CHAPTER XII.

PRACTICAL MEASUREMENTS.

212. Illustrations.—The practical application of denominate numbers to a special kind of work is facilitated in many cases by the use of a special unit which is peculiar to that particular kind of work. For example, if it be required to determine how many shingles are necessary to cover a roof 40 feet long and 30 feet wide, the computation is greatly simplified by the knowledge of the fact that, on the average, a roof space of 100 square feet contains 1000 shingles. Thus, since the above roof contains 12 times 100 square feet, 12000 shingles will be required to cover it.

Similarly, if it be required to determine how many bricks will be needed to build a wall 50 feet long, 30 feet high, and 3 bricks thick, the reckoning is greatly facilitated by the knowledge that a piece of wall 1 foot square and 3 bricks thick contains 21 bricks. Hence, to build the above wall will require 50 × 30 × 21 or 31500 bricks.

213. General Methods.—It will be observed that computations of this kind consist in

1st, the determination of the number of units of area or volume in a given object, from linear measurements (see Arts. 175, 179).

2d, the use of a special unit in each kind of work applicable to a unit of area or volume of the given material. In the numerical applications of these methods frequent opportunities occur to diminish the work by *cancellation*. All the operations to be performed should be grouped together, and all possible cancellations made, before the final reduction is made.

It should also be remembered that in computations based on measure-

ments, it is not necessary to carry the work beyond the fourth or fifth figure, since all ordinary measurements are not accurate beyond these figures.

APPLICATIONS RELATING TO AREAS.

214. Rectangular Areas of Land.—In computing the area of a piece of land, the ordinary unit is the *acre*. In such computations it is convenient to remember that

$$43560 \text{ sq. ft.} = 1 \text{ acre.}$$

Hence, an acre is a square, each side of which is 208 + feet, or 70 − paces.

Other units of area frequently used are:

$$160 \text{ sq. rds.} = 1 \text{ A.}$$
$$4840 \text{ sq. yds.} = 1 \text{ A.}$$
$$640 \text{ A.} = 1 \text{ sq. mi.}$$

Ex. 1. How many acres in a field 320 feet long and 213 feet wide?

$$\text{No. acres} = \frac{\overset{8}{\cancel{320}} \times \overset{71}{\cancel{213}}}{\underset{363}{\underset{\cancel{1089}}{\cancel{43560}}}} = \frac{568}{363} = 1\tfrac{205}{363} \textit{ Ans.}$$

Ex. 2. How many acres in a meadow which averages $\frac{1}{4}$ mile in width and is $\frac{1}{2}$ mile long?

$$\text{Area} = \tfrac{1}{4} \times \tfrac{1}{2} \text{ sq. mi.} = \tfrac{1}{8} \text{ sq. mi.} = \tfrac{1}{8} \times 640 \text{ A.} = 80 \text{ acres.}$$

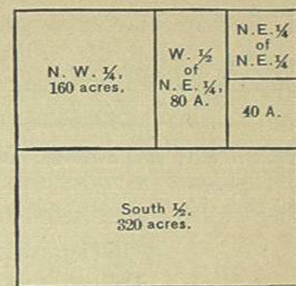
215. Townships and Sections.—In the eastern part of the United States, land, when settled, was divided according to the convenience or whim of the original settlers, and hence without any regular order or system. In the Western and Southern States most of the land was originally owned by the government, and has been divided according to a systematic plan, and disposed of in this form to settlers.

It is divided, first, into square **townships**, each side of which is 6 miles long; hence, each township contains 36 square miles. The sides of townships run east and west, and north and south.

Each township is subdivided into 36 **sections**, each containing 1 square mile, or 640 acres. The sections in a township are numbered according to a regular plan from 1 to 36.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

TOWNSHIP.



1 SECTION = 640 ACRES.

A section is subdivided into *quarter-sections*, each containing 160 acres. Quarter-sections are subdivided into half-quarter-sections and quarter-quarter-sections or lots. A lot therefore contains 40 acres.

EXERCISE 95.

How many acres in a field*:

1. 3600 ft. long and 121 ft. wide.
2. 1815 yd. long and 256 ft. wide.
3. 495 yd. by 220 ft.
4. 84 ft. × 55 yd.*

Find the areas of the following rectangular surfaces:

5. 17 ft. long and 12 ft. wide in square yards.
6. 8 yd. long and $5\frac{1}{2}$ yd. wide in square rods.
7. 140 rd. by 72 rd. in acres.
8. 7 yd. 2 ft. by 3 yd. 1 ft. in square yards.
9. 45 rd. 3 yd. 2 ft. × 30 rd. 3 yd. in square rods.
10. 30 rd. 3 yd. 2 in. × 8 rd. 4 yd. in integral units.
11. A road 13 mi. long and 3 rds. wide in acres.
12. A ceiling 4 yd. 2 ft. × 3 yd. 1 ft. in square feet.
13. How many acres in three sections? In 5 sections? In $\frac{1}{2}$ section? In $\frac{3}{8}$ section? In $\frac{21}{40}$ section?
14. How many rods of fence are necessary to enclose a section? A half-section? A quarter-section?

