x+1.4y-0.11x-0.47y$
$=1.3x-0.11x+1.4y-0.47y$
$=(1.3-0.11)x+(1.4-0.47)y$
$=1.19x+0.93y$

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10. $\frac{2}{3}a+\frac{5}{6}b-27-\frac{4}{5}a-\frac{7}{6}b$

$=\frac{2}{3}a-\frac{4}{5}a+\frac{5}{6}b-\frac{7}{6}b-27$

$=\left(\frac{2}{3}-\frac{4}{5}\right)a+\left(\frac{5}{6}-\frac{7}{6}\right)b-27$

$=\left(\frac{2}{3}\cdot\frac{5}{5}-\frac{4}{5}\cdot\frac{3}{3}\right)a+\left(\frac{5-7}{6}\right)b-27$

$=\left(\frac{10}{15}-\frac{12}{15}\right)a+\left(-\frac{2}{6}\right)b-27$

$=\left(\frac{10-12}{15}\right)a+\left(-\frac{1}{3}\cdot\frac{2}{2}\right)b-27$

$=-\frac{2}{15}a-\frac{1}{3}b-27$

14 Removing Parentheses and Combining Like Terms

1. $-(-2c)=-1(-2c)=(-1)(-2)c=2c$

2. $-(b+4)=-1(b+4)=-1\cdot b+(-1)\cdot 4=-b-4$

3. $-(x-8)=-1(x-8)=-1\cdot x+(-1)\cdot(-8)$

$=-x+8$, or $8-x$

4. $-(t-y)=-1(t-y)=-1\cdot t+(-1)\cdot(-y)$

$=-t+y$, or $y-t$

5. $-(r+s+t)=-1(r+s+t)$

$=-1\cdot r+(-1)\cdot s+(-1)\cdot t$

$=-r-s-t$

6. $-(8x-6y+13)=-1(8x-6y+13)$

$=-1\cdot 8x+(-1)\cdot(-6y)+(-1)\cdot 13$

$=-8x+6y-13$

7. $4m-(3m-1)=4m-3m+1=m+1$

8. $7a-[9-3(5a-2)]=7a-[9-3(5a)-3(-2)]$

$=7a-[9-15a+6]$

$=7a-[-15a+9+6]$

$=7a-[-15a+15]$

$=7a+15a-15$

$=22a-15$

9. $-2(x+3)-5(x-4)=-2x-6-5x+20$

$=(-2x-5x)+(-6+20)$

$=-7x+14$

10. $8x-(-3y+7)+(9x-11)=8x+3y-7+9x-11$

$=(8x+9x)+3y+(-7-11)$

$=17x+3y-18$

11. $[7(x+5)-19]-[4(x-6)+10]$

$=[7x+35-19]-[4x-24+10]$

$=[7x+16]-[4x-14]$

$=7x+16-4x+14$

$=(7x-4x)+(16+14)$

$=3x+30$

12. $5\{-2+3[4-2(3+5)]\}=5\{-2+3[4-2(8)]\}$

$=5\{-2+3[4-16]\}$

$=5\{-2+3[-12]\}$

$=5\{-2-36\}$

$=5\{-38\}$

$=-190$

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Chapter 1

Algebra and Problem Solving

Exercise Set 1.1

1. A letter that can be any one of a set of numbers is called a *variable*.

2. A letter representing a specific number that never changes is called a *constant*.

3. When $x = 10$, the *value* of the expression $4x$ is 40.

4. In a^b, the letter a is called the *base* and the letter b is called the *exponent*.

5. When all variables in a variable expression are replaced by numbers and a result is calculated, we say that we are *evaluating* the expression.

6. To calculate $4+12\div 3\cdot 2$, the first operation that we perform is *division*.

7. A number that can be written in the form a/b, where a and b are integers (with $b \neq 0$) is said to be a *rational* number.

8. A real number that cannot be written as a quotient of two integers is an example of an *irrational* number.

9. Division can be used to show that $\frac{7}{40}$ can be written as a *terminating* decimal.

10. Division can be used to show that $\frac{13}{7}$ can be written as a *repeating* decimal.

11. Five less than some number
Let n represent the number; $n - 5$

12. Let n represent the number; $n + 10$, or $10 + n$

13. Twice a number
Let x represent the number; $2x$

14. Let t represent the number: $8t$

15. Twenty-nine percent of some number
Let x represent the number; $0.29x$, or $\frac{29}{100}x$

16. Let x represent the number; $0.13x$, or $\frac{13}{100}x$

17. Six less than half of a number
Let y represent the number; $\frac{1}{2}y - 6$

18. Let y represent the number; $2y + 3$

19. Seven more than ten percent of some number
Let s represent the number; $0.1s + 7$, or $\frac{10}{100}s + 7$

20. Let s represent the number; $0.06s - 4$, or $\frac{6}{100}s - 4$

21. One less than the product of two numbers
Let m and n represent the numbers; $mn - 1$

22. Let m and n represent the number; $m - n + 1$

23. Ninety miles per every four gallons of gas
We have

$$90 \div 4, \text{ or } \frac{90}{4}.$$

24. $100 \div 60$, or $\frac{100}{60}$

25. The area of a square is given by $A = s^2$. We substitute $s = 6$ and solve.

$$A = s^2 = 6^2 = 36 \text{ ft}^2$$

26. $A = s^2 = 12^2 = 144 \text{ ft}^2$

27. The area of a square is given by $A = s^2$. We substitute $s = 0.5$ and solve.

$$A = s^2 = 0.5^2 = 0.25 \text{ m}^2$$

28. $A = s^2 = 2.5^2 = 6.25 \text{ m}^2$

29. The area of a triangle is given by $A = \frac{1}{2}bh$. We substitute $b = 5$, $h = 7$ and solve.

$$A = \frac{1}{2}bh = \frac{1}{2}(5)(7) = 17.5 \text{ ft}^2$$

30. $A = \frac{1}{2}bh = \frac{1}{2}(2.9)(2.1) = 3.045 \text{ m}^2$

31. The area of a triangle is given by $A = \frac{1}{2}bh$. We substitute $b = 7$, $h = 3.2$ and solve.

$$A = \frac{1}{2}bh = \frac{1}{2}(7)(3.2) = 11.2 \text{ ft}^2$$

32. $A = \frac{1}{2}bh = \frac{1}{2}(3.6)(4) = 7.2 \text{ ft}^2$

33. Substitute and carry out the operations indicated.

$$\begin{aligned} 3(x-7)+2 &= 3(10-7)+2 \\ &= 3(3)+2 \\ &= 9+2 \\ &= 11 \end{aligned}$$

34. $5+(2x-3) = 5+(2\cdot 8-3)$
$= 5+(16-3)$
$= 5+13$
$= 18$

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35. Substitute and carry out the operations indicated.

$$\begin{aligned}12+3(n+2)^2 &= 12+3(1+2)^2\\ &= 12+3(3)^2\\ &= 12+3(9)\\ &= 12+27\\ &= 39\end{aligned}$$

36. $$\begin{aligned}(n-10)^2-8 &= (15-10)^2-8\\ &= (5)^2-8\\ &= 25-8\\ &= 17\end{aligned}$$

37. Substitute and carry out the operations indicated.

$$\begin{aligned}4x+y &= 4\cdot 2+3\\ &= 8+3\\ &= 11\end{aligned}$$

38. $$\begin{aligned}8a-b &= 8\cdot 5-7\\ &= 40-7\\ &= 33\end{aligned}$$

39. Substitute and carry out the operations indicated.

$$\begin{aligned}20+r^2-s &= 20+(5)^2-10\\ &= 20+25-10\\ &= 35\end{aligned}$$

40. $$\begin{aligned}m^3+7-n &= 2^3+7-8\\ &= 8+7-8\\ &= 7\end{aligned}$$

41. Substitute and carry out the operations indicated.

$$\begin{aligned}2c\div 3b &= 2\cdot 6\div 3\cdot 2\\ &= 12\div 3\cdot 2\\ &= 4\cdot 2\\ &= 8\end{aligned}$$

42. $$\begin{aligned}3z\div 2y &= 3\cdot 6\div 2\cdot 1\\ &= 18\div 2\cdot 1\\ &= 9\cdot 1\\ &= 9\end{aligned}$$

43. $3n^2p-3pn^2 = 3\cdot 5^2\cdot 9-3\cdot 9\cdot 5^2$

Observe that $3\cdot 5^2\cdot 9$ and $3\cdot 9\cdot 5^2$ represent the same number, so their difference is 0.

44. $$\begin{aligned}2a^3b-2b^2 &= 2\cdot 3^3\cdot 7-2\cdot 7^2\\ &= 2\cdot 27\cdot 7-2\cdot 49\\ &= 54\cdot 7-98\\ &= 378-98\\ &= 280\end{aligned}$$

45. Substitute and carry out the operations indicated.

$$\begin{aligned}5x\div(2+x-y) &= 5\cdot 6\div(2+6-2)\\ &= 5\cdot 6\div(8-2)\\ &= 5\cdot 6\div 6\\ &= 30\div 6\\ &= 5\end{aligned}$$

46. $$\begin{aligned}3(m+2n)\div m &= 3(7+2\cdot 0)\div 7\\ &= 3(7+0)\div 7\\ &= 3\cdot 7\div 7\\ &= 21\div 7\\ &= 3\end{aligned}$$

47. Substitute and carry out the operations indicated.

$$\begin{aligned}[10-(a-b)]^2 &= [10-(7-2)]^2\\ &= [10-5]^2\\ &= 5^2\\ &= 25\end{aligned}$$

48. $$\begin{aligned}\left[17-(x+y)\right]^2 &= [17-(4+1)]^2\\ &= [17-5]^2\\ &= 12^2\\ &= 144\end{aligned}$$

49. Substitute and carry out the operations indicated.

$$\begin{aligned}[5(r+s)]^2 &= [5(1+2)]^2\\ &= [5(3)]^2\\ &= 15^2\\ &= 225\end{aligned}$$

50. $$\begin{aligned}[3(a-b)]^2 &= [3(7-5)]^2\\ &= [3(2)]^2\\ &= 6^2\\ &= 36\end{aligned}$$

51. Substitute and carry out the operations indicated.

$$\begin{aligned}x^2-\left[3(x-y)\right]^2 &= 6^2-[3(6-4)]^2\\ &= 6^2-[3(2)]^2\\ &= 6^2-6^2\\ &= 0\end{aligned}$$

52. $$\begin{aligned}m^2-[2(m-n)]^2 &= 7^2-[2(7-5)]^2\\ &= 7^2-[2(2)]^2\\ &= 7^2-4^2\\ &= 49-16\\ &= 33\end{aligned}$$

53. Substitute and carry out the operations indicated.

$$\begin{aligned}(m-2n)^2-2(m+n) &= (8-2\cdot 1)^2-2(8+1)\\ &= (8-2)^2-2(9)\\ &= 6^2-2(9)\\ &= 36-2(9)\\ &= 36-18\\ &= 18\end{aligned}$$

54. $$\begin{aligned}(r-s)^2-3(2r-s) &= (11-3)^2-3(2\cdot 11-3)\\ &= 8^2-3(22-3)\\ &= 8^2-3(19)\\ &= 64-3(19)\\ &= 64-57\\ &= 7\end{aligned}$$

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55. List the letters in the set: {a, l, g, e, b, r}

56. {Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday}

57. List the numbers in the set: {1, 3, 5, 7, … }

58. {2, 4, 6, 8, … }

59. List the numbers in the set: {10, 20, 30, 40, … }

60. {5, 10, 15, 20, … }

61. Specify the conditions under which a number is in the set: $\{x|x$ is an even number between 9 and 99$\}$

62. $\{n|n$ is a multiple of 5 between 7 and 79$\}$

63. Specify the conditions under which a number is in the set: $\{x|x$ is whole number less than 5$\}$

64. $\{x|x$ is an integer greater than -4 and less than 3$\}$

65. Specify the conditions under which a number is in the set: $\{x|x$ is an odd number between 10 and 20$\}$

66. $\{x|x$ is an even number between 23 and 33$\}$

67. **a.** 0 and 6 are whole numbers.
b. –3, 0, and 6 are integers.
c. –8.7, –3, 0, $\frac{2}{3}$, and 6 are rational numbers.
d. $\sqrt{7}$ is an irrational number.
e. All of the given numbers are real numbers.

68. **a.** 0, 3
b. –4, 0, 3
c. $-\frac{9}{2}$, –4, –1.2, 0, 3
d. $\sqrt{5}$
e. All of the given numbers are real numbers.

69. **a.** 0 and 8 are whole numbers.
b. –17, 0, and 8 are integers.
c. –17, –0.01, 0, $\frac{5}{4}$, and 8 are rational numbers.
d. $\sqrt{77}$ is an irrational number.
e. All of the given numbers are real numbers.

70. **a.** 0, 1
b. –5, 0, 1
c. –6.08, –5, 0, 1, $\frac{99}{2}$
d. $\sqrt{17}$
e. All of the given numbers are real numbers.

71. Since 196 is a natural number, the statement is true.

72. Since every member of the set of natural numbers is also a member of the set of whole numbers, the statement is true.

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

74. Since $\sqrt{8}$ is not a rational number, the statement is false.

75. Since $\frac{2}{3}$ is not an integer, the statement is false.

76. Since every member of the set of irrational numbers is also a member of the set of real numbers, the statement is true.

77. Since $\sqrt{10}$ is an irrational number, and every member of the set of irrational numbers is a member of the set of real numbers, the statement is true.

78. Since 4.3 is not an integer, the statement is true.

79. Since the set of integers includes some numbers that are not natural numbers, the statement is true.

80. Since every member of the set of rational numbers is also a member of the set of real numbers, the statement is true.

81. Since the set of rational numbers includes some numbers that are not integers, the statement is false.

82. Since $\frac{8}{15}$ is not an irrational number, the statement is false.

83. *Writing Exercise.* Rational numbers can be expressed as p/q, where p and q are integers and $q \neq 0$. The set of integers is a subset of the set of rational numbers in which p is a multiple of q.

84. *Writing Exercise.* Charlie is not following the rules for the order of operations. He is performing the operations as if the expression had been written as $(15-4+1)\div(2\cdot 3)$.

85. *Writing Exercise.* The statement is true because every member of the set {2, 4, 6} is also a member of the set {2, 4, 6}.

86. *Writing Exercise.* Mia's statement is true since 6 is an integer. Giovanni writes that the *set that contains* 6 is an integer. This is not true. If Giovanni had written $\{6\}\subseteq\mathbb{Z}$, his statement would have been true.

87. The quotient of the sum of two numbers and their difference
Let a and b represent the numbers. Then we have $\frac{a+b}{a-b}$.

88. Let m and n represent the numbers; $3(m^3+n^3)$

89. Half of the difference of the squares of two numbers
Let r and s represent the numbers. Then we have
$\frac{1}{2}(r^2-s^2)$, or $\frac{r^2-s^2}{2}$.

90. Let x and y represent the numbers; $(x-y)(x+y)$

91. The only whole number that is not also a natural number is 0. Using roster notation to name the set, we have {0}.

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92. {–1, –2, –3, …}

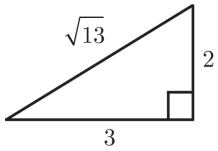
93. List the numbers in the set: {5, 10, 15, 20, …}

94. {3, 6, 9, 12, …}

95. List the numbers in the set: {1, 3, 5, 7, …}

96. {…, –4, –2, 0, 2, 4, …}

97. Recall from geometry that when a right triangle has legs of length 2 and 3, the length of the hypotenuse is $\sqrt{2^2+3^2} = \sqrt{4+9} = \sqrt{13}$. We draw such a triangle:



Exercise Set 1.2

1. It is true that the sum of the two negative number is always negative.

2. The product of two negative numbers is positive, so the statement is false.

3. It is true that the product of a negative number and a positive number is always negative.

4. The statement is false. Consider –2 + 5 = 3, for example.

5. The statement is false. Consider –5+2 = –3, for example.

6. If a and b are negative with $a < b$, then a is farther than b from 0 on the number line, so it is true that $|a| > |b|$.

7. The statement is false. Let $a = 2$ and $b = 6$. Then $2 < 6$ and $|2| < |6|$.

8. It is true that the commutative law of addition states that for all real numbers a and b, $a + b$ and $b + a$ are equivalent.

9. It is true that the associative law of multiplication states that for all real numbers a, b, and c, $(ab)c$ is equivalent to $a(bc)$.

10. It is the commutative law of multiplication, not the distributive law that states that the order in which two numbers are multiplied does not change the result, so the statement is false.

11. Commutative law

12. Associative law

13. Distributive law

14. Commutative law

15. Commutative law

16. Distributive law

17. $|-10| = 10$ –10 is 10 units from 0

18. 3

19. $|7| = 7$ 7 is 7 units from 0

20. 13

21. $|-46.8| = 46.8$ –46.8 is 46.8 units from 0

22. 36.9

23. $|0| = 0$ 0 is 0 units from itself

24. $3\frac{3}{4}$

25. $\left|1\frac{7}{8}\right| = 1\frac{7}{8}$ $1\frac{7}{8}$ is $1\frac{7}{8}$ units from 0

26. 7.24

27. $|-4.21| = 4.21$ –4.21 is 4.21 units from 0

28. 5.309

29. $-5 \le -4$
–5 is less than or equal to –4, a true statement since –5 is to the left of –4.

30. –2 is less than or equal to –8; false

31. $-9 > 1$
–9 is greater than 1, a false statement since –9 is to the left of 1.

32. –9 is less than 1; true

33. $0 \ge -5$
0 is greater than or equal to –5, a true statement since –5 is to the left of 0.

34. 9 is less than or equal to 9; true

35. $-8 < -3$
–8 is less than –3, a true statement since –8 is to the left of –3.

36. 7 is greater than or equal to –8; true

37. $-4 \ge -4$
–4 is greater than or equal to –4. Since –4 = –4 is true, $-4 \ge -4$ is true.

38. 2 is less than 2; false

39. $-5 < -5$
–5 is less than –5, a false statement since –5 does not lie to the left of itself.

40. –2 is greater than –12; true

41. 4 + 8
Two positive numbers: Add the numbers getting 12. The answer is positive 12.

42. 12

43. (–3) + (–9)
Two negative numbers: Add the absolute values, getting 12. The answer is negative, –12.

44. –14

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45. –5.3 + 2.8
A negative number and a positive number: The absolute values are 5.3 and 2.8. Subtract 2.8 from 5.3 to get 2.5. The negative number is farther from 0, so the answer is negative, –2.5.

46. 3.6

47. $\frac{2}{7}+\left(-\frac{3}{5}\right)=\frac{10}{35}+\left(-\frac{21}{35}\right)$
A positive and negative number. The absolute values are $\frac{10}{35}$ and $\frac{21}{35}$. Subtract $\frac{10}{35}$ from $\frac{21}{35}$ to get $\frac{11}{35}$. The negative number is farther from 0, so the answer is negative, $-\frac{11}{35}$.

48. $-\frac{1}{40}$

49. –3.26 + (–5.8)
Two negative numbers: Add the absolute values, getting 9.06. The answer is negative, –9.06.

50. –9.6

51. $-\frac{1}{9}+\frac{2}{3}=-\frac{1}{9}+\frac{6}{9}$
A negative and positive number. The absolute values are $\frac{1}{9}$ and $\frac{6}{9}$. Subtract $\frac{1}{9}$ from $\frac{6}{9}$ to get $\frac{5}{9}$. The positive number is farther from 0, so the answer is positive, $\frac{5}{9}$.

52. $\frac{3}{10}$

53. –6.25 + 0
One number is zero: The sum is the other number, –6.25.

54. –3.69

55. 4.19 + (–4.19)
A negative and a positive number: The numbers have the same absolute value, 4.19, so the answer is 0.

56. 0

57. –18.3 + 22.1
A negative and a positive number; The absolute values are 18.3 and 22.1. Subtract 18.3 from 22.1 to get 3.8. The positive number is farther from 0, so the answer is positive, 3.8.

58. –6.6

59. The opposite of 2.37 is –2.37, because 2.37 + (–2.37) = 0.

60. –6.98

61. The opposite of –56 is 56, because –56 + 56 = 0.

62. 11

63. The opposite of 0 is 0, because 0 + 0 = 0.

64. $2\frac{1}{3}$

65. If $x = 8$, then $-x = -8$. (The opposite of 8 is –8.)

66. –12

67. If $x=-\frac{1}{10}$, then $-x=-\left(-\frac{1}{10}\right)=\frac{1}{10}$. (The opposite of $-\frac{1}{10}$ is $\frac{1}{10}$.)

68. $\frac{8}{3}$

69. If $x = –4.67$, then $–x = –(–4.67) = 4.67$. (The opposite of –4.67 is 4.67.)

70. –3.14

71. If $x = 0$, then $–x = 0$. (The opposite of 0 is 0.)

72. 7

73. $10-4=10+(-4)=6$ Change the sign and add.

74. 8

75. $4-10=4+(-10)=-6$ Change the sign and add.

76. –8

77. $-5-(-12)=-5+12=7$ Change the sign and add.

78. 4

79. –5 – 14 = –5 + (–14) = –19

80. –17

81. 2.7 – 5.8 = 2.7 + (–5.8) = –3.1

82. –0.5

83. $-\frac{3}{5}-\frac{1}{2}=-\frac{3}{5}+\left(-\frac{1}{2}\right)=-\frac{6}{10}+\left(-\frac{5}{10}\right)=-\frac{11}{10}$ Finding a common denominator

84. $-\frac{13}{15}$

85. –31 – (–31) = 0
A negative and a positive number: The numbers have the same absolute value, 31, so the answer is 0.

86. 0

87. $0-(-5.37)=0+5.37=5.37$ Change the sign and add.

88. –9.09

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89. (–3)8
Two numbers with unlike signs: Multiply their absolute values, getting 24. The answer is negative, –24.

90. –45

91. (–2)(–11)
Two numbers with the same sign: Multiply their absolute values, getting 22. The answer is positive, 22.

92. 42

93. (4.2)(–5)
Two numbers with unlike signs: Multiply their absolute values, getting 21. The answer is negative, –21.

94. –28

95. $\frac{3}{7}(-1)$
Two numbers with unlike signs: Multiply their absolute values, getting $\frac{3}{7}$. The answer is negative, $-\frac{3}{7}$.

96. $-\frac{2}{5}$

97. $(-17.45)\cdot 0 = 0$

98. 0

99. $-\frac{2}{3}\left(\frac{3}{4}\right)$
Two numbers with unlike signs: Multiply their absolute values, getting $\frac{1}{2}$. The answer is negative, $-\frac{1}{2}$.

100. $-\frac{1}{4}$

101. $\frac{-28}{-7}$
Two numbers with same sign: Divide their absolute values, getting 4. The answer is positive, 4.

102. 3

103. $\frac{-100}{25}$
Two numbers with unlike signs: Divide their absolute values getting 4. The answer is negative, –4.

104. –10

105. $\frac{73}{-1}$
Two numbers with unlike signs: Divide their absolute values, getting 73. The answer is negative, –73.

106. –62

107. $\frac{0}{-7} = 0$

108. 0

109. The reciprocal of 8 is $\frac{1}{8}$, because $8\cdot\frac{1}{8}=1$.

110. $-\frac{1}{7}$

111. The reciprocal of $-\frac{5}{7}$ is $-\frac{7}{5}$, because $-\frac{5}{7}\cdot\left(-\frac{7}{5}\right)=1$.

112. $\frac{3}{4}$

113. Does not exist

114. $-\frac{10}{9}$

115. $\frac{3}{5}\div\frac{6}{7}$
$=\frac{3}{5}\cdot\frac{7}{6}$ Multiplying by the reciprocal of $\frac{6}{7}$
$=\frac{21}{30}$, or $\frac{7}{10}$

116. $\frac{2}{3}\div\frac{5}{6}=\frac{2}{3}\cdot\frac{6}{5}=\frac{12}{15}=\frac{4}{5}$

117. $\left(-\frac{3}{5}\right)\div\frac{1}{2}$
$=-\frac{3}{5}\cdot\frac{2}{1}$ Multiplying by the reciprocal of $\frac{1}{2}$
$=-\frac{6}{5}$

118. $\left(-\frac{4}{7}\right)\div\frac{1}{3}=-\frac{4}{7}\cdot\frac{3}{1}=-\frac{12}{7}$

119. $\left(-\frac{2}{9}\right)\div(-8)$
$=-\frac{2}{9}\cdot\left(-\frac{1}{8}\right)$ Multiplying by the reciprocal of -8
$=\frac{2}{72}$, or $\frac{1}{36}$

120. $\left(-\frac{2}{11}\right)\div(-6)=-\frac{2}{11}\cdot\left(-\frac{1}{6}\right)=\frac{2}{66}$, or $\frac{1}{33}$

121. $-\frac{12}{7}\div\left(-\frac{12}{7}\right)$
This is a number divided by itself so the quotient is 1. We would also do this exercise as follows.
$-\frac{12}{7}\div\left(-\frac{12}{7}\right)=-\frac{12}{7}\cdot\left(-\frac{7}{12}\right)$ Multiplying by the reciprocal of $-\frac{12}{7}$
$=1$

122. $\left(-\frac{2}{7}\right)\div(-1)=-\frac{2}{7}\cdot(-1)=\frac{2}{7}$

123. $-4^2=-(4\cdot 4)=-16$ Squaring 4 and then taking the opposite

124. $(-4)^2=(-4)(-4)=16$

125. $-(-3)^2-(-3)(-3)=-9$ Squaring (-3) and then taking the opposite

126. $-(-2)^2=-(-2)(-2)=-4$

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127. $(2-5)^2 = (-3)^2$ Working within the
$= 9$ parentheses first

128. $2^2 - 5^2 = 4 - 25 = -21$

129. $9 - (8 - 3 \cdot 2^3) = 9 - (8 - 3 \cdot 8)$ Working within the
$= 9 - (8 - 24)$ parentheses first
$= 9 - (-16)$
$= 9 + 16$
$= 25$

130. $19 - (4 + 2 \cdot 3^2) = 19 - (4 + 2 \cdot 9) = 19 - (4 + 18)$
$= 19 - 22 = -3$

131. $\dfrac{5 \cdot 2 - 4^2}{27 - 2^4} = \dfrac{5 \cdot 2 - 16}{27 - 16} = \dfrac{10 - 16}{11} = \dfrac{-6}{11}$, or $-\dfrac{6}{11}$

132. $\dfrac{7 \cdot 3 - 5^2}{9 + 4 \cdot 2} = \dfrac{7 \cdot 3 - 25}{9 + 8} = \dfrac{21 - 25}{17} = \dfrac{-4}{17}$, or $-\dfrac{4}{17}$

133. $\dfrac{3^4 - (5-3)^4}{8 - 2^3} = \dfrac{3^4 - 2^4}{8 - 8} = \dfrac{81 - 16}{0}$

Since division by 0 is undefined, this quotient is undefined.

134. $\dfrac{4^3 - (7-4)^2}{3^2 - 7} = \dfrac{4^3 - 3^2}{9 - 7} = \dfrac{64 - 9}{2} = \dfrac{55}{2}$

135. $\dfrac{(2-3)^3 - 5|2-4|}{7 - 2 \cdot 5^2} = \dfrac{(-1)^3 - 5|-2|}{7 - 2 \cdot 25} = \dfrac{-1 - 5(2)}{7 - 50}$
$= \dfrac{-1 - 10}{-43} = \dfrac{-11}{-43} = \dfrac{11}{43}$

136. $\dfrac{8 \div 4 \cdot 6|4^2 - 5^2|}{9 - 4 + 11 - 4^2} = \dfrac{8 \div 4 \cdot 6|16 - 25|}{9 - 4 + 11 - 16} = \dfrac{8 \div 4 \cdot 6|-9|}{5 + 11 - 16}$
$= \dfrac{8 \div 4 \cdot 6 \cdot 9}{16 - 16} = \dfrac{2 \cdot 6 \cdot 9}{0}$

Since division by 0 is undefined, this quotient is undefined.

