Working with Feet and Inches

A foot is broken up into twelve equal parts called inches. On a tape measure, each inch is divided into sixteenths. To add or subtract, arrange the feet over feet, inches over inches, and any fractions above each other. When carrying inches remember there are 12 inches in a foot, and to borrow a foot gives you 12 inches (not 10!).

\[
\begin{array}{c}
6' - 4 \frac{1}{2}'' \\
8' - 6'' \\
+14' - 1\frac{1}{4}'' \\
\hline
28' - 10 \frac{3}{4}''
\end{array} \\
\begin{array}{c}
8' - 9'' \\
32' - 11'' \\
+104' - 6'' \\
\hline
144' - 26''
\end{array}
\]

To change feet into inches, multiply by 12. A board 8 feet long is 96 inches long (8 × 12 = 96).

To convert \(7' - 3''\) into inches, multiply the 7 feet by 12 and add the 3 inches (\(7 \times 12 = 84, 84 + 3 = 87\) inches).

To change inches into feet, divide by 12. A board that is 60 inches long would be 5 feet (\(60 \div 12 = 5\) feet). When converting inches to feet, any remainder is left as inches. A 75-inch board would be 6 feet 3 inches long (\(75 \div 12 = 6,\) remainder 3).

\[
\begin{array}{c}
13' - 10'' \\
- 6' - 4'' \\
\hline
7' - 6''
\end{array} \\
\begin{array}{c}
31' - 17'' \\
-10' - 5'' \\
\hline
21' - 8''
\end{array}
\]

A yard is 3 feet long. There are 36 inches in a yard.

Practice Exercises

Convert to feet:
1. 144"
2. 21 yards
3. 120"
4. 96"
5. 84"
6. 48 yards

Convert to inches:
7. 12'
8. 8' - 4''
9. 17'
10. 15' - 7''
11. 4 yards
12. 4' - 5''
13. 5' - 6''
+3' - 4''
14. 3' - 3''
+7' - 10''
15. 127' - 11''
52' - 5''
+6' - 10''
16. 6' - 5''
23' - 10''
+82' - 9''
17. 24' - 7''
-8' - 5''
18. 12' - 10''
-4' - 8''
19. 8' - 6''
-4' - 8''
20. 23' - 6''
-7' - 6''

Linear Measurements - Exercises

Linear measurements are simply how long something is—whether it is the length of a 2 x 4, the amount of trim boards needed, the perimeter of a lot, or the number of edge forms required.

1. A pile of lumber contains 198 boards 8 ft. long, 273 boards 10 ft. long, 135 boards 12 ft. long, and 18 boards 16 ft. long. How many feet of boards are in the pile?

2. How many feet of base are needed in a room that is 24 feet long and 18 feet wide (add all 4 walls)?

3. Oak is sold at $1.02 per foot. The job requires 8 pieces 10 ft. long and 17 pieces 8 ft. long. How many feet of oak are needed? How much will they cost?

4. The rabbits are getting into the garden. How much fencing is used to enclose a 24 ft. by 32 ft. area?

5. A carpenter can place 72 ft. of floor joists per hour. How many feet are done after 8 hours?

6. A roll of insulation is used for every three feet of framed wall. If there are 80 feet of wall to insulate, how many rolls must be bought?

7. Both edges of a concrete foundation wall top surface require a chamfer. The wall is 64 feet long. If the chamfer pieces are each 8 feet long, how many pieces are needed?

Fractions

A fraction is a part of a whole number. The fraction is made up of two numbers. The top number is called the numerator and the bottom number is called the denominator.

The denominator tells the number of equal parts the whole figure is being divided up into (divisor). The fraction 1/2 shows that the quantity will be divided into two equal parts.

The numerator tells how many of these parts are being used. The fraction 3/4 has the divisor of 4 indicating that the figure is divided into four equal parts. The numerator of 3 indicates that 3 of these parts are needed.

A proper fraction has a numerator that is smaller than the denominator (3/4). An improper fraction has a larger numerator than the denominator (5/4). A mixed number has both a whole number and a fraction (2 1/4).