* The statement of the dimensions of an object is often much abbreviated by the use of "by" or by the sign ×, which is then read "by."

15. How many square feet in the floor of a room 16 ft. 8 in. by 12 ft. 6 in.? How many sq. yds. in ceiling of same room?
16. How many sq. ft. on side of a barn 60 ft. 6 in. long by 22 ft. 4 in. high?

216. Circular Areas.—It is proved by geometrical methods that the area of a circle is determined with sufficient accuracy for all practical purposes by the formula (see Arts. 323, 325),

Area of a circle = 3.1416 × (*square of radius of the circle*).

Ex. What part of an acre is grazed over by a cow tied by a tether 100 feet long?

$$\text{Area} = 3.1416 \times 100 \times 100 \text{ sq. ft.} = 31416 \text{ sq. ft.}$$

$$= \tfrac{31416}{43560} \text{ A.} = 0.721 + \text{acre, } \textit{Area.}$$

EXERCISE 96.

Find the areas of the following circles:

1. Radius = 10 ft.
2. Diameter = 30 ft.
3. Radius = 8 yd. 2 ft.
4. Diameter = 78 rd. $3\frac{2}{3}$ yd.

How many acres in each of the following circles:

5. Radius = 180 rd.
6. Diameter = 125 rd.
7. Diameter = $63\frac{1}{2}$ rd.
8. Radius = 200 rd. $2\frac{1}{5}$ yd.

9. A pond in the shape of a circle has a radius of 25 rd. 5 yd. How many acres in its surface?
10. How many square inches on the face of a coin whose radius is 0.5 in.? Another, whose radius is 1.5 in.?

217. In **paving**, the unit of computation is the **square yard.** In **roofing, flooring,** etc., the unit is the **square**, which equals 100 sq. ft.

In roofing with shingles, the average shingle is taken to be 18 in. long, 4 in. wide, with 5 in. exposed to the weather. 1000 shingles, or a bundle, are allowed for shingling 1 square.

EXERCISE 97.

What will be the cost of:

1. Shingling a roof 48 ft. × 23 ft. 8 in. @ $8.45 per square?

2. Paving a walk 640 ft. long and 8 ft. 3 in. wide @ $2.10 per square yard?

3. Lining a surface 80 ft. 3 in. × 61 ft. 9 in. @ $1.35 per sq. yd.?

4. Tinning a roof 23 yd. 2 ft. 3 in. × 19 yd. 1 ft. 6 in. @ $1.10 a sq. yd.?

5. The shingles for a roof on a building 80 feet long, if the rafters are 36 ft., and shingles cost $7.25 per M.?

6. Paving a city street 3 miles long and 40 feet wide, at 80 cents per sq. yd.?

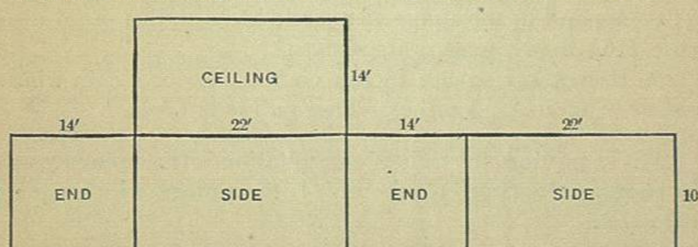
218. In **plastering, painting,** etc., the unit of computation is the **square yard.**

Custom varies as to the allowance to be made for openings in a wall, made by doors, windows, etc. One rule is that no deduction be made for openings in a room, aggregating less than 7 sq. yds., and that for openings aggregating more than 7 sq. yds. one-half their sum be deducted.

Ex. What will it cost to plaster the walls and ceiling of a room 22 ft. long, 14 ft. wide, and 10 ft. high, at $.33 a square yard, deducting half the area of 2 doors, each 7 × 3 ft., and 5 windows, each 6 × 3 ft.?

SOLUTION.

The walls and ceiling may be conveniently indicated as follows:



The walls (that is, the ends and sides combined) make a rectangle 2 × 22 + 2 × 14 feet, or 72 feet long.