137. $|2^2 - 7|^3 + 4 = |4 - 7|^3 + 4 = |-3|^3 + 4 = 3^3 + 4$
$= 27 + 4 = 31$

138. $|-2 - 3| \cdot 4^2 - 3 = |-5| \cdot 4^2 - 3 = 5 \cdot 4^2 - 3 = 5 \cdot 16 - 3$
$= 80 - 3 = 77$

139. $32 - (-5)^2 + 15 \div (-3) \cdot 2$
$= 32 - 25 + 15 \div (-3) \cdot 2$ Evaluating the exponential expression
$= 32 - 25 - 5 \cdot 2$ Dividing
$= 32 - 25 - 10$ Multiplying
$= -3$ Subtracting

140. $43 - (-9 + 2)^2 + 18 \div 6 \cdot (-2)$
$= 43 - (-7)^2 + 18 \div 6 \cdot (-2)$
$= 43 - 49 + 18 \div 6 \cdot (-2)$
$= 43 - 49 + 3 \cdot (-2)$
$= 43 - 49 - 6$
$= -12$

141. Using the commutative law of addition, we have
$6 + xy = xy + 6$.
Using the commutative law of multiplication, we have
$6 + xy = 6 + yx$.

142. $4a + 7b = 7b + 4a$
or $4a + 7b = a \cdot 4 + 7b$
or $4a + 7b = 4a + b \cdot 7$
or $4a + 7b = a \cdot 4 + b \cdot 7$

143. Using the commutative law of multiplication, we have
$-9(ab) = (ab)(-9)$
or $-9(ab) = -9(ba)$

144. $(7x)y = y(7x)$
or $(7x)y = (x \cdot 7)y$

145. $(3x)y$
$= 3(xy)$ Associative law of multiplication

146. $(-7a)b$

147. $(3y + 4) + 10$
$= 3y + (4 + 10)$ Associative law of addition

148. $(x + 2y) + 5$

149. $7(x+1) = 7 \cdot x + 7 \cdot 1$ Using the distributive law
$= 7x + 7$

150. $3a + 15$

151. $5(m - n) = 5 \cdot m - 5 \cdot n$ Using the distributive law
$= 5m - 5n$

152. $6s - 6t$

153. $-5(2a + 3b)$
$= -5 \cdot 2a + (-5) \cdot 3b$
$= -10a - 15b$

154. $-6c - 10d$

155. $9a(b - c + d)$
$= 9a \cdot b - 9a \cdot c + 9a \cdot d$
$= 9ab - 9ac + 9ad$

156. $5xy - 5xz + 5xw$

157. $5x + 50 = 5 \cdot x + 5 \cdot 10 = 5(x + 10)$

158. $5(d + 6)$

159. $9p - 3 = 3 \cdot 3p - 3 \cdot 1 = 3(3p - 1)$

160. $3(5x - 1)$

161. $7x - 21y + 14z = 7 \cdot x - 7 \cdot 3y + 7 \cdot 2z = 7(x - 3y + 2z)$

162. $3(2y - 3x - w)$

163. $255 - 34b = 17 \cdot 15 - 17 \cdot 2b = 17(15 - 2b)$

164. $13(t - 11)$

165. $xy + x = x \cdot y + x \cdot 1 = x(y + 1)$

166. $b(a + 1)$

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167. *Writing Exercise.* The sum has the same sign as the number that is farther from 0.

168. *Writing Exercise.* "Five is less than x" can be translated to $5 < x$. "Five less than x" is an expression translated to $x - 5$.

169. *Writing Exercise.* The quotient 7/0 is defined to be the number that gives a result of 7 when multiplied by 0. There is no such number, so we say the quotient is undefined.

170. *Writing Exercise.* When we factor the expression $2x + 4$, one factor is 2.

171. $(8-5)^3 + 9 = 36$

172. $2 \cdot (7 + 3^2 \cdot 5) = 104$

173. $5 \cdot 2^3 \div (3-4)^4 = 40$

174. $(2-7) \cdot 2^2 + 9 = -11$

175.
$$\begin{aligned} &17 - \sqrt{11-(3+4)} \div [-5-(-6)]^2 \\ &= 17 - \sqrt{11-7} \div [-5+6]^2 \\ &= 17 - \sqrt{4} \div [1]^2 \\ &= 17 - 2 \div 1 \\ &= 17 - 2 \\ &= 15 \end{aligned}$$

176.
$$\begin{aligned} &15 - 1 + \sqrt{5^2 - (3+1)^2}\,(-1) \\ &= 15 - 1 + \sqrt{5^2 - (4)^2}\,(-1) \\ &= 15 - 1 + \sqrt{25-16}\,(-1) \\ &= 15 - 1 + \sqrt{9}\,(-1) \\ &= 15 - 1 + 3(-1) \\ &= 15 - 1 - 3 \\ &= 11 \end{aligned}$$

177. Any value of a such that $a \le -6.2$ satisfies the given conditions. The largest of these values is –6.2.

178.
$$\begin{aligned} &5(a+bc) \\ &= (a+bc)5 && \text{Commutative law of multiplication} \\ &= a \cdot 5 + (bc)5 && \text{Distributive law} \\ &= a \cdot 5 + (cb)5 && \text{Commutative law of multiplication} \\ &= a \cdot 5 + c(b \cdot 5) && \text{Associative law of multiplication} \\ &= c(b \cdot 5) + a \cdot 5 && \text{Commutative law of addition} \end{aligned}$$

179. *Writing Exercise.* No; $5 - 3 = 2$, but $3 - 5 = -2$; also $8 \div 2 = 4$, but $2 \div 8 = 0.25$.

180. *Writing Exercise.* No; $(12-6) - 2 = 6 - 2 = 4$, but $12 - (6-2) = 12 - 4 = 8$; also $(12 \div 6) \div 2 = 2 \div 2 = 1$, but $12 \div (6 \div 2) = 12 \div 3 = 4$.

181. a. Let t represent the temperature at midnight, in °F; $-16 - 5 = t$; $t = -21$. The temperature at midnight was –21°F.

b. Let x represent the temperature outside Ethan's jet, in °F; $42 - 3.5(20) = x$; $x = -28$. The temperature outside Ethan's jet is –28°F.

Exercise Set 1.3

1. Two equations are *equivalent* if they have the same solutions.

2. An equation in x of the form $ax = b$ is a *linear* equation.

3. A *contradiction* is an equation that is never true.

4. An *identity* is an equation that is always true.

5. By the distributive law, the expression $2(x + 7)$ is equivalent to the expression $2x + 14$, so they are equivalent expressions.

6. $2(x + 7) = 11$ and $2x + 14 = 11$ are equations and they have the same solution, $-\frac{3}{2}$, so they are equivalent equations.

7. $4x - 9 = 7$ and $4x = 16$ are equations and they have the same solution, 4, so they are equivalent equations.

8. Combining like terms in the expression $5x - 9 - x$, we get the expression $4x - 9$, so these are equivalent expressions.

9. Combining like terms in the expression $8t + 5 - 2t + 1$, we get the expression $6t + 6$, so these are equivalent expressions.

10. $5t - 2 + t = 8$ and $6t = 10$ are equations and they have the same solution, $\frac{5}{3}$, so they are equivalent equations.

11. $3t = 21$ and $t + 4 = 11$
Each equation has only one solution, the number 7. Thus, the equations are equivalent.

12. For $t = 9$, the first equation is true, but the second is false. They are not equivalent.

13. $12 - x = 3$ and $2x = 20$
When x is replaced by 9, the first equation is true, but the second equation is false. Thus the equations are not equivalent.

14. Each equation has only one solution, the number 4, so they are equivalent.

15. $5x = 2x$ and $\frac{4}{x} = 3$
When x is replaced by 0, the first equation is true, but the second equation is not defined. Thus the equations are not equivalent.

16. For $x = 3$, the first equation is true but the second is not defined. They are not equivalent.

17.
$$\begin{aligned} &x - 2.9 = 13.4 \\ &x - 2.9 + 2.9 = 13.4 + 2.9 && \text{Adding princple; adding 2.9} \\ &x + 0 = 13.4 + 2.9 && \text{Law of opposites} \\ &x = 16.3 \end{aligned}$$

Check:
$$\begin{array}{r|l} x - 2.9 = 13.4 & \\ \hline 16.3 - 2.9 & 13.4 \\ \stackrel{?}{=} & \\ 13.4 = 13.4 & \text{TRUE} \end{array}$$

The solution is 16.3.

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18. $y + 4.3 = 11.2$
$y = 6.9$

19. $8t = 72$
$\frac{1}{8} \cdot 8t = \frac{1}{8} \cdot 72$ Multiplication principle; multiplying by $\frac{1}{8}$, the reciprocal of 8
$1t = 9$
$t = 9$
Check:
$$\begin{array}{r|l} 8t = 72 & \\ \hline 8 \cdot 9 & 72 \\ \stackrel{?}{=} & \\ 72 = 72 & \text{TRUE} \end{array}$$
The solution is 9.

20. $9t = 63$
$t = 7$

21. $\frac{2}{3}x = 30$
$\frac{3}{2} \cdot \frac{2}{3}x = \frac{3}{2} \cdot 30$
$1x = 45$
$x = 45$
Check:
$$\begin{array}{r|l} \frac{2}{3}x = 30 & \\ \hline \frac{2}{3} \cdot 45 & 30 \\ \stackrel{?}{=} & \\ 30 = 30 & \text{TRUE} \end{array}$$
The solution is 45.

22. $\frac{5}{4}x = -80$
$x = \frac{4}{5}(-80)$
$x = -64$

23. $4a + 25 = 9$
$4a + 25 - 25 = 9 - 25$
$4a = -16$
$\frac{1}{4} \cdot 4a = \frac{1}{4}(-16)$
$1a = -4$
$a = -4$
Check:
$$\begin{array}{r|l} 4a + 25 = 9 & \\ \hline 4(-4) + 25 & 9 \\ -16 + 25 & \\ \stackrel{?}{=} & \\ 9 = 9 & \text{TRUE} \end{array}$$
The solution is –4.

24. $5a - 11 = 24$
$5a = 35$
$a = 7$

25. $2y - 8 = 9$
$2y - 8 + 8 = 9 + 8$
$2y = 17$
$\frac{1}{2} \cdot 2y = \frac{1}{2} \cdot 17$
$1y = \frac{17}{2}$
$y = \frac{17}{2}$
Check:
$$\begin{array}{r|l} 2y - 8 = 9 & \\ \hline 2\left(\frac{17}{2}\right) - 8 & 9 \\ 17 - 8 & 9 \\ \stackrel{?}{=} & \\ 9 = 9 & \text{TRUE} \end{array}$$
The solution is $\frac{17}{2}$.

26. $3y + 4 = 2$
$3y = -2$
$y = -\frac{2}{3}$

27. $9t^2 + t^2 = (9+1)t^2 = 10t^2$

28. $8a^2$

29. $16a - a = (16 - 1)a = 15a$

30. $10t$

31. $n - 8n = (1 - 8)n = -7n$

32. $-2p$

33. $5x - 3x + 8x = (5 - 3 + 8)x = 10x$

34. $-6x$

35. $18p - 12 + 3p + 8$
$= 18p + 3p - 12 + 8$ Commutative law of addition
$= (18 + 3)p + (-12 + 8)$
$= 21p - 4$

36. $5y + 13$

37. $-7t^2 + 3t + 5t^3 - t^3 + 2t^2 - t$
$= (-7 + 2)t^2 + (3 - 1)t + (5 - 1)t^3$
$= -5t^2 + 2t + 4t^3$

38. $-12n + 6n^2 + 5n^3$

39. $2x + 3(5x - 7)$
$= 2x + 15x - 21$
$= 17x - 21$

40. $5x + 4(x + 11) = 5x + 4x + 44 = 9x + 44$

41. $7a - (2a + 5)$
$= 7a - 2a - 5$
$= 5a - 5$

42. $x - (5x + 9) = x - 5x - 9 = -4x - 9$

43. $m - (6m - 2)$
$= m - 6m + 2$
$= -5m + 2$

44. $5a - (4a - 3) = 5a - 4a + 3 = a + 3$

45. $3d - 7 - (5 - 2d)$
$= 3d - 7 - 5 + 2d$
$= 5d - 12$

46. $8x - 9 - (7 - 5x) = 8x - 9 - 7 + 5x = 13x - 16$

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47. $2(x-3)+4(7-x)$
$=2x-6+28-4x$
$=-2x+22$

48. $3(y+6)+5(2-4y)=3y+18+10-20y=-17y+28$

49. $3p-4-2(p+6)$
$=3p-4-2p-12$
$=p-16$

50. $8c-1-3(2c+1)=8c-1-6c-3=2c-4$

51. $-2(a-5)-[7-3(2a-5)]$
$=-2a+10-[7-6a+15]$
$=-2a+10-[22-6a]$
$=-2a+10-22+6a$
$=4a-12$

52. $-3(b+2)-[9-5(8b-1)]$
$=-3b-6-[9-40b+5]$
$=-3b-6-[14-40b]$
$=-3b-6-14+40b$
$=37b-20$

53. $5\{-2x+3[2-4(5x+1)]\}$
$=5\{-2x+3[2-20x-4]\}$
$=5\{-2x+3[-20x-2]\}$
$=5\{-2x-60x-6\}$
$=5\{-62x-6\}$
$=-310x-30$

54. $7\{-7x+8[5-3(4x+6)]\}$
$=7\{-7x+8[5-12x-18]\}$
$=7\{-7x+8[-12x-13]\}$
$=7\{-7x-96x-104\}$
$=7\{-103x-104\}$
$=-721x-728$

55. $8y-\{6[2(3y-4)-(7y+1)]+12\}$
$=8y-\{6[6y-8-7y-1]+12\}$
$=8y-\{6[-y-9]+12\}$
$=8y-\{-6y-54+12\}$
$=8y-\{-6y-42\}$
$=8y+6y+42$
$=14y+42$

56. $2y+\{7[3(2y-5)-(8y+7)]+9\}$
$=2y+\{7[6y-15-8y-7]+9\}$
$=2y+\{7[-2y-22]+9\}$
$=2y+\{-14y-154+9\}$
$=2y+\{-14y-145\}$
$=2y-14y-145$
$=-12y-145$

57. $4x+5x=63$
$9x=63$
$\frac{1}{9}\cdot 9x=\frac{1}{9}\cdot 63$
$x=7$

Check: $4x+5x=63$

$4\cdot 7+5\cdot 7$	63
$28+35$	

$\overset{?}{63=63}$ TRUE

The solution is 7.

58. $3x-7x=60$
$-4x=60$
$x=-15$

59. $\frac{1}{4}y-\frac{2}{3}y=5$
$\frac{3}{12}y-\frac{8}{12}y=5$
$-\frac{5}{12}y=5$
$\left(-\frac{12}{5}\right)\left(-\frac{5}{12}y\right)=\left(-\frac{12}{5}\right)\cdot 5$
$1y=-12$
$y=-12$

Check: $\frac{1}{4}y-\frac{2}{3}y=5$

$\frac{1}{4}(-12)-\frac{2}{3}(-12)$	5
$-3+8$	

$\overset{?}{5=5}$ TRUE

The solution is –12.

60. $\frac{3}{5}t-\frac{1}{2}t=3$
$\frac{1}{10}t=3$
$t=\frac{10}{1}\cdot 3=30$

61. $4(t-3)-t=6$
$4t-12-t=6$
$3t-12=6$
$3t-12+12=6+12$
$3t=18$
$\frac{1}{3}\cdot 3t=\frac{1}{3}\cdot 18$
$t=6$

Check: $4(t-3)-t=6$

$4(6-3)-6$	6
$4(3)-6$	
$12-6$	

$\overset{?}{6=6}$ TRUE

The solution is 6.

62. $2(t+5)+t=4$
$2t+10+t=4$
$3t=-6$
$t=-2$

63. $3(x+4)=7x$
$3x+12=7x$
$3x+12-3x=7x-3x$
$12=4x$
$\frac{1}{4}\cdot 12=\frac{1}{4}\cdot 4x$
$3=x$

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Check: $3(x+4)=7x$

$3(3+4)$	$7\cdot 3$
$3\cdot 7$	

$\overset{?}{21=21}$ TRUE

The solution is 3.

64. $3(y+5)=8y$

$3y+15=8y$

$15=5y$

$3=y$

65. $70=10(3t-2)$

$70=30t-20$

$70+20=30t-20+20$

$90=30t$

$\frac{1}{30}\cdot 90=\frac{1}{30}\cdot 30t$

$3=t$

Check: $70=10(3t-2)$

70	$10(3\cdot 3-2)$
	$10(9-2)$
	$10\cdot 7$

$\overset{?}{70=70}$ TRUE

The solution is 3.

66. $27=9(5y-2)$

$27=45y-18$

$45=45y$

$1=y$

67. $1.8(2-n)=9$

$3.6-1.8n=9$

$3.6-1.8n-3.6=9-3.6$

$-1.8n=5.4$

$\left(-\frac{1}{1.8}\right)(-1.8n)=\left(-\frac{1}{1.8}\right)\cdot 5.4$

$n=-3$

Check: $1.8(2-n)=9$

$1.8(2-(-3))$	9
$1.8(2+3)$	
$1.8(5)$	

$\overset{?}{9=9}$ TRUE

The solution is –3.

68. $2.1(3-x)=8.4$

$6.3-2.1x=8.4$

$-2.1x=2.1$

$x=-1$

69. $5y-(2y-10)=25$

$5y-2y+10=25$

$3y+10=25$

$3y+10-10=25-10$

$3y=15$

$\frac{1}{3}\cdot 3y=\frac{1}{3}\cdot 15$

$y=5$

Check: $5y-(2y-10)=25$

$5\cdot 5-(2\cdot 5-10)$	25
$25-(10-10)$	
$25-0$	

$\overset{?}{25=25}$ TRUE

The solution is 5.

70. $8x-(3x-5)=40$

$8x-3x+5=40$

$5x=35$

$x=7$

71. $\frac{9}{10}y-\frac{7}{10}=\frac{21}{5}$

$\frac{9}{10}y-\frac{7}{10}+\frac{7}{10}=\frac{21}{5}+\frac{7}{10}$

$\frac{9}{10}y=\frac{42}{10}+\frac{7}{10}$

$\frac{9}{10}y=\frac{49}{10}$

$\frac{10}{9}\cdot\frac{9}{10}y=\frac{10}{9}\cdot\frac{49}{10}$

$y=\frac{49}{9}$

Check: $\frac{9}{10}y-\frac{7}{10}=\frac{21}{5}$

$\frac{9}{10}\cdot\frac{49}{9}-\frac{7}{10}$	$\frac{21}{5}$
$\frac{49}{10}-\frac{7}{10}$	
$\frac{42}{10}$	

$\frac{21}{5}\overset{?}{=}\frac{21}{5}$ TRUE

The solution is $\frac{49}{9}$.

72. $\frac{4}{5}t-\frac{3}{10}=\frac{2}{5}$

$\frac{4}{5}t=\frac{7}{10}$

$t=\frac{5}{4}\cdot\frac{7}{10}=\frac{7}{8}$

73. $7r-2+5r=6r+6-4r$

$12r-2=2r+6$

$12r-2-2r=2r+6-2r$

$10r-2=6$

$10r-2+2=6+2$

$10r=8$

$\frac{1}{10}\cdot 10r=\frac{1}{10}\cdot 8$

$r=\frac{8}{10}$

$r=\frac{4}{5}$

Check: $7r-2+5r=6r+6-4r$

$7\cdot\frac{4}{5}-2+5\cdot\frac{4}{5}$	$6\cdot\frac{4}{5}+6-4\cdot\frac{4}{5}$
$\frac{28}{5}-2+4$	$\frac{24}{5}+6-\frac{16}{5}$

$\frac{38}{5}\overset{?}{=}\frac{38}{5}$ TRUE

The solution is $\frac{4}{5}$.

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74. $9m-15-2m=6m-1-m$
$7m=15+5m-1$
$2m=14$
$m=7$

75. $\frac{2}{3}(x-2)-1=\frac{1}{4}(x-3)$
$\frac{2}{3}x-\frac{4}{3}-1=\frac{1}{4}x-\frac{3}{4}$
$\frac{2}{3}x-\frac{7}{3}=\frac{1}{4}x-\frac{3}{4}$
$\frac{2}{3}x-\frac{7}{3}-\frac{1}{4}x=\frac{1}{4}x-\frac{3}{4}-\frac{1}{4}x$
$\frac{5}{12}x-\frac{7}{3}=-\frac{3}{4}$
$\frac{5}{12}x-\frac{7}{3}+\frac{7}{3}=-\frac{3}{4}+\frac{7}{3}$
$\frac{5}{12}x=\frac{19}{12}$
$\frac{12}{5}\cdot\frac{5}{12}x=\frac{12}{5}\cdot\frac{19}{12}$
$x=\frac{19}{5}$

The check is left to the student. The solution is $\frac{19}{5}$.

76. $\frac{1}{4}(6t+48)-20=-\frac{1}{3}(4t-72)$
$\frac{3}{2}t+12-20=-\frac{4}{3}t+24$
$\frac{3}{2}t-8=-\frac{4}{3}t+24$
$\frac{17}{6}t=32$
$t=\frac{6}{17}\cdot 32=\frac{192}{17}$

77. $2(t-5)-3(2t-7)=12-5(3t+1)$
$2t-10-6t+21=12-15t-5$
$-4t+11=-15t+7$
$-4t+11+15t=-15t+7+15t$
$11t+11=7$
$11t+11-11=7-11$
$11t=-4$
$\frac{1}{11}\cdot 11t=\frac{1}{11}(-4)$
$t=-\frac{4}{11}$

Check:

$2(t-5)-3(2t-7)=12-5(3t+1)$

$2\left(-\frac{4}{11}-5\right)-3\left(2\left(-\frac{4}{11}\right)-7\right)$	$12-5\left(3\left(-\frac{4}{11}\right)+1\right)$
$2\left(-\frac{59}{11}\right)-3\left(-\frac{8}{11}-7\right)$	$12-5\left(-\frac{12}{11}+1\right)$
$-\frac{118}{11}-3\left(-\frac{85}{11}\right)$	$12-5\left(-\frac{1}{11}\right)$
$-\frac{118}{11}+\frac{255}{11}$	$12+\frac{5}{11}$

$\frac{137}{11}\stackrel{?}{=}\frac{137}{11}$ TRUE

The solution is $-\frac{4}{11}$.

78. $4t+8-6(2t-1)=3(4t-3)-7(t-2)$
$4t+8-12t+6=12t-9-7t+14$
$-8t+14=5t+5$
$9=13t$
$\frac{9}{13}=t$

79. $3[2-4(x-1)]=3-4(x+2)$
$3[2-4x+4]=3-4x-8$
$3[6-4x]=-4x-5$
$18-12x=-4x-5$
$18-12x+12x=-4x-5+12x$
$18=8x-5$
$18+5=8x-5+5$
$23=8x$
$\frac{1}{8}\cdot 23=\frac{1}{8}(8x)$
$\frac{23}{8}=x$

Check: $3[2-4(x-1)]=3-4(x+2)$

$3\left[2-4\left(\frac{23}{8}-1\right)\right]$	$3-4\left(\frac{23}{8}+2\right)$
$3\left[2-4\left(\frac{15}{8}\right)\right]$	$3-4\left(\frac{39}{8}\right)$
$3\left[2-\frac{15}{2}\right]$	$3-\frac{39}{2}$
$3\left(-\frac{11}{2}\right)$	$\frac{6}{2}-\frac{39}{2}$

$-\frac{33}{2}\stackrel{?}{=}-\frac{33}{2}$ TRUE

The solution is $\frac{23}{8}$.

80. $5+2(x-3)=2[5-4(x+2)]$
$5+2x-6=2[5-4x-8]$
$2x-1=2[-4x-3]$
$2x-1=-8x-6$
$10x=-5$
$x=-\frac{1}{2}$

81. $2x+2=2(x+1)$
$2x+2=2x+2$
$2x+2-2x=2x+2-2x$
$2=2$

All real numbers are solutions. The solution set is the set of all real numbers. The equation is an identity.

82. $x+2=x+3$
$2=3$

Since the original equation is equivalent to the false equation 2 = 3, there is no solution. The solution set is $\varnothing$. The equation is a contradiction.

83. $7x-2-3x=4x$
$4x-2=4x$
$4x-2-4x=4x-4x$
$-2=0$

Since the original equation is equivalent to the false equation –2 = 0, there is no solution. The solution set is $\varnothing$. The equation is a contradiction.

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84. $3t+5+t=5+4t$
$4t+5=5+4t$
$5=5$
All real numbers are solutions. The solution set is the set of all real numbers. The equation is an identity.

85. $2+9x=3(4x+1)-1$
$2+9x=12x+3-1$
$2+9x=12x+2$
$2+9x-2=12x+2-2$
$9x=12x$
$9x-9x=12x-9x$
$0=3x$
$\frac{1}{3}\cdot 0=\frac{1}{3}\cdot 3x$
$0=x$
The solution set is $\{0\}$. The equation is a conditional equation.

86. $4+7x=7(x+1)$
$4+7x=7x+7$
$4=7$ False equation
The solution set is $\varnothing$. The equation is a contradiction.

87. $3x-(8-x)=6x-2(x+4)$
$3x-8+x=6x-2x-8$
$4x-8=4x-8$
$4x-8-4x=4x-8-4x$
$-8=-8$
All real numbers are solutions. The solution set is the set of all real numbers. The equation is an identity.

88. $\frac{1}{3}(2x-7)=\frac{1}{2}(x+3)$
$\frac{2}{3}x-\frac{7}{3}=\frac{1}{2}x+\frac{3}{2}$
$\frac{1}{6}x=\frac{23}{6}$
$x=23$
The solution set is $\{23\}$. The equation is a conditional equation.

89. $-9t+2=-9t-7\left(6\div 2(49)+8\right)$
Observe that $-7\left(6\div 2(49)+8\right)$ is a negative number. Then on the left side we have $-9t$ plus a positive number and on the right side we have $-9t$ plus a negative number. This is a contradiction, so the solution set is $\varnothing$.

90. $-9t+2=2-9t-5\left(8\div 4\left(1+3^4\right)\right)$
Observe that $5\left(8\div 4\left(1+3^4\right)\right)$ is a positive number. Then the constant term on the right side of the equation is 2 minus a positive number. That is, it is a number less than 2. Thus, on the left we have $-9t+2$ and on the right we have $-9t$ plus a number less than 2. This is a contradiction, so the solution set is $\varnothing$.

91. $2\{9-3[-2x-4]\}=12x+42$
$2\{9+6x+12\}=12x+42$
$2\{21+6x\}=12x+42$
$42+12x=12x+42$
$42+12x-12x=12x+42-12x$
$42=42$
The original equation is equivalent to the equation $42=42$, which is true for all real numbers. Thus the solution set is the set of all real numbers. The equation is an identity.

92. $3\{7-2[7x-4]\}=-40x+45$
$3\{7-14x+8\}=-40x+45$
$3\{15-14x\}=-40x+45$
$45-42x=-40x+45$
$0=2x$
$0=x$
The solution set is $\{0\}$. The equation is conditional.

93. *Writing Exercise.* The statement, "The equation has no solution," says that there is no number that makes the equation true. The statement, "The solution of the equation is zero" says that there is a number, the number zero, that makes the equation true.

94. *Writing Exercise.* Most would not consider this to be the best approach, since it introduces fractions that must be added to complete the solution.

95. *Writing Exercise.*
$3x+6y+4x+2y$
$=3x+4x+6y+2y$ Commutative law of addition
$=(3+4)x+(6+2)y$ Distributive law
$=7x+8y$

96. *Writing Exercise.* Equivalent expressions have the same value for all possible replacements. Any replacement that does not make any of the expressions undefined can be substituted for the variable. Equivalent equations have the same solution(s). True equations result only when a solution is substituted for the variable.

97. $-0.00458y+1.7787=13.002y-1.005$
$-13.00658y+1.7787=-1.005$
$-13.00658y=-2.7837$
$y=\frac{-2.7837}{-13.00658}$
$0.2140224409\approx y$
The check is left to the student. The solution is approximately 0.2140224409.