Measurements using fractions are easier if the fractions are written in the lowest terms. This does not change their value; for example, 1/2 = 2/4 = 4/8, etc. Try to think of it as if you were making change with money. Two quarters (50 cents) is equal to 5 dimes or 10 nickels or even 50 pennies. When reducing a fraction, find a number that will go into both the numerator and the denominator evenly. This number is called a common factor.

4/16 = 4/16 ÷ 4/4 = 1/4

The only number (besides 1) that can go evenly into both 4 and 16 is 4. When the numerator is one, the fraction cannot be reduced any further (4 is the common factor).

Adding Fractions

Adding fractions with the same denominator is basic addition. Add the numerators:

1/8 + 3/8 + 3/8 = 7/8  (1 + 3 + 3 = 7)

To reduce an improper fraction, divide the numerator (7) by the denominator (4). The answer is the whole number (1) and the remainder of 3 put into a fraction.

3/4 + 1/4 + 3/4 = 7/4  (3 + 1 + 3 = 7)  1

7/4 = 1 - 3/4  (7 ÷ 4 = 1 remainder 3)  4

Lowest Common Denominator

When the denominators are not the same, you must first find the lowest common denominator (LCD). This is a number that can be evenly divided by each of the denominators you are adding or subtracting. Sometimes this can be done by just looking at the fractions. The LCD of 1/4, 1/2, and 1/8 would be 8 because it can be divided by 4, 2, and 8. If the LCD cannot be determined by inspection, then it may be found mathematically.

To find the LCD of the following fractions 3/4, 5/8, 11/32, and 7/12, there are two ways. Factoring is one way of determining the LCD; for example,

- 4 is 2 × 2,
- 8 is 2 × 2 × 2,
- 32 is 2 × 2 × 2 × 2 × 2, and
- 12 is 3 × 2 × 2.

The LCD would need to be 2 × 2 × 2 × 2 × 2 × 2 × 3 or 96. All of the factors for each denominator must be found in the LCD; for example,

- 4 times 24 = 96,
- 8 times 12 = 96,
- 32 times 3 = 96, and
- 12 times 8 = 96.

To change the fractions to include the new denominator, remember to do the same thing to the numerator as you did to the denominator.

Another way of determining the LCD is through division.

Using the same fractions 3/4, 5/8, 11/32, and 7/12:

- 4, 8, 32, 12 Place the denominators in a line

2) 4, 8, 32, 12

Find the smallest number that can be divided into 2 or more of the denominators

Divide as many denominators by 2

Repeat the division because 2 will go into 2 or more of the denominators

Repeat again (if a number cannot be divided by the divisor, bring the number down) Now one is the only number that can be divided into the remaining numbers

2 × 2 × 2 × 1 × 1 × 4 × 3 = 96

Adding Mixed Numbers

When adding whole numbers, common fractions, and mixed fractions:

- add the fractions and reduce to lowest terms;
- add the whole numbers; then
- add the sums

Add 6, 5/8, and 1−3/4

6 Write all numbers in a column
5/8
+1 3/4

6
5/8 Reduce the fractions to LCD (8)
+1 6/8 Add the numerators and put over the LCD
7 11/8 = 1 3/8 Subtract the numerators
the LCD
Reduce the fraction
Add the whole numbers
7
+1 3/8 Add the sums
8 3/8

When subtracting common fractions:

- reduce all fractions to their LCD; then
- subtract the numerators and put over the LCD and reduce to lowest terms.

Subtract 1/4 from 5/8:

1/4 = 2/8 Reduce fraction to LCD
5/8 - 2/8 Set up problem
5 - 2 = 3 Subtract the numerators
3/8 Put answer over LCD
5/8 - 2/8 = 3/8 This answer is in lowest terms

When subtracting fractions from whole numbers, you need to borrow 1 and change it into a fraction, much like changing a dollar bill into change for the phone.

- Subtract 1 from the whole number and change it into a fraction with the same denominator as the other fraction.
- Subtract the fractions, leaving the answer over the denominator.
- Reduce to lowest terms, if needed.
- Bring the remaining whole number down.