Hence, area of walls = 72 × 10 sq. ft. = 720 sq. ft
area of ceiling = 22 × 14 sq. ft. = 308 sq. ft.
Total area = 1028 sq. ft.

Area of doors = 2 × 7 × 3 sq. ft. = 42 sq. ft.
Area of windows = 5 × 6 × 3 sq. ft. = 90 sq. ft.
132 sq. ft.

Area deducted = ½ × 132 sq. ft. = 66 sq. ft. = $\frac{22}{3}$ sq. yds.
Net area = 962 sq. ft.

$$\text{Cost of plastering} = \frac{\$0.\overset{.11}{\cancel{33}} \times 962}{\underset{3}{\cancel{9}}} = \$35.27, \textit{ Cost.}$$

EXERCISE 98.

What will it cost to:

1. Paint the walls and ceiling of a room 30 ft. by 16 ft. by 9 ft. high at 8 ct. a sq. yd.?

2. Plaster a room 24 ft. × 20 ft. × 16 ft. at 42 ct. a sq. yd., allowing half of 3 doors each 7 ft. × 3½ ft., and 5 windows each 5 ft. × 3½ ft.?

3. Paint a room 40 ft. × 31 ft. 6 in. × 9 ft. 6 in. at 5 ct. a sq. yd. for the floor and 7 ct. for the rest, allowing a deduction of 10 sq. yd. for windows and doors?

4. Plaster the five rectangular faces of a church, whose inside dimensions are 60 yds. 2 ft. × 40 yds. 1 ft. 6 in. × 30 ft. at 9 ct. per sq. yd., if $\frac{1}{10}$ of the entire *wall* surface is deducted for openings?

219. Carpeting.—To determine the number of yards of carpet needed to carpet a room, it is necessary to *determine the number of strips which the room will require; and to multiply the number of strips by the length of each strip.*

The number of strips is determined by dividing the width of the room (if the carpet runs lengthwise), or the length of the room (if the carpet runs crosswise), by the width of a single strip (usually 1 yd. or ¾ yd.). A part of a strip is regarded as a whole strip, the part not needed being folded under. When the carpet is figured, in order to match the figures, strips of carpet must usually be taken a little longer than the length of the room (and the unused ends folded under).

Ex. How many yards of carpet, $\frac{3}{4}$ yd. wide, will be required to cover a floor 26 feet long and 17 feet wide, if the carpet runs lengthwise and $\frac{1}{6}$ of a yard is wasted in matching patterns?

SOLUTION.

$$\text{No. of strips} = \tfrac{17}{3} \div \tfrac{3}{4} = 7\tfrac{5}{9}, \text{ or } 8.$$
$$\text{Length of a strip} = \tfrac{26}{3} \text{ yd.} + \tfrac{1}{6} \text{ yd.} = \tfrac{53}{6} \text{ yd.} = 8\tfrac{5}{6} \text{ yd.}$$
$$\text{No. yds.} = 8 \times 8\tfrac{5}{6} = 70\tfrac{2}{3}, \textit{ Result.}$$

EXERCISE 99.

1. A room $8\frac{1}{2} \times 7\frac{1}{3}$ yards is to be carpeted by unfigured carpet a yard wide, and strips are to run lengthwise. How many yards will be required?

2. If carpet is $\frac{3}{4}$ yd. wide, strips run lengthwise, and there is $\frac{1}{6}$ yd. wasted in matching patterns, how many yards must be bought for a room 9 yd. long and 5 yd. wide?

3. How many yards of carpet, $\frac{7}{8}$ yd. wide, will be required for a room 17 yd. $\times$ 17 ft., if strips run lengthwise? If strips run crosswise?

4. Find the cost of carpeting a room 19 ft. long and 14 ft. wide, with carpet $\frac{3}{4}$ yd. wide and costing $1.50 a yard, when the strips run crosswise and there is a waste of $\frac{1}{4}$ yd. in matching.

5. A room 13 ft. $\times$ $10\frac{1}{2}$ ft. is to be carpeted with carpet $\frac{3}{4}$ yd. wide and worth $2.25 a yard. There will be waste of $\frac{3}{16}$ yd. in matching. Will it be cheaper to run the strips lengthwise or across the room? How much cheaper?

220. Papering.—The unit used for wall paper is the *roll*, a roll being 8 yards long, 18 inches, or $\frac{1}{2}$ yard, wide. (The double roll, 16 yards long and 18 inches wide, is also used at times.)