98. $4.23x-17.898=-1.65x-42.454$
$5.88x=-24.556$
$x\approx -4.176190476$

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99. $6x-\{5x-[7x-(4x-(3x+1))]\}=6x+5$
$6x-\{5x-[7x-(4x-3x-1)]\}=6x+5$
$6x-\{5x-[7x-(x-1)]\}=6x+5$
$6x-\{5x-[7x-x+1]\}=6x+5$
$6x-\{5x-[6x+1]\}=6x+5$
$6x-\{5x-6x-1\}=6x+5$
$6x-\{-x-1\}=6x+5$
$6x+x+1=6x+5$
$7x+1=6x+5$
$x=4$

100. $8x-\{3x-[2x-(5x-(7x-1))]\}=8x+7$
$8x-\{3x-[2x-(-2x+1)]\}=8x+7$
$8x-\{3x-[4x-1]\}=8x+7$
$8x-\{-x+1\}=8x+7$
$9x-1=8x+7$
$x=8$

101. $23-2\{4+3[x-1]\}+5\{x-2(x+3)\}$
$=7\{x-2[5-(2x+3)]\}$
$23-2\{4+3x-3\}+5\{x-2x-6\}$
$=7\{x-2[5-2x-3]\}$
$23-2\{3x+1\}+5\{-x-6\}=7\{x-2[-2x+2]\}$
$23-6x-2-5x-30=7\{x+4x-4\}$
$-11x-9=7\{5x-4\}$
$-11x-9=35x-28$
$-9=46x-28$
$19=46x$
$\frac{19}{46}=x$

The check is left to the student. The solution is $\frac{19}{46}$.

102. $17-3\{5+2[x-2]\}+4\{x-3(x+7)\}$
$=9\{x+3[2+3(4-x)]\}$
$17-3\{5+2x-4\}+4\{x-3x-21\}$
$=9\{x+3[2+12-3x]\}$
$17-3\{1+2x\}+4\{-2x-21\}=9\{x+3[14-3x]\}$
$17-3-6x-8x-84=9\{x+42-9x\}$
$-14x-70=9\{-8x+42\}$
$-14x-70=-72x+378$
$58x-70=378$
$58x=448$
$x=\frac{448}{58}$, or $\frac{224}{29}$

103. *Writing Exercise*. Answers may vary. One such equation is $\frac{2}{5}x+\frac{1}{10}=\frac{9}{5}x-\frac{3}{10}$. If we first multiply both sides by 10, we avoid having to add fractions when we use the addition principle.

104. a. $y=500+0.1x$

b. $y=500+0.1x$
$900=500+0.1x$
$400=0.1x$
$4000=x$
Jasmine's sales were \$4000 that week.

Mid-Chapter Review

1. $3x-2(x-1)=3x-2x+2$
$=x+2$

2. $3x-2(x-1)=6x$
$3x-2x+2=6x$
$x+2=6x$
$2=5x$
$\frac{2}{5}=x$

3. Five less than three times a number
Let n represent the number; $3n-5$

4. $2a\div 3x-a+x=2(3)\div 3(5)-3+5$
$=6\div 3(5)-3+5$
$=2(5)-3+5$
$=10-3+5$
$=12$

5. The area of a triangle is given by $A=\frac{1}{2}bh$. We substitute $b=\frac{1}{2}$, $h=3$ and solve.

$$A=\frac{1}{2}bh=\frac{1}{2}\left(\frac{1}{2}\right)(3)=\frac{3}{4}\text{ ft}^2$$

6. $\frac{1}{2}-\left(-\frac{1}{3}\right)=\frac{5}{6}$

7. $-32\div(-0.8)=\frac{-32}{-0.8}=40$
Two numbers with same sign: Divide their absolute values, getting 40. The answer is positive, 40.

8. 2.52

9. $\left(\frac{3}{10}\right)\left(-\frac{2}{5}\right)=-\frac{6}{50}$, or $-\frac{3}{25}$
Two numbers with unlike signs: Multiply their absolute values, getting $\frac{3}{25}$. The answer is negative, $-\frac{3}{25}$.

10. $8-2^3\div 4\cdot(-2)+1-2=8-8\div 4\cdot(-2)+1-2$
$=8-2\cdot(-2)+1-2$
$=8+4+1-2$
$=11$

11. $(x+3)+y$
$=x+(3+y)$ Associative law of addition

12. $3x-5-x+12=2x+7$

13. $4t-(3t-1)=4t-3t+1$
$=t+1$

14. $8x+2[x-(x-1)]=8x+2[x-x+1]$
$=8x+2[1]$
$=8x+2$

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15. $-(p-4)-[3-(9-2p)]+p$
$=-p+4-[3-9+2p]+p$
$=-p+4-[-6+2p]+p$
$=-p+4+6-2p+p$
$=-2p+10$

16. $2x-6=3x+5$
$2x-6-2x=3x+5-2x$
$-6=x+5$
$-6-5=x+5-5$
$-11=x$

17. $5-(t-2)=6$
$5-t+2=6$
$7-t=6$
$-t=-1$
$t=1$

18. $6(y-1)-2(y+1)=4(y-2)$
$6y-6-2y-2=4y-8$
$4y-8=4y-8$
$-8=-8$
All real numbers are solutions. The solution set is the set of all real numbers. The equation is an identity.

19. $3(x-1)-2(2x+1)=5(x-1)$
$3x-3-4x-2=5x-5$
$-x-5=5x-5$
$-x-5+x=5x-5+x$
$-5=6x-5$
$-5+5=6x-5+5$
$0=6x$
$\frac{1}{6}\cdot 0=\frac{1}{6}\cdot 6x$
$0=x$

20. $\frac{1}{3}t-2=\frac{1}{6}+t$
$-2=\frac{1}{6}+\frac{4}{3}t$
$-\frac{13}{6}=\frac{4}{3}t$
$-\frac{13}{4}=t$

Exercise Set 1.4

1. The five steps of the problem solving process:
1. Familiarize
2. Translate
3. Carry out
4. Check
5. State

2. Carry out

3. *State* Give the answer clearly.

4. Translate

5. *Familiarize* Read the problem carefully.

6. Check

7. ***Familiarize***. We want to find two numbers. We can let x represent the first number and note that the second number is 9 more than the first. Also the sum of the numbers is 91.
Translate. The second number can be named $x + 9$. We translate to an equation:

First number	plus	second number	is	91.
↓	↓	↓	↓	↓
x	$+$	$(x+9)$	$=$	91

8. Let x and $x + 6$ represent the numbers;
$x + (x + 6) = 88$

9. ***Familiarize***. Let t = the time, in hours, it will take Maja to paddle 8 mi. We will use the formula Distance = Speed × Time. Maja's speed paddling against the current is (4.6 – 2.1) mph.
Translate. We substitute in the formula
$8 = (4.6 – 2.1)t$.

10. Let t = the time, in hours, it will take the plane to travel 725 km into the wind. The speed of the plane flying into the wind is 390 – 65 km/h. Then we have
$725 = (390 – 65)t$.

11. ***Familiarize***. There are three angle measures involved, and we want to find all three. We can let x represent the smallest angle measure and note that the second is one more than x and the third is one more than the second, or two more than x. We also note that the sum of the three angle measures must be 180°.
Translate. The three angle measures are x, $x + 1$, and $x + 2$. We translate to an equation:

First	plus	second	plus	third	is	180°.
↓	↓	↓	↓	↓	↓	↓
x	$+$	$(x+1)$	$+$	$(x+2)$	$=$	180

12. Let c = the cost without the 15% discount. Then the discounted price was c – 15%c, or $c – 0.15c$. Then we have $c – 0.15c = 272$.

13. ***Familiarize***. Since the escalator's speed is 100 ft/min and Dominik's walking speed is 90 ft/min, Dominik will move at a speed of 90 + 100 ft/min on the escalator. Let t = the time, in minutes, it takes to reach the top.
Translate. We will use the formula Distance = Speed × Time.

Distance	=	Speed	×	Time
↓	↓	↓	↓	↓
190	$=$	$(90+100)$	$\times$	t

14. Let t represent the time, in seconds, that is takes Alida to walk the length of the sidewalk. Alida will move at a speed of (2 + 3) ft/sec. Then we have $900 = (2 + 3)t$.

15. ***Familiarize***. Let w represent the wholesale price, in dollars. Then the wholesale price raised by 50% is $w + 0.5w$.

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Translate.

Wholesale price raised 50%	plus	$1.50	is	selling price.
↓	↓	↓	↓	↓
$w + 0.5w$	+	1.50	=	22.50

16. Let b = the original amount of the bill. Then the discounted price was $b - 5\%b$, or $b - 0.05b$. Then we have

$$b - 0.05b = 142.50.$$

17. ***Familiarize***. Let t = the time, in minutes, required for the plane to reach 29,000 ft. Since Distance = Speed × Time, the plane will travel $3500 \times t$ ft in t min. Note that the plane starts at an altitude of 8000 ft.

Translate.

Current attitude	plus	distance climbed	is	29,000 ft.
↓	↓	↓	↓	↓
8000	+	$3500t$	=	29,000

18. ***Familiarize***. Let x represent the measure of the second angle. Then the first angle is four times x, and the third angle is 5° more than twice x. The sum of the three angles is 180°.

Translate. The first angle is $4x$, the second angle is x, and the third angle is $2x + 5$. Translate to an equation:

First	plus	second	plus	third	is	180°.
↓	↓	↓	↓	↓	↓	↓
$4x$	+	x	+	$(2x + 5)$	=	180

19. ***Familiarize***. Note that each odd integer is 2 more than the one preceding it. If we let n represent the first odd integer then $n + 2$ represents the next odd integer and $(n + 2) + 2$, or $n + 4$ is the third odd integer.

Translate.

First	plus	twice the second	plus	three times the third	is	70.
↓	↓	↓	↓	↓	↓	↓
n	+	$2(n + 2)$	+	$3(n + 4)$	=	70

20. Let x represent the first even integer. Then the second even integer is $x + 2$. We have

$$2x + 3(x + 2) = 76.$$

21. ***Familiarize***. The perimeter of an equilateral triangle is 3 times the length of a side. Let s = the length of a side of the smaller triangle. Then $2s$ = the length of a side of the larger triangle. The sum of the two perimeters is 90 cm.

Translate.

Perimeter of smaller triangle	plus	perimeter of larger triangle	is	90 cm.
↓	↓	↓	↓	↓
$3s$	+	$3 \cdot 2s$	=	90

22. Let x represent the longer length; $x + \frac{2}{3}x = 10$

23. ***Familiarize***. Let c represent the number of calls Faven will need on the next shift if Faven is to average 3 calls per shift. We find the average by adding the number of calls on each of the 5 shifts and then dividing by the number of addends.

Translate.

Average number of calls per shift	is	3.
↓	↓	↓
$\frac{5 + 2 + 1 + 3 + c}{5}$	=	3

24. Let x represent the score on the next test;

$$\frac{93 + 89 + 72 + 80 + 96 + x}{6} = 88$$

25. ***Familiarize***. Let p represent the price Tony paid for his graphing calculator.

Translate.

Price Tess paid	is	price Tony paid	less	$13.
↓	↓	↓	↓	↓
124	=	p	−	13

Carry out. We solve the equation.

$$124 = p - 13$$
$$137 = p \quad \text{Adding 13 to both sides}$$

Check. The price Tess paid, $124, is $13 less than $137, so the answer checks.

State. Tony paid $137 for his graphing calculator.

26. Let s represent the number of students in Amani's class. Solve $35 = s + 12$.

$s = 23$ students

27. ***Familiarize***. Let r represent the average monthly rent of an apartment in Charlotte, in dollars.

Translate.

Rent in Greenville	is	$\frac{5}{7}$	of	rent in Charlotte
↓	↓	↓	↓	↓
1100	=	$\frac{5}{7}$	·	r

Carry out. We solve the equation.

$$1100 = \frac{5}{7}r$$
$$\frac{7}{5} \cdot 1100 = \frac{7}{5} \cdot \frac{5}{7}r$$
$$1540 = r$$

Check. Since $\frac{5}{7}$ of $1540 is $1100, the answer checks.

State. The average monthly apartment rent in Charlotte is $1540.

28. Let p represent the amount Adi paid for a haircut in Kansas City.

Solve $75 = \frac{5}{3}p$

p = $45

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29. ***Familiarize***. Let x represent the number of flu shots given by Caleb. Then $x + 11$ represents the number of flu shots given by Miguel.
Translate.

$$\underbrace{\text{Total flu shots}}_{\downarrow} \quad \underbrace{\text{is}}_{\downarrow} \quad \underbrace{53}_{\downarrow}$$
$$x + (x + 11) \quad = \quad 53$$

Carry out. We solve the equation.

$$\begin{aligned} x + (x + 11) &= 53 \\ 2x + 11 &= 53 \\ 2x &= 42 \qquad \text{Subtracting 11 from both sides} \\ x &= 21 \end{aligned}$$

If $x = 21$, then $x + 11 = 21 + 11$, or 32.
Check. 32 is 11 more than 21. Also, 21 + 32 = 53 flu shots. The answer checks.
State. Miguel gave 32 flu shots.

30. Let c represent the number of calls Paul made.
Solve $256 = (c - 12) + c$
$c = 134$
$c - 12 = 134 - 12 = 122$
Meghan made 122 calls.

31. ***Familiarize***. Let w represent the width of the mirror, in cm. Then $3w$ represents the length. Recall that the formula for the perimeter P of a rectangle with length l and width w is $P = 2l + 2w$.
Translate.

$$\underbrace{\text{Perimeter}}_{\downarrow} \quad \underbrace{\text{is}}_{\downarrow} \quad \underbrace{120 \text{ cm}}_{\downarrow}$$
$$2 \cdot 3w + 2 \cdot w \quad = \quad 120$$

Carry out. We solve the equation.

$$\begin{aligned} 2 \cdot 3w + 2 \cdot w &= 120 \\ 6w + 2w &= 120 \\ 8w &= 120 \\ w &= 15 \end{aligned}$$

When $w = 15$, then $3w = 3 \cdot 15 = 45$.
Check. If the length is 45 cm and the width is 15 cm, then the length is three times the width. Also $P = 2 \cdot 45 + 2 \cdot 15 = 90 + 30 = 120$ cm. The answer checks.
State. The length of the mirror is 45 cm, and the width is 15 cm.

32. Let w represent the width of the tile, in cm. Then $2w$ represents the length.
Solve $2 \cdot 2w + 2 \cdot w = 21$.
$w = 3.5$, so $2w = 2(3.5) = 7$
The length of the tile is 7 cm, and the width is 3.5 cm.

33. ***Familiarize***. Let l represent the length of the greenhouse, in meters. Then $\frac{1}{4}l$ represents the width.
Recall that the formula for the perimeter P, of a rectangle with length l and width w is $P = 2l + 2w$.
Translate.

$$\underbrace{\text{Perimeter}}_{\downarrow} \quad \underbrace{\text{is}}_{\downarrow} \quad \underbrace{130 \text{ m}}_{\downarrow}$$
$$2l + 2 \cdot \frac{1}{4}l \quad = \quad 130$$

Carry out. We solve the equation.

$$\begin{aligned} 2l + 2 \cdot \frac{1}{4}l &= 130 \\ 2l + \frac{1}{2}l &= 130 \\ \frac{5}{2}l &= 130 \\ \frac{2}{5} \cdot \frac{5}{2}l &= \frac{2}{5} \cdot 130 \\ l &= 52 \end{aligned}$$

When $l = 52$, then $\frac{1}{4}l = 13$.
Check. If the length is 52 m and the width is 13 m, then the width is $\frac{1}{4}$ of the length. Also, $P = 2 \cdot 52 + 2 \cdot 13 = 104 + 26 = 130$ m. The answer checks.
State. The length of the greenhouse is 52 m, and the width is 13 m.

34. Let y = the length; then $\frac{1}{3}y =$ the width.
Solve $2 \cdot y + 2 \cdot \frac{1}{3}y = 32$.
$y = 12$, so the length is 12 m, and the width is $\frac{1}{3} \cdot 12$ m, or 4 m.

35. The Familiarize and Translate steps were done in Exercise 9.
$8 = (4.6 - 2.1)t$.
Carry out. We solve the equation.

$$\begin{aligned} 8 &= (4.6 - 2.1)t \\ 8 &= 2.5t \\ \frac{8}{2.5} &= \frac{2.5}{2.5}t \\ 3.2 &= t \end{aligned}$$

Check. At a speed of 2.5 mph, in 3.2 hr, Maja paddles 2.5(3.2), or 8 mi. Our answer checks.
State. Maja takes 3.2 hr to paddle 8 mi.

36. $190 = (90 + 100)t$
$t = 1$ min

37. The Familiarize and Translate steps were done in Exercise 11.
Carry out. We solve the equation.

$$\begin{aligned} x + (x + 1) + (x + 2) &= 180 \\ 3x + 3 &= 180 \\ 3x &= 180 - 3 \\ 3x &= 177 \\ \frac{1}{3} \cdot 3x &= \frac{1}{3} \cdot 177 \\ x &= 59 \end{aligned}$$

When $x = 59$, then $x + 1 = 59 + 1 = 60$, and $x + 2 = 59 + 2 = 61$.
Check. The angles, 59°, 60°, and 61° are consecutive integers. Also 59° + 60° + 61° = 180°. The answer checks.
State. The measures of the angles are 59°, 60°, and 61°.

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38. $4x + x + (2x + 5) = 180$
$7x + 5 = 180$
$7x = 180 - 5$
$7x = 175$
$\frac{1}{7} \cdot 7x = \frac{1}{7} \cdot 175$
$x = 25$
When $x = 25$, then $4x = 4 \cdot 25 = 100$, and $2x + 5 = 2 \cdot 25 + 5 = 55$.
The measures of the angles are 100°, 25°, and 55°.

39. The Familiarize and Translate steps were done in Exercise 16.
Carry out. We solve the equation.
$c - 0.05c = 142.50$
$0.95c = 142.50$
$\frac{0.95c}{0.95} = \frac{142.50}{0.95}$
$c = 150$
Check. 5% of \$150 is \$7.50 and \$150 – \$7.50 = \$142.50.
The answer checks.
State. The cost would have been \$150 if the bill had not been paid promptly.

40. $c - 0.15c = 272$
$c = \$320$
The original cost of the order was \$320.

41. The Familiarize and Translate steps were done in Exercise 15.
Carry out. We solve the equation.
$1.5w + 1.50 = 22.50$
$1.5w = 21$
$w = \frac{1}{1.5} \cdot 21$
$w = 14$
Check. If a wholesale price of \$14 is raised by 50%, we have \$14 + 0.5(\$14) = \$14 + \$7 = \$21. When \$1.50 is added to this figure, we have \$21 + \$1.50 = \$22.50. The answer checks.
State. The wholesale price is \$14.00.

42. $2n + 3(n + 2) = 76$
$2n + 3n + 6 = 76$
$5n + 6 = 76$
$5n = 70$
$n = 14$
When $n = 14$, then $n + 2 = 14 + 2 = 16$. The integers are 14 and 16.

43. *Writing Exercise*. Answers may vary. One possibility is: Jason has $\frac{1}{3}$ of a pizza. He offers half to Beth. What part of the pizza did Beth receive?

44. *Writing Exercise*. Answers may vary. One possibility is: A garden is $16\frac{1}{2}$ ft long. Flowers are to be planted $1\frac{1}{3}$ ft apart. Find the number of rows of flowers.

45. *Writing Exercise*. The manner in which a guess or estimate is manipulated can give insight into the form of the equation to which the problem will be translated.

46. *Writing Exercise*. If a problem is not translated correctly in Step 2 (Translate), it is very probable that the solution of the equation is not a solution of the original problem.

47. ***Familiarize***. The average score on the first four tests is $\frac{83 + 91 + 78 + 81}{4}$, or 83.25. Let x = the number of points above this average that Enrique scores on the next test. Then the score on the fifth test is $83.25 + x$.
Translate.

Average score on 5 tests	is	2	more than	average score on 4 tests.
$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$
$\frac{83 + 91 + 78 + 81 + (83.25 + x)}{5}$	$=$	2	$+$	83.25

Carry out. Carry out some algebraic manipulation.
$\frac{83 + 91 + 78 + 81 + (83.25 + x)}{5} = 2 + 83.25$
$\frac{416.25 + x}{5} = 85.25$
$416.25 + x = 426.25$
$x = 10$
Check. If Enrique scores 10 points more than the average of the first four tests on the fifth test, his score will be 83.25 + 10, or 93.25. Then the five-test average will be $\frac{83 + 91 + 78 + 81 + 93.25}{5}$, or 85.25. This is 2 points above the 4-test average, so the answer checks.
State. Enrique must score 10 points above the four-test average in order to raise the average 2 points.

48. Let x = the height; then the sides are given by $x + 1$, $x + 2$, and $x + 3$, where $x + 2$ represents the base.
Solve $(x + 1) + (x + 2) + (x + 3) = 42$.
$x = 12$, so the height of the triangle is 12 in., and the base is 12 + 2, or 14 in. Then the area is $\frac{1}{2} \cdot 14 \text{ in.} \cdot 12 \text{ in.}$, or 84 sq in.

49. ***Familiarize***. Let b = the number of butterflies counted in 2017. From 2017 to 2018 the number of butterflies increased 62%, so $b + 0.62b$, or $1.62a$. From 2018 to 2019 the number of butterflies increased 2879%, so $1.62b + 28.79(1.62b)$, or $29.79(1.62b)$. From 2019 to 2020 the numbers decreased 98%, so $29.79(1.62b) - 0.98(29.79)(1.62b)$, or $0.02(29.79)(1.62b)$. From 2020 to 2021, the numbers increased 44%, so the number of butterflies became $0.02(29.79)(1.62b) + 0.44(0.02)(29.79)(1.62b)$, or $1.44(0.02)(29.79)(1.62b)$.
Translate.

Butterflies in 2017	were	12,180.
$\downarrow$	$\downarrow$	$\downarrow$
$1.44(0.02)(29.79)(1.62b)$	$=$	12,180

Carry out. We solve the equation.
$1.44(0.02)(29.79)(1.62b) = 12{,}180$
$b = \frac{12{,}180}{1.44(0.02)(29.79)(1.62)}$
$b \approx 8763$

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Check. If the number of butterflies in 2017 was 8763 , then in 2018 there were 1.62(8763), or 14,196. In 2019 there were 29.79(14,196), or 422,899. In 2020 there were 0.02(422,899), or 8458, and in 2021 there were 1.44(8458), or 12,180. Our answer checks.
State. There were about 8763 butterflies in 2017.

50. Let x represent the number by which the reduced salary would have to be multiplied in order to return it to the original salary S. Note that $n\%$ can be expressed as $0.01n$ in decimal notation.

$$\underbrace{\text{Reduced salary}} \quad \text{times} \quad \underbrace{\text{what number}} \quad \text{is} \quad \underbrace{\text{original salary.}}$$

$$\downarrow \qquad \downarrow \qquad \downarrow \qquad \downarrow \qquad \downarrow$$

$$S(1-0.01n) \quad \cdot \quad x \quad = \quad S$$

$$S(1-0.01n)(x) = S$$

$$x = \frac{1}{1-0.01n}, \text{ or } \frac{100}{100-n}$$

Connecting the Concepts

1. $2x-3=7$
$2x=10$
$x=5$

2. $2x-c=h$
$2x=c+h$
$x=\frac{c+h}{2}$

3. $8-3(y-7)=2y$
$8-3y+21=2y$
$-3y+29=2y$
$29=5y$
$\frac{29}{5}=y$

4. $8-n(y-c)=ay$
$8-ny+nc=ay$
$8+nc=ay+ny$
$8+nc=y(a+n)$
$\frac{8+nc}{a+n}=y$

5. $\frac{a}{3}-\frac{1}{2}=4a$
$6\left(\frac{a}{3}-\frac{1}{2}\right)=6(4a)$
$2a-3=24a$
$-3=22a$
$-\frac{3}{22}=a$

6. $\frac{a}{3}-\frac{n}{2}=xa$
$6\left(\frac{a}{3}-\frac{n}{2}\right)=6(xa)$
$2a-3n=6xa$
$-3n=6xa-2a$
$-3n=a(6x-2)$
$\frac{-3n}{6x-2}=a \quad \text{or } a=\frac{3n}{2-6x}$

Exercise Set 1.5

1. A formula is an *equation* that uses letters to represent a relationship between two or more quantities.

2. The formula $A=\pi r^2$ is used to calculate the *area* of a circle.

3. The formula $C=\pi d$ is used to calculate the *circumference* of a circle.

4. The formula $A=\frac{1}{2}bh$ is used to calculate the area of a triangle of height h and base b.

5. The formula $A=bh$ is used to calculate the area of a parallelogram of height h and base length b.

6. The formula $l=A/w$ can be used to determine the *length* of a rectangle, given its area and width.

7. In the formula for the area of a trapezoid, $A=\frac{h}{2}(b_1+b_2)$ the numbers 1 and 2 are referred to as *subscripts*.

8. When two or more terms on the same side of a formula contain the letter for which we are solving, we can *factor* so that the letter is only written once.