5 Subtract 5/8 from 5
- 5/8
Borrow 1 from 5 (4 plus 8/8 equals 5)

\[
\begin{array}{c}
5 \frac{8}{8} \\
- \frac{5}{8} \\
\hline
\end{array}
\]

\[
\begin{array}{c}
4 \\
5 \frac{8}{8} \\
- \frac{5}{8} \\
\hline
2 \frac{5}{8}
\end{array}
\]

Subtract the fractions

\[
\begin{array}{c}
4 \\
5 \frac{8}{8} \\
- \frac{5}{8} \\
\hline
4 \frac{3}{8}
\end{array}
\]

Bring the whole number down

To subtract mixed numbers from whole numbers, just subtract the whole numbers after the fractions are done.

\[
\begin{array}{c}
4 \\
5 \frac{16}{16} \\
-2 \frac{3}{16} \\
\hline
2 \frac{13}{16}
\end{array}
\]

\[
\begin{array}{c}
4 \\
5 \frac{16}{16} \\
-2 \frac{3}{16} \\
\hline
2 \frac{13}{16}
\end{array}
\]

\[
\begin{array}{c}
4 \\
5 \frac{16}{16} \\
-2 \frac{3}{16} \\
\hline
2 \frac{13}{16}
\end{array}
\]

Ruler in Sixteenths

This is an example of an inch divided into sixteenths. The longest line divides the inch in half. The two next longest lines mark quarters. Four lines divide quarters into eights. The eight shortest lines separate the sixteenths. Practice reading a tape until you are comfortable reading 1/16, 1/8, 3/16, 1/4, 5/16, 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, and 15/16 without trying to count the lines. Start with the half-inch mark. The short mark before it is 7/16 and the mark right after it is 9/16.

Try one-quarter — the mark before is 3/16 and the one after it is 5/16. The mark before three-quarters is 11/16 and the one after it is 13/16. The eighths seem to take care of themselves. Notice that the numerators (the top numbers) are all odd numbers. This keeps the fractions in their simplest form. Although 2/16 is a fraction of an inch, it is simpler to call it 1/8. The same is true of 8/16, it is equal to both 4/8 and 2/4, but we say 1/2. Eventually, a quick glance will tell you the measurement.

Practice Exercises with Fractions

Reduce to lowest terms:

1. \[
\frac{8}{12}
\]

2. \[
\frac{20}{32}
\]

3. \[
\frac{6}{8}
\]

4. \[
\frac{14}{16}
\]

Reduce to a mixed fraction:

5. \[
\frac{13}{8}
\]

6. \[
\frac{145}{12}
\]

7. \[
\frac{18}{4}
\]

8. \[
\frac{96}{8}
\]

Change to sixteenths:

9. \[
\frac{1}{4}
\]

10. \[
\frac{3}{8}
\]

11. \[
\frac{1}{2}
\]

12. \[
\frac{7}{8}
\]

Add the fractions and reduce all answers to lowest terms:

13. \[
\frac{3}{8} + \frac{2}{8} + \frac{1}{8} =
\]

14. \[
\frac{5}{16} + \frac{3}{16} + \frac{7}{16} =
\]

15. \[
\frac{1}{2} + \frac{3}{4}
\]

16. \[
\frac{3}{8} + \frac{5}{16}
\]

17. \[
\frac{7}{8} + \frac{5}{16} + \frac{13}{32}
\]

18. \[
\frac{1}{8} + \frac{3}{16} + \frac{5}{12}
\]

Subtracting Fractions

Solve the problems and reduce fractions to lowest terms:

1. \( \frac{5}{8} \) - \( \frac{3}{8} \)
2. \( \frac{9}{16} \) - \( \frac{3}{16} \)
3. \( \frac{3}{4} \) - \( \frac{1}{4} \)
4. \( \frac{21}{32} \) - \( \frac{17}{32} \)
5. \( \frac{5}{8} \) - \( \frac{3}{16} \)
6. \( \frac{15}{16} \) - \( \frac{3}{4} \)
7. \( \frac{3}{4} \) - \( \frac{4}{32} \)
8. \( \frac{31}{32} \) - \( \frac{5}{8} \)
9. \( \frac{2}{3} \) - \( \frac{3}{16} \)
10. \( \frac{4}{5} \) - \( \frac{5}{8} \)
11. \( \frac{7}{14} \) - \( \frac{1}{4} \)
12. \( \frac{3}{12} \) - \( \frac{11}{16} \)
13. \( \frac{11}{8} \) - \( \frac{8}{5} \)
14. \( \frac{22}{16} \) - \( \frac{5}{8} \)
15. \( \frac{2}{1} \) - \( \frac{1}{1} \)
16. \( \frac{12}{3} \) - \( \frac{1}{2} \)
17. \( \frac{18}{4} \) - \( \frac{7}{8} \)
18. \( \frac{11}{2} \) - \( \frac{2}{3} \)
19. \( \frac{68}{12} \) - \( \frac{9}{32} \)
20. \( \frac{47}{1} \) - \( \frac{4}{32} \)
21. \( \frac{7}{1} \) - \( \frac{1}{2} \)

