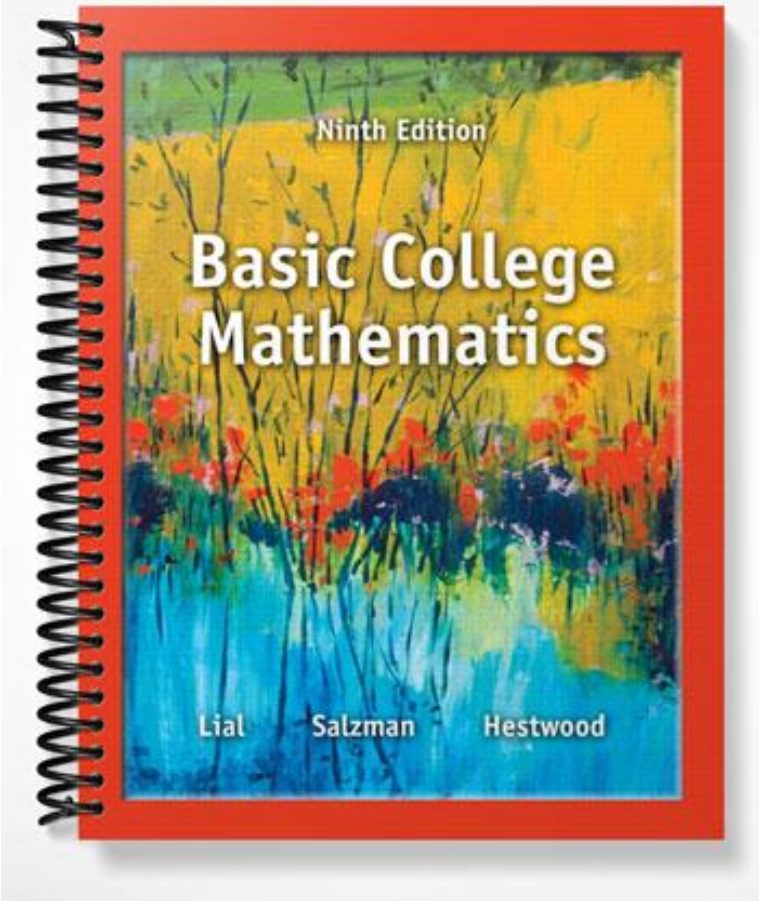
SOLUTIONS MANUAL



CHAPTER 2 MULTIPLYING AND DIVIDING FRACTIONS

2.1 Basics of Fractions

2.1 Margin Exercises

1. **(a)** The figure has 4 equal parts.

Three parts are shaded: $\frac{3}{4}$

One part is unshaded: $\frac{1}{4}$

(b) The figure has 6 equal parts.

One part is shaded: $\frac{1}{6}$

Five parts are unshaded: $\frac{5}{6}$

2. **(a)** An area equal to 8 of the $\frac{1}{7}$ parts is shaded.

$$\frac{8}{7}$$

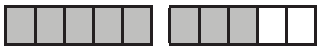
(b) An area equal to 7 of the $\frac{1}{4}$ parts is shaded.

$$\frac{7}{4}$$

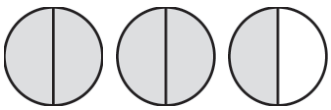
3. **(a)** $\frac{2}{3}$ ← Numerator
← Denominator

(b) $\frac{1}{4}$ ← Numerator
← Denominator

(c) $\frac{8}{5}$ ← Numerator
← Denominator



(d) $\frac{5}{2}$ ← Numerator
← Denominator



4. **(a)** Proper fractions: numerator *smaller* than denominator.

$$\frac{2}{3}, \frac{3}{4}, \frac{1}{3}$$

(b) Improper fractions: numerator *greater than or equal to* denominator.

$$\frac{4}{3}, \frac{8}{8}, \frac{3}{1}$$

2.1 Section Exercises

1. $\frac{4}{5}$ ← Numerator
← Denominator

2. $\frac{5}{6}$ ← Numerator
← Denominator

3. $\frac{9}{8}$ ← Numerator
← Denominator

4. $\frac{7}{5}$ ← Numerator
← Denominator

5. The fraction $\frac{3}{8}$ represents $\underline{3}$ of the $\underline{8}$ equal parts into which a whole is divided.

6. The fraction $\frac{7}{16}$ represents $\underline{7}$ of the $\underline{16}$ equal parts into which a whole is divided.

7. The fraction $\frac{5}{24}$ represents $\underline{5}$ of the $\underline{24}$ equal parts into which a whole is divided.

8. The fraction $\frac{24}{32}$ represents $\underline{24}$ of the $\underline{32}$ equal parts into which a whole is divided.

9. The figure has 4 equal parts.
Three parts are shaded: $\frac{3}{4}$

One part is unshaded: $\frac{1}{4}$

10. The figure has 8 equal parts.
Five parts are shaded: $\frac{5}{8}$

Three parts are unshaded: $\frac{3}{8}$

11. The figure has 3 equal parts.
One part is shaded: $\frac{1}{3}$

Two parts are unshaded: $\frac{2}{3}$

12. An area equal to 5 of the $\frac{1}{3}$ parts is shaded: $\frac{5}{3}$

One part is unshaded: $\frac{1}{3}$

13. Each of the two figures is divided into 5 parts and 7 are shaded: $\frac{7}{5}$

Three are unshaded: $\frac{3}{5}$

14. An area equal to 11 of the $\frac{1}{6}$ parts is shaded: $\frac{11}{6}$

One part is unshaded: $\frac{1}{6}$

15. Five of the 6 bills have a lifespan of 2 years or greater: $\frac{5}{6}$
Four of the 6 bills have a lifespan of 4 years or less: $\frac{4}{6}$
Two of the 6 bills have a lifespan of 9 years: $\frac{2}{6}$

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16. Four of the 9 coins are pennies: $\frac{4}{9}$

Three of the 9 coins are nickels: $\frac{3}{9}$

Two of the 9 coins are dimes: $\frac{2}{9}$

17. There are 25 students, and 8 are hearing impaired.

$\frac{8}{25}$ $\leftarrow$ hearing impaired students (numerator)
$\leftarrow$ total students (denominator)

18. There are 215 shopping carts of which 76 are in the parking lot ($215 - 76 = 139$ are *not* in the parking lot, but are in the store).

Fraction of carts in store: $\frac{139}{215}$

19. There are 520 rooms. 217 are for nonsmokers, and $520 - 217 = 303$ are for smokers.

$$\frac{303}{520}$$

20. There are 46 employees. $46 - 15 = 31$ are part-time.

$$\frac{31}{46}$$

21. Proper fractions: numerator *smaller* than denominator.

$$\frac{1}{3}, \frac{5}{8}, \frac{7}{16}$$

Improper fractions: numerator *greater than or equal to* denominator.

$$\frac{8}{5}, \frac{6}{6}, \frac{12}{2}$$

22. Proper fractions: numerator *smaller* than denominator.

$$\frac{1}{3}, \frac{3}{8}, \frac{3}{4}$$

Improper fractions: numerator *greater than or equal to* denominator.

$$\frac{16}{12}, \frac{10}{8}, \frac{6}{6}$$

23. Proper fractions: numerator *smaller* than denominator.

$$\frac{3}{4}, \frac{9}{11}, \frac{7}{15}$$

Improper fractions: numerator *greater than or equal to* denominator.

$$\frac{3}{2}, \frac{5}{5}, \frac{19}{18}$$

24. Proper fractions: numerator *smaller* than denominator.

none

Improper fractions: numerator *greater than or equal to* denominator.

$$\frac{12}{12}, \frac{15}{11}, \frac{13}{12}, \frac{11}{8}, \frac{17}{17}, \frac{19}{12}$$

25. Answers will vary. One possibility is

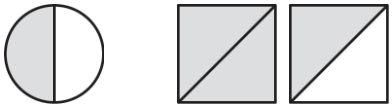
$\frac{3}{4}$ $\leftarrow$ Numerator
$\leftarrow$ Denominator

The denominator shows the number of equal parts in the whole and the numerator shows how many of the parts are being considered.

26. An example is $\frac{1}{2}$ as a proper fraction and $\frac{3}{2}$ as an improper fraction.

A proper fraction has a numerator *smaller* than the denominator.

An improper fraction has a numerator that is *greater than or equal to* the denominator.



$\frac{1}{2}$ $\frac{3}{2}$
Proper fraction Improper fraction

2.2 Mixed Numbers

2.2 Margin Exercises

1. **(a)** The figure shows 1 whole object with 3 equal parts, all shaded, and a second whole with 2 parts shaded, so 5 parts are shaded in all.

$$1\frac{2}{3} = \frac{5}{3}$$

(b) Since each of these diagrams is divided into $\underline{4}$ pieces, the denominator will be $\underline{4}$. The number of pieces shaded is $\underline{9}$.

$$2\frac{1}{4} = \frac{9}{4}$$

2. **(a)** $6\frac{1}{2}$ $6 \cdot \underline{2} = \underline{12}$ Multiply 6 and 2.
$12 + 1 = 13$ Add 1.
$6\frac{1}{2} = \frac{\underline{13}}{\underline{2}}$

(b) $7\frac{3}{4}$ $7 \cdot 4 = 28$ Multiply 7 and 4.
$28 + 3 = 31$ Add 3.
$7\frac{3}{4} = \frac{31}{4}$

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(c) $4\frac{7}{8}$ $4 \cdot 8 = 32$ Multiply 4 and 8.

$32 + 7 = 39$ Add 7.

$4\frac{7}{8} = \frac{39}{8}$

(d) $8\frac{5}{6}$ $8 \cdot 6 = 48$ Multiply 8 and 6.

$48 + 5 = 53$ Add 5.

$8\frac{5}{6} = \frac{53}{6}$

3. **(a)** $\frac{6}{5}$ Divide 6 by 5.

$$5\overline{)6} \quad \begin{matrix} 1 \leftarrow \text{Whole number part} \\ \\ 1 \leftarrow \text{Remainder} \end{matrix}$$

$\frac{6}{5} = 1\frac{1}{5}$

(b) $\frac{9}{4}$ Divide 9 by 4.

$$4\overline{)9} \quad \begin{matrix} 2 \leftarrow \text{Whole number part} \\ \\ 1 \leftarrow \text{Remainder} \end{matrix}$$

$\frac{9}{4} = 2\frac{1}{4}$

(c) $\frac{35}{5}$ Divide 35 by 5.

$$5\overline{)35} \quad \begin{matrix} 7 \leftarrow \text{Whole number part} \\ \\ 0 \leftarrow \text{Remainder} \end{matrix}$$

$\frac{35}{5} = 7$

(d) $\frac{78}{7}$ Divide 78 by 7.

$$7\overline{)78} \quad \begin{matrix} 11 \leftarrow \text{Whole number part} \\ \\ \\ 1 \leftarrow \text{Remainder} \end{matrix}$$

$\frac{78}{7} = 11\frac{1}{7}$

2.2 Section Exercises

1. $\frac{12}{12}$ is an improper fraction since the numerator is *greater than or equal to* the denominator. The statement is *true*.

2. $\frac{2}{3}$ is a proper fraction since the numerator is *smaller than* the denominator. The statement is *true*.

3. $7\frac{2}{5}$ $7 \cdot 5 = 35$ Multiply 7 and 5.

$35 + 2 = 37$ Add 2.

$7\frac{2}{5} = \frac{37}{5}$

The mixed number $7\frac{2}{5}$ can be changed to the improper fraction $\frac{37}{5}$, not $\frac{14}{5}$. The statement is *false*.

4. The statement "Some mixed number cannot be changed to an improper fraction" is *false* since any mixed number *can* be changed to an improper fraction.

5. $6\frac{1}{2}$ $6 \cdot 2 = 12$ Multiply 6 and 2.

$12 + 1 = 13$ Add 1.

$6\frac{1}{2} = \frac{13}{2}$

The mixed number $6\frac{1}{2}$ can be changed to the improper fraction $\frac{13}{2}$, not $\frac{12}{2}$. The statement is *false*.

6. $5\frac{5}{6}$ $5 \cdot 6 = 30$ Multiply 5 and 6.

$30 + 5 = 35$ Add 5.

$5\frac{5}{6} = \frac{35}{6}$

The statement is *true*.

7. $1\frac{1}{4}$ $1 \cdot 4 = 4$ Multiply 1 and 4.

$4 + 1 = 5$ Add 1.

$1\frac{1}{4} = \frac{5}{4}$

8. $2\frac{1}{2}$ $2 \cdot 2 = 4$ Multiply 2 and 2.

$4 + 1 = 5$ Add 1.

$2\frac{1}{2} = \frac{5}{2}$

9. $4\frac{3}{5}$ $4 \cdot 5 = 20$ Multiply 4 and 5.

$20 + 3 = 23$ Add 3.

$4\frac{3}{5} = \frac{23}{5}$

10. $8\frac{1}{4}$ $8 \cdot 4 = 32$ Multiply 8 and 4.

$32 + 1 = 33$ Add 1.

$8\frac{1}{4} = \frac{33}{4}$

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11. $8\frac{1}{2}$ $8 \cdot 2 = 16$ Multiply 8 and 2.
$16 + 1 = 17$ Add 1.
$8\frac{1}{2} = \frac{17}{2}$

12. $1\frac{7}{11}$ $1 \cdot 11 = 11$ Multiply 1 and 11.
$11 + 7 = 18$ Add 7.
$1\frac{7}{11} = \frac{18}{11}$

13. $10\frac{1}{8}$ $10 \cdot 8 = 80$ Multiply 10 and 8.
$80 + 1 = 81$ Add 1.
$10\frac{1}{8} = \frac{81}{8}$

14. $12\frac{2}{3}$ $12 \cdot 3 = 36$ Multiply 12 and 3.
$36 + 2 = 38$ Add 2.
$12\frac{2}{3} = \frac{38}{3}$

15. $10\frac{3}{4}$ $10 \cdot 4 = 40$ Multiply 10 and 4.
$40 + 3 = 43$ Add 3.
$10\frac{3}{4} = \frac{43}{4}$

16. $3\frac{3}{8}$ $3 \cdot 8 = 24$ Multiply 3 and 8.
$24 + 3 = 27$ Add 3.
$3\frac{3}{8} = \frac{27}{8}$

17. $5\frac{4}{5}$ $5 \cdot 5 = 25$ Multiply 5 and 5.
$25 + 4 = 29$ Add 4.
$5\frac{4}{5} = \frac{29}{5}$

18. $2\frac{8}{9}$ $2 \cdot 9 = 18$ Multiply 2 and 9.
$18 + 8 = 26$ Add 8.
$2\frac{8}{9} = \frac{26}{9}$

19. $8\frac{3}{5}$ $8 \cdot 5 = 40$ Multiply 8 and 5.
$40 + 3 = 43$ Add 3.
$8\frac{3}{5} = \frac{43}{5}$

20. $3\frac{4}{7}$ $3 \cdot 7 = 21$ Multiply 3 and 7.
$21 + 4 = 25$ Add 4.
$3\frac{4}{7} = \frac{25}{7}$

21. $4\frac{10}{11}$ $4 \cdot 11 = 44$ Multiply 4 and 11.
$44 + 10 = 54$ Add 10.
$4\frac{10}{11} = \frac{54}{11}$

22. $11\frac{5}{8}$ $11 \cdot 8 = 88$ Multiply 11 and 8.
$88 + 5 = 93$ Add 5.
$11\frac{5}{8} = \frac{93}{8}$

23. $32\frac{3}{4}$ $32 \cdot 4 = 128$ Multiply 32 and 4.
$128 + 3 = 131$ Add 3.
$32\frac{3}{4} = \frac{131}{4}$

24. $15\frac{3}{10}$ $15 \cdot 10 = 150$ Multiply 15 and 10.
$150 + 3 = 153$ Add 3.
$15\frac{3}{10} = \frac{153}{10}$

25. $18\frac{5}{12}$ $18 \cdot 12 = 216$ Multiply 18 and 12.
$216 + 5 = 221$ Add 5.
$18\frac{5}{12} = \frac{221}{12}$

26. $19\frac{8}{11}$ $19 \cdot 11 = 209$ Multiply 19 and 11.
$209 + 8 = 217$ Add 8.
$19\frac{8}{11} = \frac{217}{11}$

27. $17\frac{14}{15}$ $17 \cdot 15 = 255$ Multiply 17 and 15.
$255 + 14 = 269$ Add 14.
$17\frac{14}{15} = \frac{269}{15}$

28. $9\frac{5}{16}$ $9 \cdot 16 = 144$ Multiply 9 and 16.
$144 + 5 = 149$ Add 5.
$9\frac{5}{16} = \frac{149}{16}$

29. $7\frac{19}{24}$ $7 \cdot 24 = 168$ Multiply 7 and 24.
$168 + 19 = 187$ Add 19.
$7\frac{19}{24} = \frac{187}{24}$

30. $9\frac{7}{12}$ $9 \cdot 12 = 108$ Multiply 9 and 12.
$108 + 7 = 115$ Add 7.
$9\frac{7}{12} = \frac{115}{12}$

31. The improper fraction $\frac{4}{3}$ can be changed to the mixed number $1\frac{1}{3}$, not $1\frac{1}{4}$. The statement is *false.*

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32. The statement "An improper fraction cannot always be written as a whole number or a mixed number" is *false* since a mixed number always has a value equal to or greater than a whole number.

33. The statement "Some improper fractions can be written as a whole number with no fraction part" is *true*. For example, $\frac{6}{2} = 3$.

34. The statement "The improper fraction $\frac{48}{6}$ can be written as the whole number 8" is *true*.

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

$$\begin{array}{r} 1 \\ 3\overline{)4} \\ \underline{3} \\ 1 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{4}{3} = 1\frac{1}{3}$

36. $\frac{11}{9}$

$$\begin{array}{r} 1 \\ 9\overline{)11} \\ \underline{9} \\ 2 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{11}{9} = 1\frac{2}{9}$

37. $\frac{9}{4}$

$$\begin{array}{r} 2 \\ 4\overline{)9} \\ \underline{8} \\ 1 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{9}{4} = 2\frac{1}{4}$

38. $\frac{7}{2}$

$$\begin{array}{r} 3 \\ 2\overline{)7} \\ \underline{6} \\ 1 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{7}{2} = 3\frac{1}{2}$

39. $\frac{54}{6}$

$$\begin{array}{r} 9 \\ 6\overline{)5\ 4} \\ \underline{5\ 4} \\ 0 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{54}{6} = 9$

40. $\frac{63}{9}$

$$\begin{array}{r} 7 \\ 9\overline{)6\ 3} \\ \underline{6\ 3} \\ 0 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{63}{9} = 7$

41. $\frac{38}{5}$

$$\begin{array}{r} 7 \\ 5\overline{)3\ 8} \\ \underline{3\ 5} \\ 3 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{38}{5} = 7\frac{3}{5}$

42. $\frac{33}{7}$

$$\begin{array}{r} 4 \\ 7\overline{)3\ 3} \\ \underline{2\ 8} \\ 5 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{33}{7} = 4\frac{5}{7}$

43. $\frac{63}{4}$

$$\begin{array}{r} 1\ 5 \\ 4\overline{)6\ 3} \\ \underline{4} \\ 2\ 3 \\ \underline{2\ 0} \\ 3 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{63}{4} = 15\frac{3}{4}$

44. $\frac{19}{5}$

$$\begin{array}{r} 3 \\ 5\overline{)1\ 9} \\ \underline{1\ 5} \\ 4 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{19}{5} = 3\frac{4}{5}$

45. $\frac{47}{9}$

$$\begin{array}{r} 5 \\ 9\overline{)4\ 7} \\ \underline{4\ 5} \\ 2 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{47}{9} = 5\frac{2}{9}$

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46. $\frac{65}{9}$

$$\begin{array}{r} 7 \\ 9\overline{)\,6\;5} \\ \underline{6\;3} \\ 2 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{65}{9} = 7\frac{2}{9}$$

47. $\frac{65}{8}$

$$\begin{array}{r} 8 \\ 8\overline{)\,6\;5} \\ \underline{6\;4} \\ 1 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{65}{8} = 8\frac{1}{8}$$

48. $\frac{37}{6}$

$$\begin{array}{r} 6 \\ 6\overline{)\,3\;7} \\ \underline{3\;6} \\ 1 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{37}{6} = 6\frac{1}{6}$$

49. $\frac{84}{5}$

$$\begin{array}{r} 1\;6 \\ 5\overline{)\,8\;4} \\ \underline{5} \\ 3\;4 \\ \underline{3\;0} \\ 4 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{84}{5} = 16\frac{4}{5}$$

50. $\frac{92}{3}$

$$\begin{array}{r} 3\;0 \\ 3\overline{)\,9\;2} \\ \underline{9} \\ 2 \\ \underline{0} \\ 2 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{92}{3} = 30\frac{2}{3}$$

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

$$\begin{array}{r} 2\;8 \\ 4\overline{)\,1\;1\;2} \\ \underline{8} \\ 3\;2 \\ \underline{3\;2} \\ 0 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{112}{4} = 28$$

52. $\frac{117}{9}$

$$\begin{array}{r} 1\;3 \\ 9\overline{)\,1\;1\;7} \\ \underline{9} \\ 2\;7 \\ \underline{2\;7} \\ 0 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{117}{9} = 13$$

53. $\frac{183}{7}$

$$\begin{array}{r} 2\;6 \\ 7\overline{)\,1\;8\;3} \\ \underline{1\;4} \\ 4\;3 \\ \underline{4\;2} \\ 1 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{183}{7} = 26\frac{1}{7}$$

54. $\frac{212}{11}$

$$\begin{array}{r} 1\;9 \\ 11\overline{)\,2\;1\;2} \\ \underline{1\;1} \\ 1\;0\;2 \\ \underline{9\;9} \\ 3 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$$\frac{212}{11} = 19\frac{3}{11}$$

55. Multiply the denominator by the whole number and add the numerator. The result becomes the new numerator, which is placed over the original denominator.

$$2\frac{1}{2} \quad (2 \cdot 2) + 1 = 5 \quad \frac{5}{2}$$

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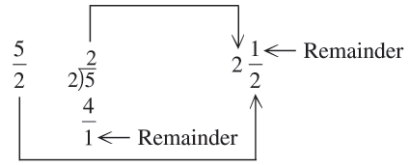
56. Divide the numerator by the denominator. The quotient is the whole number of the mixed number and the remainder is the numerator of the fraction part. The denominator is unchanged.



57. $250\frac{1}{2}$ $250 \cdot 2 = 500$

$500 + 1 = 501$

$250\frac{1}{2} = \frac{501}{2}$

58. $185\frac{3}{4}$ $185 \cdot 4 = 740$

$740 + 3 = 743$

$185\frac{3}{4} = \frac{743}{4}$

59. $333\frac{1}{3}$ $333 \cdot 3 = 999$

$999 + 1 = 1000$

$333\frac{1}{3} = \frac{1000}{3}$

60. $138\frac{4}{5}$ $138 \cdot 5 = 690$

$690 + 4 = 694$

$138\frac{4}{5} = \frac{694}{5}$

61. $522\frac{3}{8}$ $522 \cdot 8 = 4176$

$4176 + 3 = 4179$

$522\frac{3}{8} = \frac{4179}{8}$

62. $622\frac{1}{4}$ $622 \cdot 4 = 2488$

$2488 + 1 = 2489$

$622\frac{1}{4} = \frac{2489}{4}$

63. $\frac{617}{4}$

$$\begin{array}{r} 154 \leftarrow \text{Whole number part} \\ 4\overline{)617} \\ 4 \\ \hline 21 \\ 20 \\ \hline 17 \\ 16 \\ \hline 1 \leftarrow \text{Remainder} \end{array}$$

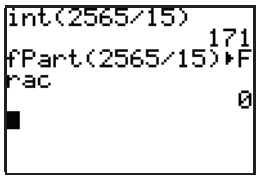
$\frac{617}{4} = 154\frac{1}{4}$

64. $\frac{760}{8}$

$$\begin{array}{r} 95 \leftarrow \text{Whole number part} \\ 8\overline{)760} \\ 72 \\ \hline 40 \\ 40 \\ \hline 0 \leftarrow \text{Remainder} \end{array}$$

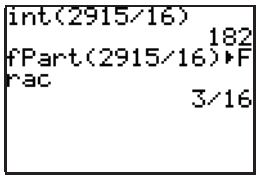
$\frac{760}{8} = 95$

65. The commands used will vary. The following is from a TI-83 Plus:



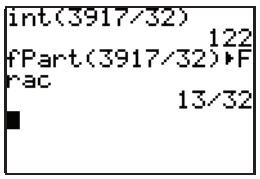
$\frac{2565}{15} = 171$

66. The commands used will vary. The following is from a TI-83 Plus:



$\frac{2915}{16} = 182\frac{3}{16}$

67. The commands used will vary. The following is from a TI-83 Plus:



$\frac{3917}{32} = 122\frac{13}{32}$

Note: You can use the following procedure on any calculator. Divide 3917 by 32 to get 122.40625. Subtract 122. Multiply by 32 to get 13. The mixed number is $122\frac{13}{32}$.

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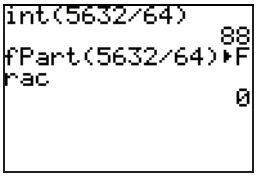
68. The commands used will vary. The following is from a TI-83 Plus:



$\frac{5632}{64} = 88$

69. The following fractions are proper fractions.

$$\frac{2}{3}, \frac{4}{5}, \frac{3}{4}, \frac{7}{10}$$

70. **(a)** The proper fractions in Exercise 69 are the ones where the numerator is less than the denominator.

(b) $\frac{2}{3}$;

$\frac{4}{5}$;

$\frac{3}{4}$;

$\frac{7}{10}$;

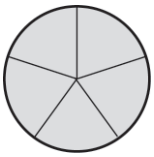
(c) The proper fractions in Exercise 69 are all less than 1.

71. The following fractions are improper fractions.

$$\frac{5}{5}, \frac{10}{3}, \frac{6}{5}$$

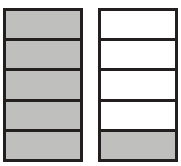
72. **(a)** The improper fractions in Exercise 71 are the ones where the numerator is equal to or greater than the denominator.

(b) $\frac{5}{5}$;



$\frac{10}{3}$;

$\frac{6}{5}$;



(c) The improper fractions in Exercise 71 are all equal to or greater than 1.

73. The following fractions can be written as whole or mixed numbers.

$\frac{5}{3}$

$$3\overline{)5}$$

1 ← Whole number part

3 ← Remainder

$\frac{5}{3} = 1\frac{2}{3}$

$\frac{7}{7}$

$$7\overline{)7}$$

1 ← Whole number part

0 ← Remainder

$\frac{7}{7} = 1$

$\frac{11}{6}$

$$6\overline{)11}$$

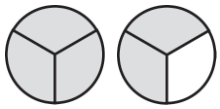
1 ← Whole number part

5 ← Remainder

$\frac{11}{6} = 1\frac{5}{6}$

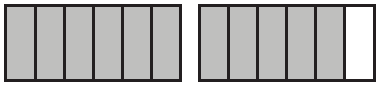
74. **(a)** The fractions that can be written as whole or mixed numbers in Exercise 73 are improper fractions, and their value is always greater than or equal to 1.