To determine the number of rolls of wall paper needed to cover the walls of a given room,

1st. *Find the number of strips of paper by multiplying the number of yards in the distance around the room by 2;*

2d. *Find the number of rolls by dividing the number of strips required by the number of strips which can be cut from a single roll.*

A part of a strip of wall to be covered counts as a whole strip, and a part of a roll needed as a whole roll. (But in cutting paper, parts left over are rejected.)

Owing to waste in matching patterns, turning corners, etc., and gain due to windows, doors, etc., the estimate of the number of rolls required can only be approximate.

Borders used at the top of the wall are sold by the linear yard.

Ex. How many rolls of paper are required to cover the walls of a room 24 ft. long, 18 ft. 6 in. wide, and 10 ft. high?

SOLUTION.

The distance around the room may be conveniently represented as follows:

$$\underbrace{24'}_{\text{length}}\;\underbrace{18'\,6''}_{\text{width}}\;24'\;18'\,6''$$

Hence, distance $= 2 \times 24 \text{ ft.} + 2 \times 18\frac{1}{2} \text{ ft.} = 85 \text{ ft.}$

$= 28\frac{1}{3}$ yds. $= 56\frac{2}{3}$ half-yds.

$\therefore$ No. strips $= 57$.

No. strips cut from one roll $= \dfrac{24 \text{ ft.}}{10 \text{ ft.}} = 2.$

No. rolls $= \frac{57}{2} = 28\frac{1}{2}$, that is 29, *Result.*

EXERCISE 100.

1. How many rolls of paper are required to paper the walls of a room 15 ft. long, 11 ft. wide, and 9 ft. high?

2. What will be the cost of the paper for the walls of a room 40 ft. long, 32 ft. wide, and 11 ft. high, at 45 cents a roll?

3. What will it cost for paper in a room $21\frac{1}{2}$ ft. long, $16\frac{1}{2}$ ft. wide, and 15 ft. high, at 60 cents a roll, if the ceiling paper runs crosswise?

4. The walls of a room 28 ft. long, 25 ft. wide, and 15 ft. high are to be papered with paper selling at 75 cents a roll; there is a border of $2\frac{1}{2}$ ft. width at 4 cents a yd., and a baseboard of 6 in. What is total cost?

[NOTE.—Strips need be only 12 feet long.]

APPLICATIONS TO VOLUMES.

221. Board Measure.—In measuring boards and lumber, the unit is the **board foot**, which is a rectangular piece of wood 1 foot square and 1 inch thick.

Large quantities of lumber are sold in terms of the **hundred** or **thousand**, by which is meant 100 board feet or 1000 board feet.

Boards less than 1 inch in thickness are estimated as if they were 1 inch thick.

A cubic foot of lumber contains 12 board feet. Hence, the number of board feet in a piece of lumber is 12 times the number of cubic feet, and the number of cubic feet is $\frac{1}{12}$ the number of lumber feet.

All **square** lumber, as planks, joists, beams, etc., is estimated in board feet.

Round timber, as masts, etc., is estimated in cubic feet. To find the number of board feet in a given board or piece of lumber, *multiply two of the dimensions in feet by the other dimension in inches.*

Ex. 1. How many board feet in a plank 16 feet long, 10 inches wide, and 3 inches thick?

The width = 10 inches = $\frac{10}{12}$ feet.

$$\therefore \text{No. board feet} = \frac{\overset{4}{\cancel{16}} \times 10 \times \cancel{3}}{\underset{\cancel{4}}{\cancel{12}}} = 40, \textit{ Result.}$$

Ex. 2. How many feet in a board 14 feet long, 10 inches wide, and $\frac{7}{8}$ inch thick?

Since $\frac{7}{8}$ inch is taken as 1 inch,

$$\text{No. board feet} = \frac{\overset{7}{\cancel{14}} \times \overset{5}{\cancel{10}} \times 1}{\underset{\cancel{6}\,3}{\cancel{12}}} = 11\tfrac{2}{3}, \textit{ Result.}$$

EXERCISE 101.

How many board feet in:

1. A plank 12 ft. long, 8 in. wide, and 2 in. thick? $\frac{3}{4}$ in. thick?

2. 5 beams 9 ft. long, 10 in. wide, and 4 in. thick? $4\frac{1}{2}$ in. thick?

3. 20 rafters 24 ft. long, 6 in. wide, and 4 in. thick?

4. 45 joists 18 ft. × 8 in. × 6 in.? If $5\frac{1}{2}$ in. thick? If $\frac{1}{2}$ in. thick?

What is the cost of:

5. 75 boards 16 ft. × 9 in. × 1 in. @ $18 per M.?

6. 12 posts 8 ft. × 5 in. × 6 in. @ $2.20 a hundred?