Multiplying Fractions

\( \frac{1}{4} \times \frac{3}{8} \) can be worked as \( \frac{1 \times 3}{4 \times 8} = \frac{3}{32} \)

Remember that when you multiply fractions, the answer gets smaller. Dividing fractions produces a larger answer.

The word of is sometimes used in place of the multiplication sign (\( \times \)).

\( \frac{1}{2} \) OF \( \frac{3}{4} \) = \( \frac{3}{8} \)

When multiplying mixed numbers, first change them into improper fractions.

\( \frac{4}{2} \times \frac{3}{4} \) becomes \( \frac{9}{2} \times \frac{11}{4} = \frac{99}{8} \)

\( (4 \times 2 + 1) \) there are 9 halves in 4 1/2

\( (2 \times 4 + 3) \) there are 11 quarters in 2 3/4

After multiplying, reduce the answer back to a mixed number

\( 99 = 12 \frac{3}{8} \) (99 ÷ 8 = 12 with a remainder of 3) \( \frac{12}{8} \)

When using cancellation, you are dividing the equation by 1 (2/2, 4/4, etc.).

Multiply 16, 3/8, and 1/2:

\( \frac{16}{1} \times \frac{3}{8} \times \frac{1}{2} = \) 

8 will divide into 16 and 8

2 will divide into 2 and 2

\( \frac{16}{1} \times \frac{3}{8} \times \frac{1}{2} = \) 

1 \( \times \frac{3}{1} \times \frac{1}{1} = 3 \) answer

Dividing Fractions

To divide fractions you must:
- invert the divisor (flip the second fraction upside-down);
- multiply across the top (numerators) and the bottom (the denominators); and
- reduce to lowest terms.

1/2 divided by 1/4 (this is asking how many times 1/4 will go into 1/2):

\( \frac{1}{2} \div \frac{1}{4} = \)

\( \frac{1}{2} \times \frac{4}{1} = \) Invert the divisor

\( \frac{1}{2} \times \frac{4}{1} = \) Multiply the fractions

\( 4 \div 2 = \) Reduce into lowest terms

1/4 will go into 1/2 2 times

When dividing mixed numbers, change them both to improper fractions, then invert the divisor and multiply as above:

\[
4 \frac{1}{2} \div 2 \frac{3}{4} = \\
9/2 \div 11/4 =
\]

\[
2 \\
9/2 \times 4/11 = 18/11 = 1 \frac{7}{11}
\]

### Practice Exercises

**Multiplying and dividing fractions — reduce to lowest terms:**

1. \(1/2 \times 3/4 = \)
2. \(1/4 \text{ of } 1/4 = \)
3. \(3/8 \times 5/16 = \)
4. \(3/5 \times 20 = \)
5. \(3/8 \times 1/16 = \)
6. \(5/8 \text{ of } 3/5 = \)
7. \(3 \frac{1}{2} \times 1 \frac{1}{16} \times 1/2 = \)
8. \(\frac{1}{8} \times \frac{5}{16} \times \frac{4}{7} \times \frac{3}{5} = \)
9. \(3 \frac{1}{4} \times 4 \frac{5}{8} \times 2 \frac{1}{2} = \)
10. \(11 \frac{1}{4} \times 2 \frac{1}{2} \times 6 = \)
11. \(3/8 \div 1/2 = \)
12. \(7/16 \div 7/8 = \)
13. \(4 \frac{1}{3} \div 6 \frac{2}{3} = \)
14. \(16 \div 1 \frac{5}{8} = \)
15. \(2 \frac{1}{8} \div 3/4 = \)
16. \(5 \div 5/8 = \)

### Word Problems with Fractions

Show your work (or the equations used) with a calculator.