9. $E=wA$
$\frac{1}{w}\cdot E=\frac{1}{w}\cdot wA$ Multiplying both sides by $\frac{1}{w}$
$\frac{E}{w}=A$ Simplifying

10. $a=\frac{F}{m}$

11. $d=rt$
$\frac{1}{t}\cdot d=\frac{1}{t}\cdot rt$ Multiplying both sides by $\frac{1}{t}$
$\frac{d}{t}=r$ Simplifying

12. $E=\frac{P}{I}$

13. $V=lwh$
$\frac{1}{lw}\cdot V=\frac{1}{lw}\cdot lwh$ Multiplying both sides by $\frac{1}{lw}$
$\frac{V}{lw}=h$ Simplifying

14. $r=\frac{I}{Pt}$

15. $L=\frac{k}{d^2}$
$d^2\cdot L=d^2\cdot\frac{k}{d^2}$ Multiplying both sides by d^2
$d^2L=k$ Simplifying

16. $F=\frac{mv^2}{r}$
$F\cdot\frac{r}{v^2}=\frac{mv^2}{r}\cdot\frac{r}{v^2}$
$\frac{Fr}{v^2}=m$

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17. $G = w + 150n$

$G - w = 150n$ Subtracting w from both sides

$\frac{1}{150}(G - w) = \frac{1}{150} \cdot 150n$ Multiplying both sides by $\frac{1}{150}$

$\frac{G - w}{150} = n$ Simplifying

18. $P = b + 1.5t$

$P - b = 1.5t$

$\frac{P - b}{1.5} = t$, or

$\frac{2}{3}(P - b) = t$

19. $2w + 2h + l = p$

$l = p - 2w - 2h$ Adding $-2w - 2h$ to both sides

20. $2w + 2h + l = p$

$2w = p - 2h - l$

$w = \frac{p - 2h - l}{2}$

21. $2x + 3y = 4$

$3y = 4 - 2x$ Subtracting $2x$ from both sides

$\frac{1}{3} \cdot 3y = \frac{1}{3}(4 - 2x)$ Multiplying both sides by $\frac{1}{3}$

$y = \frac{4 - 2x}{3}$ Simplifying

or $y = -\frac{2}{3}x + \frac{4}{3}$

22. $3x - 7y = 2$

$-7y = -3x + 2$

$y = \frac{3x - 2}{7}$ or $y = \frac{3}{7}x - \frac{2}{7}$

23. $Ax + By = C$

$By = C - Ax$ Subtracting Ax from both sides

$\frac{1}{B} \cdot By = \frac{1}{B}(C - Ax)$ Multiplying both sides by $\frac{1}{B}$

$y = \frac{C - Ax}{B}$ Simplifying

24. $P = 2l + 2w$

$P - 2w = 2l$

$\frac{P - 2w}{2} = l$, or $\frac{P}{2} - w = l$

25. $C = \frac{5}{9}(F - 32)$

$\frac{9}{5} \cdot C = \frac{9}{5} \cdot \frac{5}{9}(F - 32)$ Multiplying both sides by $\frac{9}{5}$

$\frac{9}{5}C = F - 32$ Simplifying

$\frac{9}{5}C + 32 = F$

26. $T = \frac{3}{10}(I - 12{,}000)$

$\frac{10}{3}T = I - 12{,}000$

$\frac{10}{3}T + 12{,}000 = I$

27. $V = \frac{4}{3}\pi r^3$

$\frac{3}{4\pi} \cdot V = \frac{3}{4\pi} \cdot \frac{4}{3}\pi r^3$ Multiplying both sides by $\frac{3}{4\pi}$

$\frac{3V}{4\pi} = r^3$ Simplifying

28. $\pi = \frac{3V}{4r^3}$

29. $np + nm = t$

$n(p + m) = t$ Factoring

$n = \frac{t}{p + m}$ Dividing both sides by $p + m$

30. $ab + ac = d$

$a(b + c) = d$

$a = \frac{d}{b + c}$

31. $uv + wv = x$

$v(u + w) = x$ Factoring

$v = \frac{x}{u + w}$ Dividing both sides by $u + w$

32. $st + rt = n$

$t(s + r) = n$

$t = \frac{n}{s + r}$

33. $A = \frac{q_1 + q_2 + q_3}{n}$

$n \cdot A = n \cdot \frac{q_1 + q_2 + q_3}{n}$ Clearing the fraction

$nA = q_1 + q_2 + q_3$

$nA \cdot \frac{1}{A} = (q_1 + q_2 + q_3) \cdot \frac{1}{A}$ Multiplying both sides by $\frac{1}{A}$

$n = \frac{q_1 + q_2 + q_3}{A}$

34. $g = \frac{km_1m_2}{d^2}$

$d^2g = km_1m_2$

$d^2 = \frac{km_1m_2}{g}$

35. $v = \frac{d_2 - d_1}{t}$

$t \cdot v = t \cdot \frac{d_2 - d_1}{t}$ Clearing the fraction

$tv = d_2 - d_1$

$tv \cdot \frac{1}{v} = (d_2 - d_1) \cdot \frac{1}{v}$ Multiplying both sides by $\frac{1}{v}$

$t = \frac{d_2 - d_1}{v}$

36. $v = \frac{s_2 - s_1}{m}$

$mv = s_2 - s_1$

$m = \frac{s_2 - s_1}{v}$

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37.
$$v = \frac{d_2 - d_1}{t}$$
$$t \cdot v = t \cdot \frac{d_2 - d_1}{t} \quad \text{Clearing the fraction}$$
$$tv = d_2 - d_1$$
$$tv - d_2 = -d_1 \quad \text{Subtracting } d_2 \text{ from both sides}$$
$$-1 \cdot (tv - d_2) = -1(-d_1) \quad \text{Multiplying both sides by } -1$$
$$-tv + d_2 = d_1, \text{ or } d_2 - tv = d_1$$

38.
$$v = \frac{s_2 - s_1}{m}$$
$$vm = s_2 - s_1$$
$$s_1 = s_2 - vm$$

39.
$$bd = c + ba$$
$$bd - ba = c \quad \text{Adding } -ba \text{ to both sides}$$
$$b(d - a) = c \quad \text{Factoring}$$
$$b = \frac{c}{d - a} \quad \text{Dividing both sides by } d - a$$

40.
$$st = n + sm$$
$$st - sm = n$$
$$s(t - m) = n$$
$$s = \frac{n}{t - m}$$

41.
$$v - w = uvw$$
$$v = uvw + w \quad \text{Adding } w \text{ to both sides}$$
$$v = w(uv + 1) \quad \text{Factoring}$$
$$\frac{v}{uv + 1} = w \quad \text{Dividing both sides by } uv + 1$$

42.
$$p - q = qrs$$
$$p = qrs + q$$
$$p = q(rs + 1)$$
$$\frac{p}{rs + 1} = q$$

43.
$$n - mk = mt^2$$
$$n = mt^2 + mk \quad \text{Adding } mk \text{ to both sides}$$
$$n = m(t^2 + k) \quad \text{Factoring}$$
$$\frac{n}{t^2 + k} = m \quad \text{Dividing both sides by } t^2 + k$$

44.
$$d - ct = ca^3$$
$$d = ca^3 + ct$$
$$d = c(a^3 + t)$$
$$\frac{d}{a^3 + t} = c$$

45. ***Familiarize***. In Example 2, we find the formula for simple interest, $I = Prt$, when I is interest, P is principal, r is the interest rate, and t is time, in years.
Translate. We want to find the interest rate, so we solve the formula for r.
$$I = Prt$$
$$\frac{1}{Pt} \cdot I = \frac{1}{Pt} \cdot Prt$$
$$\frac{I}{Pt} = r$$
Carry out. The model $r = \frac{I}{Pt}$ can be used to find the rate of interest at which an amount (the principal) must be invested in order to earn a given amount. We substitute \$2600 for P, $\frac{1}{2}$ for t (6 months = $\frac{1}{2}$ yr), and \$104 for I.
$$\frac{I}{Pt} = r$$
$$\frac{\$104}{\$2600\left(\frac{1}{2}\right)} = r$$
$$\frac{104}{1300} = r$$
$$0.08 = r$$
$$8\% = r$$
Check. Since $\$2600(0.08)\left(\frac{1}{2}\right) = \$104$, the answer checks.
State. The interest rate must be 8%.

46. Solve $I = Prt$ for P and substitute.
$$P = \frac{I}{rt} = \frac{\$150}{0.04(2)} = \$1875$$

47. ***Familiarize***. In the text, we find the formula for the area of a parallelogram, $A = bh$, where b is the base and h is the height.
Translate. We solve the formula for h.
$$A = bh$$
$$\frac{1}{b} \cdot A = \frac{1}{b} \cdot bh$$
$$\frac{A}{b} = h$$
Carry out. The model $h = \frac{A}{b}$ can be used to find the height of any parallelogram for which the area and base are known. We substitute 96 for A and 6 for b.
$$h = \frac{A}{b}$$
$$h = \frac{96}{6}$$
$$h = 16$$
Check. We repeat the calculation. The answer checks.
State. The height is 16 cm.

48. Solve $A = bh$ for b and substitute.
$$b = \frac{A}{h} = \frac{84}{7} = 12 \text{ cm}$$

49. ***Familiarize and Translate***. In Example 1, the formula for area is solved for length, l:
$$l = \frac{A}{w}$$
Carry out. We substitute 400 for A and 8 for w and calculate l.
$$l = \frac{400}{8} = 50$$
Check. We could repeat the calculations or substitute in the original formula and then solve for l. The answer checks.
State. Jean can paint 50 feet of fence that is 8 feet tall.

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50. See Example 1. Also note total area is 20(4) = 80 sq ft.

Solve $l = \frac{20(4)}{10} = 8$ ft

51. ***Familiarize***. The formula for the area of a trapezoid is $A = \frac{1}{2}h(b_1 + b_2)$, where A is the area, h is the height, and b_1 and b_2 are the bases.

Translate. The unknown dimension is the height, so we solve the formula for h. We have $h = \frac{2A}{b_1 + b_2}$.

Carry out. We substitute.

$$h = \frac{2A}{b_1 + b_2}$$
$$h = \frac{2 \cdot 90}{8 + 12}$$
$$h = \frac{180}{20}$$
$$h = 9$$

Check. We repeat the calculation. The answer checks.
State. The unknown dimension, the height of the trapezoid, is 9 ft.

52. Solve $P = 2l + 2w$ for l and substitute.

$$l = \frac{P - 2w}{2} = \frac{76 - 2 \cdot 13}{2} = \frac{76 - 26}{2} = \frac{50}{2} = 25 \text{ ft}$$

53. Observe that 4% of \$1000 is \$40, so \$40 is the amount of simple interest that would be earned in 1 yr. Thus, it will take 1 yr for the investment to be worth \$1040.

54. $t = \frac{A - P}{Pr}$ (See Example 3)

$$t = \frac{1178 - 950}{950(0.03)} = 8 \text{ years}$$

55. ***Familiarize and Translate***. We will use the model developed in Example 5, $m = \pi r^2 hD$ to find the weight of the salt. Then we will add 28 g, the weight of the empty canister, to find the weight of the filled canister.

Carry out. We substitute 4 for r, 13.6 for h, and 2.16 for D and calculate m.

$$m = \pi r^2 hD$$
$$= \pi(4)^2(13.6)(2.16)$$
$$\approx 1476.6$$

Add the weight of the empty canister:

$$1476.6 + 28 = 1504.6$$

Check. We repeat the calculations. The answer checks.
State. The filled canister weighs about 1504.6 g.

56. We will use the model developed in Example 5, $m = \pi r^2 hD$ to find the weight of a gold coin. Then we will subtract 26.4 g, the weight of the silver coin found in Example 5, to determine how much more a gold coin would weigh.

$$m = \pi(2)^2(0.2)(19.3) \approx 48.5$$

Find the difference in weights:

$$48.5 - 26.4 = 22.1 \approx 22 \text{ g}$$

57. ***Familiarize***. We use the formula given, $A = \frac{q_1 + q_2 + q_3}{3}$.

Translate. The unknown quantity is third test score q_3. We solve the formula for q_3.

$$A = \frac{q_1 + q_2 + q_3}{3}$$
$$3A = q_1 + q_2 + q_3$$
$$q_3 = 3A - q_1 - q_2$$

Carry out. We substitute 90 for A, 91 for q_1, 86 for q_2 and calculate q_3.

$$q_3 = 3(90) - 91 - 86 = 93$$

Check. We repeat the calculations. The answer checks.
State. The third test score earned must be 93.

58. $L = \frac{E(H_i - H_f)}{H_i}$

$$1470 = \frac{E(13 - 7)}{13}$$
$$E = 3185 \text{ mL}$$

59. ***Familiarize***. We will use the formula given in the text, $R = r + \frac{400(W - L)}{N}$.

Translate. We solve the formula for r.

$$R = r + \frac{400(W - L)}{N}$$
$$R - \frac{400(W - L)}{N} = r$$

Carry out. We substitute 1305 for R, 5 for w, 3 for L, and 5 + 3, or 8, for N and calculate r.

$$1305 - \frac{400(5 - 3)}{8} = r$$
$$1205 = r$$

Check. We can repeat the calculation or substitute in the original formula and then solve for r. The answer checks.
State. The average rating of Ulana's opponents was 1205.

60. Calculate $r = 1050 - \frac{400(2 - 5)}{2 + 5}$. (See Exercise 59.)

$$r \approx 1221$$

61. ***Familiarize***. We will use the formula given in the text, $K = 917 + 6(w + h - a)$.

Translate. We solve the formula for h.

$$K = 917 + 6(w + h - a)$$
$$K = 917 + 6w + 6h - 6a$$
$$K - 917 - 6w + 6a = 6h$$
$$\frac{K - 917 - 6w + 6a}{6} = h$$

Carry out. We substitute 1901 for K, 120 for w, and 23 for a and calculate h.

$$\frac{1901 - 917 - 6 \cdot 120 + 6 \cdot 23}{6} = h$$
$$67 = h$$

Check. We can repeat the calculation or substitute in the original formula and then solve for h. The answer checks.
State. Julie is 67 in., or 5 ft 7 in., tall.

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62. First solve the given formula for w.

$$K = 917 + 6(w + h - a)$$
$$K = 917 + 6w + 6h - 6a$$
$$K - 917 - 6h + 6a = 6w$$
$$\frac{K - 917 - 6h + 6a}{6} = w$$

Then substitute and calculate w. Note that 5 ft 4 in. is 64 in.

$$\frac{1901 - 917 - 6 \cdot 64 + 6 \cdot 31}{6} = w$$
$$131 \text{ lb} = w$$

63. ***Familiarize***. We use the formula given in the text.

$g = 0.0778n + 4.55s - 2.2029$.

Translate. We solve the formula for n.

$$g = 0.0778n + 4.55s - 2.2029$$
$$n = \frac{g - 4.55s + 2.2029}{0.0778}$$

Carry out. We substitute 3.0 for g and 1.02 for s and calculate n.

$$n = \frac{3.0 - 4.55(1.02) + 2.2029}{0.0778}$$
$$n \approx 7.22$$

Check. We can repeat the calculations or substitute in the original formula and solve for n. The answer checks.

State. There should be 7.22 words per sentence.

64. First solve the given formula for s.

$$g = 0.0778n + 4.55s - 2.2029$$
$$s = \frac{g - 0.0778n + 2.2029}{4.55}$$

Then we substitute and calculate s.

$$s = \frac{3.8 - 0.0778(5) + 2.2029}{4.55}$$
$$\approx 1.23 \text{ syllables per word}$$

65. ***Familiarize***. We use the formula given in the text.

$S = \dfrac{HR(W_i - W_n)}{1000}$.

Translate. We solve the formula for R.

$$S = \frac{HR(W_i - W_n)}{1000}$$
$$R = \frac{1000S}{H(W_i - W_n)}$$

Carry out. We substitute 100 for W_i, 15 for W_n, 2000 for H, and \$20.40 for S, and calculate R.

$$R = \frac{1000(20.40)}{2000(100 - 15)} = 0.12$$

Check. We can repeat the calculations or substitute in the original formula and solve for R. The answer checks.

State. The cost is \$0.12 per kWh.

66. First solve the given formula for W_n.

$$S = \frac{HR(W_i - W_n)}{1000}$$
$$W_n = W_i - \frac{1000S}{HR}$$

Then we substitute and calculate W_n.

$$W_n = 150 - \frac{1000(42.90)}{2600(0.15)}$$
$$= 40 \text{ watts}$$

67. ***Familiarize***. We use the formula given in the text.

$$r = \frac{tmap}{hs}$$

Translate. We solve the formula for t.

$$r = \frac{tmap}{hs}$$
$$t = \frac{rhs}{map}$$

Carry out. We substitute 30 for s, 4 for h, 0.05 for m, 100 for a, 0.15 for p, 3.2 for r and solve for t.

$$t = \frac{3.2 \cdot 4 \cdot 30}{0.05 \cdot 100 \cdot 0.15}$$
$$t = 512$$

Check. We repeat the calculation or substitute in the original formula and solve for t. The answer checks.

State. The average daily blog traffic is 512 visits per day.

68. First solve the given formula for h.

$$r = \frac{tmap}{hs}$$
$$h = \frac{tmap}{rs}$$

Then we substitute and calculate h.

$$h = \frac{1200 \cdot 0.04 \cdot 150 \cdot 0.14}{4.8 \cdot 35} = 6 \text{ hrs}$$

69. ***Familiarize***. We will use Goiten's model, $I = 1.08(T/N)$. Note that 8 hr = 8 × 1 hr = 8 × 60 min = 480 min.

Translate. We solve the formula for N.

$$I = 1.08\left(\frac{T}{N}\right)$$
$$N \cdot I = N(1.08)\left(\frac{T}{N}\right)$$
$$NI = 1.08T$$
$$N = \frac{1.08T}{I}$$

Carry out. We substitute 480 for T and 15 for I.

$$N = \frac{1.08T}{I}$$
$$N = \frac{1.08(480)}{15}$$
$$N = 34.56$$
$$N \approx 34 \quad \text{Rounding down}$$

Check. We repeat the calculations. The answer checks.

State. Dr. Cruz should schedule 34 appointments in one day.

70. Solve $I = 1.08\left(\dfrac{T}{N}\right)$ for T and substitute.

$$T = \frac{NI}{1.08} = \frac{25 \cdot 20}{1.08} \approx 463 \text{ min, or } 7.7 \text{ hr}$$

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71. ***Familiarize***. We will use Thurnau's model, $P = 9.337da - 299$.

Translate. Since we want to find the diameter of the fetus' head, we solve for d.

$$P = 9.337da - 299$$
$$P + 299 = 9.337da$$
$$\frac{P + 299}{9.337a} = d$$

Carry out. Substitute 1614 for P and 24.1 for a in the formula and calculate:

$$\frac{1614 + 299}{9.337(24.1)} = d$$
$$8.5 \approx d$$

Check. We repeat the calculation. The answer checks.

State. The diameter of the fetus' head at 29 weeks is about 8.5 cm.

72. $P = 94.593c + 34.227a - 2134.616$

$$P - 34.227a + 2134.616 = 94.593c$$
$$\frac{P - 34.227a + 2134.616}{94.593} = c$$
$$\frac{1277 - 34.227(23.4) + 2134.616}{94.593} = c$$
$$27.6 \text{ cm} \approx c$$

73. *Writing Exercise*. Yes. The formula for the area of the parallelogram is $A = \frac{1}{2}h(b_1 + b_2)$. For a rectangle, $b_1 = b_2$. Simplifying the formula, we have, $A = \frac{1}{2}h(b_1 + b_1) = \frac{1}{2}h(2b_1) = hb_1$, which is the same as the usual formula for the area of a rectangle, $A = lw$.

74. *Writing Exercise*. Not necessarily; miscalculation of the age of the fetus at the time the ultrasonic image was taken could affect the result. Mismeasurement of the fetal head and/or abdomen could also affect the result.

75. *Writing Exercise*. The formulas will be used to predict fetal birth weight P, so it is most convenient to have P alone on one side.

76. *Writing Exercise*. Since N is the sum of the number of wins, losses, and draws, playing to a draw will help Heidi if she has more losses than wins because $W - L$ is negative and, the larger the value of N, the smaller the number that is subtracted from r to calculate her rating. Conversely, playing to a draw will hurt her if she has more wins than losses because $W - L$ is positive and, the larger the value of N, the smaller the number that is added to r to calculate her rating.

77. ***Familiarize***. First we find the volume of the ring. Note that the inner diameter is 2 cm, so the inner radius is 2/2 or 1 cm. Then the volume of the ring is the volume of a right circular cylinder with height 0.5 cm and radius
1 + 0.15, or 1.15 cm, less the volume of a right circular cylinder with height 0.5 cm and radius 1 cm. Recall that the formula for the volume of a right circular cylinder is $V = \pi r^2 h$. Then the volume of the ring is $\pi(1.15)^2(0.5) - \pi(1)^2(0.5) = 0.16125\pi$ cm^3.

Translate. To find the weight of the ring we will use the formula $D = \frac{m}{V}$. Solving for m, we get

$$D = \frac{m}{V}$$
$$V \cdot D = V \cdot \frac{m}{V}$$
$$V \cdot D = m$$

Carry out. We substitute in the formula $m = V \cdot D$

$$m = 0.16125\pi(21.5)$$
$$m \approx 10.9$$

Check. We repeat the calculations. The answer checks.

State The ring will weigh about 10.9 g.

78. $m = \pi r^2 hD$ (See Example 6.)

$$\frac{m}{\pi r^2 D} = h$$
$$\frac{177.6}{\pi\left(\frac{1.85}{2}\right)^2(8.93)} = h$$
$$7.4 \text{ cm} \approx h$$

79. *Writing Exercise*. The trapezoids, positioned as shown, form a parallelogram with base $b_1 + b_2$ and height h. The area of a parallelogram is base × height, so the area of the given parallelogram is $(b_1 + b_2)h$, or $h(b_1 + b_2)$. Since the area of each trapezoid is one-half the area of the parallelogram, the area of a trapezoid is $\frac{1}{2} \cdot h(b_1 + b_2)$, or $\frac{h}{2}(b_1 + b_2)$.

80. $A = 4lw + w^2$

$$A - w^2 = 4lw$$
$$\frac{A - w^2}{4w} = l \quad \text{Multiplying both sides by } \frac{1}{4w}$$

81. $s = v_i t + \frac{1}{2}at^2$

$$s - v_i t = \frac{1}{2}at^2$$
$$2(s - v_i t) = at^2$$
$$\frac{2(s - v_i t)}{t^2} = a, \text{ or}$$
$$\frac{2s - 2v_i t}{t^2} = a$$

82. $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$$P_1 V_1 T_2 = P_2 V_2 T_1$$
$$T_2 = \frac{P_2 V_2 T_1}{P_1 V_1}$$

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83. $b=\dfrac{h+w+p}{a+w+p+f}$

$b(a+w+p+f)=h+w+p$ Multiplying both sides by $a+w+p+f$

$ab+bw+bp+bf=h+w+p$

$bw-w=h+p-ab-bp-bf$

$w(b-1)=h+p-b(a+p+f)$

$w=\dfrac{h+p-b(a+p+f)}{b-1}$ Multiplying both sides by $\dfrac{1}{b-1}$

84. $m=\dfrac{\dfrac{d}{e}}{\dfrac{e}{f}}$

$\dfrac{me}{f}=\dfrac{d}{e}$ Multiplying both sides by $\dfrac{e}{f}$

$\dfrac{me^2}{f}=d$ Multiplying both sides by e

85. $\dfrac{b}{a-b}=c$

$b=c(a-b)$

$b+bc=ac$

$b(1+c)=ac$

$b=\dfrac{ac}{1+c}$

86. $\dfrac{a}{a+b}=c$

$a=c(a+b)$

$a=ac+bc$

$a-ac=bc$

$a(1-c)=bc$

$a=\dfrac{bc}{1-c}$

87. $s+\dfrac{s+t}{s-t}=\dfrac{1}{t}+\dfrac{s+t}{s-t}$

Observe that if we subtract $\dfrac{s+t}{s-t}$ from both sides we are left with an equivalent equation, $s=\dfrac{1}{t}$. We solve this equation for t.

$s=\dfrac{1}{t}$

$st=1$ Multiplying both sides by t

$t=\dfrac{1}{s}$ Multiplying both sides by $\dfrac{1}{s}$

Exercise Set 1.6

1. The power rule

2. Raising a quotient to a power

3. Raising a product to a power

4. The quotient rule

5. The product rule

6. The power rule

7. Raising a quotient to a power

8. Raising a product to a power

9. The quotient rule

10. The product rule

11. $6^4\cdot 6^7=6^{4+7}=6^{11}$

12. 3^{17}

13. $m^0\cdot m^8=m^{0+8}=m^8$

14. t^6

15. $5x^4\cdot 4x^3=5\cdot 4\cdot x^4\cdot x^3=20x^{4+3}=20x^7$

16. $6a^9$

17. $(-3a^2)(-8a^6)=(-3)(-8)a^2\cdot a^6=24a^{2+6}=24a^8$

18. $-24m^9$

19. $(m^5n^2)(m^3np^0)=(m^5m^3)(n^2n)(p^0)=m^{5+3}n^{2+1}\cdot 1$
$=m^8n^3$

20. x^7y^7

21. $\dfrac{t^8}{t^3}=t^{8-3}=t^5$

22. $\dfrac{a^{11}}{a^8}=a^{11-8}=a^3$

23. $\dfrac{15a^7}{3a^2}=\dfrac{15}{3}a^{7-2}=5a^5$

24. $3t^6$

25. $\dfrac{m^7n^9}{m^2n^5}=m^{7-2}\cdot n^{9-5}=m^5n^4$

26. mn^3

27. $\dfrac{32x^8y^5}{8x^2y}=\dfrac{32}{8}\cdot x^{8-2}\cdot y^{5-1}=4x^6y^4$

28. $5x^6y^6$

29. $\dfrac{28x^{10}y^9z^8}{-7x^2y^3z^2}=\dfrac{28}{-7}\cdot x^{10-2}\cdot y^{9-3}\cdot z^{8-2}=-4x^8y^6z^6$

30. $5x^6y^3z^2$

31. $-x^0=-(-2)^0=-(1)=-1$

32. $(-x)^0=(-(-2))^0=2^0=1$

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33. $(4x)^0 = (4(-2))^0 = (-8)^0 = 1$

34. $4x^0 = 4(-2)^0 = 4 \cdot 1 = 4$

35. $t^{-9} = \frac{1}{t^9}$

36. $\frac{1}{m^2}$

37. $6^{-2} = \frac{1}{6^2} = \frac{1}{36}$

38. $5^{-3} = \frac{1}{5^3} = \frac{1}{125}$

39. $(-3)^{-2} = \frac{1}{(-3)^2} = \frac{1}{9}$

40. $(-2)^{-4} = \frac{1}{(-2)^4} = \frac{1}{16}$

41. $-3^{-2} = -\frac{1}{3^2} = -\frac{1}{9}$

42. $-2^{-4} = -\frac{1}{2^4} = -\frac{1}{16}$

43. $-1^{-10} = -\frac{1}{1^{10}} = -1$

44. $-10^{-2} = -\frac{1}{10^2} = -\frac{1}{100}$

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

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

47. $6x^{-1} = 6 \cdot \frac{1}{x} = \frac{6}{x}$

48. $9x^{-4} = 9 \cdot \frac{1}{x^4} = \frac{9}{x^4}$

49. $3a^8b^{-6} = 3a^8 \cdot \frac{1}{b^6} = \frac{3a^8}{b^6}$

50. $5a^{-7}b^4 = \frac{5b^4}{a^7}$

51. $\frac{2z^{-3}}{x^5} = \frac{2}{x^5} \cdot \frac{1}{z^3} = \frac{2}{x^5z^3}$

52. $\frac{5a^{-1}}{b} = \frac{5}{b} \cdot \frac{1}{a} = \frac{5}{ab}$

53. $\frac{3y^2}{z^{-4}} = 3y^2 \cdot z^4 = 3y^2z^4$

54. $\frac{t^{-6}}{7s^2} = \frac{1}{7s^2} \cdot \frac{1}{t^6} = \frac{1}{7s^2t^6}$

55. $\frac{ab^{-1}}{c^{-1}} = a \cdot \frac{1}{b} \cdot c = \frac{ac}{b}$

56. $\frac{x^{-3}y^4}{z^{-5}} = \frac{1}{x^3} \cdot y^4z^5 = \frac{y^4z^5}{x^3}$

57. $\frac{pq^{-2}r^{-3}}{2u^5v^{-4}} = \frac{p}{2u^5} \cdot \frac{1}{q^2} \cdot \frac{1}{r^3} \cdot v^4 = \frac{pv^4}{2q^2r^3u^5}$

58. $\frac{5a^{-3}bc^{-1}}{d^{-6}f^2} = \frac{5b}{f^2} \cdot \frac{1}{a^3} \cdot \frac{1}{c} \cdot d^6 = \frac{5bd^6}{a^3cf^2}$

59. $\frac{1}{x^3} = x^{-3}$

60. n^{-4}

61. $\frac{1}{(-10)^3} = (-10)^{-3}$

62. 12^{-5}

63. $8^{10} = \frac{1}{8^{-10}}$

64. $\frac{1}{(-6)^{-4}}$

65. $4x^2 = 4 \cdot \frac{1}{x^{-2}} = \frac{4}{x^{-2}}$

66. $\frac{-4}{y^{-5}}$, or $-\frac{4}{y^{-5}}$

67. $\frac{1}{(5y)^3} = (5y)^{-3}$

68. $(5x)^{-5}$

69. $\frac{1}{3y^4} = \frac{1}{3} \cdot \frac{1}{y^4} = \frac{1}{3} \cdot y^{-4} = \frac{y^{-4}}{3}$

70. $\frac{b^{-3}}{4}$

71. $6^{-3} \cdot 6^{-5} = 6^{-3+(-5)} = 6^{-8}$, or $\frac{1}{6^8}$

72. 4^{-3}, or $\frac{1}{4^3}$

73. $a \cdot a^{-8} = a^{1+(-8)} = a^{-7}$, or $\frac{1}{a^7}$

74. b^3

75. $x^{-7} \cdot x^2 \cdot x^5 = x^{-7+2+5} = x^0 = 1$

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76. a

77. $(4mn^3)(-2m^3n^2) = 4(-2)\cdot m\cdot m^3\cdot n^3\cdot n^2$
$= -8m^{1+3}n^{3+2}$
$= -8m^4n^5$

78. $-18x^8y$

79. $(-7x^4y^{-5})(-5x^{-6}y^8) = (-7)(-5)\cdot x^4\cdot x^{-6}\cdot y^{-5}\cdot y^8$
$= 35x^{4+(-6)}y^{-5+8}$
$= 35x^{-2}y^3$, or $\dfrac{35y^3}{x^2}$

80. $24u^{-10}v^6$, or $\dfrac{24v^6}{u^{10}}$

81. $(5a^{-2}b^{-3})(2a^{-4}b) = 5\cdot 2\cdot a^{-2}\cdot a^{-4}\cdot b^{-3}\cdot b$
$= 10a^{-2+(-4)}b^{-3+1}$
$= 10a^{-6}b^{-2}$, or $\dfrac{10}{a^6b^2}$

82. $6a^{-4}b^{-9}$, or $\dfrac{6}{a^4b^9}$

83. $\dfrac{10^{-3}}{10^6} = 10^{-3-6} = 10^{-9}$, or $\dfrac{1}{10^9}$

84. 12^{-12}, or $\dfrac{1}{12^{12}}$

85. $\dfrac{2^{-7}}{2^{-5}} = 2^{-7-(-5)} = 2^{-7+5} = 2^{-2}$, or $\dfrac{1}{2^2}$, or $\dfrac{1}{4}$

86. 9^2, or 81

87. $\dfrac{y^4}{y^{-5}} = y^{4-(-5)} = y^{4+5} = y^9$

88. a^5

89. $\dfrac{24a^5b^3}{-8a^4b} = \dfrac{24}{-8}a^{5-4}b^{3-1} = -3ab^2$

90. $3m^3n^{-5}$, or $\dfrac{3m^3}{n^5}$

91. $\dfrac{15m^5n^3}{10m^{10}n^{-4}} = \dfrac{15}{10}m^{5-10}n^{3-(-4)} = \dfrac{3}{2}m^{-5}n^7$, or $\dfrac{3n^7}{2m^5}$