(b) $\frac{5}{3} = 1\frac{2}{3}$;



$\frac{7}{7} = 1$;

$\frac{11}{6} = 1\frac{5}{6}$;



2.3 Factors

2.3 Margin Exercises

1. **(a)** Factorizations of 18:

$1 \cdot 18 = 18 \quad 2 \cdot 9 = 18 \quad 3 \cdot 6 = 18$

The factors of 18 are 1, 2, 3, 6, 9, and 18.

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(b) Factorizations of 16:

$1 \cdot 16 = 16 \quad 2 \cdot 8 = 16 \quad 4 \cdot 4 = 16$

The factors of 16 are 1, 2, 4, 8, and 16.

(c) Factorizations of 36:

$1 \cdot 36 = 36 \quad 2 \cdot 18 = 36 \quad 3 \cdot 12 = 36 \quad 4 \cdot 9 = 36$
$6 \cdot 6 = 36$

The factors of 36 are 1, 2, 3, 4, 6, 9, 12, 18, and 36.

(d) Factorizations of 80:

$1 \cdot 80 = 80 \quad 2 \cdot 40 = 80 \quad 4 \cdot 20 = 80 \quad 5 \cdot 16 = 80$
$8 \cdot 10 = 80$

The factors of 80 are 1, 2, 4, 5, 8, 10, 16, 20, 40, and 80.

2. 4, 7, 9, 13, 17, 19, 29, 33

7, 13, 17, 19, and 29 are prime because they are divisible only by themselves and 1.

3. 2, 4, 5, 6, 8, 10, 11, 13, 19, 21, 27, 28, 33, 36, 42

2, 5, 11, 13, and 19 each have no factor other than themselves or 1; 4, 6, 8, 10, 28, 36, and 42 each have a factor of 2; 21, 27, and 33 have a factor of 3. So 4, 6, 8, 10, 21, 27, 28, 33, 36, and 42 are composite.

4. **(a)** $8 \div 2 = 4$
$4 \div 2 = 2$ *prime*
$8 = 2 \cdot \underline{2} \cdot \underline{2}$

(b) $28 \div 2 = 14$
$14 \div 2 = 7$ *prime*
$28 = 2 \cdot \underline{2} \cdot \underline{7}$

(c) $18 \div 2 = 9$
$9 \div 3 = 3$ *prime*
$18 = 2 \cdot 3 \cdot 3$

(d) $40 \div 2 = 20$
$20 \div 2 = 10$
$10 \div 2 = 5$ *prime*
$40 = 2 \cdot 2 \cdot 2 \cdot 5$

5. **(a)** This division is done from the "bottom-up."

$$\begin{array}{r} 1 \\ 3\overline{)3} \\ 3\overline{)9} \\ 2\overline{)18} \\ 2\overline{)36} \end{array}$$

Quotient is 1.
Divide 3 by 3.
Divide 9 by 3.
Divide 18 by 2.
Divide 36 by 2.

This division is done from the "top-down."

$$\begin{array}{r} 18 \\ 2\overline{)36} \\ 9 \\ 2\overline{)18} \\ 3 \\ 3\overline{)9} \\ 1 \\ 3\overline{)3} \end{array}$$

Divide 36 by 2.
Divide 18 by 2.
Divide 9 by 3.
Divide 3 by 3.
Quotient is 1.

Either method is correct and yields the prime factorization as follows:

$$36 = 2 \cdot 2 \cdot 3 \cdot \underline{3} = 2^2 \cdot \underline{3^2}$$

(b)
$$\begin{array}{r} 27 \\ 2\overline{)54} \\ 9 \\ 3\overline{)27} \\ 3 \\ 3\overline{)9} \\ 1 \\ 3\overline{)3} \end{array}$$

Divide 54 by 2.
Divide 27 by 3.
Divide 9 by 3.
Divide 3 by 3.
Quotient is 1.
$54 = 2 \cdot 3 \cdot 3 \cdot 3 = 2 \cdot 3^3$

(c)
$$\begin{array}{r} 30 \\ 2\overline{)60} \\ 15 \\ 2\overline{)30} \\ 5 \\ 3\overline{)15} \\ 1 \\ 5\overline{)5} \end{array}$$

Divide 60 by 2.
Divide 30 by 2.
Divide 15 by 3.
Divide 5 by 5.
Quotient is 1.
$60 = 2 \cdot 2 \cdot 3 \cdot 5 = 2^2 \cdot 3 \cdot 5$

(d)
$$\begin{array}{r} 27 \\ 3\overline{)81} \\ 9 \\ 3\overline{)27} \\ 3 \\ 3\overline{)9} \\ 1 \\ 3\overline{)3} \end{array}$$

Divide 81 by 3.
Divide 27 by 3.
Divide 9 by 3.
Divide 3 by 3.
Quotient is 1.
$81 = 3 \cdot 3 \cdot 3 \cdot 3 = 3^4$

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6. **(a)**
$2\overline{)48}$ Divide 48 by 2.
$2\overline{)24}$ Divide 24 by 2.
$2\overline{)12}$ Divide 12 by 2.
$2\overline{)6}$ Divide 6 by 2.
$3\overline{)3}$ Divide 3 by 3.
Quotient is 1.
$48 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 3 = 2^4 \cdot 3$

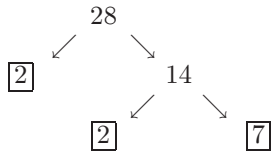
(b)
$2\overline{)44}$ Divide 44 by 2.
$2\overline{)22}$ Divide 22 by 2.
$11\overline{)11}$ Divide 11 by 11.
Quotient is 1.
$44 = 2 \cdot 2 \cdot 11 = 2^2 \cdot 11$

(c)
$2\overline{)90}$ Divide 90 by 2.
$3\overline{)45}$ Divide 45 by 3.
$3\overline{)15}$ Divide 15 by 3.
$5\overline{)5}$ Divide 5 by 5.
Quotient is 1.
$90 = 2 \cdot 3 \cdot 3 \cdot 5 = 2 \cdot 3^2 \cdot 5$

(d)
$2\overline{)120}$ Divide 120 by 2.
$2\overline{)60}$ Divide 60 by 2.
$2\overline{)30}$ Divide 30 by 2.
$3\overline{)15}$ Divide 15 by 3.
$5\overline{)5}$ Divide 5 by 5.
Quotient is 1.
$120 = 2 \cdot 2 \cdot 2 \cdot 3 \cdot 5 = 2^3 \cdot 3 \cdot 5$

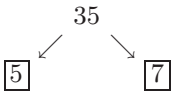
(e)
$2\overline{)180}$ Divide 180 by 2.
$2\overline{)90}$ Divide 90 by 2.
$3\overline{)45}$ Divide 45 by 3.
$3\overline{)15}$ Divide 15 by 3.
$5\overline{)5}$ Divide 5 by 5.
Quotient is 1.
$180 = 2 \cdot 2 \cdot 3 \cdot 3 \cdot 5 = 2^2 \cdot 3^2 \cdot 5$

7. **(a)**



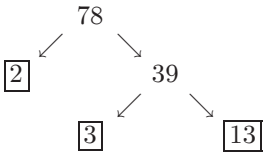
$28 = 2 \cdot 2 \cdot 7 = 2^2 \cdot 7$

(b)



$35 = 5 \cdot 7$

(c)



$78 = 2 \cdot 3 \cdot 13$

2.3 Section Exercises

1. Factorizations of 8:

$$1 \cdot 8 = 8 \quad 2 \cdot 4 = 8$$

The factors of 8 are 1, 2, 4, and 8. The statement is *false* (missing 1).

2. Factorizations of 12:

$$1 \cdot 12 = 12 \quad 2 \cdot 6 = 12 \quad 3 \cdot 4 = 12$$

The factors of 12 are 1, 2, 3, 4, 6, and 12. The statement is *true*.

3. Factorizations of 15:

$$1 \cdot 15 = 15 \quad 3 \cdot 5 = 15$$

The factors of 15 are 1, 3, 5, and 15. The statement is *true*.

4. Factorizations of 28:

$$1 \cdot 28 = 28 \quad 2 \cdot 14 = 28 \quad 4 \cdot 7 = 28$$

The factors of 28 are 1, 2, 4, 7, 14, and 28. The statement is *false* (missing 1 and 28).

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5. Factorizations of 48:

$1 \cdot 48 = 48 \quad 2 \cdot 24 = 48 \quad 3 \cdot 16 = 48 \quad 4 \cdot 12 = 48$
$6 \cdot 8 = 48$

The factors of 48 are 1, 2, 3, 4, 6, 8, 12, 16, 24, and 48.

6. Factorizations of 30:

$1 \cdot 30 = 30 \quad 2 \cdot 15 = 30 \quad 3 \cdot 10 = 30 \quad 5 \cdot 6 = 30$

The factors of 30 are 1, 2, 3, 5, 6, 10, 15, and 30.

7. Factorizations of 56:

$1 \cdot 56 = 56 \quad 2 \cdot 28 = 56 \quad 4 \cdot 14 = 56 \quad 7 \cdot 8 = 56$

The factors of 56 are 1, 2, 4, 7, 8, 14, 28, and 56.

8. Factorizations of 72:

$1 \cdot 72 = 72 \quad 2 \cdot 36 = 72 \quad 3 \cdot 24 = 72 \quad 4 \cdot 18 = 72$
$6 \cdot 12 = 72 \quad 8 \cdot 9 = 72$

The factors of 72 are 1, 2, 3, 4, 6, 8, 9, 12, 18, 24, 36, and 72.

9. Factorizations of 36:

$1 \cdot 36 = 36 \quad 2 \cdot 18 = 36 \quad 3 \cdot 12 = 36 \quad 4 \cdot 9 = 36$
$6 \cdot 6 = 36$

The factors of 36 are 1, 2, 3, 4, 6, 9, 12, 18, and 36.

10. Factorizations of 20:

$1 \cdot 20 = 20 \quad 2 \cdot 10 = 20 \quad 4 \cdot 5 = 20$

The factors of 20 are 1, 2, 4, 5, 10, and 20.

11. Factorizations of 40:

$1 \cdot 40 = 40 \quad 2 \cdot 20 = 40 \quad 4 \cdot 10 = 40 \quad 5 \cdot 8 = 40$

The factors of 40 are 1, 2, 4, 5, 8, 10, 20, and 40.

12. Factorizations of 60:

$1 \cdot 60 = 60 \quad 2 \cdot 30 = 60 \quad 3 \cdot 20 = 60 \quad 4 \cdot 15 = 60$
$5 \cdot 12 = 60 \quad 6 \cdot 10 = 60$

The factors of 60 are 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, and 60.

13. Factorizations of 64:

$1 \cdot 64 = 64 \quad 2 \cdot 32 = 64 \quad 4 \cdot 16 = 64 \quad 8 \cdot 8 = 64$

The factors of 64 are 1, 2, 4, 8, 16, 32, and 64.

14. Factorizations of 84:

$1 \cdot 84 = 84 \quad 2 \cdot 42 = 84 \quad 3 \cdot 28 = 84 \quad 4 \cdot 21 = 84$
$6 \cdot 14 = 84 \quad 7 \cdot 12 = 84$

The factors of 84 are 1, 2, 3, 4, 6, 7, 12, 14, 21, 28, 42, and 84.

15. Factorizations of 82:

$1 \cdot 82 = 82 \quad 2 \cdot 41 = 82$

The factors of 82 are 1, 2, 41, and 82.

16. Factorizations of 39:

$1 \cdot 39 = 39 \quad 3 \cdot 13 = 39$

The factors of 39 are 1, 3, 13, and 39.

17. 6 is divisible by 2 and 3, so 6 is composite.

18. 9 is divisible by 3, so 9 is composite.

19. 5 is only divisible by itself and 1, so it is prime.

20. 16 is divisible by 2, so 16 is composite.

21. 10 is divisible by 2 and 5, so 10 is composite.

22. 13 is only divisible by itself and 1, so it is prime.

23. 19 is only divisible by itself and 1, so it is prime.

24. 17 is only divisible by itself and 1, so it is prime.

25. 25 is divisible by 5, so 25 is composite.

26. 48 is divisible by 2 and 3, so 48 is composite.

27. 47 is only divisible by itself and 1, so it is prime.

28. 45 is divisible by 3 and 5, so 45 is composite.

29. 40

$$\begin{array}{r} 20 \\ 2\overline{)40} \end{array}$$ Divide 40 by 2.

$$\begin{array}{r} 10 \\ 2\overline{)20} \end{array}$$ Divide 20 by 2.

$$\begin{array}{r} 5 \\ 2\overline{)10} \end{array}$$ Divide 10 by 2.

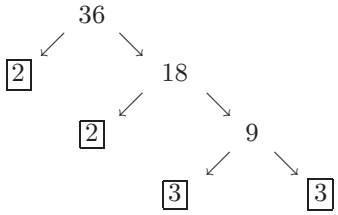
$$\begin{array}{r} 1 \\ 5\overline{)5} \end{array}$$ Divide 5 by 5.

Quotient is 1.

$40 = 2 \cdot 2 \cdot 2 \cdot 5 = 2^3 \cdot 5$

The correct choice is **(b)**.

30.



$36 = 2 \cdot 2 \cdot 3 \cdot 3 = 2^2 \cdot 3^2$

The correct choice is **(c)**.

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31. 100

$2\overline{)100}$ $\quad\begin{matrix}50\end{matrix}$ Divide 100 by 2.

$2\overline{)50}$ $\quad\begin{matrix}25\end{matrix}$ Divide 50 by 2.

$5\overline{)25}$ $\quad\begin{matrix}5\end{matrix}$ Divide 25 by 5.

$5\overline{)5}$ $\quad\begin{matrix}1\end{matrix}$ Divide 5 by 5.

Quotient is 1.

$100 = 2 \cdot 2 \cdot 5 \cdot 5 = 2^2 \cdot 5^2$

The correct choice is **(a)**.

32. 8

$2\overline{)8}$ $\quad\begin{matrix}4\end{matrix}$ Divide 8 by 2.

$2\overline{)4}$ $\quad\begin{matrix}2\end{matrix}$ Divide 4 by 2.

$2\overline{)2}$ $\quad\begin{matrix}1\end{matrix}$ Divide 2 by 2.

Quotient is 1.

$8 = 2 \cdot 2 \cdot 2 = 2^3$

33. 6

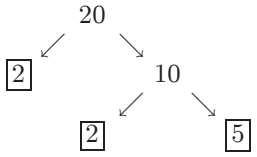
$2\overline{)6}$ $\quad\begin{matrix}3\end{matrix}$ Divide 6 by 2.

$3\overline{)3}$ $\quad\begin{matrix}1\end{matrix}$ Divide 3 by 3.

Quotient is 1.

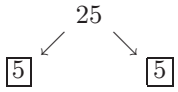
$6 = 2 \cdot 3$

34. We can also use a factor tree.



$20 = 2 \cdot 2 \cdot 5 = 2^2 \cdot 5$

35.



$25 = 5 \cdot \underline{5} = 5^2$

36. 56

$2\overline{)56}$ $\quad\begin{matrix}28\end{matrix}$ Divide 56 by 2.

$2\overline{)28}$ $\quad\begin{matrix}14\end{matrix}$ Divide 28 by 2.

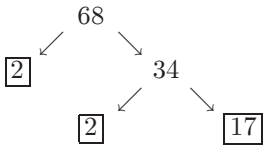
$2\overline{)14}$ $\quad\begin{matrix}7\end{matrix}$ Divide 14 by 2.

$7\overline{)7}$ $\quad\begin{matrix}1\end{matrix}$ Divide 7 by 7.

Quotient is 1.

$56 = \underline{2} \cdot \underline{2} \cdot 2 \cdot 7 = 2^3 \cdot 7$

37.



$68 = 2 \cdot 2 \cdot 17 = 2^2 \cdot 17$

38. 70

$2\overline{)70}$ $\quad\begin{matrix}35\end{matrix}$ Divide 70 by 2.

$5\overline{)35}$ $\quad\begin{matrix}7\end{matrix}$ Divide 35 by 5.

$7\overline{)7}$ $\quad\begin{matrix}1\end{matrix}$ Divide 7 by 7.

Quotient is 1.

$70 = 2 \cdot 5 \cdot 7$

39. 72

$2\overline{)72}$ $\quad\begin{matrix}36\end{matrix}$ Divide 72 by 2.

$2\overline{)36}$ $\quad\begin{matrix}18\end{matrix}$ Divide 36 by 2.

$2\overline{)18}$ $\quad\begin{matrix}9\end{matrix}$ Divide 18 by 2.

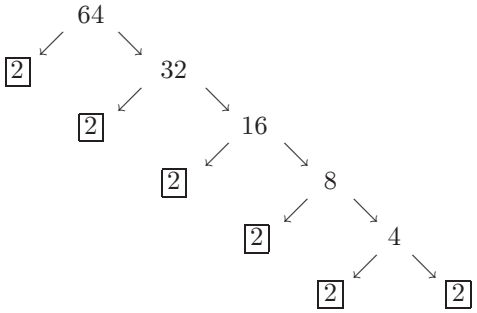
$3\overline{)9}$ $\quad\begin{matrix}3\end{matrix}$ Divide 9 by 3.

$3\overline{)3}$ $\quad\begin{matrix}1\end{matrix}$ Divide 3 by 3.

Quotient is 1.

$72 = 2 \cdot 2 \cdot 2 \cdot 3 \cdot 3 = 2^3 \cdot 3^2$

40.



$64 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = 2^6$

41. 44

$2\overline{)44}$ $\quad\begin{matrix}22\end{matrix}$ Divide 44 by 2.

$2\overline{)22}$ $\quad\begin{matrix}11\end{matrix}$ Divide 22 by 2.

$11\overline{)11}$ $\quad\begin{matrix}1\end{matrix}$ Divide 11 by 11.

Quotient is 1.

$44 = 2 \cdot 2 \cdot 11 = 2^2 \cdot 11$

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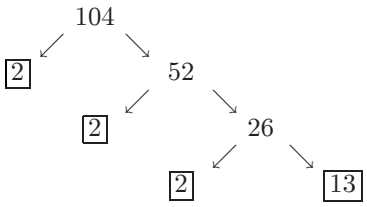
42.



$104 = 2 \cdot 2 \cdot 2 \cdot 13 = 2^3 \cdot 13$

43. 100

$2\overline{)100}$ Divide 100 by 2. (quotient 50)

$2\overline{)50}$ Divide 50 by 2. (quotient 25)

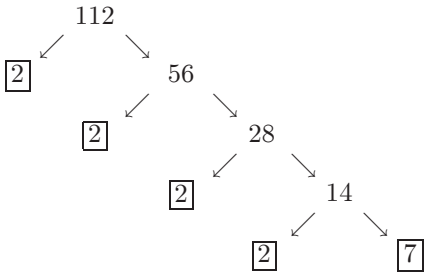
$5\overline{)25}$ Divide 25 by 5. (quotient 5)

$5\overline{)5}$ Divide 5 by 5. (quotient 1)

Quotient is 1.

$100 = 2 \cdot 2 \cdot 5 \cdot 5 = 2^2 \cdot 5^2$

44.



$112 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 7 = 2^4 \cdot 7$

45. 125

$5\overline{)125}$ Divide 125 by 5. (quotient 25)

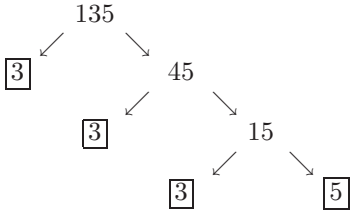
$5\overline{)25}$ Divide 25 by 5. (quotient 5)

$5\overline{)5}$ Divide 5 by 5. (quotient 1)

Quotient is 1.

$125 = 5 \cdot 5 \cdot 5 = 5^3$

46.



$135 = 3 \cdot 3 \cdot 3 \cdot 5 = 3^3 \cdot 5$

47. 180

$2\overline{)180}$ Divide 180 by 2. (quotient 90)

$2\overline{)90}$ Divide 90 by 2. (quotient 45)

$3\overline{)45}$ Divide 45 by 3. (quotient 15)

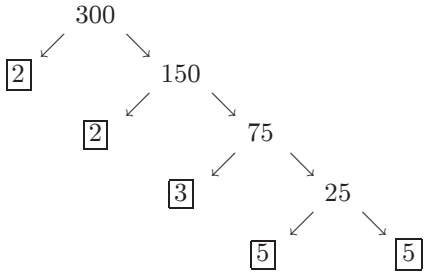
$3\overline{)15}$ Divide 15 by 3. (quotient 5)

$5\overline{)5}$ Divide 5 by 5. (quotient 1)

Quotient is 1.

$180 = 2 \cdot 2 \cdot 3 \cdot 3 \cdot 5 = 2^2 \cdot 3^2 \cdot 5$

48.



$300 = 2 \cdot 2 \cdot 3 \cdot 5 \cdot 5 = 2^2 \cdot 3 \cdot 5^2$

49. 320

$2\overline{)320}$ Divide 320 by 2. (quotient 160)

$2\overline{)160}$ Divide 160 by 2. (quotient 80)

$2\overline{)80}$ Divide 80 by 2. (quotient 40)

$2\overline{)40}$ Divide 40 by 2. (quotient 20)

$2\overline{)20}$ Divide 20 by 2. (quotient 10)

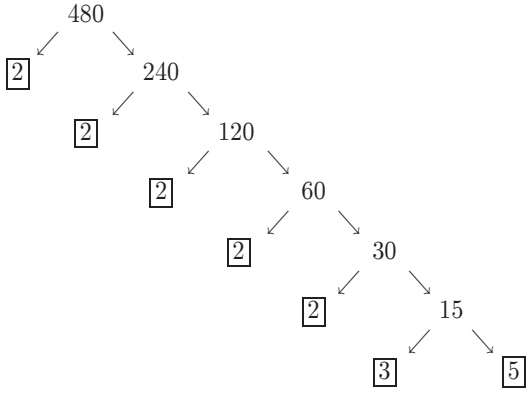
$2\overline{)10}$ Divide 10 by 2. (quotient 5)

$5\overline{)5}$ Divide 5 by 5. (quotient 1)

Quotient is 1.

$320 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 5 = 2^6 \cdot 5$

50.



$480 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 3 \cdot 5 = 2^5 \cdot 3 \cdot 5$

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51. 360

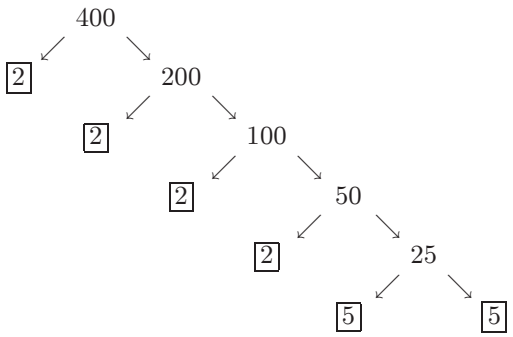
$$\begin{array}{r} 180 \\ 2\overline{)360} \\ 90 \\ 2\overline{)180} \\ 45 \\ 2\overline{)90} \\ 15 \\ 3\overline{)45} \\ 5 \\ 3\overline{)15} \\ 1 \\ 5\overline{)5} \end{array}$$

Divide 360 by 2.
Divide 180 by 2.
Divide 90 by 2.
Divide 45 by 3.
Divide 15 by 3.
Divide 5 by 5.

Quotient is 1.

$360 = 2 \cdot 2 \cdot 2 \cdot 3 \cdot 3 \cdot 5 = 2^3 \cdot 3^2 \cdot 5$

52.



$400 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 5 \cdot 5 = 2^4 \cdot 5^2$

53. Answers will vary. A sample answer follows. A prime number is a whole number that has exactly two *different* factors, itself and 1. Examples include 2, 3, 5, 7, and 11. A composite number has a factor(s) other than itself or 1. Examples include 4, 6, 8, 9, and 10. The numbers 0 and 1 are neither prime nor composite.

54. No even number other than 2 is prime because all even numbers have 2 as a factor. Many odd numbers are multiples of prime numbers and are not prime. For example, 9, 21, 33, and 45 are all multiples of 3.

55. All the possible factors of 24 are 1, 2, 3, 4, 6, 8, 12, and 24. This list includes both prime numbers and composite numbers. The prime factors of 24 include only prime numbers. The prime factorization of 24 is

$$24 = 2 \cdot 2 \cdot 2 \cdot 3 = 2^3 \cdot 3.$$

56. Yes, you can divide by 3s before you divide by 2. No, the order of division does not matter. As long as you use only prime numbers, your answers will be correct. However, it does seem easier to always start with 2 and then use progressively greater prime numbers. The prime factorization of 36 is

$$36 = 2 \cdot 2 \cdot 3 \cdot 3 = 2^2 \cdot 3^2.$$

57. 350

$$\begin{array}{r} 175 \\ 2\overline{)350} \\ 35 \\ 5\overline{)175} \\ 7 \\ 5\overline{)35} \\ 1 \\ 7\overline{)7} \end{array}$$

Divide 350 by 2.
Divide 175 by 5.
Divide 35 by 5.
Divide 7 by 7.

Quotient is 1.

$350 = 2 \cdot 5 \cdot 5 \cdot 7 = 2 \cdot 5^2 \cdot 7$

58. 640

$$\begin{array}{r} 320 \\ 2\overline{)640} \\ 160 \\ 2\overline{)320} \\ 80 \\ 2\overline{)160} \\ 40 \\ 2\overline{)80} \\ 20 \\ 2\overline{)40} \\ 10 \\ 2\overline{)20} \\ 5 \\ 2\overline{)10} \\ 1 \\ 5\overline{)5} \end{array}$$

Divide 640 by 2.
Divide 320 by 2.
Divide 160 by 2.
Divide 80 by 2.
Divide 40 by 2.
Divide 20 by 2.
Divide 10 by 2.
Divide 5 by 5.

Quotient is 1.

$640 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 5 = 2^7 \cdot 5$

59. 960

$$\begin{array}{r} 480 \\ 2\overline{)960} \\ 240 \\ 2\overline{)480} \\ 120 \\ 2\overline{)240} \\ 60 \\ 2\overline{)120} \\ 30 \\ 2\overline{)60} \\ 15 \\ 2\overline{)30} \\ 5 \\ 3\overline{)15} \\ 1 \\ 5\overline{)5} \end{array}$$

Divide 960 by 2.
Divide 480 by 2.
Divide 240 by 2.
Divide 120 by 2.
Divide 60 by 2.
Divide 30 by 2.
Divide 15 by 3.
Divide 5 by 5.

Quotient is 1.