1. A carpenter makes $963.60 for a 40-hour week. What is his hourly wage?
2. One thousand one hundred and forty-four sheets of drywall are used to hang an office building. If each office averages 52 sheets, how many offices are there?
3. If it takes 7/8 yard of concrete to pour a column, how much will it take to pour 24 columns?
4. Determine the number of hours required to lay 847 square feet of subflooring at the rate of 82 feet per hour.
5. The interior walls of a house are framed 3 1/2 inches. Both sides are covered with 1/2-inch drywall. How thick are the partitions?
6. The exterior walls of a house are 5 1/2 inches thick. Insulation board 1/2 inch thick is installed on the outside. This is covered with 5/8-inch cedar. After 1/2-inch drywall is hung inside, what is the total thickness of the wall?
7. How many pieces of 3/4-inch plywood are in a stack that is 89 1/4 inches tall?
8. The cost of a new garage is $14,824. What is the total cost to build 12 of these garages?
9. There are 806 four-penny finish nails in a pound. How many are there in 19 1/4 pounds?
10. If there are 670 shingles per square (100 square feet) when laid 5 inches to the weather, how many shingles are needed to cover 32 squares?
11. A rough piece of oak is 2 1/16 inches thick. The planer takes off 5/32 inch from each side. How thick is it now?

12. A carpenter can frame 1,000 board feet of wall in 21.4 hours. How many feet of wall can be done after a 40-hour work week?

13. If the carpenter used 13 pounds of nails during the week and there are 332 nails per pound, how many nails were driven?

14. Each column takes 1 1/3 sheet of 3/4-inch plywood. How much plywood is needed for 24 columns?

15. A stack of lumber has 948 2 3/4s. If 1/4 of the stack is used, how many are gone?

16. If 2/3 of the remaining lumber from problem 15 is used, how many are left?

17. The scale for plans of a building is 1/4-inch = 1 foot. How long is the building if it scales 23 3/4 inches?

18. A carpenter must divide a layout stick 75 inches long into 12 equal spaces. How long is each space?

**Board Feet**

A board foot is 1" thick by 12" wide and 1' long. Lumber is often sold at a price per thousand board feet. M is the Roman numeral for 1000.

<table>
<thead>
<tr>
<th>Thickness (in) × Width (in) × Length (feet)</th>
<th>Board feet</th>
</tr>
</thead>
</table>

**Example:** To figure the number of board feet in a 1" × 8" × 16':

\[
\frac{4 \times 1 \times 8 \times 16}{12} = \frac{32}{2} = 16 \text{ board feet}
\]

If more than one of the same sized boards are being figured, multiply it.

\[
\text{Number of Pieces} \times T \times W \times L = \frac{12}{12}
\]

**Example:** To figure the number of board feet in 24 pieces of 2" × 4" × 16':

\[
\frac{2 \times 24 \times 2 \times 4 \times 16}{12} = 256
\]

If lengths are given in inches, multiply the denominator by 12.

**Example:** To figure the number of board feet in 4 pieces of 1" × 6" × 18":

\[
\frac{4 \times 1 \times 6 \times 18}{12 \times 12} = \frac{3}{2} = 3 \text{ board feet}
\]

**Board Feet Exercises**

**NOTE:** Lumber less than 1" thick is counted as a full inch. Greater than 1" thick, standard thicknesses are 1 1/4", 1 1/2", 2", 3", 4", 5", 6", etc.

For odd widths, count the next standard width larger. Standard widths are 2", 3", 4", 5", 6", 8", 10", 12", etc.

Find the number of board feet in the following:

1. 15 pieces of 1/2" × 4" × 16'
2. 54 pieces of 3/4" × 9 1/4" × 14'
3. 84 pieces of 5/8" × 8" × 16'
4. 47 pieces of $3/4" \times 3.1/2" \times 18'$

5. 17 boards, $1" \times 12" \times 10'$

6. 9 boards $1\ 1/2" \times 22" \times 16'$

7. 7 planks $2" \times 12" \times 14'$

8. 10 pieces $2" \times 6" \times 12'$

9. 2 pieces $1" \times 2" \times 22"$

10. 7 pieces $1" \times 2\ 1/4" \times 17"$

11. 25 pieces $3/4" \times 3" \times 12'$

12. 60 linear feet of $1" \times 4"$

13. 260 linear feet of $2" \times 6"$

14. 140 linear feet of $2" \times 4"$

15. 68 linear feet of $1" \times 3"$

Area

Area of a square is side times side or side squared. The answer is left as square inches (sq. in.) or square feet (sq. ft.). It is never changed to feet and inches, as this would be a length, not an area.