7. 85 joists 12 ft. × 11 in. × 4 in. @ $23 per M.?

222. Capacity of Bins.—Instead of determining the number of bushels which a bin will contain by actually filling the bin and counting the number of bushels, it is much more convenient to compute the capacity of the bin in bushels from the linear dimensions of the bin.

Since a bushel contains 2150.42 cubic inches, to find the capacity of a bin in bushels, *divide the number of cubic inches in the volume of the bin by 2150.42.*

Ex. 1. How many bushels will a bin 20 feet long, 8 feet wide, and 4 feet deep contain?

$$\text{No. bushels} = \frac{20 \times 8 \times 4 \times 1728}{2150.42} = 514.28.$$

Since 2150.42 cubic inches = $1\frac{1}{4}$ cubic feet nearly, in many cases a sufficiently accurate computation of the number of bushels in a bin is obtained by dividing the number of cubic feet in the bin by $1\frac{1}{4}$, that is, by multiplying it by $\frac{4}{5}$. Hence, *the approximate number of bushels in a bin* = $\frac{4}{5}$ *the number of cubic feet in the bin.*

Ex. 2. Approximately how many bushels will a bin 15 × 8 × 6 feet hold?

$$\text{Approx. no. bush.} = \frac{\overset{3}{\cancel{15}} \times 8 \times 6 \times 4}{\cancel{5}} = 576.$$

Grain, seeds, and small fruits are sold by **stricken measure.** Coarser materials, as potatoes, corn in the ear, etc., are sold by **heaped measure.**

The number of bushels by heaped measure = $\frac{4}{5}$ *the number by stricken measure.*

Ex. 3. How many bushels of corn in the ear will a bin $15 \times 8 \times 6$ feet hold?

$$\text{No. bushels} = \frac{\overset{3}{\cancel{15}} \times 8 \times 6 \times 4 \times 4}{\cancel{5} \times 5} = 460\tfrac{4}{5}.$$

EXERCISE 102.

1. How many cubic inches in a box 16 in. long, 10 in. wide, and 3 in. deep? What part of a cu. ft. is that?

2. Required the number of cu. yds. in a wall 2 yd. 2 ft. 8 in. long, 1 yd. 1 ft. 6 in. wide, and 2 yd. 9 in. high.

3. How many bushels of oats can be put in a bin $15 \times 7 \times 6$ ft.? (Accurate.)

4. How many bushels of wheat can be put into a bin $24 \times 16 \times 10$ ft.? (Approximate.)

5. A bin $22 \times 20 \times 8$ ft. is full of potatoes. About how many bushels in it?

6. A crib of corn is $60 \times 15 \times 6$ ft. About how many bushels of corn in the crib?

7. A bin $6 \times 7 \times 8$ ft. is $\frac{2}{3}$ full of wheat. It is bought by approximate measurement at 70 ct. a bushel, and sold under accurate measurement at 90 ct. a bushel. What was the gain?

223. Capacity of Cisterns.—It is convenient to be able to determine the capacity of a cistern or tank, in gallons, from the linear dimensions of the tank.

Since a gallon contains 231 cu. in., to find the capacity of a cistern in gallons, *divide the number of cubic inches which the cistern contains by* 231.

The capacity of a large cistern is also obtained sometimes

in terms of larger units, as the barrel ($31\frac{1}{2}$ gals.), or the hogshead (63 gals.).

Ex. How many gallons will a tank $22 \times 10 \times 6$ ft. contain?

$$\text{No. gals.} = \frac{\overset{2}{\cancel{22}} \times 10 \times \overset{2}{\cancel{6}} \times 1728}{\underset{\underset{7}{\cancel{21}}}{\cancel{231}}} = 9874\tfrac{2}{7}.$$

EXERCISE 103.

How many gallons in a cistern:

1. Containing 125 cu. ft.?
2. Containing 132 cu. yds.?
3. $12 \times 11 \times 8$ ft.?
4. $22 \times 21 \times 20$ ft.?
5. $8 \times 7 \times 6$ yds.?
6. $90 \times 14 \times 10$ ft.?

224. Excavations and Embankments.—In moving earth the unit is a cubic yard, or 27 cubic feet, called a *load.*

Ex. What is the cost of excavating a cellar $18 \times 24 \times 6$ ft., at 10 cents a load?

$$\text{No. loads} = \frac{\overset{2}{\cancel{18}} \times 24 \times \overset{2}{\cancel{6}}}{\underset{\cancel{9}}{\cancel{27}}} = 96.$$

$$\text{Cost} = 96 \times \$.10 = \$9.60.$$

225. Stone Work and Masonry.—In stone work and masonry the usual unit is the *perch*, or $24\frac{3}{4}$ cubic feet.

A perch of stone is a rectangular pile $16\frac{1}{2}$ feet long, $1\frac{1}{2}$ feet wide, and 1 foot deep, and containing, therefore, $24\frac{3}{4}$ cubic feet.