$960 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 3 \cdot 5 = 2^6 \cdot 3 \cdot 5$

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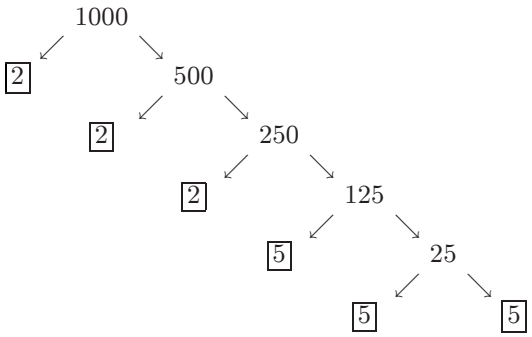
60.



$1000 = 2 \cdot 2 \cdot 2 \cdot 5 \cdot 5 \cdot 5 = 2^3 \cdot 5^3$

61. 1560

$$\begin{array}{r|l} 780 & \\ 2\overline{)1560} & \text{Divide 1560 by 2.} \\ 390 & \\ 2\overline{)780} & \text{Divide 780 by 2.} \\ 195 & \\ 2\overline{)390} & \text{Divide 390 by 2.} \\ 65 & \\ 3\overline{)195} & \text{Divide 195 by 3.} \\ 13 & \\ 5\overline{)65} & \text{Divide 65 by 5.} \\ 1 & \\ 13\overline{)13} & \text{Divide 13 by 13.} \end{array}$$

Quotient is 1.

$1560 = 2 \cdot 2 \cdot 2 \cdot 3 \cdot 5 \cdot 13 = 2^3 \cdot 3 \cdot 5 \cdot 13$

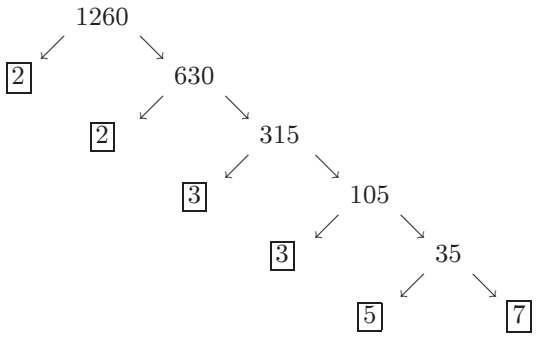
62. 2000

$$\begin{array}{r|l} 1000 & \\ 2\overline{)2000} & \text{Divide 2000 by 2.} \\ 500 & \\ 2\overline{)1000} & \text{Divide 1000 by 2.} \\ 250 & \\ 2\overline{)500} & \text{Divide 500 by 2.} \\ 125 & \\ 2\overline{)250} & \text{Divide 250 by 2.} \\ 25 & \\ 5\overline{)125} & \text{Divide 125 by 5.} \\ 5 & \\ 5\overline{)25} & \text{Divide 25 by 5.} \\ 1 & \\ 5\overline{)5} & \text{Divide 5 by 5.} \end{array}$$

Quotient is 1.

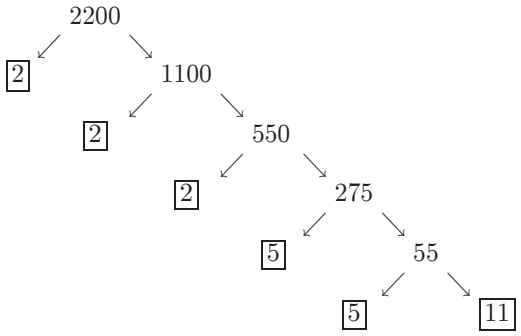
$2000 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 5 \cdot 5 \cdot 5 = 2^4 \cdot 5^3$

63.



$1260 = 2 \cdot 2 \cdot 3 \cdot 3 \cdot 5 \cdot 7 = 2^2 \cdot 3^2 \cdot 5 \cdot 7$

64.



$2200 = 2 \cdot 2 \cdot 2 \cdot 5 \cdot 5 \cdot 11 = 2^3 \cdot 5^2 \cdot 11$

65. The prime numbers less than 50 are 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, and 47.

66. A prime number is a whole number that is evenly divisible by itself and 1 only.

67. No. Every other even number is divisible by 2 in addition to being divisible by itself and 1.

68. No. A multiple of a prime number can never be prime because it will always be divisible by the prime number.

69. 2100

$$\begin{array}{r|l} 1050 & \\ 2\overline{)2100} & \text{Divide 2100 by 2.} \\ 525 & \\ 2\overline{)1050} & \text{Divide 1050 by 2.} \\ 175 & \\ 3\overline{)525} & \text{Divide 525 by 3.} \\ 35 & \\ 5\overline{)175} & \text{Divide 175 by 5.} \\ 7 & \\ 5\overline{)35} & \text{Divide 35 by 5.} \\ 1 & \\ 7\overline{)7} & \text{Divide 7 by 7.} \end{array}$$

Quotient is 1.

$2100 = 2 \cdot 2 \cdot 3 \cdot 5 \cdot 5 \cdot 7$

70. $2100 = 2 \cdot 2 \cdot 3 \cdot 5 \cdot 5 \cdot 7 = 2^2 \cdot 3 \cdot 5^2 \cdot 7$

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2.4 Writing a Fraction in Lowest Terms

2.4 Margin Exercises

1. **(a)** 6, 12; 2
$6 = 2 \cdot 3 \quad 12 = 2 \cdot 6$

Yes, 2 is a common factor of 6 and 12.

(b) 32, 64; 8
$32 = 8 \cdot 4 \quad 64 = 8 \cdot 8$

Yes, 8 is a common factor of 32 and 64.

(c) 32, 56; 16
$32 = 16 \cdot 2$, but 16 is not a factor of 56.

No.

(d) 75, 81; 1
$75 = 75 \cdot 1 \quad 81 = 81 \cdot 1$

Yes, 1 is a common factor of 75 and 81.

2. **(a)** $\dfrac{4}{5}$

4 and 5 have no common factor other than 1.
Yes, it is in lowest terms.

(b) $\dfrac{6}{18}$

6 and 18 have a common factor of 6.
No, it is not in lowest terms.

(c) $\dfrac{9}{15}$

9 and 15 have a common factor of 3.
No, it is not in lowest terms.

(d) $\dfrac{17}{46}$

17 and 46 have no common factor other than 1.
Yes, it is in lowest terms.

3. **(a)** $\dfrac{8}{16} = \dfrac{8 \div 8}{16 \div \underline{8}} = \dfrac{1}{\underline{2}}$

(b) $\dfrac{9}{12} = \dfrac{9 \div \underline{3}}{12 \div 3} = \dfrac{\underline{3}}{4}$

(c) $\dfrac{28}{42} = \dfrac{28 \div 14}{42 \div 14} = \dfrac{2}{3}$

(d) $\dfrac{30}{80} = \dfrac{30 \div 10}{80 \div 10} = \dfrac{3}{8}$

(e) $\dfrac{16}{40} = \dfrac{16 \div 8}{40 \div 8} = \dfrac{2}{5}$

4. **(a)** $\dfrac{12}{36} = \dfrac{2 \cdot 2 \cdot 3}{2 \cdot \underline{2} \cdot \underline{3} \cdot 3}$

$= \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{3}} \cdot 3} = \dfrac{1 \cdot 1 \cdot 1}{1 \cdot 1 \cdot 1 \cdot 3} = \dfrac{\underline{1}}{3}$

(b) $\dfrac{32}{56} = \dfrac{2 \cdot 2 \cdot 2 \cdot 2 \cdot \underline{2}}{2 \cdot 2 \cdot \underline{2} \cdot 7}$

$= \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 2 \cdot 2}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 7} = \dfrac{1 \cdot 1 \cdot 1 \cdot 2 \cdot 2}{1 \cdot 1 \cdot 1 \cdot 7} = \dfrac{4}{\underline{7}}$

(c) $\dfrac{74}{111} = \dfrac{2 \cdot \overset{1}{\cancel{37}}}{3 \cdot \underset{1}{\cancel{37}}} = \dfrac{2 \cdot 1}{3 \cdot 1} = \dfrac{2}{3}$

(d) $\dfrac{124}{340} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 31}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 5 \cdot 17} = \dfrac{1 \cdot 1 \cdot 31}{1 \cdot 1 \cdot 5 \cdot 17} = \dfrac{31}{85}$

5. **(a)** $\dfrac{24}{48}$ and $\dfrac{36}{72}$

$\dfrac{24}{48} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 2 \cdot \underset{1}{\cancel{3}}} = \dfrac{1 \cdot 1 \cdot 1 \cdot 1}{1 \cdot 1 \cdot 1 \cdot 2 \cdot 1} = \dfrac{1}{2}$

$\dfrac{36}{72} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{3}} \cdot \overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 2 \cdot \underset{1}{\cancel{3}} \cdot \underset{1}{\cancel{3}}} = \dfrac{1 \cdot 1 \cdot 1 \cdot 1}{1 \cdot 1 \cdot 2 \cdot 1 \cdot 1} = \dfrac{1}{2}$

The fractions are *equivalent* ($\frac{1}{2} = \frac{1}{2}$).

(b) $\dfrac{45}{60}$ and $\dfrac{50}{75}$

$\dfrac{45}{60} = \dfrac{3 \cdot \overset{1}{\cancel{3}} \cdot \overset{1}{\cancel{5}}}{2 \cdot 2 \cdot \underset{1}{\cancel{3}} \cdot \underset{1}{\cancel{5}}} = \dfrac{3 \cdot 1 \cdot 1}{2 \cdot 2 \cdot 1 \cdot 1} = \dfrac{3}{4}$

$\dfrac{50}{75} = \dfrac{2 \cdot \overset{1}{\cancel{5}} \cdot \overset{1}{\cancel{5}}}{3 \cdot \underset{1}{\cancel{5}} \cdot \underset{1}{\cancel{5}}} = \dfrac{2 \cdot 1 \cdot 1}{3 \cdot 1 \cdot 1} = \dfrac{2}{3}$

The fractions are *not equivalent* ($\frac{3}{4} \neq \frac{2}{3}$).

(c) $\dfrac{20}{4}$ and $\dfrac{110}{22}$

$\dfrac{20}{4} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 5}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}}} = \dfrac{1 \cdot 1 \cdot 5}{1 \cdot 1} = 5$

$\dfrac{110}{22} = \dfrac{\overset{1}{\cancel{2}} \cdot 5 \cdot \overset{1}{\cancel{11}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{11}}} = \dfrac{1 \cdot 5 \cdot 1}{1 \cdot 1} = 5$

The fractions are *equivalent* ($5 = 5$).

(d) $\dfrac{120}{220}$ and $\dfrac{180}{320}$

$\dfrac{120}{220} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 2 \cdot 3 \cdot \overset{1}{\cancel{5}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{5}} \cdot 11} = \dfrac{1 \cdot 1 \cdot 2 \cdot 3 \cdot 1}{1 \cdot 1 \cdot 1 \cdot 11} = \dfrac{6}{11}$

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$$\frac{180}{320} = \frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot 3\cdot 3\cdot\overset{1}{\cancel{5}}}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot 2\cdot 2\cdot 2\cdot 2\cdot\underset{1}{\cancel{5}}} = \frac{1\cdot 1\cdot 3\cdot 3\cdot 1}{1\cdot 1\cdot 2\cdot 2\cdot 2\cdot 2\cdot 1} = \frac{9}{16}$$

The fractions are *not equivalent* ($\frac{6}{11} \neq \frac{9}{16}$).

2.4 Section Exercises

1. A number can be divided by 2 if the number is an even number.

2. A number can be divided by 5 if the number ends in 5 or 0.

3. Any number can be divided by 10 if the number ends in 0.

4. If the sum of a number's digits is divisible by 3, the number is divisible by 3.

		2	3	5	10
5.	60	✓	✓	✓	✓
6.	90	✓	✓	✓	✓
7.	48	✓	✓	X	X
8.	36	✓	✓	X	X
9.	160	✓	X	✓	✓
10.	175	X	X	✓	X
11.	138	✓	✓	X	X
12.	150	✓	✓	✓	✓

13. $\frac{6}{8} = \frac{6\div 2}{8\div 2} = \frac{3}{4}$, *true*

14. $\frac{7}{12}$ is in lowest terms, so the fractions $\frac{7}{12}$ and $\frac{1}{2}$ are not equivalent. *false*

15. $\frac{5}{16}$ is in lowest terms, so the fractions $\frac{5}{16}$ and $\frac{3}{8}$ are not equivalent. *false*

16. $\frac{4}{12} = \frac{4\div 4}{12\div 4} = \frac{1}{3}$, *true*

17. $\frac{15}{25} = \frac{15\div 5}{25\div 5} = \frac{3}{5}$

18. $\frac{32}{48} = \frac{32\div 16}{48\div 16} = \frac{2}{3}$

19. $\frac{36}{42} = \frac{36\div 6}{42\div 6} = \frac{6}{7}$

20. $\frac{22}{33} = \frac{22\div 11}{33\div 11} = \frac{2}{3}$

21. $\frac{56}{64} = \frac{56\div 8}{64\div 8} = \frac{7}{8}$

22. $\frac{21}{35} = \frac{21\div 7}{35\div 7} = \frac{3}{5}$

23. $\frac{180}{210} = \frac{180\div 30}{210\div 30} = \frac{6}{7}$

24. $\frac{72}{80} = \frac{72\div 8}{80\div 8} = \frac{9}{10}$

25. $\frac{72}{126} = \frac{72\div 18}{126\div 18} = \frac{4}{7}$

26. $\frac{73}{146} = \frac{73\div 73}{146\div 73} = \frac{1}{2}$

27. $\frac{12}{600} = \frac{12\div 12}{600\div 12} = \frac{1}{50}$

28. $\frac{8}{400} = \frac{8\div 8}{400\div 8} = \frac{1}{50}$

29. $\frac{96}{132} = \frac{96\div 12}{132\div 12} = \frac{8}{11}$

30. $\frac{165}{180} = \frac{165\div 15}{180\div 15} = \frac{11}{12}$

31. $\frac{60}{108} = \frac{60\div 12}{108\div 12} = \frac{5}{9}$

32. $\frac{112}{128} = \frac{112\div 16}{128\div 16} = \frac{7}{8}$

33. $\frac{18}{24} = \frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{3}}\cdot 3}{\underset{1}{\cancel{2}}\cdot 2\cdot 2\cdot\underset{1}{\cancel{3}}} = \frac{1\cdot 1\cdot 3}{1\cdot 2\cdot 2\cdot 1} = \frac{3}{4}$

34. $\frac{16}{64} = \frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot 2\cdot 2} = \frac{1\cdot 1\cdot 1\cdot 1}{1\cdot 1\cdot 1\cdot 1\cdot 2\cdot 2} = \frac{1}{4}$

35. $\frac{35}{40} = \frac{\overset{1}{\cancel{5}}\cdot 7}{2\cdot 2\cdot 2\cdot\underset{1}{\cancel{5}}} = \frac{1\cdot 7}{2\cdot 2\cdot 2\cdot 1} = \frac{7}{8}$

36. $\frac{20}{32} = \frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot 5}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot 2\cdot 2\cdot 2} = \frac{1\cdot 1\cdot 5}{1\cdot 1\cdot 2\cdot 2\cdot 2} = \frac{5}{8}$

37. $\frac{90}{180} = \frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{3}}\cdot\overset{1}{\cancel{3}}\cdot\overset{1}{\cancel{5}}}{\underset{1}{\cancel{2}}\cdot 2\cdot\underset{1}{\cancel{3}}\cdot\underset{1}{\cancel{3}}\cdot\underset{1}{\cancel{5}}} = \frac{1\cdot 1\cdot 1\cdot 1}{1\cdot 2\cdot 1\cdot 1\cdot 1} = \frac{1}{2}$

38. $\frac{36}{48} = \frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{3}}\cdot 3}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot 2\cdot 2\cdot\underset{1}{\cancel{3}}} = \frac{1\cdot 1\cdot 1\cdot 3}{1\cdot 1\cdot 2\cdot 2\cdot 1} = \frac{3}{4}$

39. $\frac{36}{12} = \frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{3}}\cdot 3}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{3}}} = \frac{1\cdot 1\cdot 1\cdot 3}{1\cdot 1\cdot 1} = 3$

40. $\frac{192}{48} = \frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot 2\cdot 2\cdot\overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{3}}} = \frac{1\cdot 1\cdot 1\cdot 1\cdot 2\cdot 2\cdot 1}{1\cdot 1\cdot 1\cdot 1\cdot 1} = 4$

41. $\frac{72}{225} = \frac{2\cdot 2\cdot 2\cdot\overset{1}{\cancel{3}}\cdot\overset{1}{\cancel{3}}}{\underset{1}{\cancel{3}}\cdot\underset{1}{\cancel{3}}\cdot 5\cdot 5} = \frac{2\cdot 2\cdot 2\cdot 1\cdot 1}{1\cdot 1\cdot 5\cdot 5} = \frac{8}{25}$

42. $\frac{65}{234} = \frac{5\cdot\overset{1}{\cancel{13}}}{2\cdot 3\cdot 3\cdot\underset{1}{\cancel{13}}} = \frac{5\cdot 1}{2\cdot 3\cdot 3\cdot 1} = \frac{5}{18}$

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43. $\frac{3}{6}$ and $\frac{18}{36}$

$$\frac{3}{6}=\frac{1\cdot\overset{1}{\cancel{3}}}{2\cdot\underset{1}{\cancel{3}}}=\frac{1}{2}$$

$$\frac{18}{36}=\frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{3}}\cdot\overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}}\cdot 2\cdot\underset{1}{\cancel{3}}\cdot\underset{1}{\cancel{3}}}=\frac{1}{2}$$

The fractions are *equivalent* ($\frac{1}{2}=\frac{1}{2}$).

44. $\frac{3}{8}$ and $\frac{27}{72}$

$$\frac{3}{8}=\frac{3}{2\cdot 2\cdot 2}=\frac{3}{8}$$

$$\frac{27}{72}=\frac{\overset{1}{\cancel{3}}\cdot\overset{1}{\cancel{3}}\cdot 3}{2\cdot 2\cdot 2\cdot\underset{1}{\cancel{3}}\cdot\underset{1}{\cancel{3}}}=\frac{3}{8}$$

The fractions are *equivalent* ($\frac{3}{8}=\frac{3}{8}$).

45. $\frac{10}{24}$ and $\frac{12}{30}$

$$\frac{10}{24}=\frac{\overset{1}{\cancel{2}}\cdot 5}{\underset{1}{\cancel{2}}\cdot 2\cdot 2\cdot 3}=\frac{5}{12}$$

$$\frac{12}{30}=\frac{\overset{1}{\cancel{2}}\cdot 2\cdot\overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{3}}\cdot 5}=\frac{2}{5}$$

The fractions are *not equivalent* ($\frac{5}{12}\neq\frac{2}{5}$).

46. $\frac{15}{35}$ and $\frac{18}{40}$

$$\frac{15}{35}=\frac{3\cdot\overset{1}{\cancel{5}}}{\underset{1}{\cancel{5}}\cdot 7}=\frac{3}{7}$$

$$\frac{18}{40}=\frac{\overset{1}{\cancel{2}}\cdot 3\cdot 3}{\underset{1}{\cancel{2}}\cdot 2\cdot 2\cdot 5}=\frac{9}{20}$$

The fractions are *not equivalent* ($\frac{3}{7}\neq\frac{9}{20}$).

47. $\frac{15}{24}$ and $\frac{35}{52}$

$$\frac{15}{24}=\frac{\overset{1}{\cancel{3}}\cdot 5}{2\cdot 2\cdot 2\cdot\underset{1}{\cancel{3}}}=\frac{5}{8}$$

$$\frac{35}{52}=\frac{5\cdot 7}{2\cdot 2\cdot 13}=\frac{35}{52}$$

The fractions are *not equivalent* ($\frac{5}{8}\neq\frac{35}{52}$).

48. $\frac{21}{33}$ and $\frac{9}{12}$

$$\frac{21}{33}=\frac{\overset{1}{\cancel{3}}\cdot 7}{\underset{1}{\cancel{3}}\cdot 11}=\frac{7}{11}$$

$$\frac{9}{12}=\frac{3\cdot\overset{1}{\cancel{3}}}{2\cdot 2\cdot\underset{1}{\cancel{3}}}=\frac{3}{4}$$

The fractions are *not equivalent* ($\frac{7}{11}\neq\frac{3}{4}$).

49. $\frac{14}{16}$ and $\frac{35}{40}$

$$\frac{14}{16}=\frac{\overset{1}{\cancel{2}}\cdot 7}{\underset{1}{\cancel{2}}\cdot 2\cdot 2\cdot 2}=\frac{7}{8}$$

$$\frac{35}{40}=\frac{\overset{1}{\cancel{5}}\cdot 7}{2\cdot 2\cdot 2\cdot\underset{1}{\cancel{5}}}=\frac{7}{8}$$

The fractions are *equivalent* ($\frac{7}{8}=\frac{7}{8}$).

50. $\frac{27}{90}$ and $\frac{24}{80}$

$$\frac{27}{90}=\frac{\overset{1}{\cancel{3}}\cdot\overset{1}{\cancel{3}}\cdot 3}{2\cdot\underset{1}{\cancel{3}}\cdot\underset{1}{\cancel{3}}\cdot 5}=\frac{3}{10}$$

$$\frac{24}{80}=\frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot 3}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot 2\cdot 5}=\frac{3}{10}$$

The fractions are *equivalent* ($\frac{3}{10}=\frac{3}{10}$).

51. $\frac{48}{6}$ and $\frac{72}{8}$

$$\frac{48}{6}=\frac{2\cdot 2\cdot 2\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{3}}}=8$$

$$\frac{72}{8}=\frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot 3\cdot 3}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}}=9$$

The fractions are *not equivalent* ($8\neq 9$).

52. $\frac{33}{11}$ and $\frac{72}{24}$

$$\frac{33}{11}=\frac{3\cdot\overset{1}{\cancel{11}}}{\underset{1}{\cancel{11}}}=3$$

$$\frac{72}{24}=\frac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{3}}\cdot 3}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{3}}}=3$$

The fractions are *equivalent* ($3=3$).

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53. $\frac{25}{30}$ and $\frac{65}{78}$

$$\frac{25}{30} = \frac{5 \cdot \overset{1}{\cancel{5}}}{2 \cdot 3 \cdot \underset{1}{\cancel{5}}} = \frac{5}{6}$$

$$\frac{65}{78} = \frac{5 \cdot \overset{1}{\cancel{13}}}{2 \cdot 3 \cdot \underset{1}{\cancel{13}}} = \frac{5}{6}$$

The fractions are *equivalent* ($\frac{5}{6} = \frac{5}{6}$).

54. $\frac{24}{72}$ and $\frac{30}{90}$

$$\frac{24}{72} = \frac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{3}} \cdot 3} = \frac{1}{3}$$

$$\frac{30}{90} = \frac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{3}} \cdot \overset{1}{\cancel{5}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{3}} \cdot 3 \cdot \underset{1}{\cancel{5}}} = \frac{1}{3}$$

The fractions are *equivalent* ($\frac{1}{3} = \frac{1}{3}$).

55. A fraction is in lowest terms when the numerator and the denominator have no common factors other than 1. Some examples are $\frac{1}{2}$, $\frac{3}{8}$, and $\frac{2}{3}$.

56. Two fractions are equivalent when they represent the same portion of a whole. For example, the fractions $\frac{10}{15}$ and $\frac{8}{12}$ are equivalent.

$$\frac{10}{15} = \frac{2 \cdot \overset{1}{\cancel{5}}}{3 \cdot \underset{1}{\cancel{5}}} = \frac{2 \cdot 1}{3 \cdot 1} = \frac{2}{3}$$

$$\frac{8}{12} = \frac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 2}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 3} = \frac{1 \cdot 1 \cdot 2}{1 \cdot 1 \cdot 3} = \frac{2}{3}$$

The fractions are *equivalent* $\left(\frac{2}{3} = \frac{2}{3}\right)$.

57. $$\frac{160}{256} = \frac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 5}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 2 \cdot 2 \cdot 2} = \frac{5}{8}$$

58. $$\frac{363}{528} = \frac{\overset{1}{\cancel{3}} \cdot \overset{1}{\cancel{11}} \cdot 11}{2 \cdot 2 \cdot 2 \cdot 2 \cdot \underset{1}{\cancel{3}} \cdot \underset{1}{\cancel{11}}} = \frac{11}{16}$$

59. $$\frac{238}{119} = \frac{2 \cdot \overset{1}{\cancel{7}} \cdot \overset{1}{\cancel{17}}}{\underset{1}{\cancel{7}} \cdot \underset{1}{\cancel{17}}} = \frac{2}{1} = 2$$

60. $$\frac{570}{95} = \frac{2 \cdot 3 \cdot \overset{1}{\cancel{5}} \cdot \overset{1}{\cancel{19}}}{\underset{1}{\cancel{5}} \cdot \underset{1}{\cancel{19}}} = \frac{6}{1} = 6$$

Summary Exercises *Fraction Basics*

1. The figure has 6 equal parts.
Five parts are shaded: $\frac{5}{6}$

One part is unshaded: $\frac{1}{6}$

2. The figure has 3 equal parts.
One part is shaded: $\frac{1}{3}$

Two parts are unshaded: $\frac{2}{3}$

3. The figure has 8 equal parts.
Five parts are shaded: $\frac{5}{8}$

Three parts are unshaded: $\frac{3}{8}$

4. $\frac{3}{4}$ ← Numerator
← Denominator

5. $\frac{8}{5}$ ← Numerator
← Denominator

6. Proper fractions: numerator *smaller* than denominator.

$$\frac{3}{5}, \frac{4}{25}, \frac{1}{32}$$

Improper fractions: numerator *greater than or equal to* denominator.

$$\frac{8}{2}, \frac{16}{7}, \frac{8}{8}$$

7. There are 36 winners in total $(12 + 9 + 7 + 3 + 3 + 2)$. Seven of the 36 winners were from Switzerland. $\frac{7}{36}$

8. Since $3 + 9 = 12$ of the winners *were* from either France or South Africa, $36 - 12 = 24$ *were not*. $\frac{24}{36} = \frac{2}{3}$

9. $2 + 12 = 14$ of the winners were from either Japan or the United States. $\frac{14}{36} = \frac{7}{18}$

10. Since 3 of the winners *were* from Canada, $36 - 3 = 33$ *were not*. $\frac{33}{36} = \frac{11}{12}$

11. $\frac{5}{2}$

$$2\overset{2}{\overline{)5}}$$ ← Whole number part
$$\underline{4}$$
$$1$$ ← Remainder

$$\frac{5}{2} = 2\frac{1}{2}$$

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12. $\frac{11}{8}$

$$\begin{array}{r} 1 \\ 8\overline{)\,1\;1} \\ \underline{8} \\ 3 \end{array}$$

1 ← Whole number part

3 ← Remainder

$$\frac{11}{8} = 1\frac{3}{8}$$

13. $\frac{9}{7}$

$$\begin{array}{r} 1 \\ 7\overline{)\,9} \\ \underline{7} \\ 2 \end{array}$$

1 ← Whole number part

2 ← Remainder

$$\frac{9}{7} = 1\frac{2}{7}$$

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

$$\begin{array}{r} 2 \\ 3\overline{)\,8} \\ \underline{6} \\ 2 \end{array}$$

2 ← Whole number part

2 ← Remainder

$$\frac{8}{3} = 2\frac{2}{3}$$

15. $\frac{64}{8}$

$$\begin{array}{r} 8 \\ 8\overline{)\,6\;4} \\ \underline{6\;4} \\ 0 \end{array}$$

8 ← Whole number part

0 ← Remainder

$$\frac{64}{8} = 8$$

16. $\frac{45}{9}$

$$\begin{array}{r} 5 \\ 9\overline{)\,4\;5} \\ \underline{4\;5} \\ 0 \end{array}$$

5 ← Whole number part

0 ← Remainder

$$\frac{45}{9} = 5$$

17. $\frac{36}{5}$

$$\begin{array}{r} 7 \\ 5\overline{)\,3\;6} \\ \underline{3\;5} \\ 1 \end{array}$$

7 ← Whole number part

1 ← Remainder

$$\frac{36}{5} = 7\frac{1}{5}$$

18. $\frac{47}{10}$

$$\begin{array}{r} 4 \\ 10\overline{)\,4\;7} \\ \underline{4\;0} \\ 7 \end{array}$$

4 ← Whole number part

7 ← Remainder

$$\frac{47}{10} = 4\frac{7}{10}$$

19. $3\frac{1}{3}$ $3 \cdot 3 = 9$ Multiply 3 and 3.