Find the area of this 3-inch square.

$3 \times 3 = 9$

(3 inches times 3 inches equals 9 square inches)

When finding the area of a square with sides expressed in feet and inches, either change the length into inches and multiply to get an answer in square inches, or convert the inches into decimals of a foot and multiply to get an answer in square feet.

Area Exercises

Find the area of the following squares in terms of square feet:

1. Side = 12' 0"
2. Side = 15' 0"
3. Side = 28"
4. Side = 42"
5. Side = 1' 9"
6. Side = 4' 5"
7. Side = 24' 6"
8. Side = 36' 3"
9. Side = 5' 6"
10. Side = 3' 9"

Find the area of the following rectangles:

11. Width = 7' Length = 5'
12. Width = 8' Length = 11'
13. Width = 8" Length = 17"
14. Width = 19" Length = 47"
15. Width = 3' 1" Length = 4' 7"
16. Width = 4' 10" Length = 7' 2"
17. Width = 27' 6" Length = 37' 6"
18. Width = 14' 3" Length = 21' 3"
19. Width = 11' 9" Length = 21'
20. Width = 15' 0" Length = 18' 6"

Find the area of the following circles:

21. Radius = 6' 0"
22. Diameter = 20"
23. Radius = 9"
24. Radius = 14' 0"
25. Radius = 3' 6"
26. Diameter = 3' 0"
27. Diameter = 8' 0"
28. Radius = 11"
29. Radius = 18"
30. A = 8' B = 15'
31. A = 7" B = 13"
32. A = 17" B = 22"
33. A = 2' 5" B = 4' 1"
34. A = 4' 10" B = 4' 5"
35. A = 10' 6" B = 15' 4"
36. B = 20" h = 10"
37. B = 4' 3" h = 2' 4"
38. B = 13' 0" h = 11' 2"
39. B = 22" h = 13"
40. B = 3' 4" h = 5' 5"
41. B = 5' 2" h = 4' 10"
42. B = 8" b = 6" h = 3"
43. B = 12' b = 8' h = 4'
44. B = 8' 10" b = 4' 3" h = 3' 2"
45. B = 7' 4" b = 5' h = 2' 11"
46. B = 18' b = 13' 3" h = 10'
47. B = 44" b = 32" h = 19"
48. Side = 4"
49. Side = 6"
50. Side = 3' 4"
51. Side = 7' 11"

Find the area of the following octagons:
52. Side = 19"
53. Side = 3' 7"
54. Side = 28'
55. Side = 9' 11"

Volume
The volume of a cube is found by multiplying side times side times side, or side cubed.

Volume is area times height or thickness:

To determine how many yards of concrete are in a form, divide the volume in cubic feet by 27 (the number of cubic feet in a cubic yard).

Volume of Solid Figures

Concrete is ordered by the cubic yard. It is easier to use cubic feet than inches when figuring concrete volume. There are 46,656 cubic inches in a cubic yard.
Frustum of a Pyramid

\[ V = \frac{(B + b + \sqrt{B \times b}) \times h}{3} \]

Where \( B \) = area of lower base
\( b \) = area of upper base

**Volume Word Problems**

Solve the following word problems:

The following six questions are based on Figure 1, which represents a basement, and Section A, which is a cross section of the footing, foundation wall, and slab. Allow five feet on all sides when excavating to provide for forming.

1. How many cubic yards of dirt were removed, assuming 3 feet of extra dirt is also removed from all sides to a depth of 8 feet?