92. $-\dfrac{4}{3}x^9y^{-2}$, or $-\dfrac{4x^9}{3y^2}$

93. $\dfrac{-6x^{-2}y^4z^8}{-24x^{-5}y^6z^{-3}} = \dfrac{-6}{-24}x^{-2-(-5)}y^{4-6}z^{8-(-3)}$
$= \dfrac{1}{4}x^3y^{-2}z^{11}$, or $\dfrac{x^3z^{11}}{4y^2}$

94. $\dfrac{1}{4}a^{10}b^{-9}c^{-1}$, or $\dfrac{a^{10}}{4b^9c}$

95. $(x^4)^3 = x^{4\cdot 3} = x^{12}$

96. a^6

97. $(9^3)^{-4} = 9^{3(-4)} = 9^{-12}$, or $\dfrac{1}{9^{12}}$

98. 8^{-12}, or $\dfrac{1}{8^{12}}$

99. $(t^{-8})^{-5} = t^{-8(-5)} = t^{40}$

100. x^{12}

101. $(-5xy)^2 = (-5)^2x^2y^2 = 25x^2y^2$

102. $-125a^3b^3$

103. $(-2a^{-2}b)^{-3} = (-2)^{-3}\cdot(a^{-2})^{-3}\cdot b^{-3} = (-2)^{-3}a^6b^{-3}$
$= \dfrac{1}{(-2)^3}\cdot a^6\cdot\dfrac{1}{b^3} = -\dfrac{a^6}{8b^3}$

104. $(-4)^{-2}x^{-12}y^4$, or $\dfrac{y^4}{16x^{12}}$

105. $\left(\dfrac{m^2n^{-1}}{4}\right)^3 = \dfrac{m^6n^{-3}}{4^3} = \dfrac{m^6n^{-3}}{64}$, or $\dfrac{m^6}{64n^3}$

106. $\dfrac{9x^{10}}{y^{-8}}$, or $9x^{10}y^8$

107. $\dfrac{(2a^3)^3\,4a^{-3}}{(a^2)^5} = \dfrac{2^3a^{3\cdot 3}4a^{-3}}{a^{2\cdot 5}} = \dfrac{8a^9\,4a^{-3}}{a^{10}}$
$= 8\cdot 4a^{9+(-3)-10} = 32a^{-4}$, or $\dfrac{32}{a^4}$

108. $\dfrac{(3x^2)^3\,2x^{-4}}{(x^4)^2} = \dfrac{27x^6\,2x^{-4}}{x^8} = 54x^{-6}$, or $\dfrac{54}{x^6}$

109. $(8x^{-3}y^2)^{-4}(8x^{-3}y^2)^4 = (8x^{-3}y^2)^{-4+4} = (8x^{-3}y^2)^0 = 1$

110. $(2a^{-1}b^3)^{-2}(2a^{-1}b^3)^{-2} = (2a^{-1}b^3)^{-4}$
$= 2^{-4}a^4b^{-12}$, or $\dfrac{a^4}{16b^{12}}$

111. $\dfrac{(5a^3b)^2}{10a^2b} = \dfrac{5^2(a^3)^2b^2}{10a^2b} = \dfrac{25a^6b^2}{10a^2b}$
$= \dfrac{25}{10}a^{6-2}b^{2-1} = \dfrac{5}{2}a^4b$, or $\dfrac{5a^4b}{2}$

112. $\dfrac{(3x^3y^4)^3}{6xy^3} = \dfrac{27x^9y^{12}}{6xy^3} = \dfrac{9}{2}x^8y^9$, or $\dfrac{9x^8y^9}{2}$

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113. $\left(\dfrac{2x^3y^{-2}}{3y^{-3}}\right)^3 = \left(\dfrac{2}{3}x^3y^{-2+3}\right)^3 = \left(\dfrac{2}{3}x^3y\right)^3 = \dfrac{2^3}{3^3}(x^3)^3y^3$
$= \dfrac{8x^9y^3}{27}$

114. $\left(\dfrac{-4x^4y^{-2}}{5x^{-1}y^4}\right)^{-4} = \left(\dfrac{-4}{5}x^5y^{-6}\right)^{-4} = \dfrac{5^4x^{-20}y^{24}}{(-4)^4}$
$= \dfrac{625x^{-20}y^{24}}{256}$, or $\dfrac{625y^{24}}{256x^{20}}$

115. $\left(\dfrac{21x^5y^{-7}}{14x^{-2}y^{-6}}\right)^0 = 1$
(Any nonzero real number raised to the zero power is 1.)

116. $\left(\dfrac{6a^{-2}b^6}{8a^{-4}b^0}\right)^{-2} = \left(\dfrac{3}{4}a^2b^6\right)^{-2} = \left(\dfrac{4}{3}\right)^2a^{-4}b^{-12}$, or $\dfrac{16}{9a^4b^{12}}$

117. $\left(\dfrac{5x^0y^{-7}}{2x^{-2}y^4}\right)^{-2} = \left(\dfrac{5}{2}x^{0+2}y^{-7-4}\right)^{-2} = \left(\dfrac{5x^2y^{-11}}{2}\right)^{-2}$
$= \left(\dfrac{2}{5x^2y^{-11}}\right)^2 = \dfrac{2^2}{5^2(x^2)^2(y^{-11})^2}$
$= \dfrac{4}{25x^4y^{-22}} = \dfrac{4}{25}x^{-4}y^{22}$, or $\dfrac{4y^{22}}{25x^4}$

118. $\left(\dfrac{4a^3b^{-9}}{6a^{-2}b^5}\right)^0 = 1$
(Any nonzero real number raised to the zero power is 1.)

119. *Writing Exercise* For any even number n.
$(-1)^n = \underbrace{[(-1)(-1)][(-1)(-1)]\cdots[(-1)(-1)]}_{n/2 \text{ pairs of factors}}$
$= \underbrace{1\cdot1\cdots1}_{n/2 \text{ factors of 1}}$
$= 1$

120. *Writing Exercise*. Since $(-17)^{-8} = \dfrac{1}{(-17)^8}$ and $(-17)^8$ is positive, then $(-17)^{-8}$ is positive.

121. *Writing Exercise*. In the expression $3-(-2)^{-1}$, the first "–" after the 3 indicates subtraction. The second "–" inside the parentheses indicates the number opposite of two, or negative two. The third "–", found in the exponent, indicates that the expression $(-2)^{-1} = \dfrac{1}{(-2)}$.

122. *Writing Exercise*. Since $5^{-6} = \dfrac{1}{5^6}$, $4^{-9} = \dfrac{1}{4^9}$, and $5^6 < 4^9$, then $5^{-6} > 4^{-9}$ is true.

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

124. $\left[7y(7-8)^{-4} - 8y(8-7)^{-2}\right]^{(-2)^2}$
$= \left[7y(7-8)^{-4} - 8y(8-7)^{-2}\right]^4$
$= \left[7y(-1)^{-4} - 8y(1)^{-2}\right]^4$
$= \left[\dfrac{7y}{(-1)^4} - \dfrac{8y}{1^2}\right]^4$
$= [7y-8y]^4$
$= [-y]^4$
$= y^4$

125. $\left\{\left[\left(8^{-a}\right)^{-2}\right]^b\right\}^{-c}\cdot\left[\left(8^0\right)^a\right]^c = 8^{-2abc}\cdot 8^0 = 8^{-2abc}$

126. $\left(3^{a+2}\right)^a = 3^{(a+2)a} = 3^{a^2+2a}$

127. $\dfrac{-28x^{b+5}y^{4+c}}{7x^{b-5}y^{c-4}} = -4x^{b+5-(b-5)}y^{4+c-(c-4)}$
$= -4x^{b+5-b+5}y^{4+c-c+4} = -4x^{10}y^8$

128. $\dfrac{4x^{2a+3}y^{2b-1}}{2x^{a+1}y^{b+1}} = \dfrac{4}{2}\cdot x^{2a+3-(a+1)}y^{2b-1-(b+1)}$
$= 2x^{2a+3-a-1}y^{2b-1-b-1} = 2x^{a+2}y^{b-2}$

129. $\dfrac{3^{q+3}-3^2(3^q)}{3(3^{q+4})} = \dfrac{3^{q+3}-3^{q+2}}{3^{q+5}} = \dfrac{3^{q+2}(3-1)}{3^{q+2}(3^3)} = \dfrac{2}{3^3} = \dfrac{2}{27}$

130. $\dfrac{25x^{a+b}y^{b-a}}{-5x^{a-b}y^{b+a}} = -5x^{a+b-(a-b)}y^{b-a-(b+a)}$
$= -5x^{a+b-a+b}y^{b-a-b-a} = -5x^{2b}y^{-2a}$

131. $\left[\left(\dfrac{a^{-2c}}{b^{7c}}\right)^{-3}\left(\dfrac{a^{4c}}{b^{-3c}}\right)^2\right]^{-a} = \left(\dfrac{a^{6c}}{b^{-21c}}\cdot\dfrac{a^{8c}}{b^{-6c}}\right)^{-a} = \left(\dfrac{a^{14c}}{b^{-27c}}\right)^{-a}$
$= \dfrac{a^{-14ac}}{b^{27ac}}$

132. Let s = side of second cube. Then $3s$ = side of first cube. Volume of first cube $= (3s)^3 = 27s^3$.
The first cube has volume 27 times as great as the second cube.

Exercise Set 1.7

1. The number 27×10^{16} *is not* written in scientific notation.

2. Very small number are represented in scientific notation using *negative* powers of 10.

3. The number 4.587×10^5 has *four* significant digits.

4. In a series of calculations, rounding should be done *at the very end*.

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5. The length of an Olympic marathon, in centimeters, is a large number so its representation in scientific notation would include a positive power of 10.

6. The thickness of a cat's whiskers, in meters, is a small number, so its representation in scientific notation would include a negative power of 10.

7. The mass of a hydrogen atom, in grams, is a small number so its representation in scientific notation would include a negative power of 10.

8. The mass of a pickup truck, in grams, is a large number so its representation in scientific notation would include a positive power of 10.

9. The time between leap years, in seconds, is a large number so its representation in scientific notation would include a positive power of 10.

10. The time between a bird's heartbeats, in hours, is a small number so its representation in scientific notation would include a negative power of 10.

11. $64,000,000,000 = \dfrac{64,000,000,000}{10^{10}} \cdot 10^{10}$
Multiplying by 1 $(10^{10}/10^{10} = 1)$
$= 6.4 \times 10^{10}$ This is scientific notation.

12. 3.7×10^{6}

13. $0.0000013 = \dfrac{0.0000013}{10^{6}} \cdot 10^{6}$ Multiplying by 1: $10^{6}/10^{6} = 1$
$= \dfrac{1.3}{10^{6}}$
$= 1.3 \times 10^{-6}$ This is scientific notation.

14. 7.8×10^{-5}

15. $0.00009 = \dfrac{0.0009}{10^{5}} \cdot 10^{5}$ Multiplying by 1: $10^{5}/10^{5} = 1$
$= \dfrac{9}{10^{5}}$
$= 9 \times 10^{-5}$ This is scientific notation.

16. 6×10^{-8}

17. $803,000,000,000 = \dfrac{803,000,000,000}{10^{11}} \cdot 10^{11}$
$= 8.03 \times 10^{11}$

18. 3.09×10^{12}

19. $0.000000904 = \dfrac{0.000000904}{10^{7}} \cdot 10^{7}$
$= \dfrac{9.04}{10^{7}}$
$= 9.04 \times 10^{-7}$

20. 8.02×10^{-9}

21. $431,700,000,000 = \dfrac{431,700,000,000}{10^{11}} \cdot 10^{11}$
$= 4.317 \times 10^{11}$

22. 9.534×10^{11}

23. $4 \times 10^{5} = 400,000$ Moving the decimal point 5 places to the right.

24. 0.000003

25. $1.2 \times 10^{-4} = 0.00012$ Moving the decimal point 4 places to the left.

26. 860,000,000

27. $3.76 \times 10^{-9} = 0.00000000376$ Moving the decimal point 9 places to the left.

28. 0.0427

29. $8.056 \times 10^{12} = 8,056,000,000,000$ Moving the decimal point 12 places to the right.

30. 50,020,000,000

31. $7.001 \times 10^{-5} = 0.00007001$ Moving the decimal point 5 places to the left.

32. 0.002049

33. $(3.4 \times 10^{-8})(2.6 \times 10^{15})$
$= (3.4 \times 2.6)(10^{-8} \times 10^{15})$
$= 8.84 \times 10^{7}$
$= 8.8 \times 10^{7}$ Rounding to 2 significant digits

34. $(1.8 \times 10^{20})(4.7 \times 10^{-12}) = 8.46 \times 10^{8}$
$= 8.5 \times 10^{8}$ (2 significant digits)

35. $(2.36 \times 10^{6})(1.4 \times 10^{-11})$
$= (2.36 \times 1.4)(10^{6} \times 10^{-11})$
$= 3.304 \times 10^{-5}$
$= 3.3 \times 10^{-5}$ Rounding to 2 significant digits

36. $(4.26 \times 10^{-6})(8.2 \times 10^{-6}) = 34.932 \times 10^{-12}$
$= 3.4932 \times 10^{-11} = 3.5 \times 10^{-11}$ (2 significant digits)

37. $(5.2 \times 10^{6})(2.6 \times 10^{4}) = (5.2 \times 2.6)(10^{6} \times 10^{4})$
$= 13.52 \times 10^{10}$
$= (1.352 \times 10) \times 10^{10}$
$= 1.352 \times (10 \times 10^{10})$
$= 1.352 \times 10^{11}$
$= 1.4 \times 10^{11}$ (2 significant digits)

38. $(6.11 \times 10^{3})(1.01 \times 10^{13}) = 6.1711 \times 10^{16}$
$= 6.17 \times 10^{16}$ (3 significant digits)

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39. $(7.01\times10^{-5})(6.5\times10^{-7})$
$=(7.01\times6.5)(10^{-5}\times10^{-7})$
$=45.565\times10^{-12}$
$=(4.5565\times10)\times10^{-12}$
$=4.5565\times10^{-11}$
$=4.6\times10^{-11}$ (2 significant digits)

40. $(4.08\times10^{-10})(7.7\times10^{5})=31.416\times10^{-5}$
$=3.1416\times10^{-4}=3.1\times10^{-4}$ (2 significant digits)

41. $(2.0\times10^{6})(3.02\times10^{-6})$
Observe that $10^{6}\times10^{-6}=1$, so the product is 2.0(3.02), or 6.04, or 6.0 rounded to two significant digits.

42. $(7.04\times10^{-9})(9.01\times10^{-7})=63.4304\times10^{-16}$
$=6.34304\times10^{-15}=6.34\times10^{-15}$ (3 significant digits)

43. $\dfrac{6.5\times10^{15}}{2.6\times10^{4}}=\dfrac{6.5}{2.6}\times\dfrac{10^{15}}{10^{4}}$
$=2.5\times10^{11}$ (2 significant digits)

44. 2.5×10^{13}

45. $\dfrac{9.4\times10^{-9}}{4.7\times10^{-2}}=\dfrac{9.4}{4.7}\times\dfrac{10^{-9}}{10^{-2}}$
$=2.0\times10^{-7}$ (2 significant digits)

46. $\dfrac{4.0\times10^{-6}}{8.0\times10^{-3}}=0.5\times10^{-3}$
$=(5.0\times10^{-1})\times10^{-3}$ (2 significant digits)
$=5.0\times10^{-4}$

47. $\dfrac{3.2\times10^{-7}}{8.0\times10^{8}}=\dfrac{3.2}{8.0}\times\dfrac{10^{-7}}{10^{8}}$
$=0.40\times10^{-15}$ (2 significant digits)
$=(4.0\times10^{-1})\times10^{-15}$
$=4.0\times10^{-16}$

48. 3.0×10^{11} (2 significant digits)

49. $\dfrac{9.36\times10^{-11}}{3.12\times10^{11}}=\dfrac{9.36}{3.12}\times\dfrac{10^{-11}}{10^{11}}$
$=3.00\times10^{-22}$ (3 significant digits)

50. 2.00×10^{10} (3 significant digits)

51. $\dfrac{6.12\times10^{19}}{3.06\times10^{-7}}=\dfrac{6.12}{3.06}\times\dfrac{10^{19}}{10^{-7}}$
$=2.00\times10^{26}$ (3 significant digits)

52. $\dfrac{4.7\times10^{-9}}{2.0\times10^{-9}}$
Observe that $\dfrac{10^{-9}}{10^{-9}}=1$, so the quotient is $\dfrac{4.7}{2.0}$, or 2.35, or 2.4, rounded to two significant digits.

53. ***Familiarize***. Let s = the number of stars. We have 8 trillion cubic light-years.
Translate. We multiply.
$$s=\frac{0.025\text{ star}}{\text{light-year}^3}\cdot 8{,}000{,}000{,}000{,}000\text{ light-years}^3$$
Carry out.
$$s=\frac{0.025\text{ star}}{\text{light-year}^3}\cdot 8{,}000{,}000{,}000{,}000\text{ light-years}^3$$
$=(2.5\times10^{-2})(8\times10^{12})$ stars
$=2\times10^{11}$ stars
Check. Recheck the translation and calculations. The answer checks.
State. There are 2×10^{11} stars in the Milky Way.

54. Let b = the number of bacteria. We have 10 million bacteria per square centimeter. Recall $1\text{ cm}^2=1\times10^{-10}\text{ km}^2$. We convert from square centimeters to square kilometers:
$$\frac{1\times10^{7}\text{ bacteria}}{1\text{ cm}^2}=\frac{1\times10^{7}\text{ bacteria}}{1\times10^{-10}\text{ km}^2}=\frac{1\times10^{17}\text{ bacteria}}{\text{km}^2}$$
$$b=\frac{1\times10^{17}\text{ bacteria}}{\text{km}^2}\cdot 14{,}000\text{ km}^2$$
$=(1\times10^{17})(1.4\times10^{4})$
$=1.4\times10^{21}$
There are 1.4×10^{21} bacteria in Hawaii's coral reef.

55. ***Familiarize***. We have a cylinder with diameter 4.0×10^{-10} in. and length 100 yd. We will use the formula for the volume of a cylinder $V=\pi r^2h$. The radius is $\dfrac{4.0\times10^{-10}}{2}$, or 2.0×10^{-10} in. We convert 100 yd to inches:
$100\text{ yd}=100\times1\text{ yd}=100\times36\text{ in.}=3600\text{ in.}$, or 3.6×10^{3} in.
Translate. We substitute in the formula.
$$V=\pi r^2h$$
$$V=\pi(2.0\times10^{-10})^2(3.6\times10^{3})$$
Carry out. We do the calculation.
$V=\pi(2.0\times10^{-10})^2(3.6\times10^{3})$
$=\pi\times4.0\times10^{-20}\times3.6\times10^{3}$
$=(\pi\times4.0\times3.6)\times(10^{-20}\times10^{3})$
$\approx45.2\times10^{-17}$
$\approx(4.52\times10)\times10^{-17}$
$\approx4.52\times10^{-16}$
$\approx4.5\times10^{-16}$ (2 significant digits)
Check. Recheck the translation and the calculations. The answer checks.
State. The volume of a 100-yd carbon nanotube is about $4.5\times10^{-16}\text{ in}^3$.

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56. ***Familiarize***. We can think of the plastic as a rectangular solid whose length is the perimeter of the house and with width 8 mil, or $8\times\frac{1}{1000}$ in.

$=8\times 0.001$ in. $=0.008$ in. $=8\times10^{-3}$ in. and height 4 ft. The perimeter of the house is $2\cdot 32$ ft $+\,2\cdot 24$ ft, or 112 ft. We will convert the perimeter and the height to in.

112 ft $=112\times1$ ft $=112\times12$ in. $=1344$ in., or 1.344×10^3 in.

4 ft $=4\times1$ ft $=4\times12$ in. $=48$ in., or 4.8×10 in.

Recall that the formula for the volume of a rectangular solid is $V=lwh$.

$$V=lwh$$
$$V=(1.344\times10^3)\times(4.8\times10)\times(8\times10^{-3})$$

Carry out. We do the calculation.

$$V=(1.344\times10^3)\times(4.8\times10)\times(8\times10^{-3})$$
$$V=(1.344\times4.8\times8)\times(10^3\times10\times10^{-3})$$
$$\approx 51.6\times10$$
$$\approx 5\times10^2 \quad \text{(1 significant digit)}$$

State. The volume of the plastic is about 5×10^2 in^3. (If we had used feet as the unit of length, the result would be about 3×10^{-1} ft^3.)

57. ***Familiarize***. Let p = the number of spam e-mails. Recall 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day, and 7 days in a week. We find the number of seconds in a week:

$$\frac{60\text{ seconds}}{1\text{ minute}}\cdot\frac{60\text{ minutes}}{1\text{ hour}}\cdot\frac{24\text{ hours}}{1\text{ day}}\cdot\frac{7\text{ days}}{1\text{ week}}$$
$$=604{,}800=6.048\times10^5\text{ sec/week}$$

Also, 3 million e-mails $=3\times10^6$ emails

and 4.2 billion users $=4.2\times10^9$ users.

Translate. We multiply the spam rate times the number of e-mails per second, times the number of seconds in a week divided by the number of users.

$$p=\left(\frac{2}{3}\right)\cdot\frac{(3\times10^6\text{ e-mails/sec})(6.048\times10^5\text{ sec/week})}{4.2\times10^9\text{ users}}$$

Carry out. We perform the calculations and write scientific notation for the answer.

$$p=\left(\frac{2}{3}\right)\cdot\frac{(3\times10^6\text{ e-mails/sec})(6.048\times10^5\text{ sec/week})}{4.2\times10^9\text{ users}}$$
$$=\frac{2(3)(6.048)}{3(4.2)}\,\frac{10^6\times10^5}{10^9}\,\frac{\text{spam e-mails/week}}{\text{user}}$$
$$=2.88\times10^2\text{ spam e-mails/week/user}$$
$$\approx 2.9\times10^2 \quad \text{(2 significant digits)}$$

Check. Recheck the translation and calculation. The answer checks.

State. Each user receives about 2.9×10^2 spam e-mails per week.

58. 319 terabytes $=3.19\times10^2$ terabytes

Convert from exabytes to terabytes.

1.134 exabytes $=1.134\times10^6$ terabytes

Divide.

$$\frac{1.134\times10^6}{3.19\times10^2}\approx 3.56\times10^3\text{ sec (3 significant digits)}$$

or approximately 1 hour

59. ***Familiarize***. Let w = the weight of each sheet.

1 ream = 500 sheets.

Translate. We divide.

$$w=\frac{2.25}{500}$$

Carry out.

$$w=\frac{2.25}{5\times10^2}$$
$$=0.450\times10^{-2}$$
$$=4.50\times10^{-3}$$

Check. Recheck the translation and calculations. The answer checks.

State. Each sheet of copier paper weighs 4.50×10^{-3} kg, or 4.50 g.

60. First we will find the number n of \$5 bills in \$4,540,000 worth of \$5 bills. Then we will find the weight w of a \$5 bill. Recall that 1 ton = 2000 lb.

$$n=\frac{4{,}540{,}000}{5}=\frac{4.54\times10^6}{5}=0.908\times10^6$$
$$=(9.08\times10^{-1})\times10^6=9.08\times10^5$$
$$w=\frac{2000}{n}=\frac{2000}{9.08\times10^5}=\frac{2\times10^3}{9.08\times10^5}$$
$$\approx 0.220\times10^{-2}=(2.20\times10^{-1})\times10^{-2}$$
$$=2.20\times10^{-3}\text{ lb} \quad \text{(3 significant digits)}$$

61. ***Familiarize***. We know that 1 light year = 5.88×10^{12} mi. Let y = the number of light years from one and of the Milky Way galaxy to the other.

Translate. The distance is $(5.88\times10^{12})y$ mi. It is also given by 5.88×10^{17} mi. We write the equation:

$$(5.88\times10^{12})y=5.88\times10^{17}$$

Carry out. We solve the equation.

$$(5.88\times10^{12})y=5.88\times10^{17}$$
$$y=\frac{5.88\times10^{17}}{5.88\times10^{12}}$$
$$y=\frac{5.88}{5.88}\times\frac{10^{17}}{10^{12}}$$
$$y=1.00\times10^5$$

Check. Since light travels 5.88×10^{12} mi in one light year, in 1.00×10^5 yr it will travel $(1.00\times10^5)\times(5.88\times10^{12})=5.88\times10^{17}$ mi. The answer checks.

State. The distance from one end of the galaxy to the other is 1.00×10^5 light years.

62. Let y = the number of light years from Earth to Sirius.

Solve: $(5.88\times10^{12})y=4.704\times10^{13}$

$$y=8.00 \quad \text{(3 significant digits)}$$

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63. ***Familiarize***. We are told that $1\text{Angstrom} = 1\times10^{-10}$ m, 1 parsec ≈ 3.26 light years, and 1 light year $= 9.46\times10^{15}$ m. Let a represent the number of Angstroms in one parsec.

Translate The length of one parsec is $a\times10^{-10}$ m. It can also be expressed as 3.26 light years, or $3.26\times9.46\times10^{15}$ m. Since these quantities represent the same number, we can write the equation.

$$a\times10^{-10} = 3.26\times9.46\times10^{15}.$$

Carry out. Solve the equation:

$$\begin{aligned} a\times10^{-10} &= 3.26\times9.46\times10^{15} \\ a\times10^{-10}\times\frac{1}{10^{-10}} &= 3.26\times9.46\times10^{15}\times\frac{1}{10^{-10}} \\ a &= \frac{3.26\times9.46\times10^{15}}{10^{-10}} \\ &= (3.26\times9.46)\times\frac{10^{15}}{10^{-10}} \\ &= 30.8396\times10^{25} \\ &= (3.08396\times10)\times10^{25} \\ &= 3.08396\times(10\times10^{25}) \\ &= 3.08\times10^{26} \quad \text{(Rounding to 3 significant digits)} \end{aligned}$$

Check. We recheck the translation and calculation.

State. There are about 3.08×10^{26} Angstroms in one parsec.

64. $\dfrac{3.26\times9.46\times10^{15}}{10^{3}} = 30.8396\times10^{12}$

$= 3.08\times10^{13}$ (3 significant digits)

65. ***Familiarize***. We have a very long cylinder. Its length is the average distance from Earth to the sun, 1.5×10^{11} m, and the diameter of its base is 3 Å. We will use the formula for the volume of a cylinder, $V = \pi r^2 h$ (See Example 8.)

Translate. We will express all distances in Angstroms.

Height (length):

$$1.5\times10^{11}\text{ m} = \frac{1.5\times10^{11}}{10^{-10}}\text{Å} = 1.5\times10^{21}\text{ Å}$$

Diameter: 3 Å

The radius is half the diameter:

Radius: $\frac{1}{2}\times 3\text{ Å} = 1.5\text{ Å}$

Now substitute into the formula (using 3.14 for π):

$$V = \pi r^2 h$$
$$V = 3.14\times1.5^2\times1.5\times10^{21}$$

Carry out. Do the calculations.

$$\begin{aligned} V &= 3.14\times1.5^2\times1.5\times10^{21} \\ &= 10.5975\times10^{21} \\ &= 1.05975\times10^{22} \\ &= 1\times10^{22} \quad \text{Rounding to 1 significant digit} \end{aligned}$$

We can convert this result to cubic meters, if desired.

$1\text{ Å} = 10^{-10}$ m, So $1\text{ cu Å} = (10^{-10})^3\text{ m}^3 = 10^{-30}\text{m}^3$.

Then $1\times10^{22}\text{ cu Å} = 1\times10^{22}\text{ cu Å}\times\dfrac{10^{-30}\text{ m}^3}{1\text{ cu Å}}$

$$= 1\times10^{22}\times10^{-30}\times\frac{\text{cu Å}}{\text{cu Å}}\times\text{m}^3 = 1\times10^{-8}\text{ m}^3.$$

Check. We recheck the translation and the calculations.

State. The volume of the sunbeam is about 1×10^{22} cu Å, or 1×10^{-8} m^3.