$9 + 1 = 10$ Add 1.

$$3\frac{1}{3} = \frac{10}{3}$$

20. $5\frac{3}{8}$ $5 \cdot 8 = 40$ Multiply 5 and 8.

$40 + 3 = 43$ Add 3.

$$5\frac{3}{8} = \frac{43}{8}$$

21. $6\frac{4}{5}$ $6 \cdot 5 = 30$ Multiply 6 and 5.

$30 + 4 = 34$ Add 4.

$$6\frac{4}{5} = \frac{34}{5}$$

22. $10\frac{3}{5}$ $10 \cdot 5 = 50$ Multiply 10 and 5.

$50 + 3 = 53$ Add 3.

$$10\frac{3}{5} = \frac{53}{5}$$

23. $12\frac{3}{4}$ $12 \cdot 4 = 48$ Multiply 12 and 4.

$48 + 3 = 51$ Add 3.

$$12\frac{3}{4} = \frac{51}{4}$$

24. $4\frac{10}{13}$ $4 \cdot 13 = 52$ Multiply 4 and 13.

$52 + 10 = 62$ Add 10.

$$4\frac{10}{13} = \frac{62}{13}$$

25. $11\frac{5}{6}$ $11 \cdot 6 = 66$ Multiply 11 and 6.

$66 + 5 = 71$ Add 5.

$$11\frac{5}{6} = \frac{71}{6}$$

26. $23\frac{5}{8}$ $23 \cdot 8 = 184$ Multiply 23 and 8.

$184 + 5 = 189$ Add 5.

$$23\frac{5}{8} = \frac{189}{8}$$

27.

$$\begin{array}{ccc} & 10 & \\ \swarrow & & \searrow \\ \boxed{2} & & \boxed{5} \end{array}$$

$10 = 2 \cdot 5$

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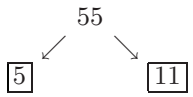
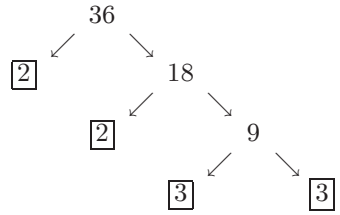
28.



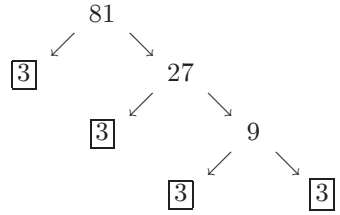
$55 = 5 \cdot 11$

29.



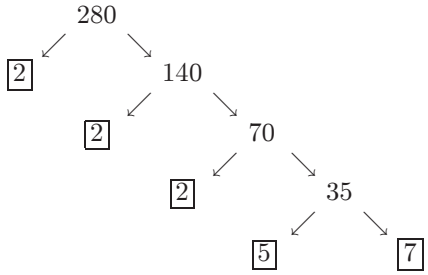
$36 = 2^2 \cdot 3^2$

30.



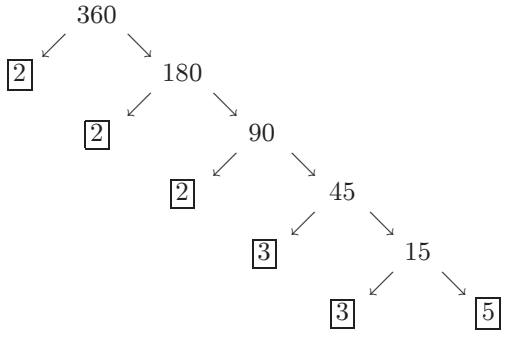
$81 = 3^4$

31.



$280 = 2^3 \cdot 5 \cdot 7$

32.



$360 = 2^3 \cdot 3^2 \cdot 5$

33. $\dfrac{4}{12} = \dfrac{4 \div 4}{12 \div 4} = \dfrac{1}{3}$

34. $\dfrac{7}{14} = \dfrac{7 \div 7}{14 \div 7} = \dfrac{1}{2}$

35. $\dfrac{4}{16} = \dfrac{4 \div 4}{16 \div 4} = \dfrac{1}{4}$

36. $\dfrac{15}{25} = \dfrac{15 \div 5}{25 \div 5} = \dfrac{3}{5}$

37. $\dfrac{18}{24} = \dfrac{18 \div 6}{24 \div 6} = \dfrac{3}{4}$

38. $\dfrac{30}{36} = \dfrac{30 \div 6}{36 \div 6} = \dfrac{5}{6}$

39. $\dfrac{56}{64} = \dfrac{56 \div 8}{64 \div 8} = \dfrac{7}{8}$

40. $\dfrac{6}{300} = \dfrac{6 \div 6}{300 \div 6} = \dfrac{1}{50}$

41. $\dfrac{25}{200} = \dfrac{25 \div 25}{200 \div 25} = \dfrac{1}{8}$

42. $\dfrac{125}{225} = \dfrac{125 \div 25}{225 \div 25} = \dfrac{5}{9}$

43. $\dfrac{88}{154} = \dfrac{88 \div 22}{154 \div 22} = \dfrac{4}{7}$

44. $\dfrac{70}{126} = \dfrac{70 \div 14}{126 \div 14} = \dfrac{5}{9}$

45. $\dfrac{24}{36} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 2 \cdot \overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{3}} \cdot 3} = \dfrac{2}{3}$

46. $\dfrac{80}{160} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{5}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 2 \cdot \underset{1}{\cancel{5}}} = \dfrac{1}{2}$

47. $\dfrac{126}{42} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{3}} \cdot 3 \cdot \overset{1}{\cancel{7}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{3}} \cdot \underset{1}{\cancel{7}}} = \dfrac{3}{1} = 3$

48. $\dfrac{96}{112} = \dfrac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 2 \cdot 3}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 7} = \dfrac{6}{7}$

2.5 Multiplying Fractions

2.5 Margin Exercises

1. $\frac{1}{4}$ of $\frac{1}{2}$ as read from the figure is the darker shaded part of the second figure. One of eight equal parts is shaded, or $\frac{1}{8}$.

$$\frac{1}{4} \cdot \frac{1}{2} = \frac{1}{8}$$

2. **(a)** $\dfrac{1}{2} \cdot \dfrac{3}{4} = \dfrac{1 \cdot 3}{2 \cdot 4} = \dfrac{3}{8}$

(b) $\dfrac{3}{5} \cdot \dfrac{1}{3} = \dfrac{\overset{1}{\cancel{3}} \cdot 1}{5 \cdot \underset{1}{\cancel{3}}} = \dfrac{1}{5}$

(c) $\dfrac{5}{6} \cdot \dfrac{1}{2} \cdot \dfrac{1}{8} = \dfrac{5 \cdot 1 \cdot 1}{6 \cdot 2 \cdot 8} = \dfrac{5}{96}$

(d) $\dfrac{1}{2} \cdot \dfrac{3}{4} \cdot \dfrac{3}{8} = \dfrac{1 \cdot 3 \cdot 3}{2 \cdot 4 \cdot 8} = \dfrac{9}{64}$

3. **(a)** $\dfrac{3}{\underset{2}{\cancel{4}}} \cdot \dfrac{\overset{1}{\cancel{2}}}{5} = \dfrac{3 \cdot 1}{2 \cdot 5} = \dfrac{3}{10}$

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(b) $\dfrac{\overset{2}{\cancel{6}}}{\underset{1}{\cancel{11}}} \cdot \dfrac{\overset{3}{\cancel{33}}}{\underset{7}{\cancel{21}}} = \dfrac{2 \cdot 3}{1 \cdot 7} = \dfrac{6}{7}$

(c) $\dfrac{\overset{1}{\cancel{20}}}{4} \cdot \dfrac{\overset{1}{\cancel{3}}}{\underset{2}{\cancel{40}}} \cdot \dfrac{1}{\underset{1}{\cancel{3}}} = \dfrac{1 \cdot 1 \cdot 1}{4 \cdot 2 \cdot 1} = \dfrac{1}{8}$

(d) $\dfrac{\overset{1}{\cancel{18}}}{17} \cdot \dfrac{1}{\underset{1}{\cancel{36}}} \cdot \dfrac{\overset{1}{\cancel{2}}}{3} = \dfrac{1 \cdot 1 \cdot 1}{17 \cdot 1 \cdot 3} = \dfrac{1}{51}$

4. **(a)** $8 \cdot \dfrac{1}{8} = \dfrac{\overset{1}{\cancel{8}}}{1} \cdot \dfrac{1}{\underset{1}{\cancel{8}}} = \dfrac{1 \cdot 1}{1 \cdot 1} = \dfrac{1}{1} = 1$

(b) $\dfrac{\overset{1}{\cancel{3}}}{4} \cdot 5 \cdot \dfrac{5}{\underset{1}{\cancel{3}}} = \dfrac{1 \cdot 5 \cdot 5}{4 \cdot 1} = \dfrac{25}{4}$ or $6\dfrac{1}{4}$

(c) $\dfrac{3}{5} \cdot 40 = \dfrac{3}{\underset{1}{\cancel{5}}} \cdot \dfrac{\overset{8}{\cancel{40}}}{1} = \dfrac{3 \cdot 8}{1 \cdot 1} = \dfrac{24}{1} = 24$

(d) $\dfrac{3}{25} \cdot \dfrac{5}{11} \cdot 99 = \dfrac{3}{\underset{5}{\cancel{25}}} \cdot \dfrac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{11}}} \cdot \dfrac{\overset{9}{\cancel{99}}}{1}$

$$= \frac{3 \cdot 1 \cdot 9}{5 \cdot 1 \cdot 1}$$

$$= \frac{27}{5} = 5\frac{2}{5}$$

5. **(a)** Area = length · width

$$= \frac{\overset{1}{\cancel{3}}}{4} \cdot \frac{1}{\underset{1}{\cancel{3}}}$$

$$= \frac{1}{4}\text{yd}^2$$

(b) Area = length · width

$$= \frac{\overset{1}{\cancel{3}}}{8} \cdot \frac{1}{\underset{1}{\cancel{3}}}$$

$$= \frac{1}{8}\text{mi}^2$$

(c) Area = length · width

$$= \frac{\overset{3}{\cancel{9}}}{\underset{1}{\cancel{7}}} \cdot \frac{1}{\underset{4}{\cancel{12}}} = \frac{3 \cdot 1}{1 \cdot 4}$$

$$= \frac{3}{4}\text{mi}^2$$

2.5 Section Exercises

1. To multiply two or more fractions, you multiply the numerators and you multiply the denominators.

2. To write a fraction in lowest terms, you must divide both the numerator and denominator by a common factor.

3. A shortcut when multiplying fractions is to divide both a numerator and a denominator by the same number.

4. Using the shortcut when multiplying fractions should result in an answer that is in lowest terms.

5. $\dfrac{1}{3} \cdot \dfrac{3}{4} = \dfrac{1}{\underset{1}{\cancel{3}}} \cdot \dfrac{\overset{1}{\cancel{3}}}{4} = \dfrac{1 \cdot 1}{1 \cdot 4} = \dfrac{1}{4}$

6. $\dfrac{2}{5} \cdot \dfrac{3}{4} = \dfrac{\overset{1}{\cancel{2}}}{5} \cdot \dfrac{3}{\underset{2}{\cancel{4}}} = \dfrac{1 \cdot 3}{5 \cdot 2} = \dfrac{3}{10}$

7. $\dfrac{2}{7} \cdot \dfrac{1}{5} = \dfrac{2 \cdot 1}{7 \cdot 5} = \dfrac{2}{35}$

8. $\dfrac{2}{3} \cdot \dfrac{1}{2} = \dfrac{\overset{1}{\cancel{2}}}{3} \cdot \dfrac{1}{\underset{1}{\cancel{2}}} = \dfrac{1 \cdot 1}{3 \cdot 1} = \dfrac{1}{3}$

9. $\dfrac{8}{5} \cdot \dfrac{15}{32} = \dfrac{\overset{1}{\cancel{8}}}{\underset{1}{\cancel{5}}} \cdot \dfrac{\overset{3}{\cancel{15}}}{\underset{4}{\cancel{32}}} = \dfrac{1 \cdot 3}{1 \cdot 4} = \dfrac{3}{4}$

10. $\dfrac{5}{9} \cdot \dfrac{4}{3} = \dfrac{5 \cdot 4}{9 \cdot 3} = \dfrac{20}{27}$

11. $\dfrac{2}{3} \cdot \dfrac{7}{12} \cdot \dfrac{9}{14} = \dfrac{\overset{1}{\cancel{2}}}{\underset{1}{\cancel{3}}} \cdot \dfrac{\overset{1}{\cancel{7}}}{\underset{2}{\cancel{12}}} \cdot \dfrac{\overset{1}{\cancel{9}}}{\underset{2}{\cancel{14}}} = \dfrac{1 \cdot 1 \cdot 1}{1 \cdot 2 \cdot 2} = \dfrac{1}{4}$

12. $\dfrac{7}{8} \cdot \dfrac{16}{21} \cdot \dfrac{1}{2} = \dfrac{\overset{1}{\cancel{7}}}{\underset{1}{\cancel{8}}} \cdot \dfrac{\overset{2}{\cancel{16}}}{\underset{3}{\cancel{21}}} \cdot \dfrac{1}{\underset{1}{\cancel{2}}} = \dfrac{1 \cdot 1 \cdot 1}{1 \cdot 3 \cdot 1} = \dfrac{1}{3}$

13. $\dfrac{3}{4} \cdot \dfrac{5}{6} \cdot \dfrac{2}{3} = \dfrac{\overset{1}{\cancel{3}}}{\underset{2}{\cancel{4}}} \cdot \dfrac{5}{6} \cdot \dfrac{\overset{1}{\cancel{2}}}{\underset{1}{\cancel{3}}} = \dfrac{1 \cdot 5 \cdot 1}{2 \cdot 6 \cdot 1} = \dfrac{5}{12}$

14. $\dfrac{5}{8} \cdot \dfrac{16}{25} = \dfrac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{8}}} \cdot \dfrac{\overset{2}{\cancel{16}}}{\underset{5}{\cancel{25}}} = \dfrac{1 \cdot 2}{1 \cdot 5} = \dfrac{2}{5}$

15. $\dfrac{6}{11} \cdot \dfrac{22}{15} = \dfrac{\overset{2}{\cancel{6}}}{\underset{1}{\cancel{11}}} \cdot \dfrac{\overset{2}{\cancel{22}}}{\underset{5}{\cancel{15}}} = \dfrac{2 \cdot 2}{1 \cdot 5} = \dfrac{4}{5}$

16. $\dfrac{14}{25} \cdot \dfrac{65}{48} \cdot \dfrac{15}{28} = \dfrac{\overset{1}{\cancel{14}}}{\underset{5}{\cancel{25}}} \cdot \dfrac{\overset{13}{\cancel{65}}}{\underset{16}{\cancel{48}}} \cdot \dfrac{\overset{1}{\cancel{15}}}{\underset{2}{\cancel{28}}} = \dfrac{1 \cdot 13 \cdot 1}{1 \cdot 16 \cdot 2} = \dfrac{13}{32}$

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17. $\frac{35}{64}\cdot\frac{32}{15}\cdot\frac{27}{72}=\frac{\overset{7}{\cancel{35}}}{\underset{2}{\cancel{64}}}\cdot\frac{\overset{1}{\cancel{32}}}{\underset{1}{\cancel{15}}}\cdot\frac{\overset{1}{\cancel{3}}\cancel{27}}{\underset{8}{\cancel{72}}}=\frac{7\cdot1\cdot1}{2\cdot1\cdot8}=\frac{7}{16}$

18. $\frac{16}{25}\cdot\frac{35}{32}\cdot\frac{15}{64}=\frac{\overset{1}{\cancel{16}}}{\underset{5}{\cancel{25}}}\cdot\frac{\overset{7}{\cancel{35}}}{\underset{2}{\cancel{32}}}\cdot\frac{\overset{3}{\cancel{15}}}{64}=\frac{1\cdot7\cdot3}{1\cdot2\cdot64}=\frac{21}{128}$

19. $\frac{39}{42}\cdot\frac{7}{13}\cdot\frac{7}{24}=\frac{\overset{1}{\cancel{3}}\cancel{39}}{\underset{2}{\cancel{42}}}\cdot\frac{\overset{1}{\cancel{7}}}{\underset{1}{\cancel{13}}}\cdot\frac{7}{24}=\frac{1\cdot1\cdot7}{2\cdot1\cdot24}=\frac{7}{48}$

20. The statement "When multiplying a fraction by a whole number, the whole number should be rewritten as the number over 1." is *true*.

21. $\frac{4}{5}\cdot8=\frac{\overset{1}{\cancel{4}}}{5}\cdot\frac{1}{\underset{2}{\cancel{8}}}=\frac{1}{10}$ is *false*.

The correct method is as follows:

$$\frac{4}{5}\cdot8=\frac{4}{5}\cdot\frac{8}{1}=\frac{32}{5}=6\frac{2}{5}$$

22. $5\cdot\frac{4}{5}=\frac{\overset{1}{\cancel{5}}}{1}\cdot\frac{4}{\underset{1}{\cancel{5}}}=\frac{4}{1}=4$

23. $20\cdot\frac{3}{4}=\frac{\overset{5}{\cancel{20}}}{1}\cdot\frac{3}{\underset{1}{\cancel{4}}}=\frac{15}{1}=15$

24. $36\cdot\frac{2}{3}=\frac{\overset{12}{\cancel{36}}}{1}\cdot\frac{2}{\underset{1}{\cancel{3}}}=\frac{24}{1}=24$

25. $36\cdot\frac{5}{8}\cdot\frac{9}{15}=\frac{\overset{9}{\cancel{36}}}{1}\cdot\frac{\overset{1}{\cancel{5}}}{\underset{2}{\cancel{8}}}\cdot\frac{\overset{3}{\cancel{9}}}{\underset{1}{\cancel{15}}}=\frac{27}{2}=13\frac{1}{2}$

26. $30\cdot\frac{3}{10}=\frac{\overset{3}{\cancel{30}}}{1}\cdot\frac{3}{\underset{1}{\cancel{10}}}=\frac{9}{1}=9$

27. $100\cdot\frac{21}{50}\cdot\frac{3}{4}=\frac{\overset{1}{\cancel{100}}}{1}\cdot\frac{21}{\underset{1}{\cancel{50}}}\cdot\frac{3}{\underset{2}{\cancel{4}}}=\frac{63}{2}=31\frac{1}{2}$

28. $400\cdot\frac{7}{8}=\frac{\overset{50}{\cancel{400}}}{1}\cdot\frac{7}{\underset{1}{\cancel{8}}}=\frac{350}{1}=350$

29. $\frac{2}{5}\cdot200=\frac{2}{\underset{1}{\cancel{5}}}\cdot\frac{\overset{40}{\cancel{200}}}{1}=\frac{80}{1}=80$

30. $\frac{6}{7}\cdot245=\frac{6}{\underset{1}{\cancel{7}}}\cdot\frac{\overset{35}{\cancel{245}}}{1}=\frac{210}{1}=210$

31. $142\cdot\frac{2}{3}=\frac{142}{1}\cdot\frac{2}{3}=\frac{284}{3}=94\frac{2}{3}$

32. $\frac{12}{25}\cdot430=\frac{12}{\underset{5}{\cancel{25}}}\cdot\frac{\overset{86}{\cancel{430}}}{1}=\frac{1032}{5}=206\frac{2}{5}$

33. $\frac{28}{21}\cdot640\cdot\frac{15}{32}=\frac{\overset{4}{\cancel{28}}}{\underset{1}{\cancel{21}}}\cdot\frac{\overset{20}{\cancel{640}}}{1}\cdot\frac{\overset{5}{\cancel{15}}}{\underset{1}{\cancel{32}}}$

$$=\frac{4\cdot20\cdot5}{1\cdot1\cdot1}$$

$$=\frac{400}{1}=400$$

34. $\frac{21}{13}\cdot520\cdot\frac{7}{20}=\frac{21}{\underset{1}{\cancel{13}}}\cdot\frac{\overset{2}{\cancel{26}}\cancel{520}}{1}\cdot\frac{7}{\underset{1}{\cancel{20}}}$

$$=\frac{21\cdot2\cdot7}{1\cdot1\cdot1}$$

$$=\frac{294}{1}=294$$

35. $\frac{54}{38}\cdot684\cdot\frac{5}{6}=\frac{\overset{9}{\cancel{54}}}{\underset{1}{\cancel{38}}}\cdot\frac{\overset{18}{\cancel{684}}}{1}\cdot\frac{5}{\underset{1}{\cancel{6}}}$

$$=\frac{9\cdot18\cdot5}{1\cdot1\cdot1}$$

$$=\frac{810}{1}=810$$

36. $\frac{76}{43}\cdot473\cdot\frac{5}{19}=\frac{\overset{4}{\cancel{76}}}{\underset{1}{\cancel{43}}}\cdot\frac{\overset{11}{\cancel{473}}}{1}\cdot\frac{5}{\underset{1}{\cancel{19}}}$

$$=\frac{4\cdot11\cdot5}{1\cdot1\cdot1}$$

$$=\frac{220}{1}=220$$

37. Area $=$ length $\cdot$ width

$$=\frac{3}{4}\cdot\frac{1}{3}=\frac{\overset{1}{\cancel{3}}}{4}\cdot\frac{1}{\underset{1}{\cancel{3}}}=\frac{1}{4}\text{ mi}^2$$

38. Area $=$ length $\cdot$ width

$$=\frac{7}{8}\cdot\frac{1}{4}=\frac{7\cdot1}{8\cdot4}=\frac{7}{32}\text{ ft}^2$$

39. Area $=$ length $\cdot$ width

$$=12\cdot\frac{3}{4}=\frac{\overset{3}{\cancel{12}}}{1}\cdot\frac{3}{\underset{1}{\cancel{4}}}=\frac{9}{1}=9\text{ meters}^2$$

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40. Area = length • width

$$= 8 \cdot \frac{3}{8} = \frac{\overset{1}{\cancel{8}}}{1} \cdot \frac{3}{\underset{1}{\cancel{8}}} = \frac{3}{1} = 3 \text{ in.}^2$$

41. Area = length • width

$$= \frac{5}{6} \cdot \frac{3}{10} = \frac{\overset{1}{\cancel{5}}}{\underset{2}{\cancel{6}}} \cdot \frac{\overset{1}{\cancel{3}}}{\underset{2}{\cancel{10}}} = \frac{1}{4} \text{ mi}^2$$

42. Area = length • width

$$= \frac{7}{5} \cdot \frac{3}{8} = \frac{21}{40} \text{ mi}^2$$

43. Multiply the numerators and multiply the denominators. An example is

$$\frac{3}{4} \cdot \frac{1}{2} = \frac{3 \cdot 1}{4 \cdot 2} = \frac{3}{8}.$$

44. You must divide a numerator and a denominator by the same number. If you do all possible divisions, your answer will be in lowest terms. One example is

$$\frac{3}{4} \cdot \frac{2}{3} = \frac{3 \cdot 2}{4 \cdot 3} = \frac{\overset{1}{\cancel{3}} \cdot \overset{1}{\cancel{2}}}{\underset{2}{\cancel{4}} \cdot \underset{1}{\cancel{3}}} = \frac{1}{2}.$$

45. Area = length • width

$$= 2 \cdot \frac{3}{4} = \frac{\overset{1}{\cancel{2}}}{1} \cdot \frac{3}{\underset{2}{\cancel{4}}} = \frac{3}{2} = 1\frac{1}{2} \text{ yd}^2$$

46. Area = width • height

$$= 2 \cdot \frac{15}{16} = \frac{\overset{1}{\cancel{2}}}{1} \cdot \frac{15}{\underset{8}{\cancel{16}}} = \frac{15}{8} = 1\frac{7}{8} \text{ yd}^2$$

47. Area = length • width

$$= 4 \cdot \frac{7}{8} = \frac{\overset{1}{\cancel{4}}}{1} \cdot \frac{7}{\underset{2}{\cancel{8}}} = \frac{7}{2} = 3\frac{1}{2} \text{ mi}^2$$

48. Area = length • width

$$= 7 \cdot \frac{3}{4} = \frac{7}{1} \cdot \frac{3}{4} = \frac{21}{4} = 5\frac{1}{4} \text{ mi}^2$$

49.

Sunny Side Soccer Park	**Creekside Soc. Park**
Area = length • width	Area = length • width
$= \frac{1}{4} \cdot \frac{3}{16}$	$= \frac{3}{8} \cdot \frac{1}{8}$
$= \frac{3}{64} \text{ mi}^2$	$= \frac{3}{64} \text{ mi}^2$

They are both the same size.

50.

Rocking Horse Ranch	**Silver Spur Ranch**
Area = length • width	Area = length • width
$= \frac{3}{4} \cdot \frac{2}{3}$	$= \frac{5}{8} \cdot \frac{4}{5}$
$= \frac{\overset{1}{\cancel{3}} \cdot \overset{1}{\cancel{2}}}{\underset{2}{\cancel{4}} \cdot \underset{1}{\cancel{3}}} = \frac{1}{2} \text{ mi}^2$	$= \frac{\overset{1}{\cancel{5}} \cdot \overset{1}{\cancel{4}}}{\underset{2}{\cancel{8}} \cdot \underset{1}{\cancel{5}}} = \frac{1}{2} \text{ mi}^2$

Neither ranch is larger in area. They are both the same size.