2. How many cubic yards of concrete are there in the footing?

3. How many cubic yards of concrete are there in the foundation walls?

4. How many cubic yards of concrete are there in the slab?

5. What is the cost of the concrete in #2, 3, and 4 at $75.00 per cubic yard?

6. How many dump truck loads of earth are removed for excavation? Each truck can carry 9 cubic yards.

Solve the following word problems:

7. How many linear feet of edge forms are needed to form the walk in Figure 2?

8. How many cubic yards of concrete are needed to pour the walk 6" deep?

9. An accent wall extends to the ceiling height of 16 feet. It has the shape of a trapezoid. It is 55 feet long at the floor and 40 feet long at the ceiling (see Figure 3).

a. How many square feet does the wall contain?

b. How many sheets of $4 \times 12$ drywall are needed to hang the wall if 10% was added for waste?

c. How many sheets of $4 \times 8$ drywall would be needed?

Solve the following word problems:

10. What is the volume of the column and capital in Figure 4?

11. How many yards of concrete would it take to pour 10 pier footings in Figure 5?

12. Find the cost of 16 cubic yards of gravel, weighing 106 pounds per cubic foot, at $9.95 per ton.

13. How many tons of gravel, weighing 106 pounds per cubic foot, will a truck carry if the inside body measurements are 5' 9" wide, 14' 6", long, and 3' 0" tall (load will be leveled to the top of the sides)?

**Triangles**

All shapes with three or more straight sides are made up of triangles. When a vertical line meets a horizontal line, a right angle is formed. A right angle is 90 degrees. The right triangle is the most common angle used by carpenters. The longest side is called the hypotenuse.

The right triangle is one half of a rectangle or square.

Rectangles have two sides that are equal in length and the two ends are equal to each other. All four inside corners are 90 degrees. A square is a rectangle with four equal sides.

**3–4–5**

Carpenters check for square either by pulling a 3–4–5 to determine a right angle or by measuring across the diagonal of a building. When using a 3–4–5 to determine a right angle, the carpenter is applying the Pythagorean Theorem. Pythagoras was a Greek
philosopher and mathematician who lived about 2,500 years ago. His theorem (a math rule of relations) states that in a right angle, the square of the hypotenuse is equal to the sum of the squares of the other two sides. This is written as a formula: $c^2 = a^2 + b^2$

where $c$ is the length of hypotenuse, and $a$ and $b$ are the lengths of the other two sides. If the two sides are known, the missing length can be found by substituting the values in the formula.

$$5 \times 5 = 3 \times 3 + 4 \times 4 \quad 25 = 9 + 16$$

Over 4,000 years ago, the Egyptians discovered the 3–4–5 triangle. A length of rope was knotted into 12 equal spaces. Three stakes were then driven at the corners spaced 3, 4, and 5 knots apart.

To increase the size of the triangle, you must multiply all parts of the triangle by the same number. For example 6–8–10 would be the result of multiplying by 2. For even greater distances, 30–40–50 could be used.

The sum of all three angles of any triangle equals 180 degrees. If the two angles are known, the other can be found by subtraction.

For example, a right triangle has a 60-degree angle:

$$180 - (90 + 60) = 180 - 150 = 30 \text{ (the missing angle is 30 degrees.)}$$

The total (180) minus the two known angles (90 + 30) equals the other angle.

A right triangle with two 45-degree angles is used frequently by carpenters. Because the angles are the same, the length of the two sides are also equal to each other. To brace a 2-foot wall with 45-degree kickers, measure 2 feet from the wall and drive the stake. The brace will be at a 45-degree angle at the top of the wall and at the stake. A quick reference to determine the length is found on the back tongue of your framing square.

Using a calculator with a square root key, you can determine the hypotenuse of any size right triangle. If one side is 7 feet and the other side is 9 feet, the formula would be: $7 \times 7 + 9 \times 9 = 49 + 81 = 130$. Now hit the square root key = 11.401756. This can be rounded off to 11.40, or rounded up to 11.402. The hypotenuse changes less than 1/16". The square root can also be computed by longhand math. However, it is not necessary for students to use this outdated practice.

In the field this can be done by measuring the diagonals of a rectangle (remember that these are the hypotenuse of two right angles). Adjust the corners in or out until the diagonals are equal. Subtract the smaller diagonal from the larger one and divide the difference in half to find out how far out of square it is (how far to move the corner).

Definitions

A straight angle equals 180° or a straight line.

Intersecting lines form opposite equal angles (angle 1 = angle 2).

Parallel lines (lines which have a constant distance separating them) cut by an intersecting line form alternate equal angles, so that angle 3 = angle 4 = angle 5 = angle 6.