66. Height: 1.5×10^{21} Å (See exercise 65.)

Radius: $\frac{5}{2}$ Å, or 2.5 Å

$$V = \pi r^2 h$$
$$V = 3.14(2.5)^2(1.5\times10^{21})$$
$$V = 29.4375\times10^{21}$$
$$V = 2.94375\times10^{22}\text{ cu Å}$$
$$\text{V} = 3\times10^{22}\text{ cu Å} \quad (1\text{ significant digit})$$

Converting to m^3 (See Exercise 65.), we have

$$\begin{aligned} 3\times10^{22}\text{ cu Å} &= 3\times10^{22}\text{ cu Å}\times\frac{10^{-30}\text{ m}^3}{1\text{ cu Å}} \\ &= 3\times10^{-8}\text{ m}^3. \end{aligned}$$

67. ***Familiarize***. First we will find d, the number of drops in a pound. Then we will find b, the number of bacteria in a drop of U.S. mud.

Translate. To find d we convert 1 pound to drops:

$$d = 1\text{ lb}\cdot\frac{16\text{ oz}}{1\text{ lb}}\cdot\frac{6.0\text{ tsp}}{1\text{ oz}}\cdot\frac{60.0\text{ drops}}{1\text{ tsp}}.$$

Then we divide to find b:

$$b = \frac{4.55\times10^{11}}{d}.$$

Carry out. We do the calculations.

$$\begin{aligned} d &= 1\text{ lb}\cdot\frac{16\text{ oz}}{1\text{ lb}}\cdot\frac{6.0\text{ tsp}}{1\text{ oz}}\cdot\frac{60.0\text{ drops}}{1\text{ tsp}} \\ &= 5760\text{ drops} \end{aligned}$$

Now we find b.

$$b = \frac{4.55\times10^{11}}{d} = \frac{4.55\times10^{11}}{5.760\times10^{3}} \approx 0.790\times10^{8}$$
$$\approx (7.90\times10^{-1})\times10^{8} = 7.9\times10^{7}$$

(Our answer must have 2 significant digits.)

Check. If there are about 7.9×10^{7} bacteria in a drop of U.S. mud, then in a pound there are about

$$\frac{7.9\times10^{7}}{1\text{ drop}}\cdot\frac{60.0\text{ drops}}{1\text{ tsp}}\cdot\frac{6.0\text{ tsp}}{1\text{ oz}}\cdot\frac{16\text{ oz}}{1\text{ lb}}$$
$$= \frac{45{,}504\times10^{7}}{1\text{ lb}} \approx 4.55\times10^{11}\text{ bacteria per pound.}$$

The answer checks.

State. About 7.9×10^{7} bacteria live in a drop of U.S. mud.

68. 100 years $= 100\times52$, or 5200 weeks

13 weeks $= \dfrac{13}{5200}$, or 0.0025 of 100 years

$$5.9\times10^{14}\times0.0025 = 5.9\times10^{14}\times2.5\times10^{-3}$$
$$= 14.75\times10^{11} = 1.475\times10^{12} \approx 1.5\times10^{12}\text{ mi}$$
(2 significant digits)

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69. ***Familiarize***. First we will find the distance C around Jupiter at the equator, in km. Then we will use the formula Speed × Time = Distance to find the speed s at which Jupiter's equator is spinning.
Translate. We will use the formula for the circumference of a circle to find the distance around Jupiter at the equator:

$$C = \pi d = \pi(1.43\times10^5).$$

Then we find the speed s at which Jupiter's equator is spinning:

$$\underbrace{\text{Speed}}_{\downarrow} \times \underbrace{\text{Time}}_{\downarrow} = \underbrace{\text{Distance}}_{\downarrow}$$
$$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow$$
$$s \times 10 = C$$

Carry out. First we find C.

$$C = \pi(1.43\times10^5) \approx 4.49\times10^5$$

Then we find s.

$$s\times10 = C$$
$$s\times10 = 4.49\times10^5$$
$$s = \frac{4.49\times10^5}{10}$$
$$s = 4.49\times10^4$$

Check. At 4.49×10^4 km/h. in 10 hr, Jupiter's equator travels $4.49\times10^4\times10$, or 4.49×10^5 km. A circle with circumference 4.49×10^5 km has a diameter of $\frac{4.49\times10^4}{\pi} \approx 1.43\times10^5$ km. The answer checks.
State. Jupiter's equator spins at a speed of about 4.49×10^4 km/h.

70. Find the circumference of a circle with radius 9.3×10^7 miles:

$$C = 2\pi r = 2\pi(9.3\times10^7) \approx 58\times10^7$$
$$= 5.8\times10^8 \text{ miles} \quad \text{(2 significant digits)}$$

71. *Writing Exercise*. Answers may vary.
The height of a section of a laser's light beam is 10.0 mm. The radius is 1.00×10^2 mm. Find the volume of the light beam. (Use 3.14 for π.)

72. *Writing Exercise*. Answers may vary.
Scientific notation is convenient when writing very large or very small numbers. It is also convenient to use scientific notation when performing computations involving very large and/or very small numbers.

73. *Writing Exercise*. \$5 million in \$20 bills contains $\frac{5\times10^6}{20} = 0.25\times10^6 = 2.5\times10^5$ bills. In Exercise 60 we found that a \$5 bill weighs about 2.20×10^{-3} lb. Assuming that a \$20 bill weighs the same as a \$5 bill, 2.5×10^5 bills would weigh $2.5\times10^5\times2.20\times10^{-3} = 5.5\times10^2$, or 550 lb.
Thus, it is not possible that a movie character is carrying \$5 million in \$20 bills in a briefcase.

74. *Writing Exercise*. For 5^n, where n is an odd natural number, the one's digit will be 5. Since this is not the case with the given calculator readout, we know that the readout is an approximation.

75. ***Familiarize***. Let d = the average density, v = the volume and m = the mass.
Translate. We divide.

$$d = \frac{m}{v}$$

To convert the volume from km^3 to cm^3,

$$v = 1.08\times10^{12}\ \text{km}^3 \cdot \left(\frac{1000\text{ m}}{1\text{ km}}\right)^3 \cdot \left(\frac{100\text{ cm}}{1\text{ m}}\right)^3$$

To convert the mass from kg to g

$$m = 5.976\times10^{24}\ \text{kg} \cdot \frac{1000\text{ g}}{1\text{ kg}}$$

Carry out. We do the calculations.

$$v = 1.08\times10^{12}\cdot(1000)^3\cdot(100)^3$$
$$= 1.08\times10^{27}$$
$$m = 5.976\times10^{24}\cdot1000$$
$$= 5.976\times10^{27}$$
$$d = \frac{m}{v} = \frac{5.976\times10^{27}}{1.08\times10^{27}}$$
$$= \frac{5.976}{1.08}\times\frac{10^{27}}{10^{27}}$$
$$= 5.53 \quad \text{(3 significant digits)}$$

Check. We recheck the translation and calculations.
State. The average density of Earth is approximately $5.53\ \text{g/cm}^3$.

76. Weight of half is $\frac{1.2\times10^{-9}}{2}$ or 6.0×10^{-10}.
Lower bound is $6.0\times10^{-10} - 3.5\times10^{-10} = 2.5\times10^{-10}$.
Upper bound is $6.0\times10^{-10} + 3.5\times10^{-10} = 9.5\times10^{-10}$.
The weight of each half is between 2.5×10^{-10} oz and 9.5×10^{-10} oz.

77. ***Familiarize***. Let r = the radius, v = the speed, and t = the time.
Translate. Convert the time 1 year to hours.

$$1 \text{ year} = 365 \text{ days} = 365\times24 \text{ hr} = 8.76\times10^3 \text{ hr}$$

Recall that $1 \text{ meter} \approx 6.21\times10^{-4}$ miles. Convert the radius from meters to miles.

$$1.5\times10^{11}\text{ m} = 1.5\times10^{11}\times6.21\times10^{-4}\text{ mi}$$
$$= 9.315\times10^7\text{ mi}$$

To find the orbital speed, divide circumference by time.

$$v = \frac{C}{t} = \frac{2\pi r}{t}$$

Carry out. We do the calculations.

$$v = \frac{2\pi(9.315\times10^7)}{8.76\times10^3}$$
$$v \approx 6.7\times10^4 \quad \text{(2 significant digits)}$$

Check. We recheck the translation and calculations.
State. Earth's orbital speed around the sun is approximately 6.7×10^4 mph.

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78. $\frac{4}{32} = 0.125 = \frac{1}{8} = 1.25 \times 10^{-1}$

79. The larger number is the one in which the power of ten has the larger exponent. Since –90 is larger than –91, 8×10^{-90} is larger than 9×10^{-91}.

$$\begin{aligned} 8 \times 10^{-90} - 9 \times 10^{-91} &= 10^{-90}\left(8 - 9 \times 10^{-1}\right) \\ &= 10^{-90}(8 - 0.9) \\ &= 7.1 \times 10^{-90} \end{aligned}$$

Thus, 8×10^{-90} is larger by 7.1×10^{-90}.

80. $$\begin{aligned} \frac{1}{8.00 \times 10^{-23}} &= \frac{1}{8.00} \times \frac{1}{10^{-23}} = 0.125 \times 10^{23} \\ &= 1.25 \times 10^{22} \end{aligned}$$

81. $$\begin{aligned} (4096)^{0.05}(4096)^{0.2} &= 4096^{0.25} \\ &= \left(2^{12}\right)^{0.25} \\ &= 2^3 \\ &= 8 \end{aligned}$$

82. The unit's digit is the digit 3 raised to some power. Look for a pattern:

Exponent	1	2	3	4	5	6	7	8
Unit's digit	3	9	7	1	3	9	7	1

$(513)^{128} = \left(513^4\right)^{32}$, so the unit's digit is 1.

83. ***Familiarize***. Observe that there are 2^{n-1} grains of sand on the nth square of the chessboard. Let g represent this quantity. Recall that a chessboard has 64 squares. Note also that $2^{10} \approx 10^3$.

Translate. We write the equation

$$g = 2^{n-1}.$$

To find the number of grains of sand on the last (or 64th) square, substitute 64 for n: $g = 2^{64-1}$.

Carry out. Recheck the translation and the calculations.

$$\begin{aligned} g &= 2^{64-1} = 2^{63} = 2^3\left(2^{10}\right)^6 \\ &\approx 2^3\left(10^3\right)^6 \approx 8 \times 10^{18} \end{aligned}$$

State. Approximately 8×10^{18} grains of sand are required for the last square.

84. Find the size of a Hubble-barn, in gallons with radius one Hubble, 10^{23} km $= 10^{23} \times 10^3$ m $= 10^{26}$ m.

$V = bh = \left(10^{-28}\right)\left(10^{26}\right) = 10^{-2}$ m^3

Convert to gallons.

$V = 10^{-2}$ m^3 $\approx 10^{-2} \times 2.6417 \times 10^2$ gal

≈ 3 gal (1 significant digit)

85. Answers will vary.

Chapter 1 Review

1. The correct choice is (e), since the equation $2x - 1 = 9$ is equivalent to $2x = 10$.

2. The correct choice is (g), since the expression $2x - 1$ is equivalent to $5x - 1 - 3x$.

3. The correct choice is (j), since the equation $\frac{3}{4}x = 5$ is equivalent to $\frac{4}{3} \cdot \frac{3}{4}x = \frac{4}{3} \cdot 5$.

4. The correct choice is (a) since the expression $\frac{3}{4}x - 5$ is equivalent to $2 + \frac{3}{4}x - 7$.

5. The correct choice is (i), since the expression $2(x + 7)$ is equivalent to $2x + 14$.

6. The correct choice is (b), since the equation $2(x + 7) = 6$ is equivalent to $2x + 14 = 6$.

7. The correct choice is (f), since the equation $4x - 3 + 2x = 5$ is equivalent to $6x - 3 = 5$.

8. The correct choice is (c), since the expression $4x - 3 + 2x$ is equivalent to $6x - 3$.

9. The correct choice is (d), since the expression $6 + 2x$ is equivalent to $2(3 + x)$.

10. The correct choice is (h), since the equation $6 = 2x$ is equivalent to $3 = x$.

11. Eight less than the quotient of two numbers

Let x and y represent the numbers.

Then we have $\frac{x}{y} - 8$.

12. Substitute and carry out the operations.

$$\begin{aligned} 7x^2 - 5y \div zx &= 7(-2)^2 - 5(3) \div (-5)(-2) \\ &= 7 \cdot 4 - 15 \div (-5) \cdot (-2) \\ &= 28 + 3 \cdot (-2) \\ &= 28 - 6 \\ &= 22 \end{aligned}$$

13. Name the set consisting of the first five odd natural numbers

$\{1, 3, 5, 7, 9\}$

or $\{x \mid x$ is an odd natural number less than $10\}$

14. $A = \frac{1}{2}(50)(70) = 1750$ cm^2

15. $|-19| = 19$ –19 is 19 units from 0

16. $|0| = 0$ 0 is 0 units from itself

17. $|6.08| = 6.08$ 6.08 is 6.08 units from 0

18. –2.3 + (–8.7)

Two negative numbers: Add the absolute values, getting 11. The answer is negative, –11.

19. $-\frac{3}{4} - \left(-\frac{4}{5}\right) = -\frac{3}{4} + \frac{4}{5} = -\frac{15}{20} + \frac{16}{20} = \frac{1}{20}$

20. 10 + (–5.6) = 4.4

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21. $12.3 - 16.1 = 12.3 + (-16.1) = -3.8$

22. $(-12)(-8)$
Two numbers with the same sign: Multiply their absolute values, getting 96. The answer is positive, 96.

23. $\left(-\frac{2}{3}\right)\left(\frac{5}{8}\right)$
Two numbers with unlike signs: Multiply their absolute values to get $\frac{10}{24}$, or $\frac{5}{12}$. The answer is negative, $-\frac{5}{12}$.

24. $\frac{72.8}{-8}$
Two numbers with unlike signs. Divide their absolute values, getting 9.1. The answer is negative, –9.1.

25. $-7 \div \frac{4}{3} = -7 \cdot \left(\frac{3}{4}\right)$ Multiplying by the reciprocal of $\frac{4}{3}$
$= -\frac{21}{4}$

26. If $a = -6.28$, then $-a = -(-6.28) = 6.28$.

27. $12 + x = x + 12$ Using the commutative law of addition

28. $5x + y = x \cdot 5 + y$ Using the commutative law of multiplication
or $= y + 5x$ Using the commutative law of addition

29. $(4 + a) + b = 4 + (a + b)$ Using the associative law of addition

30. $x(yz) = (xy)z$ Using the associative law of multiplication

31. $12m + 4n - 2 = 2 \cdot 6m + 2 \cdot 2n - 2 \cdot 1$
$= 2(6m + 2n - 1)$

32. $3x^3 - 6x^2 + x^3 + 5$
$= (3 + 1)x^3 - 6x^2 + 5$
$= 4x^3 - 6x^2 + 5$

33. $7x - 4[2x + 3(5 - 4x)]$
$= 7x - 4[2x + 15 - 12x]$
$= 7x - 4[-10x + 15]$
$= 7x + 40x - 60$
$= 47x - 60$

34. $3(t + 1) - t = 4$
$3t + 3 - t = 4$
$2t + 3 = 4$
$2t + 3 - 3 = 4 - 3$
$2t = 1$
$\frac{1}{2} \cdot 2t = \frac{1}{2} \cdot 1$
$t = \frac{1}{2}$

The solution is $\frac{1}{2}$.

35. $\frac{2}{3}n - \frac{5}{6} = \frac{8}{3}$
$\frac{2}{3}n - \frac{5}{6} + \frac{5}{6} = \frac{8}{3} + \frac{5}{6}$
$\frac{2}{3}n = \frac{16}{6} + \frac{5}{6}$
$\frac{2}{3}n = \frac{21}{6}$
$\frac{3}{2} \cdot \frac{2}{3}n = \frac{3}{2} \cdot \frac{21}{6}$
$n = \frac{21}{4}$

The solution is $\frac{21}{4}$.

36. $-9x + 4(2x - 3) = 5(2x - 3) + 7$
$-9x + 8x - 12 = 10x - 15 + 7$
$-x - 12 = 10x - 8$
$-x - 12 + x = 10x - 8 + x$
$-12 = 11x - 8$
$-12 + 8 = 11x - 8 + 8$
$-4 = 11x$
$\frac{1}{11}(-4) = \frac{1}{11} \cdot 11x$
$-\frac{4}{11} = x$

The solution is $-\frac{4}{11}$.

37. $3(x - 4) + 2 = x + 2(x - 5)$
$3x - 12 + 2 = x + 2x - 10$
$3x - 10 = 3x - 10$
$-10 = -10$
All real numbers are solutions. The solution set is the set of all real numbers. The equation is an identity.

38. $5t - (7 - t) = 4t + 2(9 + t)$
$5t - 7 + t = 4t + 18 + 2t$
$6t - 7 = 6t + 18$
$-7 = 18$ False equation

The solution set is $\varnothing$. The equation is a contradiction.

39. ***Familiarize***. Let x represent the number.
Translate.

Twice the number	plus	15	is	21.
↓	↓	↓	↓	↓
$2x$	+	15	=	21

40. ***Familiarize***. Let x = one number, then $x - 19$ = the other number.
Translate.

First number	plus	second number	is	115.
↓	↓	↓	↓	↓
x	+	$(x - 19)$	=	115

Carry out. We solve the equation.
$x + x - 19 = 115$
$2x - 19 = 115$
$2x - 19 + 19 = 115 + 19$
$2x = 134$
$x = 67$
When $x = 67$, $x - 19 = 67 - 19 = 48$

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Check. 48 is 19 less than 67. Also 48 + 67 = 115. The answer checks.
State. The smaller number is 48.

41. ***Familiarize***. Let x represent the measure of the second angle. Then the first angle is three times x, and the third angle is two times x. The sum of the three angles is 180°.
Translate. The first angle is $3x$, the second angle is x, and the third angle is $2x$. Translate to an equation:

First	plus	second	plus	third	is	180°.
↓	↓	↓	↓	↓	↓	↓
$3x$	+	x	+	$2x$	=	180

Carry out. We solve the equation.

$$3x + x + 2x = 180$$
$$6x = 180$$
$$x = 30$$

When $x = 30$, then $2x = 2 \cdot 30 = 60$, and $3x = 3 \cdot 30 = 90$.
Check. One angle, 90°, is 3 times the 30° angle, and the third angle, 60°, is two times the 30° angle. Also 60° + 30° + 90° = 180°. The answer checks.
State. The measures of the angles are 90°, 30°, and 60°.

42. $x = \dfrac{bc}{t}$

$tx = bc$ Multiplying both sides by t

$\dfrac{tx}{b} = c$ Multiplying both sides by $\dfrac{1}{b}$

43. $c = mx - rx$

$c = x(m - r)$

$\dfrac{c}{m - r} = x$

44. ***Familiarize***. Recall the formula for the volume of a right circular cylinder is $V = \pi r^2 h$.
Translate. We solve the formula for h.

$$V = \pi r^2 h$$
$$h = \frac{V}{\pi r^2}$$

Carry out. We substitute 3.5 for r, 538.51 for V, and 3.14 for π and calculate.

$$h = \frac{538.51}{3.14(3.5)^2}$$
$$h = 14$$

Check. We can repeat the calculation or substitute into the original formula and then solve for h. The answer checks.
State. The height of the candle is 14 cm.

45. $(-4mn^8)(7m^3n^2)$
$= (-4)(7)m \cdot m^3 \cdot n^8 \cdot n^2$
$= -28m^{1+3}n^{8+2}$
$= -28m^4n^{10}$

46. $\dfrac{12x^3y^8}{3x^2y^2} = \dfrac{12}{3}x^{3-2}y^{8-2} = 4xy^6$

47. $a^0 = (-8)^0 = 1$
$a^2 = (-8)^2 = 64$
$-a^2 = -(-8)^2 = -64$

48. $3^{-5} \cdot 3^7 = 3^{-5+7} = 3^2$, or 9

49. $(2t^4)^3 = 2^3 \cdot (t^4)^3 = 8t^{12}$

50. $(-5a^{-3}b^2)^{-3} = (-5)^{-3}(a^{-3})^{-3}(b^2)^{-3}$
$= -\dfrac{1}{5^3} \cdot a^9 \cdot b^{-6}$
$= -\dfrac{a^9}{125b^6}$

51. $\left(\dfrac{x^2y^3}{z^4}\right)^{-2} = \dfrac{(x^2)^{-2}(y^3)^{-2}}{(z^4)^{-2}} = \dfrac{x^{-4}y^{-6}}{z^{-8}} = \dfrac{z^8}{x^4y^6}$

52. $\left(\dfrac{3m^{-5}n}{9m^2n^{-2}}\right)^4 = \left(\dfrac{1}{3}m^{-5-2}n^{1-(-2)}\right)^4$
$= \left(\dfrac{1}{3}m^{-7}n^3\right)^4$
$= \dfrac{m^{-28}n^{12}}{81}$
$= \dfrac{n^{12}}{81m^{28}}$

53. $\dfrac{4(9-2\cdot3)-3^2}{4^2-3^2} = \dfrac{4(9-6)-9}{16-9} = \dfrac{4(3)-9}{7} = \dfrac{12-9}{7} = \dfrac{3}{7}$

54. $1-(2-5)^2+5\div10\cdot4^2$
$= 1-(-3)^2+5\div10\cdot16$
$= 1-9+\dfrac{1}{2}\cdot16$
$= 1-9+8$
$= 0$

55. $0.000307 = \dfrac{0.000307\times10^4}{10^4} = \dfrac{3.07}{10^4} = 3.07\times10^{-4}$

56. $30{,}860{,}000{,}000$
$= \dfrac{30{,}860{,}000{,}000}{10^{13}}\times10^{13}$
$= 3.086\times10^{13}$

57. $(8.7\times10^{-9})\times(4.3\times10^{15})$
$= (8.7\times4.3)(10^{-9}\times10^{15})$
$= 37.41\times10^6$
$= (3.741\times10)\times10^6$
$= 3.7\times10^7$ (2 significant digits)

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58. $\dfrac{1.2\times10^{-12}}{6.1\times10^{-7}} = \dfrac{1.2}{6.1}\times\dfrac{10^{-12}}{10^{-7}}$
$= 0.1967\times10^{-5}$
$= (1.967\times10^{-1})\times10^{-5}$
$= 1.967\times10^{-6}$
$\approx 2.0\times10^{-6}$ (2 significant digits)

59. ***Familiarize***. Recall the formula for the volume is $V = lwh$. We convert 1.2 m to mm.

$$1.2 \text{ m} = 1.2 \text{ m}\times\frac{1000 \text{ mm}}{1 \text{ m}} = 1200 \text{ mm}$$

We convert 79 m to mm.

$$79 \text{ m} = 79 \text{ m}\times\frac{1000 \text{ mm}}{1 \text{ m}} = 79{,}000 \text{ mm}$$

Translate. We substitute into the formula.

$V = lwh$
$V = (1200)\times(79{,}000)\times(0.00015)$

Carry out. We do the calculations.

$V = (1200)\times(79{,}000)\times(0.00015)$
$= 14{,}220 \text{ mm}^3$,
or $1.4\times10^4 \text{ mm}^3$ (2 significant digits)
or $1.4\times10^{-5} \text{ m}^3$

Check. We recheck the translation and the calculations.

State. The volume of the sheet is about $1.4\times10^4 \text{ mm}^3$, or or $1.4\times10^{-5} \text{ m}^3$.

60. *Writing Exercise*. To write an equation that has no solution, begin with a simple equation that is false for any value of x, such as $x = x + 1$. Then add or multiply by the same quantities on both sides of the equation to construct a more complicated equation with no solution.

61. *Writing Exercise*.

a. $-(-x)$ is positive when x is positive; the opposite of the opposite of a number is the number itself;

b. $-x^2$ is never positive; x^2 is always nonnegative, so the opposite of x^2 is always nonpositive;

c. $-x^3$ is positive when x is negative; x^3 is negative when x is negative, and the opposite of a negative number is positive;

d. $(-x)^2$ is positive when $x \neq 0$; the square of any nonzero number is positive;

e. x^{-2} is positive when $x \neq 0$; $x^{-2} = \dfrac{1}{x^2}$ and x^2 is positive when x is nonzero.

62. First we express the quotient, 3 parts per billion, as the fraction and then express as a percent.

$\dfrac{3}{1{,}000{,}000{,}000}$
$= \dfrac{3}{1{,}000{,}000{,}000}\cdot\dfrac{100}{100}$
$= \dfrac{300}{1{,}000{,}000{,}000}\%$
$= 0.0000003\%$

63. $a + b(c - a^2)^0 + (abc)^{-1}$
$= 3 + (-2)(-4 - (3)^2)^0 + (3(-2)(-4))^{-1}$
$= 3 + (-2)(1) + (24)^{-1}$
$= 3 - 2 + \dfrac{1}{24}$
$= 1 + \dfrac{1}{24}$
$= 1\dfrac{1}{24}$, or $\dfrac{25}{24}$

64. ***Familiarize***. First we find the area of each pizza. Then we find the price per square inch of each pizza. Recall, the formula for the area of a circle is $A = \pi r^2$ and the radius is $\dfrac{d}{2}$.

Translate. For each pizza, the price per square inch is the cost of each pizza divided by the area of each pizza.

$$P = \frac{C}{A}$$

Carry out. We substitute in the formula $A = \pi r^2$. For the first pizza, which costs \$12, $r = \dfrac{13}{2}$, or 6.5. We use 3.14 for π.

$A = 3.14(6.5)^2 = 132.665$

So the price per square inch is

$$P = \frac{12}{132.665} \approx 0.09$$

For the second pizza, which costs \$15, $r = \dfrac{17}{2}$, or 8.5. We use 3.14 for π.

$A = 3.14(8.5)^2 = 226.865$

So the price per square inch is

$$P = \frac{15}{226.865} \approx 0.07$$

Check. Repeat the calculations. The answer checks.
State. The 17-inch pizza is about 9¢ per square inch, while the 13-inch pizza is about 7¢ per square inch. The 17-inch pizza is a better deal.

65. ***Familiarize and Translate***. The surface area of a cube is the sum of the areas of the six sides, each a square, or $S_a = 6s^2$.

We can solve for the side s, by substituting.

$486 = 6s^2$
$81 = s^2$
$9 = s$

Recall the formula for the volume of a cube is $V = s^3$.

Carry out. We substitute.

$V = 9^3 = 729$

Check. We repeat the calculations. The answer checks.

State. The volume of the cube is 729 cm^3.

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66.
$$m = \frac{x}{y-z}$$
$$m(y-z) = x$$
$$my - mz = x$$
$$-mz = -my + x$$
$$z = \frac{-my+x}{-m}, \text{ or } \frac{my-x}{m}$$

67.
$$\frac{(3^{-2})^a \cdot (3^b)^{-2a}}{(3^{-2})^b \cdot (9^{-b})^{-3a}} = \frac{(3^{-2})^a \cdot (3^b)^{-2a}}{(3^{-2})^b \cdot \left[(3^2)^{-b}\right]^{-3a}} = \frac{3^{-2a} \cdot 3^{-2ab}}{3^{-2b} \cdot 3^{6ab}}$$
$$= 3^{-2a-2ab+2b-6ab}$$
$$= 3^{-2a+2b-8ab}$$

68.
$$5x - 7(x+3) - 4 = 2(7-x) + ___$$
$$5x - 7x - 21 - 4 = 14 - 2x + ___$$
$$-2x - 25 = 14 - 2x + ___$$
$$-25 = 14 + ___$$
$$-39 = ___$$

69.
$$20 - 7[3(2x+4) - 10] = 9 - 2(x-5) + ___$$
$$20 - 7[6x + 12 - 10] = 9 - 2x + 10 + ___$$
$$20 - 7[6x + 2] = 19 - 2x + ___$$
$$20 - 42x - 14 = 19 - 2x + ___$$
$$6 - 42x = 19 - 2x + ___$$
$$6 - 40x = 19 + ___$$
$$-40x = ___$$

70.
$$a \cdot 2 + cb + cd + ad$$
$$= ad + a \cdot 2 + cb + cd$$
$$= a(d+2) + c(b+d)$$

71. Answers will vary; $\sqrt{5}/4$ is one example.

Chapter 1 Test

1. Let m and n represent the numbers; $mn - 4$

2.
$$a^3 - 5b + b \div ac$$
$$= (-2)^3 - 5(6) + 6 \div (-2) \cdot (3)$$
$$= -8 - 5(6) + 6 \div (-2) \cdot 3$$
$$= -8 - 30 + (-3) \cdot 3$$
$$= -8 - 30 - 9$$
$$= -47$$

3. We substitute 7.8 for b and 46.5 for h and multiply.
$$A = \frac{1}{2} \cdot b \cdot h = \frac{1}{2}(7.8)(46.5) = 181.35 \text{ sq m}$$

4. $-15 + (-16)$
Two negative numbers: Add the absolute values, getting 31. The answer is negative, –31.