51. $4000 + 2000 + 1000 + 800 + 400 + 200 + 100 + 80 = \underline{8580 \text{ supermarkets}}$
The estimate of the total number of supermarkets in these states is 8580.

52. $3753 + 2202 + 1349 + 826 + 441 + 163 + 98 + 80 = \underline{8912 \text{ supermarkets}}$, which is the exact total number of supermarkets in these states.

53. An estimate of the number of supermarkets in medium to large population areas in New York is

$$\frac{4}{5} \cdot 2000 = \frac{4}{\underset{1}{\cancel{5}}} \cdot \frac{\overset{400}{\cancel{2000}}}{1} = 1600.$$

The exact value is

$$\frac{4}{5} \cdot 2202 = \frac{4}{5} \cdot \frac{2202}{1} = \frac{8808}{5} = 1761\frac{3}{5}.$$

Rounding gives us 1762 supermarkets.

54. An estimate of the number of supermarkets in New Hampshire which are in shopping centers, is

$$\frac{3}{8} \cdot 200 = \frac{3}{\underset{1}{\cancel{8}}} \cdot \frac{\overset{25}{\cancel{200}}}{1} = 75.$$

The exact value is

$$\frac{3}{8} \cdot 163 = \frac{3}{8} \cdot \frac{163}{1} = \frac{489}{8} = 61\frac{1}{8}.$$

Rounding gives us 61 supermarkets.

55. We need a multiple of 5 with *two* nonzero digits that is close to 2202. A reasonable choice is 2200 and an estimate is

$$\frac{4}{5} \cdot 2200 = \frac{4}{\underset{1}{\cancel{5}}} \cdot \frac{\overset{440}{\cancel{2200}}}{1} = 1760 \text{ supermarkets.}$$

This value is closer to the exact value because using 2200 as a rounded guess is closer to 2202 than using 2000 as a rounded guess.

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56. We need a multiple of 8 with *two* nonzero digits that is close to 163. A reasonable choice is 160 and an estimate is

$$\frac{3}{8} \cdot 160 = \frac{3}{\cancel{8}_{1}} \cdot \frac{\overset{20}{\cancel{160}}}{1} = 60 \text{ supermarkets.}$$

This value is closer to the exact value because using 160 as a rounded guess is closer to 163 than using 200 as a rounded guess.

2.6 Applications of Multiplication

2.6 Margin Exercises

1. **(a)** *Step 1*
The problem asks us to find the amount of money they can save in a year.

Step 2
Find the amount they can save by multiplying $\frac{3}{8}$ and 81,576.

Step 3
We can estimate this amount using $\frac{1}{2}$ and 82,000.

$$\frac{1}{2} \cdot 82{,}000 = \frac{1}{\cancel{2}_{1}} \cdot \frac{\overset{41{,}000}{\cancel{82{,}000}}}{1} = \underline{41{,}000}$$

Step 4
Now solve the problem using the original values.

$$\frac{3}{8} \cdot 81{,}576 = \frac{3}{\cancel{8}_{1}} \cdot \frac{\overset{10{,}197}{\cancel{81{,}576}}}{1} = \underline{30{,}591}$$

Step 5
They can save $30,591 in a year.

Step 6
The answer is reasonably close to our estimate.

(b) *Step 1*
The problem asks us to find the amount of money she will receive as retirement income.

Step 2
To find her retirement income, multiply $\frac{5}{8}$ and $62,504.

Step 3
We can estimate this amount using $\frac{1}{2}$ and 63,000.

$$\frac{1}{2} \cdot 63{,}000 = \frac{1}{\cancel{2}_{1}} \cdot \frac{\overset{31{,}500}{\cancel{63{,}000}}}{1} = 31{,}500$$

Step 4
Now solve the problem using the original values.

$$\frac{5}{8} \cdot 62{,}504 = \frac{5}{\cancel{8}_{1}} \cdot \frac{\overset{7813}{\cancel{62{,}504}}}{1} = 39{,}065$$

Step 5
She will receive $39,065 as retirement income.

Step 6
The answer is reasonably close to our estimate.

2. *Step 1*
The problem asks for the number of prescriptions paid for by a third party.

Step 2
A third party pays for $\frac{5}{16}$ of the total number of prescriptions, 3696.

Step 3
An estimate is $\frac{1}{4} \cdot 4000 = \frac{1}{\cancel{4}_{1}} \cdot \frac{\overset{1000}{\cancel{4000}}}{1} = 1000.$

Step 4
The exact value is

$$\frac{5}{16} \cdot 3696 = \frac{5}{\cancel{16}_{1}} \cdot \frac{\overset{231}{\cancel{3696}}}{1} = 1155.$$

Step 5
A third party pays for 1155 prescriptions.

Step 6
The answer is reasonably close to our estimate.

3. *Step 1*
The problem asks for the fraction of students who speak Spanish.

Step 2
$\frac{3}{4}$ of the $\frac{1}{3}$ of the students who speak a foreign language, speak Spanish.

Step 3
An estimate is $\frac{3}{4} \cdot \frac{1}{3} = \frac{\overset{1}{\cancel{3}}}{4} \cdot \frac{1}{\underset{1}{\cancel{3}}} = \frac{1}{4}.$

Step 4
The exact value is $\frac{1}{4}$, which is the same as the estimate since we didn't round.

Step 5
The fraction of students who speak Spanish is $\frac{1}{4}$.

Step 6
The answer, $\frac{1}{4}$, matches our estimate.

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4. **(a)** From the circle graph, the fraction is $\frac{1}{5}$.

(b) Multiply $\frac{1}{5}$ by the number of people in the survey, 2500. Since we can estimate the answer using the exact values, our estimated answer will be the same as the exact answer.

$$\frac{1}{5} \cdot 2500 = \frac{1}{\cancel{5}_{1}} \cdot \frac{\overset{500}{\cancel{2500}}}{1} = \frac{500}{1} = \underline{500}$$

500 children buy food from vending machines.

(c) From the circle graph, the fraction is $\frac{1}{10}$.

(d) Multiply $\frac{1}{10}$ by 2500. Since we can estimate the answer using the exact values, our estimated answer will be the same as the exact answer.

$$\frac{1}{10} \cdot 2500 = \frac{1}{\cancel{10}_{1}} \cdot \frac{\overset{250}{\cancel{2500}}}{1} = \frac{250}{1} = 250$$

250 children buy food from a convenience store or street vendor.

2.6 Section Exercises

1. The words that are indicator words for multiplication are *of*, *times*, *twice*, *triple*, *product*, and *twice as much*.

2. The final step when solving an application problem is to <u>check your work</u>.

3. When you multiply length by width you are finding the <u>area</u> of a rectangular surface.

4. When calculating area, the length and the width must be in the same units of measurement. If the measurements are both in miles, the answer will be in <u>square</u> miles and shown as mi^2.

5. Multiply the length and the width.

$$\frac{3}{4} \cdot \frac{2}{3} = \frac{\overset{1}{\cancel{3}} \cdot \overset{1}{\cancel{2}}}{\underset{2}{\cancel{4}} \cdot \underset{1}{\cancel{3}}} = \frac{1}{2}$$

The area of the digital photo frame is $\frac{1}{2}$ ft^2.

6. Multiply the length and width.

$$\frac{14}{15} \cdot \frac{3}{4} = \frac{\overset{7}{\cancel{14}} \cdot \overset{1}{\cancel{3}}}{\underset{5}{\cancel{15}} \cdot \underset{2}{\cancel{4}}} = \frac{7}{10}$$

The area of the floor is $\frac{7}{10}$ yd^2.

7. Multiply the length and the width.

$$\frac{4}{3} \cdot \frac{2}{3} = \frac{8}{9}$$

The area of the cookie sheet is $\frac{8}{9}$ ft^2.

8. Multiply $\frac{2}{5}$ by 16,000,000.

$$\frac{2}{5} \cdot 16{,}000{,}000 = \frac{2}{\cancel{5}_{1}} \cdot \frac{\overset{3{,}200{,}000}{\cancel{16{,}000{,}000}}}{1} = 6{,}400{,}000$$

6,400,000 people who shop at flea markets on a daily basis purchase produce.

9. Multiply the length and the width.

$$\frac{4}{5} \cdot \frac{3}{8} = \frac{\overset{1}{\cancel{4}} \cdot 3}{5 \cdot \underset{2}{\cancel{8}}} = \frac{3}{10}$$

The area of the top of the table is $\frac{3}{10}$ yd^2.

10. Multiply the number of bowls by the fraction eaten in the summer months.

$$\frac{3}{10} \cdot 160 = \frac{3}{\cancel{10}_{1}} \cdot \frac{\overset{16}{\cancel{160}}}{1} = 48$$

The average person consumes 48 bowls of cereal in the summer months.

11. Multiply $\frac{3}{8}$ by 6848.

$$\frac{3}{8} \cdot 6848 = \frac{3}{\cancel{8}_{1}} \cdot \frac{\overset{856}{\cancel{6848}}}{1} = 2568$$

He earned \$2568 on his job.

12. Multiply $\frac{3}{8}$ by 400.

$$\frac{3}{8} \cdot 400 = \frac{3}{\cancel{8}_{1}} \cdot \frac{\overset{50}{\cancel{400}}}{1} = 150$$

The average household does 150 loads of wash in the winter months.

13. Multiply the daily parking fee by the fraction.

$$40 \cdot \frac{7}{8} = \frac{\overset{5}{\cancel{40}}}{1} \cdot \frac{7}{\underset{1}{\cancel{8}}} = 35$$

The daily parking fee in Boston is \$35.

14. Multiply the daily parking fee by the fraction.

$$35 \cdot \frac{4}{5} = \frac{\overset{7}{\cancel{35}}}{1} \cdot \frac{4}{\underset{1}{\cancel{5}}} = 28$$

The daily parking fee in San Francisco is \$28.

15. **(a)** $\frac{7}{12}$ of the 1560 runners are women.

$$\frac{7}{12} \cdot 1560 = \frac{7 \cdot \overset{130}{\cancel{1560}}}{\underset{1}{\cancel{12}} \cdot 1} = 910$$

910 runners are women.

(b) The number of runners that are men is

$$1560 - 910 = 650.$$

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16. **(a)** Multiply the fraction of nonsmoking rooms by the number of rooms.

$$\frac{9}{17} \cdot 408 = \frac{9}{\cancel{17}_{1}} \cdot \frac{\overset{24}{\cancel{408}}}{1} = 216$$

There are 216 nonsmoking rooms.

(b) The number of smoking rooms is

$$408 - 216 = 192.$$

17. The smallest sector of the circle graph is the *4 hours* group, so this response was given by the least number of people. To find how many people gave this response, multiply $\frac{3}{20}$ by the total number of people, 1020.

$$\frac{3}{20} \cdot 1020 = \frac{3 \cdot \overset{51}{\cancel{1020}}}{\cancel{20}_{1} \cdot 1} = 153$$

153 people gave this response.

18. The largest sector of the circle graph is the *2 hours or less* group, so this response was given by the greatest number of people. To find how many people gave this response, multiply $\frac{3}{5}$ by the total number of people, 1020.

$$\frac{3}{5} \cdot 1020 = \frac{3 \cdot \overset{204}{\cancel{1020}}}{\cancel{5}_{1} \cdot 1} = 612$$

612 people gave this response.

19. The only group that is *not* willing to wait 4 hours or less is the *8 hours* group, and the fraction corresponding to that group is $\frac{1}{4}$. Thus, the fraction willing to wait 4 hours or less is

$$1 - \tfrac{1}{4} = \tfrac{4}{4} - \tfrac{1}{4} = \tfrac{3}{4}.$$

The total number of people willing to wait 4 hours or less is

$$\frac{3}{4} \cdot 1020 = \frac{3 \cdot \overset{255}{\cancel{1020}}}{\cancel{4}_{1} \cdot 1} = 765.$$

20. The only group that is *not* willing to wait 4 hours or more is the *2 hours or less* group, and the fraction corresponding to that group is $\frac{3}{5}$. Thus, the fraction willing to wait 4 hours or more is

$$1 - \tfrac{3}{5} = \tfrac{5}{5} - \tfrac{3}{5} = \tfrac{2}{5}.$$

The total number of people willing to wait 4 hours or more is

$$\frac{2}{5} \cdot 1020 = \frac{2 \cdot \overset{204}{\cancel{1020}}}{\cancel{5}_{1} \cdot 1} = 408.$$

21. Because everyone is included and fractions are given for *all* groups, the sum of the fractions must be *1*, or *all* of the people.

22. Answers will vary. Some possibilities are

1. You made an addition error.
2. The fractions on the circle graph are incorrect.
3. The fraction errors were caused by rounding.

23. Add the income for all twelve months to find the income for the year.

$$6075 + 5812 + 6488 + 6030 + 5820 + 6398 + 7040 + 5232 + 5670 + 7012 + 6465 + 7958 = 76{,}000$$

The Owens family had income of $76,000 for the year.

24. Multiply the fraction $\frac{1}{4}$ by the total income ($76,000).

$$\frac{1}{4} \cdot 76{,}000 = \frac{1}{\cancel{4}_{1}} \cdot \frac{\overset{19{,}000}{\cancel{76{,}000}}}{1} = 19{,}000$$

Their taxes were $19,000.

25. From Exercise 23, the total income is $76,000. The circle graph shows that $\frac{1}{5}$ of the income is for rent.

$$\frac{1}{5} \cdot 76{,}000 = \frac{1}{\cancel{5}_{1}} \cdot \frac{\overset{15{,}200}{\cancel{76{,}000}}}{1} = 15{,}200$$

The amount of their rent is $15,200.

26. Multiply the fraction $\frac{5}{16}$ by the total income.

$$\frac{5}{16} \cdot 76{,}000 = \frac{5}{\cancel{16}_{1}} \cdot \frac{\overset{4750}{\cancel{76{,}000}}}{1} = 23{,}750$$

They spent $23,750 on food.

27. Multiply the total income by the fraction saved.

$$\frac{1}{16} \cdot 76{,}000 = \frac{1}{\cancel{16}_{1}} \cdot \frac{\overset{4750}{\cancel{76{,}000}}}{1} = 4750$$

The Owens family saved $4750 for the year.

28. Multiply the fraction $\frac{1}{8}$ by the total income.

$$\frac{1}{8} \cdot 76{,}000 = \frac{1}{\cancel{8}_{1}} \cdot \frac{\overset{9500}{\cancel{76{,}000}}}{1} = 9500$$

They spent $9500 on clothing.

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29. The error was made when dividing 21 by 3 and writing 3 instead of 7. The correct solution is

$$\frac{9}{10} \times \frac{20}{21} = \frac{\overset{3}{\cancel{9}}}{\underset{1}{\cancel{10}}} \times \frac{\overset{2}{\cancel{20}}}{\underset{7}{\cancel{21}}} = \frac{6}{7}.$$

30. Yes, the statements are true. Since whole numbers are 1 or greater, when you multiply, the product will always be greater than either of the numbers multiplied. But, when you multiply two proper fractions, you are finding a fractional part of a fraction, and the product will be smaller than either of the two proper fractions.

31. Multiply the cost in the United States by $\frac{3}{8}$.

$$2000 \cdot \frac{3}{8} = \frac{\overset{250}{\cancel{2000}}}{1} \cdot \frac{3}{\underset{1}{\cancel{8}}} = 750$$

The cost of laser eye surgery for one eye in Thailand is $750.

32. Multiply the cost in the United States by $\frac{3}{50}$.

$$36{,}300 \cdot \frac{3}{50} = \frac{\overset{726}{\cancel{36{,}300}}}{1} \cdot \frac{3}{\underset{1}{\cancel{50}}} = 2178$$

The cost of a knee replacement in Mexico is $2178.

33. We want $\frac{1}{128}$ of the actual length.

$$\frac{1}{128} \cdot 256 = \frac{1}{\underset{1}{\cancel{128}}} \cdot \frac{\overset{2}{\cancel{256}}}{1} = 2$$

The length of the scale model is 2 feet.

34. First multiply $\frac{1}{10}$ and 10,000 to find the number of pounds saved.

$$\frac{1}{10} \cdot 10{,}000 = \frac{1}{\underset{1}{\cancel{10}}} \cdot \frac{\overset{1000}{\cancel{10{,}000}}}{1} = 1000$$

To find the weight of the test truck, subtract:

$$10{,}000 - 1000 = 9000 \text{ pounds.}$$

The test truck weighs 9000 pounds.

35. First multiply $\frac{2}{3}$ and 27,000 to find the number of her votes from senior citizens.

$$\frac{2}{3} \cdot 27{,}000 = \frac{2}{\underset{1}{\cancel{3}}} \cdot \frac{\overset{9000}{\cancel{27{,}000}}}{1} = 18{,}000$$

To find the votes needed from voters other than the senior citizens, subtract:

$$27{,}000 - 18{,}000 = 9000 \text{ votes.}$$

She needs 9000 votes from voters other than the senior citizens.

36. Multiply the fraction $\frac{5}{16}$ by the cost ($24,400).

$$\frac{5}{16} \cdot 24{,}400 = \frac{5}{\underset{1}{\cancel{16}}} \cdot \frac{\overset{1525}{\cancel{24{,}400}}}{1} = 7625$$

To find the amount borrowed in the first years, subtract:

$$\$24{,}400 - \$7625 = \$16{,}775$$

$16,775 was borrowed in the first years.

37. Multiply the remaining $\frac{1}{8}$ of the estate by the fraction going to the American Cancer Society.

$$\frac{1}{4} \cdot \frac{1}{8} = \frac{1}{32}$$

$\frac{1}{32}$ of the estate goes to the American Cancer Society.

38. Multiply the remaining $\frac{3}{5}$ of their total investments by the fraction invested in bonds.

$$\frac{3}{5} \cdot \frac{1}{3} = \frac{\overset{1}{\cancel{3}}}{5} \cdot \frac{1}{\underset{1}{\cancel{3}}} = \frac{1}{5}$$

The couple invested $\frac{1}{5}$ of their total investment in bonds.

2.7 Dividing Fractions

2.7 Margin Exercises

1. **(a)** $\frac{4}{5} \times \frac{5}{4}$; The reciprocal of $\frac{4}{5}$ is $\frac{5}{4}$ because

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

(b) $\frac{3}{8} \times \frac{8}{3}$; The reciprocal of $\frac{3}{8}$ is $\frac{8}{3}$ because

$$\frac{3}{8} \cdot \frac{8}{3} = \frac{24}{24} = 1.$$

(c) The reciprocal of $\frac{9}{4}$ is $\frac{4}{9}$ because

$$\frac{9}{4} \cdot \frac{4}{9} = \frac{36}{36} = 1.$$

(d) The reciprocal of 16 is $\frac{1}{16}$ because

$$\frac{16}{1} \cdot \frac{1}{16} = \frac{16}{16} = 1.$$

2. **(a)** $\frac{1}{4} \div \frac{2}{3} = \frac{1}{4} \cdot \frac{3}{2} = \frac{1 \cdot 3}{4 \cdot 2} = \frac{3}{8}$

(b) $\frac{3}{8} \div \frac{5}{8} = \frac{3}{8} \cdot \frac{8}{5} = \frac{3 \cdot \overset{1}{\cancel{8}}}{\underset{1}{\cancel{8}} \cdot 5} = \frac{3}{5}$

(c) $\dfrac{\frac{2}{3}}{\frac{4}{5}} = \frac{2}{3} \div \frac{4}{5} = \frac{\overset{1}{\cancel{2}}}{3} \cdot \frac{5}{\underset{2}{\cancel{4}}} = \frac{1 \cdot 5}{3 \cdot 2} = \frac{5}{6}$

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(d) $\dfrac{\frac{5}{6}}{\frac{7}{12}} = \frac{5}{6} \div \frac{7}{12}$

$$= \frac{5}{\cancel{6}_{1}} \cdot \frac{\overset{2}{\cancel{12}}}{7} = \frac{5 \cdot 2}{1 \cdot 7} = \frac{10}{7} = 1\frac{3}{7}$$

3. **(a)** $10 \div \frac{1}{2} = 10 \cdot \frac{2}{1} = \frac{10}{1} \cdot \frac{2}{1} = 20$

(b) $6 \div \frac{6}{7} = \frac{6}{1} \div \frac{6}{7} = \frac{\overset{1}{\cancel{6}}}{1} \cdot \frac{7}{\cancel{6}_{1}} = 7$

(c) $\frac{4}{5} \div 6 = \frac{4}{5} \div \frac{6}{1} = \frac{\overset{2}{\cancel{4}}}{5} \cdot \frac{1}{\cancel{6}_{3}} = \frac{2 \cdot 1}{5 \cdot 3} = \frac{2}{15}$

(d) $\frac{3}{8} \div 4 = \frac{3}{8} \div \frac{4}{1} = \frac{3}{8} \cdot \frac{1}{4} = \frac{3 \cdot 1}{8 \cdot 4} = \frac{3}{32}$

4. **(a)** *Step 1*
The problem asks for the number of $\frac{5}{6}$-ounce dispensers that can be filled using 40 ounces of eye drops.

Step 2
Divide the total number of ounces of eye drops by the fraction of an ounce each dispenser holds.

Step 3
An estimate is $40 \div 1 = 40$.

Step 4
Solving gives us

$$40 \div \frac{5}{6} = \frac{40}{1} \div \frac{5}{6}$$

$$= \frac{\overset{8}{\cancel{40}}}{1} \cdot \frac{6}{\cancel{5}_{1}} = \frac{8 \cdot 6}{1 \cdot 1} = \frac{48}{1} = 48$$

Step 5
$48\ \frac{5}{6}$-ounce dispensers can be filled.

Step 6
The answer is reasonably close to our estimate.

(b) *Step 1*
The problem asks for the number of $\frac{4}{5}$-quart bottles that can be filled from a 120-quart cask.

Step 2
Divide the total number of quarts in the cask by the size of the bottles.

Step 3
An estimate is $120 \div 1 = 120$.

Step 4
Solving gives us

$$120 \div \frac{4}{5} = \frac{120}{1} \div \frac{4}{5}$$

$$= \frac{\overset{30}{\cancel{120}}}{1} \cdot \frac{5}{\cancel{4}_{1}} = \frac{30 \cdot 5}{1 \cdot 1} = \frac{150}{1} = 150$$

Step 5
$150\ \frac{4}{5}$-quart bottles can be filled.

Step 6
The answer is reasonably close to our estimate.

5. **(a)** *Step 1*
The problem asks for the fraction of the bonus money that each employee will receive.

Step 2
Divide the fraction of the bonus money, $\frac{3}{4}$, by the number of employees, 12.

Step 3
An estimate is $1 \div 12 = \frac{1}{12}$.

Step 4
Solving gives us

$$\frac{3}{4} \div 12 = \frac{3}{4} \div \frac{12}{1} = \frac{\overset{1}{\cancel{3}}}{4} \cdot \frac{1}{\cancel{12}_{4}} = \frac{1 \cdot 1}{4 \cdot 4} = \frac{1}{16}$$

Step 5
Each employee will receive $\frac{1}{16}$ of the bonus money.

Step 6
The answer is reasonably close to our estimate.

(b) *Step 1*
The problem asks for the fraction of the prize money that each employee will receive.

Step 2
Since they donate $\frac{1}{5}$ of the winnings, they have

$$1 - \tfrac{1}{5} = \tfrac{5}{5} - \tfrac{1}{5} = \tfrac{4}{5}$$

of the winnings left to divide. Divide the fraction of the winnings that remain, $\frac{4}{5}$, by the number of employees, 8.

Step 3
An estimate is $1 \div 8 = \frac{1}{8}$.

Step 4
Solving gives us

$$\frac{4}{5} \div 8 = \frac{4}{5} \div \frac{8}{1} = \frac{\overset{1}{\cancel{4}}}{5} \cdot \frac{1}{\cancel{8}_{2}} = \frac{1}{10}$$

Step 5
Each employee will receive $\frac{1}{10}$ of the prize money.

Step 6
The answer is reasonably close to our estimate.