The side opposite a 30° angle of a 30–60 degree triangle will equal 1/2 of the hypotenuse. $A = 1/2 \ C$.

An acute triangle has all angles measuring less than 90 degrees.

An obtuse triangle has an angle that is greater than 90 degrees.
An equilateral triangle has three equal sides and three equal angles of 60 degrees each.

A scalene triangle has sides of different lengths and three different angles.

An isosceles triangle has two equal sides and two equal angles.

An angle inscribed in a semicircle will always be a right angle.

A degree is divided into 60 equal parts called minutes. Minutes are symbolized by '. Just like a clock, a minute has 60 seconds. Seconds are shown with a " mark. This measurement, $48^\circ\cdot32'\cdot56''$, would be read forty-eight degrees, thirty-two minutes and fifty-six seconds.

Angles can be added and subtracted. To add $3^\circ\cdot35'\cdot29''$ with $12^\circ\cdot6'\cdot20''$, line the degrees up with the degrees, the minutes with the minutes, and the seconds with the seconds. Add each column separately.

$$
\begin{array}{c}
3^\circ\cdot35'\cdot29'' \\
+12^\circ\cdot6'\cdot20'' \\
\hline
15^\circ\cdot41'\cdot49''
\end{array}
$$

NOTE: When adding minutes and seconds that total more than 60, subtract multiples of 60 and carry the multiples to the higher value.

Example:

\[
\begin{align*}
117 \text{ seconds} & \quad 144 \text{ minutes} \\
-60 (1 \times 60) & \quad -120 (2 \times 60) \\
57 \text{ remainder} & \quad 24 \text{ remainder} \\
\end{align*}
\]

$117 \text{ seconds} = 1 \text{ min.} 57 \text{ sec.}$

$144 \text{ minutes} = 2 \text{ degrees} 24 \text{ min.}$

To subtract $12^\circ\cdot10'\cdot14''$ from $30^\circ\cdot27'\cdot38''$, again, line up the degrees, minutes, and seconds.

\[
\begin{align*}
30^\circ\cdot27'\cdot38'' \\
-12^\circ\cdot10'\cdot14'' \\
\hline
18^\circ\cdot17'\cdot24''
\end{align*}
\]

NOTE: When you borrow during subtraction, remember that 1 degree = 60 minutes and 1 minute = 60 seconds.

**Practice Exercises with Angles**

Find the missing angle of the triangle.

1. $20, 40$
2. $80, 40$
3. $90, 60$
4. 30, 60
5. 70, 50
6. 58, 79
7. 65, 90
8. 90, 50

Multiples of 3–4–5 Triangles
9. 6 – 8 –
10. 9 – – 15
11. – 40 – 50
12. 12 – 16 –
13. 36 – – 60
14. – 28 – 35
15. 24 – 32 –
16. 15 – – 25

Solve:
17. \(36^\circ\cdot50^\prime\cdot40^\prime\prime\) \(+167^\circ\cdot9^\prime\cdot40^\prime\prime\)
18. \(91^\circ\cdot47^\prime\cdot30^\prime\prime\) \(+27^\circ\cdot39^\prime\cdot42^\prime\prime\)
19. \(107^\circ\cdot18^\prime\cdot20^\prime\prime\) \(-77^\circ\cdot27^\prime\cdot15^\prime\prime\)
20. \(180^\circ\) \(-88^\circ\cdot35^\prime\cdot7^\prime\prime\)

21. 300 minutes = ___ degrees
22. 270 seconds = ___ minutes ___ seconds
23. 184 minutes = ___ degrees ___ minutes

Assume all spaces are equal:
Determine the degrees of the angles in each circle

A = ___ degrees
B = ___ degrees
C = ___ degrees
D = ___ degrees
E = ___ degrees

\(\triangle ABC\)\n
\(\triangle DEF\)\n
Solve for the missing angles:
\(F = ___\) degrees ___ minutes
\(G = ___\) degrees ___ minutes
\(H = ___\) degrees ___ minutes

Find the values of the missing angles:

A = ___
B = ___
C = ___
D = ___
E = ___
F = ___
G = ___
H = ___
I = ___
J = ___
K = ___
L = ___
M = ___
N = ___
O = ___
P = ___
Q = ___
R = ___
S = ___
T = ___