As used in a wall, the perch is regarded as consisting of 22 cubic feet of stone, with $2\frac{3}{4}$ cubic feet allowed for mortar and filling.

Sometimes, however, masonry is estimated by the cubic foot.

EXERCISE 104.

Find the number of perches of masonry in these walls:

1. $75 \times 3 \times 2$ ft.
2. $12 \times 11 \times 4\frac{1}{2}$ ft.
3. 55 yd. $\times$ 16 ft. $\times$ 4 ft.
4. 60 yd. $\times$ 15 ft. $\times$ 5 ft.

How many cubic yards of earth in the following excavations:

5. Cellar $30 \times 20 \times 7$ ft.?

6. Tunnel 90 rd. 4 yd. $\times$ 12 yd. $\times$ 20 ft.?

7. Find the cost of opening a railroad cut 90 yards long, averaging 40 ft. wide and 32 ft. deep, at $1.25 a cu. yd.

8. A wall 374 ft. long and 6 ft. square at the end is to be built at $3.75 a perch of 22 cu. ft. Find cost.

9. A foundation 70 ft. long, 9 ft. deep, and 8 ft. wide is to be laid. For necessary excavations the charge is 60 cts. a load, and for building the wall $4.50 a perch ($24\frac{3}{4}$ cu. ft.). What is the entire cost?

226. Brickwork.—In brickwork the unit is usually **one thousand bricks**, but sometimes the cubic foot is used.

The average size of bricks is $8 \times 4 \times 2$ inches.

The following practical units are also used:

1. A square foot of wall, 1 brick or 4 inches thick, contains 7 common bricks.

2. A square foot of wall, 2 bricks or 9 inches thick, contains 14 bricks.

3. A square foot of wall, 3 bricks or 13 inches thick, contains 21 bricks.

Hence, to find the number of common bricks required for a wall,

Multiply the number of square feet in the wall by 7, *if the wall is* 1 *brick thick; by* 14, *if it is* 2 *bricks thick; by* 21, *if it is* 3 *bricks thick.*

In a building, the corners, doors, and window-spaces are deducted in estimating the number of bricks, but not in estimating labor.

Ex. How many common bricks will be required to build a house 40 ft. long, 24 ft. wide, 18 ft. high, the walls being 13 in. thick, allowing 280 sq. ft. for doors and windows?

SOLUTION.

Entire distance around the building = 2(40 + 24) ft. = 128 ft.
Entire area of wall = 128×18 sq. ft. = 2304 sq. ft.
Deduction for 4 corners = $\frac{13}{12} \times 18 \times 4$ sq. ft. = 78 sq. ft.
Deduction for windows, etc. = 280 sq. ft.
Entire deduction = 358 sq. ft.
Net area of walls = 2304 sq. ft. − 358 sq. ft. = 1946 sq. ft.
No. bricks = 1946×21 = 40,866, *Result.*

Bricks are often of special shapes and sizes. Thus, Philadelphia and Baltimore bricks are $8\frac{1}{4} \times 4\frac{1}{8} \times 2\frac{3}{8}$ in.; Maine bricks are $7\frac{1}{2} \times 3\frac{3}{8} \times 2\frac{3}{8}$ in.; Milwaukee bricks are $8\frac{1}{2} \times 4\frac{1}{8} \times 2\frac{3}{8}$ in.; North River bricks are $8 \times 3\frac{1}{2} \times 2\frac{1}{4}$ in., etc. To determine the number of bricks of a special kind required to make a wall, *increase each of the three dimensions of the brick by $\frac{1}{4}$ in. to allow for mortar, and divide the contents of the wall by the contents of* 1 *brick.*

In computing the number of bricks in a pavement, no change is made in the dimensions of a brick, since no allowance is made for mortar.

EXERCISE 105.

1. How many common bricks are required to build a house 36×32 ft., and 26 ft. high, the wall to be 3 bricks thick, if an allowance of 150 sq. ft. is made for openings?

2. What will they cost at $16 a thousand?

3. How much will the bricks for a house 40×36 ft., 32 ft. high, and walls 13 in. thick, cost at $18 per M.? What is the cost of laying them at $2.25 a sq. yd.?

(No allowance for corners or openings.)