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2.7 Section Exercises

1. When you invert or flip a fraction, you have the reciprocal of the fraction.

2. To find the reciprocal of a whole number, you must first write the whole number over 1, and then invert it.

3. To divide by a fraction, you must first invert the divisor and then change division to multiplication.

4. After completing a fraction division problem, it is best to write the answer in lowest terms.

5. The reciprocal of $\frac{3}{8}$ is $\frac{8}{3}$ because $\frac{3}{8} \cdot \frac{8}{3} = \frac{24}{24} = 1$.

6. The reciprocal of $\frac{2}{5}$ is $\frac{5}{2}$ because $\frac{2}{5} \cdot \frac{5}{2} = \frac{10}{10} = 1$.

7. The reciprocal of $\frac{5}{6}$ is $\frac{6}{5}$ because $\frac{5}{6} \cdot \frac{6}{5} = \frac{30}{30} = 1$.

8. The reciprocal of $\frac{12}{7}$ is $\frac{7}{12}$ because

$$\frac{12}{7} \cdot \frac{7}{12} = \frac{84}{84} = 1.$$

9. The reciprocal of $\frac{8}{5}$ is $\frac{5}{8}$ because $\frac{8}{5} \cdot \frac{5}{8} = \frac{40}{40} = 1$.

10. The reciprocal of $\frac{13}{20}$ is $\frac{20}{13}$ because

$$\frac{13}{20} \cdot \frac{20}{13} = \frac{260}{260} = 1.$$

11. The reciprocal of 4 is $\frac{1}{4}$ because $\frac{4}{1} \cdot \frac{1}{4} = \frac{4}{4} = 1$.

12. The reciprocal of 10 is $\frac{1}{10}$ because

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

13. $\frac{1}{2} \div \frac{3}{4} = \frac{1}{\cancel{2}_{1}} \cdot \frac{\cancel{4}^{2}}{3} = \frac{2}{3}$

14. $\frac{5}{8} \div \frac{7}{8} = \frac{5}{\cancel{8}_{1}} \cdot \frac{\cancel{8}^{1}}{7} = \frac{5}{7}$

15. $\frac{7}{8} \div \frac{1}{3} = \frac{7}{8} \cdot \frac{3}{1} = \frac{21}{8} = 2\frac{5}{8}$

16. $\frac{7}{8} \div \frac{3}{4} = \frac{7}{\cancel{8}_{2}} \cdot \frac{\cancel{4}^{1}}{3} = \frac{7}{6} = 1\frac{1}{6}$

17. $\frac{3}{4} \div \frac{5}{3} = \frac{3}{4} \cdot \frac{3}{5} = \frac{9}{20}$

18. $\frac{4}{5} \div \frac{9}{4} = \frac{4}{5} \cdot \frac{4}{9} = \frac{16}{45}$

19. $\frac{7}{9} \div \frac{7}{36} = \frac{\cancel{7}^{1}}{\cancel{9}_{1}} \cdot \frac{\cancel{36}^{4}}{\cancel{7}_{1}} = \frac{4}{1} = 4$

20. $\frac{5}{8} \div \frac{5}{16} = \frac{\cancel{5}^{1}}{\cancel{8}_{1}} \cdot \frac{\cancel{16}^{2}}{\cancel{5}_{1}} = 2$

21. $\frac{15}{32} \div \frac{5}{64} = \frac{\cancel{15}^{3}}{\cancel{32}_{1}} \cdot \frac{\cancel{64}^{2}}{\cancel{5}_{1}} = \frac{6}{1} = 6$

22. $\frac{7}{12} \div \frac{14}{15} = \frac{\cancel{7}^{1}}{\cancel{12}_{4}} \cdot \frac{\cancel{15}^{5}}{\cancel{14}_{2}} = \frac{5}{8}$

23. $\frac{\frac{13}{20}}{\frac{4}{5}} = \frac{13}{20} \div \frac{4}{5} = \frac{13}{\cancel{20}_{4}} \cdot \frac{\cancel{5}^{1}}{4} = \frac{13}{16}$

24. $\frac{\frac{9}{10}}{\frac{3}{5}} = \frac{9}{10} \div \frac{3}{5} = \frac{\cancel{9}^{3}}{\cancel{10}_{2}} \cdot \frac{\cancel{5}^{1}}{\cancel{3}_{1}} = \frac{3}{2} = 1\frac{1}{2}$

25. $\frac{\frac{5}{6}}{\frac{25}{24}} = \frac{5}{6} \div \frac{25}{24} = \frac{\cancel{5}^{1}}{\cancel{6}_{1}} \cdot \frac{\cancel{24}^{4}}{\cancel{25}_{5}} = \frac{4}{5}$

26. $\frac{\frac{28}{15}}{\frac{21}{5}} = \frac{28}{15} \div \frac{21}{5} = \frac{\cancel{28}^{4}}{\cancel{15}_{3}} \cdot \frac{\cancel{5}^{1}}{\cancel{21}_{3}} = \frac{4}{9}$

27. $12 \div \frac{2}{3} = \frac{12}{1} \div \frac{2}{3} = \frac{\cancel{12}^{6}}{1} \cdot \frac{3}{\cancel{2}_{1}} = \frac{18}{1} = 18$

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

29. $\frac{18}{\frac{3}{4}} = 18 \div \frac{3}{4} = \frac{18}{1} \div \frac{3}{4} = \frac{\cancel{18}^{6}}{1} \cdot \frac{4}{\cancel{3}_{1}} = 24$

30. $\frac{12}{\frac{3}{4}} = 12 \div \frac{3}{4} = \frac{12}{1} \div \frac{3}{4} = \frac{\cancel{12}^{4}}{1} \cdot \frac{4}{\cancel{3}_{1}} = 16$

31. $\frac{\frac{4}{7}}{8} = \frac{4}{7} \div 8 = \frac{4}{7} \div \frac{8}{1} = \frac{\cancel{4}^{1}}{7} \cdot \frac{1}{\cancel{8}_{2}} = \frac{1}{14}$

32. $\frac{\frac{7}{10}}{3} = \frac{7}{10} \div 3 = \frac{7}{10} \div \frac{3}{1} = \frac{7}{10} \cdot \frac{1}{3} = \frac{7}{30}$

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33. $\frac{8}{9}$ of a quart divided into 4 parts:

$$\frac{8}{9} \div 4 = \frac{8}{9} \div \frac{4}{1} = \frac{\overset{2}{\cancel{8}}}{9} \cdot \frac{1}{\underset{1}{\cancel{4}}} = \frac{2}{9}$$

Each horse will get $\frac{2}{9}$ of a quart.

34. Divide the number of quarts of shampoo by the fraction of a quart each container holds.

$$15 \div \frac{3}{8} = \frac{\overset{5}{\cancel{15}}}{1} \cdot \frac{8}{\underset{1}{\cancel{3}}} = 40$$

Harold can fill 40 containers.

35. Divide the total number of cups by the size of the measuring cup.

$$5 \div \frac{1}{3} = \frac{5}{1} \div \frac{1}{3} = \frac{5}{1} \cdot \frac{3}{1} = 15$$

They need to fill the measuring cup 15 times.

36. Divide the total number of pounds of jelly beans by the size of the bag.

$$408 \div \frac{3}{8} = \frac{408}{1} \div \frac{3}{8} = \frac{\overset{136}{\cancel{408}}}{1} \cdot \frac{8}{\underset{1}{\cancel{3}}} = 1088$$

1088 $\frac{3}{8}$-pound bags can be filled.

37. Divide the total number of ounces of eye drops by the fraction of an ounce each dispenser holds.

$$11 \div \frac{1}{8} = \frac{11}{1} \div \frac{1}{8} = \frac{11}{1} \cdot \frac{8}{1} = 88$$

88 dispensers can be filled.

38. Divide the number of pounds of peanuts by the fraction of pounds of peanuts each person will likely eat.

$$10 \div \frac{5}{16} = \frac{\overset{2}{\cancel{10}}}{1} \cdot \frac{16}{\underset{1}{\cancel{5}}} = 32$$

32 guests can be served with 10 pounds of peanuts.

39. Divide the total weight of a carton by the weight per fastener.

$$25 \div \frac{5}{32} = \frac{\overset{5}{\cancel{25}}}{1} \cdot \frac{32}{\underset{1}{\cancel{5}}} = \frac{160}{1} = 160$$

There are 160 $\frac{5}{32}$-pound fasteners in each carton.

40. Divide the total acreage by the acreage per lot.

$$210 \div \frac{3}{4} = \frac{\overset{70}{\cancel{210}}}{1} \cdot \frac{4}{\underset{1}{\cancel{3}}} = \frac{280}{1} = 280$$

There are 280 $\frac{3}{4}$-acre lots in the subdivision.

41. Answers will vary. A sample answer follows:

You can divide two fractions by multiplying the first fraction by the reciprocal of the second fraction (divisor).

42. Sometimes the answer is less and sometimes it is greater.

$$\frac{1}{4} \div \frac{7}{8} = \frac{1}{\underset{1}{\cancel{4}}} \cdot \frac{\overset{2}{\cancel{8}}}{7} = \frac{2}{7} \quad \text{(less than } \tfrac{7}{8}\text{, but not less than } \tfrac{1}{4}\text{)}$$

$$\frac{1}{2} \div \frac{1}{4} = \frac{1}{\underset{1}{\cancel{2}}} \cdot \frac{\overset{2}{\cancel{4}}}{1} = \frac{2}{1} = 2 \quad \text{(greater)}$$

43. Each loafcake requires $\frac{3}{4}$ pound of jellybeans, so to make 16 loafcakes, use multiplication.

$$\frac{3}{4} \cdot 16 = \frac{3}{\underset{1}{\cancel{4}}} \cdot \frac{\overset{4}{\cancel{16}}}{1} = 12$$

12 pounds will be needed.

44. We want $\frac{7}{8}$ of 1520 patients—use multiplication.

$$\frac{7}{8} \cdot 1520 = \frac{7}{\underset{1}{\cancel{8}}} \cdot \frac{\overset{190}{\cancel{1520}}}{1} = \frac{1330}{1} = 1330$$

1330 patients were still taking their drugs.

45. Divide the 156 cans of compound by the fraction of a can needed for each new home.

$$156 \div \frac{3}{4} = \frac{156}{1} \cdot \frac{4}{3} = \frac{\overset{52}{\cancel{156}}}{1} \cdot \frac{4}{\underset{1}{\cancel{3}}} = 208$$

208 homes can be plumbed.

46. Divide the 50 gallons of differential fluid by the fraction of a gallon needed for each car serviced.

$$50 \div \frac{2}{3} = \frac{50}{1} \cdot \frac{3}{2} = \frac{\overset{25}{\cancel{50}}}{1} \cdot \frac{3}{\underset{1}{\cancel{2}}} = 75$$

75 cars can be serviced.

47. **(a)** In $\frac{2}{3}$ of the 186 visits, doctors failed to discuss the issues—use multiplication.

$$\frac{2}{3} \cdot 186 = \frac{2}{\underset{1}{\cancel{3}}} \cdot \frac{\overset{62}{\cancel{186}}}{1} = 124$$

The doctors failed to discuss the issues in 124 visits.

(b) The doctors *did* discuss the issues in $186 - 124 = 62$ visits.

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48. **(a)** $\frac{4}{5}$ of the 285 miles have been completed—use multiplication.

$$\frac{4}{5} \cdot 285 = \frac{4}{\cancel{5}_{1}} \cdot \frac{\overset{57}{\cancel{285}}}{1} = 228$$

He has gone 228 miles.

(b) The number of miles that remain is $285 - 228 = 57$ miles.

49. Divide the 912 yards of fabric by the fraction of a yard needed for each dish towel.

$$912 \div \frac{3}{8} = \frac{912}{1} \cdot \frac{8}{3} = \frac{\overset{304}{\cancel{912}}}{1} \cdot \frac{8}{\cancel{3}_{1}} = 2432$$

2432 towels can be made.

50. Multiply the number of applicants by the fraction of jobs available per applicant.

$$300 \cdot \frac{1}{60} = \frac{\overset{5}{\cancel{300}}}{1} \cdot \frac{1}{\cancel{60}_{1}} = 5$$

There are 5 job openings.

51. The indicator words for multiplication are underlined below.

more than	per
double	twice
times	product
less than	difference
equals	twice as much

52. The indicator words for division are underlined below.

fewer	sum of
goes into	divide
per	quotient
equals	double
loss of	divided by

53. To divide two fractions, multiply the first fraction by the reciprocal of the second fraction.

54. The reciprocal of $\frac{3}{4}$ is $\frac{4}{3}$ because $\frac{3}{4} \cdot \frac{4}{3} = \frac{12}{12} = 1$.

The reciprocal of $\frac{7}{8}$ is $\frac{8}{7}$ because $\frac{7}{8} \cdot \frac{8}{7} = \frac{56}{56} = 1$.

The reciprocal of 5 is $\frac{1}{5}$ because $\frac{5}{1} \cdot \frac{1}{5} = \frac{5}{5} = 1$.

The reciprocal of $\frac{12}{19}$ is $\frac{19}{12}$ because

$$\frac{12}{19} \cdot \frac{19}{12} = \frac{228}{228} = 1.$$

55. **(a)** To find the perimeter of any flat equal-sided 3-, 4-, 5-, or 6-sided figure, multiply the length of one side by 3, 4, 5, or 6, respectively.

(b) The stamp has four sides, so multiply $\frac{15}{16}$ by 4.

$$\frac{15}{16} \times 4 = \frac{15}{\cancel{16}_{4}} \times \frac{\overset{1}{\cancel{4}}}{1} = \frac{15}{4} = 3\frac{3}{4} \text{ in.}$$

The perimeter of the stamp is $3\frac{3}{4}$ inches.

56. $\text{Area} = \text{length} \cdot \text{width}$

$$= \frac{15}{16} \cdot \frac{15}{16} = \frac{225}{256}$$

The area is $\frac{225}{256}$ in.^{2}. Multiply the length by the width to find the area of any rectangle.

2.8 Multiplying and Dividing Mixed Numbers

2.8 Margin Exercises

1. **(a)** $4\frac{2}{3}$

$4\frac{2}{3}$ ← 2 is more than $1\frac{1}{2}$.
$4\frac{2}{3}$ ← Half of 3 is $1\frac{1}{2}$.

$4\frac{2}{3}$ rounds up to 5.

(b) $3\frac{2}{5}$

$3\frac{2}{5}$ ← 2 is less than $2\frac{1}{2}$.
$3\frac{2}{5}$ ← Half of 5 is $2\frac{1}{2}$.

$3\frac{2}{5}$ rounds down to 3.

(c) $5\frac{3}{4}$

$5\frac{3}{4}$ ← 3 is more than 2.
$5\frac{3}{4}$ ← Half of 4 is 2.

$5\frac{3}{4}$ rounds up to 6.

(d) $4\frac{7}{12}$

$4\frac{7}{12}$ ← 7 is more than 6.
$4\frac{7}{12}$ ← Half of 12 is 6.

$4\frac{7}{12}$ rounds up to 5.

(e) $1\frac{1}{2}$

$1\frac{1}{2}$ ← 1 is the same as 1.
$1\frac{1}{2}$ ← Half of 2 is 1.

$1\frac{1}{2}$ rounds up to 2.

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(f) $8\frac{4}{9}$

$8\frac{4}{9}$ ← 4 is less than $4\frac{1}{2}$.
$8\frac{4}{9}$ ← Half of 9 is $4\frac{1}{2}$.

$8\frac{4}{9}$ rounds down to 8.

2. **(a)** $3\frac{1}{4} \cdot 6\frac{2}{3}$

Estimate: $3\frac{1}{4}$ rounds to 3. $6\frac{2}{3}$ rounds to 7.
$\underline{3} \cdot \underline{7} = \underline{21}$

Exact: $3\frac{1}{4} \cdot 6\frac{2}{3} = \frac{13}{\cancel{4}_{1}} \cdot \frac{\overset{5}{\cancel{20}}}{3} = \frac{65}{3} = 21\frac{2}{3}$

(b) $4\frac{2}{3} \cdot 2\frac{3}{4}$

Estimate: $4\frac{2}{3}$ rounds to 5. $2\frac{3}{4}$ rounds to 3.
$\underline{5} \cdot \underline{3} = \underline{15}$

Exact:

$$4\frac{2}{3} \cdot 2\frac{3}{4} = \frac{14}{3} \cdot \frac{11}{4} = \frac{\overset{7}{\cancel{14}}}{3} \cdot \frac{11}{\cancel{4}_{2}} = \frac{77}{6} = 12\frac{5}{6}$$

(c) $3\frac{3}{5} \cdot 4\frac{4}{9}$

Estimate: $3\frac{3}{5}$ rounds to 4. $4\frac{4}{9}$ rounds to 4.
$\underline{4} \cdot \underline{4} = \underline{16}$

Exact:

$$3\frac{3}{5} \cdot 4\frac{4}{9} = \frac{18}{5} \cdot \frac{40}{9} = \frac{\overset{2}{\cancel{18}}}{\cancel{5}_{1}} \cdot \frac{\overset{8}{\cancel{40}}}{\cancel{9}_{1}} = 16$$

(d) $5\frac{1}{4} \cdot 3\frac{3}{5}$

Estimate: $5\frac{1}{4}$ rounds to 5. $3\frac{3}{5}$ rounds to 4.
$\underline{5} \cdot \underline{4} = \underline{20}$

Exact:

$$5\frac{1}{4} \cdot 3\frac{3}{5} = \frac{21}{4} \cdot \frac{18}{5} = \frac{21}{\cancel{4}_{2}} \cdot \frac{\overset{9}{\cancel{18}}}{5} = \frac{189}{10} = 18\frac{9}{10}$$

3. **(a)** $3\frac{1}{8} \div 6\frac{1}{4}$

Estimate: $3\frac{1}{8}$ rounds to 3. $6\frac{1}{4}$ rounds to 6.
$\underline{3} \div \underline{6} = \underline{\frac{1}{2}}$

Exact:

$$3\frac{1}{8} \div 6\frac{1}{4} = \frac{25}{8} \div \frac{25}{4} = \frac{25}{8} \cdot \frac{4}{25} = \frac{\overset{1}{\cancel{25}}}{\cancel{8}_{2}} \cdot \frac{\overset{1}{\cancel{4}}}{\cancel{25}_{1}} = \frac{1}{2}$$

(b) $10\frac{1}{3} \div 2\frac{1}{2}$

Estimate: $10\frac{1}{3}$ rounds to 10. $2\frac{1}{2}$ rounds to 3.
$\underline{10} \div \underline{3} = \underline{3\frac{1}{3}}$

Exact:

$$10\frac{1}{3} \div 2\frac{1}{2} = \frac{31}{3} \div \frac{5}{2} = \frac{31}{3} \cdot \frac{2}{5} = \frac{62}{15} = 4\frac{2}{15}$$

(c) $8 \div 5\frac{1}{3}$

Estimate: 8 rounds to 8. $5\frac{1}{3}$ rounds to 5.
$\underline{8} \div \underline{5} = \underline{1\frac{3}{5}}$

Exact:

$$8 \div 5\frac{1}{3} = \frac{8}{1} \div \frac{16}{3} = \frac{\overset{1}{\cancel{8}}}{1} \cdot \frac{3}{\cancel{16}_{2}} = \frac{3}{2} = 1\frac{1}{2}$$

(d) $13\frac{1}{2} \div 18$

Estimate: $13\frac{1}{2}$ rounds to 14. 18 rounds to 18.
$\underline{14} \div \underline{18} = \frac{14}{18} = \underline{\frac{7}{9}}$

Exact:

$$13\frac{1}{2} \div 18 = \frac{27}{2} \div \frac{18}{1} = \frac{\overset{3}{\cancel{27}}}{2} \cdot \frac{1}{\cancel{18}_{2}} = \frac{3}{4}$$

4. Multiply the amount of paint needed for each car by the number of cars.

Estimate: $2\frac{5}{8}$ rounds to 3. 15 rounds to 15.
$\underline{3} \cdot 16 = 48$

Exact: $2\frac{5}{8} \cdot 16 = \frac{21}{\cancel{8}_{1}} \cdot \frac{\overset{2}{\cancel{16}}}{1} = \frac{42}{1} = 42$

42 quarts are needed for 16 cars. The answer is reasonably close to the estimate.

5. **(a)** Divide the total pounds of brass by the number of pounds needed for one engine.

Estimate: 57 rounds to 57. $4\frac{3}{4}$ rounds to 5.
$57 \div 5 \approx 11$

Exact:

$$57 \div 4\frac{3}{4} = \frac{57}{1} \div \frac{19}{4} = \frac{\overset{3}{\cancel{57}}}{1} \cdot \frac{4}{\cancel{19}_{1}} = \frac{12}{1} = 12$$

12 propellers can be manufactured from 57 pounds of brass. The answer is reasonably close to the estimate.

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(b) Divide the total number of quarts by the number of quarts needed for each oil change.

Estimate: 609 rounds to 600. $21\frac{3}{4}$ rounds to 22. $600 \div 22 \approx 27$

Exact:

$$609 \div 21\frac{3}{4} = 609 \div \frac{87}{4} = \frac{\overset{7}{\cancel{609}}}{1} \cdot \frac{4}{\underset{1}{\cancel{87}}} = 28$$

28 oil changes can be made with 609 quarts of oil. The answer is reasonably close to the estimate.

2.8 Section Exercises

1. The statement "When multiplying two mixed numbers, the reciprocal of the second mixed number must be used." is *false*. A reciprocal is used when *dividing* fractions, not *multiplying* fractions.

2. The statement "If you were dividing a mixed number by the whole number 10, the reciprocal of 10 would be $\frac{10}{1}$." is *false*. The reciprocal of 10 is $\frac{1}{10}$.

3. The statement "To round mixed numbers before estimating the answer, decide whether the numerator of the fraction part is less than or more than half of the denominator." is *true*.

4. The statement "When rounding mixed numbers to estimate the answer to a problem, the estimated answer can vary quite a bit from the exact answer. However, it can still show whether the exact answer is reasonable." is *true*.

5. $4\frac{1}{2} \cdot 1\frac{3}{4}$

Estimate: $5 \cdot 2 = 10$

Exact: $4\frac{1}{2} \cdot 1\frac{3}{4} = \frac{9}{2} \cdot \frac{7}{4} = \frac{63}{8} = 7\frac{7}{8}$

6. $2\frac{1}{2} \cdot 2\frac{1}{4}$

Estimate: $3 \cdot 2 = 6$

Exact: $2\frac{1}{2} \cdot 2\frac{1}{4} = \frac{5}{2} \cdot \frac{9}{4} = \frac{45}{8} = 5\frac{5}{8}$

7. $1\frac{2}{3} \cdot 2\frac{7}{10}$

Estimate: $2 \cdot 3 = 6$

Exact: $1\frac{2}{3} \cdot 2\frac{7}{10} = \frac{5}{3} \cdot \frac{27}{10} = \frac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{3}}} \cdot \frac{\overset{9}{\cancel{27}}}{\underset{2}{\cancel{10}}} = \frac{9}{2} = 4\frac{1}{2}$

8. $4\frac{1}{2} \cdot 2\frac{1}{4}$

Estimate: $5 \cdot 2 = 10$

Exact: $4\frac{1}{2} \cdot 2\frac{1}{4} = \frac{9}{2} \cdot \frac{9}{4} = \frac{81}{8} = 10\frac{1}{8}$

9. $3\frac{1}{9} \cdot 1\frac{2}{7}$

Estimate: $3 \cdot 1 = 3$

Exact: $3\frac{1}{9} \cdot 1\frac{2}{7} = \frac{28}{9} \cdot \frac{9}{7} = \frac{\overset{4}{\cancel{28}}}{\underset{1}{\cancel{9}}} \cdot \frac{\overset{1}{\cancel{9}}}{\underset{1}{\cancel{7}}} = \frac{4}{1} = 4$

10. $6\frac{1}{4} \cdot 3\frac{1}{5}$

Estimate: $6 \cdot 3 = 18$

Exact: $6\frac{1}{4} \cdot 3\frac{1}{5} = \frac{\overset{5}{\cancel{25}}}{\underset{1}{\cancel{4}}} \cdot \frac{\overset{4}{\cancel{16}}}{\underset{1}{\cancel{5}}} = \frac{20}{1} = 20$

11. $8 \cdot 6\frac{1}{4}$

Estimate: $8 \cdot 6 = 48$

Exact: $8 \cdot 6\frac{1}{4} = \frac{8}{1} \cdot \frac{25}{4} = \frac{\overset{2}{\cancel{8}}}{1} \cdot \frac{25}{\underset{1}{\cancel{4}}} = \frac{50}{1} = 50$

12. $6 \cdot 2\frac{1}{3}$

Estimate: $6 \cdot 2 = 12$

Exact: $6 \cdot 2\frac{1}{3} = \frac{\overset{2}{\cancel{6}}}{1} \cdot \frac{7}{\underset{1}{\cancel{3}}} = \frac{14}{1} = 14$

13. $4\frac{1}{2} \cdot 2\frac{1}{5} \cdot 5$

Estimate: $5 \cdot 2 \cdot 5 = 10 \cdot 5 = 50$

Exact: $4\frac{1}{2} \cdot 2\frac{1}{5} \cdot 5 = \frac{9}{2} \cdot \frac{11}{\underset{1}{\cancel{5}}} \cdot \frac{\overset{1}{\cancel{5}}}{1} = \frac{99}{2} = 49\frac{1}{2}$

14. $5\frac{1}{2} \cdot 1\frac{1}{3} \cdot 2\frac{1}{4}$

Estimate: $6 \cdot 1 \cdot 2 = 12$

Exact: $5\frac{1}{2} \cdot 1\frac{1}{3} \cdot 2\frac{1}{4} = \frac{11}{2} \cdot \frac{\overset{1}{\cancel{4}}}{\underset{1}{\cancel{3}}} \cdot \frac{\overset{3}{\cancel{9}}}{\underset{1}{\cancel{4}}} = \frac{33}{2} = 16\frac{1}{2}$

15. $3 \cdot 1\frac{1}{2} \cdot 2\frac{2}{3}$

Estimate: $3 \cdot 2 \cdot 3 = 6 \cdot 3 = 18$

Exact: $3 \cdot 1\frac{1}{2} \cdot 2\frac{2}{3} = \frac{\overset{1}{\cancel{3}}}{1} \cdot \frac{3}{\underset{1}{\cancel{2}}} \cdot \frac{\overset{4}{\cancel{8}}}{\underset{1}{\cancel{3}}} = \frac{12}{1} = 12$

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16. $\frac{2}{3} \cdot 3\frac{2}{3} \cdot \frac{6}{11}$

Estimate: $1 \cdot 4 \cdot 1 = 4$

Exact: $\frac{2}{3} \cdot 3\frac{2}{3} \cdot \frac{6}{11} = \frac{2}{3} \cdot \frac{\overset{1}{\cancel{11}}}{\underset{1}{\cancel{3}}} \cdot \frac{\overset{2}{\cancel{6}}}{\underset{1}{\cancel{11}}} = \frac{4}{3} = 1\frac{1}{3}$

17. $3\frac{1}{4} \cdot 7\frac{5}{8}$ *Estimate*: $3 \cdot 8 = 24$

The best estimate is choice **(d)**.

18. $5\frac{3}{4} \cdot 2\frac{2}{5}$ *Estimate*: $6 \cdot 2 = 12$

The best estimate is choice **(a)**.

19. $2\frac{1}{8} \div 1\frac{3}{4}$ *Estimate*: $2 \div 2 = 1$

The best estimate is choice **(b)**.

20. $8\frac{3}{5} \div 2\frac{3}{8}$ *Estimate*: $9 \div 2 = 4\frac{1}{2}$

The best estimate is choice **(c)**.