5. $-7.5 + 3.8$
A negative and positive number: The absolute values are 7.5 and 3.8. Subtract 3.8 from 7.5 to get 3.7. The negative number is farther from 0, so the answer is negative, –3.7.

6. $29.5 - 43.7 = 29.5 + (-43.7) = -14.2$

7. $-6.4(5.3)$
Two numbers with unlike signs: Multiply their absolute values getting 33.92. The answer is negative, –33.92.

8.
$$-\frac{7}{6} - \left(-\frac{5}{4}\right) = -\frac{7}{6} + \frac{5}{4}$$
$$= -\frac{14}{12} + \frac{15}{12}$$
$$= \frac{1}{12}$$

9. $-\frac{2}{7}\left(-\frac{5}{14}\right)$
Two numbers with the same sign: Multiply their absolute values getting $\frac{10}{98}$, or $\frac{5}{49}$. The answer is positive, $\frac{5}{49}$.

10. $\frac{-42.6}{-7.1}$
Two numbers with the same sign: Divide their absolute values, getting 6. The answer is positive, 6.

11.
$$\frac{2}{5} \div \left(-\frac{3}{10}\right) = \frac{2}{5} \cdot \left(-\frac{10}{3}\right)$$
Two numbers with unlike signs: Divide their absolute values getting $\frac{4}{3}$. The answer is negative, $-\frac{4}{3}$.

12.
$$7 + (1-3)^2 - 9 \div 2^2 \cdot 6$$
$$= 7 + (-2)^2 - 9 \div 4 \cdot 6$$
$$= 7 + 4 - \frac{9}{4} \cdot 6$$
$$= 7 + 4 - \frac{27}{2}$$
$$= 11 - \frac{27}{2}$$
$$= -\frac{5}{2}$$

13. Using the commutative law of addition, we have $3 + x = x + 3$.

14. $4y - 10 - 7y - 19 = (4-7)y - 10 - 19 = -3y - 29$

15.
$$10x - 7 = 38x + 49$$
$$-7 = 28x + 49$$
$$-56 = 28x$$
$$-2 = x$$
The solution is –2.

16.
$$13t - (5 - 2t) = 5(3t - 1)$$
$$13t - 5 + 2t = 15t - 5$$
$$15t - 5 = 15t - 5$$
$$-5 = -5 \quad \text{True}$$
All real numbers are solutions. The equation is an identity.

17.
$$2p = sp + t$$
$$2p - sp = t$$
$$p(2-s) = t$$
$$p = \frac{t}{2-s}$$

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18. ***Familiarize***. Let x = the number of points on the sixth test.

Translate

$$\underbrace{\text{Average score on 6 tests}}_{\downarrow} \quad \text{is} \quad \underbrace{85}_{\downarrow}$$

$$\frac{84+80+76+96+80+x}{6} = 85$$

Carry out. We solve the equation.

$$\frac{416+x}{6} = 85$$
$$416 + x = 510$$
$$x = 94$$

Check. $\frac{84+80+76+96+80+94}{6}$, or 85. The answer checks.

State. Linda must score 94 so her average will be 85.

19. ***Familiarize***. Let x represent the first odd integer. Then the second odd integer is $x + 2$ and the third is $x + 2 + 2$, or $x + 4$.

Translate.

$$\underbrace{\text{Four times the first}}_{\downarrow\ 4x} \text{ plus } \underbrace{\text{Three times the second}}_{\downarrow\ 3(x+2)} \text{ plus } \underbrace{\text{Two times the third}}_{\downarrow\ 2(x+4)} \text{ is } \underbrace{167}_{\downarrow\ 167}$$

Carry out. We solve the equation.

$$4x + 3(x+2) + 2(x+4) = 167$$
$$4x + 3x + 6 + 2x + 8 = 167$$
$$9x + 14 = 167$$
$$9x = 153$$
$$x = 17$$

$x + 2 = 19$

$x + 4 = 21$

Check. $4 \cdot 17 + 3 \cdot 19 + 2 \cdot 21$, or 68 + 57 + 42, or 167. The answer checks.

State. The consecutive odd integers are 17, 19, and 21.

20. $3x - 7 - (4 - 5x) = 3x - 7 - 4 + 5x = 8x - 11$

21. $6b - [7 - 2(9b - 1)]$
$= 6b - [7 - 18b + 2]$
$= 6b - [9 - 18b]$
$= 6b - 9 + 18b$
$= 24b - 9$

22. $\left(7x^{-4}y^{-7}\right)\left(-6x^{-6}y\right)$
$= (7)(-6)\left(x^{-4}x^{-6}\right)\left(y^{-7}y\right)$
$= -42x^{-4+(-6)}y^{-7+1}$
$= -42x^{-10}y^{-6}$, or $-\frac{42}{x^{10}y^{6}}$

23. $-6^{-2} = -\frac{1}{6^2}$, or $-\frac{1}{36}$

24. $\left(-5x^{-1}y^{3}\right)^{3} = (-5)^{3}\left(x^{-1}\right)^{3}\left(y^{3}\right)^{3}$
$= -125x^{-3}y^{9}$
$= -\frac{125y^{9}}{x^{3}}$

25. $\left(\frac{2x^{3}y^{-6}}{-4y^{-2}}\right)^{-2} = \left(-\frac{2}{4}x^{3}y^{-6-(-2)}\right)^{-2} = \left(-\frac{1}{2}x^{3}y^{-4}\right)^{-2}$
$= \left(-\frac{1}{2}\right)^{-2}\left(x^{3}\right)^{-2}\left(y^{-4}\right)^{-2}$
$= (-2)^{2}x^{-6}y^{8} = \frac{4y^{8}}{x^{6}}$

26. $\left(7x^{3}y\right)^{0} = 1$

27. $\left(9.05\times10^{-3}\right)\left(2.22\times10^{-5}\right)$
$= (9.05\times2.22)\times\left(10^{-3}\times10^{-5}\right)$
$= 20.091\times10^{-8}$
$= \left(2.0091\times10^{1}\right)\times10^{-8}$
$= 2.0091\times10^{-7}$
$\approx 2.01\times10^{-7}$ (3 significant digits)

28. $\frac{1.8\times10^{-4}}{4.8\times10^{-7}} = \frac{1.8}{4.8}\times\frac{10^{-4}}{10^{-7}}$
$= 0.375\times10^{3}$
$= \left(3.75\times10^{-1}\right)\times10^{3}$
$= 3.75\times10^{2}$
$\approx 3.8\times10^{2}$ (2 significant digits)

29. ***Familiarize***. Let n = the smallest number of neutrinos that could have the same mass as an alpha particle of mass 3.62×10^{-27} kg.

Translate. We divide.

$$n = \frac{3.62\times10^{-27}\ \text{kg}}{1.8\times10^{-36}\ \text{kg}}$$

Carry out. We perform the calculation and write scientific notation for the answer.

$$n = \frac{3.62\times10^{-27}\ \text{kg}}{1.8\times10^{-36}\ \text{kg}}$$
$$= \frac{3.62}{1.8}\times\frac{10^{-27}}{10^{-36}}$$
$$\approx 2.0\times10^{9} \quad \text{(2 significant digits)}$$

Check. We multiply the answer by the maximum mass of a neutrino.

$\left(2.0\times10^{9}\right)\left(1.8\times10^{-36}\right) = 3.6\times10^{-27} \approx 3.62\times10^{-27}$

The answer checks.

State. The smallest number of neutrinos that could have the same mass as an alpha particle of mass 3.62×10^{-27} kg is about 2.0×10^{9} neutrinos.

30. $\left(2x^{3a}y^{b+1}\right)^{3c} = 2^{3c}\cdot\left(x^{3a}\right)^{3c}\cdot\left(y^{b+1}\right)^{3c} = 8^{c}x^{9ac}y^{3bc+3c}$

31. $\frac{-27a^{x+1}}{3a^{x-2}} = \frac{-27}{3}\cdot a^{(x+1)-(x-2)} = -9a^{3}$

32. $-\frac{5x+2}{x+10} = 1$
$-(5x+2) = 1(x+10)$
$-5x - 2 = x + 10$
$-2 = 6x + 10$
$-12 = 6x$
$-2 = x$

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Chapter 2

Graphs, Functions, and Linear Equations

Exercise Set 2.1

1. The two perpendicular number lines that are used for graphing are called axes.

2. Because the order in which the numbers are listed is important, numbers listed in the form (x, y) are called ordered pairs.

3. In the third quadrant, both coordinates of a point are negative.

4. In the fourth quadrant, a point's first coordinate is positive and its second coordinate is negative.

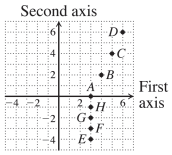
5. To graph an equation means to make a drawing that represents all solutions of the equation.

6. An equation whose graph is a straight line is said to be a linear equation.

7. A is 5 units right of the origin and 3 units up, so its coordinates are (5, 3).
B is 4 units left of the origin and 3 units up, so its coordinates are (–4, 3).
C is 0 units right or left of the origin and 2 units up, so its coordinates are (0, 2).
D is 2 units left of the origin and 3 units down, so its coordinates are (–2, –3).
E is 4 units right of the origin and 2 units down, so its coordinates are (4, –2).
F is 5 units left of the origin and 0 units up or down, so its coordinates are (–5, 0).

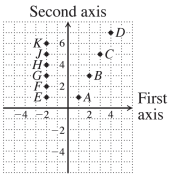
8. G is 2 units right of the origin and 4 units up, so its coordinates are (2, 4).
H is 3 units left of the origin and 1 unit up, so its coordinates are (–3, 1).
I is 0 units right or left of the origin and 2 units down, so its coordinates are (0, –2).
J is 2 units right of the origin and 2 units down, so its coordinates are (2, –2).
K is 5 units left of the origin and 4 units down, so its coordinates are (–5, –4).
L is 4 units right of the origin and 0 units up or down, so its coordinates are (4, 0).

9.

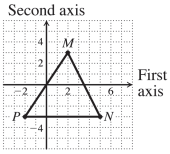


$A(3, 0)$ is 3 units right and 0 units up or down.
$B(4, 2)$ is 4 units right and 2 units up.
$C(5, 4)$ is 5 units right and 4 units up.
$D(6, 6)$ is 6 units right and 6 units up.
$E(3, -4)$ is 3 units right and 4 units down.
$F(3, -3)$ is 3 units right and 3 units down.
$G(3, -2)$ is 3 units right and 2 units down.
$H(3, -1)$ is 3 units right and 1 unit down.

10.



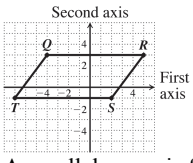
11.



A triangle is formed. The area of a triangle is found by using the formula $A = \frac{1}{2}bh$. In this triangle the base and height are 7 units and 6 units, respectively.

$$A = \frac{1}{2}bh = \frac{1}{2} \cdot 7 \cdot 6 = \frac{42}{2} = 21 \text{ square units}$$

12.

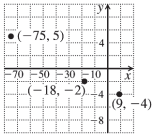


A parallelogram is formed.

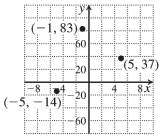
$A = bh$

$A = 9 \cdot 4 = 36$ square units

13. The smallest first coordinate is –75 and the largest is 9. The smallest second coordinate is –4 and the largest is 5. The points are in quadrants II, III, and IV.



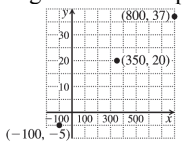
14. The smallest first coordinate is –5 and the largest is 5. The smallest second coordinate is –14 and the largest is 83. The points are in quadrants I, II, and III.



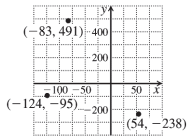
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15. The smallest first coordinate is –100 and the largest is 800. The smallest second coordinate is –5 and the largest is 37. The points are in quadrants I and III.



16. The smallest first coordinate is –124 and the largest is 54. The smallest second coordinate is –238 and the largest is 491. The points are in quadrants II, III, and IV.



17. The first coordinate is positive and the second negative, so the point (7, –2) is in quadrant IV.

18. III

19. Both coordinates are negative, so the point (–4, –3) is in quadrant III.

20. IV

21. The first coordinate is zero, so the point (0, –3) is on the y-axis.

22. x-axis

23. The first coordinate is negative and the second positive, so the point (–4.9, 8.3) is in quadrant II.

24. I

25. The second coordinate is zero, so the point $\left(-\frac{5}{2},\ 0\right)$ is on the x-axis.

26. y-axis

27. Both coordinates are positive, so the point (160, 2) is in quadrant I.

28. II

29.
$$\begin{array}{r|l} y = 3x - 7 & \\ \hline -1 & 3\cdot 2 - 7 \\ & 6 - 7 \\ & \stackrel{?}{=} \\ & -1 = -1 \end{array}$$
Substituting 2 for x and -1 for y (alphabetical order of variables)

Since $-1 = -1$ is true, (2, –1) is a solution of $y = 3x - 7$.

30.
$$\begin{array}{r|l} y = 5x - 1 & \\ \hline 4 & 5\cdot 1 - 1 \\ & \stackrel{?}{=} \\ & 4 = 4 \end{array}$$
Yes

31.
$$\begin{array}{r|l} 2x - y = 5 & \\ \hline 2\cdot 3 - 2 & 5 \\ 6 - 2 & \\ & \stackrel{?}{=} \\ & 4 = 5 \end{array}$$
Substituting 3 for x and 2 for y (alphabetical order of variables)

Since $4 = 5$ is false, (3, 2) is not a solution of $2x - y = 5$.

32.
$$\begin{array}{r|l} 3x - y = 5 & \\ \hline 3\cdot 5 - 5 & 5 \\ & \stackrel{?}{=} \\ & 10 = 5 \end{array}$$
No

33.
$$\begin{array}{r|l} a - 5b = 8 & \\ \hline 3 - 5(-1) & 8 \\ 3 + 5 & \\ & \stackrel{?}{=} \\ & 8 = 8 \end{array}$$
Substituting 3 for a and -1 for b

Since $8 = 8$ is true, (3, –1) is a solution of $a - 5b = 8$.

34.
$$\begin{array}{r|l} 2u - v = -6 & \\ \hline 2\cdot 1 - (-4) & -6 \\ & \stackrel{?}{=} \\ & 6 = -6 \end{array}$$
No

35.
$$\begin{array}{r|l} 6x + 8y = 4 & \\ \hline 6\cdot\frac{2}{3} + 8\cdot 0 & 4 \\ 4 + 0 & \\ & \stackrel{?}{=} \\ & 4 = 4 \end{array}$$
Substituting $\frac{2}{3}$ for x and 0 for y

Since $4 = 4$ is true, $\left(\frac{2}{3},\ 0\right)$ is a solution of $6x + 8y = 4$.

36.
$$\begin{array}{r|l} 7a + 10b = 6 & \\ \hline 7\cdot 0 + 10\cdot\frac{3}{5} & 6 \\ & \stackrel{?}{=} \\ & 6 = 6 \end{array}$$
Yes

37.
$$\begin{array}{r|l} r - s = 4 & \\ \hline 6 - (-2) & 4 \\ 6 + 2 & \\ & \stackrel{?}{=} \\ & 8 = 4 \end{array}$$
Substituting 6 for r and -2 for s

Since $8 = 4$ is false, (6, –2) is not a solution of $r - s = 4$.

38.
$$\begin{array}{r|l} 2x - y = 11 & \\ \hline 2\cdot 4 - (-3) & 11 \\ & \stackrel{?}{=} \\ & 11 = 11 \end{array}$$
Yes

39.
$$\begin{array}{r|l} y = 2x^2 & \\ \hline 1 & 2(2)^2 \\ & \stackrel{?}{=} \\ & 1 = 8 \end{array}$$
Substituting 2 for x and 1 for y

Since $1 = 8$ is false, (2, 1) is not a solution of $y = 2x^2$.

40.
$$\begin{array}{r|l} r^2 - s = 5 & \\ \hline (-2)^2 - (-1) & 5 \\ & \stackrel{?}{=} \\ & 5 = 5 \end{array}$$
Yes

41.
$$\begin{array}{r|l} x^3 + y = 1 & \\ \hline (-2)^3 + 9 & 1 \\ -8 + 9 & \\ & \stackrel{?}{=} \\ & 1 = 1 \end{array}$$
Substituting -2 for x and 9 for y

Since $1 = 1$ is true, (–2, 9) is a solution of $x^3 + y = 1$.

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42. $y = x^3 - 5$

$2 \mid 3^3 - 5$

$2 \stackrel{?}{=} 22$

No

43. $y = 3x$

To find an ordered pair, we choose any number for x and then determine y by substitution.

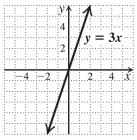
When $x = 0$, $y = 3 \cdot 0 = 0$.

When $x = 1$, $y = 3 \cdot 1 = 3$.

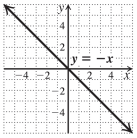
When $x = -2$, $y = 3 \cdot (-2) = -6$.

x	y	(x, y)
0	0	(0, 0)
1	3	(1, 3)
–2	–6	(–2, –6)

Plot these points, draw the line they determine, and label the graph $y = 3x$.



44. Graph $y = -x$.



45. $y = x + 4$

To find an ordered pair, we choose any number for x and then determine y by substitution.

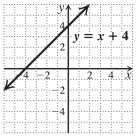
When $x = 0$, $y = 0 + 4 = 4$.

When $x = 1$, $y = 1 + 4 = 5$.

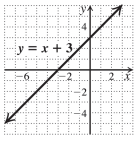
When $x = -2$, $f = -2 + 4 = 2$.

x	y	(x, y)
0	4	(0, 4)
1	5	(1, 5)
–2	2	(–2, 2)

Plot these points, draw the line they determine, and label the graph $y = x + 4$.



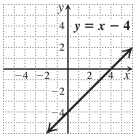
46. Graph $y = x + 3$.



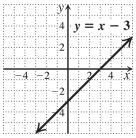
47. $y = x - 4$

To find an ordered pair, we choose any number for x and then determine y by substitution. For example, if we choose 1 for x, then $y = 1 - 4 = -3$. We find several ordered pairs, plot them and draw the line.

x	y	(x, y)
1	–3	(1, –3)
0	–4	(0, –4)
–2	–6	(–2, –6)



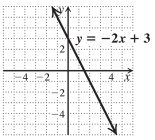
48. Graph $y = x - 3$.



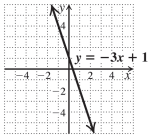
49. $y = -2x + 3$

To find an ordered pair, we choose any number for x and then determine y. For example, if $x = 1$, then $y = -2 \cdot 1 + 3 = -2 + 3 = 1$. We find several ordered pairs, plot them, and draw the line.

x	y
1	1
3	–3
–1	5
0	3



50. Graph $y = -3x + 1$.



51. $y + 2x = 3$

$y = -2x + 3$ Solving for y

Observe that this is the equation that was graphed in Exercise 49. The graph is shown above.

52. $y + 3x = 1$

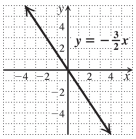
$y = -3x + 1$

Observe that this is the equation that was graphed in Exercise 50. The graph is shown above.

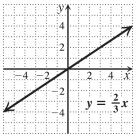
53. $y = -\frac{3}{2}x$

To find an ordered pair, we choose any number for x and then determine y by substitution. For example, if $x = 2$, then $y = -\frac{3}{2} \cdot 2 = -3$. We find several ordered pairs, plot them and draw the line.

x	y
2	–3
0	0
–4	6



54. Graph $y = \frac{2}{3}x$.



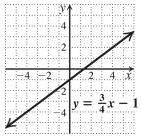
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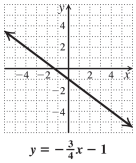
55. $y = \frac{3}{4}x - 1$

To find an ordered pair, we choose any number for x and then determine y by substitution. For example, if $x = 4$, then $y = \frac{3}{4} \cdot 4 - 1 = 3 - 1 = 2$. We find several ordered pairs, plot them and draw the line.

x	y
4	2
0	−1
−8	−7



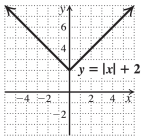
56. Graph $y = -\frac{3}{4}x - 1$.



57. $y = |x| + 2$

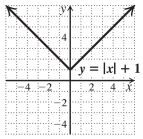
We select x-values and find the corresponding y-values. The table lists some ordered pairs. We plot these points.

x	y
3	5
1	3
0	2
−1	3
−3	5



Note that the graph is V-shaped, centered at (0, 2).

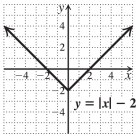
58. Graph $y = |x| + 1$.



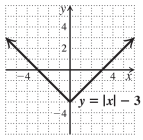
59. $y = |x| - 2$

We select x-values and find the corresponding y-values. The table lists some ordered pairs. We plot these points.

x	y
3	1
1	−1
0	−2
−1	−1
−4	2



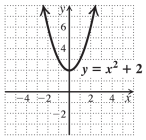
60. Graph $y = |x| - 3$.



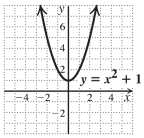
61. $y = x^2 + 2$

To find an ordered pair, we choose any number for x and then determine y. For example, if $x = 2$, then $y = 2^2 + 2 = 6$. We find several ordered pairs, plot them, and connect them with a smooth curve.

x	y
2	6
1	3
0	2
−1	3
−2	6



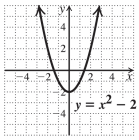
62. Graph $y = x^2 + 1$.



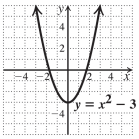
63. $y = x^2 - 2$

To find an ordered pair, we choose any number for x and then determine y. For example, if $x = 2$, then $y = 2^2 - 2 = 4 - 2 = 2$. We find several ordered pairs, plot them, and connect them with a smooth curve.

x	y
2	2
1	−1
0	−2
−1	−1
−2	2



64. Graph $y = x^2 - 3$.



65. *Writing Exercise.* You could measure time in years, because it seems reasonable that each graph represents a ten-year span. Answers may vary.

66. *Writing Exercise.* Yes. It seems reasonable that passion increases rapidly, then decreases sharply, and finally levels off; that intimacy increases steadily until passion peaks and then continues to increase but at a lower rate; and that commitment increases rapidly during the period when passion is decreasing, eventually leveling off at a high value.

67.
$$\begin{aligned} 3 - 2(1-4)^2 \div 6 \cdot 2 &= 3 - 2(-3)^2 \div 6 \cdot 2 \\ &= 3 - 2(9) \div 6 \cdot 2 \\ &= 3 - 18 \div 6 \cdot 2 \\ &= 3 - 3 \cdot 2 \\ &= 3 - 6 \\ &= -3 \end{aligned}$$

68.
$$\begin{aligned} 3(x-7) - 4(2-3x) &= 3x - 21 - 8 + 12x \\ &= 15x - 29 \end{aligned}$$

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69. $\left(2x^6y\right)^2 = 4x^{12}y^2$

70. $\dfrac{24a^{-1}b^{10}}{-14a^{11}b^{-16}} = -\dfrac{12b^{26}}{7a^{12}}$

71. *Writing Exercise*. When $x < 0$, then $y < 0$ and the graph contains points in quadrant III. When $0 < x < 30$, then $y < 0$ and the graph contains points in quadrant IV. When $x > 30$, then $y > 0$ and the graph contains points in quadrant I. Thus, the graph passes through three quadrants.

72. *Writing Exercise*. The lines will intersect at (a, b). The point of intersection must be a point that is on both lines, so its first coordinate must be a since the first coordinate of every point on the first line is a and its second coordinate must be b since the second coordinate of every point on the second line is b.

73. **a.** Graph III seems most appropriate for this situation. It reflects less than 40 hours of work per week until September, 40 hours per week from September until December, and more than 40 hours per week in December.

b. Graph II seems most appropriate for this situation. It reflects 40 hours of work per week until September, 20 hours per week from September until December, and 40 hours per week again in December.

c. Graph I seems most appropriate for this situation. It reflects more than 40 hours of work per week until September, 40 hours per week from September until December, and more than 40 hours per week again in December.

d. Graph IV seems most appropriate for this situation. It reflects less than 40 hours of work per week until September, approximately 20 hours per week from September until December, and about 40 hours per week in December.

74. **a.** Graph IV seems most appropriate for this situation. It reflects driving speeds on local streets for the first 10 and last 5 minutes and freeway cruising speeds from 10 through 30 minutes.

b. Graph III seems most appropriate for this situation. It reflects driving speeds on local streets for the first 10 minutes, and expresses train speed for the next 20 minutes, and walking speeds for the final 5 minutes.

c. Graph I seems most appropriate for this situation. It reflects walking speeds for the first 10 and last 5 minutes and express bus speeds from 10 through 30 minutes.

d. Graph II seems most appropriate for this situation. It reflects that the speed was 0 mph for the first 10 minutes, the time spent waiting at the bus stop. Then it shows driving speeds that fall to 0 mph several times during the next 20 minutes, indicating that the school bus stops for other students during this period of time. Finally, it shows a walking speed for the last 5 minutes.

75. **a.** Graph III seems most appropriate for this situation. It reflects a constant speed for a lakeshore loop.

b. Graph II seems most appropriate for this situation. In climbing a monster hill, the speed gradually decreases, the speed bottoms out at the top of the hill, and increases for the downhill ride.

c. Graph IV seems most appropriate for this situation. For interval training, the speed is constant for an interval, then increases to a new constant speed for an interval, then returns to the first speed. The sequence repeats.

d. Graph I seems most appropriate for this situation. For a variety of intervals, the speed varies with no particular pattern of increase or decrease in speed.

76. Substitute $-\frac{1}{3}$ for x and $\frac{1}{4}$ for y in each equation.

a.
$$\begin{array}{r|l} -\frac{3}{2}x - 3y = -\frac{1}{4} & \\ \hline -\frac{3}{2}\left(-\frac{1}{3}\right) - 3\left(\frac{1}{4}\right) & -\frac{1}{4} \\ \frac{1}{2} - \frac{3}{4} & \\ -\frac{1}{4} \stackrel{?}{=} -\frac{1}{4} & \end{array}$$

Since $-\frac{1}{4} = -\frac{1}{4}$ is true, $\left(-\frac{1}{3}, \frac{1}{4}\right)$ is a solution.

b.
$$\begin{array}{r|l} 8y - 15x = \frac{7}{2} & \\ \hline 8\left(\frac{1}{4}\right) - 15\left(-\frac{1}{3}\right) & \frac{7}{2} \\ 2 + 5 & \\ 7 \stackrel{?}{=} \frac{7}{2} & \end{array}$$

Since $7 = \frac{7}{2}$ is false, $\left(-\frac{1}{3}, \frac{1}{4}\right)$ is not a solution.

c.
$$\begin{array}{r|l} 0.16y = -0.09x + 0.1 & \\ \hline 0.16\left(\frac{1}{4}\right) & -0.09\left(-\frac{1}{3}\right) + 0.1 \\ 0.04 & 0.03 + 0.1 \\ 0.04 \stackrel{?}{=} 0.13 & \end{array}$$

Since $0.04 = 0.13$ is false, $\left(-\frac{1}{3}, \frac{1}{4}\right)$ is not a solution.

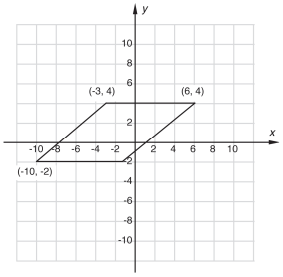
d.
$$\begin{array}{r|l} 2(-y+2) - \frac{1}{4}(3x-1) = 4 & \\ \hline 2\left(-\frac{1}{4}+2\right) - \frac{1}{4}\left[3\left(-\frac{1}{3}\right)-1\right] & 4 \\ 2\left(\frac{7}{4}\right) - \frac{1}{4}(-2) & \\ \frac{7}{2} + \frac{1}{2} & \\ \frac{8}{2} & \\ 4 \stackrel{?}{=} 4 & \end{array}$$

Since $4 = 4$ is true, $\left(-\frac{1}{3}, \frac{1}{4}\right)$ is a solution.