4. What will be the cost of the bricks and the laying of them, for a house 45 ft. sq., 28 ft. high, walls 3 bricks thick, after a deduction of 425 sq. ft. of surface for openings and corners, if bricks are worth $14 a thousand and laying them costs $2.75 per M.?

5. A pavement, 90 ft. long, $10\frac{1}{2}$ ft. wide, is laid with Milwaukee bricks on the edge, 60 to a square yard. What is the cost, at the rate of $10 per M. for the bricks and 2 cts. a sq. ft. for the labor?

227. Other Units of Weight or Volume.—It is sometimes useful to determine the number of tons in a heap or bin of coal, from the linear dimensions of the heap or bin.

From 36 to 40 cu. ft. of ordinary anthracite coal make 1 ton.
From 36 to 45 cu. ft. of bituminous coal make 1 ton.
About $34\frac{1}{2}$ cu. ft. of Lehigh white-ash coal (egg size) make 1 ton.
About 35 cu. ft. of Schuylkill white-ash coal (egg size) make 1 ton.
About 36 cu. ft. of Schuylkill gray or red-ash coal make 1 ton.

Similarly, to determine the number of tons of a quantity of hay from its linear dimensions:

About 500 cu. ft. of hay loose or in loads = 1 ton.
About 400 cu. ft. of hay in a mow = 1 ton.
About 270 cu. ft. of hay in a settled stack = 1 ton.

Coal is at times sold in small quantities by the *bushel*. A bushel weighs 72 lbs. and is about $\frac{1}{28}$ ton.

EXERCISE 106.

1. A box $6 \times 5 \times 4$ ft. is full of ordinary coal. Counting a ton to 38 cu. ft., how many tons are there in the box? How many tons if it were full of Lehigh white-ash coal?

2. A mow of hay is $40 \times 28 \times 20$ ft. How many tons of hay will it contain?

3. How many tons of bituminous coal in a train of 42 cars averaging $36 \times 7 \times 5$ ft.?
(Allow 40 cu. ft. to the ton.)

4. A farmer hauled 60 loads of hay, and they averaged $18 \times 9 \times 10$ ft. What was its value at $18 a ton?

5. What advantage is there in determining the number of tons of hay or of coal by measurements of the dimensions of the mows or bins? In what other ways might these weights be determined?

EXERCISE 107.

REVIEW.

1. Find the area of a circle whose radius is 3 inches. Another, whose radius is 7 inches. Radius is 8 feet. Radius is 20 rods. Radius is .15 inch. Radius is $\frac{3}{4}$ yard.

2. Find in acres the area of a farm 1 mile 250 rods × 85 rods.

3. Which is the larger volume, $111\frac{3}{4}$ gallons or 12 bushels?

4. How many square inches in the entire exterior surface of a box $10 \times 9 \times 8$ inches? What part of a cubic yard will it contain?

5. About a square lawn 40 rods on a side is laid a drive 3 yards wide. How many square rods in the drive?

6. A box is made of 2-inch material, and the outer dimensions are $12 \times 10 \times 9$ inches. How many cubic inches in the material of the box including the lid? How many cubic inches will the box contain?

7. How many board feet in a load of 40 rafters, each 18 feet long and 8×6 inches at the end?

8. A railroad passes through a farm, taking a strip $1\frac{1}{2}$ miles long and 66 feet wide. What is the value of this land at $80 an acre?

9. To dig a sewer 3 miles long, 8 feet deep, and 4 feet wide, the contract called for 80 cents per cubic yard. What did it cost?

10. How many bushels of grass seed will a bin $14 \times 10 \times 9$ feet contain? How many bushels of potatoes?

11. What will it cost to lay a wall 200 rods long and 5×8 feet on the end, at $2.60 a perch (22 cubic feet)?

12. What will be the cost of carpeting a room 7×11 feet with carpet $\frac{3}{4}$ yard wide, worth $1.50 a yard, and put down crosswise?

13. The walls of a room 16 feet × 13 feet, and 9 feet high, are papered with paper worth 60 cents a roll, and the ceiling is painted at 30 cents a square yard. What will it cost?

A large parlor is 50×38 feet, and 14 feet high.

14. What will carpet cost, $\frac{7}{8}$ yard wide and worth $2.50 a yard, if put down lengthwise and every strip wastes $\frac{1}{4}$ yard in matching?

15. What will papering its walls cost at 90 cents a roll, allowing $\frac{1}{3}$ of one end for windows and doors?

16. What will painting the ceiling cost at 18 cents a square yard?

17. What is the area of the largest circle that can be drawn in the ceiling?

18. What will it cost to roof a barn whose rafters are 18 feet 6 inches long, and the ridge-pole 35 feet, at $8.40 per square?