21. $1\frac{1}{4} \div 3\frac{3}{4}$

Estimate: $1 \div 4 = \frac{1}{4}$

Exact: $1\frac{1}{4} \div 3\frac{3}{4} = \frac{5}{4} \div \frac{15}{4} = \frac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{4}}} \cdot \frac{\overset{1}{\cancel{4}}}{\underset{3}{\cancel{15}}} = \frac{1}{3}$

22. $1\frac{1}{8} \div 2\frac{1}{4}$

Estimate: $1 \div 2 = \frac{1}{2}$

Exact: $1\frac{1}{8} \div 2\frac{1}{4} = \frac{9}{8} \div \frac{9}{4} = \frac{\overset{1}{\cancel{9}}}{\underset{2}{\cancel{8}}} \cdot \frac{\overset{1}{\cancel{4}}}{\underset{1}{\cancel{9}}} = \frac{1}{2}$

23. $2\frac{1}{2} \div 3$

Estimate: $3 \div 3 = 1$

Exact: $2\frac{1}{2} \div 3 = \frac{5}{2} \div \frac{3}{1} = \frac{5}{2} \cdot \frac{1}{3} = \frac{5}{6}$

24. $2\frac{3}{4} \div 2$

Estimate: $3 \div 2 = \frac{3}{2} = 1\frac{1}{2}$

Exact: $2\frac{3}{4} \div 2 = \frac{11}{4} \div \frac{2}{1} = \frac{11}{4} \cdot \frac{1}{2} = \frac{11}{8} = 1\frac{3}{8}$

25. $9 \div 2\frac{1}{2}$

Estimate: $9 \div 3 = 3$

Exact: $9 \div 2\frac{1}{2} = \frac{9}{1} \div \frac{5}{2} = \frac{9}{1} \cdot \frac{2}{5} = \frac{18}{5} = 3\frac{3}{5}$

26. $5 \div 1\frac{7}{8}$

Estimate: $5 \div 2 = \frac{5}{2} = 2\frac{1}{2}$

Exact: $5 \div 1\frac{7}{8} = \frac{5}{1} \div \frac{15}{8} = \frac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{1}}} \cdot \frac{8}{\underset{3}{\cancel{15}}} = \frac{8}{3} = 2\frac{2}{3}$

27. $\frac{5}{8} \div 1\frac{1}{2}$

Estimate: $1 \div 2 = \frac{1}{2}$

Exact: $\frac{5}{8} \div 1\frac{1}{2} = \frac{5}{8} \div \frac{3}{2} = \frac{5}{\underset{4}{\cancel{8}}} \cdot \frac{\overset{1}{\cancel{2}}}{3} = \frac{5}{12}$

28. $\frac{3}{4} \div 2\frac{1}{2}$

Estimate: $1 \div 3 = \frac{1}{3}$

Exact: $\frac{3}{4} \div 2\frac{1}{2} = \frac{3}{4} \div \frac{5}{2} = \frac{3}{\underset{2}{\cancel{4}}} \cdot \frac{\overset{1}{\cancel{2}}}{5} = \frac{3}{10}$

29. $1\frac{7}{8} \div 6\frac{1}{4}$

Estimate: $2 \div 6 = \frac{2}{6} = \frac{1}{3}$

Exact: $1\frac{7}{8} \div 6\frac{1}{4} = \frac{15}{8} \div \frac{25}{4} = \frac{\overset{3}{\cancel{15}}}{\underset{2}{\cancel{8}}} \cdot \frac{\overset{1}{\cancel{4}}}{\underset{5}{\cancel{25}}} = \frac{3}{10}$

30. $8\frac{2}{5} \div 3\frac{1}{2}$

Estimate: $8 \div 4 = 2$

Exact: $8\frac{2}{5} \div 3\frac{1}{2} = \frac{42}{5} \div \frac{7}{2} = \frac{\overset{6}{\cancel{42}}}{5} \cdot \frac{2}{\underset{1}{\cancel{7}}} = \frac{12}{5} = 2\frac{2}{5}$

31. $5\frac{2}{3} \div 6$

Estimate: $6 \div 6 = 1$

Exact: $5\frac{2}{3} \div 6 = \frac{17}{3} \div \frac{6}{1} = \frac{17}{3} \cdot \frac{1}{6} = \frac{17}{18}$

32. $5\frac{3}{4} \div 2$

Estimate: $6 \div 2 = 3$

Exact: $5\frac{3}{4} \div 2 = \frac{23}{4} \div \frac{2}{1} = \frac{23}{4} \cdot \frac{1}{2} = \frac{23}{8} = 2\frac{7}{8}$

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33. Multiply each amount by $2\frac{1}{2}$.

(a) Applesauce: $\frac{3}{4}$ cup

Estimate: $1 \cdot 3 = 3$ cups

Exact: $\frac{3}{4} \cdot 2\frac{1}{2} = \frac{3}{4} \cdot \frac{5}{2} = \frac{15}{8} = 1\frac{7}{8}$ cups

(b) Salt: $\frac{1}{2}$ tsp.

Estimate: $1 \cdot 3 = 3$ tsp.

Exact: $\frac{1}{2} \cdot 2\frac{1}{2} = \frac{1}{2} \cdot \frac{5}{2} = \frac{5}{4} = 1\frac{1}{4}$ tsp.

(c) Flour: $1\frac{3}{4}$ cups

Estimate: $2 \cdot 3 = 6$ cups

Exact: $1\frac{3}{4} \cdot 2\frac{1}{2} = \frac{7}{4} \cdot \frac{5}{2} = \frac{35}{8} = 4\frac{3}{8}$ cups

34. Multiply each amount by $1\frac{1}{2}$.

(a) Flour: $1\frac{3}{4}$ cups

Estimate: $2 \cdot 2 = 4$ cups

Exact: $1\frac{3}{4} \cdot 1\frac{1}{2} = \frac{7}{4} \cdot \frac{3}{2} = \frac{21}{8} = 2\frac{5}{8}$ cups

(b) Applesauce: $\frac{3}{4}$ cup

Estimate: $1 \cdot 2 = 2$ cups

Exact: $\frac{3}{4} \cdot 1\frac{1}{2} = \frac{3}{4} \cdot \frac{3}{2} = \frac{9}{8} = 1\frac{1}{8}$ cups

(c) Vegetable oil: $\frac{1}{3}$ cup

Estimate: $0 \cdot 2 = 0$ cups

Exact: $\frac{1}{3} \cdot 1\frac{1}{2} = \frac{1}{3} \cdot \frac{3}{2} = \frac{1}{\cancel{3}_{1}} \cdot \frac{\cancel{3}^{1}}{2} = \frac{1}{2}$ cup

35. Divide each amount by 2.

(a) Vanilla extract: $\frac{1}{2}$ tsp.

Estimate: $1 \div 2 = \frac{1}{2}$ tsp.

Exact: $\frac{1}{2} \div 2 = \frac{1}{2} \div \frac{2}{1} = \frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$ tsp.

(b) Applesauce: $\frac{3}{4}$ cup

Estimate: $1 \div 2 = \frac{1}{2}$ cup

Exact: $\frac{3}{4} \div 2 = \frac{3}{4} \div \frac{2}{1} = \frac{3}{4} \cdot \frac{1}{2} = \frac{3}{8}$ cup

(c) Flour: $1\frac{3}{4}$ cups

Estimate: $2 \div 2 = 1$ cup

Exact: $1\frac{3}{4} \div 2 = \frac{7}{4} \div \frac{2}{1} = \frac{7}{4} \cdot \frac{1}{2} = \frac{7}{8}$ cup

36. Divide each amount by 3.

(a) Flour: $1\frac{3}{4}$ cups

Estimate: $2 \div 3 = \frac{2}{3}$ cup

Exact: $1\frac{3}{4} \div 3 = \frac{7}{4} \div \frac{3}{1} = \frac{7}{4} \cdot \frac{1}{3} = \frac{7}{12}$ cup

(b) Salt: $\frac{1}{2}$ tsp.

Estimate: $1 \div 3 = \frac{1}{3}$ teaspoon

Exact: $\frac{1}{2} \div 3 = \frac{1}{2} \div \frac{3}{1} = \frac{1}{2} \cdot \frac{1}{3} = \frac{1}{6}$ teaspoon

(c) Applesauce: $\frac{3}{4}$ cup

Estimate: $1 \div 3 = \frac{1}{3}$ cup

Exact: $\frac{3}{4} \div 3 = \frac{3}{4} \div \frac{3}{1} = \frac{\cancel{3}^{1}}{4} \cdot \frac{1}{\cancel{3}_{1}} = \frac{1}{4}$ cup

37. Divide the number of gallons available by the number of gallons needed for each unit.

Estimate: $329 \div 12 \approx 27$ units

Exact: $329 \div 11\frac{3}{4} = \frac{329}{1} \div \frac{47}{4} = \frac{\cancel{329}^{7}}{1} \cdot \frac{4}{\cancel{47}_{1}} = 28$

28 units can be painted with 329 gallons of paint.

38. Divide the number of total minutes by the number of minutes per moment.

Estimate: $480 \div 2 = 240$ moments

Exact:

$480 \div 1\frac{1}{2} = \frac{480}{1} \div \frac{3}{2} = \frac{\cancel{480}^{160}}{1} \cdot \frac{2}{\cancel{3}_{1}} = \frac{320}{1} = 320$

There are 320 moments in an 8-hour work day.

39. Each handle requires $19\frac{1}{2}$ inches of steel tubing. Use multiplication.

Estimate: $45 \cdot 20 = 900$ in.

Exact: $45 \cdot 19\frac{1}{2} = \frac{45}{1} \cdot \frac{39}{2} = \frac{1755}{2} = 877\frac{1}{2}$ in.

$877\frac{1}{2}$ inches of steel tubing is needed to make 45 jacks.

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40. Assume that the $61\frac{1}{2}$ inch length listed in the overall dimensions is the length of the handle. Use multiplication.

Estimate: $182 \cdot 62 = 11{,}284$ in.

Exact: $182 \cdot 61\frac{1}{2} = \frac{\overset{91}{\cancel{182}}}{1} \cdot \frac{123}{\underset{1}{\cancel{2}}} = 11{,}193$ in.

The amount of wood that is necessary to make 182 handles is 11,193 inches.

41. The answer should include:

Step 1
Change mixed numbers to improper fractions.

Step 2
Multiply the fractions.

Step 3
Write the answer in lowest terms, changing to mixed or whole numbers where possible.

42. The additional step is to use the reciprocal of the second fraction (divisor).

43. Multiply the amount of money for each cell phone times the number of cell phones to get the total amount of money from the sale of gold.

Estimate: \$1 • 130 million = \$130 million

Exact: $1\frac{2}{5} \cdot 130 \text{ million} = \frac{7}{5} \cdot \frac{130}{1} = \frac{910}{5} = 182$
$= 182$ million

You would have \$182 million from the sale of the gold.

44. Divide the number of square yards of carpet by the amount of carpet needed for each apartment unit.

Estimate: $6750 \div 63 \approx 107$ units

Exact:

$$6750 \div 62\frac{1}{2} = \frac{6750}{1} \div \frac{125}{2} = \frac{\overset{54}{\cancel{6750}}}{1} \cdot \frac{2}{\underset{1}{\cancel{125}}} = 108$$

108 units can be carpeted.

45. Divide the total amount of firewood to be delivered by the amount of firewood that can be delivered per trip.

Estimate: $140 \div 1 = 140$ trips

Exact: $140 \div 1\frac{1}{4} = \frac{140}{1} \div \frac{5}{4} = \frac{\overset{28}{\cancel{140}}}{1} \cdot \frac{4}{\underset{1}{\cancel{5}}} = 112$

112 trips will be needed to deliver 140 cords of firewood.

46. Divide the total amount of roofing material by the amount of roofing material needed for each roof.

Estimate: $1827 \div 32 \approx 57$ homes

Exact:

$$1827 \div 31\frac{1}{2} = \frac{1827}{1} \div \frac{63}{2} = \frac{\overset{29}{\cancel{1827}}}{1} \cdot \frac{2}{\underset{1}{\cancel{63}}} = 58$$

58 homes can be re-roofed with 1827 squares of roofing material.

47. **(a)** The maximum height of the standard jack is $17\frac{3}{4}$ inches. Use multiplication.

Estimate: $18 \cdot 4 = 72$ in.

Exact: $17\frac{3}{4} \cdot 4 = \frac{71}{\underset{1}{\cancel{4}}} \cdot \frac{\overset{1}{\cancel{4}}}{1} = \frac{71}{1} = 71$ in.

The hydraulic lift must raise the car 71 inches.

(b) There are 12 inches in a foot, so the 6-foot-tall mechanic is $6 \times 12 = 72$ inches tall. So no, the mechanic can not stand under the car without bending.

48. **(a)** The maximum height of the low-profile jack is $15\frac{1}{16}$ inches. Use division.

Estimate: $15 \div 3 = 5$ in.

Exact: $15\frac{1}{16} \div 3 = \frac{241}{16} \cdot \frac{1}{3} = \frac{241}{48} = 5\frac{1}{48}$ in.

The low-profile lift must raise the car $5\frac{1}{48}$ inches.

(b) No, because 6 in. is greater than $5\frac{1}{48}$ in.

49. Multiply the swimming speed of the person times the number of times faster that a shark can swim than a person.

Estimate: $6 \cdot 6 = 36$ miles per hour

Exact: $6\frac{1}{8} \cdot 5\frac{1}{2} = \frac{49}{8} \cdot \frac{11}{2} = \frac{539}{16} = 33\frac{11}{16}$

The shark can swim $33\frac{11}{16}$ miles per hour.

50. Multiply the boxes of tile per floor times the number of floors (homes) to get the total number of boxes needed.

Estimate: $24 \cdot 24 = 576$ boxes

Exact: $24\frac{2}{7} \cdot 24 = \frac{170}{7} \cdot \frac{24}{1} = \frac{4080}{7} = 582\frac{6}{7}$

$582\frac{6}{7}$ boxes of tile are needed.

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Chapter 2 Review Exercises

1. $\frac{1}{3}$ There are 3 parts, and 1 is shaded.

2. $\frac{5}{8}$ There are 8 parts, and 5 are shaded.

3. $\frac{2}{4}$ There are 4 parts, and 2 are shaded.

4. Proper fractions have numerator (top) smaller than denominator (bottom).

They are: $\frac{1}{8}, \frac{3}{4}, \frac{2}{3}$.

Improper fractions have numerator (top) larger than or equal to the denominator (bottom).

They are: $\frac{4}{3}, \frac{5}{5}$.

5. Proper fractions have numerator (top) smaller than denominator (bottom).

They are: $\frac{15}{16}, \frac{1}{8}$

Improper fractions have numerator (top) larger than or equal to the denominator (bottom).

They are: $\frac{6}{5}, \frac{16}{13}, \frac{5}{3}$

6. $4\frac{3}{4}$ $4 \cdot 4 = 16$

$16 + 3 = 19$

$4\frac{3}{4} = \frac{19}{4}$

7. $9\frac{5}{6}$ $9 \cdot 6 = 54$

$54 + 5 = 59$

$9\frac{5}{6} = \frac{59}{6}$

8. $\frac{27}{8}$

$$\begin{array}{r} 3 \\ 8\overline{)27} \\ \underline{24} \\ 3 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{27}{8} = 3\frac{3}{8}$

9. $\frac{63}{5}$

$$\begin{array}{r} 12 \\ 5\overline{)63} \\ \underline{5} \\ 13 \\ \underline{10} \\ 3 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{63}{5} = 12\frac{3}{5}$

10. Factorizations of 6:

$1 \cdot 6 = 6 \quad 2 \cdot 3 = 6$

The factors of 6 are 1, 2, 3, and 6.

11. Factorizations of 24:

$1 \cdot 24 = 24 \quad 2 \cdot 12 = 24 \quad 3 \cdot 8 = 24 \quad 4 \cdot 6 = 24$

The factors of 24 are 1, 2, 3, 4, 6, 8, 12, and 24.

12. Factorizations of 55:

$1 \cdot 55 = 55 \quad 5 \cdot 11 = 55$

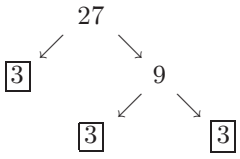
The factors of 55 are 1, 5, 11, and 55.

13. Factorizations of 90:

$1 \cdot 90 = 90 \quad 2 \cdot 45 = 90 \quad 3 \cdot 30 = 90 \quad 5 \cdot 18 = 90$
$6 \cdot 15 = 90 \quad 9 \cdot 10 = 90$

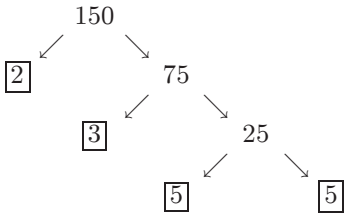
The factors of 90 are 1, 2, 3, 5, 6, 9, 10, 15, 18, 30, 45, and 90.

14.



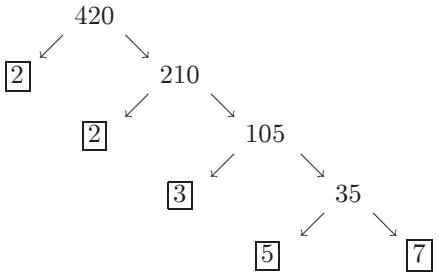
$27 = 3 \cdot 3 \cdot 3 = 3^3$

15.



$150 = 2 \cdot 3 \cdot 5 \cdot 5 = 2 \cdot 3 \cdot 5^2$

16.



$420 = 2 \cdot 2 \cdot 3 \cdot 5 \cdot 7 = 2^2 \cdot 3 \cdot 5 \cdot 7$

17. $5^2 = 5 \cdot 5 = 25$

18. $6^2 \cdot 2^3 = 36 \cdot 8 = 288$

19. $8^2 \cdot 3^3 = 64 \cdot 27 = 1728$

20. $4^3 \cdot 2^5 = 64 \cdot 32 = 2048$

21. All 24 parts out of a possible 24 parts are gold.

$\frac{24}{24} = 1$

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22. 18 of the possible $18+6=24$ parts are gold.

$$\frac{18}{24}=\frac{18\div 6}{24\div 6}=\frac{3}{4}$$

23. 14 of the possible $14+10=24$ parts are gold.

$$\frac{14}{24}=\frac{14\div 2}{24\div 2}=\frac{7}{12}$$

24. 10 of the possible $10+14=24$ parts are gold.

$$\frac{10}{24}=\frac{10\div 2}{24\div 2}=\frac{5}{12}$$

25. $\dfrac{25}{60}=\dfrac{\overset{1}{\cancel{5}}\cdot 5}{2\cdot 2\cdot 3\cdot \underset{1}{\cancel{5}}}=\dfrac{5}{12}$

26. $\dfrac{384}{96}=\dfrac{\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot\overset{1}{\cancel{2}}\cdot 2\cdot 2\cdot\overset{1}{\cancel{3}}}{\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{2}}\cdot\underset{1}{\cancel{3}}}=\dfrac{4}{1}=4$

27. $\dfrac{3}{4}$ and $\dfrac{48}{64}$

$\dfrac{48}{64}=\dfrac{48\div 16}{64\div 16}=\dfrac{3}{4}$

The fractions are equivalent ($\frac{3}{4}=\frac{3}{4}$).

28. $\dfrac{5}{8}$ and $\dfrac{70}{120}$

$\dfrac{70}{120}=\dfrac{70\div 10}{120\div 10}=\dfrac{7}{12}$

The fractions are not equivalent ($\frac{5}{8}\neq\frac{7}{12}$).

29. $\dfrac{2}{3}$ and $\dfrac{360}{540}$

$\dfrac{360}{540}=\dfrac{360\div 180}{540\div 180}=\dfrac{2}{3}$

The fractions are equivalent ($\frac{2}{3}=\frac{2}{3}$).

30. $\dfrac{4}{5}\cdot\dfrac{3}{4}=\dfrac{\overset{1}{\cancel{4}}}{5}\cdot\dfrac{3}{\underset{1}{\cancel{4}}}=\dfrac{1\cdot 3}{5\cdot 1}=\dfrac{3}{5}$

31. $\dfrac{3}{10}\cdot\dfrac{5}{8}=\dfrac{3}{\underset{2}{\cancel{10}}}\cdot\dfrac{\overset{1}{\cancel{5}}}{8}=\dfrac{3\cdot 1}{2\cdot 8}=\dfrac{3}{16}$

32. $\dfrac{70}{175}\cdot\dfrac{5}{14}=\dfrac{\overset{1}{\cancel{5}}\cdot\overset{2}{\cancel{70}}}{\underset{7}{\cancel{175}}}\cdot\dfrac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{14}}}=\dfrac{1\cdot 1}{7\cdot 1}=\dfrac{1}{7}$

33. $\dfrac{44}{63}\cdot\dfrac{3}{11}=\dfrac{\overset{4}{\cancel{44}}}{\underset{21}{\cancel{63}}}\cdot\dfrac{\overset{1}{\cancel{3}}}{\underset{1}{\cancel{11}}}=\dfrac{4\cdot 1}{21\cdot 1}=\dfrac{4}{21}$

34. $\dfrac{5}{16}\cdot 48=\dfrac{5}{\underset{1}{\cancel{16}}}\cdot\dfrac{\overset{3}{\cancel{48}}}{1}=\dfrac{5\cdot 3}{1\cdot 1}=\dfrac{15}{1}=15$

35. $\dfrac{5}{8}\cdot 1000=\dfrac{5}{\underset{1}{\cancel{8}}}\cdot\dfrac{\overset{125}{\cancel{1000}}}{1}=\dfrac{5\cdot 125}{1\cdot 1}=\dfrac{625}{1}=625$

36. $\dfrac{2}{3}\div\dfrac{1}{2}=\dfrac{2}{3}\cdot\dfrac{2}{1}=\dfrac{2\cdot 2}{3\cdot 1}=\dfrac{4}{3}=1\dfrac{1}{3}$

37. $\dfrac{5}{6}\div\dfrac{1}{2}=\dfrac{5}{\underset{3}{\cancel{6}}}\cdot\dfrac{\overset{1}{\cancel{2}}}{1}=\dfrac{5}{3}=1\dfrac{2}{3}$

38. $\dfrac{\frac{15}{18}}{\frac{10}{30}}=\dfrac{15}{18}\div\dfrac{10}{30}$

$=\dfrac{\overset{5}{\cancel{15}}}{\underset{6}{\cancel{18}}}\cdot\dfrac{\overset{3}{\cancel{30}}}{\underset{1}{\cancel{10}}}=\dfrac{5\cdot\overset{1}{\cancel{3}}}{\underset{2}{\cancel{6}}\cdot 1}=\dfrac{5\cdot 1}{2\cdot 1}=\dfrac{5}{2}=2\dfrac{1}{2}$

39. $\dfrac{\frac{3}{4}}{\frac{3}{8}}=\dfrac{3}{4}\div\dfrac{3}{8}=\dfrac{\overset{1}{\cancel{3}}}{\underset{1}{\cancel{4}}}\cdot\dfrac{\overset{2}{\cancel{8}}}{\underset{1}{\cancel{3}}}=\dfrac{1\cdot 2}{1\cdot 1}=2$

40. $7\div\dfrac{7}{8}=\dfrac{7}{1}\div\dfrac{7}{8}=\dfrac{\overset{1}{\cancel{7}}}{1}\cdot\dfrac{8}{\underset{1}{\cancel{7}}}=\dfrac{1\cdot 8}{1\cdot 1}=8$

41. $18\div\dfrac{3}{4}=\dfrac{\overset{6}{\cancel{18}}}{1}\cdot\dfrac{4}{\underset{1}{\cancel{3}}}=\dfrac{6\cdot 4}{1\cdot 1}=24$

42. $\dfrac{5}{8}\div 3=\dfrac{5}{8}\div\dfrac{3}{1}=\dfrac{5}{8}\cdot\dfrac{1}{3}=\dfrac{5\cdot 1}{8\cdot 3}=\dfrac{5}{24}$

43. $\dfrac{2}{3}\div 5=\dfrac{2}{3}\div\dfrac{5}{1}=\dfrac{2}{3}\cdot\dfrac{1}{5}=\dfrac{2\cdot 1}{3\cdot 5}=\dfrac{2}{15}$

44. $\dfrac{\frac{12}{13}}{3}=\dfrac{12}{13}\div 3=\dfrac{12}{13}\div\dfrac{3}{1}=\dfrac{\overset{4}{\cancel{12}}}{13}\cdot\dfrac{1}{\underset{1}{\cancel{3}}}=\dfrac{4\cdot 1}{13\cdot 1}=\dfrac{4}{13}$

45. To find the area, multiply the length and the width.

$$2\frac{3}{4}\cdot\frac{1}{2}=\frac{11}{4}\cdot\frac{1}{2}=\frac{11}{8}=1\frac{3}{8}$$

The area is $1\frac{3}{8}$ ft^2.

46. To find the area, multiply the length and the width.

$$4\frac{1}{2}\cdot\frac{7}{8}=\frac{9}{2}\cdot\frac{7}{8}=\frac{63}{16}=3\frac{15}{16}$$

The area is $3\frac{15}{16}$ yd^2.

47. Multiply the length and width.

$$108\cdot 72\frac{3}{4}=\frac{\overset{27}{\cancel{108}}}{1}\cdot\frac{291}{\underset{1}{\cancel{4}}}=7857$$

The area is 7857 ft^2.

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48. Multiply the length and width.

$$6 \cdot \frac{11}{12} = \frac{\overset{1}{\cancel{6}}}{1} \cdot \frac{11}{\underset{2}{\cancel{12}}} = \frac{11}{2}$$

The area is $5\frac{1}{2}$ ft^2.

49. $5\frac{1}{2} \cdot 1\frac{1}{4}$

Estimate: $6 \cdot 1 = 6$

Exact: $5\frac{1}{2} \cdot 1\frac{1}{4} = \frac{11}{2} \cdot \frac{5}{4} = \frac{55}{8} = 6\frac{7}{8}$

50. $2\frac{1}{4} \cdot 7\frac{1}{8} \cdot 1\frac{1}{3}$

Estimate: $2 \cdot 7 \cdot 1 = 14$

Exact: $2\frac{1}{4} \cdot 7\frac{1}{8} \cdot 1\frac{1}{3} = \frac{\overset{3}{\cancel{9}}}{4} \cdot \frac{57}{\underset{2}{\cancel{8}}} \cdot \frac{\overset{1}{\cancel{4}}}{\underset{1}{\cancel{3}}} = \frac{171}{8} = 21\frac{3}{8}$

51. $15\frac{1}{2} \div 3$

Estimate: $16 \div 3 = \frac{16}{3} = 5\frac{1}{3}$

Exact: $15\frac{1}{2} \div 3 = \frac{31}{2} \cdot \frac{1}{3} = \frac{31}{6} = 5\frac{1}{6}$

52. $4\frac{3}{4} \div 6\frac{1}{3}$

Estimate: $5 \div 6 = \frac{5}{6}$

Exact: $4\frac{3}{4} \div 6\frac{1}{3} = \frac{19}{4} \div \frac{19}{3} = \frac{\overset{1}{\cancel{19}}}{4} \cdot \frac{3}{\underset{1}{\cancel{19}}} = \frac{3}{4}$

53. Divide the total tons of almonds by the size of the bins.

Estimate: $300 \div \frac{1}{2} = 300 \cdot 2 = 600$ bins

Exact: $320 \div \frac{5}{8} = \frac{\overset{64}{\cancel{320}}}{1} \cdot \frac{8}{\underset{1}{\cancel{5}}} = 512$

512 bins will be needed to store the almonds.

54. The 4 other equal partners own

$$1 - \tfrac{2}{5} = \tfrac{3}{5}$$

of the business. Divide that amount by 4.

$$\frac{3}{5} \div 4 = \frac{3}{5} \div \frac{4}{1} = \frac{3}{5} \cdot \frac{1}{4} = \frac{3}{20}$$

Each of the other partners owns $\frac{3}{20}$ of the business.

55. Divide the total yardage by the amount needed for each pull cord.

Estimate: $158 \div 4 \approx 40$ pull cords

Exact:

$$157\frac{1}{2} \div 4\frac{3}{8} = \frac{315}{2} \div \frac{35}{8} = \frac{\overset{9}{\cancel{315}}}{\underset{1}{\cancel{2}}} \cdot \frac{\overset{4}{\cancel{8}}}{\underset{1}{\cancel{35}}} = 36$$

36 pull cords can be made.

56. Multiply the weight per gallon times the number of aquariums times the gallons per aquarium.

Estimate: $8 \cdot 2 \cdot 50 = 800$

Exact: $8\frac{1}{3} \cdot 2 \cdot 50 = \frac{25}{3} \cdot \frac{2}{1} \cdot \frac{50}{1} = \frac{2500}{3}$

The weight of the water is $\frac{2500}{3}$, or $833\frac{1}{3}$ pounds.