77. Plot (–10,–2), (–3, 4), and (6, 4), and sketch a parallelogram.

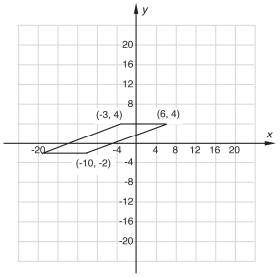
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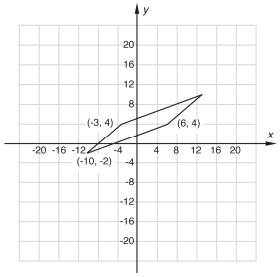
Since (6, 4) is 9 units directly to the right of (–3, 4), a fourth vertex could lie 9 units directly to the right of (–10,–2). Then its coordinates are (–10 + 9,–2), or (–1,–2).

If we connect the points in a different order, we get a second parallelogram.



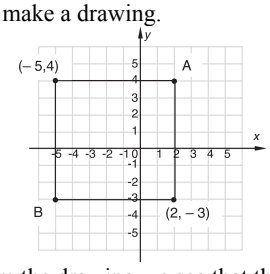
Since (–3, 4) is 9 units directly to the left of (6, 4), a fourth vertex could lie 9 units directly to the left of (–10,–2). Then its coordinates are (–10 – 9,–2), or (–19,–2).

If we connect the points in yet a different order, we get a third parallelogram.



Since (6, 4) lies 16 units directly to the right of and 6 units above (–10, –2), a fourth vertex could lie 16 units to the right of and 6 units above (–3, 4). Its coordinates are (–3 + 16, 4 + 6), or (13, 10).

78. We make a drawing.

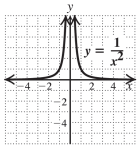


From the drawing we see that the vertex A is 2 units right and up 4 units. Thus, its coordinates are (2, 4). We also see that vertex B is 5 units left and down 3 units, so its coordinates are (–5,–3). We also see that the distance between any pair of adjacent vertices is 7 units. The area of a square whose side has length 7 units is $7 \cdot 7$, or 49 square units.

79. $y = \frac{1}{x^2}$

Choose x-values from –4 to 4 and use a calculator to find the corresponding y-values. (Note that we cannot choose 0 as a first coordinate since $1/0^2$, or 1/0, is not defined.) Plot the points and draw the graph. Note that it has two branches, one on each side of the y-axis.

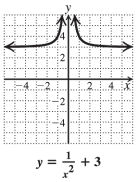
x	y
–4	0.0625
–3	$0.\overline{1}$
–2	0.25
–1	1
–0.5	4
0.5	4
1	1
2	0.25
3	$0.\overline{1}$
4	0.0625



80. $y = \frac{1}{x^2} + 3$

Choose x-values from –4 to 4 and use a calculator to find the corresponding y-values. (Note that we cannot choose 0 as a first coordinate since 1/0 is not defined.) Plot the points and draw the graph. Note that it has two branches, one in the first quadrant and the other in the second quadrant.

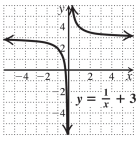
x	y
–4	3.0625
–3	$3.\overline{1}$
–2	3.25
–1	4
–0.25	19
0.25	19
1	4
2	3.25
3	$3.\overline{1}$
4	3.0625



81. $y = \frac{1}{x} + 3$

Choose x-values from –4 to 4 and use a calculator to find the corresponding y-values. (Note that we cannot choose 0 as a first coordinate since 1/0 is not defined.) Plot the points and draw the graph. Note that it has two branches, one in the first quadrant and the other in the second and third quadrants.

x	y
–4	2.75
–3	2.67
–2	2.5
–1	2
–0.25	–1
0.25	7
1	4
2	3.5
3	3.33
4	3.25



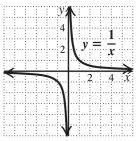
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82. $y = \frac{1}{x}$

Choose x-values from –4 to 4 and use a calculator to find the corresponding y-values. (Note that we cannot choose 0 as a first coordinate since 1/0 is not defined.) Plot the points and draw the graph. Note that it has two branches, one in the first quadrant and the other in the third quadrant.

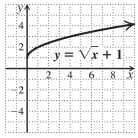
x	y
–4	–0.25
–3	–0.33
–2	–0.5
–1	–1
–0.25	–4
0.25	4
1	1
2	0.5
3	0.33
4	0.25



83. $y = \sqrt{x} + 1$

Choose x-values from 0 to 10 and use a calculator to find the corresponding y-values. Plot the points and draw the graph.

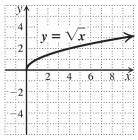
x	y
0	1
1	2
2	2.414
3	2.732
4	3
5	3.236
6	3.449
7	3.646
8	3.828
9	4
10	4.162



84. $y = \sqrt{x}$

Choose x-values from 0 to 10 and use a calculator to find the corresponding y-values. Plot the points and draw the graph.

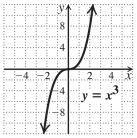
x	y
0	0
1	1
2	1.414
3	1.732
4	2
5	2.236
6	2.449
7	2.646
8	2.828
9	3
10	3.162



85. $y = x^3$

Choose x-values from –2 to 2 and use a calculator to find the corresponding y-values. Plot the points and draw the graph.

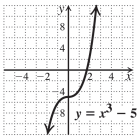
x	y
–2	–8
–1.5	–3.375
–1	–1
–0.5	–0.125
–0.25	–0.016
0	0
0.5	0.125
1	1
1.5	3.375
2	8



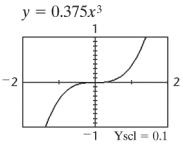
86. $y = x^3 - 5$

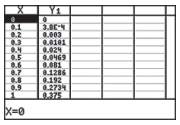
Choose x-values from –2 to 2 and use a calculator to find the corresponding y-values. Plot the points and draw the graph.

x	y
–2	–13
–1.5	–8.375
–1	–6
–0.5	–5.125
–0.25	–5.016
0	–5
0.5	–4.875
1	–4
1.5	–1.625
2	3

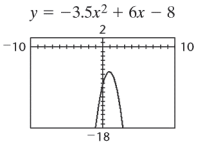


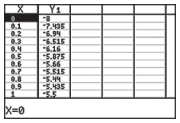
87. a. $y = 0.375x^3$



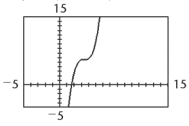


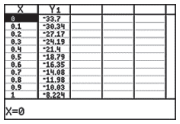
b. $y = -3.5x^2 + 6x - 8$



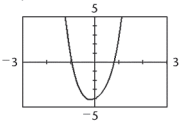


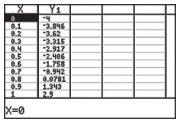
c. $y = (x - 3.4)^3 + 5.6$



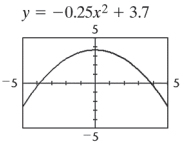


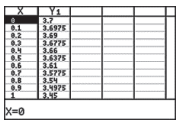
88. a. $y = 2.3x^4 + 3.4x^2 + 1.2x - 4$





b. $y = -0.25x^2 + 3.7$

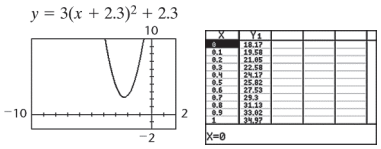




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c.



Exercise Set 2.2

1. A function is a special kind of correspondence between two sets.

2. In any function, each member of the domain is paired with exactly one member of the range.

3. For any function, the set of all inputs, or first values, is called the domain.

4. For any function, the set of all outputs, or second values, is called the range.

5. When a function is graphed, members of the domain are located on the horizontal axis.

6. When a function is graphed, members of the range are located on the vertical axis.

7. The notation $f(3)$ is read "f of 3," "f at 3," or "the value of f at 3."

8. The vertical-line test can be used to determine whether or not a graph represents a function.

9. The correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

10. The correspondence is not a function because a member of the domain (2) corresponds to more than one member of the range.

11. The correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

12. The correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

13. The correspondence is not a function because a member of the domain (Frances McDormand) corresponds to more than one member of the range.

14. The correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

15. The correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

16. The correspondence is not a function because two members of the domain (Florida and Kansas) each corresponds to more than one member of the range.

17. The correspondence is a function, because each flash drive has only one storage capacity.

18. The correspondence is not a function, since it is reasonable to assume that at least one member of a rock band plays more than one instrument.

19. This correspondence is a function, because each player has only one uniform number.

20. This correspondence is a function, because each triangle has only one number for its area.

21. a. The domain is the set of all x-values of the set. It is $\{-3, -2, 0, 4\}$.
b. The range is the set of all y-values of the set. It is $\{-10, 3, 5, 9\}$.
c. The correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

22. a. Domain: $\{0, 1, 2, 5\}$
b. Range: $\{-1, 3\}$
c. Yes

23. a. The domain is the set of all x-values of the set. It is $\{1, 2, 3, 4, 5\}$.
b. The range is the set of all y-values of the set. It is $\{1\}$.
c. The correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

24. a. Domain: $\{1\}$
b. Range: $\{1, 2, 3, 4, 5\}$
c. No

25. a. The domain is the set of all x-values of the set. It is $\{-2, 3, 4\}$.
b. The range is the set of all y-values of the set. It is $\{-8, -2, 4, 5\}$.
c. The correspondence is not a function, because a member of the domain (4) corresponds to more than one member of the range.

26. a. Domain: $\{0, 4, 7, 8\}$
b. Range: $\{0, 4, 7, 8\}$
c. Yes

27. a. Locate 1 on the horizontal axis and then find the point on the graph for which 1 is the first coordinate. From that point, look to the vertical axis to find the corresponding y-coordinate, –2. Thus, $f(1) = -2$.
b. The set of all x-values in the graph extends from –2 to 5, so the domain is $\{x \mid -2 \le x \le 5\}$.
c. To determine which member(s) of the domain are paired with 2, locate 2 on the vertical axis. From there look left and right to the graph to find any points for which 2 is the second coordinate. One such point exists. Its first coordinate is 4. Thus, the x-value for which $f(x) = 2$ is 4.
d. The set of all y-values in the graph extends from –3 to 4, so the range is $\{y \mid -3 \le y \le 4\}$.

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28. a. $f(1) = 3$.

b. The set of all x-values in the graph is $\{x \mid -1 \le x \le 4\}$.

c. The only point whose second coordinate is 2 is $(3,\ 2)$, so the x-value for which $f(x) = 2$ is 3.

d. The set of all y-values in the graph is $\{y \mid 1 \le y \le 4\}$.

29. a. Locate 1 on the horizontal axis and then find the point on the graph for which 1 is the first coordinate. From that point, look to the vertical axis to find the corresponding y-coordinate, –2. Thus, $f(1) = -2$.

b. The set of all x-values in the graph extends from –4 to 2, so the domain is $\{x \mid -4 \le x \le 2\}$.

c. To determine which member(s) of the domain are paired with 2, locate 2 on the vertical axis. From there look left and right to the graph to find any points for which 2 is the second coordinate. One such point exists. Its first coordinate is –2. Thus, the x-value for which $f(x) = 2$ is –2.

d. The set of all y-values in the graph extends from –3 to 3, so the range is $\{y \mid -3 \le y \le 3\}$.

30. a. $f(1) = 3$.

b. The set of all x-values in the graph is $\{x \mid -4 \le x \le 3\}$.

c. The only point whose second coordinate is 2 is $(0,\ 2)$, so the x-value for which $f(x) = 2$ is 0.

d. The set of all y-values in the graph is $\{y \mid -5 \le y \le 4\}$.

31. a. Locate 1 on the horizontal axis and then find the point on the graph for which 1 is the first coordinate. From that point, look to the vertical axis to find the corresponding y-coordinate, 3. Thus, $f(1) = 3$.

b. The set of all x-values in the graph extends from –4 to 3, so the domain is $\{x \mid -4 \le x \le 3\}$.

c. To determine which member(s) of the domain are paired with 2, locate 2 on the vertical axis. From there look left and right to the graph to find any points for which 2 is the second coordinate. One such point exists. Its first coordinate is –3. Thus, the x-value for which $f(x) = 2$ is –3.

d. The set of all y-values in the graph extends from –2 to 5, so the range is $\{y \mid -2 \le y \le 5\}$.

32. a. $f(1) = 4$

b. The set of all x-values in the graph is $\{x \mid -4 \le x \le 4\}$.

c. The points whose second coordinate is 2 are $(-4,\ 2)$ and $(-1,\ 2)$, so the x-values for which $f(x) = 2$ are –4 and –1.

d. The set of all y-values in the graph is $\{y \mid 0 \le y \le 5\}$.

33. a. Locate 1 on the horizontal axis and then find the point on the graph for which 1 is the first coordinate. From that point, look to the vertical axis to find the corresponding y-coordinate, 3. Thus, $f(1) = 3$.

b. The domain is the set of all x-values in the graph. It is $\{-4, -3, -2, -1,\ 0,\ 1,\ 2\}$.

c. To determine which member(s) of the domain are paired with 2, locate 2 on the vertical axis. From there look left and right to the graph to find any points for which 2 is the second coordinate. There are two such points, (–2, 2) and (0, 2). Thus, the x-values for which $f(x) = 2$ are –2 and 0.

d. The range is the set of all y-values in the graph. It is $\{1, 2, 3, 4\}$.

34. a. $f(1) = 1$.

b. The set of all x-values in the graph is $\{-3, -1, 1, 3, 5\}$.

c. The only point whose second coordinate is 2 is $(3,\ 2)$, so the x-value for which $f(x) = 2$ is 3.

d. The set of all y-values in the graph is $\{-1, 0, 1, 2, 3\}$.

35. a. Locate 1 on the horizontal axis and then find the point on the graph for which 1 is the first coordinate. From that point, look to the vertical axis to find the corresponding y-coordinate, 4. Thus, $f(1) = 4$.

b. The set of all x-values in the graph extends from –3 to 4, so the domain is $\{x \mid -3 \le x \le 4\}$.

c. To determine which member(s) of the domain are paired with 2, locate 2 on the vertical axis. From there look left and right to the graph to find any points for which 2 is the second coordinate. There are two such points, (–1, 2) and (3, 2). Thus, the x-values for which $f(x) = 2$ are –1 and 3.

d. The set of all y-values in the graph extends from –4 to 5, so the range is $\{y \mid -4 \le y \le 5\}$.

36. a. $f(1) = 2$

b. The set of all x-values in the graph is $\{x \mid -5 \le x \le 2\}$.

c. There are two points whose second coordinates are 2. They are $(-5,\ 2)$ and $(1,\ 2)$. Thus, the x-values for which $f(x) = 2$ are -5 and 1.

d. The set of all y-values in the graph is $\{y \mid -3 \le y \le 5\}$.

37. a. Locate 1 on the horizontal axis and then find the point on the graph for which 1 is the first coordinate. From that point, look to the vertical axis to find the corresponding y-coordinate, 2. Thus, $f(1) = 2$.

b. The set of all x-values in the graph extends from –4 to 4, so the domain is $\{x \mid -4 \le x \le 4\}$.

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c. To determine which member(s) of the domain are paired with 2, locate 2 on the vertical axis. From there look left and right to the graph to find any points for which 2 is the second coordinate. All points in the set $\{x \mid 0 < x \le 2\}$ satisfy this condition. These are the x-values for which $f(x) = 2$.

d. The range is the set of all y-values in the graph. It is $\{1, 2, 3, 4\}$.

38. a. $f(1) = 1$

b. The set of all x-values in the graph is $\{x \mid -4 < x \le 5\}$.

c. The second coordinate is 2 for $\{x \mid 2 < x \le 5\}$.

d. The set of all y-values in the graph is $\{-1, 1, 2\}$.

39. The domain of f is the set of all x-values that are used in the points on the curve.
The domain is $\{x \mid x \text{ is a real number}\}$ or $\mathbb{R}$.
The range of f is the set of all y-values that are used in the points on the curve.
The range is $\{y \mid y \text{ is a real number}\}$ or $\mathbb{R}$.

40. Domain: $\mathbb{R}$
Range: $\mathbb{R}$

41. The domain of f is the set of all x-values that are used in the points on the curve.
The domain is $\{x \mid x \text{ is a real number}\}$ or $\mathbb{R}$.
The range of f is the set of all y-values that are used in the points on the curve.
The range is $\{4\}$.

42. Domain: $\mathbb{R}$
Range: $\{-2\}$

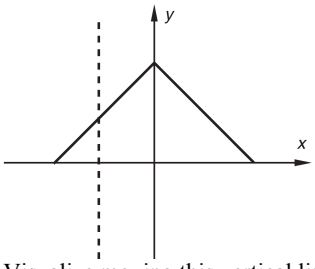
43. The domain of f is the set of all x-values that are used in the points on the curve.
The domain is $\{x \mid x \text{ is a real number}\}$ or $\mathbb{R}$.
The range of f is the set of all y-values that are used in the points on the curve.
The range is $\{y \mid y \ge 1\}$.

44. Domain: $\mathbb{R}$
Range: $\{y \mid y \le 4\}$

45. The domain of f is the set of all x-values that are used in the points on the curve. The domain is $\{x \mid x \ge 0\}$.
The range of f is the set of all y-values that are used in the points on the curve. The range is $\{y \mid y \ge 0\}$.

46. Domain: $\{x \mid x \le 3\}$
Range: $\{y \mid y \ge 0\}$

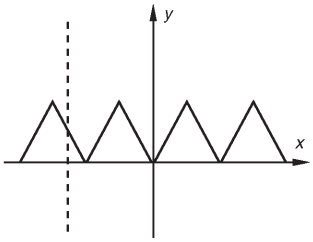
47. We can use the vertical-line test:



Visualize moving this vertical line across the graph. No vertical line will intersect the graph more than once. Thus, the graph is a graph of a function.

48. No; it fails the vertical line test.

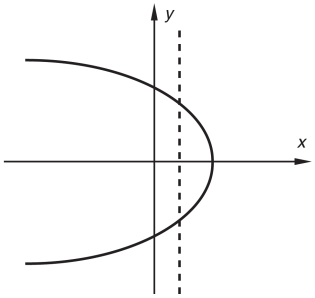
49. We can use the vertical-line test:



Visualize moving this vertical line across the graph. No vertical line will intersect the graph more than once. Thus, the graph is a graph of a function.

50. No; it fails the vertical-line test.

51. We can use the vertical line test.



It is possible for a vertical line to intersect the graph more than once. Thus this is not the graph of a function.

52. Yes; it passes the vertical-line test.

53. $g(x) = 2x + 5$

a. $g(0) = 2(0) + 5 = 0 + 5 = 5$

b. $g(-4) = 2(-4) + 5 = -8 + 5 = -3$

c. $g(-7) = 2(-7) + 5 = -14 + 5 = -9$

d. $g(8) = 2(8) + 5 = 16 + 5 = 21$

e. $g(a + 2) = 2(a + 2) + 5 = 2a + 4 + 5 = 2a + 9$

f. $g(a) + 2 = 2(a) + 5 + 2 = 2a + 7$

54. $h(x) = 5x - 1$

a. $h(4) = 5(4) - 1 = 20 - 1 = 19$

b. $h(8) = 5(8) - 1 = 40 - 1 = 39$

c. $h(-3) = 5(-3) - 1 = -15 - 1 = -16$

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d. $h(-4)=5(-4)-1=-20-1=-21$

e. $h(a-1)=5(a-1)-1=5a-5-1=5a-6$

f. $h(a)+3=5(a)-1+3=5a+2$

55. $f(n)=5n^2+4n$

a. $f(0)=5\cdot 0^2+4\cdot 0=0+0=0$

b. $f(-1)=5(-1)^2+4(-1)=5-4=1$

c. $f(3)=5\cdot 3^2+4\cdot 3=45+12=57$

d. $f(t)=5t^2+4t$

e. $f(2a)=5(2a)^2+4\cdot 2a=5\cdot 4a^2+8a=20a^2+8a$

f. $f(3)-9=5\cdot 3^2+4\cdot 3-9=5\cdot 9+4\cdot 3-9$
$=45+12-9=48$

56. $g(n)=3n^2-2n$

a. $g(0)=3\cdot 0^2-2\cdot 0=0-0=0$

b. $g(-1)=3(-1)^2-2(-1)=3+2=5$

c. $g(3)=3\cdot 3^2-2\cdot 3=27-6=21$

d. $g(t)=3t^2-2t$

e. $g(2a)=3(2a)^2-2\cdot 2a=3\cdot 4a^2-4a=12a^2-4a$

f. $g(3)-4=3\cdot 3^2-2\cdot 3-4=3\cdot 9-2\cdot 3-4$
$=27-6-4=17$

57. $f(x)=\dfrac{x-3}{2x-5}$

a. $f(0)=\dfrac{0-3}{2\cdot 0-5}=\dfrac{-3}{0-5}=\dfrac{-3}{-5}=\dfrac{3}{5}$

b. $f(4)=\dfrac{4-3}{2\cdot 4-5}=\dfrac{1}{8-5}=\dfrac{1}{3}$

c. $f(-1)=\dfrac{-1-3}{2(-1)-5}=\dfrac{-4}{-2-5}=\dfrac{-4}{-7}=\dfrac{4}{7}$

d. $f(3)=\dfrac{3-3}{2\cdot 3-5}=\dfrac{0}{6-5}=\dfrac{0}{1}=0$

e. $f(x+2)=\dfrac{x+2-3}{2(x+2)-5}=\dfrac{x-1}{2x+4-5}=\dfrac{x-1}{2x-1}$

f. $f(a+h)=\dfrac{a+h-3}{2(a+h)-5}=\dfrac{a+h-3}{2a+2h-5}$

58. $r(x)=\dfrac{3x-4}{2x+5}$

a. $r(0)=\dfrac{3\cdot 0-4}{2\cdot 0+5}=-\dfrac{4}{5}$

b. $r(2)=\dfrac{3\cdot 2-4}{2\cdot 2+5}=\dfrac{2}{9}$

c. $r\left(\dfrac{4}{3}\right)=\dfrac{3\cdot\frac{4}{3}-4}{2\cdot\frac{4}{3}+5}=\dfrac{4-4}{\frac{8}{3}+5}=\dfrac{0}{\frac{23}{3}}=0$

d. $r(-1)=\dfrac{3(-1)-4}{2(-1)+5}=\dfrac{-7}{3}$, or $-\dfrac{7}{3}$

e. $r(x+3)=\dfrac{3(x+3)-4}{2(x+3)+5}=\dfrac{3x+9-4}{2x+6+5}=\dfrac{3x+5}{2x+11}$

f. $r(a+h)=\dfrac{3(a+h)-4}{2(a+h)+5}=\dfrac{3a+3h-4}{2a+2h+5}$

59. Given the input, find the output.
$f(x)=2x-5$
$f(8)=2(8)-5=16-5=11$

60. $f(x)=2x-5$
$13=2x-5$
$18=2x$
$9=x$

61. Given the output, find the input.
$f(x)=2x-5$
$-5=2x-5$
$0=2x$
$0=x$

62. $f(x)=2x-5$
$f(-4)=2(-4)-5=-8-5=-13$

63. Given the output, find the input.
$f(x)=\dfrac{1}{3}x+4$
$\dfrac{1}{2}=\dfrac{1}{3}x+4$
$-\dfrac{7}{2}=\dfrac{1}{3}x$
$-\dfrac{21}{2}=x$

64. $f(x)=\dfrac{1}{3}x+4$
$-\dfrac{1}{3}=\dfrac{1}{3}x+4$
$-\dfrac{13}{3}=\dfrac{1}{3}x$
$-13=x$

65. Given the input, find the output.
$f(x)=\dfrac{1}{3}x+4$
$f\left(\dfrac{1}{2}\right)=\dfrac{1}{3}\left(\dfrac{1}{2}\right)+4=\dfrac{1}{6}+4=\dfrac{25}{6}$

66. $f(x)=\dfrac{1}{3}x+4$
$f\left(-\dfrac{1}{3}\right)=\dfrac{1}{3}\left(-\dfrac{1}{3}\right)+4=-\dfrac{1}{9}+4=\dfrac{35}{9}$

67. Given the output 7, find the input.
$f(x)=4-x$
$7=4-x$
$3=-x$
$-3=x$

68. $f(x)=5x+1$
$\dfrac{1}{2}=5x+1$
$-\dfrac{1}{2}=5x$
$-\dfrac{1}{10}=x$

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69. Given the output –3, find the input.

$f(x) = 0.1x - 0.5$

$-3 = 0.1x - 0.5$

$-2.5 = 0.1x$

$-25 = x$

70. $f(x) = 2.3 - 1.5x$

$10 = 2.3 - 1.5x$

$7.7 = -1.5x$

$x = -\frac{77}{15}$ or $-5.1\overline{3}$

71. $A(s) = s^2 \frac{\sqrt{3}}{4}$

$A(4) = 4^2 \frac{\sqrt{3}}{4} = 4\sqrt{3} \approx 6.93$

The area is $4\sqrt{3}$ cm$^2 \approx 6.93$ cm^2.

72. $A(6) = 6^2 \frac{\sqrt{3}}{4} = \frac{36\sqrt{3}}{4} = 9\sqrt{3}$ in$^2 \approx 15.59$ in^2

73. $V(r) = 4\pi r^2$

$V(3) = 4\pi(3)^2 = 36\pi$

The area is 36π in$^2 \approx 113.10$ in^2.

74. $V(5) = 4\pi(5)^2 = 100\pi$ cm$^2 \approx 314.16$ cm^2

75. $H(x) = 3.08x + 70.45$

$H(34) = 3.08(34) + 70.45 = 175.17$

The predicted height is 175.17 cm.

76. $F(C) = \frac{9}{5}C + 32$

$F(-5) = \frac{9}{5}(-5) + 32 = -9 + 32 = 23$

The equivalent temperature is 23°F.

77. Locate the point that is directly above 225. Then estimate its second coordinate by moving horizontally from the point to the vertical axis. The rate is about 75 heart attacks per 10,000 males.

78. 125 heart attacks per 10,000 males

79. Locate the point that is directly to the right of 100. Then estimate its first coordinate by moving vertically from the point to the horizontal axis. The blood cholesterol is about 250 milligrams per deciliter.

80. 175 milligrams per deciliter

81. $f(x) = \frac{5}{x-3}$

Since $\frac{5}{x-3}$ cannot be computed when the denominator is 0, we find the x-value that causes $x-3$ to be 0:

$x - 3 = 0$

$x = 3$ Adding 3 to both sides

Thus, 3 is not in the domain of f, while all other real numbers are. The domain of f is $\{x \mid x \text{ is a real number and } x \neq 3\}$.

82. $f(x) = \frac{7}{6-x}$

Since $\frac{7}{6-x}$ cannot be computed when the denominator is 0, we find the x-value that causes $6-x$ to be 0:

$6 - x = 0$

$6 = x$ Adding x on both sides

Thus, 6 is not in the domain of f, while all other real numbers are. The domain of f is $\{x \mid x \text{ is a real number and } x \neq 6\}$.

83. $g(x) = 2x + 1$

Since we can compute $2x+1$ for any real number x, the domain is the set of all real numbers.

84. $g(x) = x^2 + 3$

Since we can compute $x^2 + 3$ for any real number x, the domain is the set of all real numbers.

85. $h(x) = |6 - 7x|$

Since we can compute $|6-7x|$ for any real number x, the domain is the set of all real numbers.

86. $h(x) = |3x - 4|$

Since we can compute $|3x-4|$ for any real number x, the domain is the set of all real numbers.

87. $f(x) = \frac{3}{8-5x}$

Solve: $8 - 5x = 0$

$x = \frac{8}{5}$

The domain is $\left\{x \middle| x \text{ is a real number and } x \neq \frac{8}{5}\right\}$.

88. $f(x) = \frac{5}{2x+1}$

Solve: $2x + 1 = 0$

$x = -\frac{1}{2}$

The domain is $\left\{x \middle| x \text{ is a real number and } x \neq -\frac{1}{2}\right\}$.

89. $h(x) = \frac{x}{x+1}$

Solve: $x + 1 = 0$

$x = -1$

The domain is $\{x | x \text{ is a real number and } x \neq -1\}$.

90. $h(x) = \frac{3x}{x+7}$

Solve: $x + 7 = 0$

$x = -7$

The domain is $\{x | x \text{ is a real number and } x \neq -7\}$.

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