19. What will it cost to floor a 3-story house, 60×42 feet, with 2-inch boards, at $34.60 per M.?

20. What will it cost to cement the floor and side walls of a cellar 25×24 feet, and 8 feet high, at 48 cents a square yard?

21. What is the cost of the carpet, running crosswise, $\frac{3}{4}$ yard wide, and worth $1.60 a yard, on a room 23×22 feet, if there must be a waste of $\frac{1}{8}$ yard for matching?

22. A bin occupying $\frac{2}{3}$ of a cellar which is $20 \times 18 \times 11$ feet is $\frac{3}{4}$ full of coal (ordinary anthracite). Find its approximate value at $5.25 a ton.

23. How many gallons will a cistern 7 feet cube contain?

24. Water weighs $62\frac{1}{2}$ pounds to the cubic foot. What will the water in a tank containing 1000 gallons weigh?

25. A county in one season built 17 miles of macadamized road 12 feet wide, at the rate of 75 cents per square yard. What was the total cost?

26. If a roll of paper a mile long will just cover $193\frac{3}{5}$ square yards, how wide is the paper? Its width is what decimal of its length?

27. What will be the cost of the palings necessary to inclose a lawn 36×41 yards, if they are 2 inches wide, placed 2 inches apart, and sell for $2.75 a hundred?

28. How many bushels will a bin hold whose dimensions are $15 \times 11\frac{1}{4} \times 8\frac{2}{3}$ feet? How many gallons?

29. A bin $15 \times 8\frac{1}{2} \times 6\frac{2}{3}$ feet was full of apples, from which enough cider was pressed to fill a tank $9\frac{1}{3} \times 4\frac{1}{2} \times 3$ feet, $\frac{3}{4}$ full. The apples were bought at 36 cents a bushel (approximately) and the cider was sold at 33 cents a gallon. Required the gain.

30. How many square yards in a circular flower-bed 56 feet across?

31. A certain tank contains 1000 gallons. How many bushels would it hold?

32. There are to be laid two cement walks, one on each side of a certain street 2 miles long. The walks are to be 60 in. wide and to cost 40 cts. a sq. yd. What is the total cost?

33. A circular pond 28 yd. across, is surrounded by a path 4 ft. wide. What is the area of the path?

34. My farm is 220 rd. long and 144 rd. wide. It is entirely surrounded with a four-wire fence. The wire cost me half a cent a foot and the posts, which are 11 ft. apart, cost 9 cents each. What did the material cost?

35. What will be the cost of plastering the walls and ceiling of a room 16 ft. 6 in. long × 11 ft. 4 in. wide × 10 ft. high @ 36 ¢ a sq. yd., allowing 15 sq. yd. for doors, etc.?

36. If a cubic foot of water weighs $62\frac{1}{2}$ lbs., what will a barrel of water weigh?

37. How many gallons of water required to weigh a ton?

38. If the diameter of a pail is 6 in., how many square inches in the bottom and lid together?

39. There is an iron cistern made of 3-in. metal plates, and without any top. If the inner dimensions are 8 ft. long, 5 ft. wide, and 10 ft. deep, how many cubic feet of iron in the material?

40. Find the weight of that iron if iron is 7 times as heavy as water.

CHAPTER XIII.

PERCENTAGE.

228. Illustration.—A man has two investments, one of $800 in real estate, which brings a return of $48 a year; and another of $500 in railroad bonds, which brings in $35 a year. Which is the better investment?

The comparison of the two investments is much facilitated by determining the proceeds of a single hundred dollars in each case, and comparing them.

Thus, if $800 in real estate brings in $48 a year.
$100 " " " $6 a year.
If $500 in bonds brings in $35 a year,
$100 " " $7 a year.

Since $7 per $100 invested is a better return than $6 per $100, the investment in bonds is relatively more profitable.

229. Value of 100 as a Basis of Comparison.—This use of a standard base, as 100, in making estimates, has two advantages: (1) it facilitates comparisons, as in the above example; (2) it leads in time to an instinctive grasp of the various rates used with reference to one hundred.

Thus, 6 per cent. (6 out of every hundred), 7 per cent., etc., come to have a sharp and definite meaning in the mind, which meaning rises instantly when such words are used.

230. Definitions and Symbols.—**Percentage** is the process of computing with reference to 100 as a base.

Per cent. (from *per*, by, and *centum*, one hundred) means by or on the hundred. Thus, when a merchant gains 15 per cent., he means that he gains $15 for every $100 invested