57. Ebony sold $\frac{1}{4}$ of 100 pounds of rice.

$$\frac{1}{4} \cdot 100 = \frac{1}{\underset{1}{\cancel{4}}} \cdot \frac{\overset{25}{\cancel{100}}}{1} = \frac{1 \cdot 25}{1 \cdot 1} = \frac{25}{1} = 25 \text{ pounds}$$

Thus, $100 - 25 = 75$ pounds remain. She gave $\frac{2}{3}$ of 75 pounds to her parents.

$$\frac{2}{3} \cdot 75 = \frac{2}{\underset{1}{\cancel{3}}} \cdot \frac{\overset{25}{\cancel{75}}}{1} = \frac{2 \cdot 25}{1 \cdot 1} = \frac{50}{1} = 50 \text{ pounds}$$

Ebony gave 50 pounds to her parents. The amount she has left is $75 - 50 = 25$ pounds.

58. Sheila paid $\frac{3}{8}$ of \$2976 for taxes, social security, and a retirement plan.

$$\frac{3}{8} \cdot 2976 = \frac{3}{\underset{1}{\cancel{8}}} \cdot \frac{\overset{372}{\cancel{2976}}}{1} = 1116$$

She paid \$1116 for taxes, social security, and a retirement plan.

She paid $\frac{9}{10}$ of the remainder,
\$2976 − \$1116 = \$1860, for basic living expenses.

$$\frac{9}{10} \cdot 1860 = \frac{9}{\underset{1}{\cancel{10}}} \cdot \frac{\overset{186}{\cancel{1860}}}{1} = \frac{9 \cdot 186}{1 \cdot 1} = 1674$$

She has \$1860 − \$1674 = \$186 left.

59. $\frac{7}{8}$ must be divided by 6.

$$\frac{7}{8} \div 6 = \frac{7}{8} \div \frac{6}{1} = \frac{7}{8} \cdot \frac{1}{6} = \frac{7 \cdot 1}{8 \cdot 6} = \frac{7}{48}$$

Each school will receive $\frac{7}{48}$ of the amount raised.

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60. $\frac{4}{5}$ of the catch must be divided evenly among 5 fishermen.

$$\frac{4}{5} \div 5 = \frac{4}{5} \div \frac{5}{1} = \frac{4}{5} \cdot \frac{1}{5} = \frac{4}{25}$$

Each fisherman receives $\frac{4}{25}$ ton.

61. **[2.5]** $\frac{1}{2} \cdot \frac{3}{4} = \frac{1 \cdot 3}{2 \cdot 4} = \frac{3}{8}$

62. **[2.5]** $\frac{2}{3} \cdot \frac{3}{5} = \frac{2}{\cancel{3}_{1}} \cdot \frac{\cancel{3}^{1}}{5} = \frac{2 \cdot 1}{1 \cdot 5} = \frac{2}{5}$

63. **[2.8]** $12\frac{1}{2} \cdot 2\frac{1}{2} = \frac{25}{2} \cdot \frac{5}{2} = \frac{125}{4} = 31\frac{1}{4}$

64. **[2.8]** $8\frac{1}{3} \cdot 3\frac{2}{5} = \frac{25}{3} \cdot \frac{17}{5} = \frac{425}{15} = \frac{85}{3} = 28\frac{1}{3}$

65. **[2.7]**

$$\frac{\frac{4}{5}}{8} = \frac{4}{5} \div 8 = \frac{4}{5} \div \frac{8}{1} = \frac{\cancel{4}^{1}}{5} \cdot \frac{1}{\cancel{8}_{2}} = \frac{1 \cdot 1}{5 \cdot 2} = \frac{1}{10}$$

66. **[2.7]** $\frac{\frac{5}{8}}{4} = \frac{5}{8} \div \frac{4}{1} = \frac{5}{8} \cdot \frac{1}{4} = \frac{5}{32}$

67. **[2.5]** $\frac{15}{31} \cdot 62 = \frac{15}{\cancel{31}_{1}} \cdot \frac{\cancel{62}^{2}}{1} = \frac{15 \cdot 2}{1 \cdot 1} = \frac{30}{1} = 30$

68. **[2.8]**

$$3\frac{1}{4} \div 1\frac{1}{4} = \frac{13}{4} \div \frac{5}{4} = \frac{13}{\cancel{4}_{1}} \cdot \frac{\cancel{4}^{1}}{5} = \frac{13 \cdot 1}{1 \cdot 5} = \frac{13}{5} = 2\frac{3}{5}$$

69. **[2.2]** $\frac{8}{5}$

$$\begin{array}{r} 1 \\ 5\overline{)8} \\ \underline{5} \\ 3 \end{array}$$

← Whole number part

← Remainder

$$\frac{8}{5} = 1\frac{3}{5}$$

70. **[2.2]** $\frac{153}{4}$

$$\begin{array}{r} 38 \\ 4\overline{)153} \\ \underline{12} \\ 33 \\ \underline{32} \\ 1 \end{array}$$

← Whole number part

← Remainder

$$\frac{153}{4} = 38\frac{1}{4}$$

71. **[2.2]** $5\frac{2}{3}$ $5 \cdot 3 = 15$

$15 + 2 = 17$

$$5\frac{2}{3} = \frac{17}{3}$$

72. **[2.2]** $38\frac{3}{8}$ $38 \cdot 8 = 304$

$304 + 3 = 307$

$$38\frac{3}{8} = \frac{307}{8}$$

73. **[2.4]** $\frac{8}{12} = \frac{\cancel{2}^{1} \cdot \cancel{2}^{1} \cdot 2}{\cancel{2}_{1} \cdot \cancel{2}_{1} \cdot 3} = \frac{1 \cdot 1 \cdot 2}{1 \cdot 1 \cdot 3} = \frac{2}{3}$

74. **[2.4]** $\frac{108}{210} = \frac{\cancel{2}^{1} \cdot 2 \cdot \cancel{3}^{1} \cdot 3 \cdot 3}{\cancel{2}_{1} \cdot \cancel{3}_{1} \cdot 5 \cdot 7} = \frac{1 \cdot 2 \cdot 1 \cdot 3 \cdot 3}{1 \cdot 1 \cdot 5 \cdot 7} = \frac{18}{35}$

75. **[2.4]** $\frac{75}{90} = \frac{75 \div 15}{90 \div 15} = \frac{5}{6}$

76. **[2.4]** $\frac{48}{72} = \frac{48 \div 24}{72 \div 24} = \frac{2}{3}$

77. **[2.4]** $\frac{44}{110} = \frac{44 \div 22}{110 \div 22} = \frac{2}{5}$

78. **[2.4]** $\frac{87}{261} = \frac{87 \div 87}{261 \div 87} = \frac{1}{3}$

79. **[2.8]** Multiply $2\frac{1}{2}$ ounces per gallon by the number of gallons.

Estimate: $3 \cdot 50 = 150$ ounces

Exact: $2\frac{1}{2} \cdot 50 = \frac{5}{\cancel{2}_{1}} \cdot \frac{\cancel{50}^{25}}{1} = \frac{5 \cdot 25}{1 \cdot 1} = \frac{125}{1} = 125$

125 ounces of the product are needed.

80. **[2.8]** Multiply the number of tanks by the number of quarts needed for each tank.

Estimate: $7 \cdot 9 = 63$ qt

Exact: $7\frac{1}{4} \cdot 9\frac{1}{3} = \frac{29}{4} \cdot \frac{28}{3} = \frac{812}{12} = \frac{203}{3} = 67\frac{2}{3}$

$67\frac{2}{3}$ quarts are needed.

81. **[2.8]** To find the area, multiply the length and the width.

$$1\frac{3}{4} \cdot \frac{7}{8} = \frac{7}{4} \cdot \frac{7}{8} = \frac{49}{32} = 1\frac{17}{32}$$

The area of the stamp is $1\frac{17}{32}$ in.^{2}.

82. **[2.8]** To find the area, multiply the length and the width.

$$\frac{7}{8} \cdot 2\frac{1}{4} = \frac{7}{8} \cdot \frac{9}{4} = \frac{63}{32} = 1\frac{31}{32}$$

The area of the patio table top is $1\frac{31}{32}$ yd^2.

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Chapter 2 Test

1. $\frac{5}{6}$ There are 6 parts, and 5 are shaded.

2. $\frac{3}{8}$ There are 8 parts, and 3 are shaded.

3. Proper fractions have the numerator (top) smaller than the denominator (bottom).

$$\frac{2}{3}, \frac{6}{7}, \frac{1}{4}, \frac{5}{8}$$

4. $3\frac{3}{8}$ $\quad 3 \cdot 8 = 24$

$24 + 3 = 27$

$3\frac{3}{8} = \frac{27}{8}$

5. $\frac{123}{4}$

$$\begin{array}{r} 30 \leftarrow \text{Whole number part} \\ 4\overline{)123} \\ \underline{12} \\ 3 \leftarrow \text{Remainder} \end{array}$$

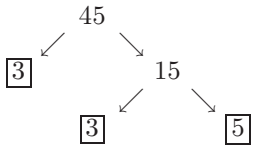
$\frac{123}{4} = 30\frac{3}{4}$

6. Factorizations of 18:

$$1 \cdot 18 = 18 \quad 2 \cdot 9 = 18 \quad 3 \cdot 6 = 18$$

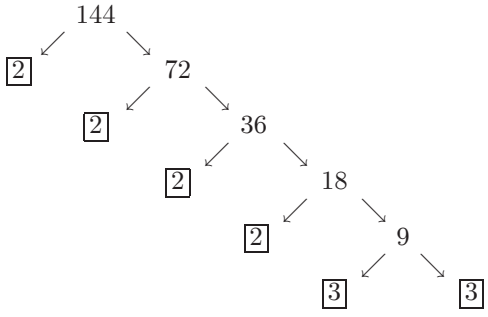
The factors of 18 are 1, 2, 3, 6, 9, and 18.

7.



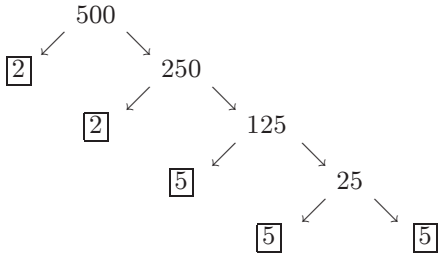
$45 = 3 \cdot 3 \cdot 5 = 3^2 \cdot 5$

8.



$144 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 3 \cdot 3 = 2^4 \cdot 3^2$

9.



$500 = 2 \cdot 2 \cdot 5 \cdot 5 \cdot 5 = 2^2 \cdot 5^3$

10. $\frac{36}{48} = \frac{36 \div 12}{48 \div 12} = \frac{3}{4}$

11. $\frac{60}{72} = \frac{60 \div 12}{72 \div 12} = \frac{5}{6}$

12. Write the prime factorization of both numerator and denominator. Divide the numerator and denominator by any common factors. Multiply the remaining factors in the numerator and denominator.

$$\frac{56}{84} = \frac{\overset{1}{\cancel{2}} \cdot \overset{1}{\cancel{2}} \cdot 2 \cdot \overset{1}{\cancel{7}}}{\underset{1}{\cancel{2}} \cdot \underset{1}{\cancel{2}} \cdot 3 \cdot \underset{1}{\cancel{7}}} = \frac{2}{3}$$

13. Multiply fractions by multiplying the numerators and multiplying the denominators. Divide two fractions by using the reciprocal of the divisor (the second fraction) and then changing division to multiplication.

14. $\frac{3}{4} \cdot \frac{4}{9} = \frac{\overset{1}{\cancel{3}}}{\underset{1}{\cancel{4}}} \cdot \frac{\overset{1}{\cancel{4}}}{\underset{3}{\cancel{9}}} = \frac{1}{3}$

15. $54 \cdot \frac{2}{3} = \frac{\overset{18}{\cancel{54}}}{1} \cdot \frac{2}{\underset{1}{\cancel{3}}} = 36$

16. Multiply the length and the width.

$$\frac{15}{16} \cdot \frac{4}{9} = \frac{\overset{5}{\cancel{15}}}{\underset{4}{\cancel{16}}} \cdot \frac{\overset{1}{\cancel{4}}}{\underset{3}{\cancel{9}}} = \frac{5 \cdot 1}{4 \cdot 3} = \frac{5}{12}$$

The area of the grill is $\frac{5}{12}$ yd^2.

17. First, find the number of seedlings that don't survive.

$$8760 \cdot \frac{3}{8} = \frac{\overset{1095}{\cancel{8760}}}{1} \cdot \frac{3}{\underset{1}{\cancel{8}}} = 3285$$

Next, subtract to find the number that do survive.

$$8760 - 3285 = 5475$$

5475 seedlings do survive.

18. $\frac{3}{4} \div \frac{5}{6} = \frac{3}{\underset{2}{\cancel{4}}} \cdot \frac{\overset{3}{\cancel{6}}}{5} = \frac{3 \cdot 3}{2 \cdot 5} = \frac{9}{10}$

19. $\frac{\frac{7}{4}}{\frac{9}{9}} = 7 \div \frac{4}{9} = \frac{7}{1} \div \frac{4}{9} = \frac{7}{1} \cdot \frac{9}{4} = \frac{63}{4} = 15\frac{3}{4}$

20. Divide the total length by the length of the pieces.

$$54 \div 2\frac{1}{4} = \frac{54}{1} \div \frac{9}{4} = \frac{\overset{6}{\cancel{54}}}{1} \cdot \frac{4}{\underset{1}{\cancel{9}}} = 24$$

24 pieces can be cut.

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21. $4\frac{1}{8} \cdot 3\frac{1}{2}$

Estimate: $4 \cdot 4 = 16$

Exact: $4\frac{1}{8} \cdot 3\frac{1}{2} = \frac{33}{8} \cdot \frac{7}{2} = \frac{231}{16} = 14\frac{7}{16}$

22. $1\frac{5}{6} \cdot 4\frac{1}{3}$

Estimate: $2 \cdot 4 = 8$

Exact: $1\frac{5}{6} \cdot 4\frac{1}{3} = \frac{11}{6} \cdot \frac{13}{3} = \frac{143}{18} = 7\frac{17}{18}$

23. $9\frac{3}{5} \div 2\frac{1}{4}$

Estimate: $10 \div 2 = 5$

Exact:

$$9\frac{3}{5} \div 2\frac{1}{4} = \frac{48}{5} \div \frac{9}{4} = \frac{\cancel{48}^{16}}{5} \cdot \frac{4}{\cancel{9}_{3}} = \frac{64}{15} = 4\frac{4}{15}$$

24. $\dfrac{8\frac{1}{2}}{1\frac{3}{4}}$

Estimate: $9 \div 2 = \frac{9}{2} = 4\frac{1}{2}$

Exact:

$$\frac{8\frac{1}{2}}{1\frac{3}{4}} = 8\frac{1}{2} \div 1\frac{3}{4} = \frac{17}{2} \div \frac{7}{4}$$

$$= \frac{17}{2} \cdot \frac{4}{7} = \frac{17 \cdot 4}{2 \cdot 7} = \frac{68}{14} = \frac{34}{7} = 4\frac{6}{7}$$

25. If $2\frac{1}{2}$ grams can be synthesized per day, multiply to find the amount synthesized in $12\frac{1}{4}$ days.

Estimate: $3 \cdot 12 = 36$ grams

Exact:

$$2\frac{1}{2} \cdot 12\frac{1}{4} = \frac{5}{2} \cdot \frac{49}{4} = \frac{5 \cdot 49}{2 \cdot 4} = \frac{245}{8} = 30\frac{5}{8}$$

$30\frac{5}{8}$ grams can be synthesized.

Cumulative Review Exercises (Chapters 1–2)

1. $\underline{7}\,\underline{8}\,3$

hundreds: 7
tens: 8

2. $\underline{8},\underline{6}\underline{2}1,785$

millions: 8
ten-thousands: 2

3.
$$\begin{array}{r} {\scriptstyle 1} \\ 71 \\ 23 \\ 47 \\ +\,36 \\ \hline 177 \end{array}$$

4.
$$\begin{array}{r} {\scriptstyle 1\ 1\ 1} \\ 82,121 \\ 5\,468 \\ 316 \\ +\,61,294 \\ \hline 149,199 \end{array}$$

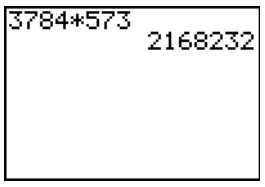
5.
$$\begin{array}{r} {\scriptstyle 4\ 13} \\ 6\,\cancel{5}\,\cancel{3}7 \\ -\,2085 \\ \hline 4452 \end{array}$$

6.
$$\begin{array}{r} {\scriptstyle 7\ 11\ 8\ 15\ 10} \\ 4,\cancel{8}\,\cancel{1}\,\cancel{9},\cancel{6}\,\cancel{0}4 \\ -\,1,597,783 \\ \hline 3,221,821 \end{array}$$

7.
$$\begin{array}{r} {\scriptstyle 2} \\ 83 \\ \times\ \ 9 \\ \hline 747 \end{array}$$

8. $9 \cdot 4 \cdot 2 = (9 \cdot 4) \cdot 2 = 36 \cdot 2 = 72$

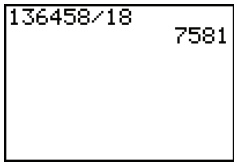
9.



10.
$$\begin{array}{r} 563 \\ \times\,800 \\ \hline \end{array} \qquad \begin{array}{r} {\scriptstyle 5\ 2} \\ 563 \\ \times\ \ 8 \\ \hline 4504 \end{array} \qquad \begin{array}{r} 563 \\ \times\,800 \\ \hline 450{,}400 \end{array}$$
Attach 00.

11. $\dfrac{63}{7} \qquad 7\overline{)63} \qquad \dfrac{63}{7} = 9$

12.



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13. $33{,}886 \div 4$

$$\begin{array}{r} 8\ 4\ 7\ 1 \ \textbf{R}2 \\ 4\overline{)3\ 3,\ 8\ 8\ 6} \\ \underline{3\ 2} \\ 1\ 8 \\ \underline{1\ 6} \\ 2\ 8 \\ \underline{2\ 8} \\ 0\ 6 \\ \underline{4} \\ 2 \end{array}$$

Check:

$$\begin{array}{r} 8471 \\ \times\quad 4 \\ \hline 33{,}884 \\ +\quad 2 \\ \hline 33{,}886 \end{array}$$

14.

$$\begin{array}{r} 2\ 2 \ \textbf{R}26 \\ 492\overline{)1\ 0,\ 8\ 5\ 0} \\ \underline{9\ 8\ 4} \\ 1\ 0\ 1\ 0 \\ \underline{9\ 8\ 4} \\ 2\ 6 \end{array}$$

Check:

$$\begin{array}{r} 492 \\ \times\quad 22 \\ \hline 984 \\ 984 \\ \hline 10{,}824 \\ +\quad 26 \\ \hline 10{,}850 \end{array}$$

15. **To the nearest ten:** $65\underline{8}3$

Next digit is 4 or less.

Tens place does not change.

All digits to the right of the underlined place change to zero. **6580**

To the nearest hundred: $6\underline{5}83$

Next digit is 5 or more.

Hundreds place changes $(5 + 1 = 6)$.

All digits to the right of the underlined place change to zero. **6600**

To the nearest thousand: $\underline{6}583$

Next digit is 5 or more.

Thousands place changes $(6 + 1 = 7)$.

All digits to the right of the underlined place change to zero. **7000**

16. **To the nearest ten:** $76{,}2\underline{7}1$

Next digit is 4 or less.

Tens place does not change.

All digits to the right of the underlined place change to zero. **76,270**

To the nearest hundred: $76{,}\underline{2}71$

Next digit is 5 or more.

Hundreds place changes $(2 + 1 = 3)$.

All digits to the right of the underlined place change to zero. **76,300**

To the nearest thousand: $7\underline{6}{,}271$

Next digit is 4 or less.

Thousands place does not change.

All digits to the right of the underlined place change to zero. **76,000**

17.

$2^5 - 6(4)$	*Exponent*
$= 32 - 6(4)$	*Multiply.*
$= 32 - 24 = 8$	*Subtract.*

18.

$\sqrt{36} - 2 \cdot 3 + 5$	*Square root*
$= 6 - 2 \cdot 3 + 5$	*Multiply.*
$= 6 - 6 + 5$	*Subtract.*
$= 0 + 5 = 5$	*Add.*

19. Multiply to find the amount used for the half-day and full-day tours; then add to find the total.

$$\begin{array}{r} 26 \\ \times\quad 9 \\ \hline 234 \end{array} \qquad \begin{array}{r} 18 \\ \times\ 17 \\ \hline 126 \\ 18 \\ \hline 306 \end{array} \qquad \begin{array}{r} 234 \\ +306 \\ \hline 540 \end{array}$$

540 gallons of fuel are needed.

20. Subtract to find the difference in cases.

$$\begin{array}{r} {}^{1}\cancel{2}\,{}^{10}\cancel{1},\ {}^{12}\cancel{2}\,{}^{8}\cancel{9}\,{}^{11}\cancel{1} \\ -\quad 4,\ 5\ 19 \\ \hline 16,\ 7\ 72 \end{array}$$

There were 16,772 more cases of pertussis than mumps.

21. Find the number of hairs lost in 2 years and subtract to find the hairs remaining.

$$\begin{array}{r} 365 \\ \times\ 100 \\ \hline 36{,}500 \end{array} \qquad \begin{array}{r} 36{,}500 \\ \times\quad 2 \\ \hline 73{,}000 \end{array} \qquad \begin{array}{r} 120{,}000 \\ -\quad 73{,}000 \\ \hline 47{,}000 \end{array}$$

47,000 hairs remain.

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22. Divide the total number of hours by the number of workers.

$$\begin{array}{r} 188 \\ 22\overline{)4136} \\ \underline{22} \\ 193 \\ \underline{176} \\ 176 \\ \underline{176} \\ 0 \end{array}$$

Each health care worker will work 188 hours.

23. Multiply the number of flushes and the amount of water used per flush to find the number of gallons of water used.

$$160 \cdot 1\frac{3}{5} = \frac{160}{1} \cdot \frac{8}{5} = \frac{\overset{32}{\cancel{160}}}{1} \cdot \frac{8}{\cancel{5}_{1}} = 256$$

256 gallons of water are used in 160 flushes.

24. Divide the total length by the length of the pieces.

$$70 \div 3\frac{1}{3} = \frac{70}{1} \div \frac{10}{3} = \frac{\overset{7}{\cancel{70}}}{1} \cdot \frac{3}{\cancel{10}_{1}} = 21$$

21 pieces can be cut.

25. $\frac{2}{3}$ is *proper* because the numerator (2) is smaller than the denominator (3).

26. $\frac{6}{6}$ is *improper* because the numerator (6) is larger than or the same as the denominator (6).

27. $\frac{9}{18}$ is *proper* because the numerator (9) is smaller than the denominator (18).

28. $3\frac{3}{8}$ $\quad 3 \cdot 8 = 24$

$24 + 3 = 27$

$3\frac{3}{8} = \frac{27}{8}$

29. $6\frac{2}{5}$ $\quad 6 \cdot 5 = 30$

$30 + 2 = 32$

$6\frac{2}{5} = \frac{32}{5}$

30. $\frac{14}{7}$

$$\begin{array}{r} 2 \\ 7\overline{)14} \\ \underline{14} \\ 0 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

$\frac{14}{7} = 2$

31. $\frac{103}{8}$

$$\begin{array}{r} 12 \\ 8\overline{)103} \\ \underline{8} \\ 23 \\ \underline{16} \\ 7 \end{array} \begin{array}{l} \leftarrow \text{Whole number part} \\ \\ \\ \leftarrow \text{Remainder} \end{array}$$

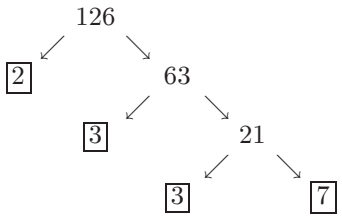
$\frac{103}{8} = 12\frac{7}{8}$

32. 72

$$\begin{array}{r} 36 \\ 2\overline{)72} \\ 18 \\ 2\overline{)36} \\ 9 \\ 2\overline{)18} \\ 3 \\ 3\overline{)9} \\ 1 \\ 3\overline{)3} \end{array}$$

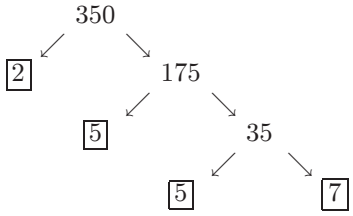
$72 = 2 \cdot 2 \cdot 2 \cdot 3 \cdot 3 = 2^3 \cdot 3^2$

33.



$126 = 2 \cdot 3 \cdot 3 \cdot 7 = 2 \cdot 3^2 \cdot 7$

34.



$350 = 2 \cdot 5 \cdot 5 \cdot 7 = 2 \cdot 5^2 \cdot 7$

35. $4^2 \cdot 2^2 = 16 \cdot 4 = 64$

36. $2^3 \cdot 6^2 = 8 \cdot 36 = 288$

37. $2^3 \cdot 4^2 \cdot 5 = 8 \cdot 16 \cdot 5$
$= 128 \cdot 5$
$= 640$

38. $\frac{42}{48} = \frac{42 \div 6}{48 \div 6} = \frac{7}{8}$

39. $\frac{24}{36} = \frac{24 \div 12}{36 \div 12} = \frac{2}{3}$

40. $\frac{30}{54} = \frac{30 \div 6}{54 \div 6} = \frac{5}{9}$

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41. $\frac{1}{2} \cdot \frac{3}{4} = \frac{1 \cdot 3}{2 \cdot 4} = \frac{3}{8}$

42. $30 \cdot \frac{2}{3} \cdot \frac{3}{5} = \frac{30}{1} \cdot \frac{2}{3} \cdot \frac{3}{5} = \frac{\overset{6}{\cancel{30}} \cdot 2 \cdot \overset{1}{\cancel{3}}}{\underset{1}{\cancel{3}} \cdot \underset{1}{\cancel{5}}} = 12$

43. $7\frac{1}{2} \cdot 3\frac{1}{3} = \frac{\overset{5}{\cancel{15}}}{\underset{1}{\cancel{2}}} \cdot \frac{\overset{5}{\cancel{10}}}{\underset{1}{\cancel{3}}} = \frac{25}{1} = 25$

44. $\frac{3}{5} \div \frac{5}{8} = \frac{3}{5} \cdot \frac{8}{5} = \frac{24}{25}$

45. $\frac{7}{8} \div 1\frac{1}{2} = \frac{7}{8} \div \frac{3}{2} = \frac{7}{\underset{4}{\cancel{8}}} \cdot \frac{\overset{1}{\cancel{2}}}{3} = \frac{7 \cdot 1}{4 \cdot 3} = \frac{7}{12}$

46. $3 \div 1\frac{1}{4} = \frac{3}{1} \div \frac{5}{4} = \frac{3}{1} \cdot \frac{4}{5} = \frac{12}{5} = 2\frac{2}{5}$

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